

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
18 January 2007 (18.01.2007)

PCT

(10) International Publication Number  
**WO 2007/009039 A1**

- (51) International Patent Classification:  
*B01D 46/52* (2006.01)    *F02M 35/024* (2006.01)
- (21) International Application Number:  
PCT/US2006/027200
- (22) International Filing Date:    11 July 2006 (11.07.2006)
- (25) Filing Language:    English
- (26) Publication Language:    English
- (30) Priority Data:  
60/699,072    13 July 2005 (13.07.2005)    US
- (71) Applicant (for all designated States except US): **DON-ALDSON COMPANY, INC.** [US/US]; 1400 West 94th Street, P.O. Box 1299, Minneapolis, MN 55440-1299 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

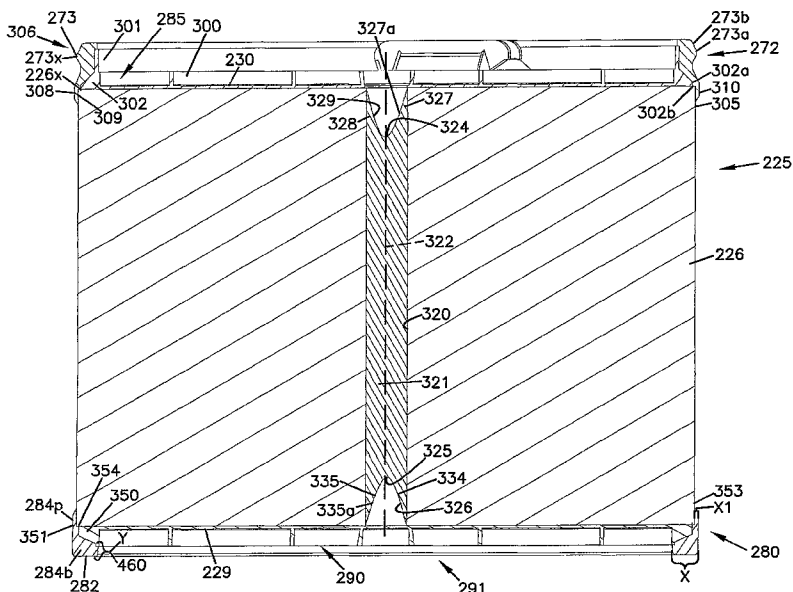
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **WHELAN, William, S.** [US/US]; 2331 Gordon Avenue, St. Paul, MN 55108 (US). **IRELAND, Robert, H.** [US/US]; 3333 Churchill Drive, Woodbury, MN 55125 (US).
- (74) Agent: **BRUESS, Steven, C.**; Merchants & Gould P.C., P.O. Box 2903, Minneapolis, MN 55402-0903 (US).

**Published:**  
— with international search report  
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: AIR FILTER CARTRIDGE AND AIR FILTER



(57) Abstract: A filter cartridge (225) is provided which includes a media pack (226) comprising filter media including a fluted sheet secured to a facing sheet. The cartridge (225) further includes a housing seal arrangement (272) positioned on an end of the media pack (226), and a housing cushion arrangement (282) positioned on an opposite end of the media pack. An air cleaner including such a filter cartridge therein is also described. Methods of assembly and use are described.

WO 2007/009039 A1

**AIR FILTER ARRANGEMENT; ASSEMBLY; AND, METHODS****Cross-Reference to Related Application**

This application is being filed on 11 July 2006, as a PCT  
5 International Patent application in the name of Donaldson Company, Inc., a U.S.  
national corporation, applicant for the designation of all countries except the US,  
and William S. Whelan and Robert H. Ireland, both citizens of the U.S., applicants  
for the designation of the US only.

The present application includes the disclosure of, with edits, US  
10 provisional application 60/699,072 filed July 13, 2005. A claim of priority to US  
60/699,072 is made to the extent appropriate. In addition, US 60/699,072 is  
incorporated herein, in its entirety, by reference.

**Field of the Disclosure**

15 The present disclosure relates to air cleaners and serviceable filter  
cartridges therefore. The disclosure particularly relates to air filter cartridges that  
utilize z-filter media comprising fluted, typically corrugated, media secured to a  
facing media and formed into media packs. The disclosure relates to formation of  
such media packs and their inclusion in serviceable filter cartridge arrangements  
20 having advantageous features thereon. An air cleaner arrangement which utilizes  
the advantageous filter cartridge, and methods of assembly and use, are also  
described.

**Background**

25 Many vehicles or other equipment with internal combustion engines  
include air cleaner arrangements thereon, for filtering air directed to the engine air  
intake. Such air cleaners typically include one or more serviceable filter cartridges  
therein. By "serviceable" in this context it is meant that a referenced filter cartridge  
is removable and replaceable within the air cleaner. As air cleaner configurations  
30 evolve, improvement in features of filter cartridges for use with those air cleaners  
are sought.

**Summary**

According to the present disclosure, a main filter element or cartridge  
is provided, for use in air filtering. In general, the filter element or cartridge

comprises a media pack including opposite flow ends, i.e., inlet and outlet flow ends. The opposite inlet and outlet ends can be planar flow faces, but alternatives are possible.

5 The media pack is formed from fluted, typically corrugated, media secured to facing media. The media is configured with a plurality of flutes extending between the opposite, i.e., inlet and outlet, flow faces; the media being closed to passage of unfiltered air completely therethrough. A typical example media pack defines: a set of inlet flutes open at the inlet end of the media pack to passage of air to be filtered therein; the inlet flutes typically being closed at a  
10 location within a distance of 10% of the total length of the inlet flutes from the outlet ends of the media pack, i.e., the inlet flutes are typically closed at the outlet end of the media pack; and, set of outlet flutes closed to passage of air to be filtered within the media pack, typically at a distance within 10% of the total length of the outlet flutes from the inlet end of the media pack, i.e., the outlet flutes are typically closed  
15 at the inlet end of the media pack. The outlet flutes are typically open to passage of filtered air therefrom at the outlet end of the media pack. Alternative media configurations are possible.

The element or cartridge further includes a housing seal arrangement positioned on one end of the media pack and a housing cushion arrangement  
20 positioned on an end of the media pack opposite the end at which the housing seal arrangement is mounted. The housing cushion arrangement comprises a compressible axial cushion member, typically positioned with at least 50% of a radial length of an end surface thereof positioned in axial overlap with the flow end of the media pack at which it is mounted. Typically, the cushion arrangement  
25 includes an axial cushion ring mounted on a preform, the preform being secured to the media pack. In one arrangement depicted, the cushion ring is a portion of a mold-in-place overmold that secures both the preform and the cushion arrangement to the media pack. In an alternate, the cushion is molded or otherwise secured to a frame piece which is then attached to the media pack.

30 In an example arrangement depicted, the housing seal arrangement comprises an outwardly directed radial seal member secured to an end of the media pack and supported by a preform having a seal support portion thereon. In one example shown, the housing seal member comprises a portion of an overmold which secures and seals the housing seal arrangement and preform to an end of the media

pack. In an alternate, the housing seal member is molded or otherwise secured to a frame piece which is then secured to a media pack.

As described, the axial cushion member of the housing cushion arrangement and the housing seal arrangement can each include a molded-in-place cushion or seal member. Typically the two molded-in-place members are  
5 independently molded with respect to one another.

According to the present disclosure, an air cleaner is provided. The air cleaner comprises a housing having a housing base and removable service cover. The housing base includes a cartridge support shoulder or shelf therein. The  
10 cartridge support shelf generally comprises a radially inwardly directed platform positioned to be engaged by the housing cushion arrangement of a serviceable filter cartridge, when the media filter cartridge is installed. Typically, the filter cartridge rests on the cartridge support shelf, with engagement being provided by the housing cushion arrangement. Also, the housing service cover includes a first housing seal  
15 surface therein, positioned for formation of a radial seal thereagainst, by the housing seal arrangement of the filter cartridge, when a service cover is installed on the housing base and the primary filter cartridge is positioned in place inside of the housing.

The housing seal surface of the service cover preferably has an axial  
20 length that is at least 1.5 mm. longer, typically at least 2.0 mm. longer and usually at least 2.5 mm (for example 2.5 mm to 4.0 mm.) longer, than an axial length of a region for engagement with the seal arrangement of the filter cartridge. Preferably, the added length extends above the serviceable main filter cartridge, when the air filter is assembled.

25 An arrangement including a safety cartridge sealed in position in the service cover, to remain therein during selected servicing of the main cartridge, is described.

Methods of operation and use are also described.

It is not necessary for a filter cartridge or air cleaner to include all of  
30 the advantageous features described herein, to obtain some advantage according to this disclosure.

### **Brief Description of the Drawings**

Fig. 1 is a fragmentary, schematic, perspective view of z-filter media useable in arrangements according to the present disclosure.

5 Fig. 2 is an enlarged schematic, cross-sectional view of a portion of the media depicted in Fig. 1.

Fig. 3 is a schematic view of examples of various corrugated media definitions.

Fig. 4 is a schematic view of a process for manufacturing media useable in selected filter cartridges according to the present disclosure.

10 Fig. 5 is a schematic end view of an optional end dart for media flutes useable in arrangements according to the present disclosure.

Fig. 6 is a schematic, side elevational view of an air cleaner arrangement according to the present disclosure.

Fig. 7 is an enlarged cross-sectional view taken along line 7-7, Fig. 6.

15 Fig. 8 is an exploded perspective view of the air cleaner of Fig. 6.

Fig. 9 is a schematic enlarged side elevational view of a serviceable main filter cartridge useable in the air cleaner of Figs. 6-8.

Fig. 10 is a schematic top plan view of the filter cartridge depicted in Fig. 9.

20 Fig. 11 is a schematic side cross-sectional view of the filter cartridge depicted in Fig. 9; Fig. 11 being taken along line 11-11, Fig. 10.

Fig. 12 is a schematic end perspective view of the filter cartridge depicted in Figs. 9-11; the end viewable in Fig. 12 being the end viewable in Fig. 10.

25 Fig. 13 is a schematic end perspective view of the filter cartridge depicted in Figs. 9-12; the view of Fig. 13 being toward an opposite end from the end viewable in Fig. 12.

Fig. 14 is an enlarged outside plan view of a preform component useable as an end frame piece in the filter cartridge of Figs. 9-13; the end piece of Fig. 14 being the end piece viewable in Fig. 12.

30 Fig. 15 is a cross-sectional view taken along line 15-15, Fig. 14.

Fig. 16 is a cross-sectional view taken along line 16-16, Fig. 14.

Fig. 17 is a fragmentary cross-sectional view taken along line 17-17, Fig. 14.

Fig. 18 is a fragmentary view taken along line 18-18, Fig. 14.

Fig. 19 is an enlarged fragmentary view of a portion of Fig. 16.

Fig. 20 is an inside plan view of the component viewable in Fig. 14.

Fig. 21 is a cross-sectional view taken along line 21-21, Fig. 20.

Fig. 22 is an enlarged fragmentary view of a portion of Fig. 21.

5 Fig. 23 is an enlarged fragmentary view of a portion of Fig. 20.

Fig. 24 is an enlarged outside plan view of a preform component useable in the filter cartridge of Figs. 9-13; the component of Fig. 24 being viewable in the end perspective view of Fig. 13.

Fig. 25 is a cross-sectional view taken along line 25-25, Fig. 24.

10 Fig. 26 is an enlarged fragmentary view of a portion of Fig. 25.

Fig. 27 is a fragmentary cross-sectional view taken along line 27-27, Fig. 24.

Fig. 28 is an inside plan view directed toward an opposite side of the component of Fig. 24, from the view of Fig. 24.

15 Fig. 29 is a cross-sectional view taken along line 29-29, Fig. 28.

Fig. 30 is an enlarged fragmentary view of a portion of Fig. 28.

Fig. 31 is an enlarged fragmentary view of a portion of Fig. 29.

Fig. 32 is a top plan view of a safety cartridge useable in the assembly of Figs. 6-8.

20 Fig. 33 is a cross-sectional view taken along line 33-33, Fig. 32.

Fig. 34 is a side elevational view of the cartridge depicted in Fig. 32.

Fig. 35 is a schematic side elevational view of a second embodiment of air cleaner arrangement according to the present disclosure.

25 Fig. 36 is a schematic exploded perspective view of the air cleaner of Fig. 35.

Fig. 37 is an enlarged schematic side elevational view of an alternate cartridge to the serviceable main filter cartridge depicted in Fig. 9, useable in the air cleaner of Figs. 35, 36, or the air cleaner of Figs. 6-8.

30 Fig. 38 is a schematic cross-sectional view of the filter cartridge depicted in Fig. 37.

Fig. 39 is a schematic outlet end plan view of the filter cartridge depicted in Figs. 37 and 38.

Fig. 40 is a schematic inlet end plan view of the filter cartridge depicted in Figs. 37 and 38.

Fig. 41 is an exploded side elevational view selected components depicted in the cartridge of Figs. 37 and 38.

### Detailed Description

#### 5 I. Z-Filter Media Configurations, Generally.

Fluted filter media can be used to provide air filter constructions in a variety of manners. One known manner is as a z-filter construction. The term "z-filter construction" as used herein, is meant to refer to a filter construction in which individual ones of corrugated, folded or otherwise formed filter flutes are used to  
10 define sets of longitudinal, typically parallel, flutes for air flow through the media; the fluid flowing along the length of the flutes between opposite inlet and outlet flow ends (or flow faces) of the media. Some examples of z-filter media are provided in U.S. patents 5,820,646; 5,772,883; 5,902,364; 5,792,247; 5,895,574; 6,210,469; 6,190,432; 6,350,296; 6,179,890; 6,235,195; Des. 399,944; Des. 428,128; Des.  
15 396,098; Des. 398,046; and, Des. 437,401; each of these fifteen cited references being incorporated herein by reference.

One type of z-filter media, utilizes two specific media components joined together, to form the media construction. The two components are: (1) a fluted (typically corrugated) media sheet; and, (2) a facing media sheet. The facing  
20 media sheet is typically non-corrugated, however it can be corrugated, for example perpendicularly to the flute direction as described in U.S. provisional 60/543,702, filed February 10, 2004; U.S. provisional 60/543,804, filed February 11, 2004, and PCT US 05/04265 filed February 9, 2005, each of which is incorporated herein by reference.

25 The fluted (typically corrugated) media sheet and the facing media sheet together, can be used to define media having parallel inlet and outlet flutes. In some instances, the fluted sheet and facing sheet are secured together and are then coiled to form a z-filter media construction. Such arrangements are described, for example, in U.S. 6,235,195 and 6,179,890, each of which is incorporated herein by  
30 reference. In certain other arrangements, some non-coiled sections of corrugated media secured to facing media, are stacked on one another, to create a filter construction. An example of this is described in Fig. 11 of 5,820,646, incorporated herein by reference.

With coiled arrangements, typically the center portion needs to be sealed against flow through the media pack, of unfiltered air. Examples of arrangements that provide for this are described in PCT Publication WO05/123214, published December 29, 2005, incorporated herein by reference.

5                   Typically, coiling of the fluted sheet/facing sheet combination around itself, to create a coiled media pack, is conducted with the facing sheet directed outwardly. Some techniques for coiling are described in U.S. provisional application 60/467,521, filed May 2, 2003 and PCT Application US 04/07927, filed March 17, 2004, now published as WO 04/082795, each of which is incorporated  
10                   herein by reference. The resulting coiled arrangement typically has, as the outer surface of the media pack, a portion of the facing sheet, as a result.

                  The term "corrugated" used herein to refer to structure in media, is meant to refer to a flute structure resulting from passing the media between two corrugation rollers, i.e., into a nip or bite between two rollers, each of which has  
15                   surface features appropriate to cause a corrugation affect in the resulting media. The term "corrugation" is not meant to refer to flutes that are formed by techniques not involving passage of media into a bite between corrugation rollers. However, the term "corrugated" is meant to apply even if the media is further modified or deformed after corrugation, for example by the folding techniques described in PCT  
20                   WO 04/007054, published January 22, 2004, incorporated herein by reference.

                  Corrugated media is a specific form of fluted media. Fluted media is media which has individual flutes (for example formed by corrugating or folding) extending thereacross.

                  Many serviceable filter element or filter cartridge configurations  
25                   utilizing z-filter media are sometimes referred to as "straight through flow configurations" or by variants thereof. In general, in this context what is meant is that the serviceable filter elements generally have an inlet flow end (or face) and an opposite exit flow end (or face), with flow entering and exiting the filter cartridge in generally the same straight through direction. The term "serviceable" in this context  
30                   is meant to refer to a media containing filter cartridge that is periodically removed from and replaced in a corresponding air cleaner. In some instances, each of the inlet flow end and outlet flow end will be generally flat or planar, with the two surfaces being parallel to one another. However, variations from this, for example non-planar faces, are possible. It is noted that in some instances during servicing, a



filter cartridge is removed from an air cleaner, and is blown out or otherwise modified to reduce dust flow therein, and than is reinstalled for use.

A straight through flow configuration (especially for a coiled media pack) is, for example, in contrast to serviceable filter cartridges such as cylindrical pleated filter cartridges of the type shown in U.S. Patent No. 6,039,778, incorporated  
5 herein by reference, in which the flow generally makes a turn as its passes through the serviceable cartridge. That is, in a 6,039,778 filter, the flow enters the cylindrical filter cartridge through a cylindrical side, and then turns to exit through an end face (in forward-flow systems). In a typical reverse-flow system, the flow  
10 enters the serviceable cylindrical cartridge through an end face and then turns to exit through a side of the cylindrical filter cartridge. An example of such a reverse-flow system is shown in U.S. Patent No. 5,613,992, incorporated by reference herein.

The term "z-filter media construction" and variants thereof as used herein, without more, is meant to refer to any or all of: a web of corrugated or  
15 otherwise fluted media secured to (facing) media with appropriate sealing to allow for definition of filter flutes (typically inlet and outlet) between opposite inlet and outlet flow faces; or, a media pack constructed or formed from such media into a three dimensional network of flutes (typically inlet and outlet flutes); and/or, a filter cartridge or construction including such a media pack.

20 In Fig. 1, an example of media 1 useable in z-filter media is shown. The media 1 is formed from a corrugated sheet 3 and a facing sheet 4.

In general, the corrugated sheet 3, Fig. 1 is of a type generally characterized herein as having a regular, curved, wave pattern of flutes or corrugations 7. The term "wave pattern" in this context, is meant to refer to a flute  
25 or corrugated pattern of alternating troughs 7b and ridges 7a. The term "regular" in this context is meant to refer to the fact that the pairs of troughs and ridges (7b, 7a) alternate with generally the same repeating corrugation (or flute) shape and size. (Also, typically in a regular configuration each trough 7b is substantially an inverse of each ridge 7a.) The term "regular" is thus meant to indicate that the corrugation  
30 (or flute) pattern comprises troughs and ridges with each pair (comprising an adjacent trough and ridge) repeating, without substantial modification in size and shape of the corrugations along at least 70% of the length of the flutes. The term "substantial" in this context, refers to a modification resulting from a change in the process or form used to create the corrugated or fluted sheet, as opposed to minor

variations from the fact that the media sheet 3 is flexible. With respect to the characterization of a repeating pattern, it is not meant that in any given filter construction, an equal number of ridges and troughs is necessarily present. The media 1 could be terminated, for example, between a pair comprising a ridge and a trough, or partially along a pair comprising a ridge and a trough. (For example, in Fig. 1 the media 1 depicted in fragmentary has eight complete ridges 7a and seven complete troughs 7b.) Also, the opposite flute ends (ends of the troughs and ridges) may vary from one another. Such variations in ends are disregarded in these definitions, unless specifically stated. That is, variations in the ends of flutes are intended to be covered by the above definitions.

In the context of the characterization of a "curved" wave pattern of corrugations, the term "curved" is meant to refer to a corrugation pattern that is not the result of a folded or creased shape provided to the media, but rather the apex 7a of each ridge and the bottom 7b of each trough is formed along a radiused curve. A typical radius for such z-filter media would be at least 0.25 mm and typically would be not more than 3 mm.

An additional characteristic of the particular regular, curved, wave pattern depicted in Fig. 1, for the corrugated sheet 3, is that at approximately a midpoint 30 between each trough and each adjacent ridge, along most of the length of the flutes 7, is located a transition region where the curvature inverts. For example, viewing back side or face 3a, Fig. 1, trough 7b is a concave region, and ridge 7a is a convex region. Of course when viewed toward front side or face 3b, trough 7b of side 3a forms a ridge; and, ridge 7a of face 3a, forms a trough. (In some instances, region 30 can be a straight segment, instead of a point, with curvature inverting at ends of the segment 30.)

A characteristic of the particular regular, curved, wave pattern corrugated sheet 3 shown in Fig. 1, is that the individual corrugations are generally straight. By "straight" in this context, it is meant that through at least 70%, typically at least 80% of the length between edges 8 and 9, the ridges 7a and troughs 7b do not change substantially in cross-section. The term "straight" in reference to corrugation pattern shown in Fig. 1, in part distinguishes the pattern from the tapered flutes of corrugated media described in Fig. 1 of WO 97/40918 and PCT Publication WO 03/47722, published June 12, 2003, incorporated herein by reference.. The tapered flutes of Fig. 1 of WO 97/40918, for example, would be a curved wave

pattern, but not a "regular" pattern, or a pattern of straight flutes, as the terms are used herein.

Referring to the present Fig. 1 and as referenced above, the media 1 has first and second opposite edges 8 and 9. When the media 1 is coiled and formed into a media pack, edge 9 is shown forming an inlet end for the media pack and edge 8 an outlet end, although an opposite orientation is possible.

Adjacent edge 8 is provided a sealant bead 10, sealing the fluted or corrugated sheet 3 and the facing sheet 4 together. Bead 10 will sometimes be referred to as a "single facer" bead, since it is a bead between the corrugated sheet 3 and facing sheet 4, which forms the single facer or media strip 1. Sealant bead 10 seals closed individual flutes 11 adjacent edge 8, to passage of air therefrom. (The simple facer bead can be positioned adjacent the inlet end, if desired.)

Adjacent edge 9, is provided seal bead 14. Seal bead 14 generally closes flutes 15 to passage of unfiltered fluid therein, adjacent edge 9. Bead 14 would typically be applied as strips of the media 1 are secured to one another during stacking. Thus bead 14 will form a seal between a back side 17 of facing sheet 4, and side 18 of the next adjacent corrugated sheet 3. When bead 14 is used in a coiled arrangement, it is referenced as a "winding bead." (When the media 1 is cut in strips and stacked (not shown), instead of coiled, bead 14 is referenced as a "stacking bead.") The winding bead (or stacking bead) can be positioned adjacent the outlet edge, if desired.

Referring to Fig. 1, once the media 1 is incorporated into a media pack, for example by stacking or coiling, it can be operated as follows. First, air in the direction of arrows 12, would enter open flutes 11 adjacent end 9. Due to the closure at end 8, by bead 10, the air would pass through the media, for example as shown by arrows 13. It could then exit the media pack, by passage through open ends 15a of the flutes 15, adjacent end 8 of the media pack. Of course operation could be conducted with air flow in the opposite direction.

For the particular arrangement shown herein in Fig. 1, the parallel corrugations 7a, 7b are generally straight completely across the media, from edge 8 to edge 9. Straight flutes or corrugations can be deformed or folded at selected locations, especially at ends. Modifications at flute ends for closure are generally disregarded in the above definitions of "regular," "curved" and "wave pattern."

Z-filter constructions which do not utilize straight, regular curved wave pattern corrugation shapes are known. For example in Yamada et al. U.S. 5,562,825 corrugation patterns which utilize somewhat semicircular (in cross section) inlet flutes adjacent narrow V-shaped (with curved sides) exit flutes are shown (see Figs. 1 and 3, of 5,562,825). In Matsumoto, et al. U.S. 5,049,326 circular (in cross-section) or tubular flutes defined by one sheet having half tubes attached to another sheet having half tubes, with flat regions between the resulting parallel, straight, flutes are shown, see Fig. 2 of Matsumoto '326. In Ishii, et al. U.S. 4,925,561 (Fig. 1) flutes folded to have a rectangular cross section are shown, in which the flutes taper along their lengths. In WO 97/40918 (FIG. 1), flutes or parallel corrugations which have a curved, wave patterns (from adjacent curved convex and concave troughs) but which taper along their lengths (and thus are not straight) are shown. Also, in WO 97/40918 flutes which have curved wave patterns, but with different sized ridges and troughs, are shown.

An alternate type of z-filter construction, using a fluted sheet secured to a facing sheet, but sealed in a different manner to prevent unfiltered air from passing completely through resulting media pack from an inlet flow face to an outlet flow face, is described in US publication 2006/0091084, published May 4, 2006 to Baldwin Filters, Inc. as Assignee. Such media can also be incorporated into an arrangement utilizing principles according to the present disclosure.

In general, useable filter media is a relatively flexible material, typically a non-woven fibrous material (of cellulose fibers, synthetic fibers or both) often including a resin therein, sometimes treated with additional materials. Thus, it can be conformed or configured into the various corrugated patterns, without unacceptable media damage. Also, it can be readily coiled or otherwise configured for use, again without unacceptable media damage. Of course, it must be of a nature such that it will maintain the required corrugated configuration, during use.

In the corrugation process, an inelastic deformation is caused to the media. This prevents the media from returning to its original shape. However, once the tension is released the flute or corrugations will tend to spring back, recovering only a portion of the stretch and bending that has occurred. The facing sheet is sometimes tacked to the fluted sheet, to inhibit this spring back in the corrugated sheet. Such tacking is shown at 20, Fig. 1.

Also, typically, the media contains a resin. During the corrugation process, the media can be heated to above the glass transition point of the resin. When the resin then cools, it will help to maintain the fluted shapes.

The media of the fluted (corrugated) sheet 3 facing sheet 4 or both, 5 can be provided with a fine fiber material on one or both sides thereof, for example in accord with U.S. 6,673,136, incorporated herein by reference.

An issue with respect to z-filter constructions made with inlet and outlet flutes relates to closing of the individual flute ends. Although alternatives are possible, typically a sealant or adhesive is provided, to accomplish the closure. As is 10 apparent from the discussion above, in typical z-filter media, especially that which uses straight inlet and outlet flutes (as opposed, for example, to tapered flutes), large sealant surface areas (and volume) at both the upstream end and the downstream end are needed. High quality seals at these locations are critical to proper operation of the media structure that results. The high sealant volume and area, creates issues 15 with respect to this.

Attention is now directed to Fig. 2, in which a z-filter media construction 40 utilizing a regular, curved, wave pattern fluted (corrugated) sheet 43, and a facing sheet 44, is depicted. The distance D1, between points 50 and 51, defines the extension of facing media 44 in region 52 underneath a given 20 (corrugated) flute 53. The length D2 of the arcuate media for the corrugated flute 53, over the same distance D1 is of course larger than D1, due to the shape of the corrugated flute 53. For a typical regular shaped media used in fluted filter applications, the linear length D2 of the media 53 between points 50 and 51 will often be at least 1.2 times D1. Typically, D2 would be within a range of 1.2 - 2.0, 25 inclusive. One particularly convenient arrangement for air filters has a configuration in which D2 is about 1.25 - 1.35 x D1. Such media has, for example, been used commercially in Donaldson Powercore™ Z-filter arrangements. Herein the ratio D2/D1 will sometimes be characterized as the flute/flat ratio or media draw for the fluted (typically corrugated) media.

30 In the corrugated cardboard industry, various standard flutes have been defined. For example the standard E flute, standard X flute, standard B flute, standard C flute and standard A flute. Figure 3, attached, in combination with Table A below provides definitions of these flutes.

Donaldson Company, Inc., (DCI) the assignee of the present disclosure, has used variations of the standard A and standard B flutes, in a variety of z-filter arrangements. These flutes are also defined in Table A and Fig. 3.

<b>TABLE A</b>	
(Flute definitions for Fig. 3)	
5	DCI A Flute: Flute/flat = 1.52:1; The Radii (R) are as follows: R1000 = .0675 inch (1.715 mm); R1001 = .0581 inch (1.476 mm); R1002 = .0575 inch (1.461 mm); R1003 = .0681 inch (1.730 mm);
10	DCI B Flute: Flute/flat = 1.32:1; The Radii (R) are as follows: R1004 = .0600 inch (1.524 mm); R1005 = .0520 inch (1.321 mm); R1006 = .0500 inch (1.270 mm); R1007 = .0620 inch (1.575 mm);
15	Std. E Flute: Flute/flat = 1.24:1; The Radii (R) are as follows: R1008 = .0200 inch (.508 mm); R1009 = .0300 inch (.762 mm); R1010 = .0100 inch (.254 mm); R1011 = .0400 inch (1.016 mm);
20	Std. X Flute: Flute/flat = 1.29:1; The Radii (R) are as follows: R1012 = .0250 inch (.635 mm); R1013 = .0150 inch (.381 mm);
25	Std. B Flute: Flute/flat = 1.29:1; The Radii (R) are as follows: R1014 = .0410 inch (1.041 mm); R1015 = .0310 inch (.7874 mm); R1016 = .0310 inch (.7874 mm);
30	Std. C Flute: Flute/flat = 1.46:1; The Radii (R) are as follows: R1017 = .0720 inch (1.829 mm); R1018 = .0620 inch (1.575 mm);
30	Std. A Flute: Flute/flat = 1.53:1; The Radii (R) are as follows: R1019 = .0720 inch (1.829 mm); R1020 = .0620 inch (1.575 mm).

Of course other, standard, flutes definitions from the corrugated box industry are known.

In general, standard flute configurations from the corrugated box industry can be used to define corrugation shapes or approximate corrugation shapes for corrugated media. Comparisons above between the DCI A flute and DCI B flute, and the corrugation industry standard A and standard B flutes, indicate some convenient variations.

40

## II. Manufacture of Z-Filter Media Configurations Using Fluted Media, Generally.

In Fig. 4, one example of a manufacturing process for making a media strip corresponding to strip 1, Fig. 1 is shown. In general, facing sheet 64 and the fluted (corrugated) sheet 66 having flutes are brought together to form a media web 69, with an adhesive bead located therebetween at 70. The adhesive bead 70 will form a single facer bead, Fig. 1. An optional darting process occurs at station 71 to form center darted section 72 located mid-web. The z-filter media or Z-media strip 74 can be cut or slit at 75 along the bead 70 to create two pieces 76, 77 of z-filter media 74, each of which has an edge with a strip of sealant (single facer bead) extending between the corrugating and facing sheet. Of course, if the optional darting process is used, the edge with a strip of sealant (single facer bead) would also have a set of flutes darted at this location. The strips or pieces 76, 77 can then be cut across, for stacking, as described below in connection with Fig. 6.

Techniques for conducting a process as characterized with respect to Fig. 4 are described in PCT WO 04/007054, published January 22, 2004 incorporated herein by reference.

Still in reference to Fig. 4, before the z-filter media 74 is put through the darting station 71 the media 74 must be formed. In the schematic shown in Fig. 4, this is done by passing a flat sheet of media 92 through a pair of corrugation rollers 94, 95. In the schematic shown in Fig. 4, the flat sheet of media 92 is unrolled from a roll 96, wound around tension rollers 98, and then passed through a nip or bite 102 between the corrugation rollers 94, 95. The corrugation rollers 94, 95 have teeth 104 that will give the general desired shape of the corrugations after the flat sheet 92 passes through the nip 102. After passing through the nip 102, the flat sheet 92 becomes corrugated and is referenced at 66 as the corrugated sheet. The corrugated sheet 66 is then secured to facing sheet 64. (The corrugation process may involve heating the media, in some instances.)

Still in reference to Fig. 4, the process also shows the facing sheet 64 being routed to the darting process station 71. The facing sheet 64 is depicted as being stored on a roll 106 and then directed to the corrugated sheet 66 to form the Z-media 74. The corrugated sheet 66 and the facing sheet 64 are secured together by adhesive or by other means (for example by sonic welding).

Referring to Fig. 4, an adhesive line 70 is shown used to secure corrugated sheet 66 and facing sheet 64 together, as the sealant bead. Alternatively, the sealant bead for forming the facing bead could be applied as shown as 70a. If the sealant is applied at 70a, it may be desirable to put a gap in the corrugation roller 95, and possibly in both corrugation rollers 94, 95, to accommodate the bead 70a.

The type of corrugation provided to the corrugated media is a matter of choice, and will be dictated by the corrugation or corrugation teeth of the corrugation rollers 94, 95. One preferred corrugation pattern will be a regular curved wave pattern corrugation, of straight flutes, as defined herein above. A typical regular curved wave pattern used, would be one in which the distance D2, as defined above, in a corrugated pattern is at least 1.2 times the distance D1 as defined above. In one preferred application, typically  $D2 = 1.25 - 1.35 \times D1$ . In some instances the techniques may be applied with curved wave patterns that are not "regular," including, for example, ones that do not use straight flutes.

As described, the process shown in Fig. 4 can be used to create the center dented section 72. Fig. 5 shows, in cross-section, one of the flutes 68 after dentic and slitting.

A fold arrangement 118 can be seen to form a dented flute 120 with four creases 121a, 121b, 121c, 121d. The fold arrangement 118 includes a flat first layer or portion 122 that is secured to the facing sheet 64. A second layer or portion 124 is shown pressed against the first layer or portion 122. The second layer or portion 124 is preferably formed from folding opposite outer ends 126, 127 of the first layer or portion 122.

Still referring to Fig. 5, two of the folds or creases 121a, 121b will generally be referred to herein as "upper, inwardly directed" folds or creases. The term "upper" in this context is meant to indicate that the creases lie on an upper portion of the entire fold 120, when the fold 120 is viewed in the orientation of Fig. 5. The term "inwardly directed" is meant to refer to the fact that the fold line or crease line of each crease 121a, 121b, is directed toward the other.

In Fig. 5, creases 121c, 121d, will generally be referred to herein as "lower, outwardly directed" creases. The term "lower" in this context refers to the fact that the creases 121c, 121d are not located on the top as are creases 121a, 121b, in the orientation of Fig. 5. The term "outwardly directed" is meant to indicate that the fold lines of the creases 121c, 121d are directed away from one another.



The terms "upper" and "lower" as used in this context are meant specifically to refer to the fold 120, when viewed from the orientation of Fig. 5. That is, they are not meant to be otherwise indicative of direction when the fold 120 is oriented in an actual product for use.

5                   Based upon these characterizations and review of Fig. 5, it can be seen that a preferred regular fold arrangement 118 according to Fig. 5 in this disclosure is one which includes at least two "upper, inwardly directed, creases." These inwardly directed creases are unique and help provide an overall arrangement in which the folding does not cause a significant encroachment on adjacent flutes.

10                   A third layer or portion 128 can also be seen pressed against the second layer or portion 124. The third layer or portion 128 is formed by folding from opposite inner ends 130, 131 of the third layer 128.

                  Another way of viewing the fold arrangement 118 is in reference to the geometry of alternating ridges and troughs of the corrugated sheet 66. The first  
15 layer or portion 122 is formed from an inverted ridge. The second layer or portion 124 corresponds to a double peak (after inverting the ridge) that is folded toward, and in preferred arrangements, folded against the inverted ridge.

                  Techniques for providing the optional dart described in connection with Fig. 5, in a preferred manner, are described in PCT WO 04/007054,  
20 incorporated herein by reference. Other techniques for media management are described in PCT application US 04/07927, filed March 17, 2004, incorporated herein by reference.

                  Techniques described herein are well adapted for use of media packs that result from coiling a strip of single facer, with an appropriately positioned  
25 winding bead, although certain of the techniques can be applied in other situations.

                  Opposite flow ends or flow faces of the media pack can be provided with a variety of different definitions. In many arrangements, the ends are generally flat and perpendicular to one another.

                  The flute seals (single facer bead, winding bead or stacking bead) can  
30 be formed from a variety of materials. In various ones of the cited and incorporated references, hot melt or polyurethane seals are described as possible for various applications. These are useable for applications described herein.

### III. Improved Filter Cartridges and Air Cleaner Arrangements.

#### A. An Example Air Cleaner Arrangement, Generally; Figs. 6-8.

Reference numeral 200, Fig. 6, generally indicates an example air cleaner according to the present disclosure. It is noted that air cleaner 200 could be provided in a variety of alternate configurations and still use many of the principles according to the present disclosure.

The air cleaner 200 comprises a housing 201. The housing 201 includes a housing bottom or base 201a, and a removable access or service cover 202. The particular housing 201 depicted, includes an air flow inlet end 203 and an air flow outlet end 204. Air passing between inlet 203 and outlet 204 is filtered by an internally received filter cartridge arrangement, discussed below.

Attention is now directed to Fig. 7, in which air cleaner 200 is depicted in cross-section. In lower region 207 of housing 201 there is positioned a precleaner arrangement 210. The precleaner arrangement 210 utilizes a plurality of centrifugal separator tubes 211 to accomplish a precleaning step of the air entering the air cleaner through inlet 203, Fig. 6. Precleaner arrangements that utilize centrifugal separator tubes are well known, examples being described in U.S. Provisional Application 60/649,301 filed February 1, 2005 and PCT Application US 05/14909 filed April 28, 2005, each of which is incorporated herein by reference.

Still referring to Fig. 7, ejector tube 214 with valve 215 thereon are positioned in lower region 207 of housing 201, for ejection of water or dust material (for example, separated by the separator arrangement 210) from interior 201i of housing 201. Ejector tubes and valve arrangements analogous to 214 and 215 are known for a variety of air cleaners.

Still referring to Fig. 7, air cleaner housing base 201a includes a main cartridge receiving a central section 220 therein, positioned above lower region 207. Within an interior section 220 is positioned a serviceable main filter cartridge 225. The main filter cartridge 225 generally comprises a media pack 226 of z-filter media in accord with the general descriptions above. Detailed discussions of the z-filter media pack 226 and main filter cartridge 225 are provided herein below, in connection with the description of Figs. 9 - 31.

For the particular air cleaner depicted in Figs. 6-8, filtering air flow through the main filter cartridge 225 occurs upwardly, i.e., air to be filtered enters

flow end 229 of the main filter cartridge 225 and exits opposite flow end 230 of the main filter cartridge 225.

5 A housing seal arrangement mounted on the filter cartridge 225, discussed herein in connection with Figs. 9 - 13, provides a seal between the filter cartridge 225 and the housing 201, to inhibit unfiltered air flow from bypassing the cartridge 225.

10 The particular air cleaner 200 depicted, includes an optional secondary or safety filter assembly 240 positioned downstream from the main filter cartridge 225. The safety filter assembly 240 is discussed herein, in connection with Figs. 32 - 34. The safety filter 240 is mounted, in the example shown, in the air cleaner access cover 202.

15 Attention is now directed to Fig. 8, in which air cleaner 200 is shown in exploded view. Cover 202 is shown removed from housing base 201a. Main filter cartridge 225 and safety filter 240 are viewable. Support ring arrangement 244, comprising metallic half rings 245 is shown. These metallic half rings 245 provide assistance in clamping of service cover 202 on the body 201, by over center latches or clamps 250. In particular, the half rings 245 provide a good surface for engagement by the clamps 250.

20 Referring to Fig. 7, during a normal service operation cover 202 is unclamped from body or base 201a. Body or base 201a remains in position in the vehicle under consideration. The typical location for air cleaner 200 would be under the hood of a vehicle such as a large truck. The cover 202 can be lifted off and, is desired can be provided with an optional hanger 254 by which cover 202 can be secured above the work area by service personnel, for example on a hook or similar structure attached to an interior of a raised vehicle hood. The optional safety filter 25 240 is typically configured to remain (if desired) secured in the cover 202 during this service operation.

The main safety filter cartridge 225 is then lifted out of the housing 201, for inspection and refurbishing or replacement.

30 In some instances it may be desirable to also change out the safety filter 240, which can be accomplished by removing the safety filter 240 from cover 202, and replacing it with a similar or identical safety filter cartridge 240. However, it is anticipated that in many instances, the safety filter 240 will not be replaced during servicing.

Referring still to Figs. 6-8, the air cleaner 200 is configured so that, if desired, body 201 can be formed in a rotomold process from plastic such as a cross-linked high density polyethylene. It is configured with a flange, shelf or shelf arrangement 260 therein on which filter cartridge 225 is positioned, during  
5 installation. The shelf arrangement 260 is formed with an upper, radial projection, surface or side 261, a lower, radial projection, surface or side 262 and a central axial wall 263 extending therebetween. The term "radial" and variants thereof, when used in this context, is meant to refer to a direction of extension toward or away from a central axis 270, Fig. 7, of the air cleaner housing body 201. The term "axial" in this  
10 context is meant to refer to a direction of extension generally parallel with a central axis 270.

In some alternate arrangements, the shelf arrangement 260 could have alternate constructions, for example, a single flange could be used.

Referring to Fig. 7, access cover 202 includes a seal surface 266  
15 thereon, for the main cartridge 225; and, a secured seal surface 267 thereon, for safety cartridge 240. It is noted typically that surface 266 is sufficiently long so that tip 225T of the main cartridge 225 is spaced from tip 240T of safety cartridge 240, usually by at least 1.5 mm, upon installation, typically 2-5 mm, upon installation.

The cover 202 would typically be molded from a rigid material such  
20 as a glass filled nylon, for example 33% glass filled nylon 6/6.

## B. The Main Filter Cartridge 225.

### 1. General Features of the Main Filter Cartridge 225, Figs. 9-13.

Attention is now directed to Fig. 9, in which filter cartridge 225 is  
25 depicted in side elevational view. Cartridge 225 comprises media pack 226 having opposite ends 226a and 226b. The media pack 226 generally comprises a straight through flow construction defining opposite flow ends or flow faces 229 and 230. The media pack 226 typically comprises a coiled single facer sheet (for example with a winding bead applied) comprising corrugated media secured to facing media,  
30 with the facing media directed to the outside. A tail end of the coiled media, not shown, can be sealed closed with sealant, such as hot melt, or with a molded polyurethane section. Seal arrangements (such as sealant beads) are used to generate a first set of flutes which are open at one flow end (for example end 229) and closed at an opposite flow end (for example end 230); and a second set of flutes which are

closed at the first flow end (for example end 229) and open at the second flow end (for example end 230). In normal operation the particular filter cartridge depicted would be positioned with flow end 229 as the inlet flow face or inlet flow end, and with end 230 positioned as the outlet flow face or outlet flow end, as described  
5 above. Alternate orientations are possible with selected principles according to the present disclosure.

Referring to Figs. 8, 9 and 10, it is noted that cartridge 225 is formed from a media pack 226 having a generally circular cross-section, i.e., a cylindrical shape. Media packs of alternate shapes can be used, in accordance with principles  
10 of the present disclosure, and with housings configured to accept such alternate shapes. An example would be an oval shape, with opposite curved ends. An example of an oval shape would be a racetrack shape, with opposite curved ends and a pair of opposite straight sides, although oval shapes with curved sides are also possible. Certain of the principles described herein can be utilized with other  
15 arrangements, for example ones that are square or rectangular (in cross-section) with curved corners, or with stacked arrangements that are square or rectangular (in cross-section).

It is noted that for the arrangement described, ends 229, 230 of the media pack 226 are each planar and parallel to each other. Alternatives are possible  
20 in cartridges using selected principles of the present disclosure, but typical cartridges using features described herein will have planar flow faces.

Referring still to Fig. 9, positioned on media pack 226 at end 226a is provided housing seal arrangement 272. A variety of types of housing seal arrangements 272 can be used. The particular air cleaner 200 depicted, is configured  
25 for utilization with a replacement filter cartridge 225 which utilizes, as a housing seal arrangement 272, an outwardly directed radial seal arrangement comprising a radially sealing surface 273. By "outwardly directed" in this context, it is meant that the housing seal surface is directed radially outwardly from central axis 275 to sealingly engage the housing. The particular housing seal arrangement 272  
30 depicted, is generally in accord with that described in PCT Publication WO05/63361, published July 14, 2005; and US Publication US 2005/0166561, published August 4, 2005; each of which is incorporated herein by reference. Further discussion of this provided below, in connection with the description of Fig. 11.

Positioned on end 226b of media pack 226, i.e., an end opposite from housing seal arrangement 272, is provided a media pack support structure 280. The support structure 280 generally includes a cushioned support arrangement 282. Further detail concerning this construction is provided herein below, in connection with Fig. 11 and other figures.

It is noted that the particular air cleaner 200 depicted, is configured for utilization of a relatively large filter cartridge 225 having an overall diameter (or largest cross-section dimension) on the order of at least 300 mm (for example 380 to 480 mm), and an overall length on the order of at least 250 mm (for example 300-400 mm). Such filter cartridges, when not loaded with contaminant, are typically constructed with an overall weight on the order of about 8 - 12 lbs (3.6 - 5.5 kg). During operation of the equipment and loading of the filter cartridge with dust and other contaminant, the filter cartridge 225 can gain in weight from 100% to 300%. Thus, the filter cartridge can become relatively heavy, during use. In addition, due to its size, the cartridge is relatively bulky to handle.

Certain techniques described herein were developed specifically for management of filter cartridges having a relatively large size, i.e., of at least about 300 mm in largest cross-sectional size and at least about 250 mm in length. However, the techniques can be provided in connection with filter cartridges of still other sizes and shapes.

Referring to Fig. 10, the top plan view of filter cartridge 225 is depicted. As with other figures herein, it is noted that with respect to the media pack 226, Fig. 10 is schematic, and individual coilings or wrappings of a single facer material in the media pack 226 are not shown, nor are open and closed ends of the various flutes at end face 230.

Extending across media end 230 is provided a grid work structure 285. The grid work structure 285 provides an anti-telescoping effect of the media pack 226. That is, the grid work 285 extends across face 230 and prevents face 230 from distorting outwardly an undesirable amount, under forces from air directed through the media pack 226, Fig. 9, in a direction from end face 229 toward end face 230, during normal use.

The particular grid work depicted comprises a center piece 286 with a plurality of outwardly (radially) projecting ribs or spokes 286a, communicating with

an outer perimeter support 286b. Intermediate or interior rings 286c and 286d, provide for further support. Alternatives for the grid work are possible.

In addition, the grid work 285 provides for mounting of handle arrangement 287. For the example shown, handle arrangement 287 comprises two  
5 handles 288 mounted on a portion of grid work 285. The two oppositely positioned handles 288 facilitate handling of the cartridge 225 by service personnel, during servicing of air cleaner 200.

Referring to Fig. 12, it can be seen that the handles 288 are each typically bridge or loop structures; each extending between a pair of adjacent ribs or  
10 spokes 286a. The bridge or loop structure allow for portions of an operator's hands to slip there under, to a location between the handles 288 and the media pack 226, for manipulating the position of the cartridge 225, even when loaded with dust. In a typical arrangement, the handles 288 will be positioned radially opposite one another, each typically at a location about 30% to 70% across a radius of the media  
15 pack 226 outwardly from a center for circular coils, although alternatives are possible.

Referring to Fig. 13, support structure 280 preferably includes cushioned support arrangement 282 and grid work 290. The grid work 290 extends across face 229 of media pack 226, to inhibit distortion of the media pack 226  
20 downwardly, when filter cartridge 225 is configured in air cleaner 200, in the orientation shown in Fig. 7. This will inhibit distortion of the media pack 226 under weight increase from load during use, and under vibration within the vehicle during use.

Referring to Fig. 13, grid work 290 generally comprises a center 291,  
25 outwardly (radially) projecting ribs or spokes 292, outer ring or support 293, and intermediate or interior rings 294, 295, although alternatives are possible.

Attention is now directed to Fig. 11, which is a cross-sectional view of cartridge 225 taken along line 11-11, Fig. 10. Referring to Fig. 11, it can be seen that for the particular example cartridge 225 depicted, the housing seal arrangement  
30 272 generally comprises a seal arrangement in accord with the descriptions of PCT Publication WO05/63361, published July 14, 2005; and US Publication US 2005/0166561, published August 4, 2005; each of these references being incorporated herein by reference.

Referring to Fig. 11, support or grid work 285 is part of a preform part 300 that includes three sections generally comprising: housing seal support section 301; media engagement periphery or skirt 302; and, media face cross piece or grid arrangement 285. By the term "preform" in this context, it is meant that component 300 is formed before cartridge 225 is assembled. Typically preform 300 is an injection molded piece, for example from glass filled nylon.

In Fig. 11 it can be seen that no portion of preform 300 extends around the outer periphery or side of the media pack. This will be typical for arrangements according to Fig. 11, although alternates are possible. For the particular arrangement depicted in Fig. 11, media engagement portion 302 includes an outer edge 302a which is brought into engagement with flow face 230 of the z-filter media pack 226 and which, for the example shown, does not project to, or beyond, an outer perimeter edge 305 of flow face 230, although alternatives are possible. The particular preform 300 depicted includes a small ridge 302b which projects slightly into media pack 226.

As described above the particular z-filter media pack 226 depicted comprises a coiled media arrangement.

Preform 300 is generally provided with an outer perimeter size such that the portion 226x (Fig. 11) of media 226 extends dimensionally peripherally beyond preform 300, usually the amount extending beyond preform 300 comprising 1 - 3 coils or layers of single facer material, in a coil unit. This is described in PCT Publication WO05/63361, published July 14, 2005; and US Publication US 2005/0166561, published August 4, 2005, incorporated herein by reference.

Referring still to Fig. 11, molded seal component 306 is positioned with a portion 308 overlapping and sealing a joint 309 where preform part 300 engages flow surface 330 of the media pack 226. Preferably the molded seal component 306 includes a portion 310 which extends beyond the joint 309 in a direction away from flow face 230 (toward opposite flow face 229) a distance of at least 5 mm, preferably at least 8 mm, and typically a distance within the range of about 9 mm to 18 mm, inclusive.

In general, portions 308 and 310 of the molded seal component 306, provide then, for a sealing between the media pack 226 and the preform part 300 at this location, and also for sealing around and against media pack 226, adjacent face 230, to inhibit undesired, contaminated, air flow at this region. Typically, if the



media pack does not include a covering or coating of some type, portions 308 and 310 will contact the single facer sheet of the media pack 226 directly. In other cases, material on the media pack will be between the media and portions 308 and 310. In both instances, portions 308 and 310 engage the media pack 226.

5 Referring to Fig. 11, molded seal component or overmold 306 further includes air cleaner seal portion 273. Air cleaner seal portion 273 includes a radial outer surface 273a, configured in a preferred manner, for sealing with an air cleaner component. The particular surface 56 is depicted, as a stepped surface portion 273b having a shape similar to the shape of the seal surface portion at reference 250  
10 depicted in U.S. patent 6,350,291 at Fig. 7, and in PCT Publication WO05/63361, published July 14, 2005; and US Publication US 2005/0166561, published August 4, 2005; the complete disclosures of each of which are incorporated herein by reference.

From review of Fig. 11, it can be seen that portion 301 of preform  
15 part 300 is positioned to back up housing seal 273 and stepped portion 273b of molded seal composition or overmold 306. Thus, preform part 300, in part, serves a function of providing for rigid backup to the strength of the seal when air cleaner housing seal portion 273 is compressed in the thickness (preferably at least 10% in thickness at the portion of most compression) upon installation in an air cleaner,  
20 with compression being of surface 273a toward portion 301. Preferably, the distance of compression is within the range of 1.5 - 2.8 mm, at the thickest part 273x of seal 273, more preferably about 1.9 - 2.5 mm. As can be seen from a review of Fig. 11, portion 301 is positioned to operate as a backup to the seal, because it projects outwardly (axially) from flow face 230, away from media pack 226.

25 Still referring to Figs. 18 and 12, it will be understood that the grid work 285 functions as a force transfer frame arrangement, to transfer forces from user grasping the handle arrangement 28, i.e. one or both of handles 288, through to the housing seal support arrangement 288, without those forces being transferred into or through the media pack 226, Fig. 11, in use. Such an arrangement and effect  
30 are described in PCT Publication WO06/12386, published March 30, 2006, incorporated hereby by reference.

Referring still to Fig. 11, the coiled media pack 226 includes center 320. The center 320 needs to be sealed against air flow therethrough. This is done by center piece or core 321. Core 321 also provides for a lead end seal of the single

facers strip. This is described in PCT Publication WO05/123214, published December 29, 2005, incorporated hereby reference.

More specifically, the media strip lead end is shown in phantom at 322. Thus, core 321 seals at least a portion of the lead end 322.

5 Still referring to Fig. 11, in general the preferred core 321 is a poured and cured-in-place core. By this it is meant that the core 321 results from pouring a fluid resin into center 320 and allowing the resin to cure in place. A variety of shapes and sizes for the core 321 are possible.

Typically when used as a lead end seal, the core 321 will be  
10 configured to extend along, or engulf, at least 80% of the lead end seal length, typically at least 90% of that length. In some instances, for example in the instance shown in Fig. 11, the core 321 may be configured to cover or enclose the entire lead end 22.

The core 321 can be configured with recesses as shown, or it can be  
15 configured to have no recesses or even to have one or more projections extending outwardly from the element.

When the core 321 is provided with recesses as shown, typically region 324 will be spaced from end face 230 at least 2 mm, and region 325 will be spaced from end 229 by at least 2 mm.

20 Region 327 extends from region 324 toward face 230, and terminates at face 230 as shown, or spaced therefrom within a preferred distance. This region defines an outer seal wall 328 with a hollow center 329. The seal wall 328 continues the sealing of the lead end 322 of the media pack 226. Region 327 can be viewed as a concave end 327a to core 321. Herein, region 327 will sometimes be referred to as  
25 a concave end 327a with an axially outwardly projecting end skirt 328.

Analogously, between region 325 and surface 229, region 334 is provided, with outer seal area 335 and inner center recess 336. Herein, region 338 will sometimes be referred to as a concave end 335 with an axially outwardly projecting end skirt  
335a.

30 Referring still to Fig. 11, as indicated above, support structure 280 includes cushioned support arrangement 282 and grid work 290. The grid work is part of a preform 291. Structural features of grid work 290, to inhibit distortion of the media pack 226 as described above. Grid work 290 further includes outer ring 350 thereon, with an outside edge 351 that preferably terminates short of outer

periphery 353 of media pack 226, adjacent end face 229. That is, preferably no part of grid work 290 extends around the media pack 226, although alternatives are possible.

5 Ring 350 includes projection 354 thereon, configured to engage media pack 226.

Although alternatives are possible, the cushion support arrangement 282 shown comprises a cured-in-place overmold which includes an axial cushion or base region 284b and a peripheral overmold region 284p. Peripheral region 284p comprises an overmold attaching support or grid 290 to media pack 226. Portion 10 284b is molded from a sufficiently soft material, to provide a cushion support when cartridge 225 is installed.

In particular, portion 284b preferably is not a rigid preform material, but rather is a cushioned material which will dampen vibrations to facilitate properly supporting the filter cartridge 225 in position, in the air cleaner assembly as shown 15 in Figs. 6-9. A rubber-like material which is flexible and soft under the conditions of use, will be acceptable. It will not be acceptable, however, to utilize a relatively rigid, preform structural piece, in typical instances. A material which will provide a dampening affect will typically be a foamed polymeric material, such as a foamed polyurethane. Typically it would be preferred that the material have a hardness, 20 Shore A, of no greater than about 40, and typically no greater than about 30, usually no greater than 25, and often lower. Some preferred materials are discussed below.

Typically, regions 284p and 284b are integral portions in axial cushion support 282. Indeed, they are typically formed integrally during molding of a single resin pool or pour.

25 The seal overmold 306, core 321, and cushion support 282 can all be formed from the same material, if desired, although such is not required. A useable material is a foam polyurethane molded to an as molded density of no greater than 28 lbs. per cu. ft. (0.45 grams/cu. cm.), typically no more than 22 lbs. per cu. ft. (0.35 grams/cu. cm.) usually no greater than 18 lbs. per cu. ft. (0.29 grams/cu. cm.) 30 and often within the range of 12 to 17 lbs. per cu. ft. (0.19 - 0.27 grams/cu. cm.).

Herein, the term "as molded density" is meant to refer to its normal definition of weight divided by volume. A water displacement test or similar test can be utilized to determine of a sample of a molded foam. It is not necessary when applying the volume test to pursue water absorption into the pores of the porous

material, to displace the air in the foam pores. Thus, the water volume displacement test used, to determine a sample volume, would be the immediate displacement, without waiting for a long period to displace air within the material pores.

Alternately stated, only the volume represented by the outer perimeter of the sample  
5 need to be used for the as molded density calculation.

In general, compression load deflection is a physical characteristic that indicates firmness, i.e. resistance to compression. In general, it is measured in terms of the amount of pressure required to deflect a given sample in an amount equal to 25% of its thickness. Compression load deflection tests can be conducted in  
10 accord with ASTM 3574, incorporated herein by reference. In general, compression load deflection may be evaluated in connection with age samples. A typical technique is to measure the compression load deflection on samples that have been fully cured for 72 hours at 75°F (24°C) or force cured at 190°F (88°C) for five hours.

15 Preferred materials for the overmold seal portion 306, and cushion support arrangement 282, will be ones, which when molded, show a compression load deflection, in accord with ASTM 3574, on a sample measure after heat aging at 158°F (7°C) for seven days, on average, 14 psi (0.96 bar) or less, typically within the range of 6 - 14 psi (0.41 - 0.96 bar), and preferably within the range of 7 - 10 psi  
20 (0.48 - 0.69 bar).

Compression set is an evaluation of the extent to which a sample of the material (that is subjected to compression of the defined type and under defined conditions) returns to its previous thickness or height when the compression forces are removed. Conditions for evaluating compression set on urethane materials are  
25 also provided in ASTM 3574, incorporated herein by reference.

Typically desirable materials for use in the overmold seal material 306 and cushion support arrangement 282, are materials which, upon cure, provide a  
cure material that has a compression set of no more than 18%, typically about 8 - 13%, when measured on a sample compressed to 50% of its height and held at that  
30 compression at a temperature of 190°F (82°C) for 22 hours.

Typically, the compression load deflection and compression set characteristics can be measured on sample plugs prepared from the same resin that is used form the feature in the cartridge, or cut from the structural feature in the cartridge. Typically, industrial processing methods will involve regularly making

test sample plugs from the resin material, rather than the direct testing on portions cut from molded pieces on filter cartridges.

Urethane resin systems capable of providing materials having physical properties within the molded density, compression set and compression load deflection definitions provided above, can be readily obtained from a variety of polyurethane resin formulators, including such suppliers as BASF Corp., Wyandotte, Michigan 48192.

Further description of the useable polyurethane for seal regions such as region 306, and by analogy a compression region such as region 282, are described in PCT Publication WO05/63361, published July 14, 2005; and US Publication US 2005/0166561, published August 4, 2005; each of which is incorporated herein by reference.

Similar materials can be utilized for the core 321. However, even lower density materials can be used, and in some instances higher density materials can be used as the core 321.

Typical resins useable in any of the three locations (housing seal overmold 306, cushion base 282, core 321) will be materials that cures to a density of at least 10 lbs. per cu. ft. (0.16 gram/cc.), although materials as low as 5 lbs. per cu. ft. (0.08 gram/cc.) may be acceptable for some applications. Again, it will be preferred that the material be one which cures to a density of no greater than about 22 lbs./cu. ft. (0.35 grams/cc.) as mentioned above, and preferably less than this value.

In Figs. 14 - 21, features of the preform useable as grid 285, are shown. In Fig. 14, an outside plan view is depicted, the view being toward the outside of the end viewable in Fig. 12. In Fig. 15, cross-sectional view along line 15 - 15, in Fig. 14, is viewable. In Fig. 16, a cross-sectional view along line 16 - 16, Fig. 14 is viewable.

In Fig. 17, a cross-sectional view taken along line 17 - 17, Fig. 14 is viewable. In Fig. 18, a cross-sectional view along line 18 - 18, Fig. 14, is viewable. In Fig. 19, enlarged view of a portion of Fig. 16 is shown. In Fig. 20, an inside plan view from an opposite side of that shown in Fig. 14 is shown. In Fig. 21, a cross-sectional view taken along line 21 - 21, Fig. 20, is viewable. In Fig. 22, an enlarged view of a portion of Fig. 21 is viewable. In Fig. 23, an enlarged view of a portion of Fig. 20 is viewable.

In Figs. 14 - 23, sample dimension and angles, for an example filter cartridge, are as follows: AA = 22.5; AB = 220 mm (8.66 in.); AC = 110 mm. (4.33 in.); AD = 421.6 mm diameter (16.60 in.); AE = 295 mm. diameter (11.61 in.); AF = 300 mm. diameter (11.81 in.); AI = 45°; AG = 132 mm. diameter (5.20 in.); AH = 127 mm. diameter (5 in.); AJ = 31.5 mm. (1.24 in.); AK = 10.5 mm. (0.41 in.); AL = 402.5 mm. (15.85 in.); AM = 10.5 mm. (0.41 in.); AN = 12.0 mm (0.47 in.); AO = 36°; AP = radius of 3.0 mm. (0.12 in.); AQ = 11.7 mm. (0.46 in.); AR = 3.9 mm. (0.15 in.); AS = 1.2 mm. (0.05 in.); AT = 0.4 mm. (0.02 in.); AU = 133°; AV = 2.6 mm. (0.10 in.); AW = 3.6 mm. (0.14 in.); AX = 15.5 mm. (0.61 in.); AY = 11.6 mm. (0.46 in.); AZ = 28.3 mm. (1.12 in.); BA = 3.03 mm (0.19 in.); BB = 33 mm. (1.3 in.); BC = 16.5 mm (0.65 in.); BD = 1.0 mm. (0.04 in.); BE = 2.0 mm. (0.08 in.).

In Figs. 24 - 31, the preform useable to form grid arrangement 290 (Figs. 11 and 13) is shown. In Fig. 24, an outside plan view is shown, corresponding to the view of Fig. 13 but in plan form. In Fig. 25, a cross-sectional view taken along line 25 - 25 (Fig. 24) is shown. In Fig. 26, an enlarged fragmentary view of a portion of Fig. 25 is shown. In Fig. 27, a cross-sectional view taken along line 27 - 27 (Fig. 24) is shown. In Fig. 28, an inside plan view opposite from that shown in Fig. 24 is depicted. In Fig. 29, a cross-sectional view taken along line 29 - 29 (Fig. 28) is shown. In Fig. 30, an enlarged view of a portion of Fig. 28 is shown. In Fig. 31, a fragmentary cross-sectional view of a portion of Fig. 29 is shown.

Example dimensions and angles in Figs. 24 - 31 are as follows: BF = diameter of 132 mm (5.20 in.); BG = diameter of 127 mm (5 in.); BH = diameter of 300 mm (11.81 in.); BI = diameter of 295 mm (11.61 in.); BJ = 45°; BK = 422.2 mm (16.62 in.); BL = 15.1 mm (0.59 in.); BM = 6.6 mm (0.26 in.); BN = 2.0 mm (0.28 in.); BO = 1.2 mm (0.05 in.); BP = 12.0 mm (0.47 in.); BQ = 11.9 mm (0.47 in.); BR = 36°; BS = 2.0 mm. (0.08 in.); BT = 3 mm radius (0.12 in.); BU = 6.93 mm (0.27 inch); BV = 37 mm (1.46 in.); BW = 18.5 mm (0.73 in.); BX = 2.1 mm (0.08 in.); BY = 1 mm (0.04 in.); BZ = 2 mm (0.08 in.); CB = 114°; CA = 2.0 mm (0.08 in.).

In general terms, the housing seal arrangement for the example shown includes a molded-in-place housing seal material. Further, the housing cushion arrangement, for the example shown, includes a molded-in-place axial cushion arrangement. The axial cushion arrangement and the housing seal

arrangement, for the example shown, are separate moldings. This will typically be preferred.

Referring to Fig. 11, it is noted that for the particular arrangement shown, at least the outside coil, and typically the outside 1-3 coils of the coiled media pack 226 are blinded off by the overmolds at opposite ends of the media pack, the overmold at end 229 being provided at 284b/284p and the overmold at end 230 being provided at 306/308/309. As a result of this blinding off of the outer 1-3 coils or wrappings, damage to the media pack outer surface will not affect filter integrity and seal integrity. This is because the flutes in these outermost flutes are closed at the exit end anyway.

C. The safety or secondary cartridge 240, Figs. 32 - 34

As indicated above in connection with the descriptions of Figs. 7 and 8, the air cleaner 200 depicted includes an optional safety filter 240 therein. The safety filter or secondary filter is depicted in more detail, in Figs. 32 - 34.

Referring to Fig. 32, the safety or secondary filter comprises pleated media 400 positioned within framework 401 having an outside housing seal 402 thereon.

Referring to Fig. 34, the safety filter 240 further includes a handle arrangement 405.

Referring to Fig. 33, the media 400 is secured in place with a comb arrangement 410.

Housing seal 402 could comprise a molded in place radial seal material secured around portion 401a of framework 401. Compressible foam polyurethane of the same type described above for use in connection with seal region 273, Fig. 9 can be used. The particular housing seal arrangement 402 depicted includes a tapered face 402a, to facilitate insertion.

Referring to Fig. 33, typical installation, end face 425 is installed upwardly, Fig. 8 and in end face 426 faces downwardly, toward primary media pack 225. Handle 405, then, is positioned to facilitate installation into and, remove from, cover piece 202, Fig. 8.

In Figs. 32 - 34, example dimensions are provided as follows: CC = 409 mm. (6.1 in.); CD = 40.6 mm. (1.6 inch); CEE = 59.9 mm. (2.36 in.).

Alternate dimensions and shapes can be for alternate systems.

It is noted that the utilization of a radial seal for housing seal arrangement 402, provides that under the compression of the seal, when installed in cover 202, the safety filter 240 will remain in place in cover 202, even when cover 202 is separated from housing body 201. This advantageous feature can be adapted for use in a variety of alternate air cleaners, with different features in the air cleaner housing and/or the main filter cartridge.

#### D. Further Observations.

Referring to Fig. 7, in particular to housing seal surface 266, it is noted that surface 266 is sufficiently long (axially) so that when fully installed, potential main cartridge housing seal surface is still provided along surface 266 before end 450 is encountered. This extra region, 266x, provides for at least the following. First, it allows for tolerance take up with respect to the length of the overall cartridge 225, to facilitate installation within housing 201. Secondly, as a cover 202 is installed, and as the housing seal arrangement 273 encounters surface 266, the installation force, i.e., clamping forces from clamps 250, Fig. 8, will tend to drive the cartridge 225 downward against the surface 261, pressing lower cushion 282 somewhat. Extra length to region 266 will facilitate installation, even under some movement of this type.

Preferably, region 266 has an overall axial length of at least 20 mm., typically at least 22 mm., usually 22 to 30 mm. For the example shown, this region is 25.4 mm long. Preferably, region 266 is configured such that when air cleaner 200 is assembled it leaves at least 1.5 mm., typically at least 2.0 mm., usually at least 2.5 mm, for example 2.5 to 4.0 mm., surface in region 266x, i.e., above a location where at cartridge 225 terminates, and below a location where step 450 or safety cartridge 240 are encountered. (Usually, about 9-12 mm of the length of region 266 is actually in contact with the housing seal of the cartridge, during installation.)

Referring to Fig. 11, cushion 282 has a minimal axial thickness at region 460, dimension Y. Preferably, at this region it is at least 3 mm thick, typically at least 5 mm thick, for example 6 mm to 10 mm thick. This will allow for good cushion, during installation and vibration. (For the example shown, this region is 7 mm thick.) The thickness of cushion 282 also needs to be sufficient to ensure that the housing seal at the opposite end is supported appropriately for engagement.



Still referring to Fig. 11, preferably the radial width (dimension X) of cushion 282 is at least 15 mm, usually at least 16 mm, typically within the range of 16 mm to 20 mm. For the example shown, this region is 17 mm wide. This will allow for a large, thick, cushion in region 282, to facilitate installation. Typically cushion 282 is sized such that at least 40%, typically at least 50%, and usually at least 90% radial dimension (width) of the cushion 282 (radial dimension being dimension X) is in axial overlap with the media pack 226, i.e., in axial overlap with end face 229. That is preferably only a relatively small amount, typically less than 50%, usually less than 10%, of the radial dimension X extends peripherally outwardly of the media pack 226, at cushion 282. Also typically dimension X1, the width of the cushion 282 and overlap with the axial surface 229 is about 0.5 mm, and typically not more than 1.5 mm.

Based on the above, it will be understood that typical preferred arrangements of the housing cushion arrangement of flexible polymeric material will have an axial overlap with the end of the media pack from which the housing cushion material is mounted, of at least 6 mm (40% of 15 mm), usually at least 7.5 mm (50% of 15 mm) and usually at least 13.5 mm (90% of 15 mm).

The outer axial surface 282x of the cushion ring 282 is typically planar, and the plane generally being perpendicular to a central axis of the filter cartridge 225. However, alternatives are possible. Surface 282X does not form critical seal to operation of the air cleaner housing, and thus it can be irregular. It is preferred that the portion of cushion in overlap with the support shelf of the housing, be sufficiently wide to provide a desirable dampening effect, and support effect. Typically a width as characterized above will be sufficient.

25

#### **IV. Additional Alternatives and Variations.**

A. Variations in housing seal configuration and/or frame pieces used with overmolded housing radial seals.

In connection with Fig. 11, a seal arrangement is indicated generally at reference numeral 272. Variations in the housing seal arrangement 272, and its structural features thereof, are possible, as previously indicated. Certain useable alternatives are described for example in U.S. provisional application 60/735,650, filed November 9, 2005, incorporated herein by reference.

30

B. Selected Alternative Constructions, Figs. 35-41.

In connection with Figs. 35-41, certain alternatives are described and shown implementable in accord with principles according to the present disclosure. The reference numeral 500, Fig. 35, generally indicates an example air cleaner. The  
5 air cleaner 500 includes numerous features generally analogous to those for air cleaner 200, Fig. 6. In particular air cleaner 500 comprises a housing 501 having a bottom or base 501a, removable access or service cover 502, an air flow inlet end 503 and an air flow outlet end 504. Air passing between inlet end 203 and outlet end 204 is filtered by an internally received filter cartridge arrangement, as  
10 described.

The air cleaner 500 would generally be in accord with the descriptions for air cleaner 200, and include an internally positioned pre-cleaner arrangement, not viewable, as well as an injector tube evacuation/valve arrangement 514. The air cleaner housing base 501a includes main cartridge receiving central  
15 section 520, in which is positioned a serviceable main filter cartridge (not depicted in Fig. 35).

In Fig. 36, air cleaner 500 is depicted in exploded view. Cover 502 is shown removed from housing base 501a. Main filter cartridge 525 and safety filter 540 are viewable. Support ring arrangement 544 is shown. The support ring  
20 arrangement 544 provides assistance in clamping of service cover 502 to body 501, by overcenter latches or clamps 550. Ring 544 is different in detail construction, for ring 244, for convenience. In particular, instead of being constructed in half rings, ring 544 comprises an elongate flexible ring secured at a joint, into a circular pattern.

25 Features having analogous locations and appearances, provide for similar operation to those described in connection with previous figures; and a detailed re-description is not provided here.

In this section, attention is specifically directed to variations in specific features for the main filter cartridge 525. These features and variations are  
30 discussed in connection with Figs. 37-41. It is noted that in many instances, analogous function is retained.

Referring first to Fig. 37, cartridge 525 comprises a media pack 560 having a first, in this instance inlet flow face 561 and a second, in this instance, outlet flow face 562. The media pack 560 may comprise a z-filter media pack, for

example a fluted sheet secured to a facing sheet coiled to form a plurality of flutes extending between the first flow face 561 and the second flow face 562; the media pack including an appropriate seal arrangement to block or prevent flow of unfiltered air completely therethrough, between the end faces 561, 562. Examples  
5 of z-filter media constructions to provide for this are described previously.

Mounted at flow face 562 is a housing seal arrangement 572. The housing seal arrangement 572 comprises a housing seal member 573, mounted around a seal support. For the particular example shown, the seal support includes a portion on which the housing seal arrangement 573 is mounted. In addition, the  
10 example support is part of a preform or framework arrangement that includes a portion 575, mounted on the media pack 560. In this manner, the housing seal arrangement is generally analogous to that described in U.S. Patents 6,190,432; 6,350,291; 6,610,117; and, 6,783,565, each of which is incorporated herein by reference. Of course variations are possible; however, typically housing seal  
15 arrangement 572 will comprise housing seal member 573 mounted on and/or around and an appropriate support or support ring, to provide backup to sealing. A variety of arrangements can be used to secure the housing seal member 573 and support ring in position. In the example shown in connection with Fig. 11, an overmold is used to provide this. For the example shown in Fig. 37, a frame extension 575  
20 surrounding the media pack 560 and adhered thereto with adhesive provides this. What will be understood, is that a variety of support arrangements for an outwardly directed radial seal are possible.

Also referring to Fig. 37, at inlet end 561 cushion arrangement 580 is depicted. The cushion arrangement 580 generally includes a cushion support  
25 arrangement 582 mounted on media pack 560. The cushion support arrangement 582 includes a cushion or cushion ring 583 secured in place on framework including a mounting ring 585 secured to media pack 560 and surrounding media pack 560. The ring 583 can be molded in place on the framework or be adhered with adhesive.

Attention is now directed to Fig. 38, in which cartridge 525 is  
30 depicted in schematic cross-section. Referring first to flow end 562, framework 575 is shown supporting housing seal arrangement 573, which is molded thereon or otherwise secured thereto. The framework 575 is secured to the media pack 560 with lip 576 surrounding the media pack 560 and adhered, with an adhesive, thereto. The adhesive also provides for sealing between the framework 575 and the media pack

560 at this location. The housing seal member 573 is backed up by support or support ring 577. For the examples shown, the support 577 is integral with ring 576, although alternatives are possible.

For the arrangements shown in Fig. 38, the media pack 560  
5 comprises a coiled single facer around a central core 590. Within center core 590 is positioned core piece 591, discussed further below. Frame piece 575 includes a central portion 592 snap fit to core 591, as discussed below.

Still referring to Fig. 38, cushion arrangement 582 comprises a  
10 molded cushion member or ring 583 secured to frame piece 585, and in particular to support 584. Typically cushion member or ring 583 would comprise compressible foam polyurethane molded in place, although it may be alternately constructed and attached differently.

Referring to Fig. 38, a view is toward outlet end 562 of cartridge 525. Frame piece 575 can be seen to comprise grid work 600 and handle arrangement 601  
15 generally analogously to that shown in Fig. 10, except for the snap fit arrangement in 592, and also the absence of an over mold for attachment.

Referring to Fig. 40, inlet end 561 of filter cartridge 525 is depicted. It may also be viewed as including grid work 610. Thus its structure is generally  
20 analogous to that shown in Fig. 13, except for the absence of an overmold for cushion member 583.

In general, then, cushion ring 583 can be analogous to similar components previously described except on a framework 584 secured in place on media pack 560 with adhesive, instead of overmold.

In Fig. 41, an exploded view is depicted, of the arrangement Fig. 38,  
25 except not showing the media pack itself, for convenience. Core piece 591 can be depicted. At 595, a projection having a snap fit end receiver member 596 is shown on core piece 591. This can snap fit with an appropriate ring member 592, Fig. 38, on frame piece 575.

In Fig. 41, then, an add on arrangement 640 is depicted, comprising  
30 features added to the media pack 560, Fig. 38, to form cartridge 525. The core 591 can be secured in place by a variety of arrangements, including for example an adhesive or mold in place attachment arrangement. Core 591 would typically include a central closed section, inhibiting air flow through central core 590, Fig. 38.

Figs. 35-41, then, depict an alternate features for application of principles described in connection with Figs. 6-34. The basic features and principles remain the same as in Figs. 6-34, with some variations in specific implementation being depicted in Figs. 35-41. Similar operation, materials and dimensions to those  
5 previously discussed for Figs. 1-34 can be used for the arrangement of Figs. 35-41.

What is claimed is:

1. An air filter cartridge comprising:
  - (a) a media pack having first and second, opposite, flow ends and comprising a plurality of flutes extending between the first and second, opposite, flow ends;
    - (i) the media pack being closed to flow of unfiltered air therethrough, during use;
  - (b) a housing seal arrangement positioned on one of the media pack flow ends;
    - (i) the housing seal arrangement comprising a seal member positioned with a seal surface around a seal support; and,
  - (c) a housing cushion arrangement positioned on a media pack flow end opposite the end on which housing seal arrangement is mounted;
    - (i) the housing cushion arrangement comprising an axial cushion ring of flexible polymeric material having an axial overlap with the end of the media pack, on which the housing cushion arrangement is mounted, of at least 6 mm.
2. An air filter cartridge according to claim 1 wherein:
  - (a) the axial cushion ring has a planar, outer, cushion surface.
3. An air filter cartridge according to any one of claims 1 and 2 wherein:
  - (a) the axial cushion ring comprises foamed polyurethane having an as-molded density of no greater than 0.35 g/cu.cm.
4. An air filter cartridge according to any one of claims 1-3 wherein:
  - (a) the housing cushion arrangement includes a preform and the axial cushion ring;
    - (i) a portion of the preform being positioned between at least a portion of an outer axial cushion surface of the axial cushion ring and the end of the media pack on which the housing cushion arrangement is mounted.

5. An air filter cartridge according to claim 4 wherein:  
(a) the axial cushion ring is a mold-in-place ring on the preform.
6. An air filter cartridge according to any one of claims 4 and 5 wherein:  
5 (a) the preform of the housing cushion arrangement includes a grid arrangement extending across the flow end of the media pack on which the housing cushion arrangement is mounted.
7. An air filter cartridge according to claim 6 wherein:  
10 (a) the grid arrangement includes a plurality of spaced, radial ribs.
8. An air filter cartridge according to claim 7 wherein:  
(a) the grid arrangement includes at least one interior ring securing the ribs together.
- 15 9. An air filter cartridge according to any one of claims 4-8 wherein:  
(a) the preform with the axial cushion ring thereon is secured to the media pack with adhesive.
- 20 10. An air filter cartridge according to any one of claims 4-8 wherein:  
(a) the axial cushion ring is a mold-in-place ring having a portion molded around the media pack to secure the preform of the housing cushion arrangement to the media pack.
- 25 11. An air filter cartridge according to any one of claims 1-10 wherein:  
(a) the axial cushion ring has an axial thickness of no less than 3 mm.
12. An air filter cartridge according to any one of claims 1-11 wherein:  
30 (a) the media pack comprises inlet and outlet flutes extending between the first and second, opposite, flow ends;  
(i) the inlet flutes comprising a plurality of flutes open at the first flow end and closed at the second flow end;  
(ii) the outlet flutes comprising a plurality of flutes closed at the first flow end and open at the second flow end;

13. An air filter cartridge according to any one of claims 1-12 wherein:
- (a) the housing seal arrangement comprises an overmold and a preform;
    - (i) the preform having the housing seal support projecting axially outwardly from the end of the media pack on which the housing seal arrangement is mounted, and;
    - (ii) the overmold having:
      - (A) a first portion sealing an interface between the preform and the end of the media pack on which the housing seal is positioned; and,
      - (B) a second portion oriented to form an outwardly directed housing radial seal, when the air filter cartridge is installed for use;
      - (C) the second portion of the overmold being positioned adjacent the housing seal support of the preform.
14. An air filter cartridge according to any one of claims 1-12 wherein:
- (a) the housing seal arrangement comprises a preform secured to the media pack with adhesive;
    - (i) the seal support comprising a portion of the preform.
15. An air filter cartridge according to any one of claims 13 and 14 wherein:
- (a) the preform of the housing seal arrangement includes a grid structure extending across the end of media pack on which the housing seal arrangement is mounted.
16. An air filter cartridge according to any one of claims 13-15 wherein:
- (a) the preform of the housing seal arrangement includes a handle arrangement on the grid structure.
17. An air filter cartridge according to claim 16 wherein:
- (a) the grid structure of the housing seal arrangement preform includes a plurality of spaced, radial ribs; and
  - (b) the filter cartridge includes two spaced handles on the preform of the housing seal arrangement;



- (i) each one of the two handles extending between two, associated radial ribs.
18. An air filter cartridge according to any one of claims 1-17 wherein:  
5 (a) first and second flow ends of the media pack are planar flow faces.
19. An air fiber filter cartridge according to any one of claims 1-18 wherein:  
(a) the media pack comprises a coiled single facer having a corrugated sheet secured to a facing sheet.
- 10 20. An air filter cartridge according to any one of claims 1-19 including:  
(a) a molded-in-place center core.
21. An air filter cartridge according to claim 1 including:  
15 (a) a central core piece surrounded by the media pack;  
(i) the central core having a snap fit end receiver member; and,  
(b) a preform positioned at an end of the media pack and snap fit to the snap fit end receiver member of the central core piece;  
(i) the preform including the housing seal arrangement thereon;  
20 and,  
(ii) the preform including a pair of spaced handle members thereon.
22. An air filter cartridge according to any one of claims 1-21 wherein:  
25 (a) the media pack has a circular cross-section.
23. An air cleaner comprising:  
(a) a housing including a housing base and a removable service cover;  
(i) the housing base including a cartridge support shelf therein;  
30 (ii) the removable service cover including a first housing seal surface therein; and  
(b) a primary air filter cartridge operably positioned within the air cleaner housing; the primary air filter cartridge comprising:  
(i) a media pack having first and second, opposite flow ends:

- (A) the media pack comprising a set of flutes extending between the opposite flow ends;
- (B) the media pack being closed to flow of unfiltered air therethrough, during use;
- 5 (ii) a housing seal arrangement positioned on the second flow end;
- (A) the housing seal arrangement comprising an outwardly directed radial seal material positioned around a seal support at the second flow end of the media pack;
- 10 (iii) a housing cushion arrangement positioned on the first flow end of the media pack;
- (iv) the air filter cartridge being positioned within the air cleaner housing with:
- (A) the outwardly directed radial seal material sealed against the first housing seal surface in the removable service cover; and
- 15 (B) the housing cushion arrangement resting on the cartridge support shelf in the housing base, with the housing seal arrangement positioned above the
- 20 housing cushion arrangement.
24. An air cleaner according to claim 23 including:
- (a) a second housing seal surface in the removable service cover; and,
- (b) a secondary filter cartridge having an outside radial seal mounted in
- 25 the service cover above the primary filter cartridge.
25. An air cleaner according to any one of claims 23 and 24 wherein:
- (a) the first housing seal surface is at least 2.5 mm. longer in axial dimension than an engaged portion of the housing seal arrangement
- 30 of the primary filter cartridge.

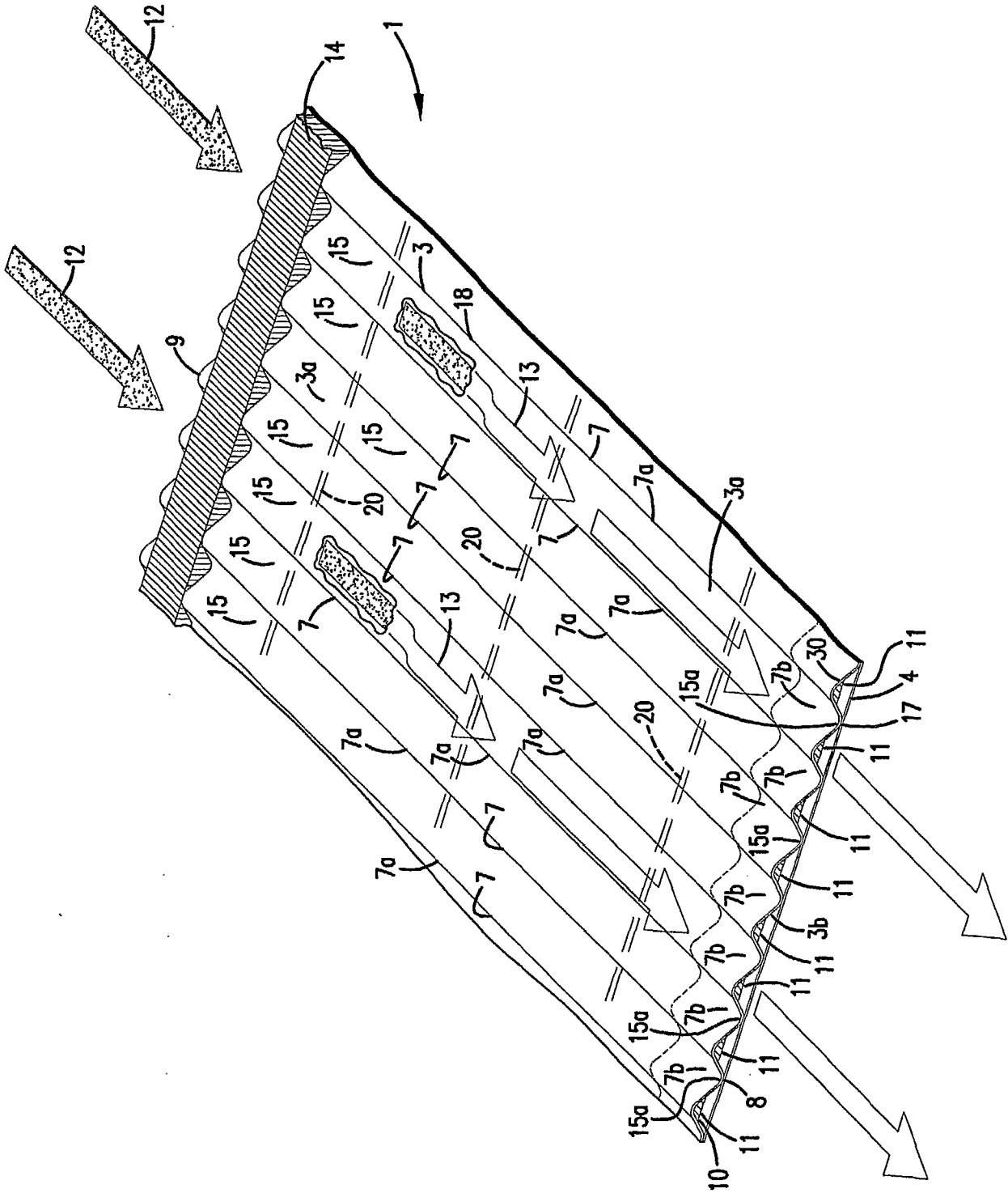


FIG. 1

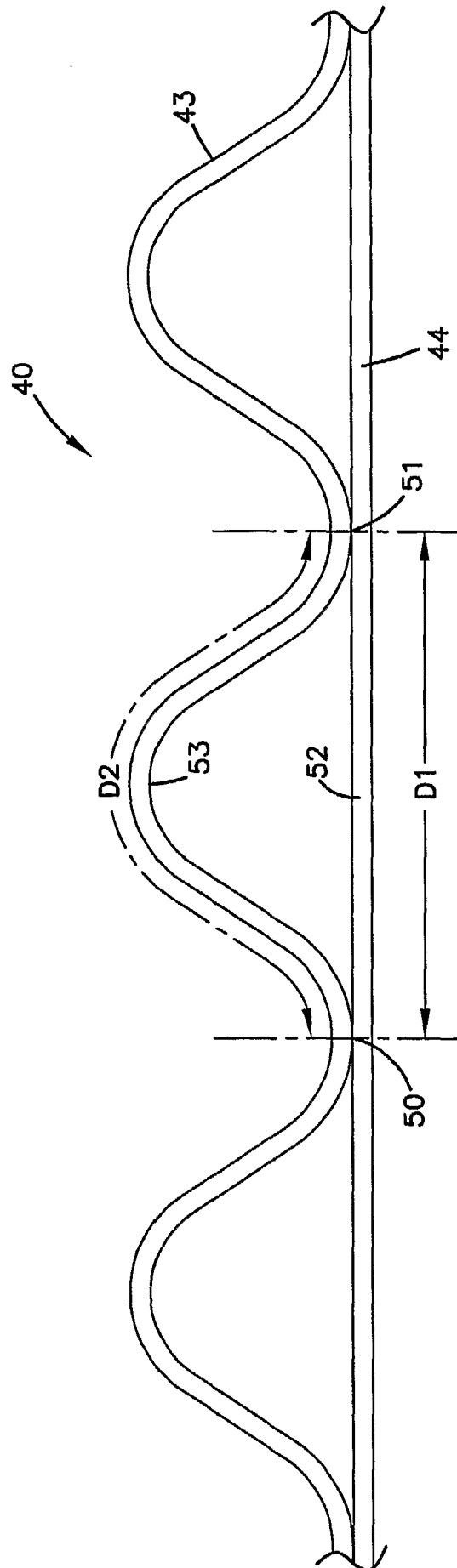
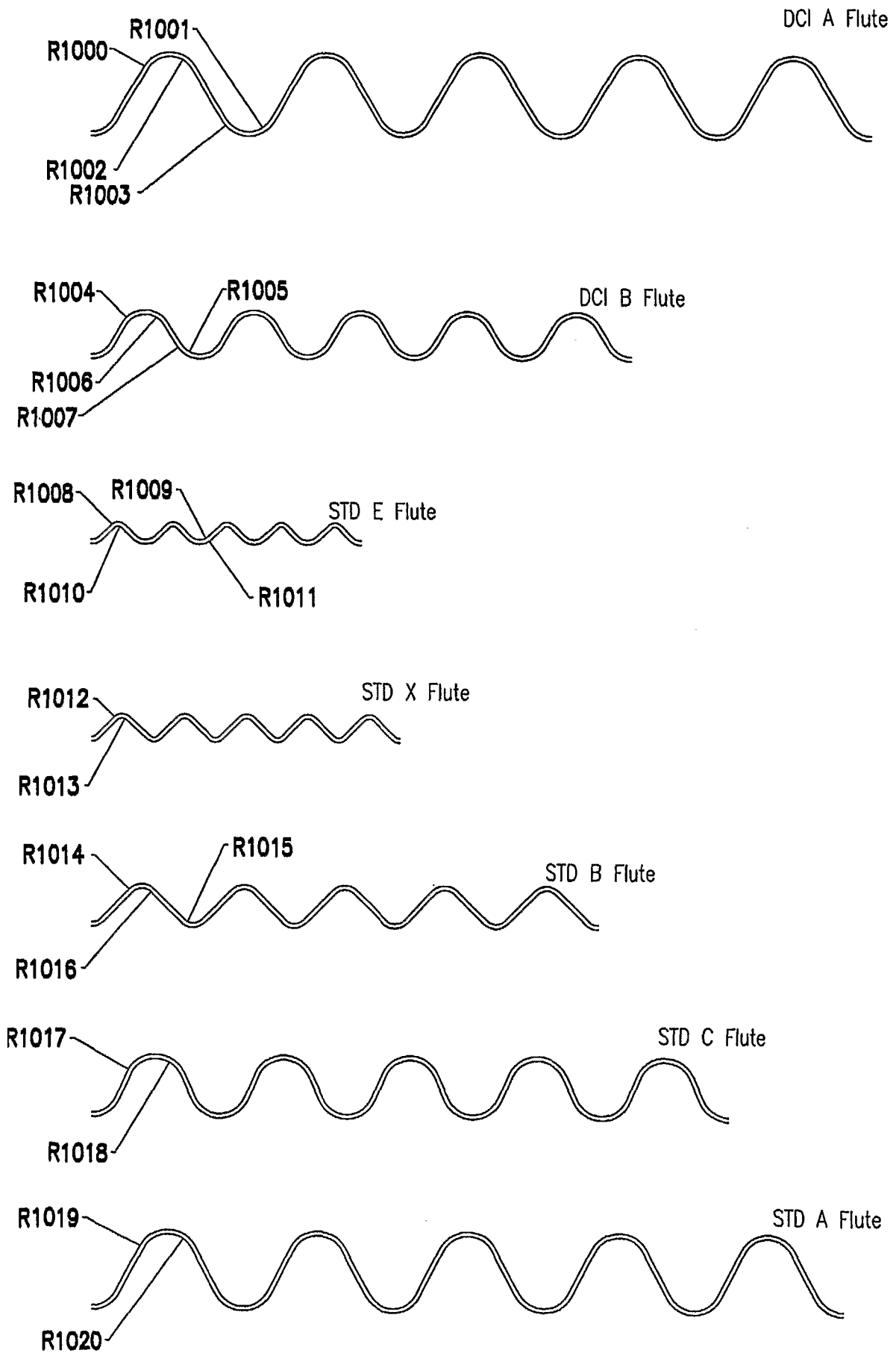


FIG. 2

FIG. 3



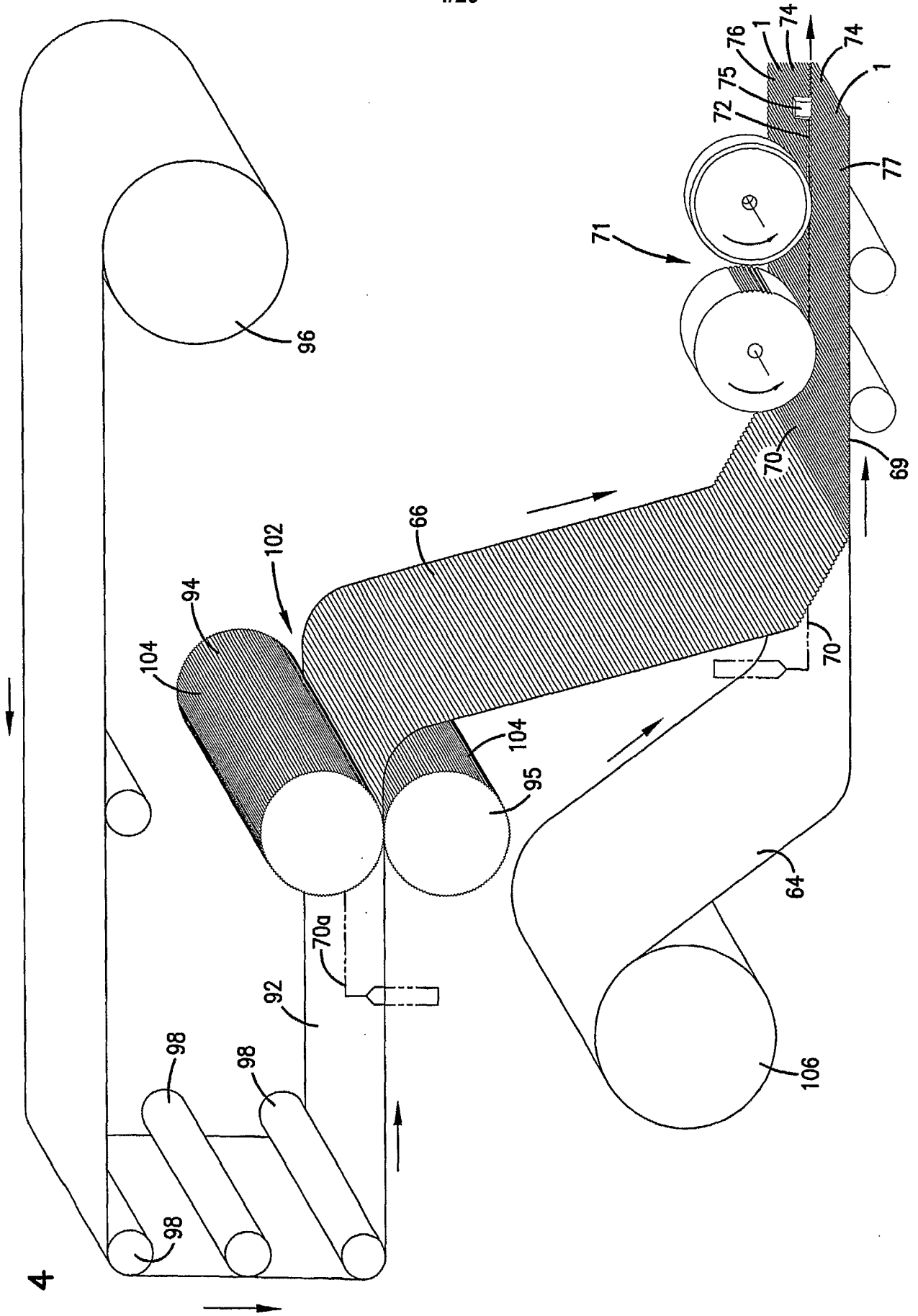
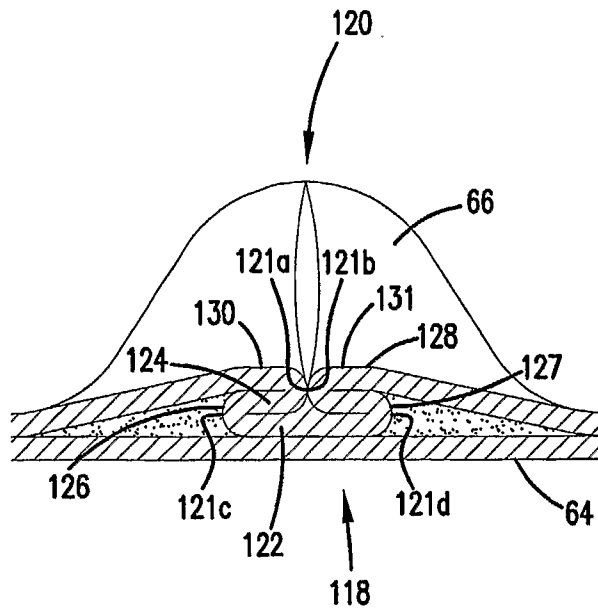


FIG. 4

FIG. 5



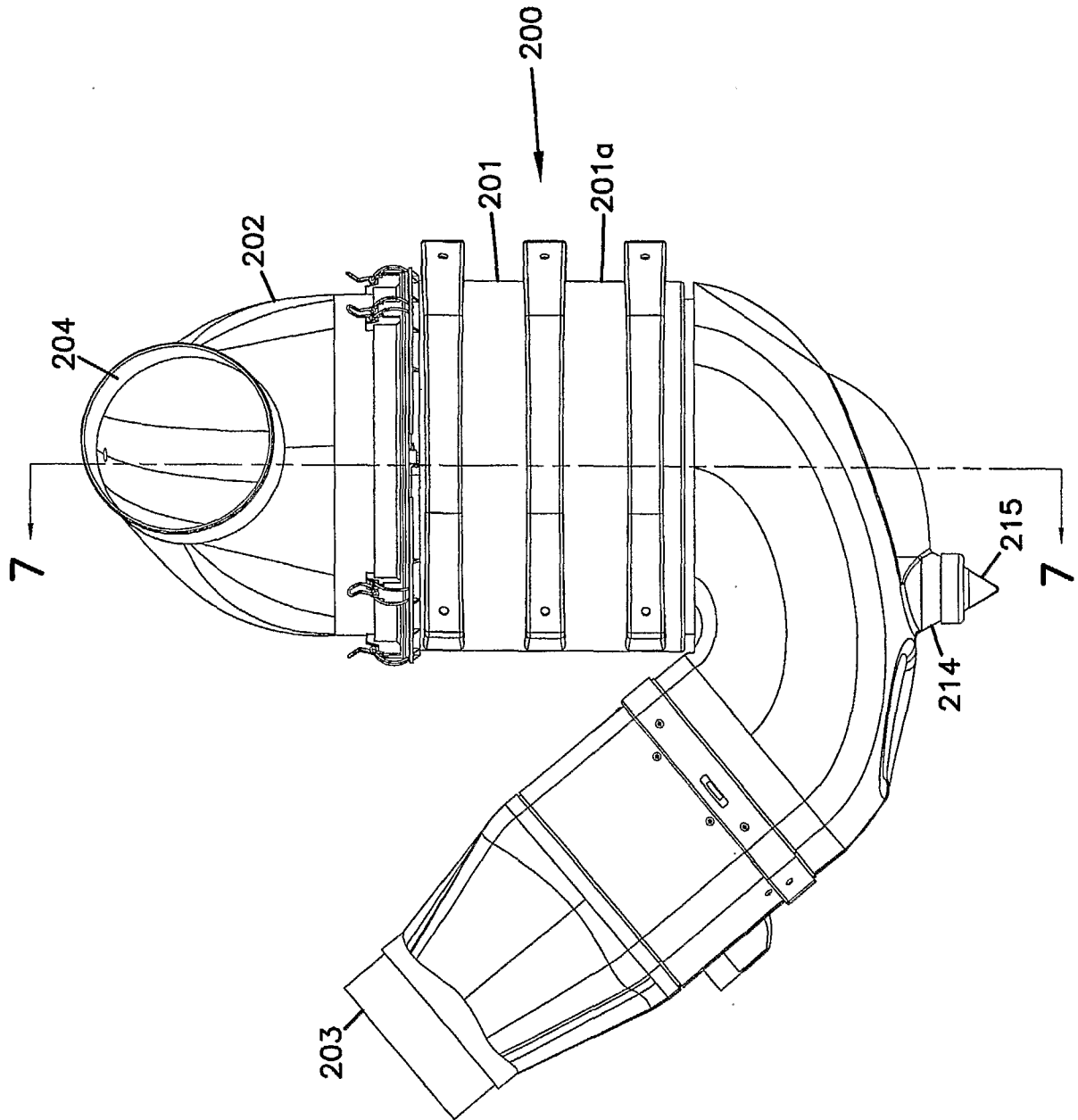


FIG. 6



FIG. 7

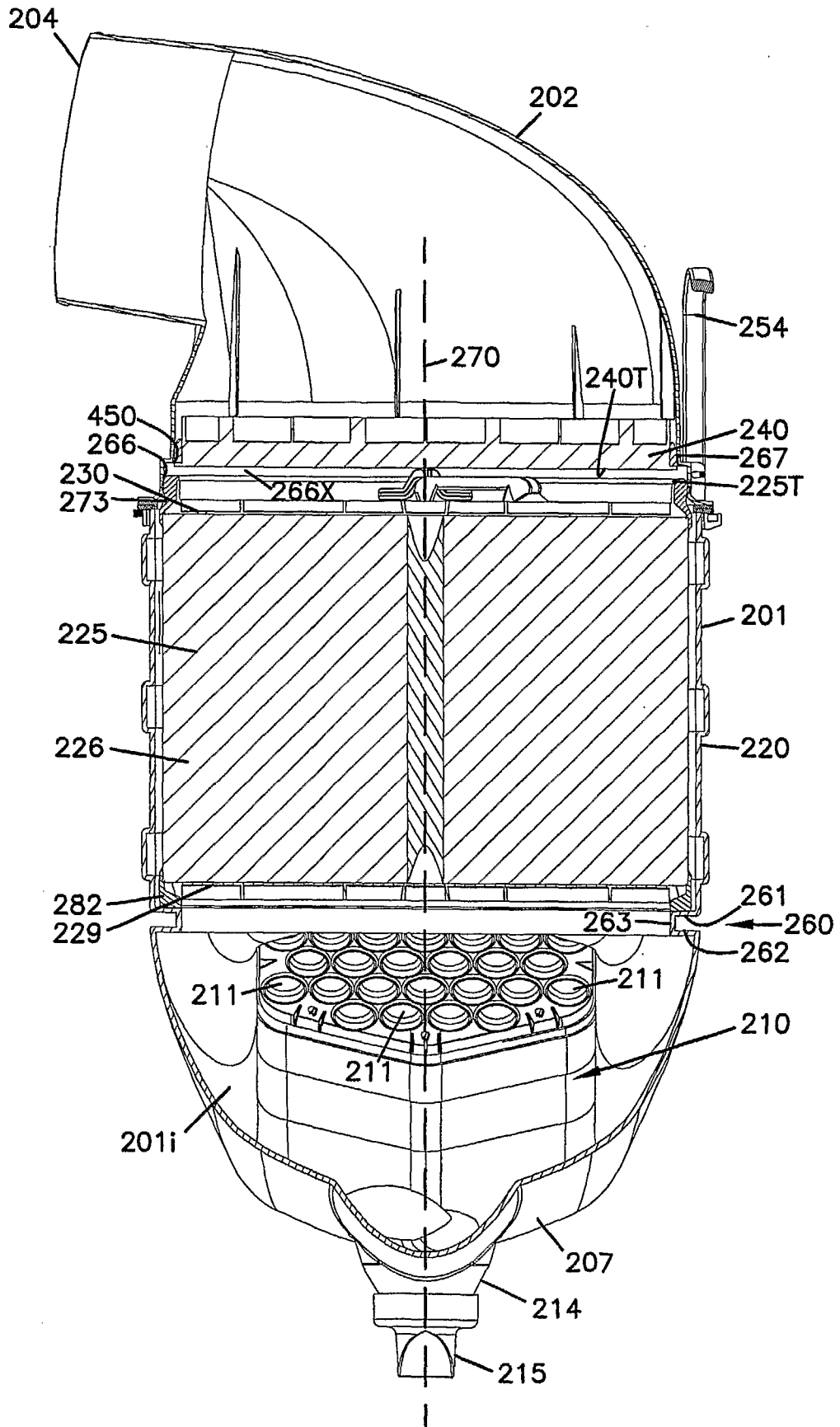
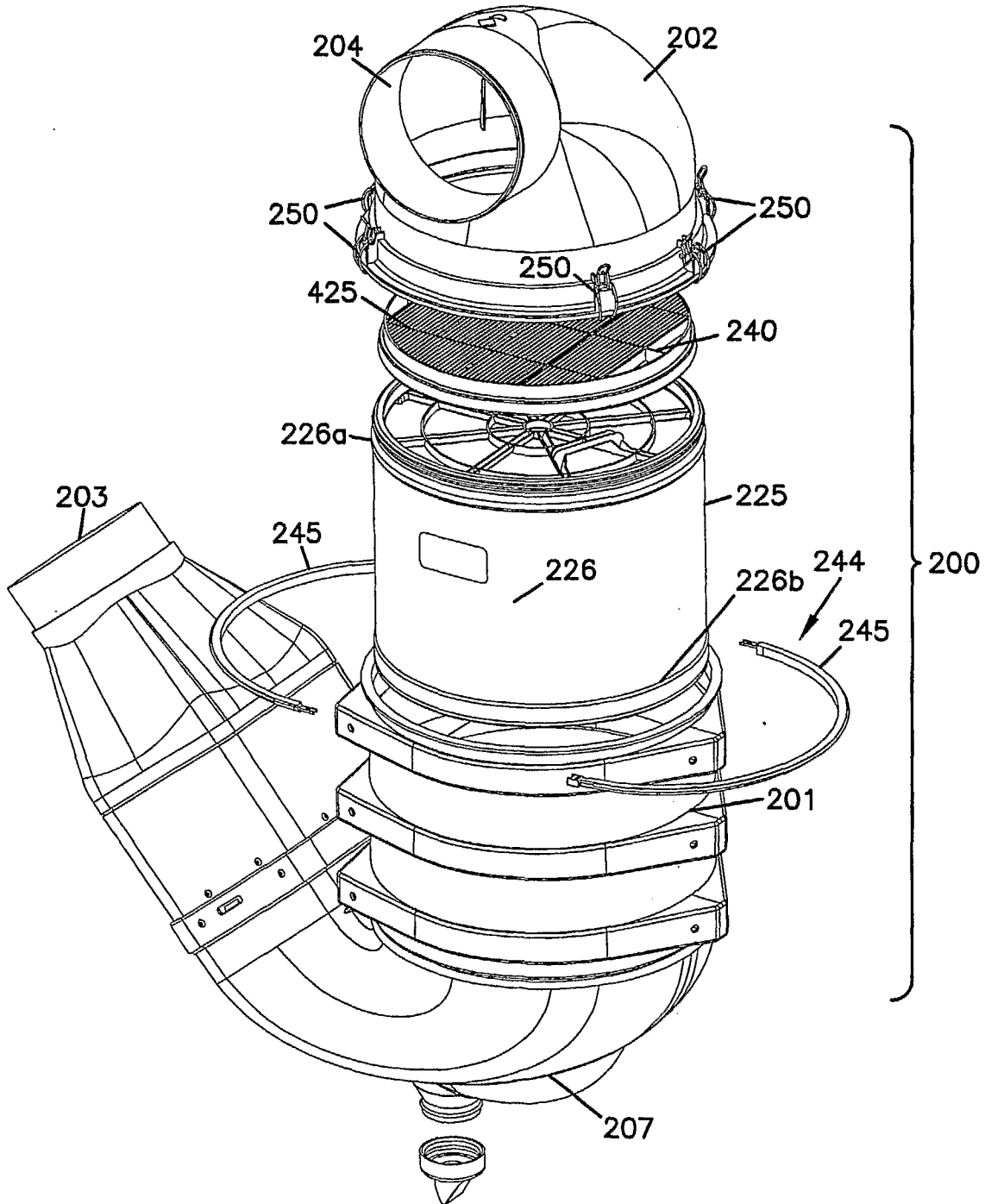


FIG. 8



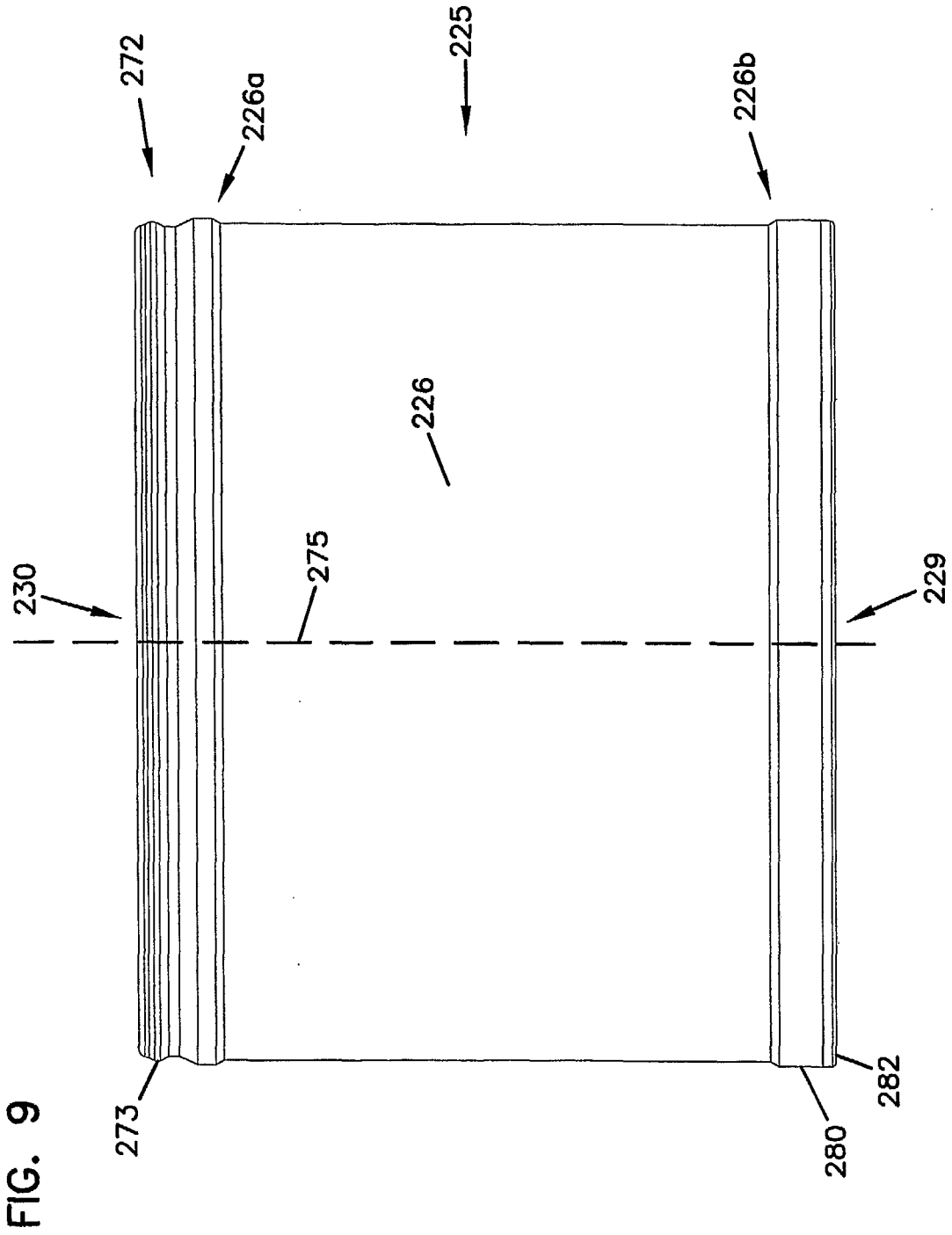
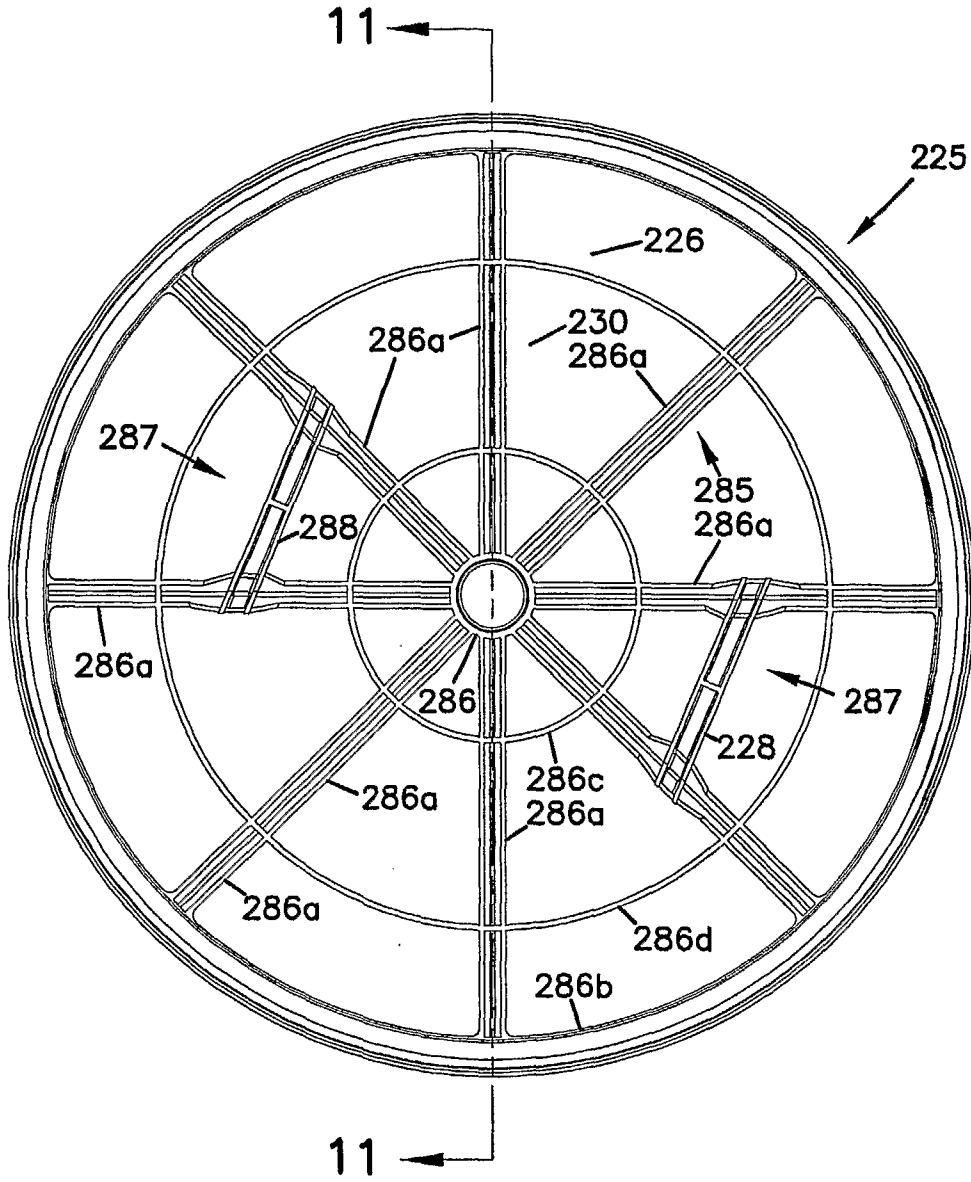


FIG. 10



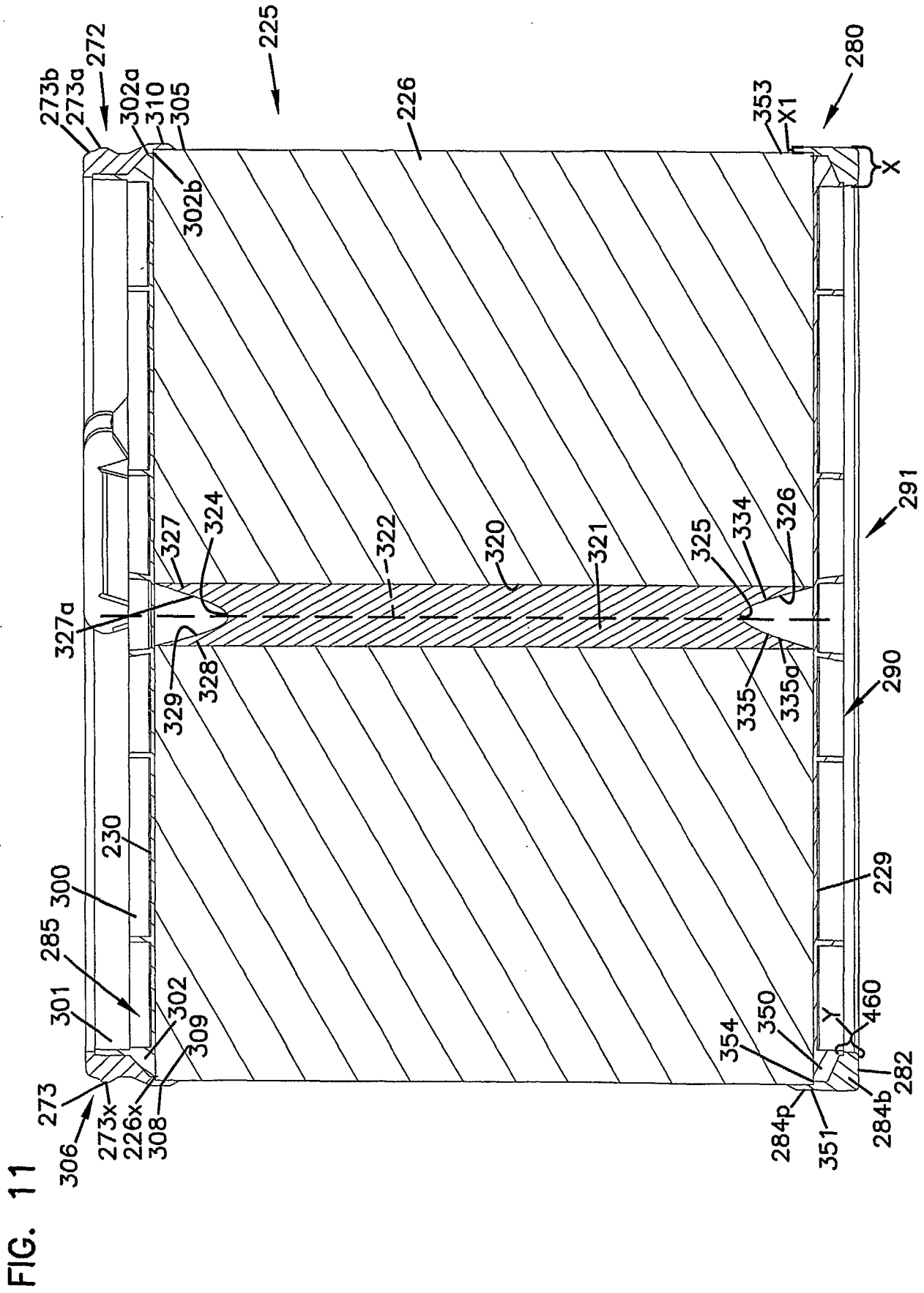


FIG. 13

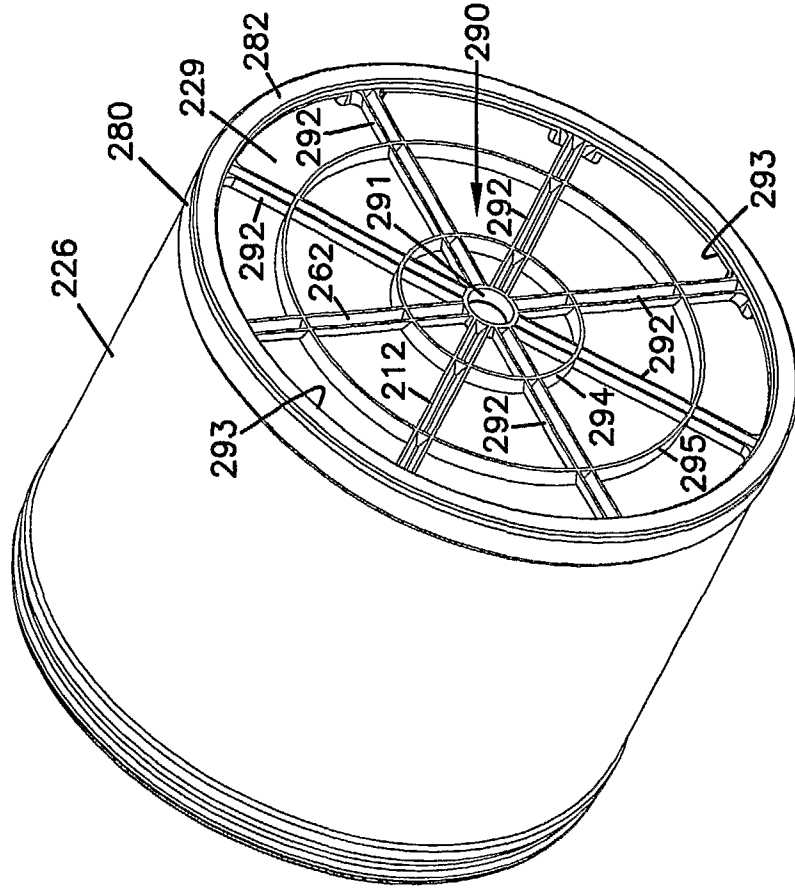
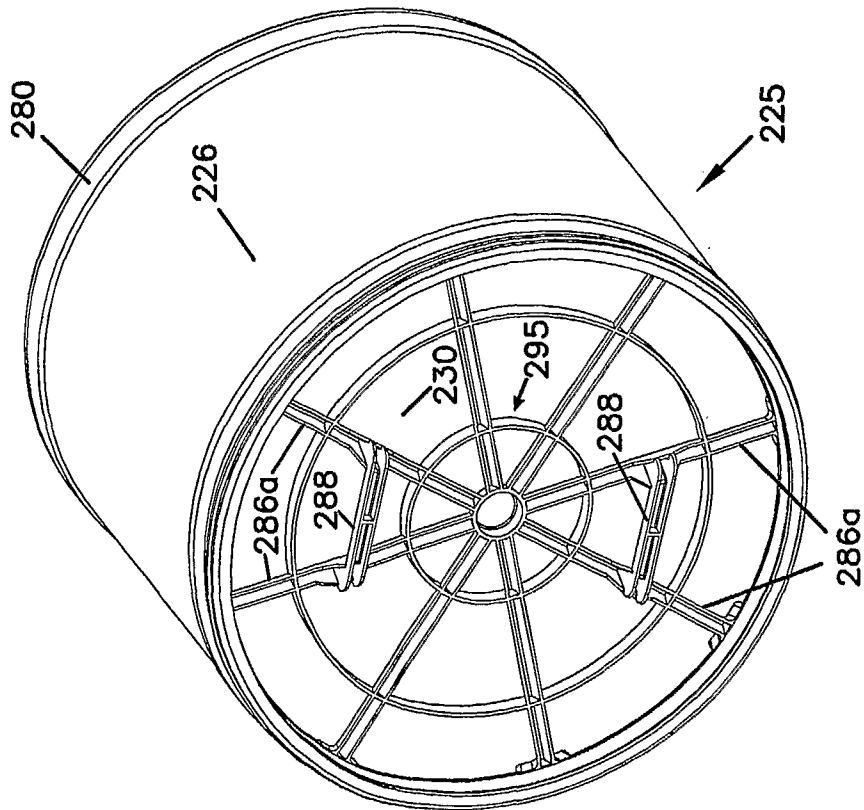


FIG. 12



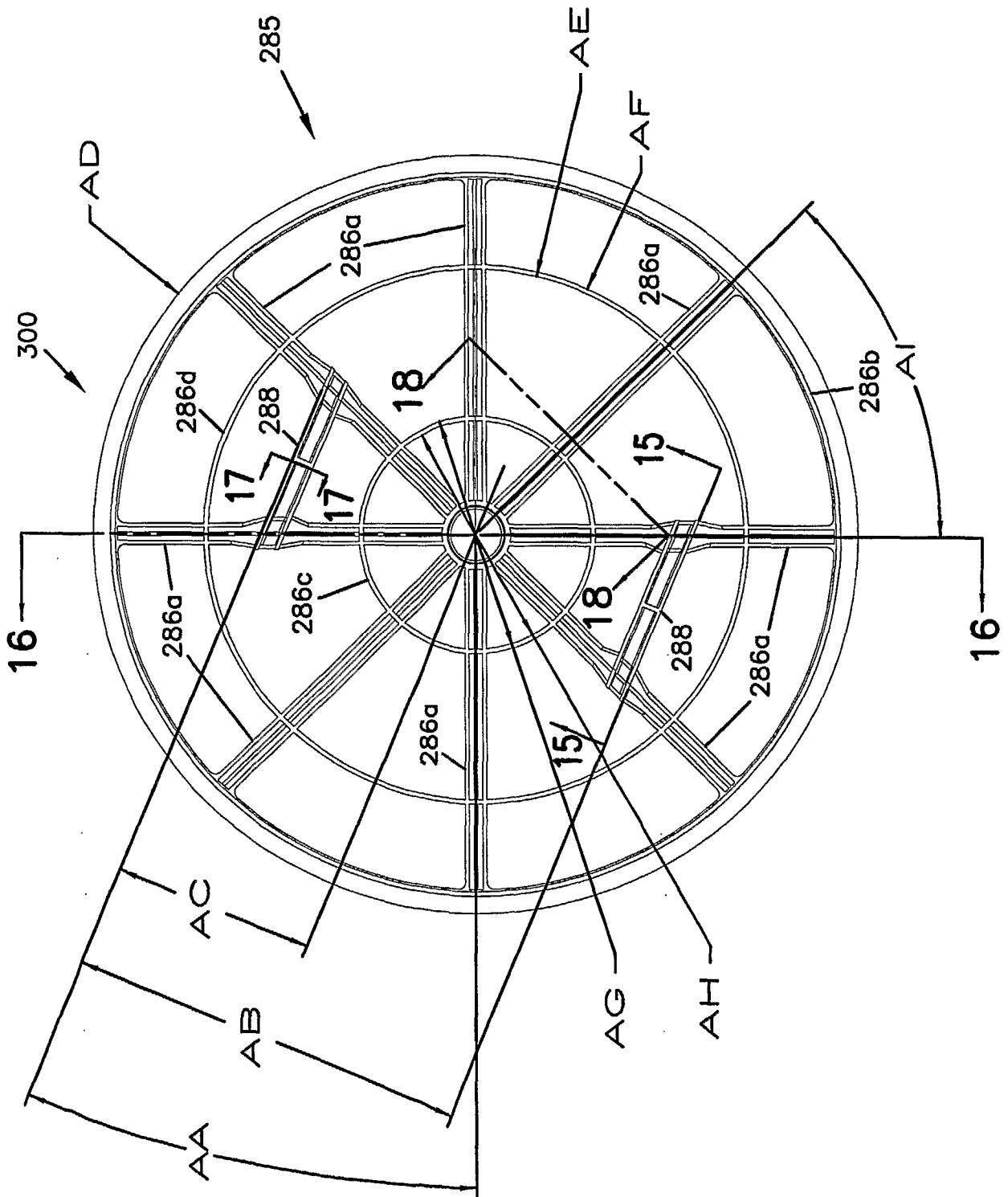


FIG. 14

FIG. 15

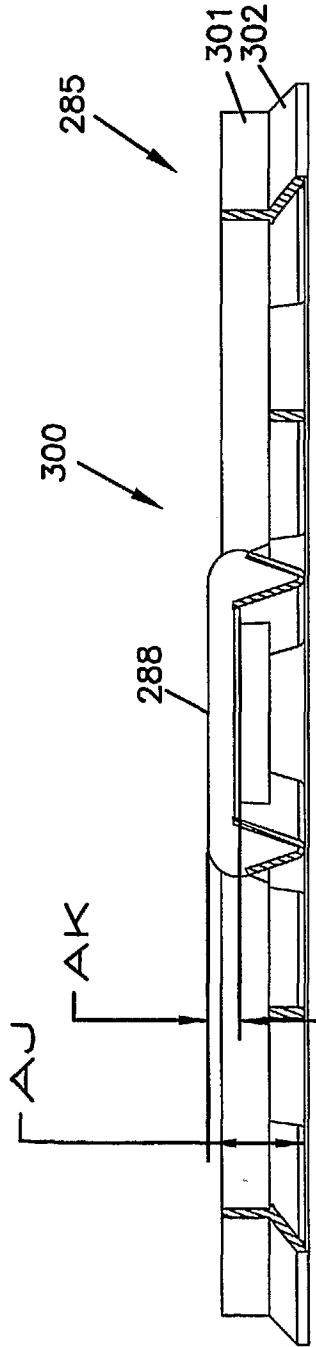


FIG. 16

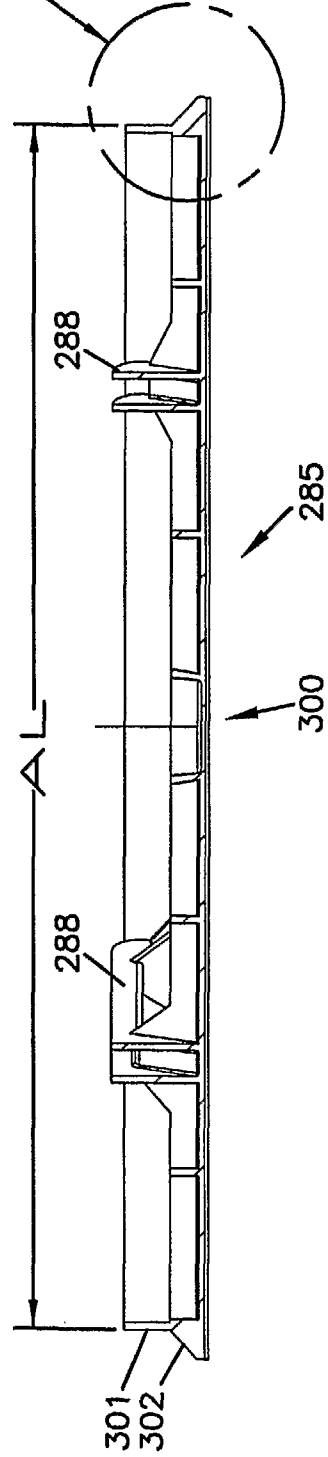


FIG.19



FIG. 17

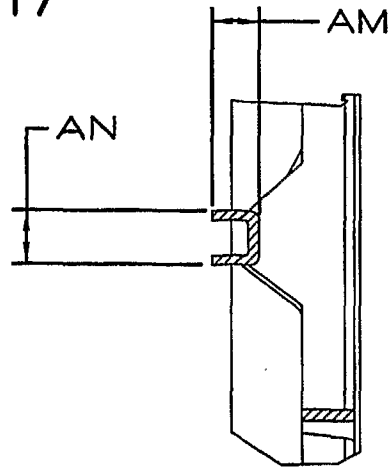


FIG. 18

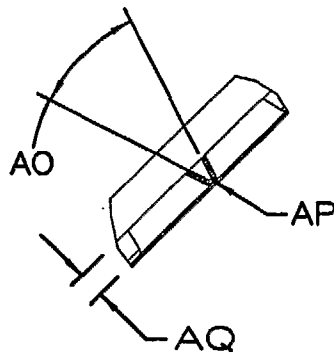
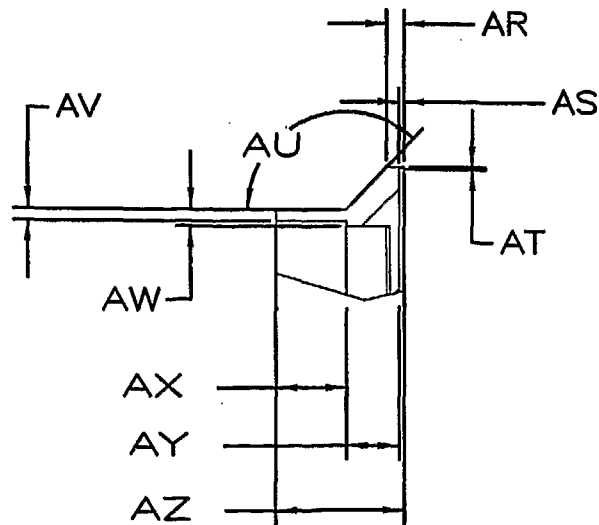


FIG. 19



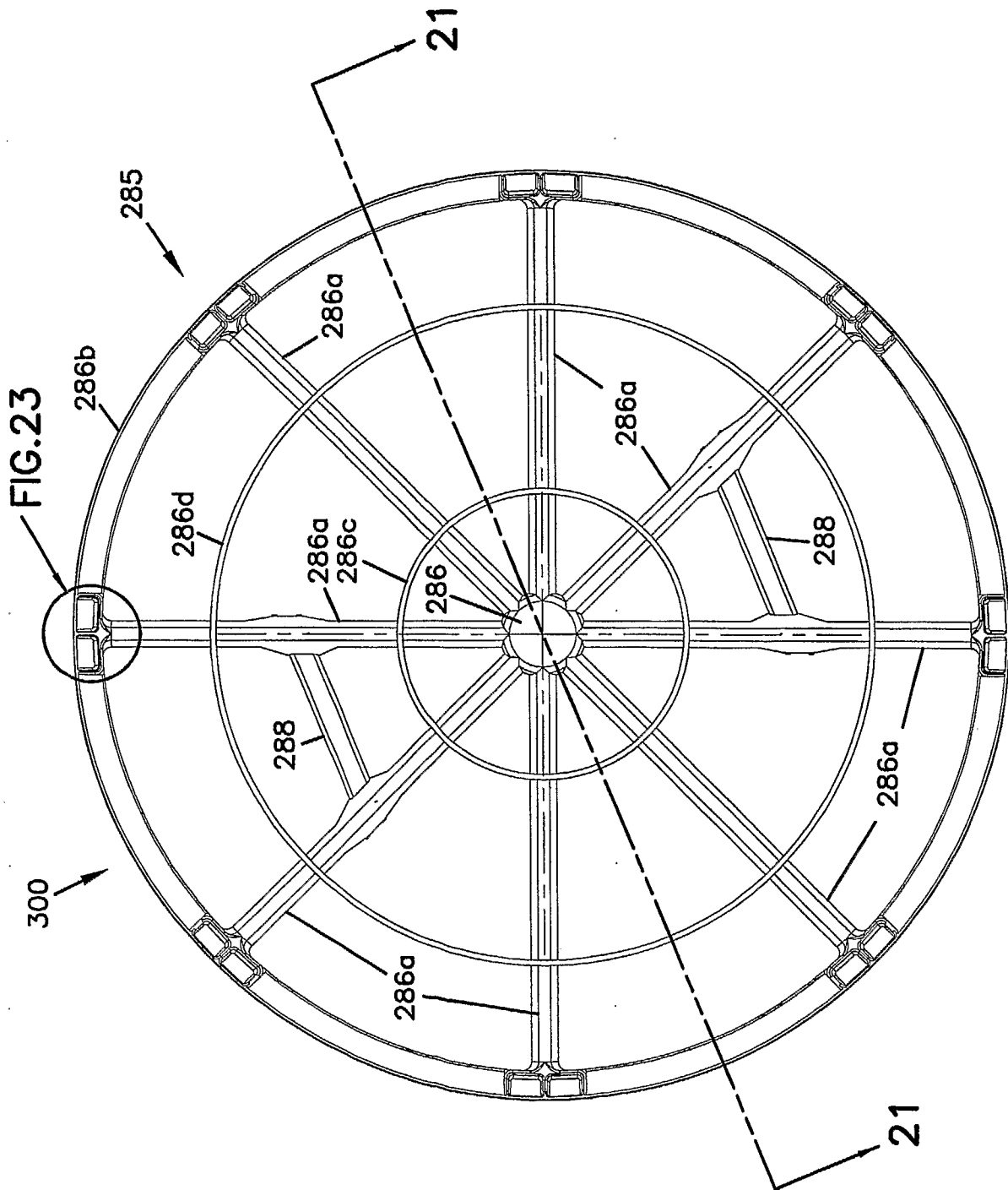
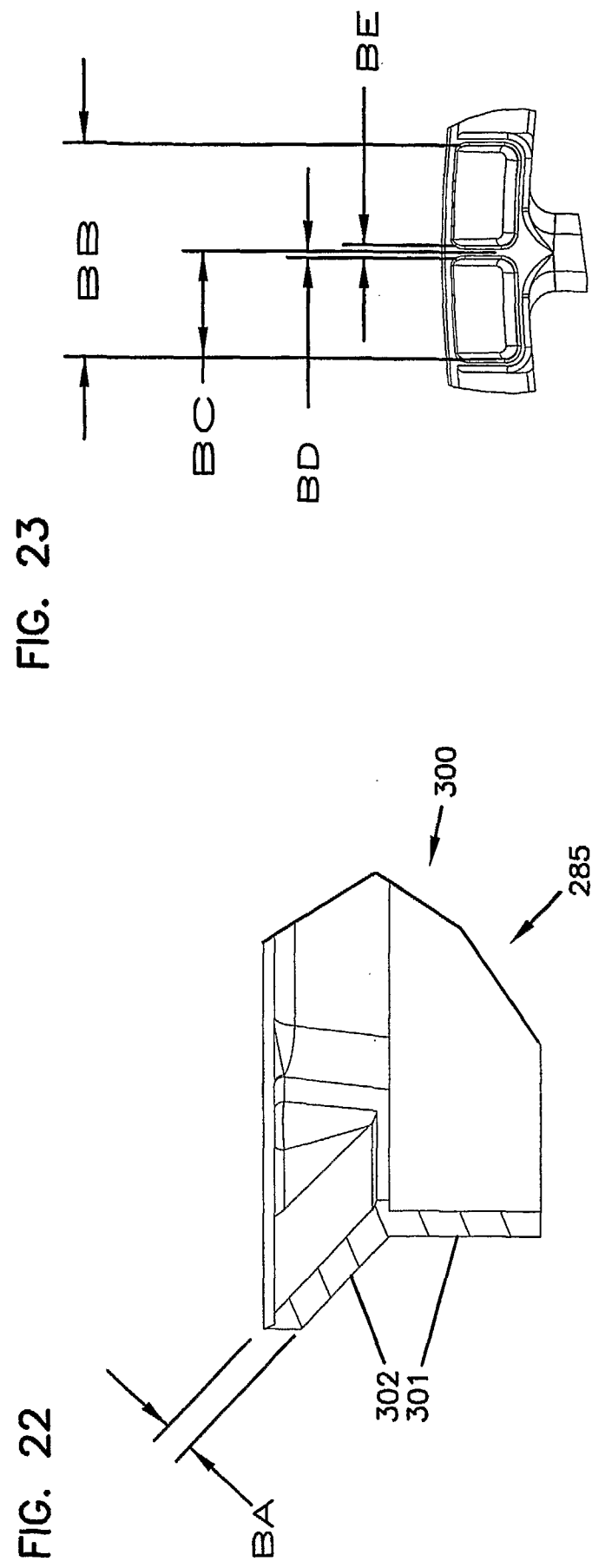
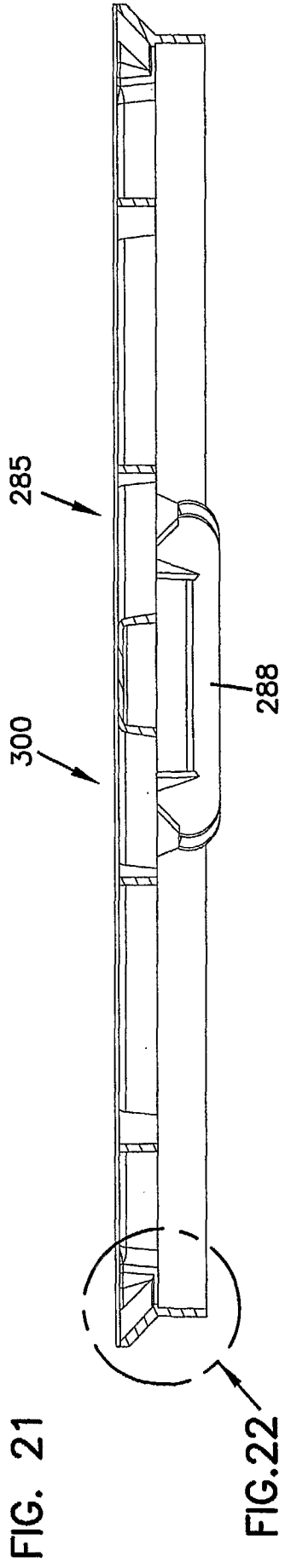


FIG. 23

FIG. 20



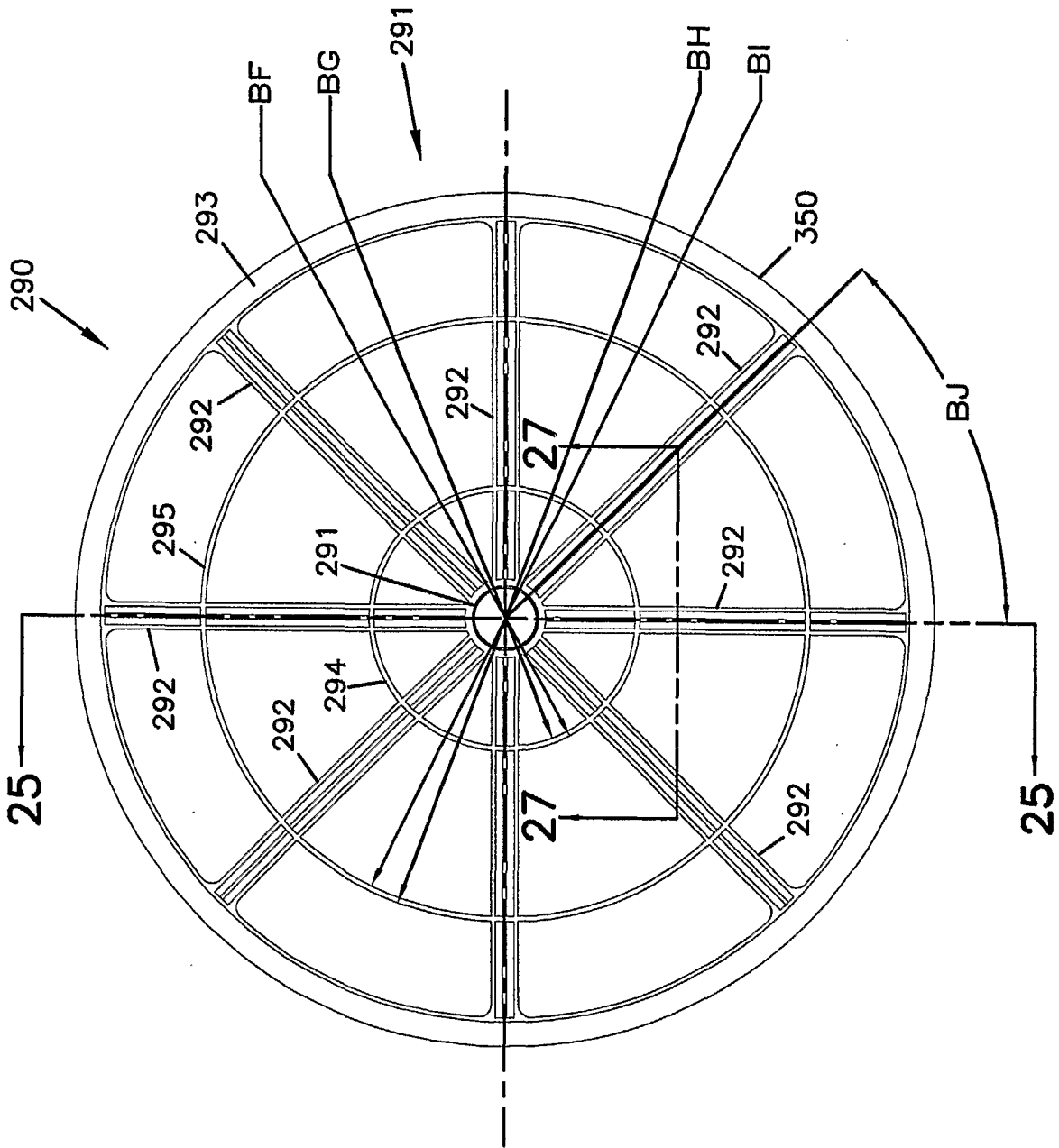


FIG. 24

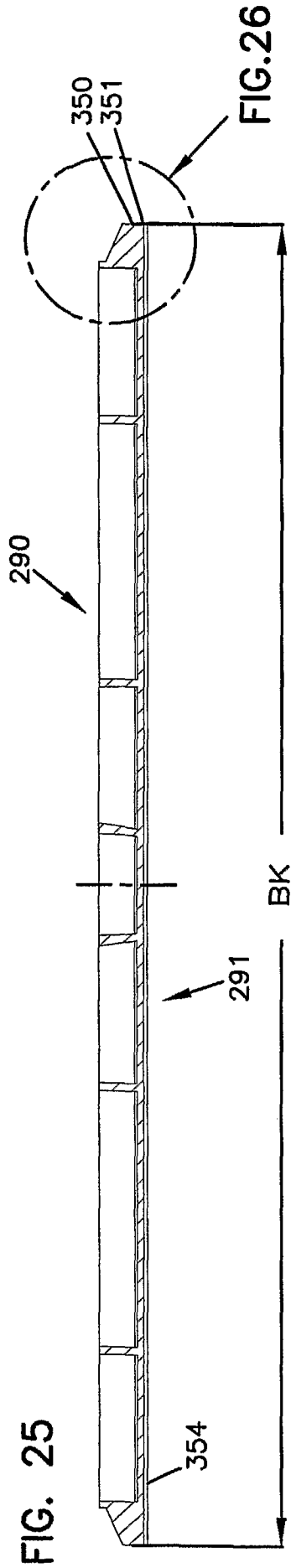


FIG. 26

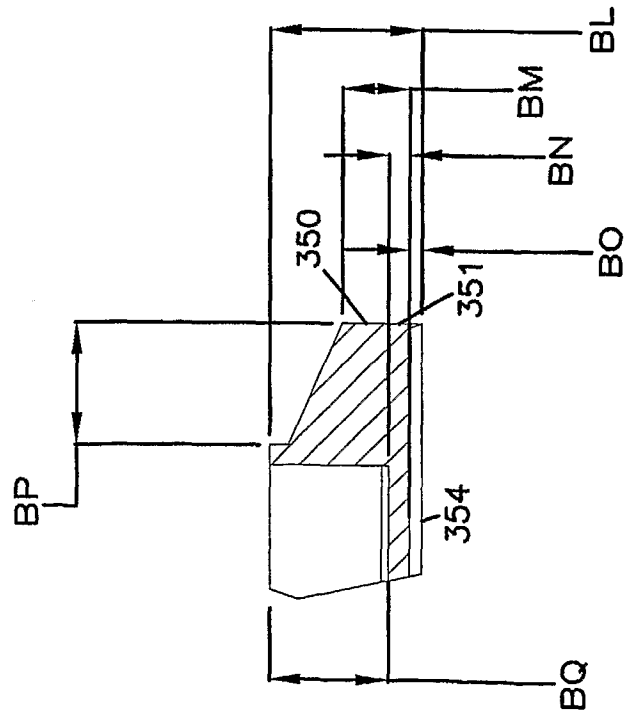
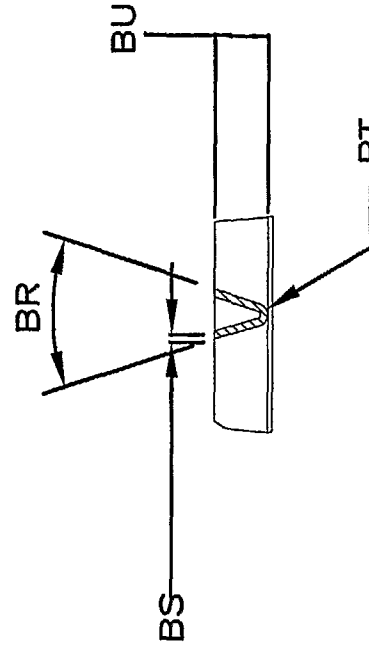


FIG. 27



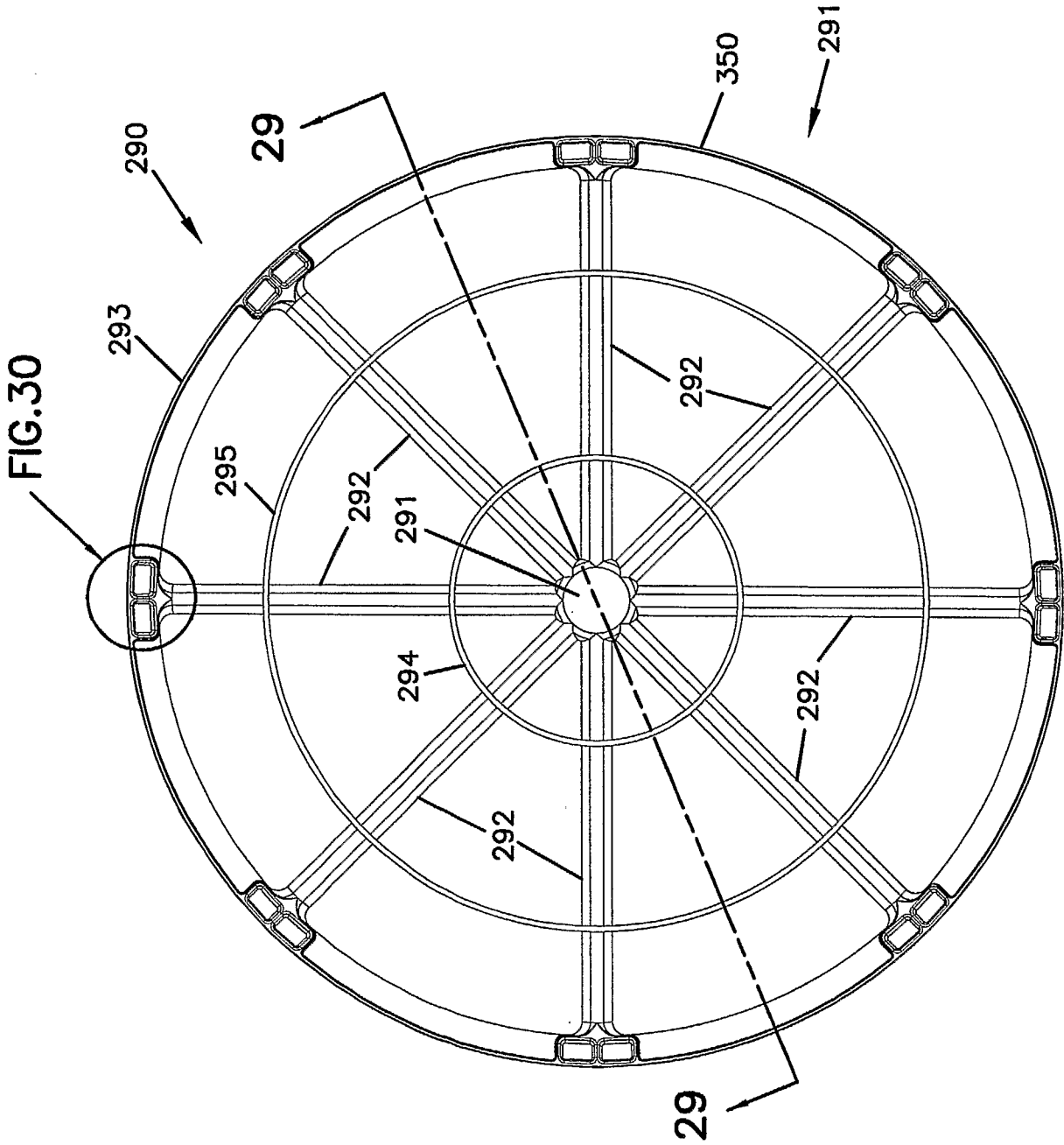


FIG. 28

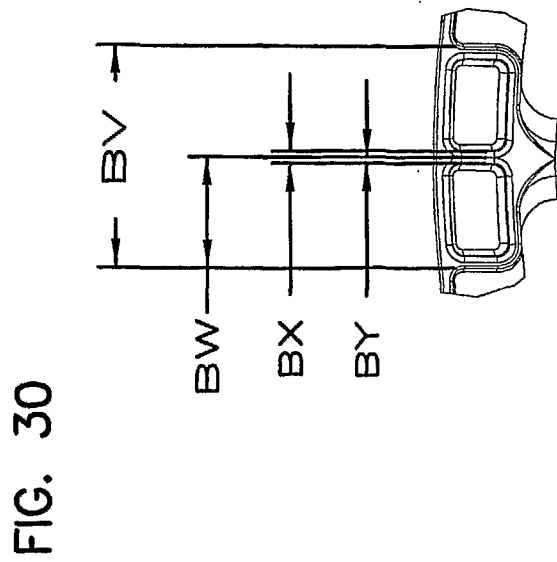
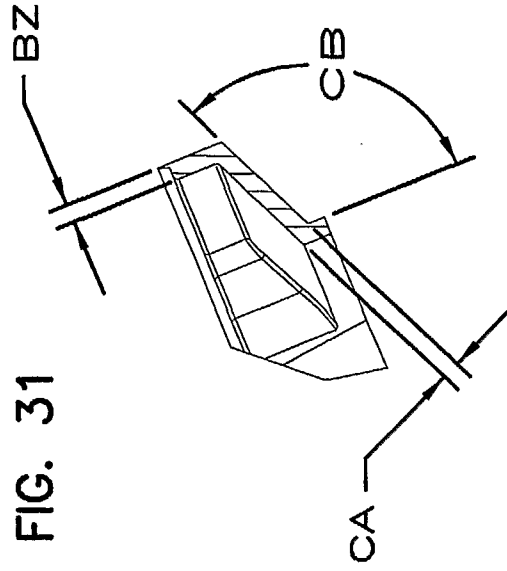
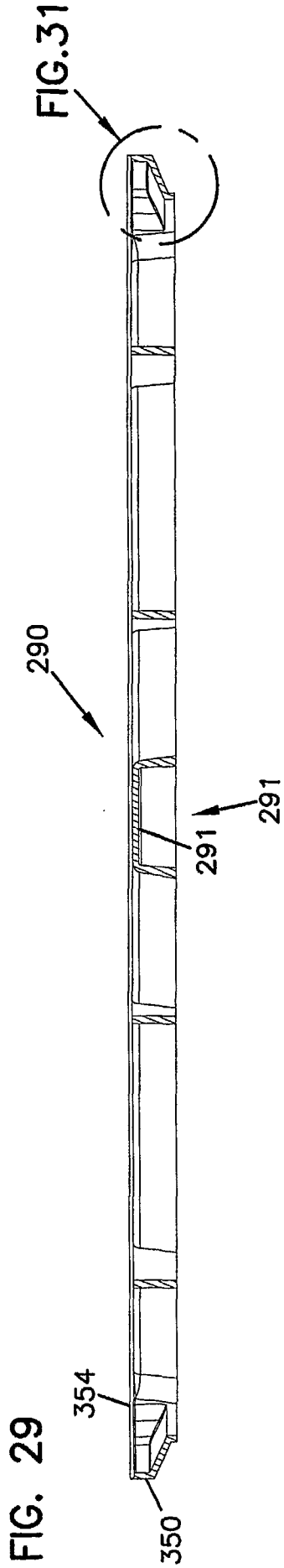


FIG. 29

FIG. 30

FIG. 31

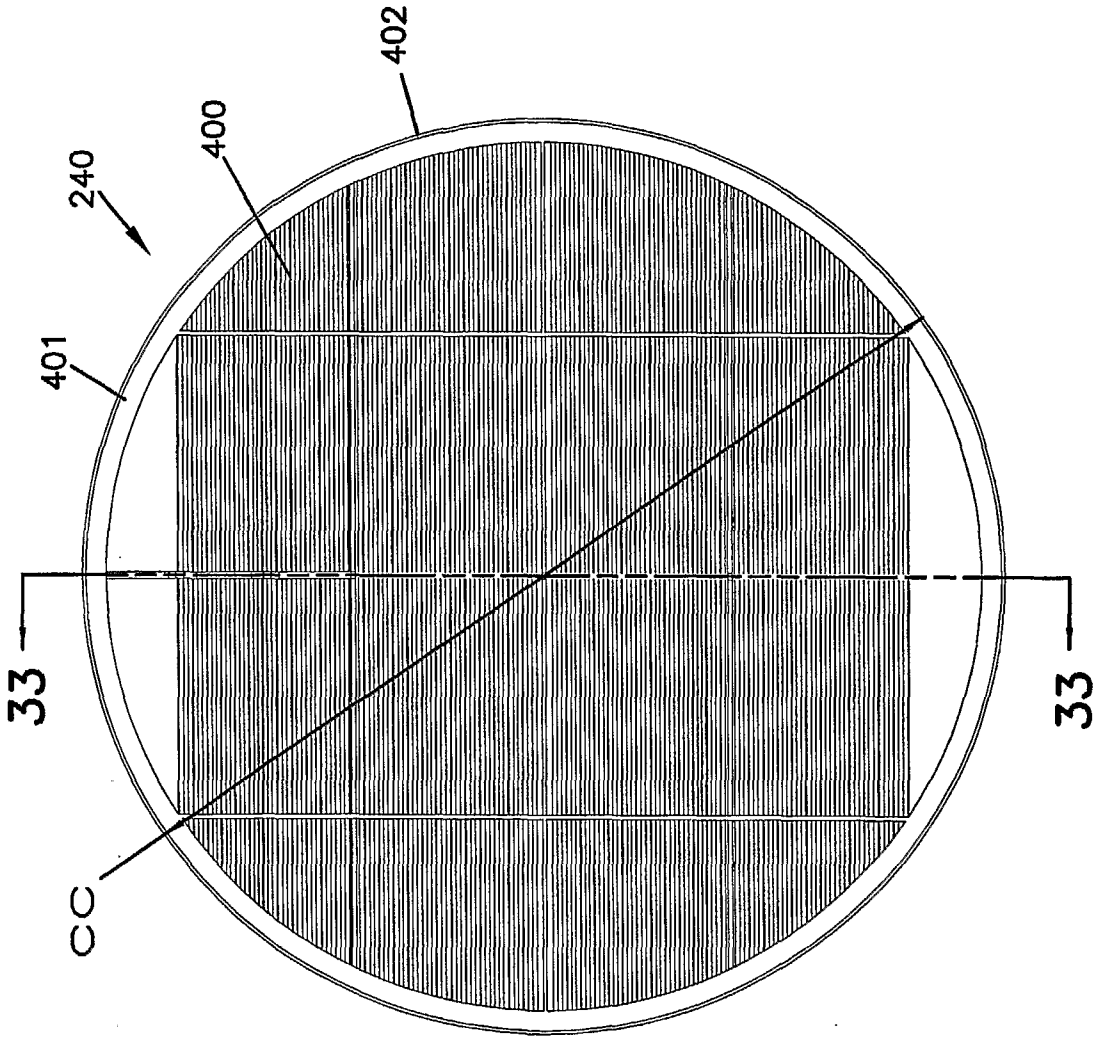


FIG. 32



FIG. 33

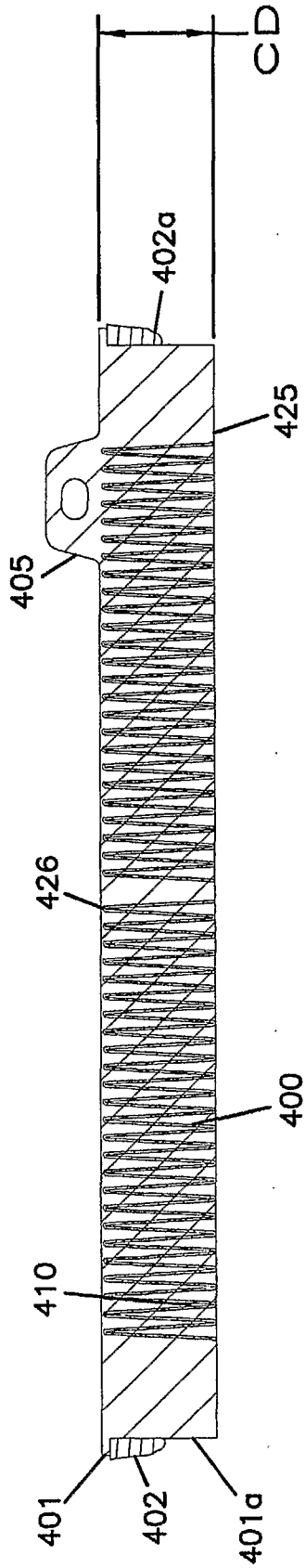


FIG. 34

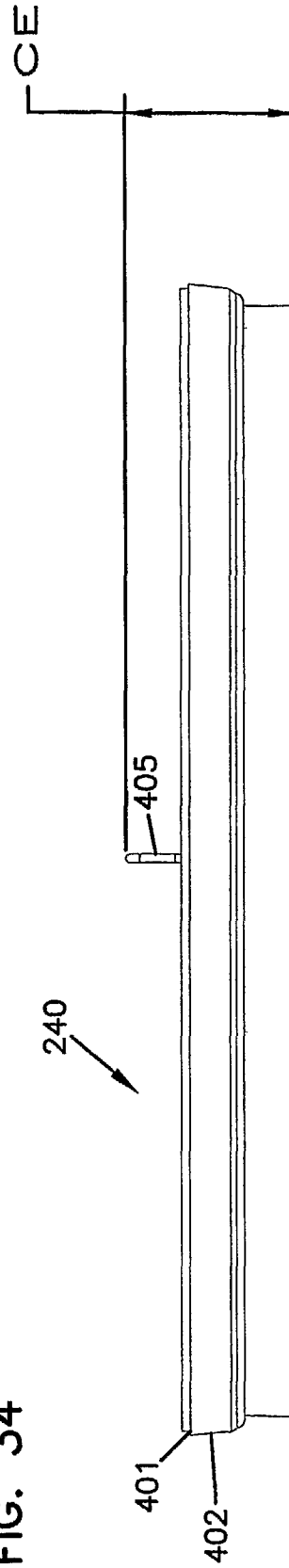


FIG.35

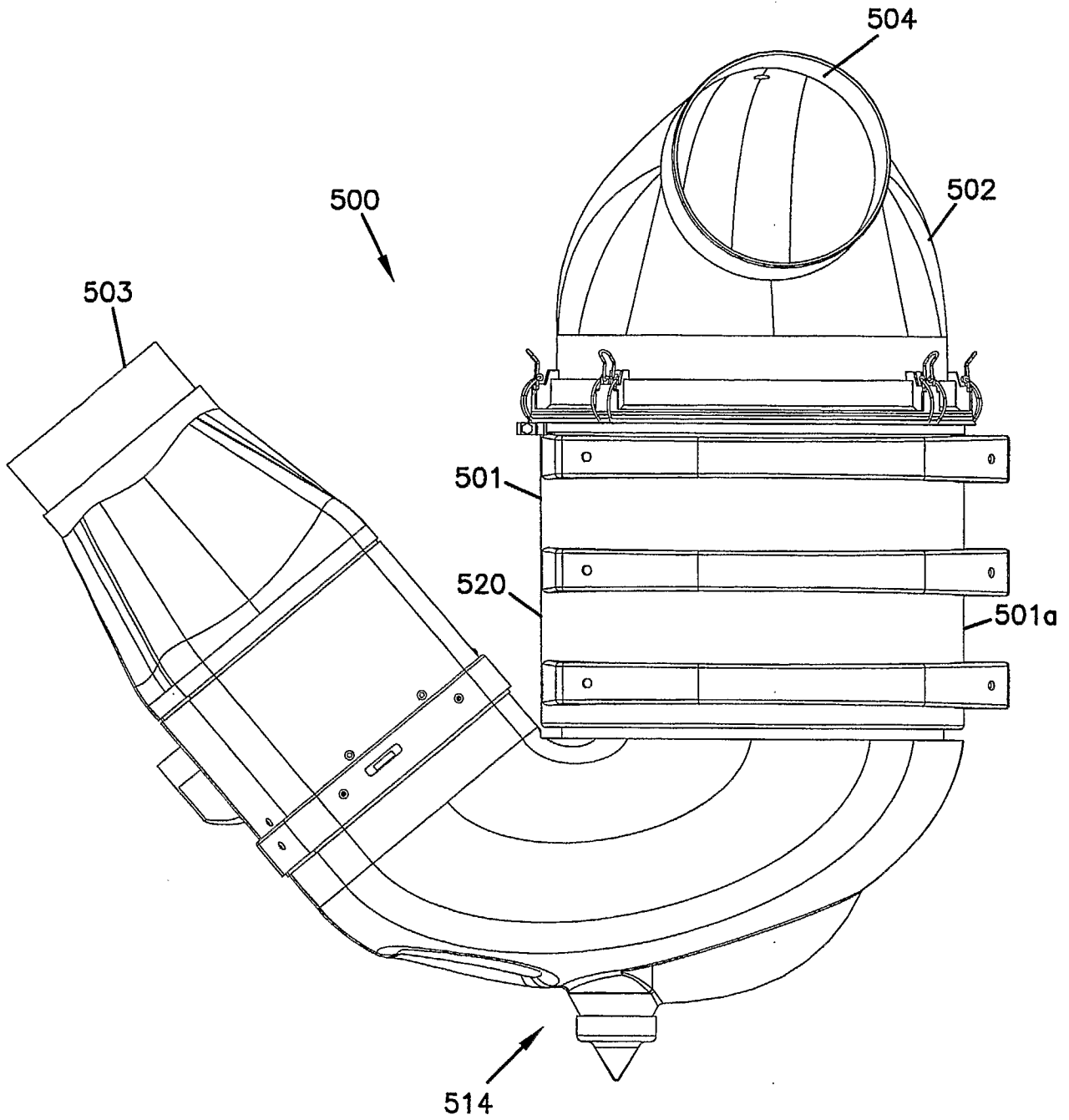
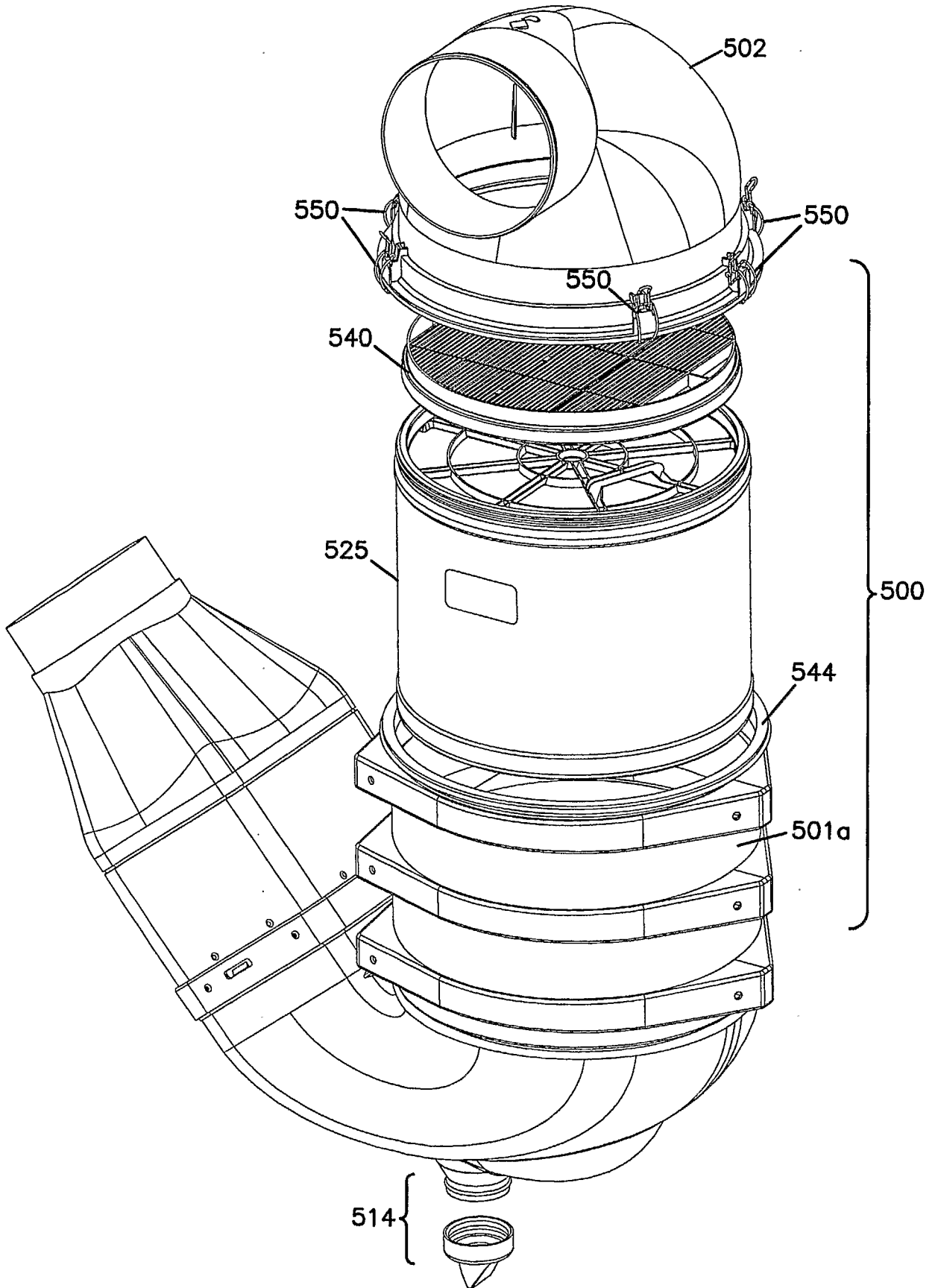


FIG.36



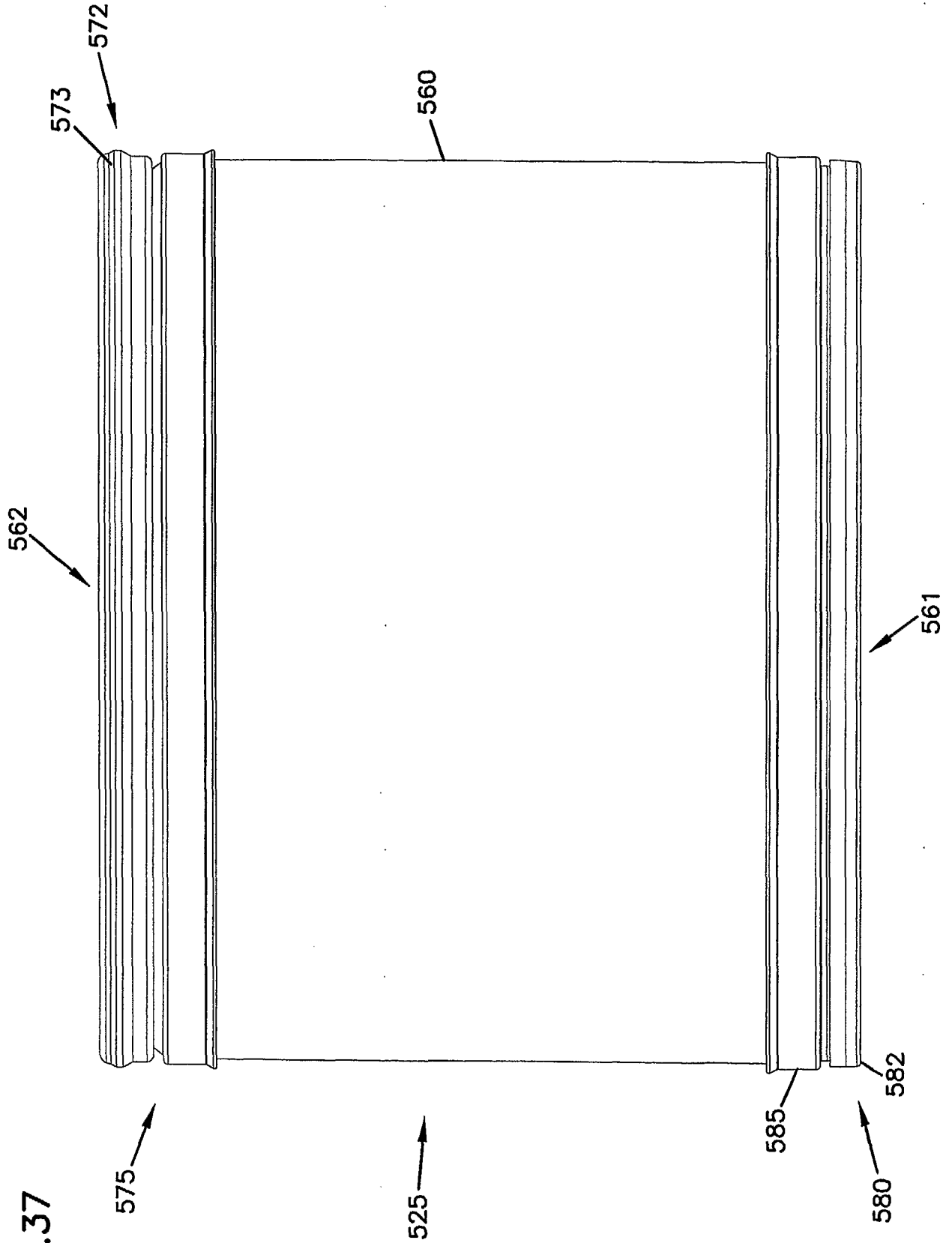


FIG.37

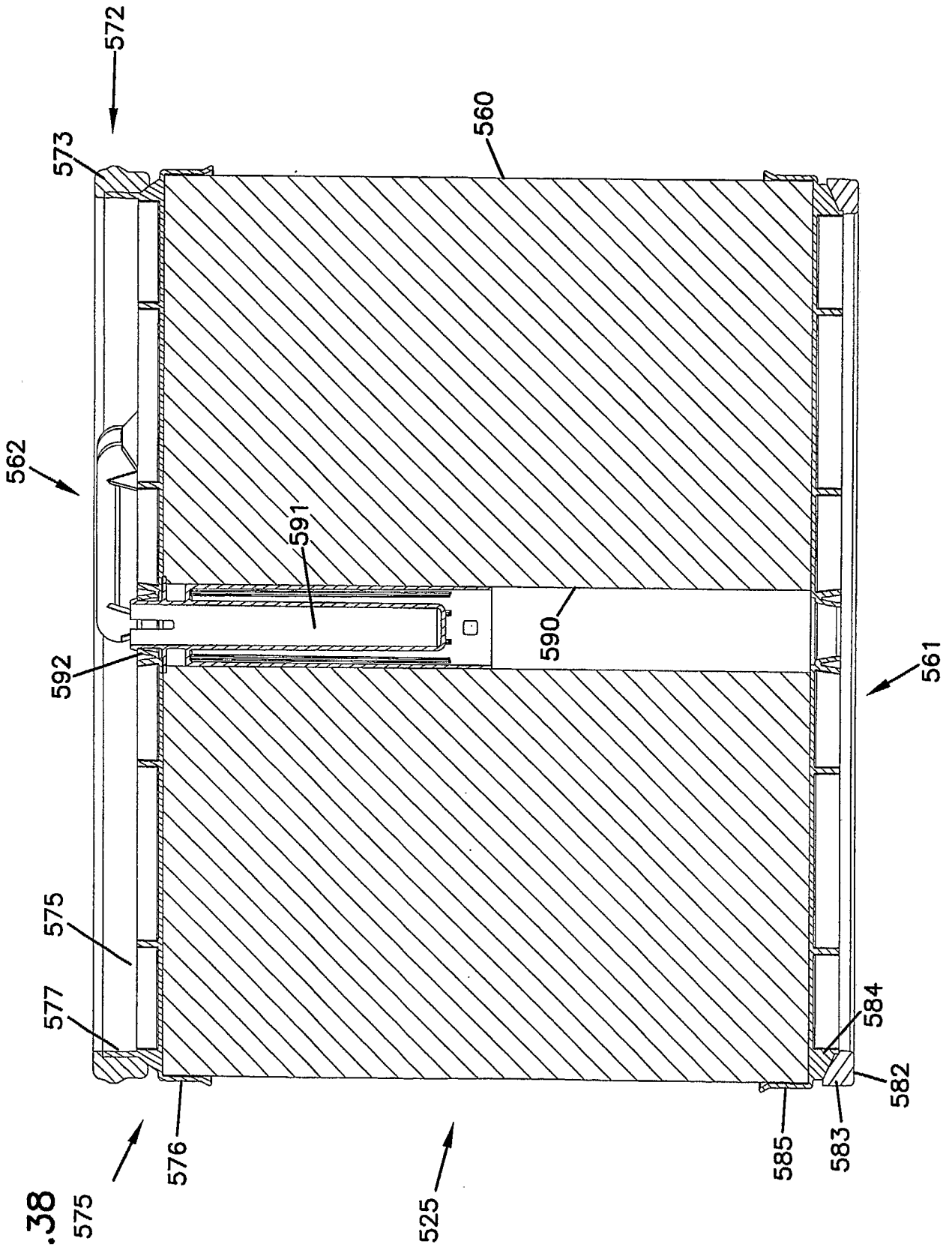


FIG.38  
575

FIG.39

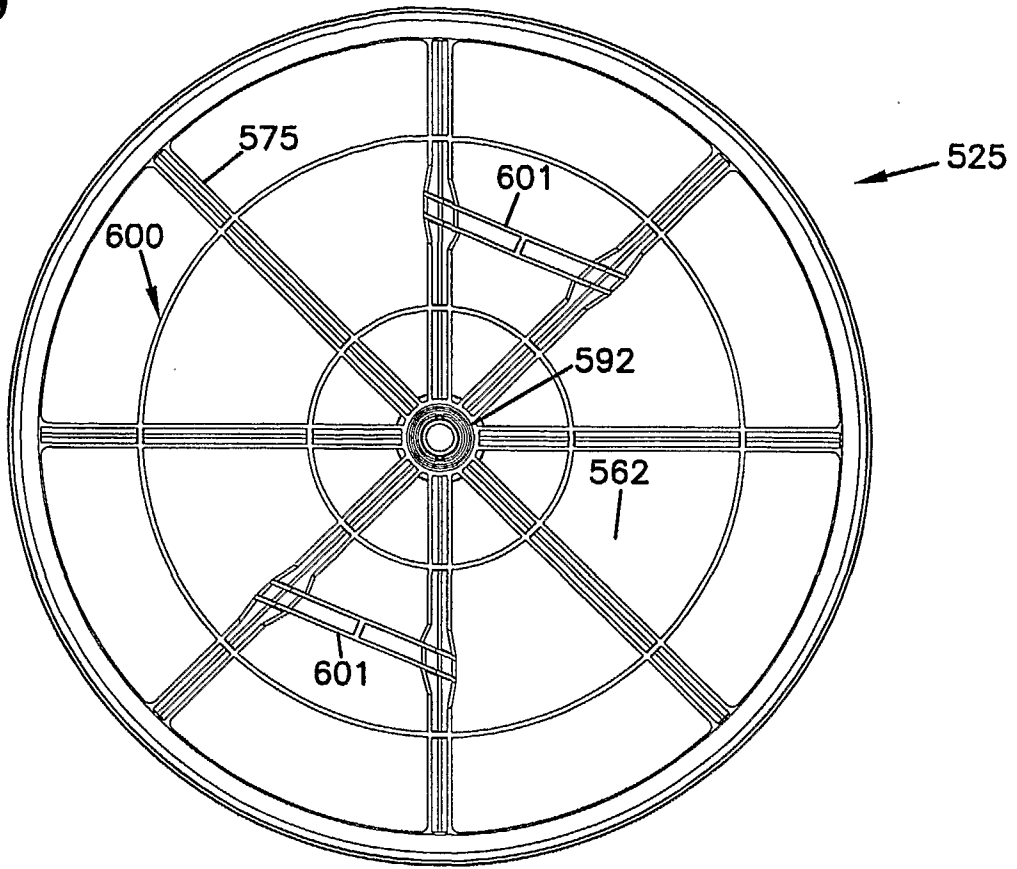


FIG.40

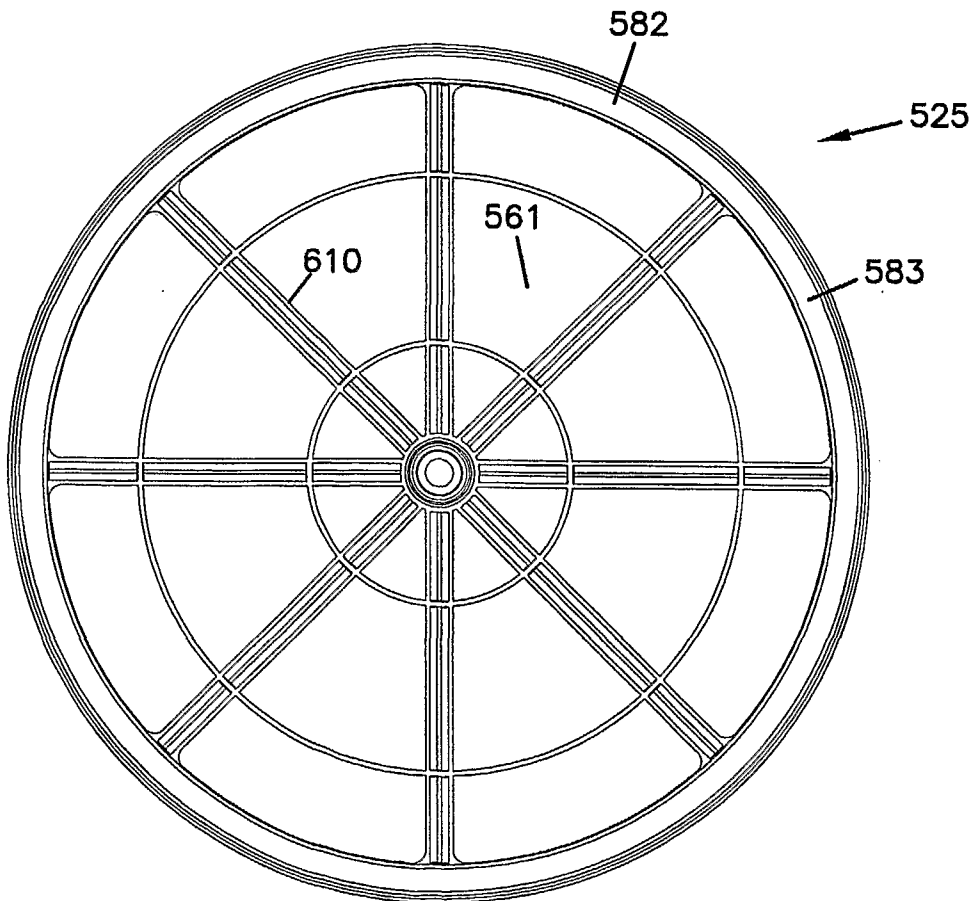
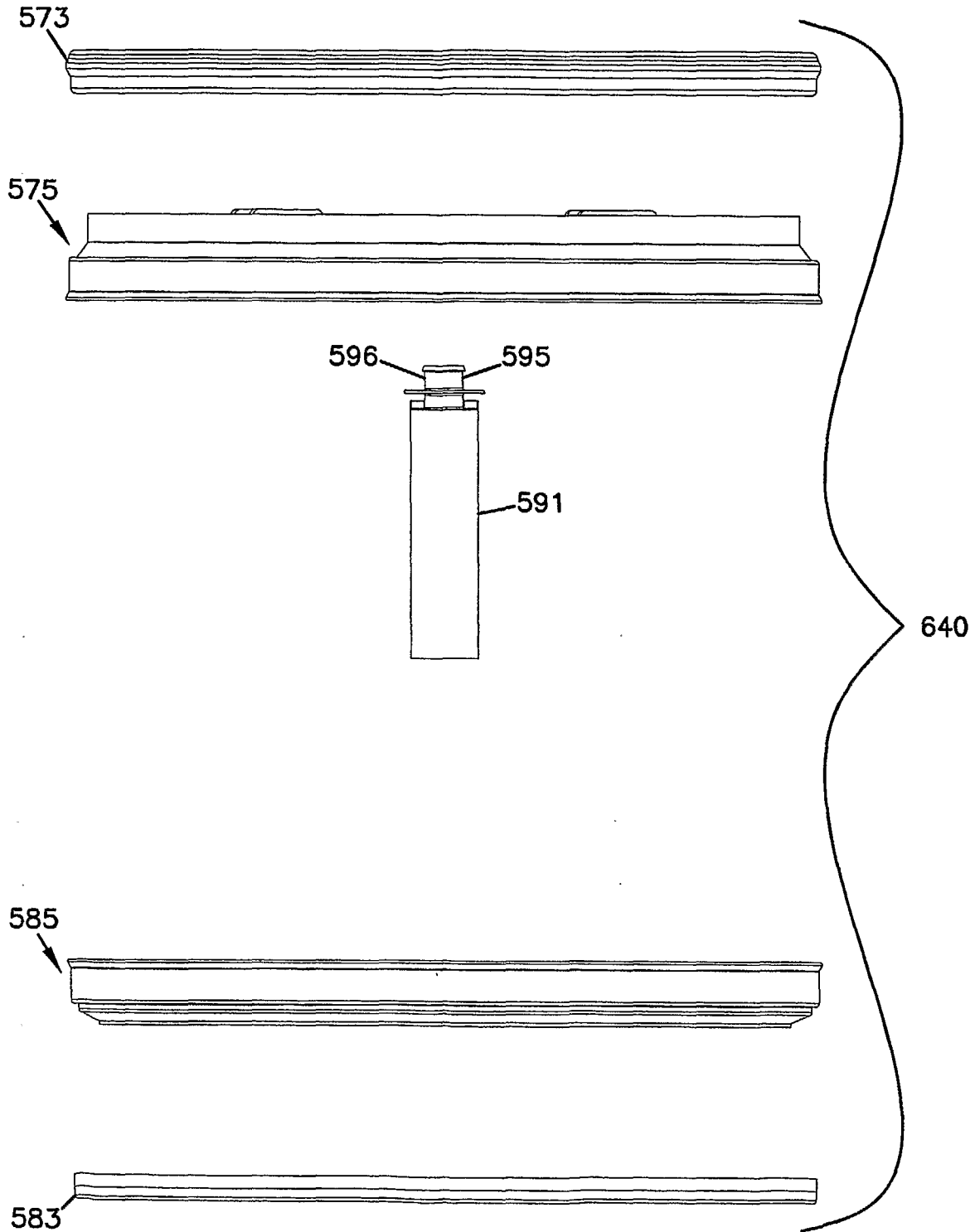


FIG.41



**INTERNATIONAL SEARCH REPORT**

International application No  
PCT/US2006/027200

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. B01D46/52 F02M35/024

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)  
B01D F02M

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 practical, 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	WO 00/50152 A (DONALDSON CO INC [US]) 31 August 2000 (2000-08-31) page 7, line 29 - page 8, line 24 page 32, lines 4-13 figures 3,7	1-3,12, 14-24
A	US 2005/022669 A1 (XU JIAN [US] ET AL) 3 February 2005 (2005-02-03) figures 1,5 paragraphs [0018], [0028] - [0030]	1,23
A	US 6 190 432 B1 (GIESEKE STEVEN SCOTT [US] ET AL) 20 February 2001 (2001-02-20) figure 9	1,23
	----- -/--	

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "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

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "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

28 November 2006

11/12/2006

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Hoffmann, Alexander



## INTERNATIONAL SEARCH REPORT

International application No

PCT/US2006/027200

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 690 712 A (ENGEL DONALD FRANCIS [US]) 25 November 1997 (1997-11-25) figures 3,5 column 7, lines 19-39 column 8, lines 13-26	1,23
A	US 2004/216434 A1 (GUNDERSON LARRY T [US] ET AL) 4 November 2004 (2004-11-04) paragraph [0020]; figures 2,7	1,23

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/US2006/027200
---

Patent document cited in search report	Publication date	Publication date	Patent family member(s)	Publication date
WO 0050152	A	31-08-2000	AU 3705300 A	14-09-2000
			US 6179890 B1	30-01-2001
			US 2001003893 A1	21-06-2001
US 2005022669	A1	03-02-2005	NONE	
US 6190432	B1	20-02-2001	US 6350291 B1	26-02-2002
			ZA 200106519 A	23-08-2002
US 5690712	A	25-11-1997	AU 696053 B2	27-08-1998
			AU 4105196 A	17-06-1996
			BR 9509763 A	07-07-1998
			CA 2206268 A1	30-05-1996
			CN 1174516 A	25-02-1998
			DE 29521599 U1	27-11-1997
			DE 69509786 D1	24-06-1999
			DE 69509786 T2	16-09-1999
			EP 0793525 A1	10-09-1997
			ES 2133830 T3	16-09-1999
			JP 2001515395 T	18-09-2001
			WO 9615841 A1	30-05-1996
			US 5613992 A	25-03-1997
US 2004216434	A1	04-11-2004	DE 102004020970 A1	18-11-2004
			GB 2401805 A	24-11-2004