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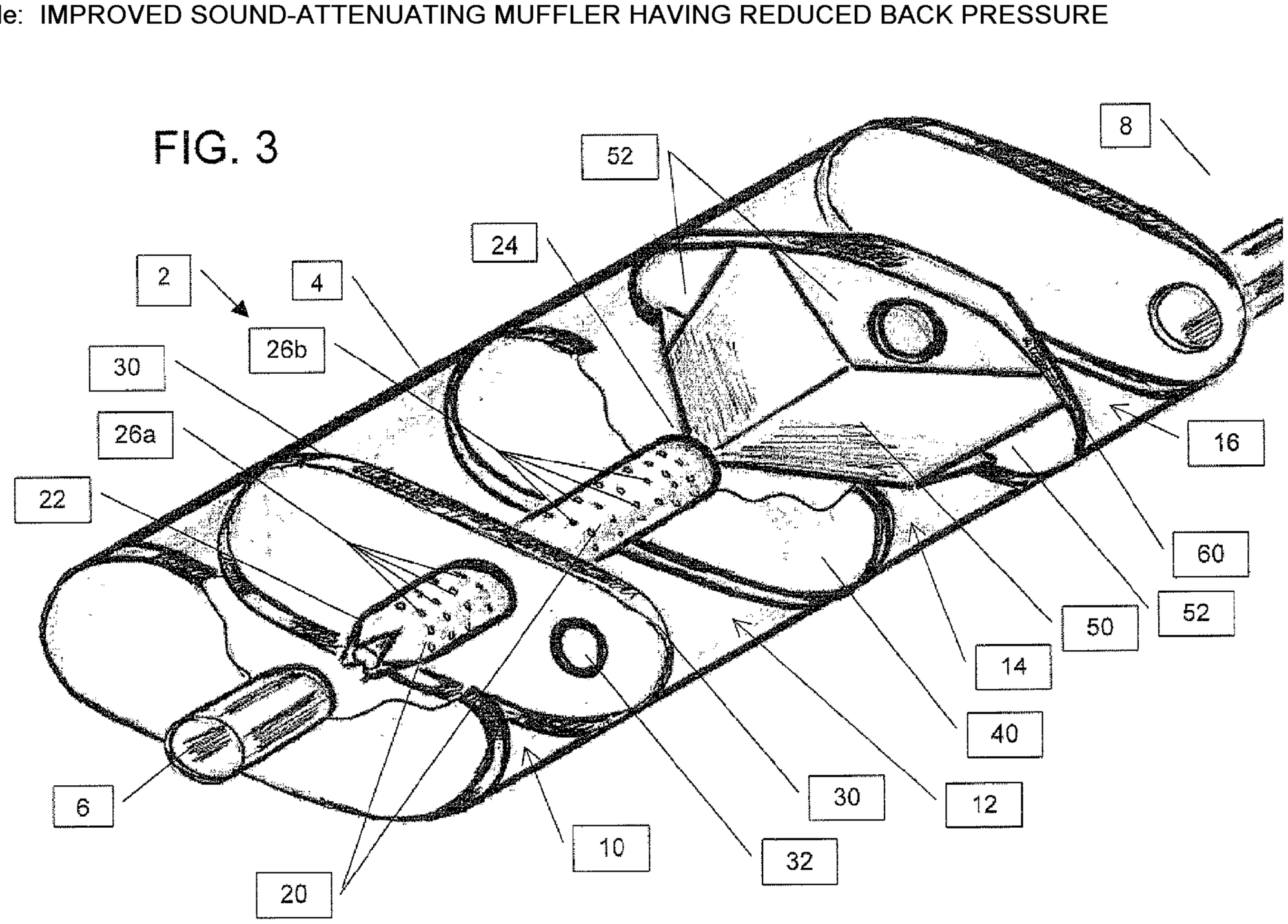
FIG. 3



(57) Abrégé/Abstract:
The present invention relates to an improvement muffler that includes an improved inlet configuration having first and second sequential chambers with a perforated central pipe passing longitudinally through a central region of both chambers for directing the exhaust gases into the third chamber in which the deflection element is deployed. Additionally, the partition separating the first and second chamber has a hole that enables some of the gas to pass from the first chamber into the second chamber not through the central pipe.

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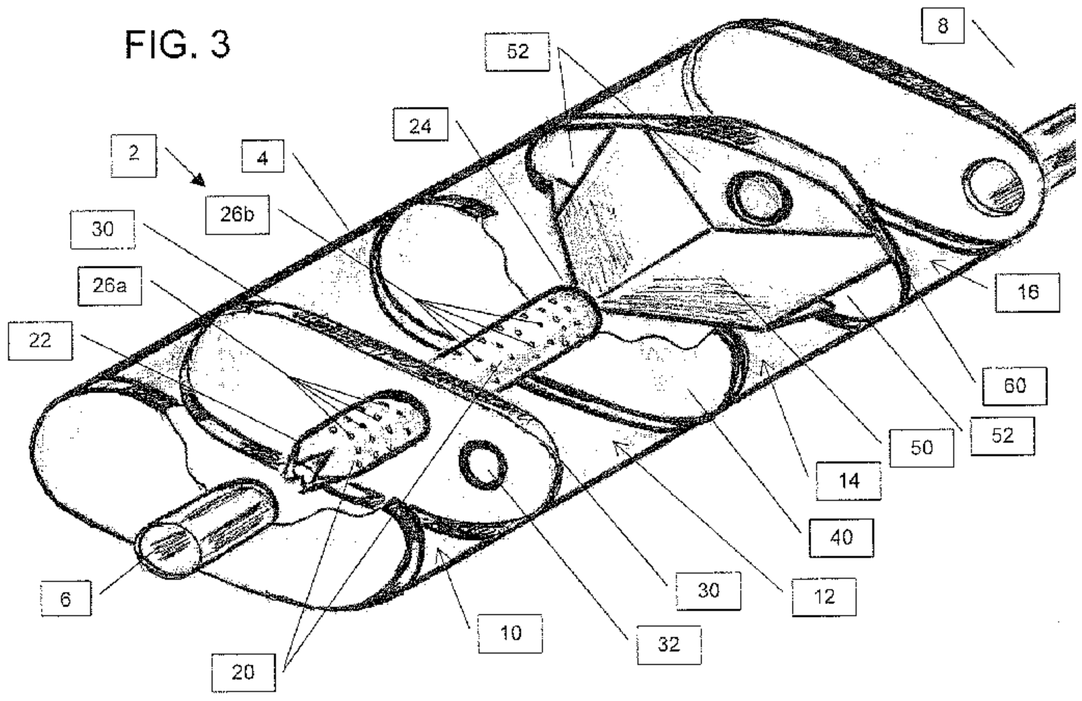
(54) Title: IMPROVED SOUND-ATTENUATING MUFFLER HAVING REDUCED BACK PRESSURE

FIG. 3



(57) Abstract: The present invention relates to an improvement muffler that includes an improved inlet configuration having first and second sequential chambers with a perforated central pipe passing longitudinally through a central region of both chambers for directing the exhaust gases into the third chamber in which the deflection element is deployed. Additionally, the partition separating the first and second chamber has a hole that enables some of the gas to pass from the first chamber into the second chamber not through the central pipe.

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Title: Improved Sound-Attenuating Muffler Having Reduced Back Pressure

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to sound-attenuating mufflers for internal combustion engines and, more particularly, to sound-attenuating mufflers generating reduced back pressure.

Numerous muffler constructions have been proposed for the attenuation of the sound component of an exhaust gas stream from an internal combustion engine. The present invention is an improvement to the low back-pressure sound-attenuating mufflers of U.S. Patent Nos. 6,286,623 and 6,776,257 to the present inventor and incorporated herein by reference.

The low back-pressure sound-attenuating mufflers of U.S. Patent Nos. 6,286,623 and 6,776,257 are well suited for sports cars.

There is therefore a need for a low back-pressure sound-attenuating muffler having a lower decibel output than the previous mufflers so as to be usable on regular passenger vehicles.

SUMMARY OF THE INVENTION

The present invention is a low back-pressure sound-attenuating muffler having a lower decibel output than the previous mufflers so as to be usable on regular passenger vehicles.

According to the teachings of the present invention there is provided, a muffler for an internal combustion engine comprising: (a) a housing having an inlet end with an inlet opening formed for a flow of exhaust gases into the housing and an outlet end with an outlet opening formed for a discharge of exhaust gases from the housing; (b) a first chamber and a second chamber sequentially arranged within the housing; (c) a perforated pipe passing longitudinally through a central region of both the first and the second chambers such that the perforated pipe extends partially into the first chamber, extends a full length of the second chamber; wherein the perforations allow the exhaust gases to enter the perforated pipe so as to be directed through an interior of the perforated pipe and into the third chamber and a partition separating the first and the second chambers includes a hole that enables some of the exhaust gases to pass from the first chamber into the second chamber without passing through the central perforated pipe.

According to a further teaching of the present invention, the perforated pipe ~~has a diameter that is 105%-110% of the diameter of the inlet opening.~~

According to a further teaching of the present invention, an upstream end of the perforated pipe is partially sealed.

According to a further teaching of the present invention, an upstream end of the perforated pipe is 60%-80% open.

According to a further teaching of the present invention, perforations in the perforated pipe extending partially into the first chamber cover 25%-35% of the surface of the perforated pipe and, perforations in the perforated pipe extending the

full length of the second chamber cover 60%-75% of the surface of the perforated pipe.

According to a further teaching of the present invention, there is also provided: (d) a third chamber containing a deflection element, the perforated pipe extending so as to open at its downstream end into a third chamber, thereby directing the exhaust gases toward the deflection element; and (e) a fourth chamber configured to channel the flow of gas to the outlet opening.

According to a further teaching of the present invention, the deflection element is a hollow pyramid having interior surfaces and exterior surfaces joining at a first end to form a pyramidal apex, the pyramidal apex pointing toward the inlet end of the muffler and extending at a second end to form an open base interconnected to a partition separating the third and the fourth cambers.

According to a further teaching of the present invention, the deflection element is a dome-shaped partition having an exterior surface, a first end of the exterior surface pointing toward the inlet end of the muffler, and widening out at a second end to form a base interconnected to a partition separating the third and the fourth cambers.

There is also provided according to the teachings of the present invention, a muffler for an internal combustion engine comprising: (a) a housing having an inlet end with an inlet opening formed for a flow of exhaust gases into the housing and an outlet end with an outlet opening formed for a discharge of exhaust gases from the housing; (b) at least a first chamber, an intermediate and a last chamber sequentially arranged within the housing, the intermediate chamber containing a

deflection element chosen from a group including: (i) a hollow pyramid; and (ii) a dome-shaped partition; (c) a pipe passing longitudinally through the first chamber so as to open at its downstream end into the intermediate chamber, thereby directing the exhaust gases toward the deflection element; and (d) a perforated pipe extending through the last chamber, the perforated pipe having an upstream opening into the intermediate chamber and configured to channel the exhaust gas to the outlet opening.

According to a further teaching of the present invention, the pipe passes longitudinally through an axially central region of the first chamber.

According to a further teaching of the present invention, a partition separating the first and the intermediate chambers includes a hole that enables some of the exhaust gases to pass freely between the first chamber and the intermediate chamber.

According to a further teaching of the present invention, the first chamber extends between 10%-85% of the total length of the housing.

According to a further teaching of the present invention, the last chamber extends between 5%-80% of the total length of the housing.

According to a further teaching of the present invention, there is also provided a sound-attenuating material deployed in at least one of the first chamber, the intermediate chamber and the last chamber.

According to a further teaching of the present invention, the sound-attenuating material is configured from at least one chosen from the group that includes mineral fibers and synthetic fibers.

According to a further teaching of the present invention, the hollow pyramid deflection element has interior surfaces and exterior surfaces joining at a first end to form a pyramidal apex, the pyramidal apex pointing toward the inlet end of the muffler and extending at a second end to form an open base interconnected to a partition separating the intermediate and the last cambers.

According to a further teaching of the present invention, the dome-shaped partition deflection element has an exterior surface, a first end of the exterior surface pointing toward the inlet end of the muffler, and widening out at a second end to form an open base interconnected to a partition separating the intermediate and the third cambers.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 is a perspective, cut open view of the muffler of U.S. Patent No. 6,286,623;

FIG. 2 is a perspective, cut-open view of the muffler of U.S. Patent No. 6,776,257;

FIG. 3 is a perspective, cut-open view of a first preferred embodiment of a muffler constructed and operational according to the teachings of the present invention;

FIG. 4 is a perspective, cut-open view showing the flow path of exhaust gases through the embodiment of FIG. 3;

FIG. 5 is a perspective, cut-open view of a second preferred embodiment of a muffler constructed and operational according to the teachings of the present invention;

FIG. 6 is a perspective, cut-open view showing the flow path of exhaust gases through the embodiment of FIG. 5;

FIG. 7 is a perspective, cut open view of a third preferred embodiment of a muffler constructed and operational according to the teachings of the present invention having a pyramidal deflection element; and

FIG. 8 is a perspective, cut-open view of a fourth preferred embodiment of a muffler constructed and operational according to the teachings of the present invention having a dome-shaped deflection element.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a low back-pressure sound-attenuating muffler having a lower decibel output than the previous mufflers so as to be usable on regular passenger vehicles.

The principles and operation of low back-pressure sound-attenuating muffler according to the present invention may be better understood with reference to the drawings and the accompanying description.

By way of introduction reference is made to the prior art low back-pressure sound-attenuating mufflers of U.S. Patent Nos. 6,286,623 and 6,776,257 to the present inventor and incorporated herein by reference.

It should be noted that as used herein, references to sequence such as first, intermediate and last refer to the relationship of elements in the drawings and are not intended to limit the scope of the present invention.

Figure 1 shows a cut open view of the muffler **200** of U.S. Patent No. 6,286,623. The muffler **200** consists of an elongated housing **202** having an inlet **206** for introducing the exhaust gases, an outlet **208** for discharging the exhaust gases, a pyramidal partition **250** and converging partitions **240** and **260**.

The exhaust gases from the internal combustion engine are introduced into the muffler **200** through the inlet **206**. The exhaust gases enter the housing **202** and flow longitudinally through the length of muffler **200** passing first through chamber **212**. The exhaust gases exit chamber **212** through an opening in partition **240**. Partition **240** is shaped like a funnel (or truncated pyramid), disposed such that the opening in the partition **240** centers the flow of exhaust gases within housing **202**. The flow exhaust gases then enters the second chamber **214** and encounters the apex **230** of pyramidal partition **250**, causing the flow to be deflected along the exterior faces of pyramidal partition **250** and towards the interior surface of the outer wall of housing **202**.

The exhaust gases flow through the four spaces **252** formed by the rugose base of the pyramidal partition **250**. A substantial first portion of the exhaust gases continue to flow in the direction of the outlet pipe **208**, thereby creating a low pressure region inside the pyramidal partition **250**. Consequently, a second portion of the exhaust gases changes direction and enters (is drawn into) the inside region of pyramidal partition **250** before continuing toward the outlet pipe **208**. The exhaust

gases flow through converging partition **260**, which is substantially identical in shape and in disposition to converging partition **240**. Thus, the flow of exhaust gases enters the third chamber **216** and is again centered within the housing **202** by the partition outlet **224** before being discharged through outlet pipe **208**.

Figure 2 shows a perspective, cut-open view of the muffler **300** of U.S. Patent No. 6,776,257. Muffler **300** includes an elongated housing **302** having an inlet **306** for introducing the exhaust gases, an outlet **308** for discharging the exhaust gases, a main partition **350**, and an aligning partition **340**.

The exhaust gases from the internal combustion engine are introduced through the inlet **306**. The exhaust gases enter housing **302** and flow longitudinally through the length of muffler **300** passing first through chamber **312**. The exhaust gases exit chamber **312** through an opening in partition **340**. Partition **340** is preferably shaped like a funnel (or truncated pyramid), and most importantly, is disposed such that the exhaust gas flow is centered within the housing **302** as the exhaust gases enter the second chamber **314** and the flow of exhaust gases encounters the top of domed partition **350**, causing the flow to be deflected along the exterior face of domed partition **350**.

The exhaust gases flow through openings **352** in the sides of domed partition **350** Openings **352** are preferably disposed on opposite sides of domed partition **350**.

Subsequently, the exhaust gases continue to flow in the direction of outlet pipe **308**, thereby creating a low pressure region inside domed partition **350**. Consequently, a portion of the exhaust gases change direction and enter (are drawn into) the inside of domed partition **350** before continuing in the direction of outlet

pipe **308**. The exhaust gases flow through converging partition **360**, which is advantageously similar in shape and in disposition to converging partition **340**, and enter the third chamber **316** before being discharged through outlet pipe **308**.

Generally speaking, the embodiments of U.S. Patent Nos. 6,286,623 and 6,776,257 as briefly described above include an inlet chamber, a deflection chamber in which a deflection element is deployed and an outlet chamber.

The first to preferred embodiments of the present invention relate to an improvement that may be used to benefit both of the previous muffler embodiments described above. Specifically, the present invention includes an improved inlet configuration having first and second sequential chambers with a perforated central pipe passing longitudinally through a central region of both chambers for directing the exhaust gases into the third chamber in which the deflection element is deployed. Additionally, the partition separating the first and second chamber has a hole that enables some of the gas to pass from the first chamber into the second chamber not through the central pipe.

Described below are two exemplary embodiments of the present invention. The first preferred embodiment of Figures 3 and 4 relates to a muffler combining the features of the present invention with the pyramidal partition deflection element of U.S. Patent No. 6,286,623. The second preferred embodiment of Figures 5 and 6 relates to a muffler combining the features of the present invention with the domed partition deflection element of U.S. Patent No. 6,776,257

Referring now to the drawings, Figures 3 and 4 illustrate a muffler **2** generally defined by a housing **4**. An inlet **6** is provided in the inlet end of the

muffler for introducing exhaust gases into the first chamber **10**. The improved inlet configuration has the first chamber **10** and a second chamber **12** sequentially arranged within muffler **2**. A perforated pipe **20**, with its upstream end **22** partially sealed, passing longitudinally through a central region of both the first **10** and the second **12** chambers such that perforated pipe **20** extends partially into the first chamber **10** and extends the full length of the second chamber **12**. Perforated pipe **20** extends at its downstream end **24** through partition **40** and opens into the third chamber **14**. The perforations **26a** allow the exhaust gases to enter the perforated pipe **20** from the first chamber **10**, while perforations **26b** allow the exhaust gases to enter the perforated pipe **20** from the second chamber **12**. Once the exhaust gases enter perforated pipe **20** they are directed through the interior of perforated pipe **20** and into the third chamber **14**. As illustrated here, the perforations **26** are formed over a predetermined percentage of the surface of pipe **20**.

The partition **30** separating the first and second chambers includes a preferably round hole **32** that enables some of the gas to pass from the first chamber **10** into the second chamber **12** without passing through the central perforated pipe **20**. Exhaust gases that enter the second chamber **12** then pass through the perforations **26** in the section of perforated pipe **20** deployed in second chamber **12**. It will be appreciated that hole **32** may be of substantially any suitable size and shape.

With this basic understanding of the general structure of the first two chambers of the muffler, it will be appreciated that inlet **6** is configured for attachment to the exhaust pipe of the vehicle on which the muffler is deployed and

therefore may vary in diameter depending on the specifications of the of the vehicle manufacturer. It will be appreciated that inlet **6** may be configured as more that one inlet pipe. It will be readily understood that in such an embodiment, the percentages listed herebelow are applied to the combined size of all inlet pipes. Similarly, the outlet pipe **8** may be configured as more that one outlet pipe and the percentages listed herebelow are applied to the combined size of all outlet pipes.

In order for the muffler of the present invention to perform at an optimum level, perforated pipe **20** has a diameter that is 100%-130% of the diameter of inlet pipe **6**. It will be appreciated that perforated pipe **20** may be implemented as more than one perforated pipe as long as the ratio of 100%-130% of the diameter of inlet pipe **6** is maintained. The upstream end **22** of the perforated pipe **20** is partially sealed so as to be 60%-80% open. The perforation holes in the perforated pipe **20** may range from 15mm-55mm in diameter. Perforations **26a** cover between 20%-40% of the surface of perforated pipe **20**, while perforations **26b** cover 50%-90% of the surface of perforated pipe **20**. Hole **32** configured in partition **30** has a diameter that is 60%-80% of the diameter of perforated pipe **20**. It will be appreciated that hole **32** may be implemented as a plurality of holes configured in partition **30**, however, the combined size of the opening still falls within the range of 60%-80% of the diameter of perforated pipe **20**. Further, embodiments in which the second chamber **12** is subdivided into a number of chambers through which perforated pipe **20** passes are within the scope of the present invention. It should be noted that these specifications apply to the embodiment of the present invention described bellow

with regard to Figures 5 and 6, as well as any muffler constructed and operational according to the teachings of the present invention.

Similar to the muffler of Figure 1, the flow of exhaust gases is centered within the housing **4** as the exhaust gases leaves the downstream end **24** of the perforated pipe **20**, enters the third chamber **14**. The flow of exhaust gases encounters the apex of pyramidal partition **50**, which is spaced a distance of 20mm-60mm from the downstream end **24** of the perforated pipe **20**, causing the flow to be deflected along the exterior faces of pyramidal partition **50** and towards the interior surface of the outer wall of housing **4**.

The exhaust gases flow then through the four spaces **52** formed by the rugose base of the pyramidal partition **50**. A substantial first portion of the exhaust gases continue to flow in the direction of the outlet pipe **120**, thereby creating a low pressure region inside the pyramidal partition **150**. Consequently, a second portion of the exhaust gases changes direction and enters (is drawn into) the inside region of pyramidal partition **50** before continuing toward the outlet pipe **8**. The exhaust gases flow through partition **60** and is again centered within the housing **100** as the exhaust gases enter the fourth chamber **16** before being discharged through outlet pipe **8**, formed in the outlet end of the muffler.

The arrows in Figure 4 illustrate the flow path of the exhaust gases through this embodiment of the muffler of the present invention.

Figures 5 and 6 illustrate a muffler **102** generally defined by a housing **4**, which includes an inlet configuration similar to the embodiment of Figures 3 and 4, therefore, the same reference numerals are used here to refer to corresponding

components. It will be appreciated that the specifications relating to component size detailed above apply equally here as well.

An inlet **6** is provided in the inlet end of the muffler for introducing exhaust gases into the first chamber **10**. The improved inlet configuration of this embodiment also has the first chamber **10** and a second chamber **12** sequentially arranged within muffler **102**. A perforated pipe **20**, with its upstream end **22** sealed, passing longitudinally through a central region of both the first **10** and the second **12** chambers such that perforated pipe **20** extends partially into the first chamber **10** and extends the full length of the second chamber **12**. Perforated pipe **20** extends at its downstream end **24** through partition **40** and opens into the third chamber **14**. The perforations **26** allow the exhaust gases to enter the perforated pipe **20** so as to be directed through the interior of perforated pipe **20** and into the third chamber **14**.

The partition **30** separating the first and second chambers includes a preferably round hole **32** that enables some of the gas to pass from the first chamber **10** into the second chamber **12** without passing through the central perforated pipe **20**. Exhaust gases that enter the second chamber **12** then pass through the perforations **26** in the section of perforated pipe **20** deployed in second chamber **12**. It will be appreciated that in this embodiment as well, hole **32** may be of substantially any suitable size and shape.

Similar to the muffler of Figure 2, the exhaust gas flow is centered within the housing **4** as the exhaust gases leaves the downstream end **24** of the perforated pipe **20**, and enters the third chamber **14** and the flow of exhaust gases encounters the top of domed partition **150**, causing the flow of exhaust gases to be deflected along the

exterior face of domed partition **150**. Dome-shaped partition **150** having an exterior surface, a first end of the exterior surface points toward the inlet end of the muffler, and widening out at a second end to form a base, said dome-shaped partition having at least two partition openings disposed between said first end and said second end of said exterior surface

The exhaust gases flow through openings **152** in the sides of domed partition **150**. Openings **152** are preferably disposed on opposite sides of domed partition **150**.

Subsequently, the exhaust gases continue to flow in the direction of outlet pipe **8** formed in the outlet end of the muffler, thereby creating a low pressure region inside domed partition **150**. Consequently, a portion of the exhaust gases change direction and enter (are drawn into) the inside of domed partition **150** before continuing in the direction of outlet pipe **8**. The exhaust gases flow through an opening (not shown) partition **160**, and enter the fourth chamber **16** before being discharged through outlet pipe **8**.

The arrows in Figure 6 illustrate the flow path of the exhaust gases through this embodiment of the muffler of the present invention.

The embodiment of Figure 7 relates to a third preferred embodiment **400** of the muffler combining features of the present invention with the pyramidal partition deflection element of U.S. Patent No. 6,286,623.

Figure 7 illustrates muffler **400** of the present invention generally defined by a housing **401** and end walls **402** and **406**. An inlet **408** for introducing exhaust gases into the muffler **400** is provided in end wall **402**. The inlet configuration of

the mufflers of the present invention includes an inlet pipe **409** that is axially centered within the housing **401** and extends from the inlet **408** through the first chamber **403** and opens at its downstream end into the intermediate chamber **417** sequentially arranged within muffler **400**.

As the flow of exhaust gases leaves the downstream end of pipe **409** and enters the intermediate chamber **417**, the flow of exhaust gases encounters the apex of pyramidal deflection element **410** causing the flow to be deflected along the exterior faces of pyramidal deflection element **410** and towards the interior surface of the outer wall of housing **401**. It will be appreciated that although pipe **409** and the apex of pyramidal deflection element **410** are illustrated herein as substantially axially centered within the housing **401**, it is within the scope of the present invention to provide a non-straight pipe that extends from an inlet that is not axially centered within the housing **401** to a downstream end that is aligned with the apex of pyramidal deflection element **410**, which need not be axially centered within the housing **401**.

Opening **413** configured in interior partition wall **404** allows exhaust gasses to enter the first chamber **403** and thereby alleviate some excess pressure that may from in the intermediate chamber **417**. It will be appreciated that interior partition wall **404** may be configured with a single opening **413** as illustrated herein, or with a plurality of opening to allow passage of exhaust gasses between the first **403** and intermediate **417** chambers.

The exhaust gases then flow through the four spaces **418** formed at the base of the pyramidal deflection element **410**. A substantial first portion of the exhaust

gases continue to flow in the direction of the opening **414** to the perforated pipe **411**, thereby creating a low pressure region inside the pyramidal deflection element **410**. Consequently, a second portion of the exhaust gases changes direction and enters (is drawn into) the inside region of pyramidal deflection element **410** before continuing toward opening **414**. The flow pattern thus created serves to decrease the sounds associated with the exhaust.

Perforated pipe **411** extends from opening **414** through the last chamber **407** to the outlet pipe **412**. As the exhaust gases flow through perforated pipe **411**, the associated sound waves pass freely through the perforations **416** into the last chamber **407** and are thereby further dissipated. Preferably, as illustrated herein, the last chamber **407** contains a sound-attenuating material made from mineral fibers or synthetic fibers either individually or in combination. Such fibers include, but are not limited to, Asbestos fibers, basalt fibers, mineral wool, glass wool, metal wools such as steel wool and bronze wool, carbon fiber and aramid fiber such as Kevlar®.

~~The embodiment of Figure 8 relates to a second preferred embodiment **500**~~ of the muffler combining the features of the present invention with the dome-shaped deflection element of U.S. Patent No. 6,776,257. Muffler 5**00** is generally defined by a housing **501** and end walls **502** and **506**. An inlet **508** for introducing exhaust gases into the muffler **500** is provided in end wall **502**. The inlet configuration of the mufflers of the present invention includes an inlet pipe **509** that is axially centered within the housing **501** and extends from the inlet **508** through the first chamber **503** and opens at its downstream end into the intermediate chamber **517** sequentially arranged within muffler 5**00**.

As the flow of exhaust gases leaves the downstream end of pipe **509** and enters the intermediate chamber **517**, the flow of exhaust gases encounters the top of the dome-shaped deflection element **520**, causing the flow of exhaust gases to be deflected along the exterior face of dome-shaped deflection element **520**. Dome-shaped deflection element **520** has an exterior surface, a first end of the exterior surface points toward the inlet end of the muffler and widens out at a second end to form a base. The dome-shaped deflection element also has at least two partition openings **522** disposed between the first end and the second end preferably formed at the base end. The exhaust gases flow through openings **522** in the sides of dome-shaped deflection element **520**. Openings **522** are preferably disposed on opposite sides of dome-shaped deflection element **520**.

It will be appreciated that although pipe **509** and the dome-shaped deflection element **520** are illustrated herein as substantially axially centered within the housing **501**, here too, it is within the scope of the present invention to provide a non-straight pipe that extends from an inlet the is not axially centered within the housing **501** to a downstream end that is aligned with the apex of dome-shaped deflection element **520**, which need not be axially centered within the housing **501**.

As discussed above, here too, opening **513** configured in interior partition wall **504** allows exhaust gasses to enter the first chamber **503** and thereby alleviate some excess pressure that may from in the intermediate chamber **517**. It will be appreciated that in this embodiment as well, interior partition wall **504** may be configured with a single opening **513** as illustrated herein, or with a plurality of

opening to allow passage of exhaust gasses between the first **503** and intermediate **517** chambers.

As the exhaust gases flow through the openings **522** formed at the base of the dome-shaped deflection element **520**, a substantial first portion of the exhaust gases continue to flow in the direction of the opening **514** to the perforated pipe **511**, thereby creating a low pressure region inside the dome-shaped deflection element **510**. Consequently, a second portion of the exhaust gases changes direction and enters (is drawn into) the inside region of dome-shaped deflection element **510** before continuing toward opening **514**. Here too, the flow pattern thus created serves to decrease the sounds associated with the exhaust.

Perforated pipe **511** extends from opening **514** through the last chamber **507** to the outlet pipe **512**. As the exhaust gases flow through perforated pipe **511**, the associated sound waves pass freely through the perforations **516** into the last chamber **507** and are thereby further dissipated. Preferably, as illustrated herein, the last chamber **507** contains a sound-attenuating material made from mineral fibers or synthetic fibers either individually or in combination, as mentioned above.

With this basic understanding of the general structure of the preferred embodiments **400** and **500** of the muffler of the present invention, it will be appreciated that inlets **408** and **508** are configured for attachment to the exhaust pipe of the vehicle on which the muffler is deployed and therefore may vary in diameter depending on the specifications of the of the vehicle manufacturer. It will be appreciated that inlets **408** and **508** may be configured as two or more inlet pipes **409** and **509** that come together and have a single downstream end that is aligned

with the apex of the deflection element. Similarly, the outlet pipes **412** and **512** may be configured as more than one outlet pipe.

It should be noted that the first chamber **403** and **503** may extend for a distance of 10%-85% of the total length of the muffler **400** and **500**. Further, the first chamber may be configured as more than one chamber.

Similarly, the last chamber **407** and **507** may extend for a distance of 5%-80% of the total length of the muffler **400** and **500**, and the last chamber may be configured as more than one chamber.

Further, although the sound-attenuating material **415** and **515** is illustrated herein as being deployed in the last chamber **407** and **507**, it will be appreciated that sound deadening material may be deployed in any of the first **403** and **503**, intermediate **417** and **517** and last **407** and **507** chambers either individually or in combination. Also, the sound-attenuating material may deployed so as to partially fill or fully fill the chamber in which it is deployed.

It will be appreciated that the above descriptions are intended only to serve as examples and that many other embodiments are possible within the spirit and the scope of the present invention.

WHAT IS CLAIMED IS:

1. A muffler for an internal combustion engine comprising:

(a) a housing having an inlet end with at least one inlet opening formed for a flow of exhaust gases into said housing and an outlet end with an outlet opening formed for a discharge of exhaust gases from said housing;

(b) a first chamber and a second chamber sequentially arranged within said housing;

(c) a perforated pipe passing longitudinally through a central region of both said first and said second chambers such that said perforated pipe extends partially into said first chamber, extends a full length of said second chamber;

wherein said perforations allow said exhaust gases to enter said perforated pipe so as to be directed through an interior of said perforated pipe and into a third chamber and a partition separating said first and said second chambers includes a hole that enables some of said exhaust gases to pass from said first chamber into the second chamber without passing through said central perforated pipe.

2. The muffler of claim 1, wherein said perforated pipe has a diameter that is 100%-130% of the diameter of said inlet opening.

3. The muffler of claim 1, wherein an upstream end of said perforated pipe is partially sealed.

4. The muffler of claim 3, wherein said upstream end of said perforated pipe is 60%-80% open.

5. The muffler of claim 1, wherein perforations in said perforated pipe extending partially into said first chamber cover 20%-40% of a surface of said perforated pipe and, perforations in said perforated pipe extending said full length of said second chamber cover 50%-90% of said surface of said perforated pipe.

6. The muffler of claim 1, further including:

(d) said third chamber containing a deflection element, said perforated pipe extending so as to open at its downstream end into said third chamber, thereby directing said exhaust gases toward said deflection element; and

(e) a fourth chamber configured to channel a flow of gas to said outlet opening.

7. The muffler of claim 6, wherein said deflection element is a hollow pyramid having interior surfaces and exterior surfaces joining at a first end to form a pyramidal apex, said pyramidal apex pointing toward said inlet end of the muffler and extending at a second end to form an open base interconnected to a partition separating said third and said fourth cambers.

8. The muffler of claim 6, wherein said deflection element is a dome-shaped partition having an exterior surface, a first end of said exterior surface pointing toward said inlet end of the muffler, and widening out at a second end to form a base interconnected to a partition separating said third and said fourth cambers.

9. A muffler for an internal combustion engine comprising:

(a) a housing having an inlet end with an inlet opening formed for a flow of exhaust gases into said housing and an outlet end with an outlet opening formed for a discharge of exhaust gases from said housing;

(b) at least a first chamber, an intermediate and a last chamber sequentially arranged within said housing, said intermediate chamber containing a deflection element chosen from a group including:

(i) a hollow pyramid; and

(ii) a dome-shaped partition;

(c) a pipe passing longitudinally through said first chamber so as to open at its downstream end into said intermediate chamber, thereby directing said exhaust gases toward said deflection element; and

(d) a perforated pipe extending through said last chamber, said perforated pipe having an upstream opening into said

intermediate chamber and configured to channel said exhaust gas to said outlet opening.

10. The muffler of claim 1, wherein said pipe passes longitudinally through an axially central region of said first chamber.

11. The muffler of claim 1, wherein a partition separating said first and said intermediate chambers includes a hole that enables some of said exhaust gases to pass freely between said first chamber and said intermediate chamber.

12. The muffler of claim 1, wherein said first chamber extends between 10%-85% of the total length of said housing.

13. The muffler of claim 1, wherein said last chamber extends between 5%-80% of the total length of said housing.

14. The muffler of claim 1, further including a sound-attenuating material deployed in at least one of said first chamber, said intermediate chamber and said last chamber.

15. The muffler of claim 6, wherein said sound-attenuating material is configured from at least one chosen from the group that includes, mineral fibers and synthetic fibers.

16. The muffler of claim 1, wherein said hollow pyramid deflection element has interior surfaces and exterior surfaces joining at a first end to form a pyramidal apex, said pyramidal apex pointing toward said inlet end of the muffler and extending at a second end to form an open base interconnected to a partition separating said intermediate and said last cambers.

17. The muffler of claim 1, wherein said dome-shaped partition deflection element has an exterior surface, a first end of said exterior surface pointing toward said inlet end of the muffler, and widening out at a second end to form an open base interconnected to a partition separating said intermediate and said third cambers.

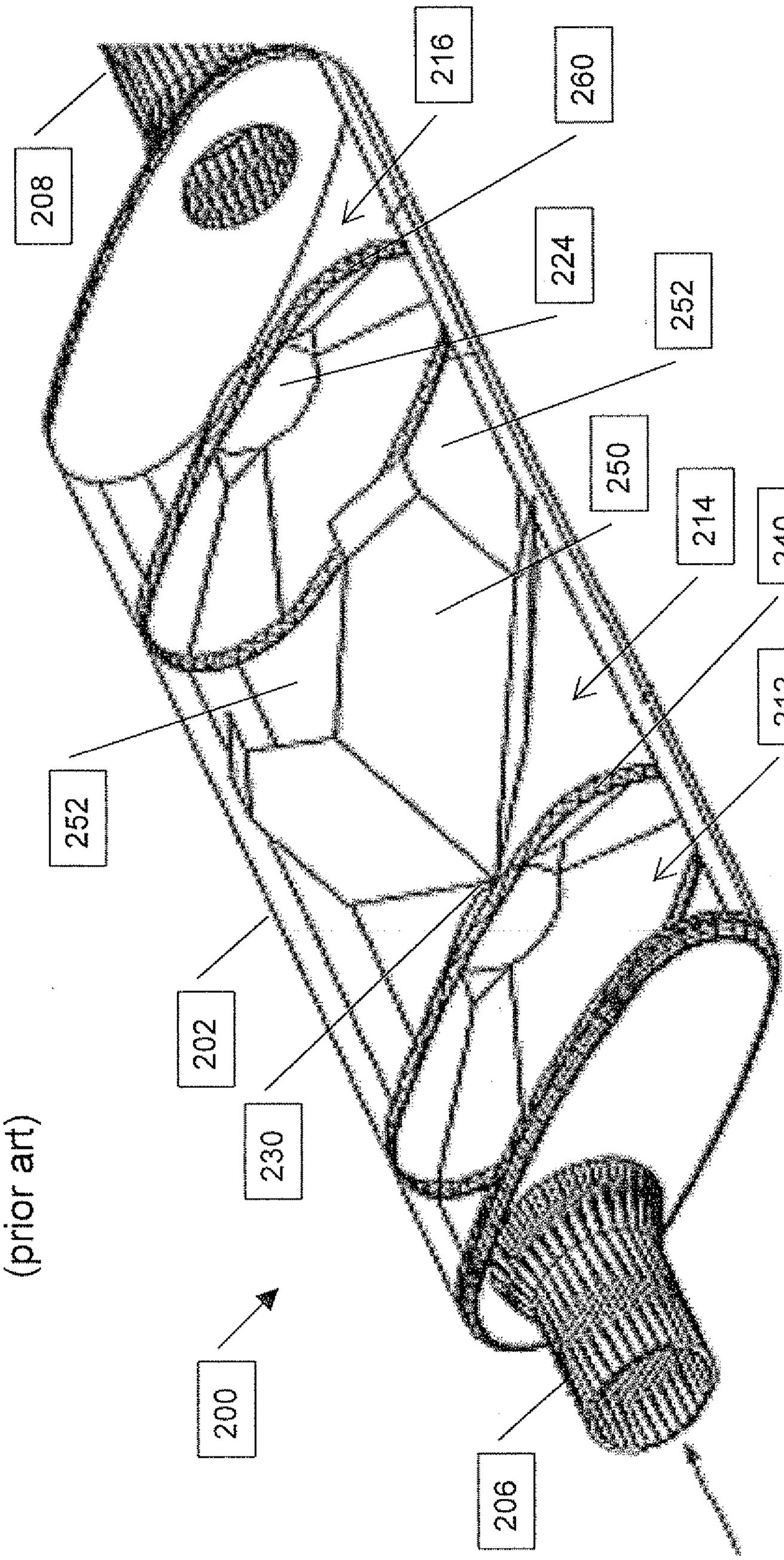

FIG. 1
(prior art)

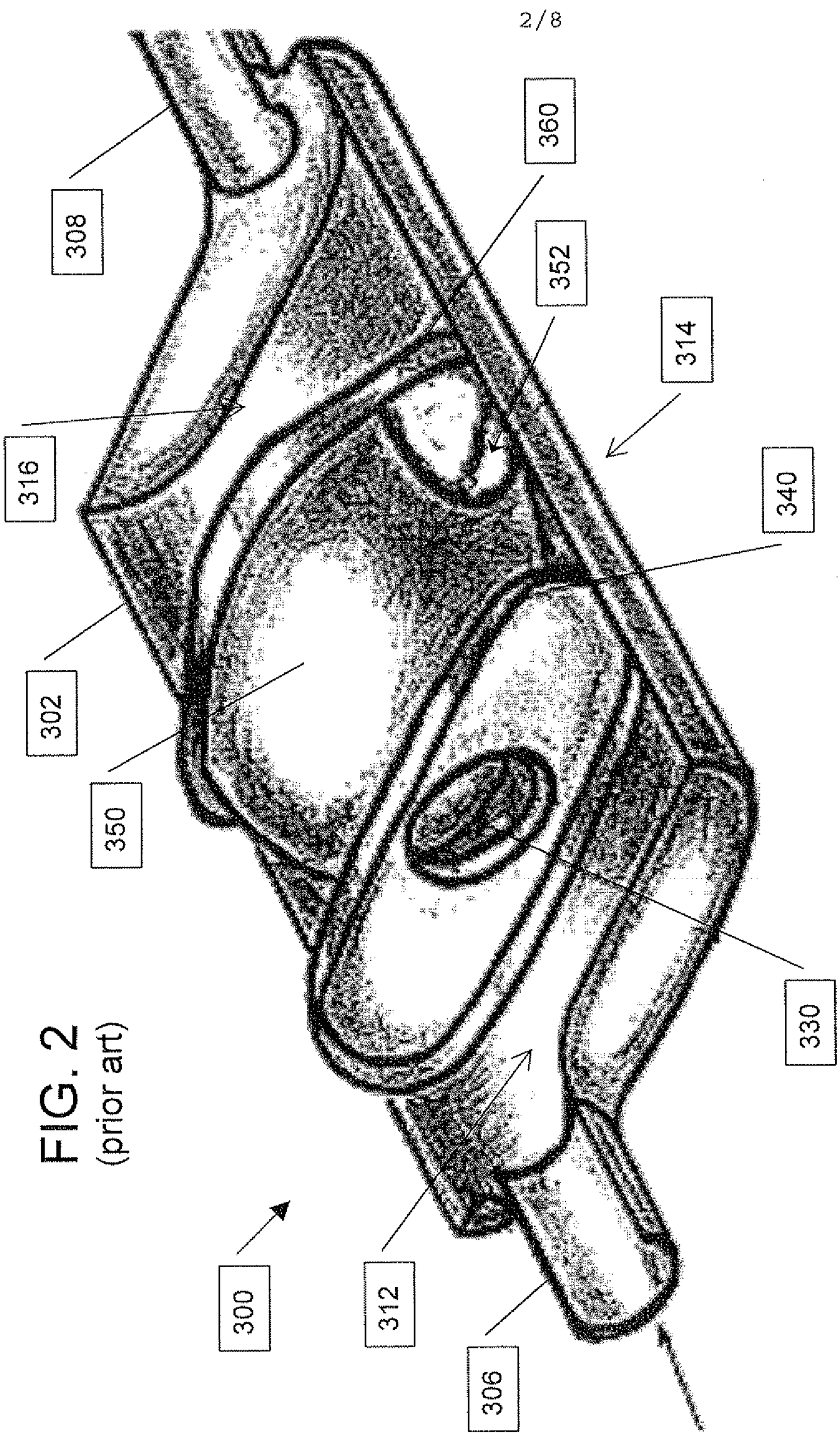

FIG. 2
(prior art)

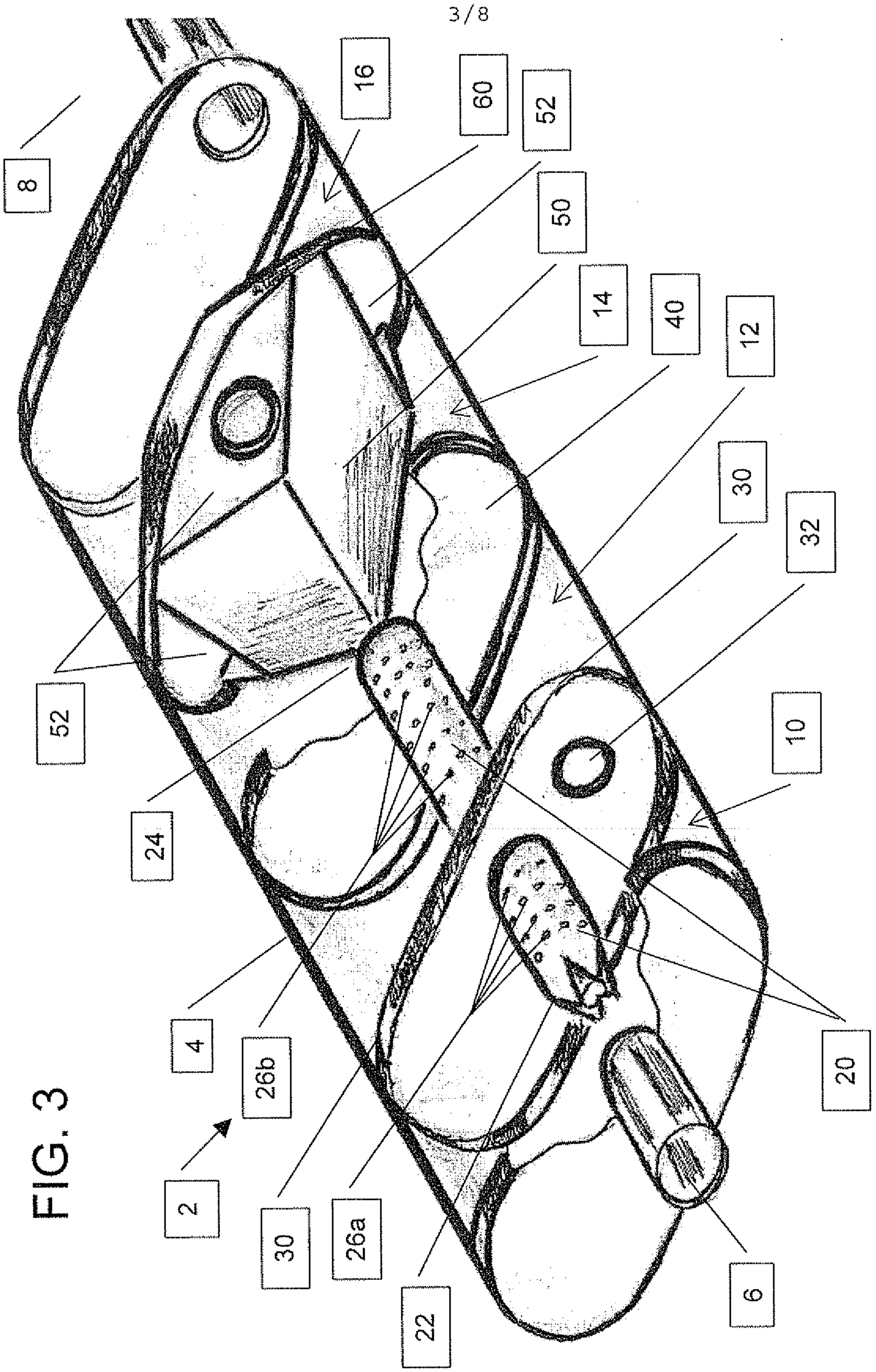

FIG. 3

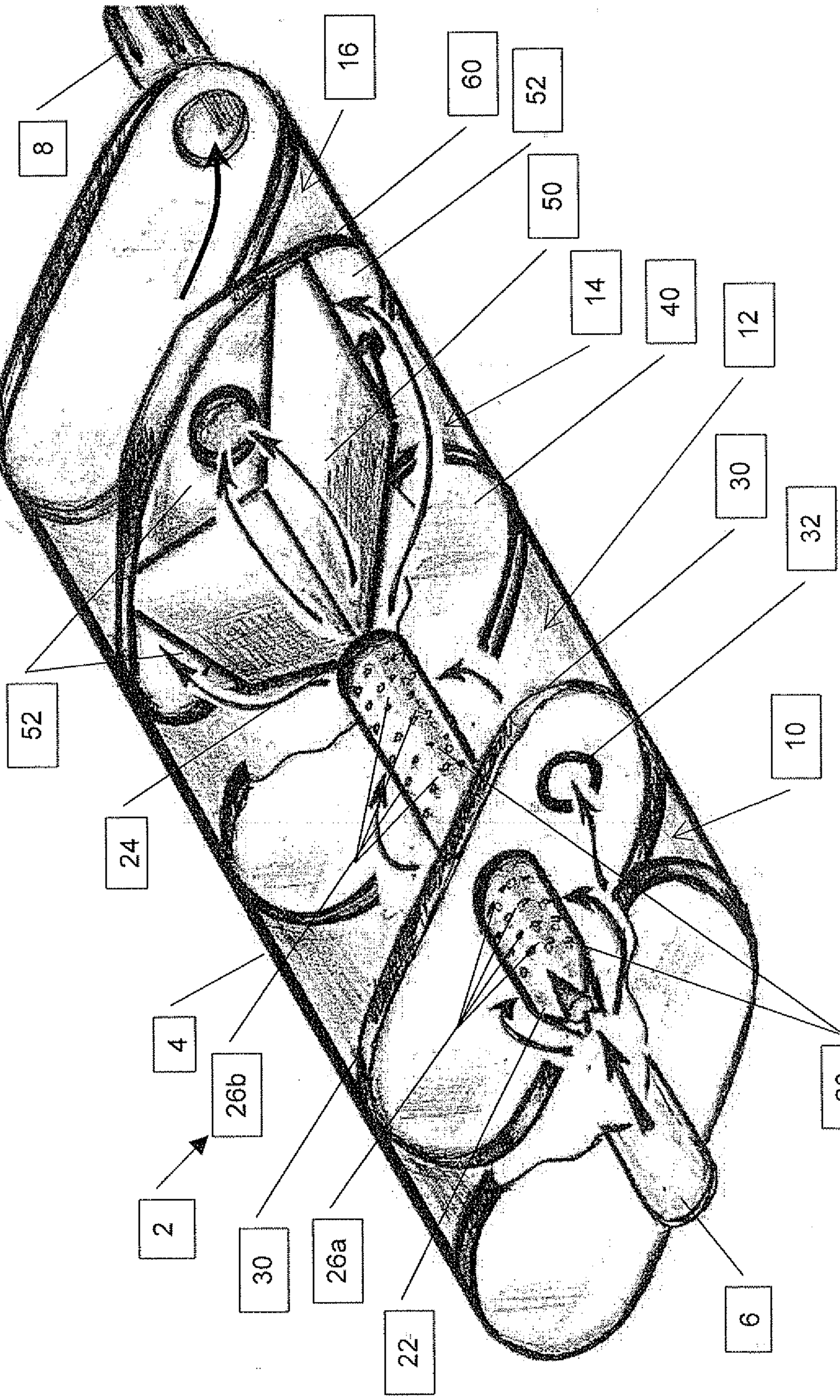

FIG. 4

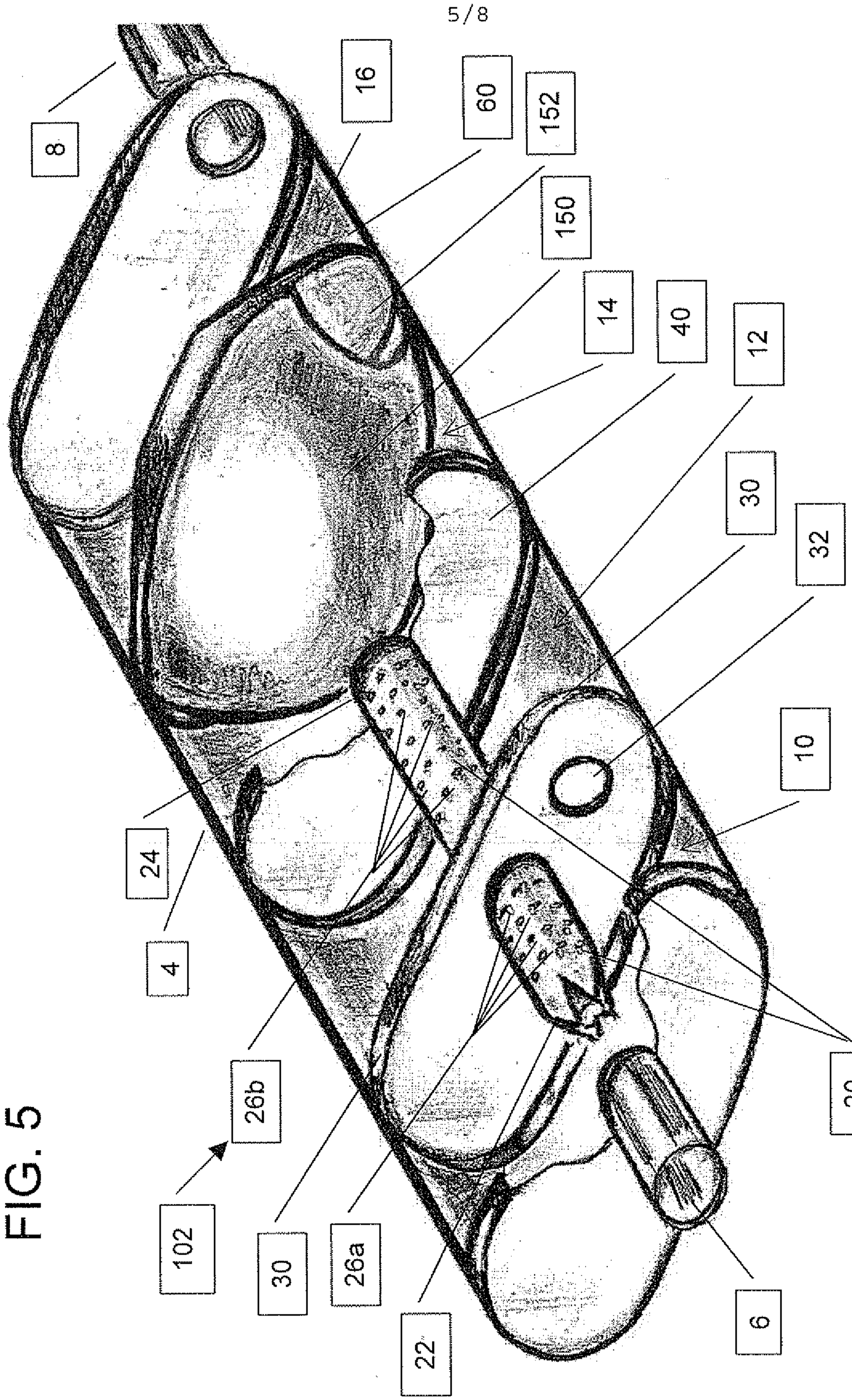

FIG. 5

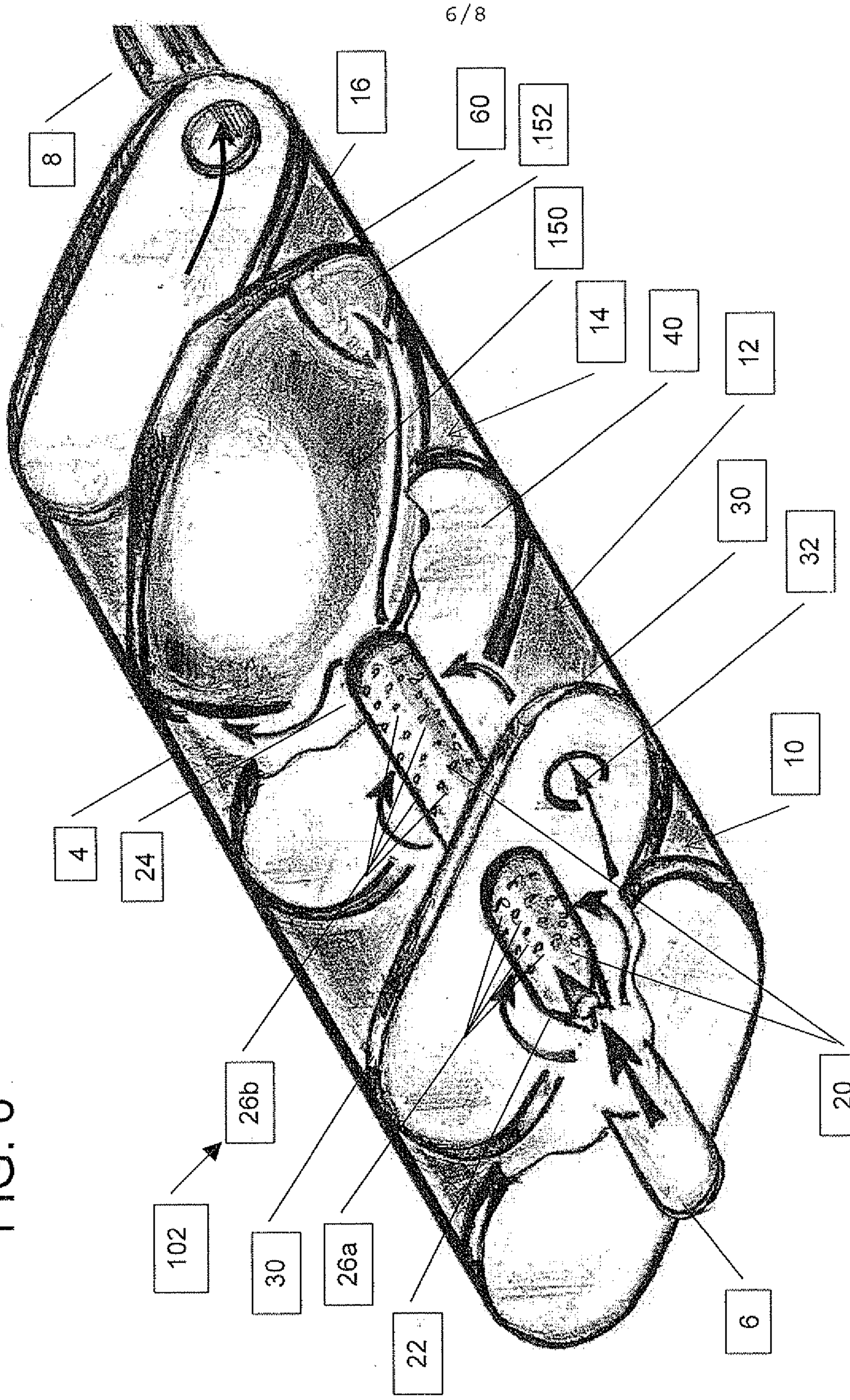

FIG. 6

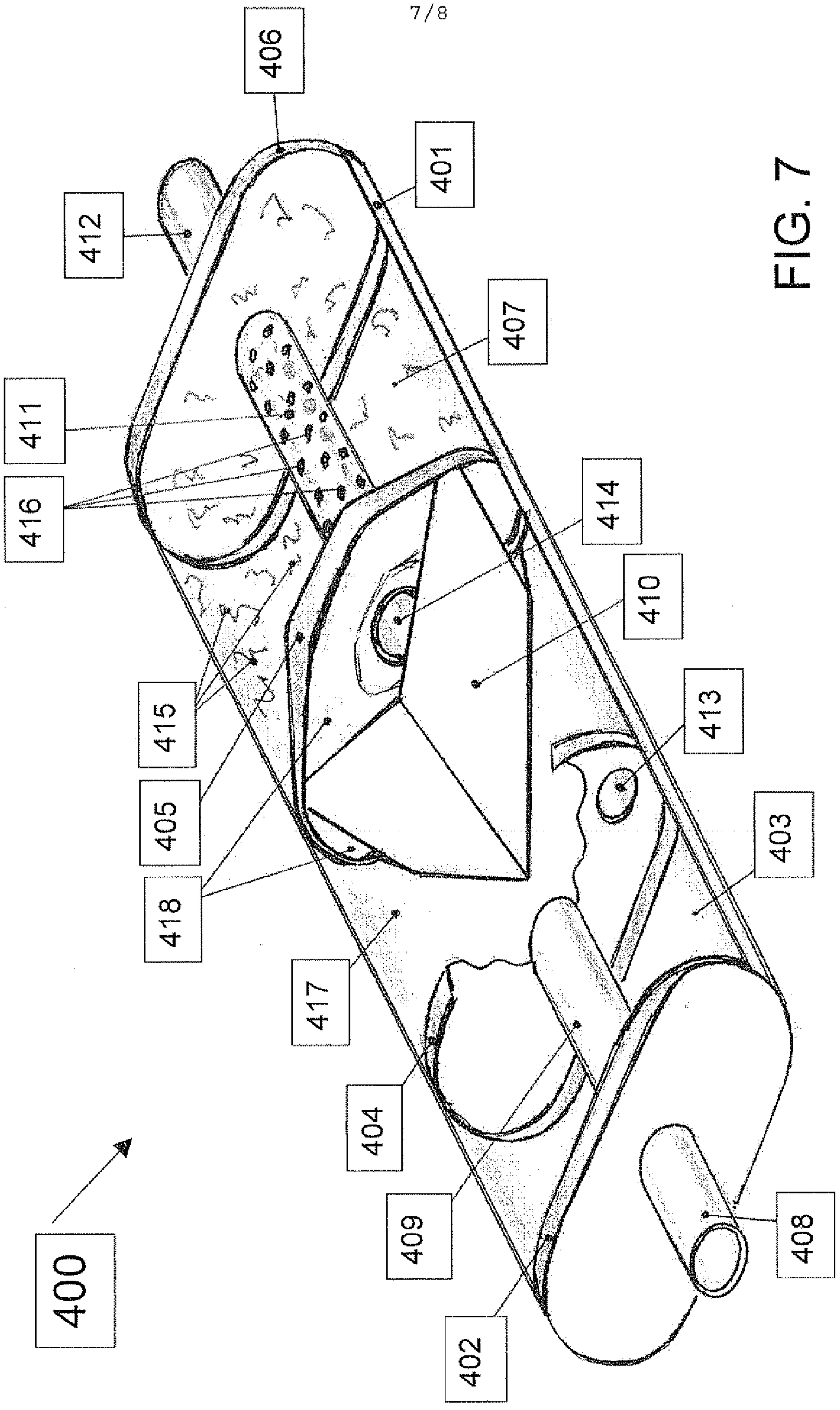
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FIG. 7

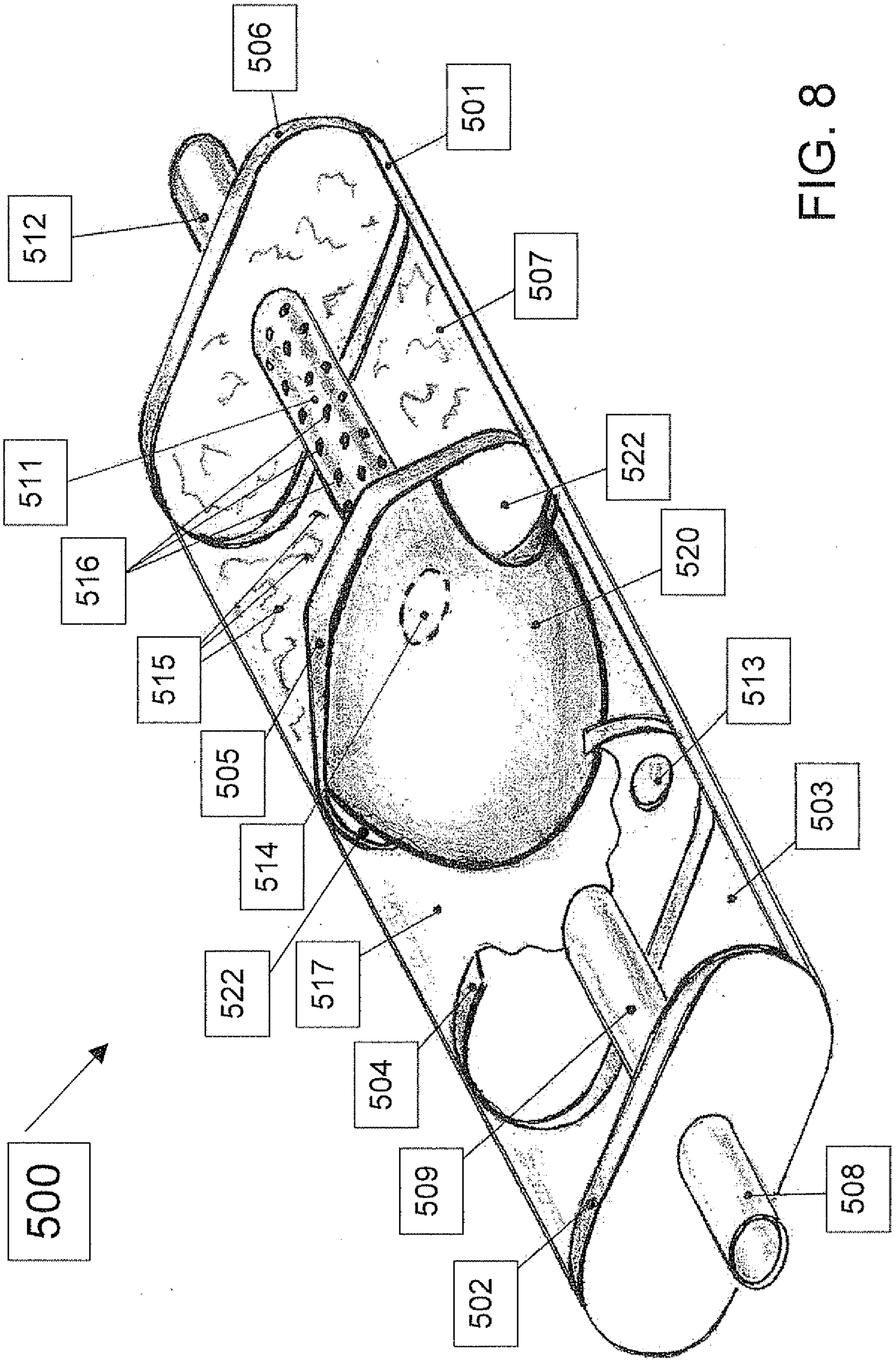
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FIG. 8

FIG. 3