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(72) Inventeurs/Inventors:
KROUPA, KEVIN, US;
PALMER, STEVE, US

(73) Propriétaire/Owner:
ALLIED HEALTHCARE PRODUCTS, INC., US

(74) Agent: GOWLING WLG (CANADA) LLP

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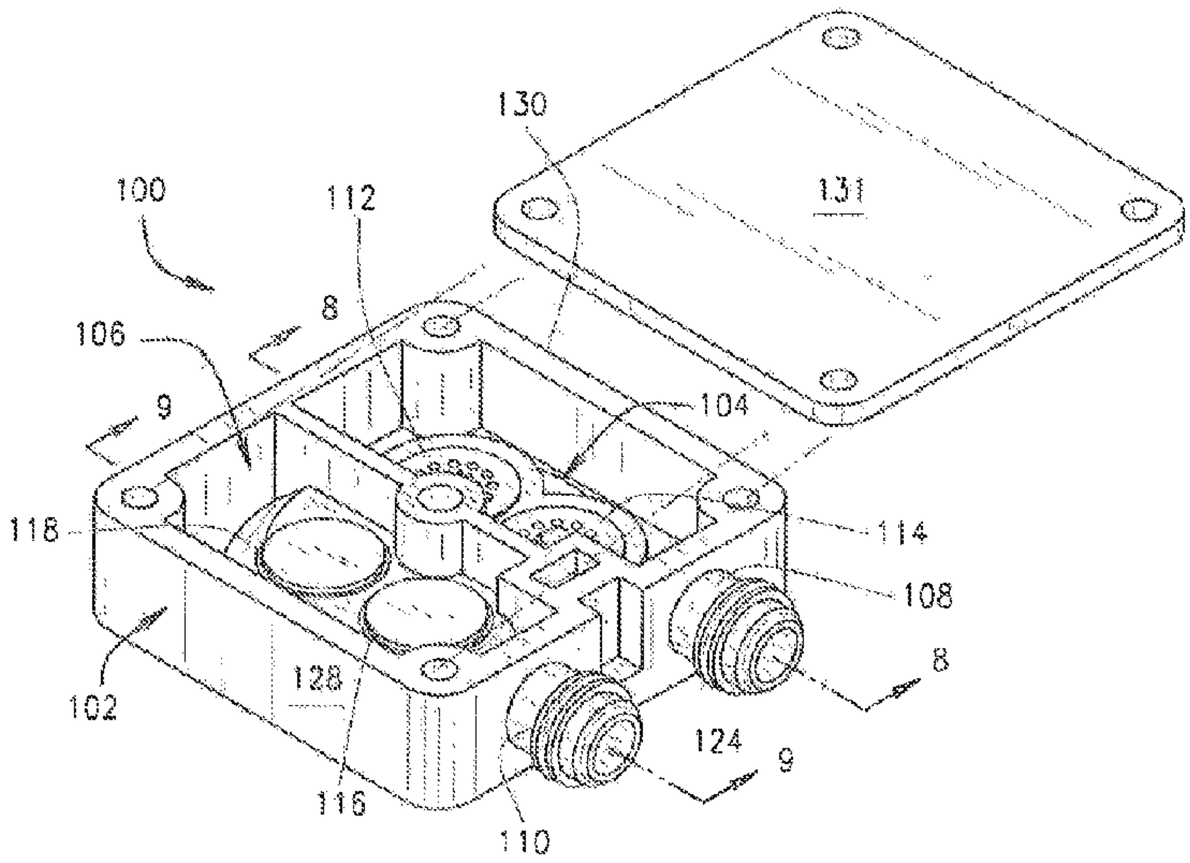
(54) Title: MULTIPLE VALVE HEAD COMPRESSOR APPARATUS




(57) Abrégé/Abstract:
A multiple valve compressor head (100) having a casing (102) defining an intake chamber (104) in selective communication with a cavity (120) through a plurality of one-way intake valves (112, 114) and an exhaust chamber (106) in selective communication with the cavity (120) through a plurality of one-way exhaust valves (116, 118) is disclosed. The casing (102) further defines an inlet port (108) for the entry of gas into the intake chamber (104) and an outlet port (110) for forcing out compressed gas from the exhaust chamber (106). In operation, the multiple valve compressor head (100) is in operative engagement with a reciprocating diaphragm that draws the gas into the intake chamber (104) and then the cavity (120) during the intake stroke of the diaphragm, while expelling compressed gas from the cavity (120) and through the outlet port (110) during the exhaust stroke of the diaphragm.

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(71) Applicant *(for all designated States except US)*: **ALLIED HEALTHCARE PRODUCTS, INC.** [US/US]; 1720 Sublette Avenue, St. Louis, Missouri 63110 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **KROUPA, Kevin** [US/US]; 1720 Sublette Avenue, St. Louis, Missouri 63110 (US). **PALMER, Steve** [US/US]; 1720 Sublette Avenue, St. Louis, Missouri 63110 (US).

(74) Agents: **BAI, Ari** et al.; Polsinelli Shughart PC, 100 South Fourth Street, Suite 1100, St. Louis, Missouri 63102-1825 (US).

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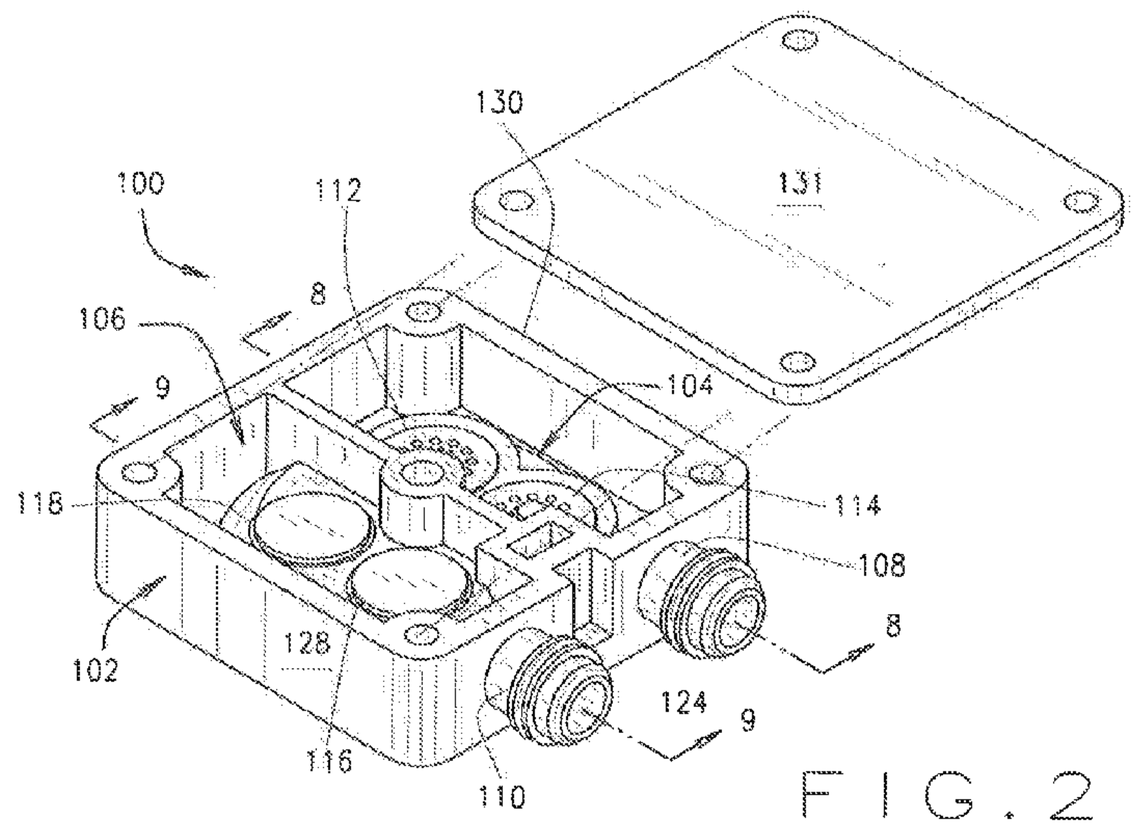


FIG. 2

**(57) Abstract**: A multiple valve compressor head (100) having a casing (102) defining an intake chamber (104) in selective communication with a cavity (120) through a plurality of one-way intake valves (112, 114) and an exhaust chamber (106) in selective communication with the cavity (120) through a plurality of one-way exhaust valves (116, 118) is disclosed. The casing (102) further defines an inlet port (108) for the entry of gas into the intake chamber (104) and an outlet port (110) for forcing out compressed gas from the exhaust chamber (106). In operation, the multiple valve compressor head (100) is in operative engagement with a reciprocating diaphragm that draws the gas into the intake chamber (104) and then the cavity (120) during the intake stroke of the diaphragm, while expelling compressed gas from the cavity (120) and through the outlet port (110) during the exhaust stroke of the diaphragm.

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# MULTIPLE VALVE HEAD COMPRESSOR APPARATUS

## FIELD

**[0001]** This document relates to a multiple valve head, and in particular a multiple valve head for a compressor apparatus used with a ventilator system.

## BACKGROUND

**[0002]** In medicine, mechanical ventilation is a method to mechanically assist or replace spontaneous breathing of a patient using a machine called a ventilator. The ventilator may include a compressor apparatus that draws in gas and delivers the compressed gas to the patient in a controlled manner to meet patient specifications. Specifically, the compressor apparatus may include one or more heads for drawing in gas for compression by a diaphragm driven against the cavity of the head in a reciprocating motion for generating compressed gas for delivery to the patient. As shown in FIGS. **1A** and **1B**, a prior art compressor head **10** used with a compressor apparatus (not shown) for generating compressed gas may include a body **12** defining an intake chamber **14** for drawing in a gas, such as air, oxygen or a mixture of different gases, through an inlet port **18** in communication with the intake chamber **14.** The intake chamber **14** is in selective communication with a cavity 19 defined on the opposite side of the body **12** through an intake valve **22.** The cavity **19** further includes an exhaust valve **24** in communication with an exhaust chamber **16** defined adjacent the intake chamber **14** that allows compressed gas to exit through an outlet port **20** of the prior art compressor head **10** for delivery to the patient. As further shown, the intake valve **22** includes an open intake side **26** having a plurality of apertures **40** in communication with the intake chamber **14** and an exhaust side **32** having a flexible flapper **34** in communication with the cavity **19.** Similarly, the exhaust valve **24** includes an open intake side **30** having a plurality of apertures **38** and an exhaust side **28** having a flexible flapper **36** in communication with the exhaust chamber **16.** In this arrangement, a diaphragm (not shown) in communication with the cavity **19** is driven in a reciprocal motion to draw in gas through the intake valve **22** of the intake chamber **14** when the diaphragm moves away from the cavity **19** and then expel compressed gas from the cavity **19** through the exhaust valve **24** that exits the outlet port **20** when the diaphragm moves toward the cavity **19.** As further shown, gas flow **A** in FIGS. **1A** and **1B** illustrates the flow of

gas through the compressor apparatus head **10** as the gas enters the inlet port **18** and compressed gas exits through the outlet port **20**.

**[0003]** Although the prior art compressor head having the single intake and exhaust valve arrangement for a compressor apparatus has proven satisfactory for its intended purpose, there is still a need for a compressor apparatus head that consumes less power while achieving greater power output.

## SUMMARY

**[0004]** In one embodiment, compressor head may include a body defining an intake chamber in selective fluid flow communication with an exhaust chamber through a cavity. A plurality of one-way intake valves are disposed between the intake chamber and the cavity for permitting one-way gas flow from the intake chamber to the cavity, while a plurality of one-way exhaust valves may be disposed between the exhaust chamber and the cavity for permitting one-way gas flow from the cavity to the exhaust chamber. An inlet port is in communication with the intake chamber for permitting the inflow of a fluid into the intake chamber and an outlet port in communication with the exhaust chamber for permitting the outflow of the compressed gas from the exhaust chamber.

**[0005]** In another embodiment, a compressor head may include a body defining an intake chamber in selective fluid flow communication with an exhaust chamber through a cavity. A pair of one-way intake valves is disposed between the intake chamber and the cavity for permitting one-way gas flow from the intake chamber to the cavity. In addition, a pair of one-way exhaust valves may be disposed between the exhaust chamber and the cavity for permitting one-way gas flow from the cavity to the exhaust chamber. An inlet port in communication with the intake chamber for permitting inflow of a gas into the intake chamber and an outlet port in communication with the exhaust chamber for permitting outflow of compressed gas from the exhaust chamber.

**[0006]** In yet another embodiment, a method for using a compressor head may include providing a compressor head having a body defining an intake chamber in selective fluid flow communication with an exhaust chamber through a cavity. A plurality of one-way intake valves may be disposed between the intake chamber and the cavity for permitting one-way gas flow from the intake chamber to the cavity, while a plurality of one-way exhaust valves may be disposed between the exhaust

chamber and the cavity for permitting one-way gas flow from the cavity to the exhaust chamber. An inlet port is in communication with the intake chamber for permitting the inflow of a gas into the intake chamber and an outlet port is in communication with the exhaust chamber for permitting the outflow of a compressed gas from the exhaust chamber. In some embodiments, the method may further include drawing the gas into the inlet port, and then allowing the gas in a pressurized state to exit through the outlet port of the compressor head having a flow rate that ranges between 4 liters per minute to 90 liters per minute.

**[0007]** In a further embodiment, a method of manufacturing a multi-valve compressor head may include:

forming a casing having an intake chamber and an exhaust chamber;

forming an inlet port in communication with the intake chamber and an outlet port in communication with the exhaust chamber;

forming a pair of one-way intake valves between the intake chamber and the exhaust chamber; and

forming a pair of one-way exhaust valves between the intake chamber and the exhaust chamber.

**[0008]** Additional objectives, advantages and novel features will be set forth in the description which follows or will become apparent to those skilled in the art upon examination of the drawings and detailed description which follows.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** FIGS. **1A** and 1B are simplified illustrations showing a top side and a bottom side of a prior art valve compressor head for a compressor apparatus;

**[0010]** FIG. **2** is an elevated perspective view showing one embodiment of a multiple valve compressor head for a compressor apparatus;

**[0011]** FIG. 3 is an opposing elevated perspective view of the multiple valve compressor head for a compressor apparatus;

**[0012]** FIG. **4** is a top view of the multiple valve compressor head for a compressor apparatus;

**[0013]** FIG. **5** is a bottom view of the multiple valve compressor head for a compressor apparatus;

**[0014]** FIG. **6** is a side view of the multiple valve compressor head for a compressor apparatus;

**[0015]** FIG. **7** is an opposing side view of the multiple valve compressor head for a compressor apparatus;

**[0016]** FIG. **8** is a cross-sectional view of the multiple valve compressor head for a compressor apparatus taken along line **8-8** of FIG. **2**;

**[0017]** FIG. **9** is a cross-sectional view of the multiple valve compressor head for a compressor apparatus taken along line **9-9** of FIG. **2**;

**[0018]** FIG. **10** is a flow chart illustrating a method for manufacturing the multiple valve compressor head for a compressor apparatus; and

**[0019]** FIG. **11** is a flow chart illustrating a method for using the multiple valve compressor head.

**[0020]** Corresponding reference characters indicate corresponding elements among the view of the drawings. The headings used in the figures should not be interpreted to limit the scope of the claims.

## DETAILED DESCRIPTION

**[0021]** In medicine, mechanical ventilation is a method to mechanically assist or replace spontaneous breathing of a patient using a machine called a ventilator. The ventilator may include a compressor apparatus that draws in gas and then delivers a compressed gas to the patient in a controlled manner to meet patient specifications. Specifically, the compressor apparatus may include one or more heads for drawing in gas for compression by a diaphragm driven against the cavity of the head in a reciprocating motion for generating compressed gas for delivery to the patient through the ventilator. Each respective compressor head includes a single intake valve for permitting one-way fluid flow from an intake chamber into the cavity and a single exhaust valve for permitting one-way fluid flow from the cavity into an exhaust chamber for egress of the gas from the compressor head to the output of the ventilator. However, it has been found that the single intake and exhaust valve arrangement of the prior art compressor head limits the efficiency and total flow output of the ventilator.

**[0022]** In view of the above, embodiments of the multiple valve compressor head as set forth herein include particular components, properties and characteristics that address issues related to improving the efficiency and total flow output of a compressor head as described in greater detail below.

**[0023]** Referring to the drawings, various embodiments of the multiple valve compressor head are illustrated and generally indicated as **100** in FIGS. **1-9.** In general, the multiple head compressor head **100** may include a casing **102** having an inlet port **108** in fluid flow communication with an intake chamber **104** for the inflow of gas into the multiple valve compressor head **100.** A pair of intake valves **112** and **114** is disposed between the intake chamber **104** and a cavity **120** for permitting one-way flow of gas from the intake chamber **104** to the cavity **120.** Moreover, a pair of exhaust valves **116** and **118** are disposed between the cavity **120** and an exhaust chamber **106** for permitting one-way flow of gas from the cavity **120** to the exhaust chamber **106.** An outlet port **110** is in fluid flow communication with the exhaust chamber **106** to allow the outflow of gas from the multiple valve compressor head **100.**

**[0024]** As further shown, the casing **102** of the multiple valve compressor head **100** may include a front side **124,** a rear side **126,** a left side **128,** a right side **130,** a top side **132,** and a bottom side **134.** Moreover, a front plate **131** may cover the top side **132** of the casing **102** while a rear plate **134** may cover the bottom side **133** of the casing **102.** In some embodiments, the inlet port **108** and the outlet port **110** may extend outwardly from the front side **124;** however, in other embodiments the inlet port **108** and outlet port **110** may extend from the rear side **126** of the casing **102.** As further shown, the inlet port **108** includes a recess **121** configured to engage a sealing element **122,** for example an 0-ring, to provide a fluid-tight seal between the inlet port **108** and the connections (not shown) to the ventilator. Similarly, the outlet port **110** includes a recess **121** configured to engage a sealing element **122** to provide a fluid-tight seal between the outlet port **110** and the connections to the ventilator. In one embodiment, the casing **102** may be made from a metallic material, such as steel, aluminum, zinc, metallic composite brass, copper and combinations thereof, while in other embodiments the casing **102** may be made from a hard plastic material, such as polycarbonate, acrylonitrile butadiene styrene (ABS), polyethylene, polystyrene, polyvinyl chloride and polytetrafluoroethylene.

**[0025]** Referring specifically to FIG. **8,** each of the intake valves **112** and **114** includes a respective plurality of conduits **144** each having a first open end **146** for permitting one-way entry of gas from the intake chamber **104** and a second open end **148** for permitting one-way exit of gas into the cavity **120** (FIG. **3).** A biased closed valve **136,** such as a flexible flapper portion, is operatively engaged with

respective second open ends **148** of the plurality of conduits **144** that permits one-way gas flow from the intake chamber **104** to the cavity **120,** but prevents opposing gas flow from the cavity **120** back into the intake chamber **104** due to the flexible nature of the flapper portion that lifts upwardly on its peripheral edge in one flow direction and closes downwardly on its peripheral edge against the second open ends **148** in the opposite flow direction. In one embodiment, the center of each biased closed valve **136** is secured to each respective intake valve **112** and **114** to permit the circumference of each biased closed valve **136** to lift upwardly when gas is expelled from the intake chamber **104** and into the cavity **120.** Conversely, the biased closed valve **136** maintains a fluid tight seal against the plurality of conduits **144** to prevent the retrograde flow of gas from the cavity **120** back into the intake chamber **104.**

**[0026]** Referring to FIG. **9,** similar to intake valves **112** and **114,** each of the exhaust valves **116** and **118** includes a respective plurality of conduits **145** each having a first open end **147** for permitting one-way entry of gas from the cavity **120** and a second open end **149** for permitting one-way exit of gas into the exhaust chamber **106.** A respective biased closed valve **138,** such as similar flexible flapper portion described above, is operatively engaged with a respective second open ends **149** of the plurality of conduits **145** that permit one-way gas flow from the cavity **120** to the exhaust chamber **106,** but prevents retrograde gas flow from the exhaust chamber **106** back into the cavity **120.** In one embodiment, the center of each flapper portion **138** is secured to each respective exhaust valve **116** and **118** to permit the circumference of each flapper portion **138** to lift upwardly when compressed gas is expelled from the cavity **120** and into the exhaust chamber **106.** Conversely, the flapper portion **138** maintains a fluid tight seal against the plurality of conduits **145** to prevent the retrograde flow of gas from the exhaust chamber **106** back into the cavity **120.**

**[0027]** In another embodiment, the intake valves **112** and **114** as well as the exhaust valves **116** and **118** may be include respective spring-loaded valves, rather than flapper portions **136** and **138,** or other such mechanism that biases the intake valves **112** and **114** and exhaust valves **116** and **118** to a closed position to permit one-way flow.

**[0028]** Referring back to FIGS. **4** and **5,** a flow of gas, designated gas flow **B,** illustrates the flow pathway of gas through the multiple valve compressor head

**100.** Specifically, gas flow **B** may enter the intake chamber **104** through inlet port **108** before entering each of the one-way intake valves **112** and **114** for entry into the cavity **120.** Once inside the cavity **120,** gas flow **B** is forced out into the exhaust chamber **106** through the pair of one-way exhaust valves **116** and **118** by the reciprocating action of the diaphragm (not shown). In one embodiment, the diaphragm may be operatively engaged to a piston that moves the diaphragm in a reciprocating action relative to the cavity **120.** Movement of the reciprocating diaphragm away the cavity **120** during an intake stroke draws gas flow **B** from the intake chamber **104** and into the cavity **120** through intake valves **112** and **114,** while movement of the diaphragm toward the cavity **120** during the exhaust stroke forces compressed gas from the cavity **120** and through the exhaust valves **116** and **118** such that the gas flow **B** enters the exhaust chamber **106.** After entry into the exhaust chamber **104,** gas flow **B** is forced out through the outlet port **110** for delivery to the patient through the ventilator at a flow rate in the range of 4-9 liters per minute.

**[0029]** Referring to FIG. **10,** a flow chart illustrates a method of manufacturing the multiple valve compressor head **100** as described above. At block **1000,** forming a casing **102** having an intake chamber **104** and an exhaust chamber **106.** At block **1002,** forming an inlet port **108** in communication with the intake chamber **104** and forming an outlet port **110** in communication with the exhaust chamber **118.** At block **1004,** forming a pair of intake valves **112** and **114** between the intake chamber **104** and the exhaust chamber **118.** At block **1006,** forming a pair of exhaust valves **116** and **118** between the intake chamber **104** and the exhaust chamber **118.** In some embodiments, the casing **102,** intake chamber **104,** exhaust chamber **118,** inlet port **108** and outlet port **110** may be manufactured using a die-caste process, a molding process and/or a milling process.

**[0030]** Referring to FIG. **11,** a flow chart illustrates a method for operating the multiple valve compressor head **100** as described above. At block **1100** and block **1102,** the multiple valve compressor head **100** having multiple intake valves **112** and **114** and multiple exhaust valves **116** and **118** is engaged to a ventilator. At block **1110,** a gas is applied to the inlet port **108** of the multiple valve compressor head **100** and drawn into the intake chamber **104.** At block **1110,** the gas is drawn through the multiple intake valves **112** and **114** and into the cavity **120.** At block **1110,** the gas is compressed in the cavity **120.** At block **1110,** the compressed gas is forced through

the multiple exhaust valves **116** and **118** and into the exhaust chamber **106** and then at block **1112** the compressed gas if then forced from the exhaust chamber **106** and through the outlet port **110.**

**[0031]** It should be understood from the foregoing that, while particular embodiments have been illustrated and described, various modifications can be made thereto without departing from the spirit and scope of the invention as will be apparent to those skilled in the art. Such changes and modifications are within the scope and teachings of this invention as defined in the claims appended hereto.

## CLAIMS

What is claimed is:

1. A compressor head **(100)** for use with a medical ventilator comprising:

a body **(102)** defining an intake chamber **(104)** in selective fluid flow communication with an exhaust chamber **(106)** through a cavity **(120)**;

a plurality of one-way intake valves **(112, 114)** disposed between the intake chamber **(104)** and the cavity **(120)** for permitting one-way gas flow from the intake chamber **(104)** to the cavity **(120)**,

wherein each of the plurality of one-way intake valves **(112, 114)** comprises:

a body defining a plurality of conduits **(144)** having a first open end **(146)** and a second open end **(148)**, wherein the second open end **(148)** is configured to be engaged to a flapper portion **(136)** for preventing fluid flow communication in one direction and at least partially disengaged from the flapper portion **(136)** for permitting fluid flow communication in an opposite direction;

a plurality of one-way exhaust valves **(116,118)** disposed between the exhaust chamber **(106)** and the cavity **(120)** for permitting one-way gas flow from the cavity **(120)** to the exhaust chamber **(106)** with the plurality of one-way exhaust valves **(116,118)** juxtaposed and directly adjacent one another;

an inlet port **(108)** in communication with the intake chamber **(104)** for permitting the inflow of a gas into the intake chamber **(104)**; and

an outlet port **(110)** in communication with the exhaust chamber **(106)** for permitting the outflow of a compressed gas from the exhaust chamber **(106)**,

wherein the compressor head **(100)** is adapted to draw a gas into the inlet port **(108)** and into the cavity **(120)** with the cavity **(120)** below the plurality of one-way intake values **(112, 114)**, pass through the plurality of one-way exhaust valves **(116, 118)** to the exhaust chamber **(106)** above the cavity **(120)** and pass through the outlet port **(110)**,

wherein the outlet port **(110)** of the compressor head **(100)** is coupled to the medical ventilator, and

wherein the compressor head **(100)** allows a gas to be drawn into the inlet port **(108)** and into the cavity **(120)** below the plurality of one-way intake values **(112,114)**, pass through the plurality of one-way exhaust valves **(116, 118)** juxtaposed and directly adjacent to one another to the exhaust chamber **(106)** above the cavity **(120)** and pass through the outlet port **(110)** to the medical ventilator.

2. The compressor head **(100)** of claim 1, wherein fluid flow communication is permitted from the first open end **(146)** to the second open end **(148)** of the plurality of conduits **(144)**.

3. The compressor head **(100)** of claim 1, wherein fluid flow communication is prevented from the second open end **(148)** to the first open end **(146)** of the plurality of conduits **(144)** by the flapper portion **(136)**.

4. The compressor head **(100)** of claim 1, wherein each of the plurality of one-way exhaust valves **(116, 118)** comprises:

a body defining a plurality of conduits **(145)** having a first open end **(147)** and a second open end **(149)**, wherein the second open end **(149)** is configured to be engaged to a flapper portion **(138)** for preventing fluid flow communication in one direction and at least partially disengaged from the flapper portion **(138)** for permitting fluid flow communication in an opposite direction.

5. The compressor head **(100)** of claim 4, wherein fluid flow communication is permitted from the first open end **(147)** to the second open end **(149)** of the plurality of conduits **(145)**.

6. The compressor head **(100)** of claim 4, wherein fluid flow communication is prevented from the second open end **(149)** to the first open end **(147)** of the plurality of conduits **(145)** by the flapper portion **(138)**.

7. The compressor head **(100)** of claim 1, wherein the gas flow from the outlet port **(110)** is in the range of 4 liters per minute to 90 liters per minute.

8. The compressor head **(100)** of claim 1, wherein the plurality of one-way intake valves **(112, 114)** are oriented such that the flapper portion **(136)** engaged to each of the plurality of one-way intake valves **(112, 114)** is in communication with the cavity **(120)**.

9. The compressor head **(100)** of claim 4, wherein the plurality of one-way exhaust valves **(116, 118)** are oriented such that the flapper portion **(138)** engaged to each of the plurality of one-way exhaust valves **(116, 118)** is in communication with the exhaust chamber **(106)**.

10. The compressor head **(100)** of claim 1, wherein the outlet port **(110)** includes a recess **(121)** configured to engage a first sealing element **(122)**.

11. The compressor head **(100)** of claim 1, wherein the inlet port **(108)** includes a recess **(121)** configured to engage a second sealing element **(122)**.

12. The compressor head **(100)** of claim 1, wherein the cavity **(120)** is configured to engage a diaphragm for compressing the fluid.

13. The compressor head **(100)** of claim 12, wherein the diaphragm moves in a reciprocating motion relative to the cavity **(120)** for drawing in the fluid into the cavity **(120)** from the intake chamber **(104)** via the plurality of one-way intake valves **(112, 114)**.

14. The compressor head **(100)** of claim 13, wherein the diaphragm moves in a reciprocating motion relative to the cavity **(120)** to force the fluid into the exhaust chamber **(106)** from the cavity **(120)** via the plurality of one-way exhaust valves **(116, 118)**.

15. The compressor head **(100)** of claim 16, wherein each of the pair of one-way exhaust valves **(116, 118)** comprises:

a body defining a plurality of conduits **(145)** having a first open end **(147)** and a second open end **(149)**, wherein the second open end **(149)** is configured to be engaged to a biased closed valve **(138)** for preventing fluid flow communication in one direction and at least partially disengaged from the biased closed valve **(138)** for permitting fluid flow communication in an opposite direction.

16. A method of manufacturing a compressor head **(100)** for use with a medical ventilator comprising: forming a casing **(102)** having an intake chamber **(104)** and an exhaust chamber **(106)**;

forming an inlet port **(108)** in communication with the intake chamber **(104)** and an outlet port **(110)** in communication with the exhaust chamber **(106)**;

forming a pair of one-way intake valves **(112, 114)** between the intake chamber and the exhaust chamber **(106)** wherein each of the pair of one-way intake valves **(112, 114)** comprises:

a body defining a plurality of conduits **(144)** having a first open end **(146)** and a second open end **(148)**, wherein the second open end **(148)** is configured to be engaged to a flapper portion **(136)** for preventing fluid flow communication in one direction and at least partially disengaged from the flapper portion **(136)** for permitting fluid flow communication in an opposite direction;

forming a pair of one-way exhaust valves **(116, 118)** between the intake chamber **(104)** and the cavity **(120)**, the pair of one-way exhaust valves **(116,118)** juxtaposed and directly adjacent one another; and

coupling the outlet port **(110)** to the medical ventilator to allow the fluid flow communication from the intake chamber **(104)** through the pair of one-way exhaust valves **(112, 114)** juxtaposed and directly adjacent to one another to the medical ventilator.

17. The method of claim 16, wherein forming the casing **(102)** comprises using at least one of a milling process, a molding process, and a die-caste process.

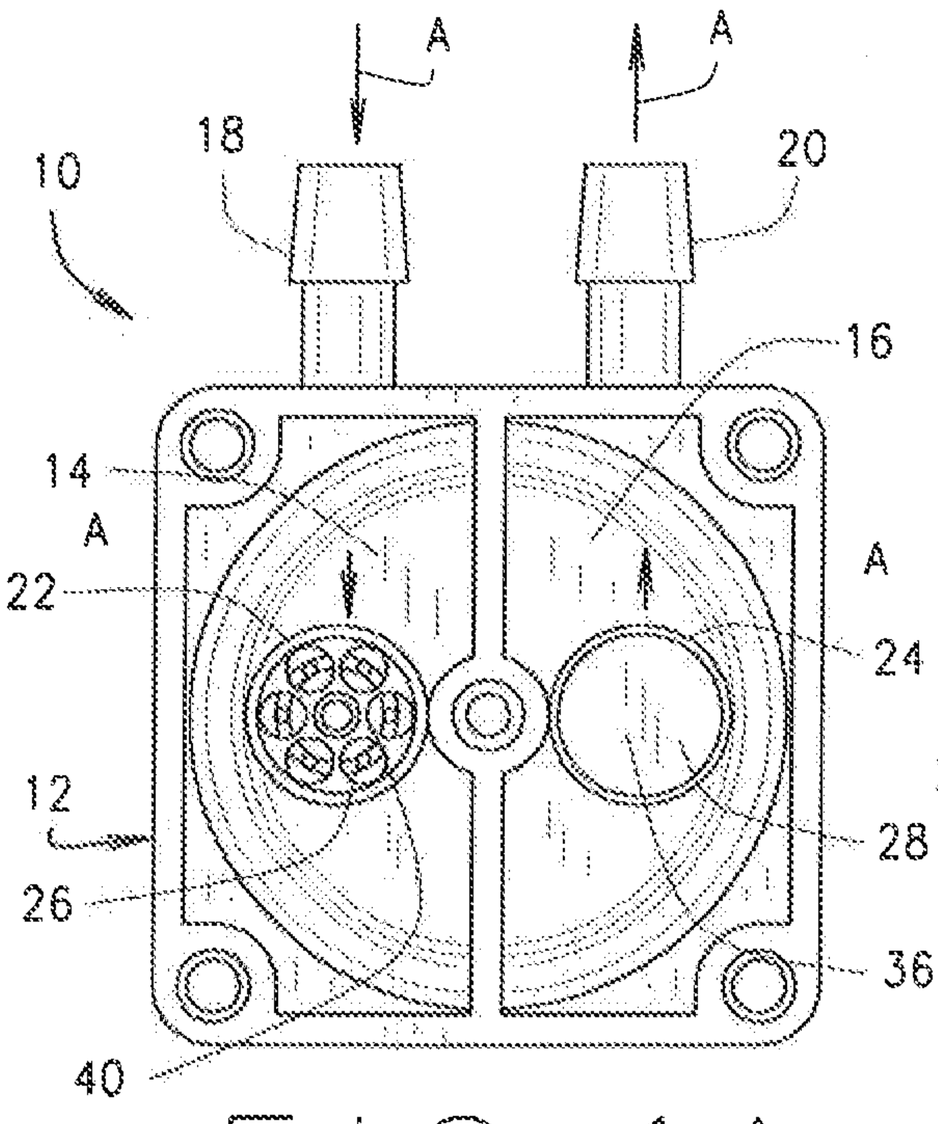



FIG. 1A
PRIOR ART

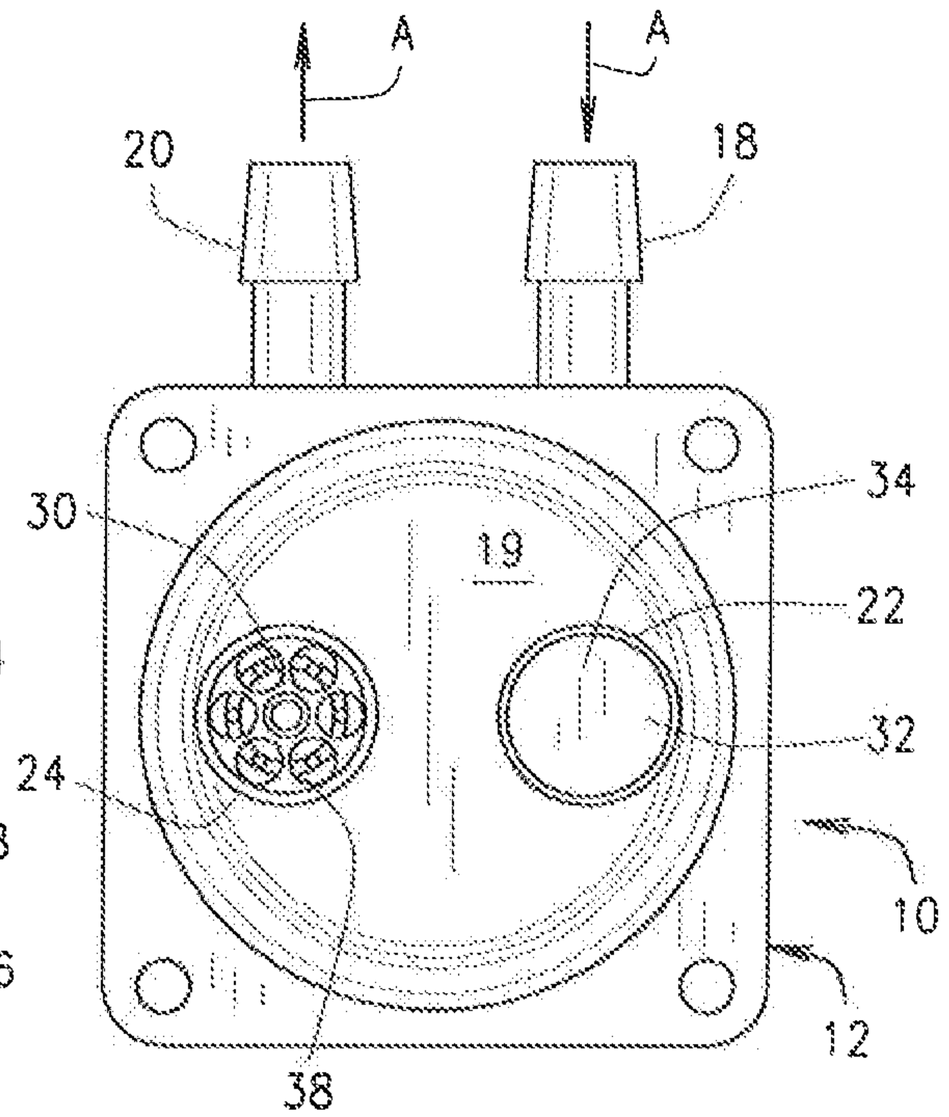



FIG. 1B
PRIOR ART

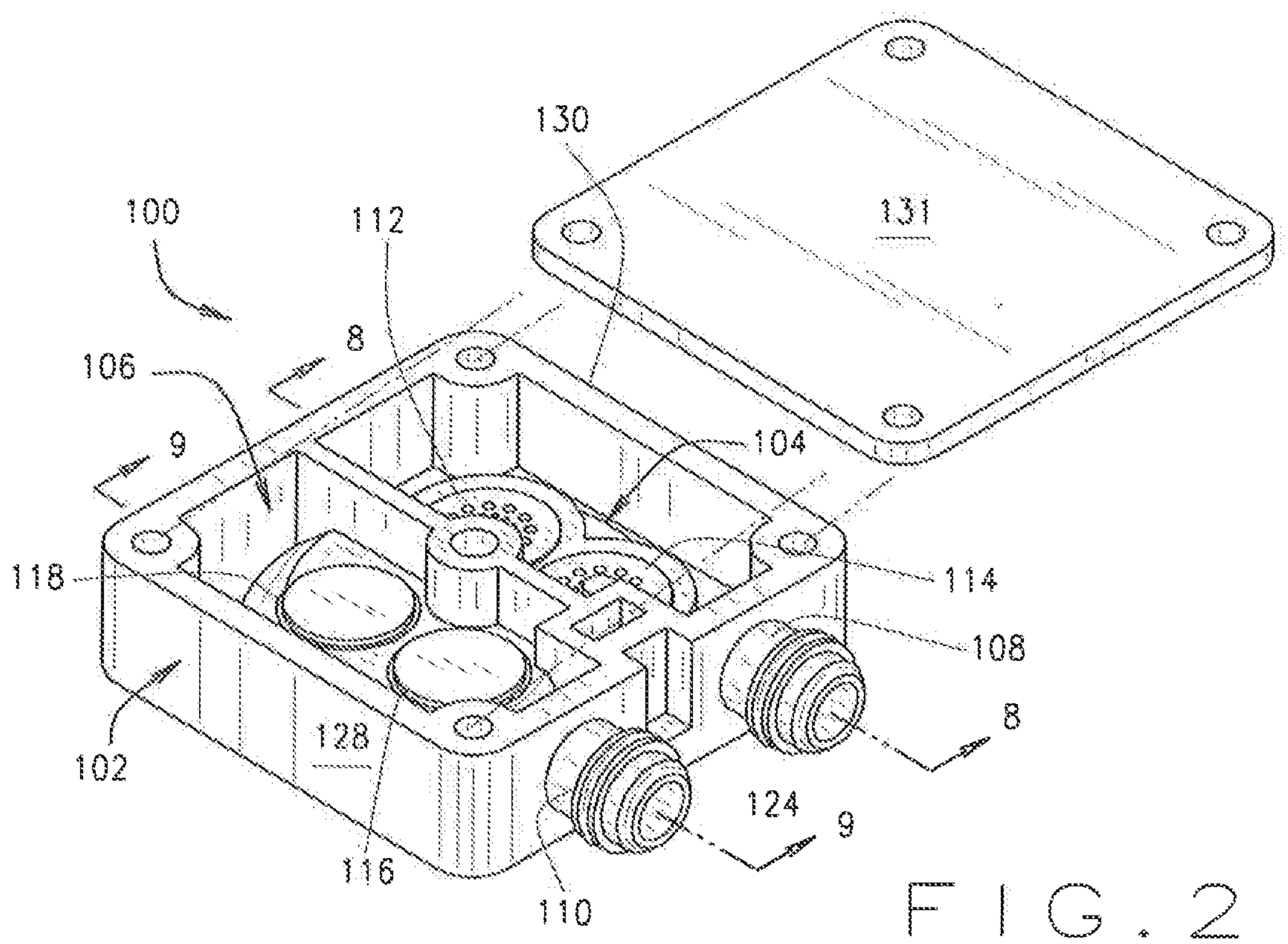



FIG. 2

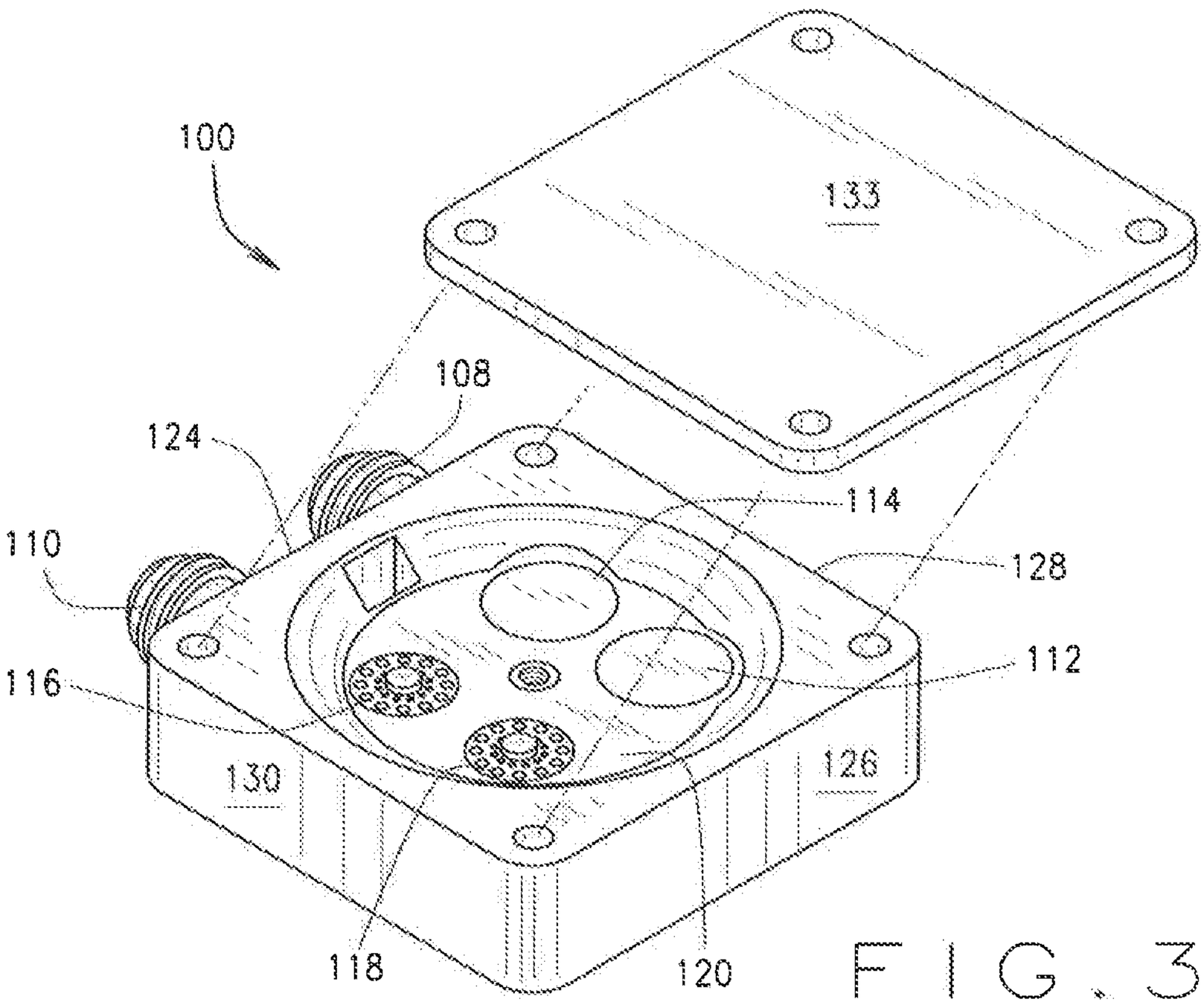



FIG. 3

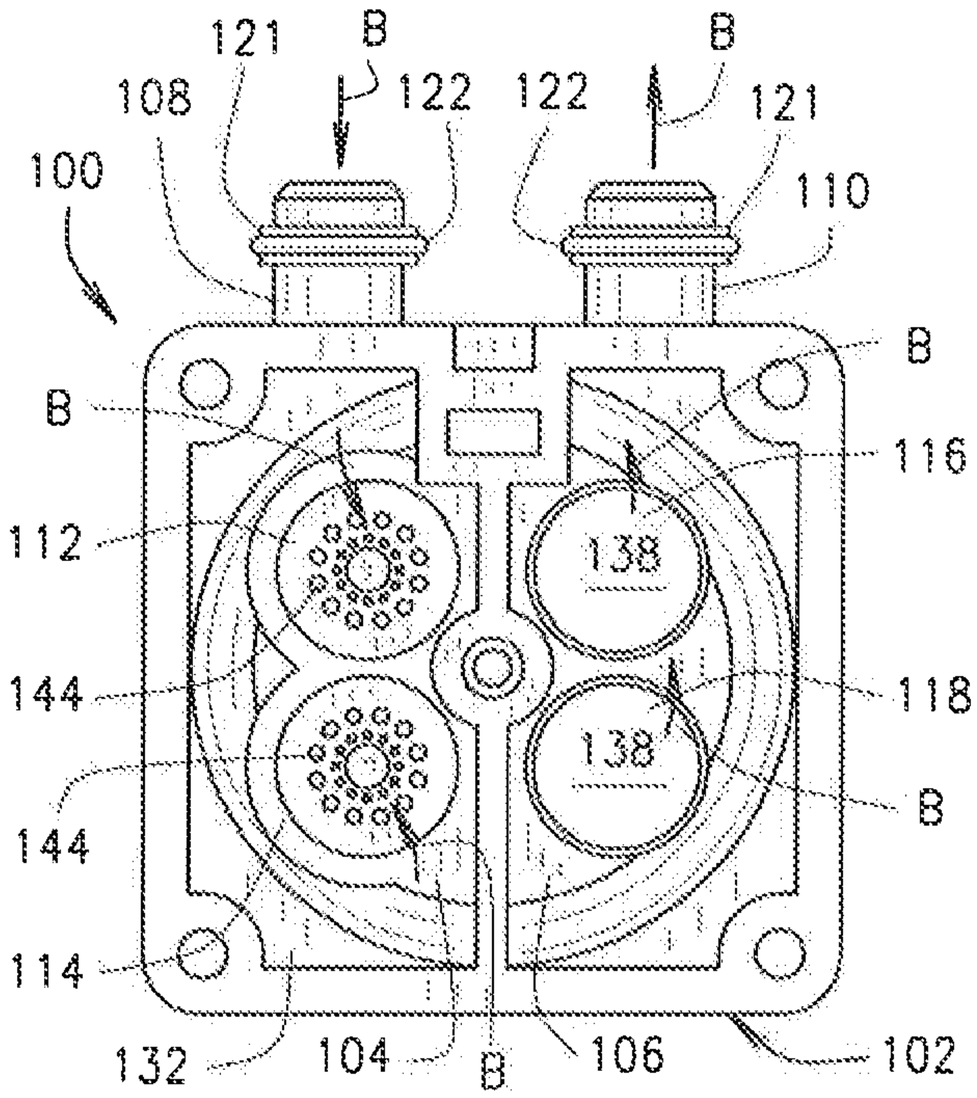



FIG. 4

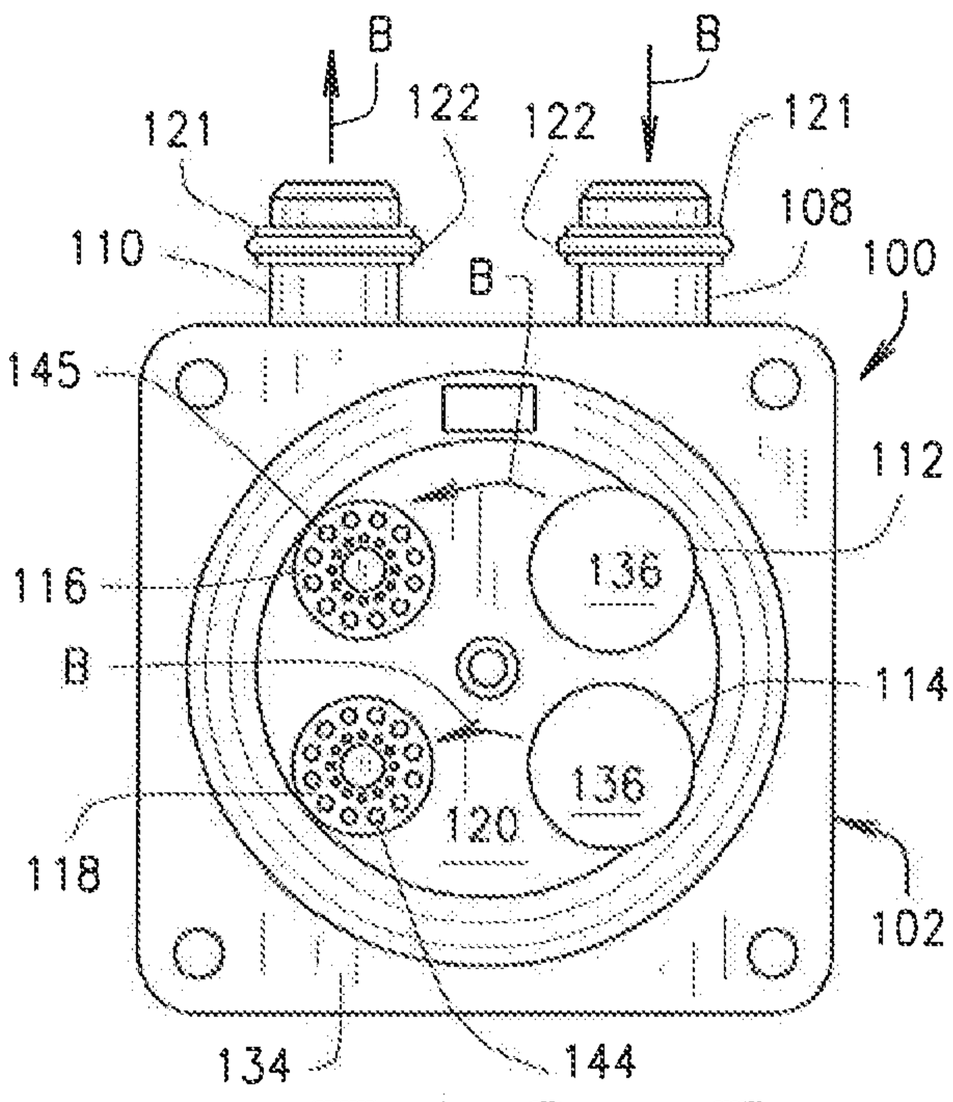



FIG. 5

REPLACEMENT SHEET

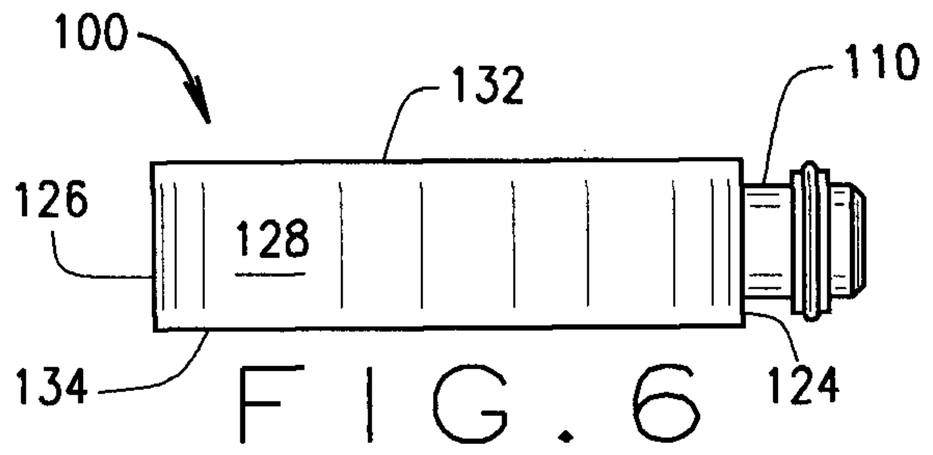



FIG. 6

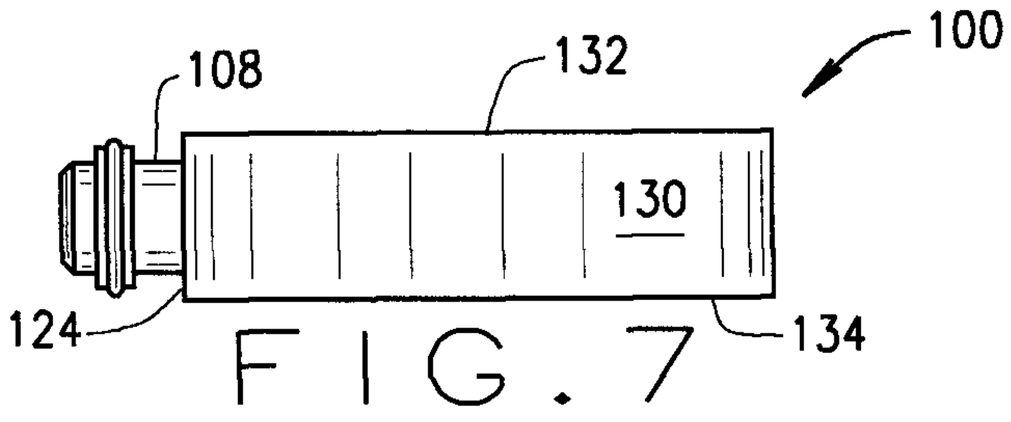



FIG. 7

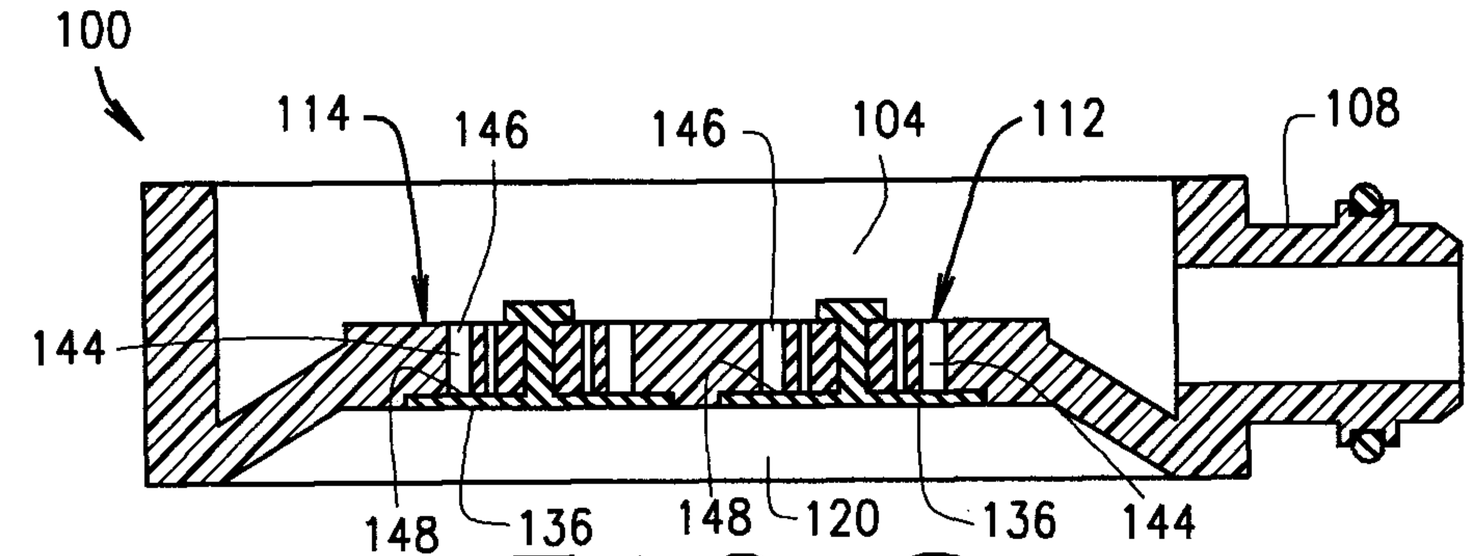



FIG. 8

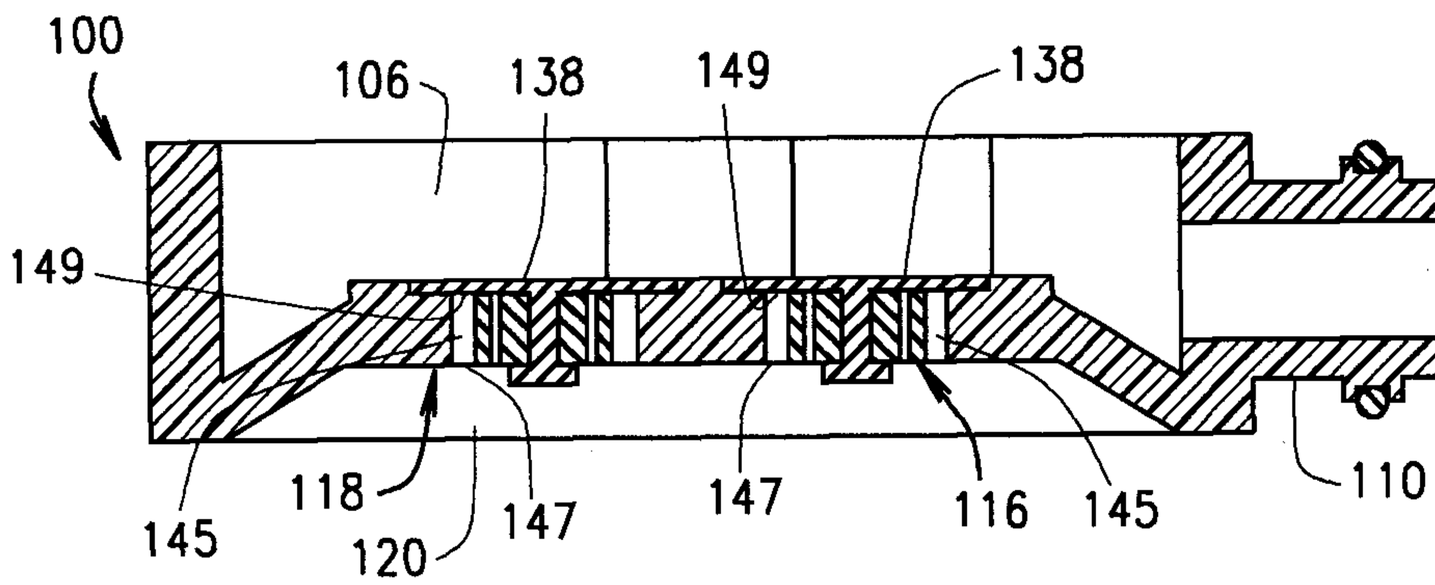



FIG. 9

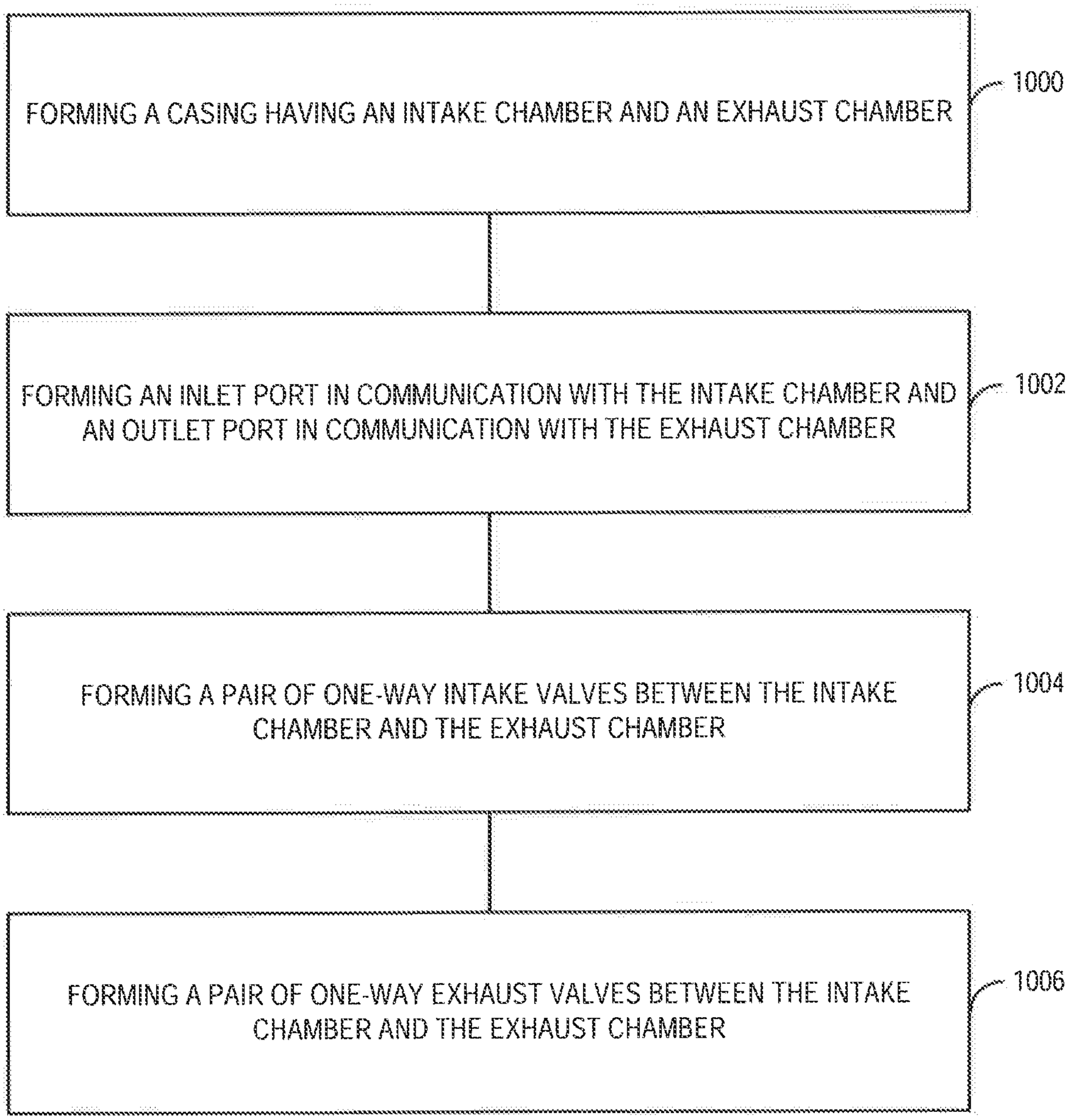

FORMING A CASING HAVING AN INTAKE CHAMBER AND AN EXHAUST CHAMBER
1000
FORMING AN INLET PORT IN COMMUNICATION WITH THE INTAKE CHAMBER AND AN OUTLET PORT IN COMMUNICATION WITH THE EXHAUST CHAMBER
1002
FORMING A PAIR OF ONE-WAY INTAKE VALVES BETWEEN THE INTAKE CHAMBER AND THE EXHAUST CHAMBER
1004
FORMING A PAIR OF ONE-WAY EXHAUST VALVES BETWEEN THE INTAKE CHAMBER AND THE EXHAUST CHAMBER
1006

FIG. 10

REPLACEMENT SHEET

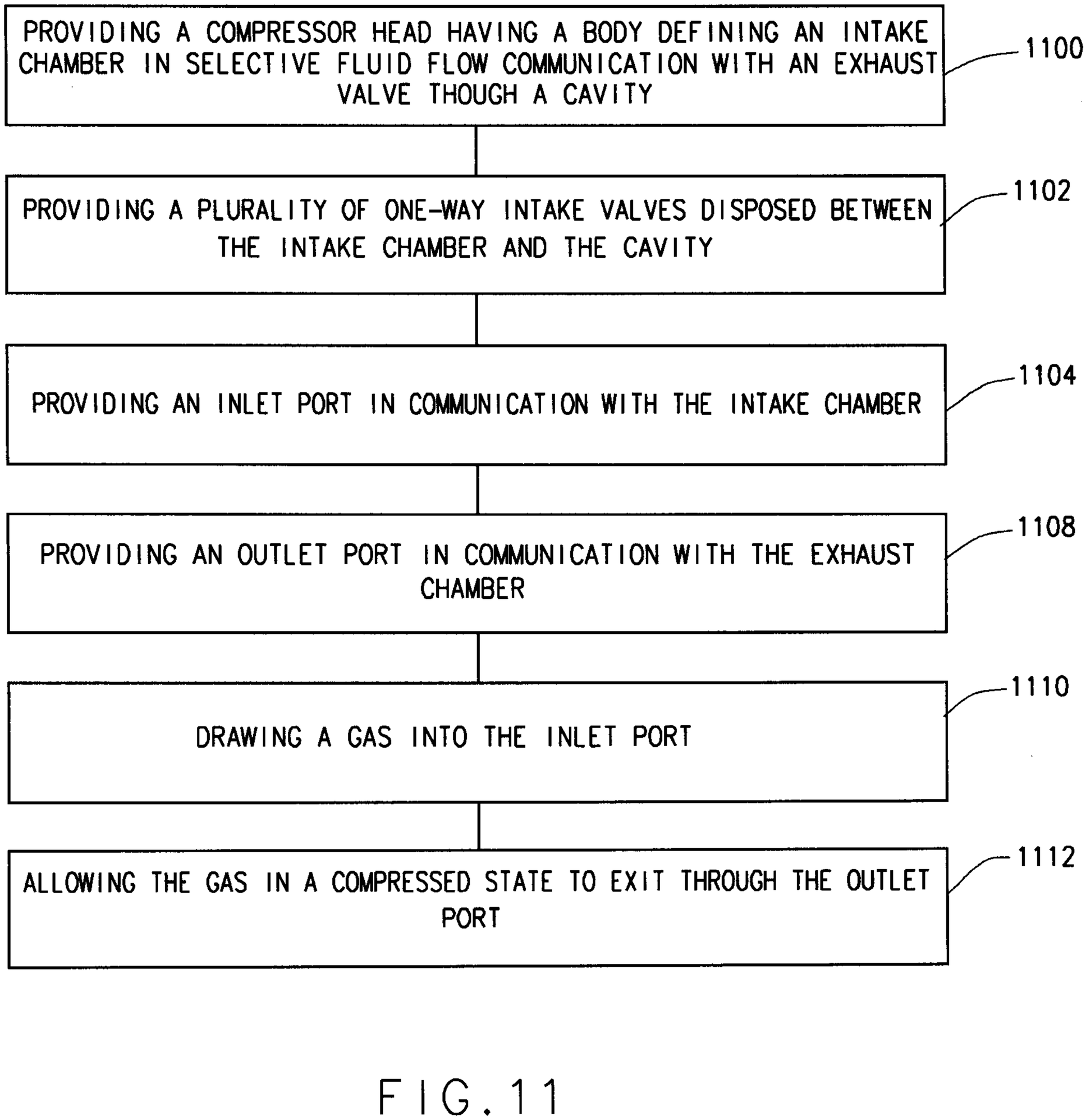
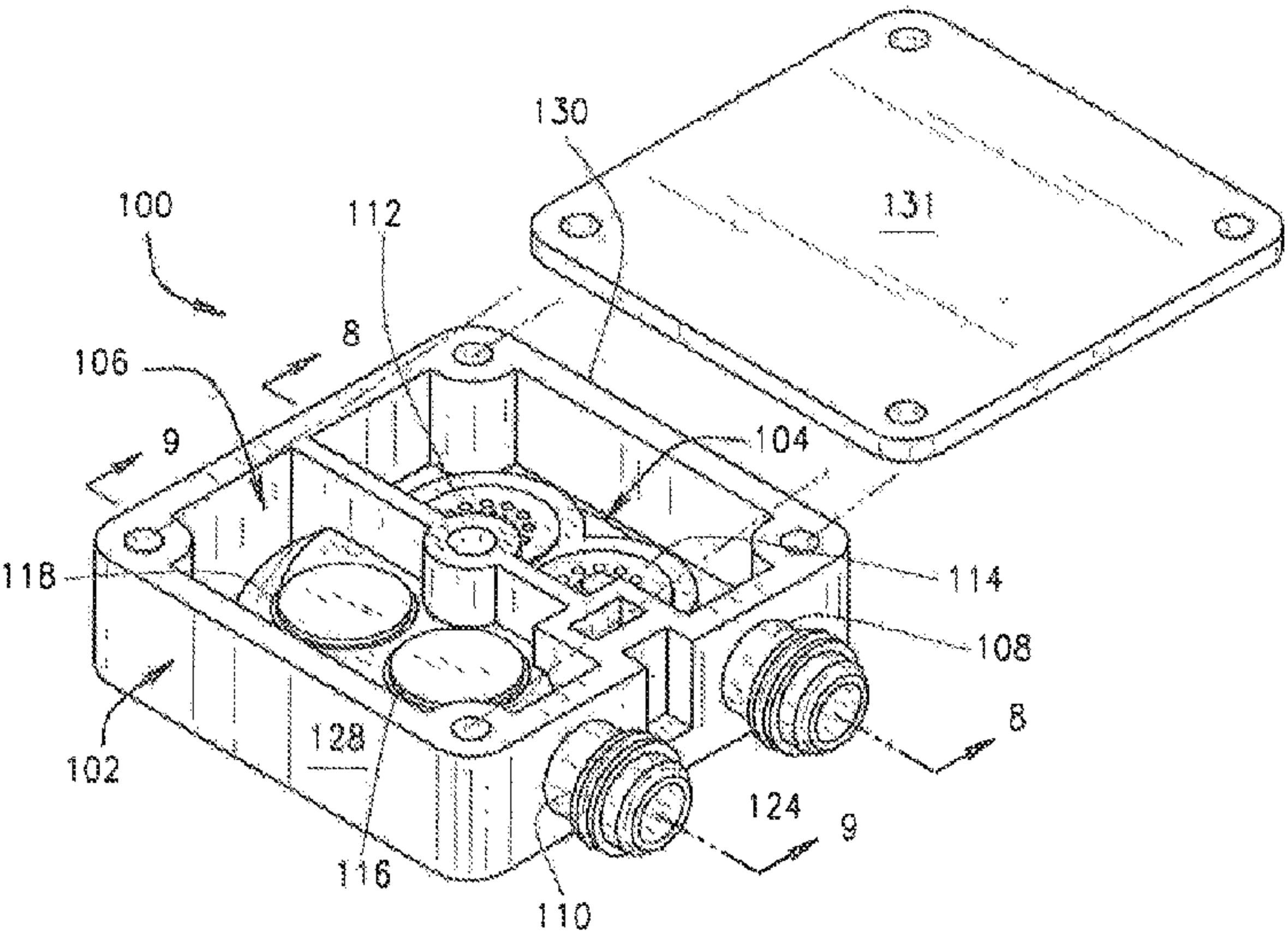



FIG.11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