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(54) **SYSTEM FOR FLUIDIZING SOLID FEEDSTOCK FROM A SOLID FEED PUMP**

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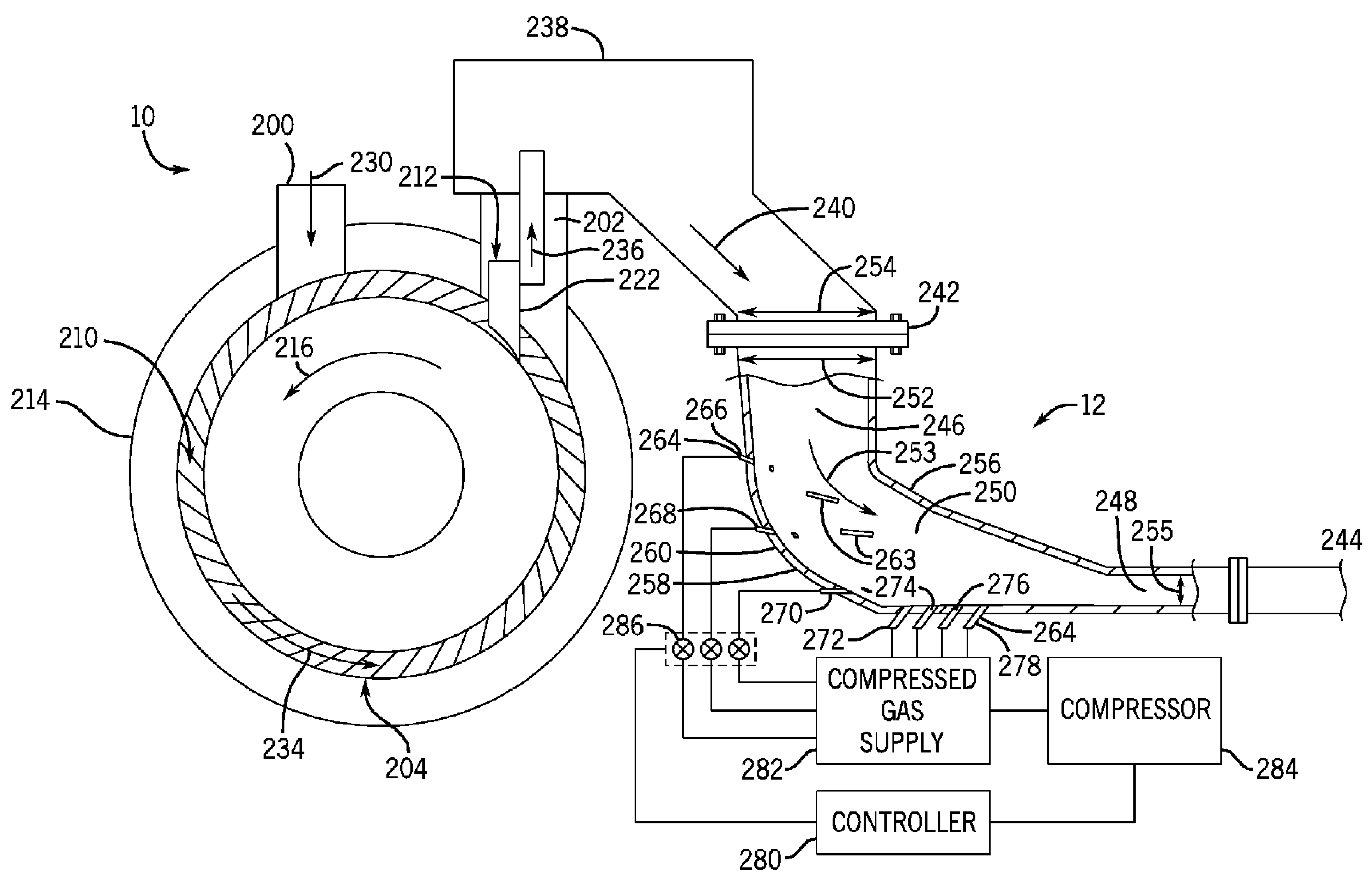
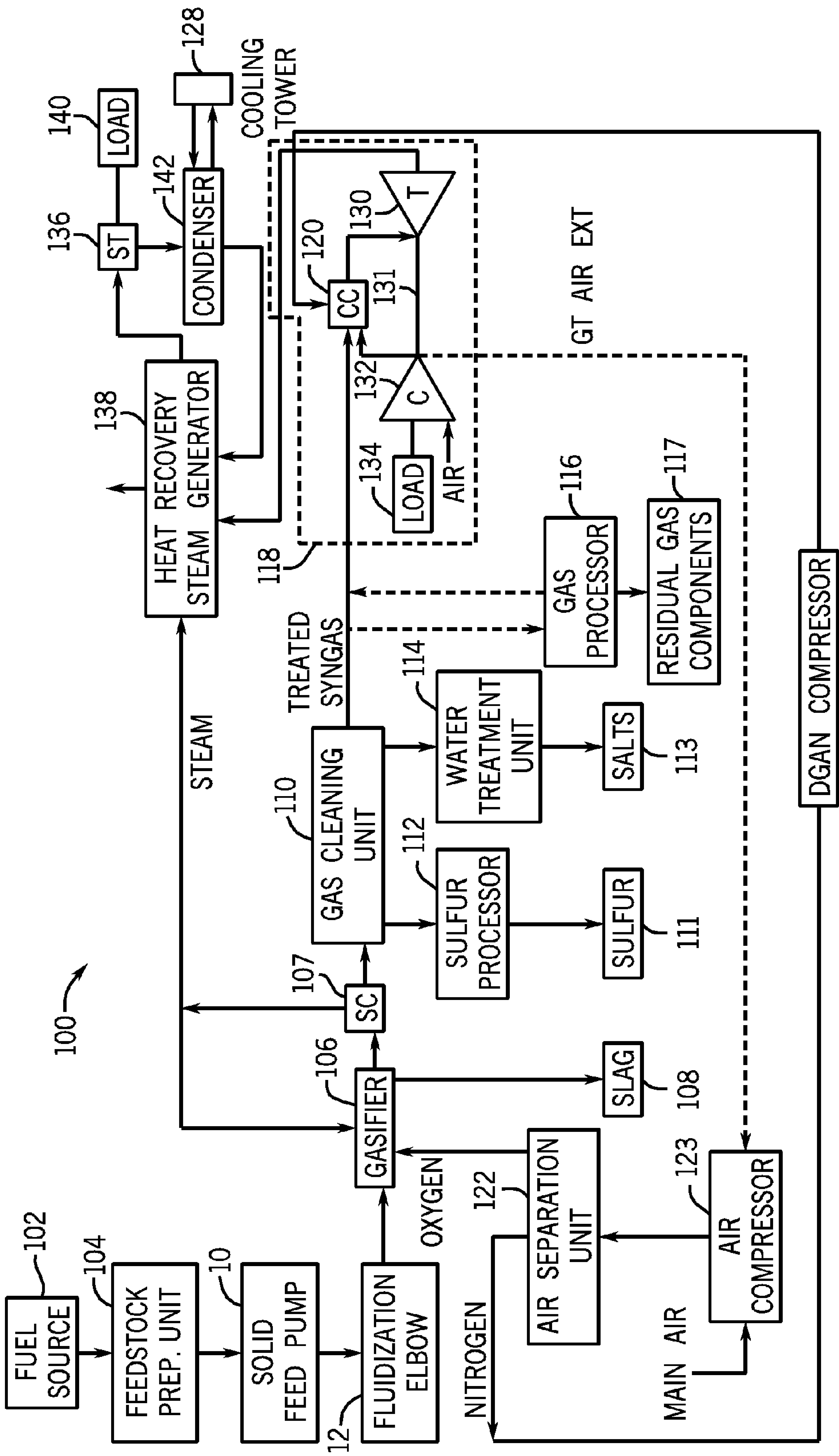
(52) **U.S. Cl.** **417/85**

(57) **ABSTRACT**

According to various embodiments, a system includes a fluidization elbow. The fluidization elbow includes an elbow inlet, an elbow outlet downstream from the elbow inlet, and an elbow body disposed between the elbow inlet and the elbow outlet, wherein the elbow body turns and converges from the elbow inlet toward the elbow outlet. The fluidization elbow also includes multiple gas nozzles coupled to the elbow body, wherein the multiple gas nozzles include injection axes that generally converge toward the elbow outlet.

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FUEL SOURCE
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FEEDSTOCK PREP. UNIT
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SOLID FEED PUMP
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FLUIDIZATION ELBOW
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OXYGEN
GASIFIER
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SLAG
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SC
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STEAM
GAS CLEANING UNIT
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SULFUR PROCESSOR
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SULFUR
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WATER TREATMENT UNIT
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SALTS
113
TREATED SYNGAS
GAS PROCESSOR
116
RESIDUAL GAS COMPONENTS
117
AIR SEPARATION UNIT
122
NITROGEN
AIR COMPRESSOR
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MAIN AIR
DGAN COMPRESSOR
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HEAT RECOVERY STEAM GENERATOR
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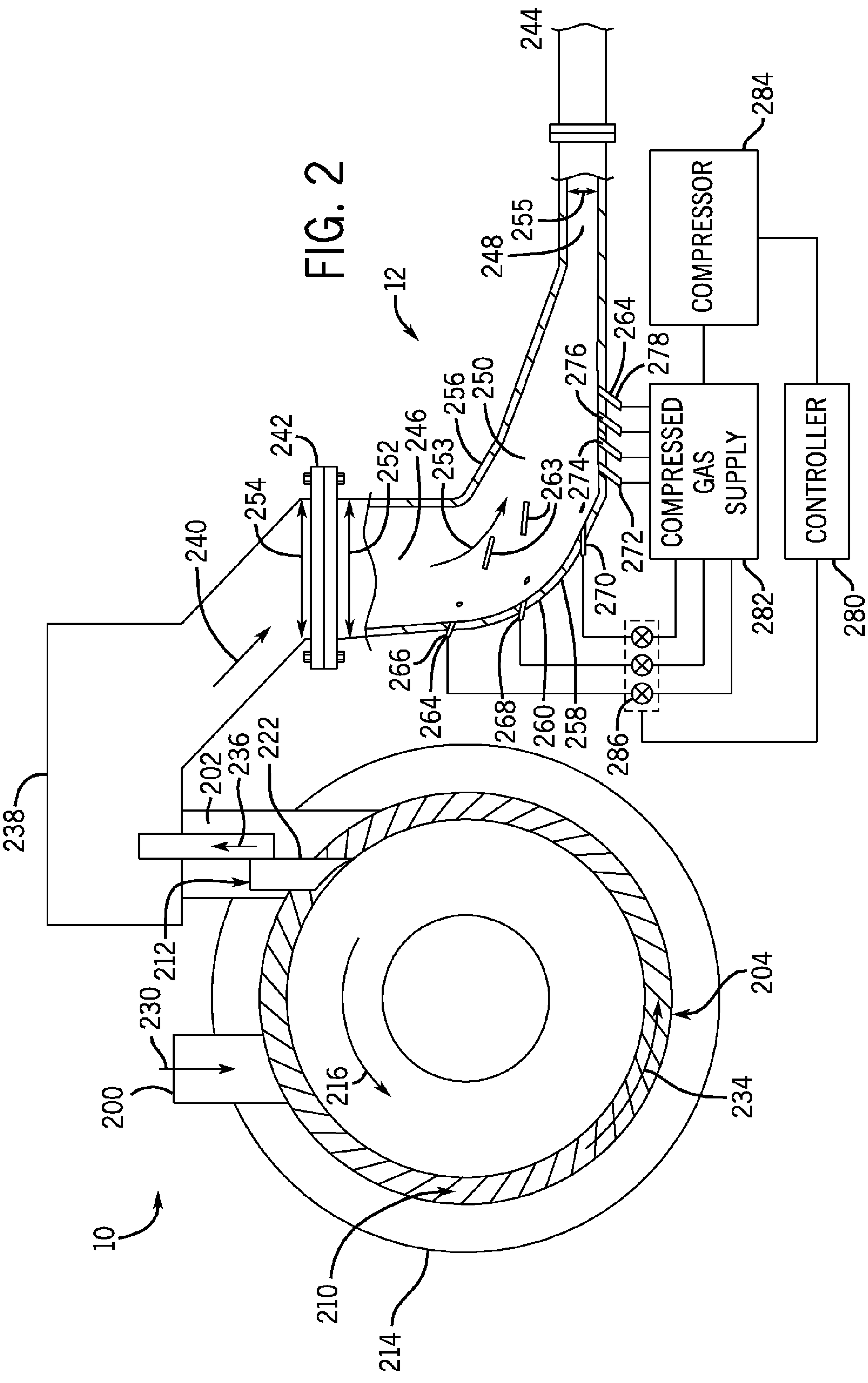
FIG. 1



COMPRESSOR
COMPRESSED GAS SUPPLY
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FIG. 2

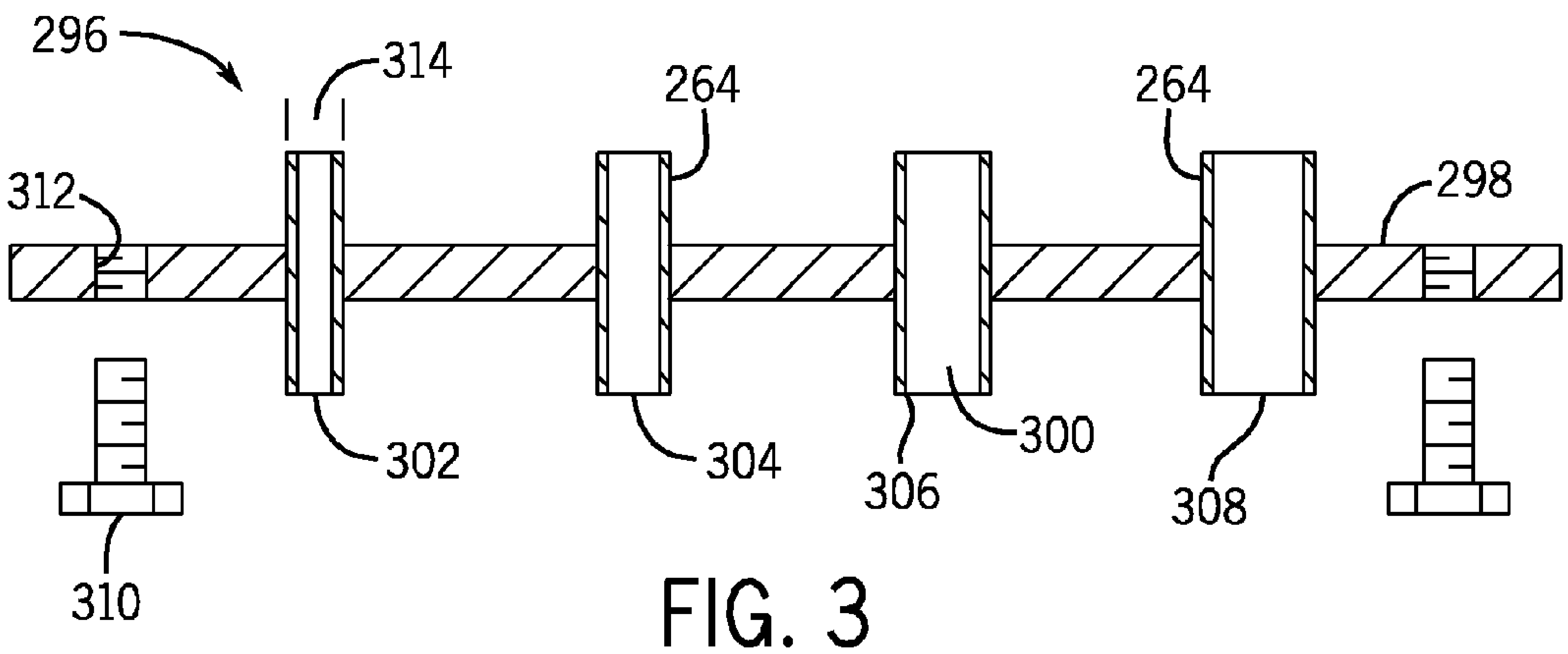

FIG. 3

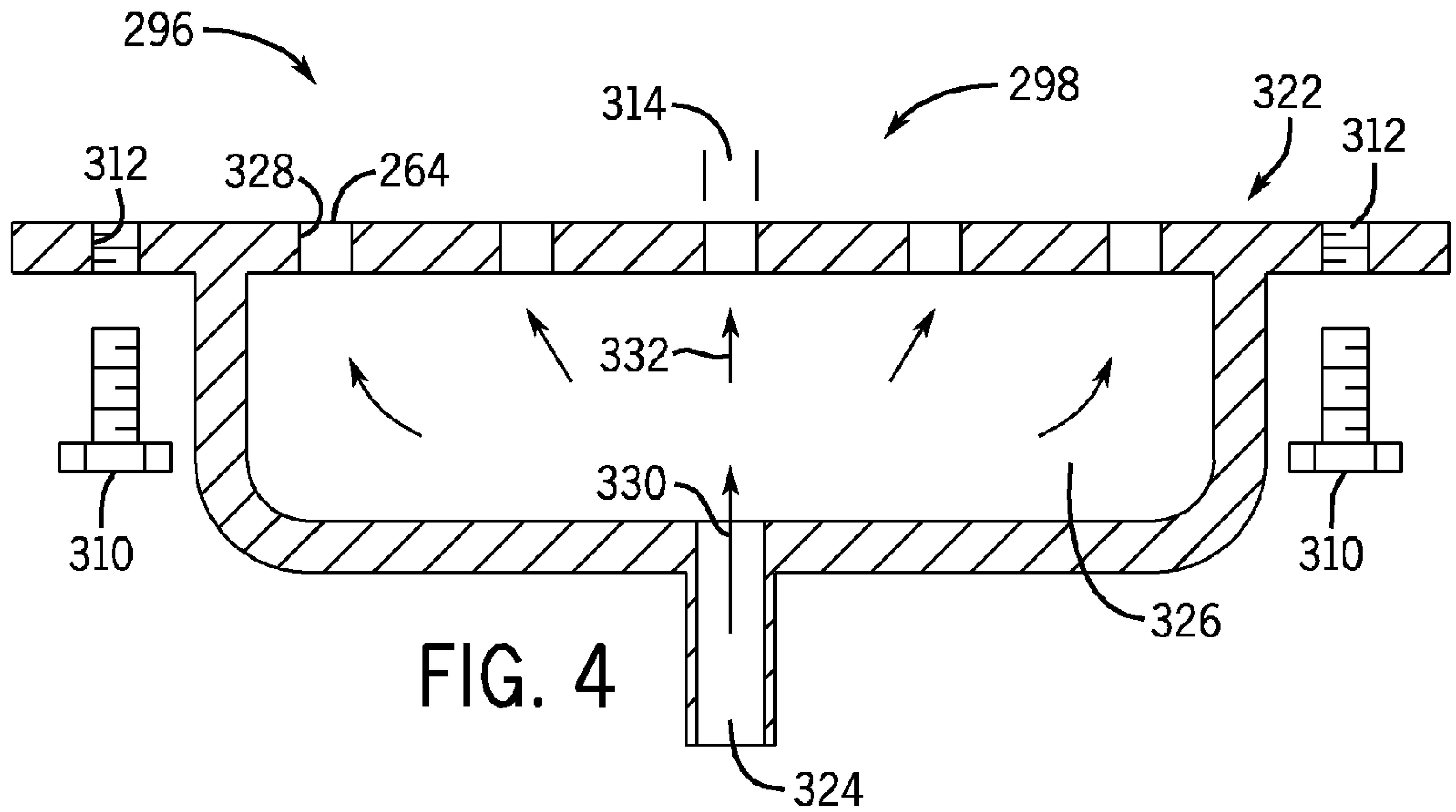

FIG. 4

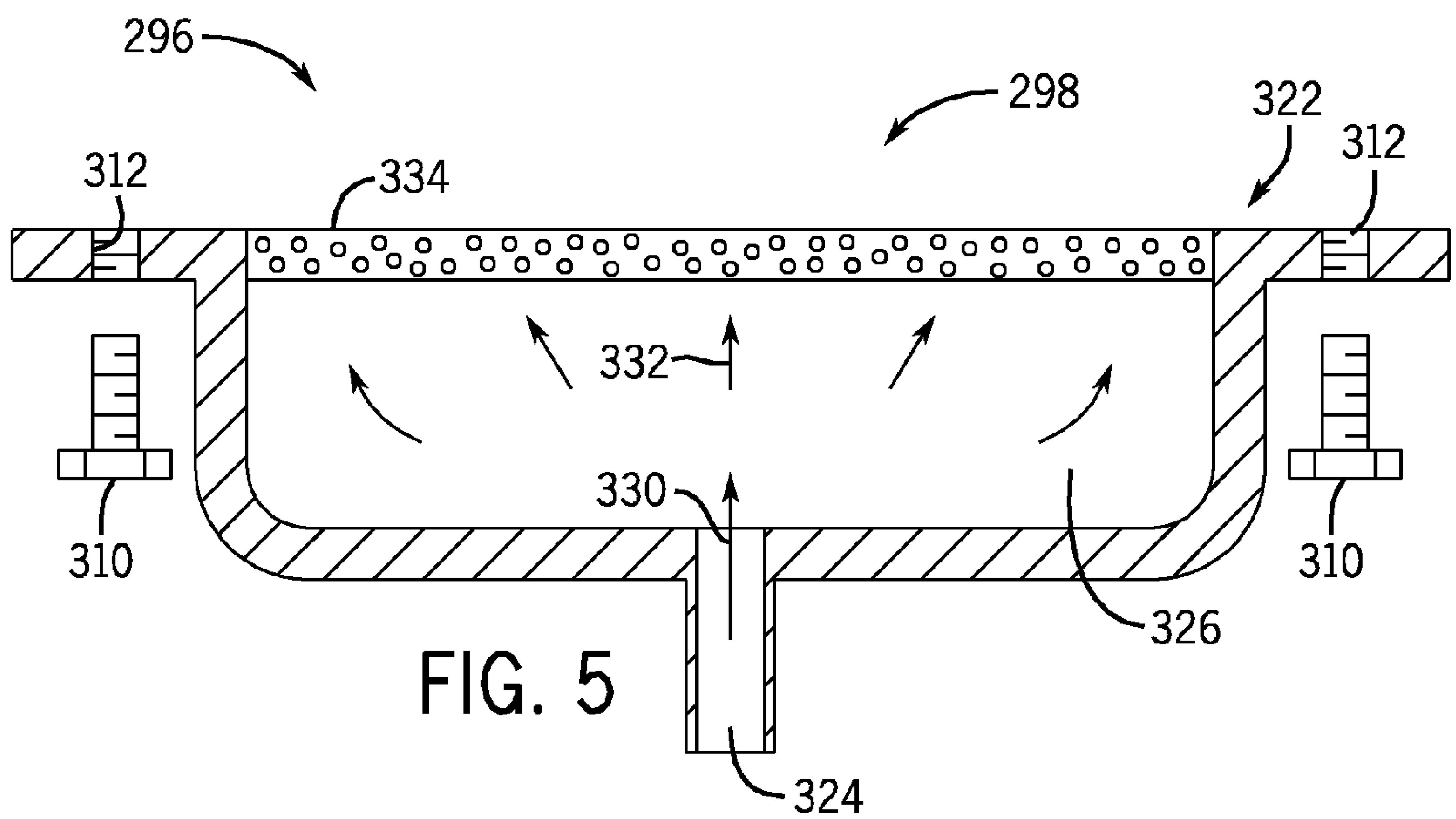

FIG. 5

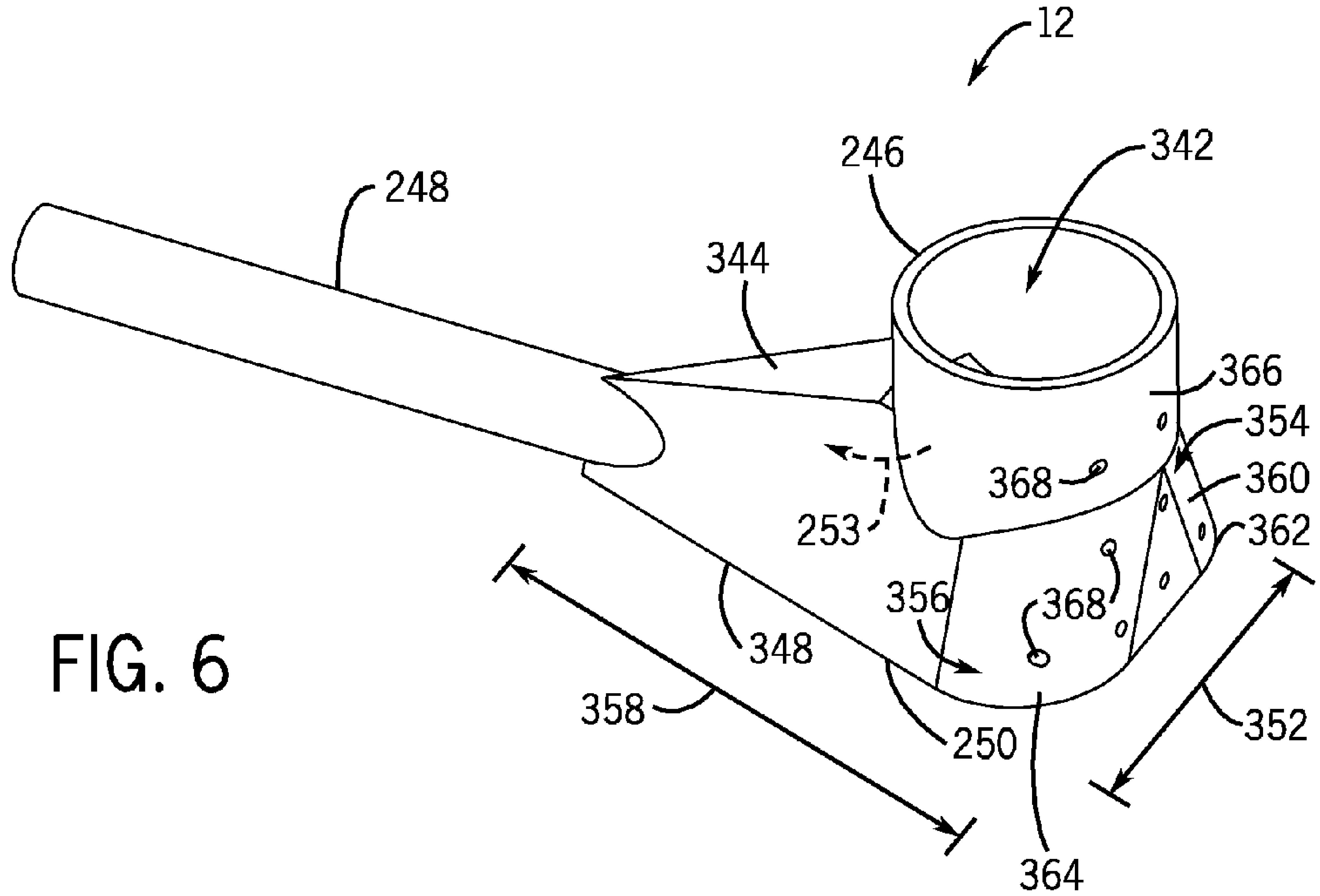
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FIG. 6

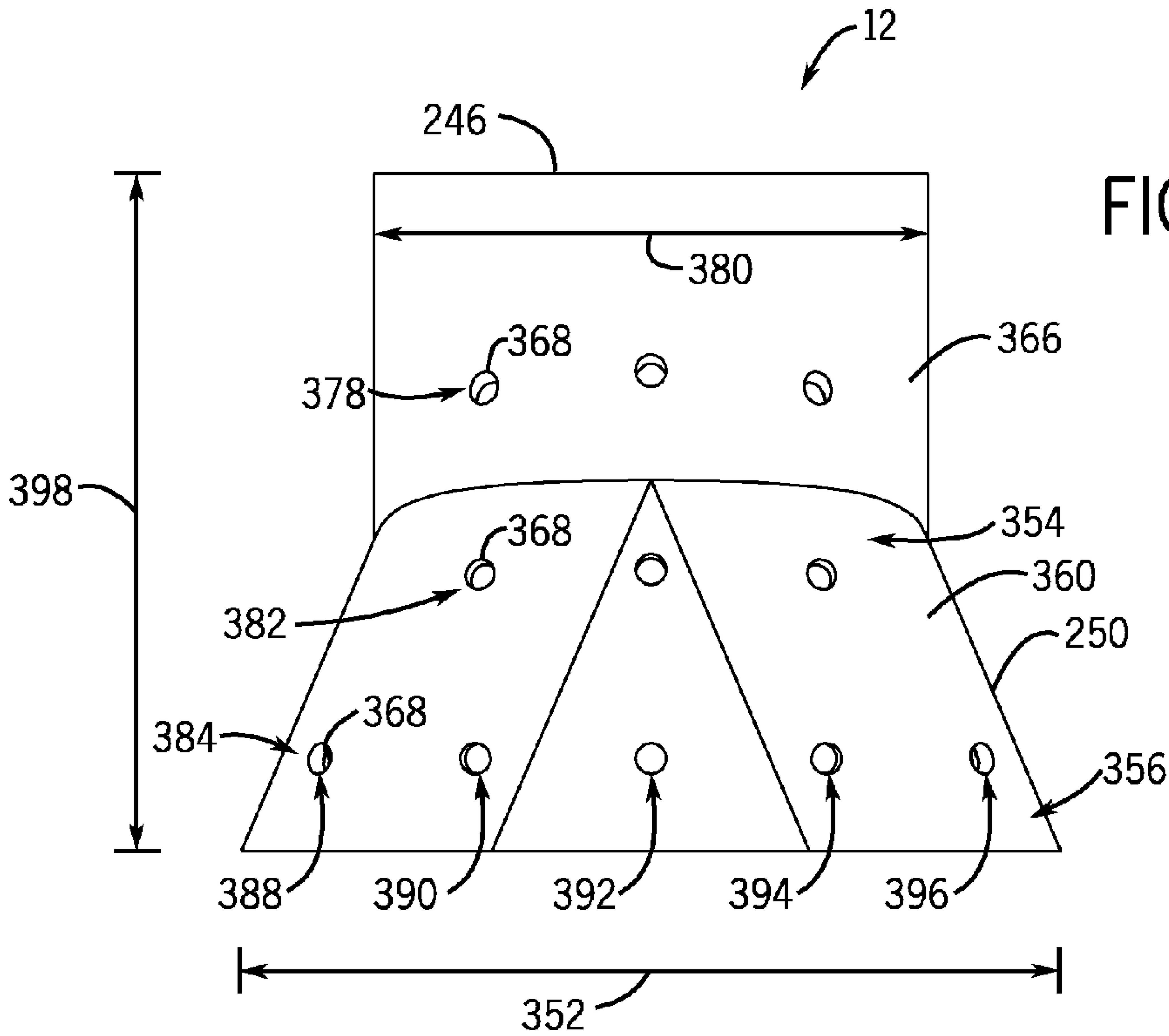
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FIG. 7

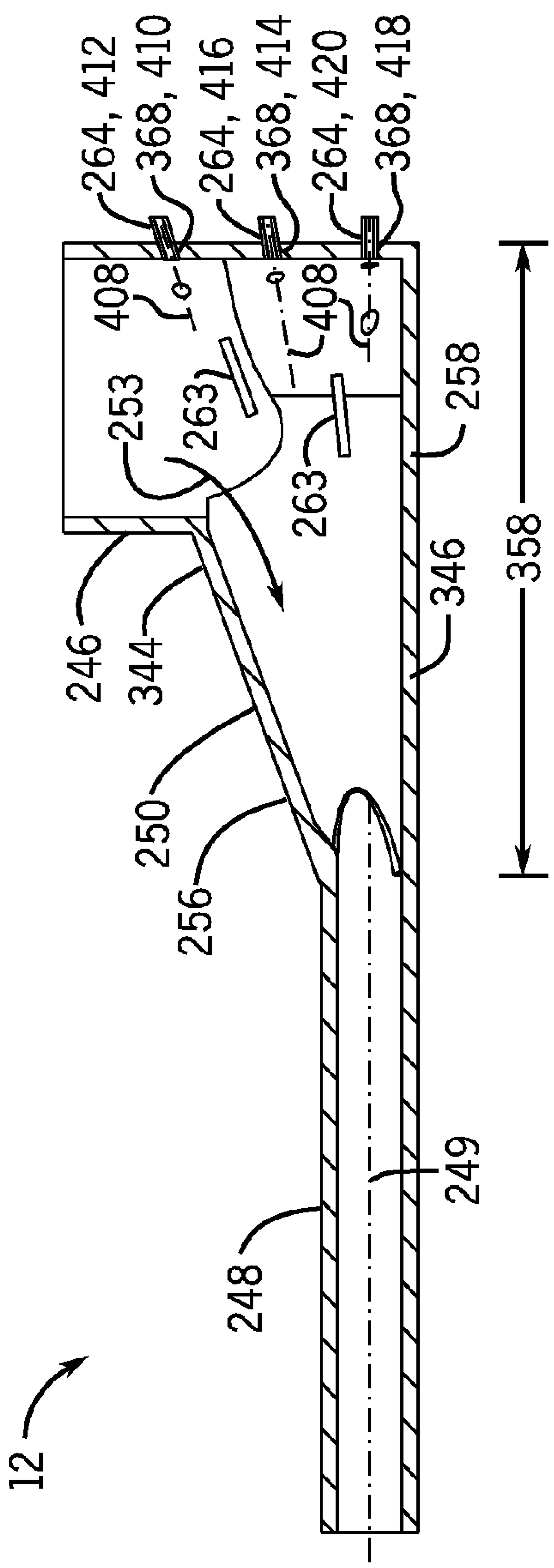
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FIG. 8

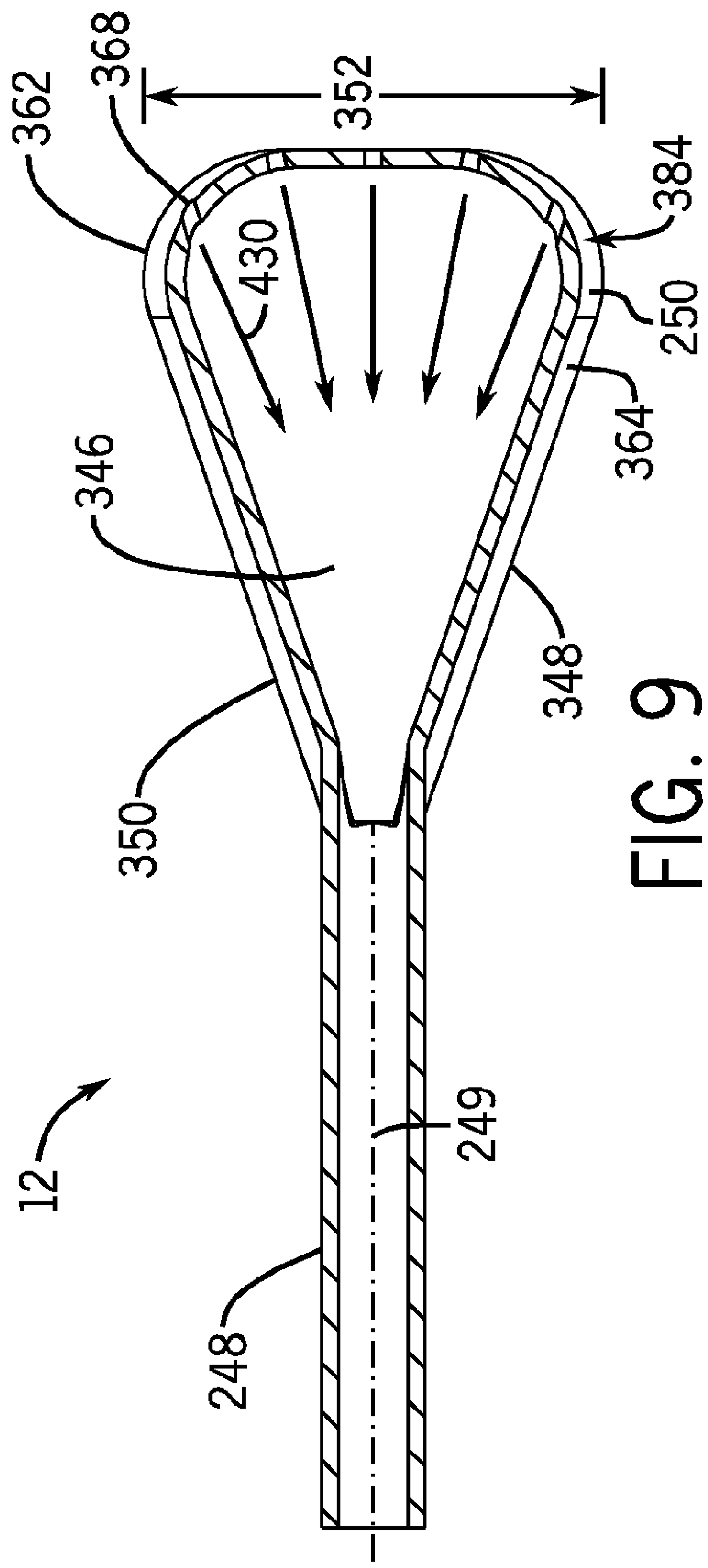
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FIG. 9

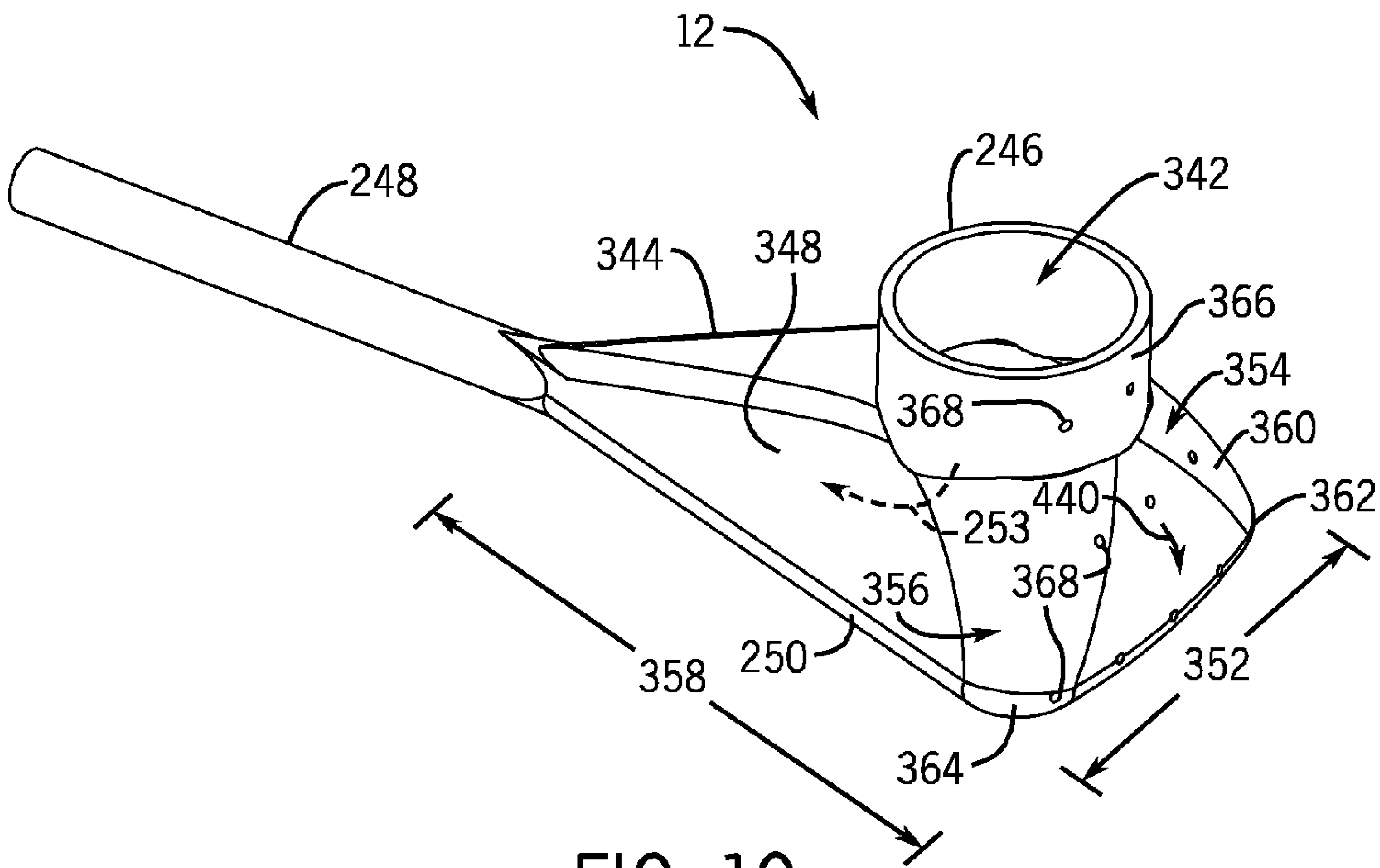
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FIG. 10

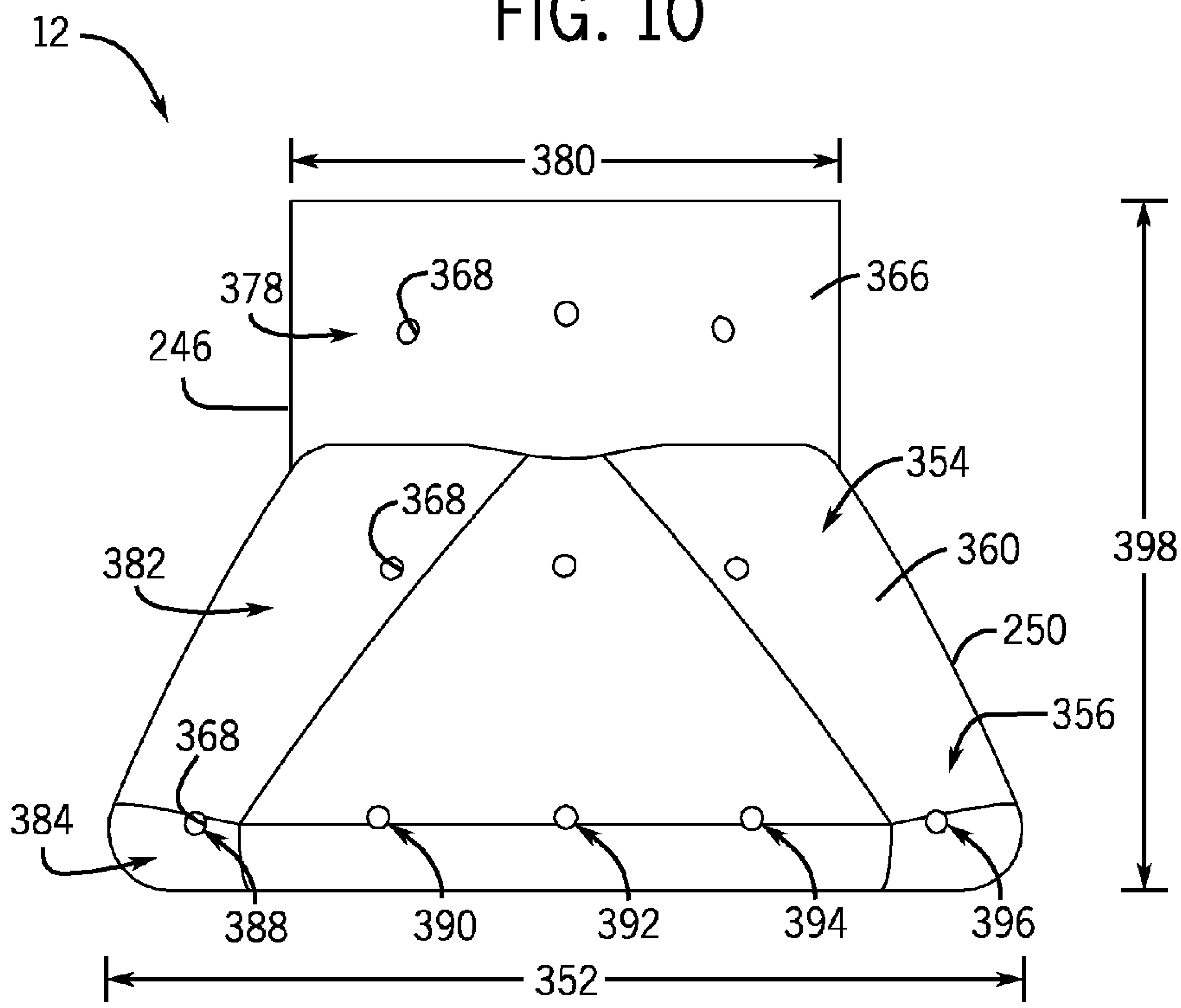
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FIG. 11

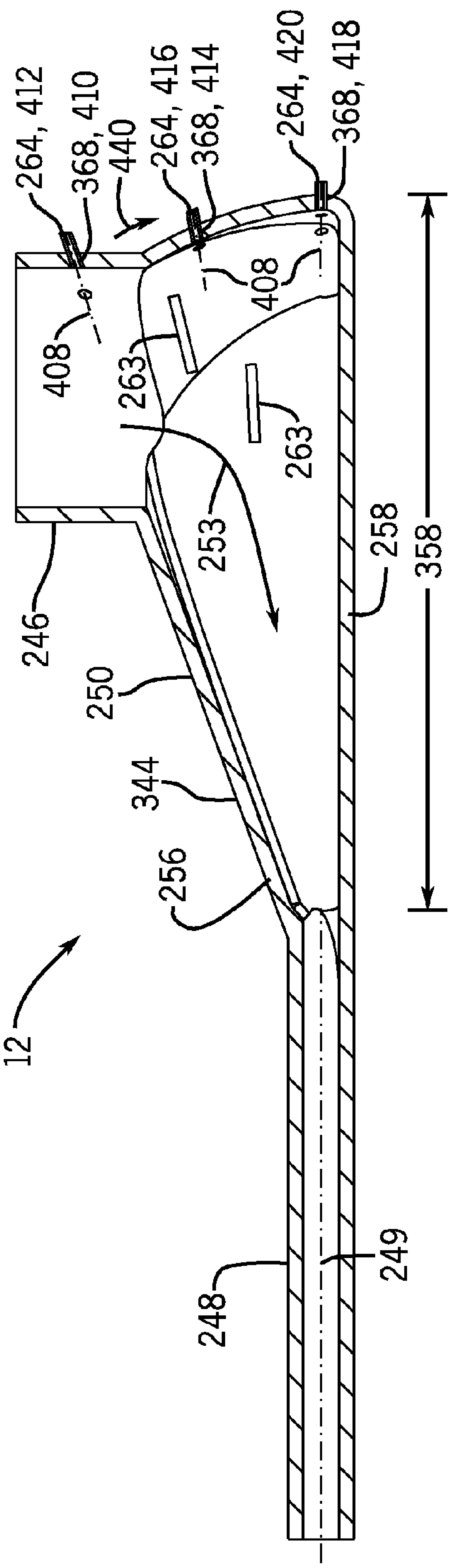
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FIG. 12

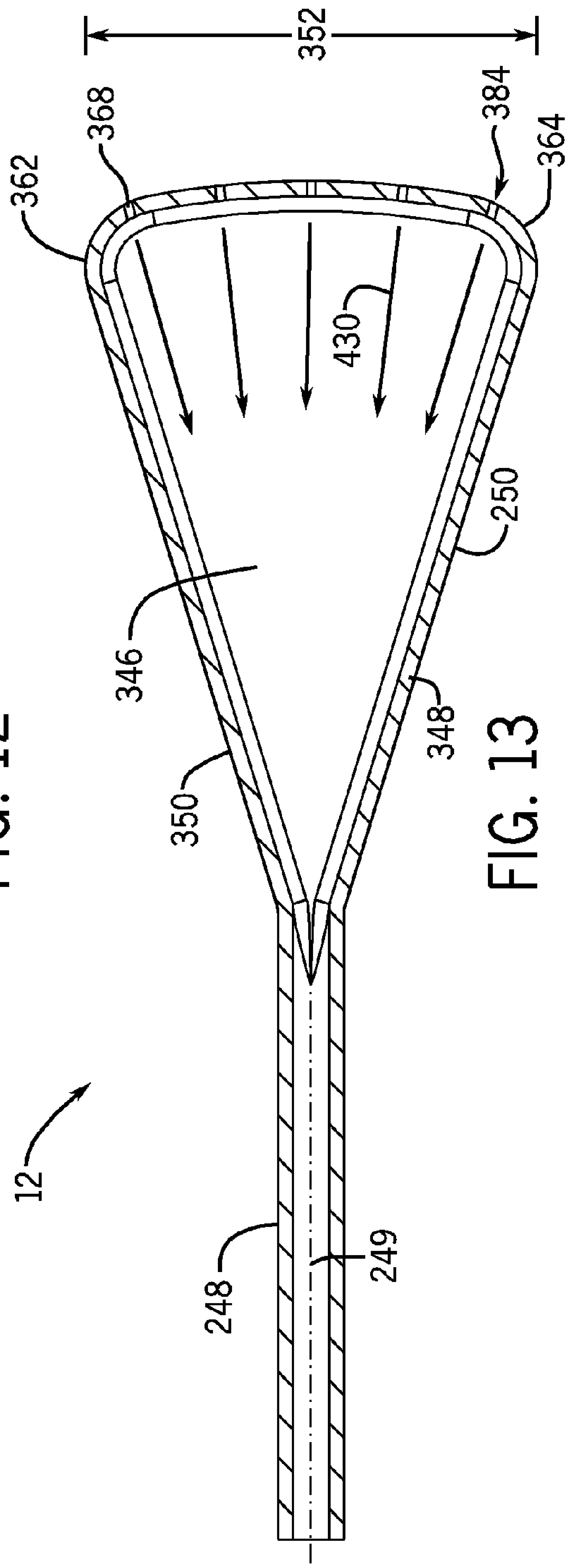
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FIG. 13

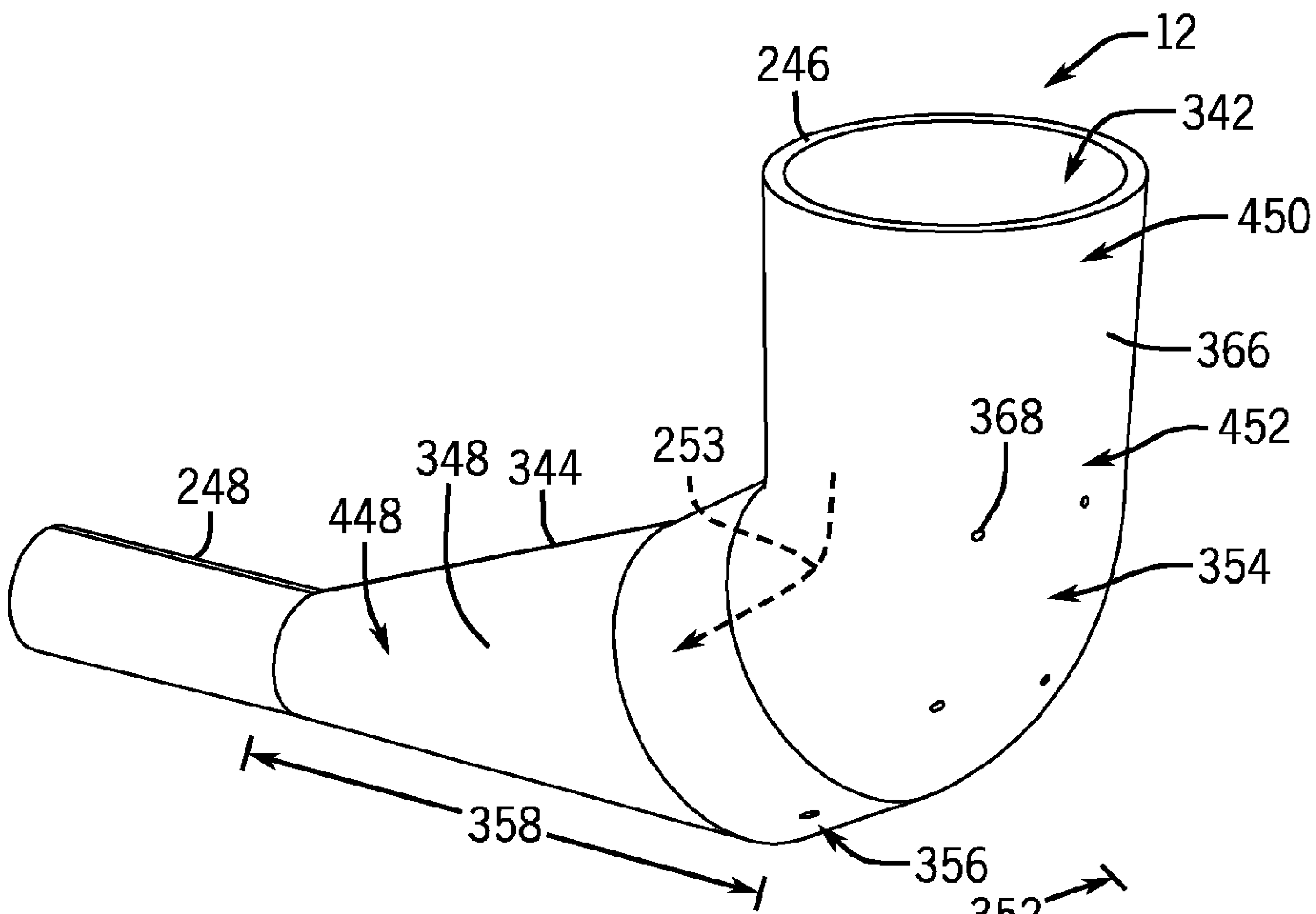
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FIG. 14

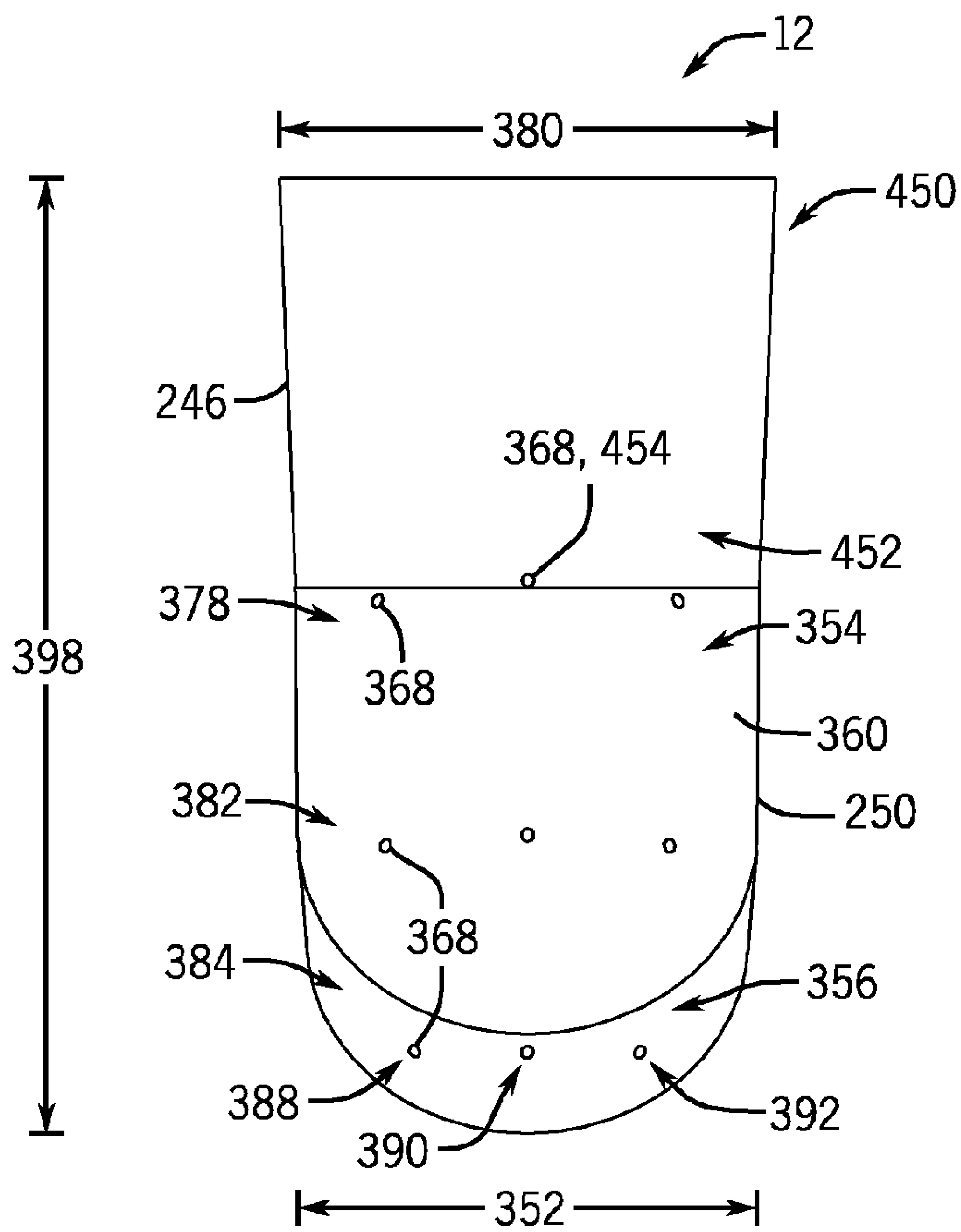
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FIG. 15

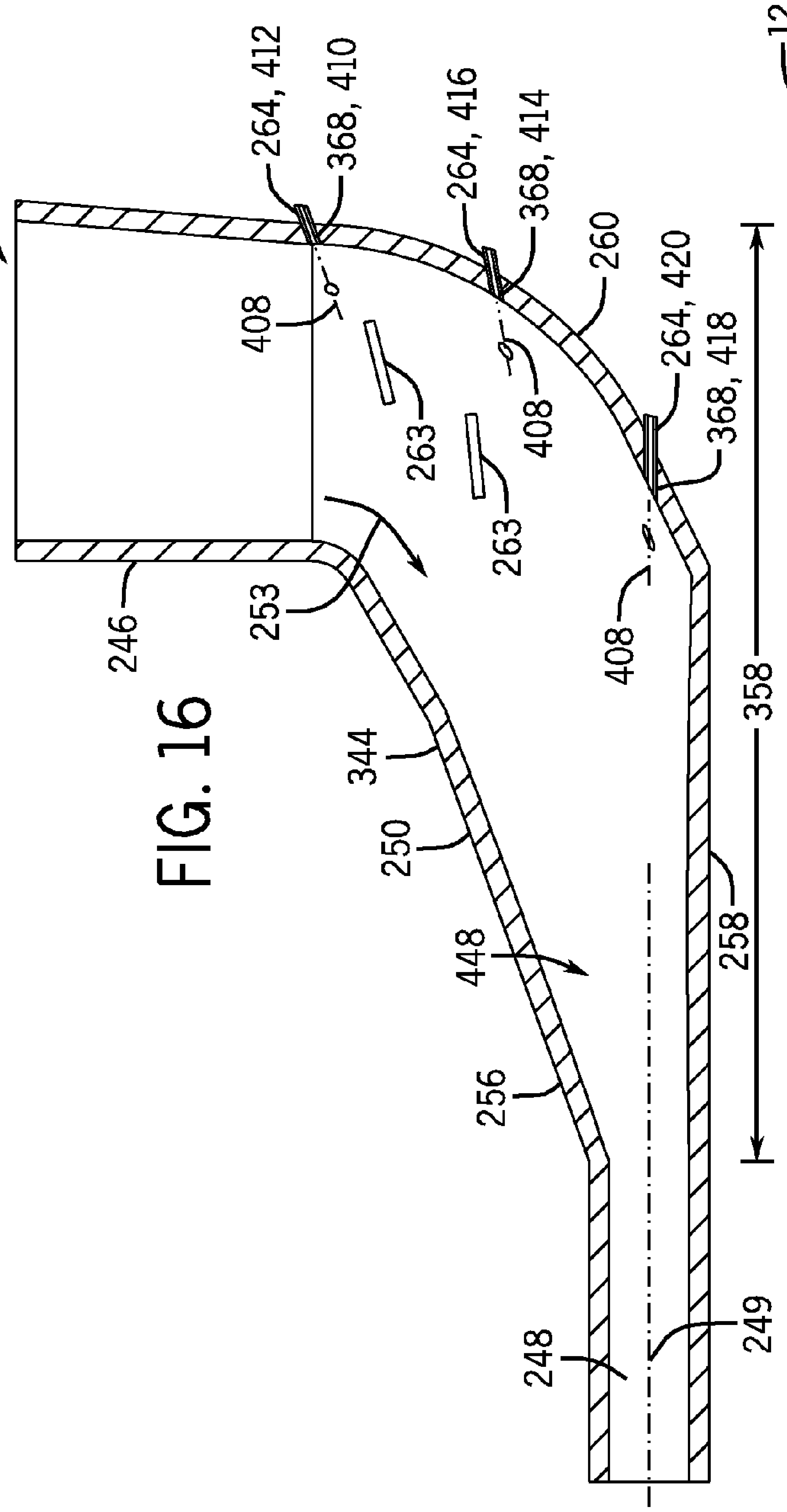
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FIG. 16

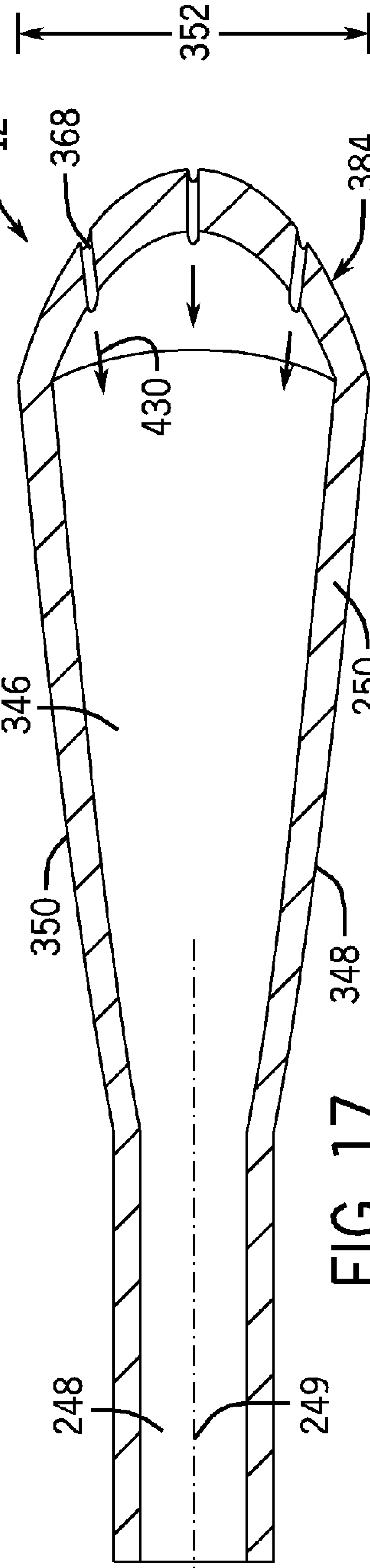
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FIG. 17

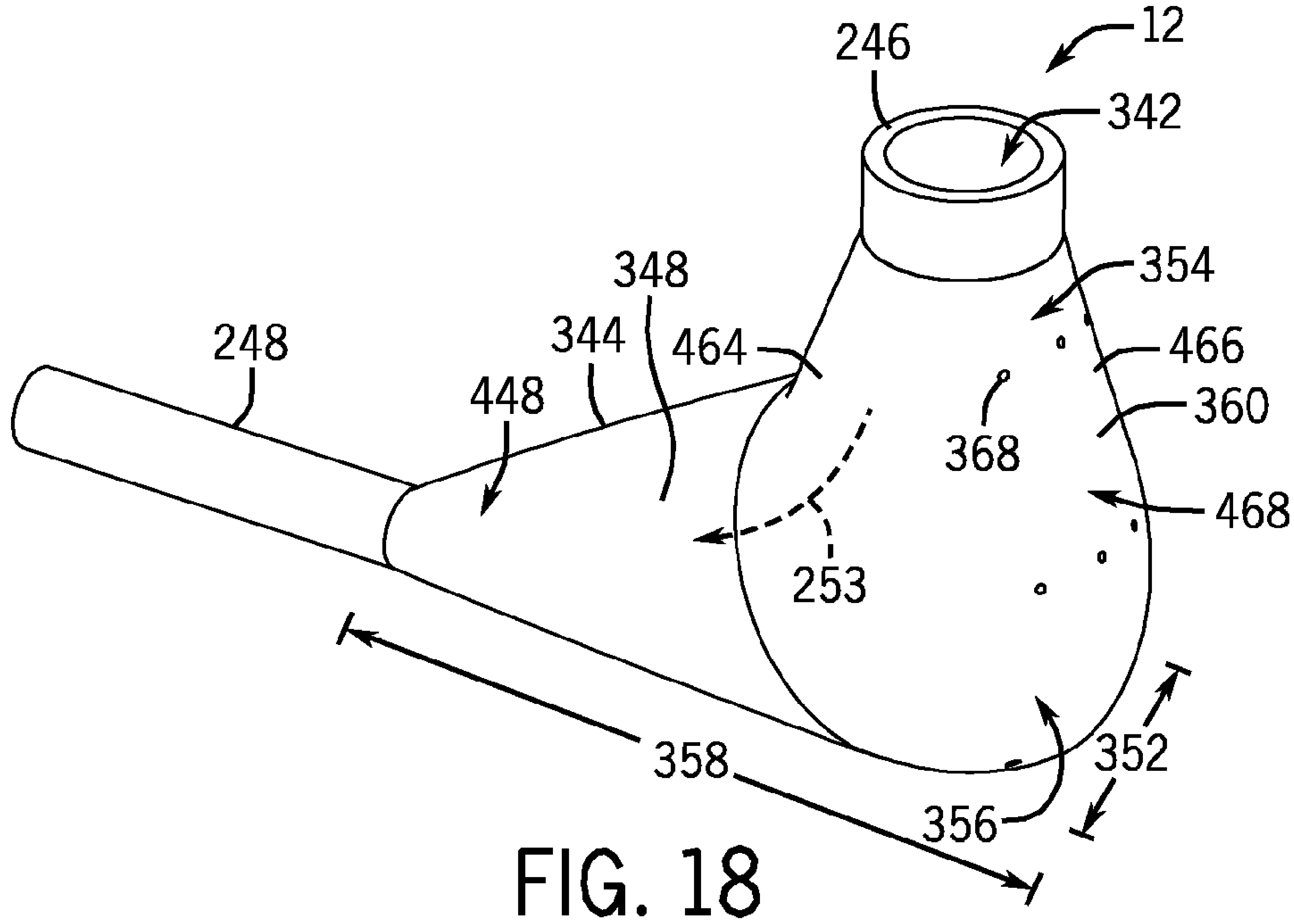
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FIG. 18

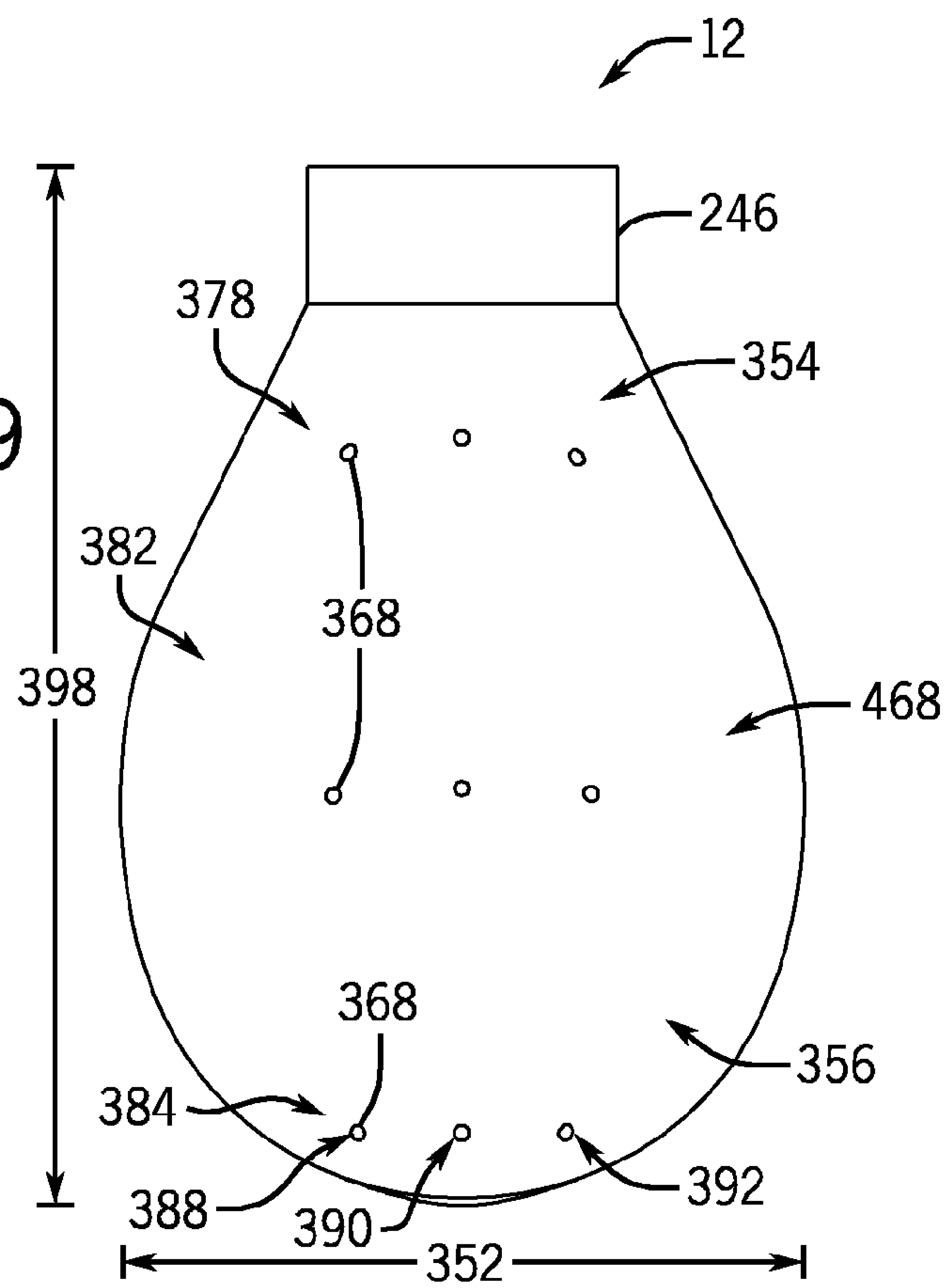
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FIG. 19

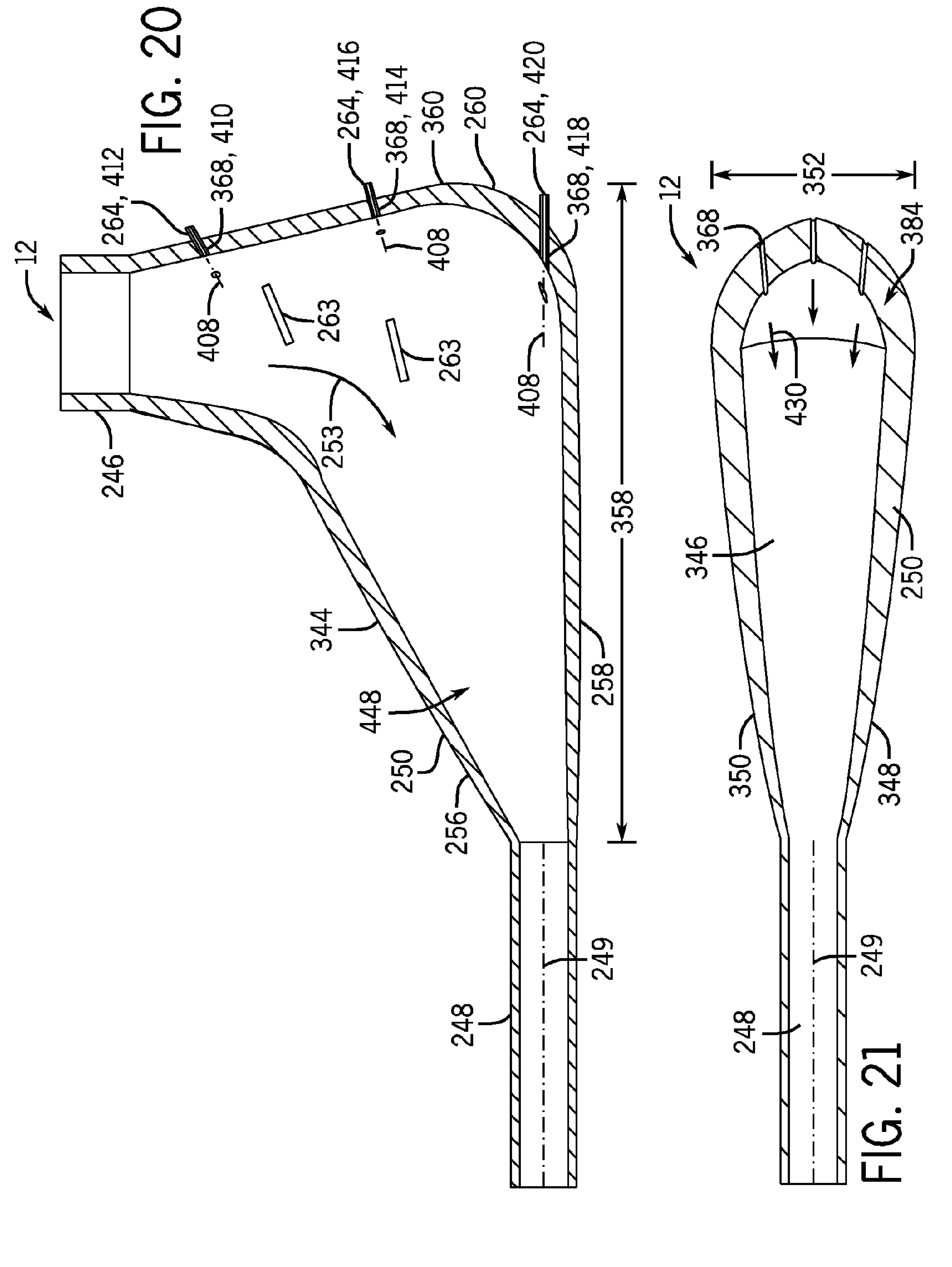
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FIG. 20

FIG. 21

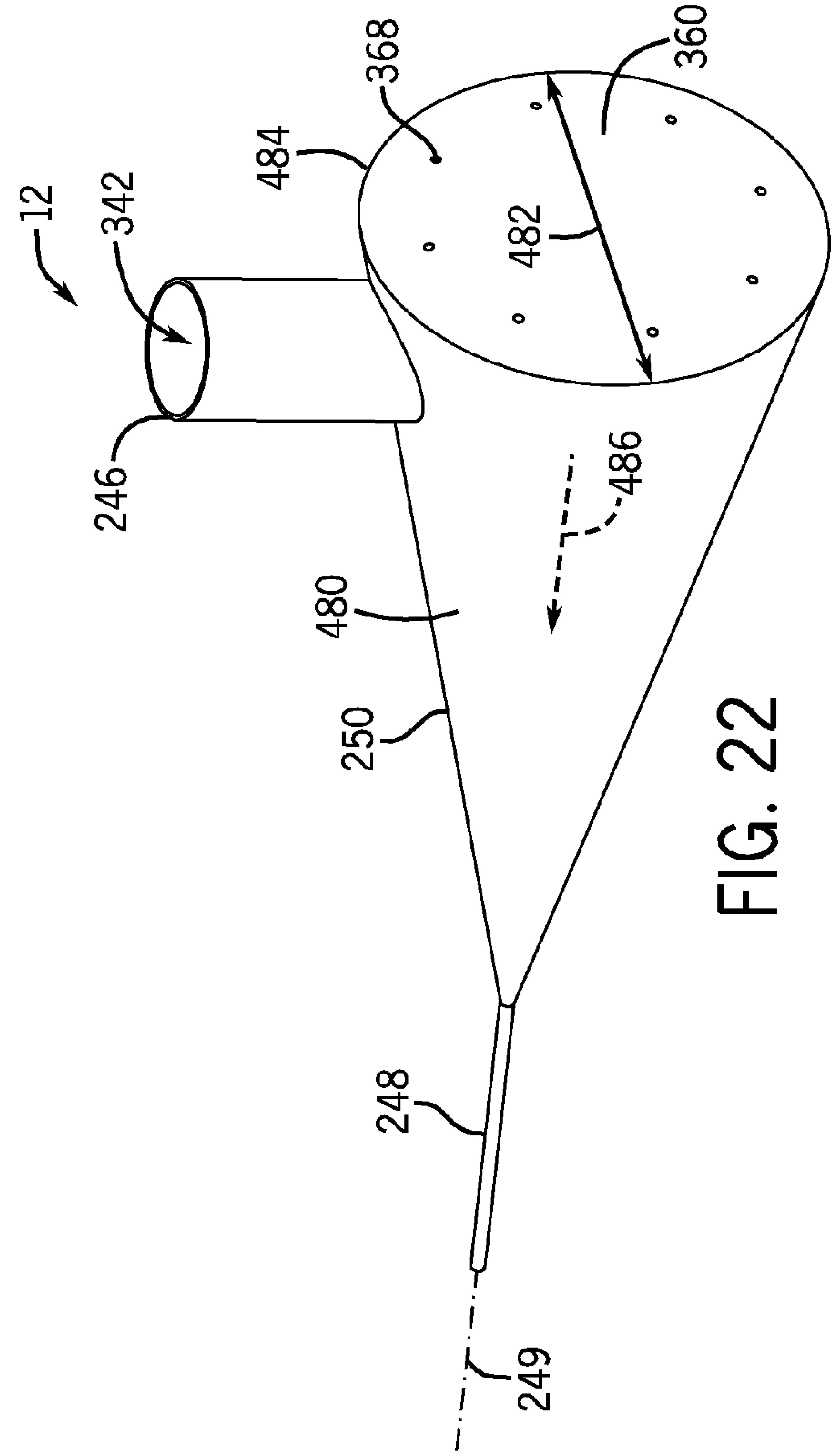
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FIG. 22

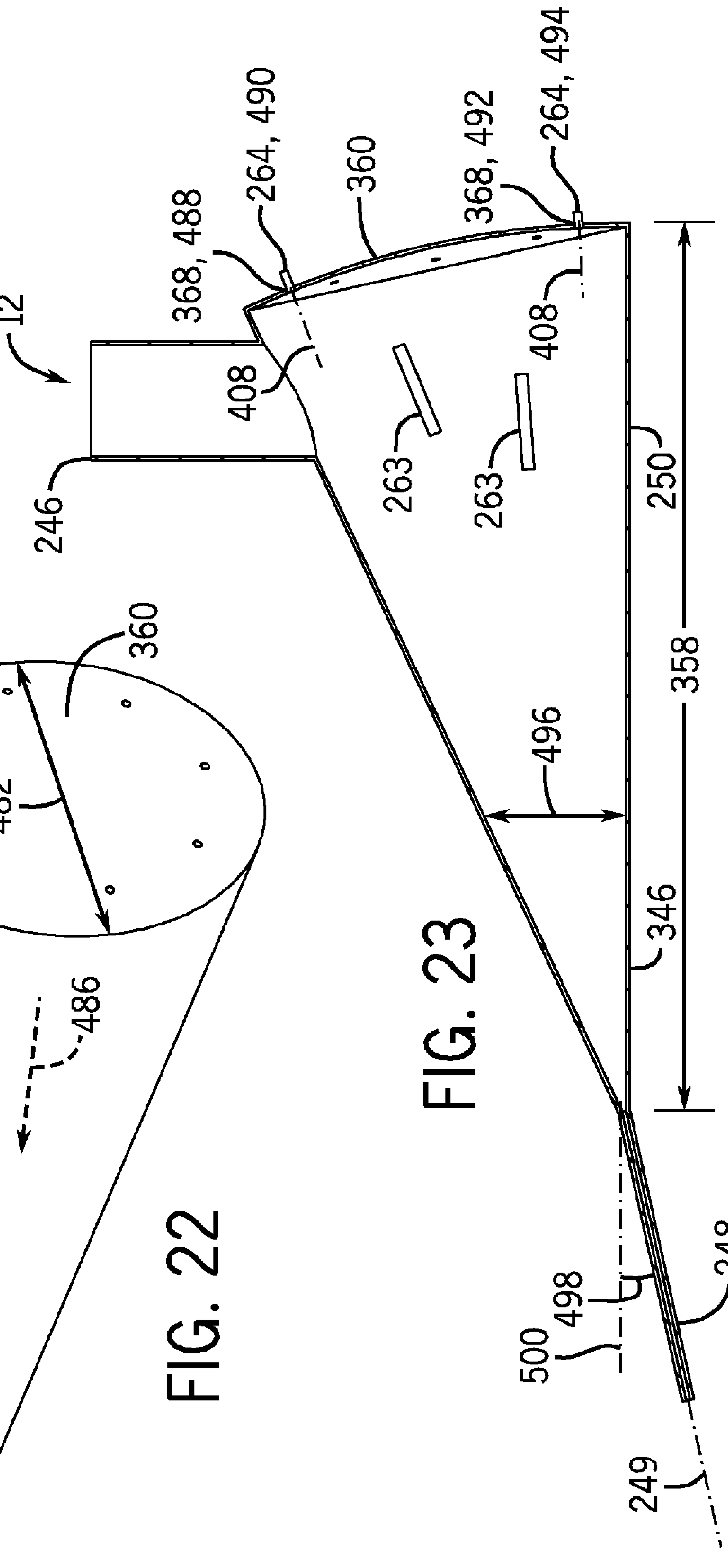
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FIG. 23

SYSTEM FOR FLUIDIZING SOLID FEEDSTOCK FROM A SOLID FEED PUMP

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to a fluidization device for transitioning solid feedstock from a solid feed pump to a high pressure conveyance system.

[0002] Gasifiers convert carbonaceous materials into a mixture of carbon monoxide and hydrogen, referred to as synthesis gas or syngas. For example, a power plant may include one or more gasifiers that react a feedstock at a high temperature with oxygen and/or steam to produce syngas, which may be treated prior to use as a fuel. As will be appreciated, providing the gasifier with a substantially uniform and homogeneous distribution of gas and feedstock particles enhances efficiency and stability of the syngas conversion process. Unfortunately, transporting the feedstock particles from a region of low gas pressure into a region of high gas pressure using a solid feed pump induces the formation of agglomerations that may decrease gasifier efficiency and stability.

BRIEF DESCRIPTION OF THE INVENTION

[0003] Certain embodiments commensurate in scope with the originally claimed invention are summarized below. These embodiments are not intended to limit the scope of the claimed invention, but rather these embodiments are intended only to provide a brief summary of possible forms of the invention. Indeed, the invention may encompass a variety of forms that may be similar to or different from the embodiments set forth below.

[0004] In accordance with a first embodiment, a system includes a solid feed pump having a pump inlet and a pump outlet, wherein the solid feed pump is configured to pump a solid feedstock, and a fluidization elbow disposed below the pump outlet. The fluidization elbow includes an elbow inlet coupled to the pump outlet, an elbow outlet downstream from the elbow inlet, an elbow body disposed between the elbow inlet and the elbow outlet, wherein the elbow body turns and converges from the elbow inlet toward the elbow outlet. The fluidization elbow also includes multiple gas nozzles coupled to the elbow body, wherein the multiple gas nozzles are configured to fluidize solid feedstock.

[0005] In accordance with a second embodiment, a system includes a fluidization elbow. The fluidization elbow includes an elbow inlet, an elbow outlet downstream from the elbow inlet, and an elbow body disposed between the elbow inlet and the elbow outlet, wherein the elbow body turns and converges from the elbow inlet toward the elbow outlet. The fluidization elbow also includes multiple gas nozzles coupled to the elbow body, wherein the multiple gas nozzles include injection axes that generally converge toward the elbow outlet.

[0006] In accordance with a third embodiment, a system includes a fluidization elbow. The fluidization elbow includes an elbow inlet, an elbow outlet downstream from the elbow inlet, and an elbow body disposed between the elbow inlet and the elbow outlet, wherein the elbow body turns and converges from the elbow inlet toward the elbow outlet. The fluidization elbow also includes multiple gas nozzles coupled to the elbow body and a controller configured to separately control gas flow through each gas nozzle of the multiple gas nozzles.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0008] FIG. **1** is a schematic block diagram of an embodiment of an integrated gasification combined cycle (IGCC) power plant utilizing a fluidization elbow between a solid feed pump and a gasifier;

[0009] FIG. **2** is a schematic diagram of an embodiment of the solid feed pump and the fluidization elbow, as shown in FIG. **1**;

[0010] FIG. **3** is a cross-sectional side view of an embodiment of a nozzle assembly;

[0011] FIG. **4** is a cross-sectional side view of an embodiment of a nozzle assembly;

[0012] FIG. **5** is a cross-sectional side view of an embodiment of a nozzle assembly;

[0013] FIG. **6** is a perspective view of an embodiment of the fluidization elbow;

[0014] FIG. **7** is a rear view of an embodiment of the fluidization elbow, as shown in FIG. **6**;

[0015] FIG. **8** is a cross-sectional side view of an embodiment of the fluidization elbow, as shown in FIG. **6**;

[0016] FIG. **9** is a cross-sectional top view of an embodiment of the fluidization elbow, as shown in FIG. **6**;

[0017] FIG. **10** is a perspective view of an embodiment of the fluidization elbow;

[0018] FIG. **11** is a rear view of an embodiment of the fluidization elbow, as shown in FIG. **10**;

[0019] FIG. **12** is a cross-sectional side view of the fluidization elbow, as shown in FIG. **10**;

[0020] FIG. **13** is a cross-sectional top view of the fluidization elbow, as shown in FIG. **10**;

[0021] FIG. **14** is a perspective view of an embodiment of the fluidization elbow;

[0022] FIG. **15** is a rear view of an embodiment of the fluidization elbow, as shown in FIG. **14**;

[0023] FIG. **16** is a cross-sectional side view of an embodiment of the fluidization elbow, as shown in FIG. **14**;

[0024] FIG. **17** is a cross-sectional top view of an embodiment of the fluidization elbow, as shown in FIG. **14**;

[0025] FIG. **18** is a perspective view of an embodiment of the fluidization elbow;

[0026] FIG. **19** is a rear view of an embodiment of the fluidization elbow, as shown in FIG. **18**;

[0027] FIG. **20** is a cross-sectional side view of an embodiment of the fluidization elbow, as shown in FIG. **18**;

[0028] FIG. **21** is a cross-sectional top view of an embodiment of the fluidization elbow, as shown in FIG. **18**;

[0029] FIG. **22** is a perspective view of an embodiment of the fluidization elbow; and

[0030] FIG. **23** is a cross-sectional side view of an embodiment of the fluidization elbow, as shown in FIG. **22**.

DETAILED DESCRIPTION OF THE INVENTION

[0031] One or more specific embodiments of the present invention will be described below. In an effort to provide a concise description of these embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[0032] When introducing elements of various embodiments of the present invention, the articles "a," "an," "the," and "said" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements.

[0033] Embodiments of the present disclosure include a fluidization device (e.g., a fluidization elbow) configured to establish a substantially uniform and homogenous flow of gas and solid particles coming out from a solid feed pump to a gasifier via a high pressure conveyance system, while substantially reducing or eliminating buildup of solids within the fluidization device. In certain embodiments, the fluidization elbow is disposed below a pump outlet of a solid feed pump (e.g., a posimetric pump) configured to pump a solid feedstock. The fluidization elbow includes an elbow inlet coupled to the pump outlet, an elbow outlet downstream from the elbow inlet, and an elbow body disposed between the elbow inlet and elbow outlet, wherein the elbow body turns and converges from the elbow inlet toward the elbow outlet. In addition, the fluidization elbow includes multiple gas nozzles coupled to the elbow body that are configured to fluidize the solid feedstock. In further embodiments of the fluidization elbow, the gas nozzles include injection axes that generally converge toward the elbow outlet. Yet further embodiments of the fluidization elbow include a controller configured to separately control gas flow through each gas nozzle of the multiple gas nozzles. In certain embodiments, the multiple gas nozzles are configured to inject multiple flow jets with different flow rates at different regions along the elbow body. For example, the multiple gas nozzles may include different nozzle diameters to affect the flow rates. In certain embodiments, the fluidization elbow includes at least one baffle disposed in the elbow body, where the baffle is configured to guide the solid feedstock around a turn of the elbow body. By utilizing these mechanical and fluid-dynamic features, the fluidization elbow may break up agglomerations within the flow of solid particles and near low velocity zones of the elbow, thereby providing the gasifier, via the higher conveyance system, with a substantially uniform and homogenous distribution of feedstock particles and gas which may enhance efficiency and stability of the syngas conversion process. Indeed, the fluidization elbow may allow a continuous flow to the gasifier with little or no residence time of the solid particles in the fluidization elbow.

[0034] FIG. **1** is a diagram of an embodiment of an integrated gasification combined cycle (IGCC) system **100** utilizing a fluidization elbow **12** between a solid feed pump **10** and a gasifier **106** as mentioned above. In certain embodiments, the solid feed pump **10** may be a posimetric pump configured to output or pump a solid feedstock (e.g., dry coal particles) at a high pressure, for example more than approximately **700** PSIG. The term "posimetric" may be defined as capable of metering (e.g., measuring an amount of) and positively displacing (e.g., trapping and forcing displacement of) a substance being delivered by the pump **10**. The pump **10** is able to meter and positively displace a defined volume of a substance, such as a solid fuel feedstock (e.g., dry coal particles). The pump path may have a circular shape or curved shape. The higher pressure solid particles then flow to the fluidization elbow **12** coupled to the pump **10**. As discussed in detail below, the fluidization elbow **12** is configured to inject gas into the flow of solid particles to converge the flow from the solid feed pump **10** to a high pressure conveyance system coupled to the gasifier **106**. The fluidization elbow **12** is also configured to prevent solids settling by reducing low velocity regions and to break up agglomerations within the flow of solid particles, thereby providing the gasifier **106** with a substantially uniform distribution of feedstock particles which may enhance the efficiency and stability of the syngas conversion process. Although the fluidization elbow **12** is discussed with reference to the IGCC system **100** in FIG. **1**, the disclosed embodiments of the fluidization elbow **12** may be used in any suitable application (e.g., production of chemicals, fertilizers, substitute natural gas, transportation fuels, or hydrogen). In other words, the following discussion of the IGCC system **100** is not intended to limit the disclosed embodiments to IGCC.

[0035] The IGCC system **100** produces and burns a synthetic gas, i.e., syngas, to generate electricity. Elements of the IGCC system **100** may include a fuel source **102**, such as a solid feed, that may be utilized as a source of energy for the IGCC. The fuel source **102** may include coal, petroleum coke, biomass, wood-based materials, agricultural wastes, tars, asphalt, or other carbon containing items. The solid fuel of the fuel source **102** may be passed to a feedstock preparation unit **104**. The feedstock preparation unit **104** may, for example, resize or reshape the fuel source **102** by chopping, milling, shredding, pulverizing, briquetting, or pelletizing the fuel source **102** to generate a dry feedstock (e.g., particulate matter).

[0036] In the illustrated embodiment, the solid feed pump **10** (e.g., posimetric pump) delivers the feedstock from the feedstock preparation unit **104** to the gasifier **106**. The solid feed pump **10** is configured to meter and pressurize (e.g., to a pressure of at least 700 PSIG) the fuel source **102** (e.g., solid feedstock) received from the feedstock preparation unit **104**. The pressurized feedstock exits an outlet of the solid feed pump **10** and flows downward (e.g., via gravity) into a fluidization device (e.g., fluidization elbow **12**) located below the outlet of the pump **10**. Although in some embodiments, the fluidization device may be located at the same height of the elbow or above. The fluidization elbow **12** transitions the flow of the solid feedstock from the solid feed pump **10** to a high pressure conveyance system (e.g., a pipeline). The high pressure conveyance system may be a pneumatic system that conveys the solid feedstock to the gasifier **106** via high velocity gas flow. The fluidization elbow **12** may converge the flow of the solid feedstock from the solid feed pump **10** to the conveyance system to accelerate the solid particles. Also, the fluidization elbow **12** may include multiple gas nozzles to reduce low velocity regions and to prevent solids settling within the elbow **12** as well as to break up agglomerations of the solid feedstock (i.e., fluidize the solid feedstock) into solid particles to create a substantially uniform and homogenous flow of the gas and solid particles into the conveyance system and subsequently the gasifier **106**. The substantially uniform and homogenous distribution of gas and feedstock particles may enhance the efficiency and stability of the syngas conversion process. The gasifier **106** converts the feedstock **102** into a syngas, e.g., a combination of carbon monoxide and hydrogen. This conversion may be accomplished by subjecting the feedstock to a controlled amount of steam and oxygen at elevated pressures, e.g., from approximately 20 bar to 85 bar, and temperatures, e.g., approximately 700 degrees Celsius to 1600 degrees Celsius, depending on the type of gasifier **106** utilized.

[0037] The gasification process includes the feedstock undergoing a pyrolysis process, whereby the feedstock is heated. Temperatures inside the gasifier **106** may vary during the pyrolysis process, depending on the fuel source **102** utilized to generate the feedstock. The heating of the feedstock during the pyrolysis process generates a solid, (e.g., char), and residue gases, (e.g., carbon monoxide, hydrogen, and nitrogen). The char remaining from the feedstock from the pyrolysis process may only weigh up to approximately 30% of the weight of the original feedstock.

[0038] A partial oxidation process also occurs in the gasifier **106**. The oxidation process may include introducing oxygen to the char and residue gases. The char and residue gases react with the oxygen to form carbon dioxide and carbon monoxide, which provides heat for the gasification reactions. The temperatures during the partial oxidation process may range from approximately 700 degrees Celsius to 1600 degrees Celsius. Steam may be introduced into the gasifier **106** during gasification. The char may react with the carbon dioxide and steam to produce carbon monoxide and hydrogen at temperatures ranging from approximately 800 degrees Celsius to 1100 degrees Celsius. In essence, the gasifier utilizes steam and oxygen to allow some of the feedstock to be "burned" to produce carbon monoxide and release energy, which drives a second reaction that converts further feedstock to hydrogen and additional carbon dioxide.

[0039] In this way, a resultant gas is created by the gasifier **106**. This resultant gas may include approximately 85% of carbon monoxide and hydrogen in equal proportions, as well as CH_4, HCl, HF, COS, NH_3, HCN, and H_2S (based on the sulfur content of the feedstock). This resultant gas may be termed untreated, raw, or sour syngas, since it contains, for example, H_2S. The gasifier **106** may also generate waste, such as slag **108**, which may be a wet ash material. This slag **108** may be removed from the gasifier **106** and disposed of, for example, as road base or as another building material. Prior to cleaning the raw syngas, a syngas cooler **107** may be utilized to cool the hot syngas. The cooling of the syngas may generate high pressure steam which may be utilized to produce electrical power as described below. After cooling the raw syngas, a gas cleaning unit **110** may be utilized to clean the raw syngas. The gas cleaning unit **110** may scrub the raw syngas to remove the HCl, HF, COS, HCN, and H_2S from the raw syngas, which may include separation of sulfur **111** in a sulfur processor **112** by, for example, an acid gas removal process in the sulfur processor **112**. Furthermore, the gas cleaning unit **110** may separate salts **113** from the raw syngas via a water treatment unit **114** that may utilize water purification techniques to generate usable salts **113** from the raw syngas. Subsequently, the gas from the gas cleaning unit **110** may include treated, sweetened, and/or purified syngas, (e.g., the sulfur **111** has been removed from the syngas), with trace amounts of other chemicals, e.g., NH_3 (ammonia) and CH_4 (methane).

[0040] A gas processor **116** may be utilized to remove residual gas components **117** from the treated syngas such as, ammonia and methane, as well as methanol or any residual chemicals. However, removal of residual gas components **117** from the treated syngas is optional, since the treated syngas may be utilized as a fuel even when containing the residual gas components **117**, e.g., tail gas. At this point, the treated syngas may include approximately 40% CO, approximately 40% H_2, and approximately 20% CO_2 and is substantially stripped of H_2S. This treated syngas may be transmitted to a combustor **120**, e.g., a combustion chamber, of a gas turbine engine **118** as combustible fuel. Alternatively, the CO_2 may be removed from the treated syngas prior to transmission to the gas turbine engine.

[0041] The IGCC system **100** may further include an air separation unit (ASU) **122**. The ASU **122** may operate to separate air into component gases by, for example, distillation techniques. The ASU **122** may separate oxygen from the air supplied to it from a supplemental air compressor **123**, and the ASU **122** may transfer the separated oxygen to the gasifier **106**. Additionally the ASU **122** may transmit separated nitrogen to a diluent nitrogen (DGAN) compressor **124**.

[0042] The DGAN compressor **124** may compress the nitrogen received from the ASU **122** at least to pressure levels equal to those in the combustor **120**, so as not to interfere with the proper combustion of the syngas. Thus, once the DGAN compressor **124** has adequately compressed the nitrogen to a proper level, the DGAN compressor **124** may transmit the compressed nitrogen to the combustor **120** of the gas turbine engine **118**. The nitrogen may be used as a diluent to facilitate control of emissions, for example.

[0043] As described previously, the compressed nitrogen may be transmitted from the DGAN compressor **124** to the combustor **120** of the gas turbine engine **118**. The gas turbine engine **118** may include a turbine **130**, a drive shaft **131** and a compressor **132**, as well as the combustor **120**. The combustor **120** may receive fuel, such as syngas, which may be injected under pressure from fuel nozzles. This fuel may be mixed with compressed air as well as compressed nitrogen from the DGAN compressor **124**, and combusted within combustor **120**. This combustion may create hot pressurized exhaust gases.

[0044] The combustor **120** may direct the exhaust gases towards an exhaust outlet of the turbine **130**. As the exhaust gases from the combustor **120** pass through the turbine **130**, the exhaust gases force turbine blades in the turbine **130** to rotate the drive shaft **131** along an axis of the gas turbine engine **118**. As illustrated, the drive shaft **131** is connected to various components of the gas turbine engine **118**, including the compressor **132**.

[0045] The drive shaft **131** may connect the turbine **130** to the compressor **132** to form a rotor. The compressor **132** may include blades coupled to the drive shaft **131**. Thus, rotation of turbine blades in the turbine **130** may cause the drive shaft **131** connecting the turbine **130** to the compressor **132** to rotate blades within the compressor **132**. This rotation of blades in the compressor **132** causes the compressor **132** to compress air received via an air intake in the compressor **132**. The compressed air may then be fed to the combustor **120** and mixed with fuel and compressed nitrogen to allow for higher efficiency combustion. Drive shaft **131** may also be connected to load **134**, which may be a stationary load, such as an electrical generator for producing electrical power, for example, in a power plant. Indeed, load **134** may be any suitable device that is powered by the rotational output of the gas turbine engine **118**.

[0046] The IGCC system **100** also may include a steam turbine engine **136** and a heat recovery steam generation (HRSG) system **138**. The steam turbine engine **136** may drive a second load **140**. The second load **140** may also be an electrical generator for generating electrical power. However, both the first and second loads **134**, **140** may be other types of loads capable of being driven by the gas turbine engine **118** and steam turbine engine **136**. In addition, although the gas turbine engine **118** and steam turbine engine **136** may drive separate loads **134** and **140**, as shown in the illustrated embodiment, the gas turbine engine **118** and steam turbine engine **136** may also be utilized in tandem to drive a single load via a single shaft. The specific configuration of the steam turbine engine **136**, as well as the gas turbine engine **118**, may be implementation-specific and may include any combination of sections.

[0047] The IGCC system **100** may also include the HRSG **138**. High pressure steam may be transported into the HSRG **138** from the syngas cooler **107**. Also, heated exhaust gas from the gas turbine engine **118** may be transported into the HRSG **138** and used to heat water and produce steam used to power the steam turbine engine **136**. Exhaust from, for example, a low-pressure section of the steam turbine engine **136** may be directed into a condenser **142**. The condenser **142** may utilize a cooling tower **128** to exchange heated water for chilled water. The cooling tower **128** acts to provide cool water to the condenser **142** to aid in condensing the steam transmitted to the condenser **142** from the steam turbine engine **136**. Condensate from the condenser **142** may, in turn, be directed into the HRSG **138**. Again, exhaust from the gas turbine engine **118** may also be directed into the HRSG **138** to heat the water from the condenser **142** and produce steam.

[0048] In combined cycle systems such as IGCC system **100**, hot exhaust may flow from the gas turbine engine **118** and pass to the HRSG **138**, along with the steam generated by the syngas cooler **107**, where it may be used to generate high-pressure, high-temperature steam. The steam produced by the HRSG **138** may then be passed through the steam turbine engine **136** for power generation. In addition, the produced steam may also be supplied to any other processes where steam may be used, such as to the gasifier **106**. The gas turbine engine **118** generation cycle is often referred to as the “topping cycle,” whereas the steam turbine engine **136** generation cycle is often referred to as the “bottoming cycle.” By combining these two cycles as illustrated in FIG. **1**, the IGCC system **100** may lead to greater efficiencies in both cycles. In particular, exhaust heat from the topping cycle may be captured and used to generate steam for use in the bottoming cycle.

[0049] FIG. **2** is a schematic diagram of an embodiment of the solid feed pump **10** and the fluidization elbow **12**, as shown in FIG. **1**. As shown in FIG. **2**, the solid feed pump **10** includes a housing **214**, inlet **200**, outlet **202**, and rotor **204**. The solid feedstock upon entering the solid feed pump **10** via inlet **200** is transported from low to high pressure (e.g., at least approximately 700 PSIG) before being discharged from the outlet **202** of the pump **10**. As illustrated, the rotor **204** includes two substantially opposed and parallel rotary discs, which include discrete cavities defined by protrusions to drive solids therebetween. The rotary discs are movable relative to the housing **214** in a rotational direction **216** from the inlet **200** towards the outlet **202**. The inlet **200** and the outlet **202** are coupled to a curved passage **210** (e.g., circular or annular passage) disposed between the two rotary discs and within the housing **214**. A solid feed guide **212** is disposed adjacent the outlet **202**. The solid feed guide **212** extends across the curved passage **210** between rotary discs. The solid feed guide **212** includes a guide wall **222**.

[0050] As particulate matter is fed through an opening **230** of the inlet **200**, the solid feed pump **10** imparts a tangential force or thrust to the particulate matter in the rotational direction **216** of the rotor **204**. The direction of flow **234** of the particulate matter is from the inlet **200** to the outlet **202**. As the particulate matter rotates through the curved passage **210**, the particulate matter encounters the guide wall **222** of the solid feed guide **212** disposed adjacent the outlet **202** extending across the curved passage **210**. In this region, the particulate matter becomes highly compacted and exits the pump **10** at a generally constant rate. The solid feed guide **212** routes the particulate matter through an opening **236** of the outlet **202** into a discharge outlet **238**. From the discharge outlet **238**, the particulate matter or solid feedstock flows downward, as generally indicated by arrow **240**, into a bottom discharge transition device (e.g., fluidization elbow **12**). In certain embodiments, the fluidization elbow **12** may be located at the same height as the outlet **238** or above the outlet.

[0051] The fluidization elbow **12** is independent of the solid feed pump **10**. The fluidization elbow **12** may be coupled to the discharge outlet **238** via, e.g., flanges **242**, or some other fastening device. The fluidization elbow **12** is disposed below the pump outlet **202**. As mentioned above, the fluidization elbow **12** transitions the flow of the solid feedstock from the solid feed pump **10** to a high pressure conveyance system **244** (e.g., a pipeline). As illustrated, the fluidization elbow **12** includes an elbow inlet **246**, an elbow outlet **248** downstream from the elbow inlet **246**, and an elbow body **250** disposed between the elbow inlet **246** and the elbow outlet **248**. The elbow inlet **246** is coupled to the pump outlet **202** via the discharge outlet **238**. The elbow outlet **248** is coupled to the gasifier **106** via the conveyance system **244**, which is coupled to the elbow outlet **248**. The elbow inlet **246** includes a diameter **252** generally the same as an outlet diameter **254** of the pump **10**. The diameter **252** of the elbow inlet **246** is larger than a diameter **255** of the elbow outlet **248**. The elbow inlet diameter **252** may be approximately 2, 3, 4, or 5 times larger than the elbow outlet diameter **255**. Alternatively, the elbow outlet diameter **255** may range from approximately 20 to 50 percent of the length of the elbow inlet diameter **252**. For example, the elbow outlet diameter **255** may be 20, 25, 30, 40, 45, or 50 percent, or any percent therebetween of the elbow inlet diameter **252**. Due to the difference in diameters **252** and **255**, the flow of conveyance gas and solid feedstock converges and accelerates from the elbow inlet **246** to the elbow outlet **248**. The elbow body **250** turns, as generally indicated by arrow **253**, and converges from the elbow inlet **246** toward the elbow outlet **248**. The elbow body **250** includes an inner bend portion **256** and an outer bend portion **258**. In certain embodiments, the outer bend portion **258** includes a wall portion **260** that curves in a downstream direction, as generally indicated by arrow **253**, from the elbow inlet **246** toward the elbow outlet **248**. Turning of the elbow body **250** may range from approximately 45 to 90 degrees, 50 to 80 degrees, or 60 to 70 degrees. For example, the elbow body **250** may turn at least approximately 45, 50, 55, 60, 65, 70, 75, 80, 85, or 90 degrees, or any angle therebetween. Overall, the fluidization elbow **12** converges the flow of the solid feedstock from the elbow inlet **246** to the elbow outlet **248** in order to allow the conveyance gas to accelerate the flow of the solid particles into the conveyance system **244**.

[0052] The fluidization elbow **12** also may include at least one baffle **263** disposed in the elbow body **250**. One or more baffles **263** may be suspended from a bottom side portion **346** of the elbow body **250**. Alternatively, the baffles **263** may be coupled to and supported by side walls of the elbow body **250** and span across the elbow body **250**. As illustrated, the baffles **263** are oriented towards the elbow outlet **248**. The baffles **263** are configured to guide the solid feedstock around the turn in the elbow body **250** as well as to prevent the build up of solid feedstock on the bottom of the fluidization elbow **12**. The number of baffles **263** may range from 1 to 10 or more. For example, the fluidization device **12** may include at least 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 baffles.

[0053] Additionally, the fluidization elbow **12** includes multiple gas nozzles **264** configured to fluidize the solid feedstock. In other words, the multiple gas nozzles **264** break up agglomerations of the solid feedstock into particles to create a substantially uniform and homogenous flow of the gas and solid particles into the conveyance system **244**. The gas nozzles **264** are coupled to the elbow body **250**. In particular, the gas nozzles **264** are disposed along the outer bend portion **258**. Indeed, the gas nozzles **264** may include sets of gas nozzles **264** disposed at different positions along a gas flow path, also indicated generally by arrow **253**, through the elbow body **250** as described in more detail below. For example, as illustrated each gas nozzle **264** represents sets of gas nozzles **264** (e.g., sets **266**, **268**, **270**, **272**, **274**, **276**, and **278**) disposed about a circumference of the fluidization elbow **12**. The gas nozzles **264** are configured to inject multiple gas jets at different regions along the elbow body **250** to reduce low velocity zones within the fluidization elbow **12**, such as at a bottom region or along walls of the elbow **12**. In certain embodiments, the gas nozzles **264** are configured to inject multiple gas jets with different flow rates at different regions along the elbow body **250**. For example, in some embodiments, the gas nozzles **264** may include different nozzle diameters to impart different flow rates to the nozzles **264**. In some embodiments, some of the gas nozzles **264** may induce swirl to mix the gas and the solid particles. The gas nozzles **264** also include injection axes that generally converge toward the elbow outlet **248**. Besides fluidizing the solid feedstock, the gas nozzles **264** help direct the flow of solid particles towards the elbow outlet **248** and the conveyance system **244**. In certain embodiments, gas nozzles **264** may be included in the baffles **263** to help direct the flow of the solid particles towards the elbow outlet **248**. High pressure, high velocity gas flow jets from the gas nozzles **264** also helps accelerate the particles into the conveyance system **244** reducing residence time of solid feedstock in the fluidization elbow **12**. The gas velocity of the jets may range from approximately 100 to 900 feet/second. For example, the gas velocity may be approximately 100, 500, or 900 feet/second or any velocity therebetween. The residence time of solids inside the elbow **12** may range from approximately 0.02 to 0.5 seconds. For example, the residence time may be approximately 0.025, 0.035, or 0.5 seconds or any time therebetween. More specifically, the fluidization elbow **12** may be configured to flow the solid feedstock with a residence time of less than approximately 1 second. The high velocity gas also helps conveyance of the solid particles into the high pressure conveyance system **244**, particularly if the conveyance system **244** operates as a pneumatic system that transfers the solid particles via high velocity gas flow into the gasifier **106**. In certain embodiments, a permeable plate may be used, instead of gas nozzles **264**, to fluidize the solid particles.

[0054] The fluidization elbow **12** also includes a controller **280** configured to separately control gas flow through each gas nozzle **264** of the multiple gas nozzles **264**. The controller **280** is configured to control each nozzle **264** individually or multiple nozzles **264** as a group. The gas nozzles **264** are coupled to a compressed gas supply **282**. A compressor **284** generates the compressed gas supply **282**. The controller **280** controls the gas flow to each gas nozzle **264** via valves **286**. As a result, the controller **280** may be configured to open or close the valves **286** and, thus, affect the amount of gas supplied to each gas nozzle **264** or each set of gas nozzles **264** to affect the flow rates. Also, the controller **280** is configured to adjust the tilt of the gas nozzles **264**. The compressor **280** is also configured to control the compressor **284** to affect the pressure of the compressed gas supply **282** provided to the gas nozzles **264**. As a result, the controller **280** via the valves **286** and the compressor **284** controls the fluidization of the solid feedstock throughout the fluidization elbow **12** to eliminate any low velocity regions. As a result, the overall design of the fluidization elbow allows for a uniform and homogenous distribution of gas and feedstock particles to flow along a smooth, converging flowpath from the solid feed pump **10** to the conveyance system **244**, and subsequently to the gasifier **106** to enhance efficiency and stability of the syngas conversion process.

[0055] The gas nozzles **264** used in embodiments of the fluidization elbow **12** may include different embodiments. For example, the gas nozzles **264** may be individually coupled to fluidization elbow **12** via a variety of mounts, e.g., threaded connections, bolted flanges, or welds between the nozzles **264** and the elbow body **250**. FIGS. **3** and **4** provide alternative embodiments for the gas nozzles **264**. For example, FIG. **3** is a cross-sectional side view of an embodiment of a nozzle assembly **296**. The nozzle assembly **296** includes a nozzle mount **298** supporting at least two gas nozzles **264** of the multiple gas nozzles **264**. As illustrated, each gas nozzle **264** includes an opening **300** for the jets of gas to pass through. Also, as illustrated, the nozzle mount **298** includes four gas nozzles **264** (**302**, **304**, **306**, and **308**). However, the number of gas nozzles **264** supported by each nozzle mount **298** may range from 2 to 100 nozzles **264**. The nozzle mount **298** is configured to secure the at least two gas nozzles **264** to the elbow body **250**. Indeed, in certain embodiments, multiple nozzle mounts **298** may be secured to the elbow body **250**. The nozzle mounts **298** may be secured to the elbow body **250** via one or more fasteners **310** (e.g., a screw or bolt) through openings **312** of the mount **298**. Alternatively, the mounts **298** may be secured via other types of fasteners. Each particular nozzle mount **298** may include gas nozzles **264** each having a same diameter **314**. In other embodiments, as illustrated, each particular nozzle mount **298** may include gas nozzles **264** (e.g., **302**, **304**, **306**, and **308**) of different diameters **314**. Each of the gas nozzles **264** supported by the nozzle mount **298** may include injection axes that generally converge toward the elbow outlet **248** when mounted on the elbow body **250**. In certain embodiments, the gas nozzles **264** supported by the nozzle mount

298 may be angled approximately 1 to 90, 10 to 80, or 30 to 60 degrees relative to the mount 298. In further embodiments, the gas nozzles 264 on each nozzle mount 298 may be parallel, converging, or diverging relative to one another.

[0056] FIG. 4 is a cross-sectional side view of another embodiment of the nozzle assembly 296. As illustrated, the nozzle assembly 296 includes nozzle mount 298 that includes a manifold 322. The manifold 322 includes a manifold inlet 324, a distribution chamber 326, and at least two gas nozzles 264 coupled to the distribution chamber 326. As illustrated, the gas nozzles 264 include openings 328 that serve as outlets from the distribution chamber 326. In certain embodiments, the openings 328 may be angled approximately 1 to 90, 10 to 80, or 30 to 60 degrees relative to the mount 298. High pressure gas enters the manifold inlet 324, as generally indicated by arrow 330, and then flows through the distribution chamber 326, as generally indicated by arrows 332, to exit via openings 328. The nozzle mount 298 may be secured to the elbow body 250 as described above. Indeed, also as above, multiple nozzle mounts 298 may be secured to the elbow body 258. As illustrated, each nozzle mount 298 may include gas nozzles 264 each having the same diameter 314. In certain embodiments, each nozzle mount 298 may include gas nozzles 264 with different diameters 314. Also, as above, each of the gas nozzles 264 supported by the nozzle mount 298 may include injection axes that generally converge toward the elbow outlet 248 when mounted on the elbow body 250.

[0057] FIG. 5 is a cross-sectional side view of another embodiment of the nozzle assembly 296. As illustrated, the nozzle assembly 296 includes nozzle mount 298 that includes a manifold 322. The manifold 322 includes a manifold inlet 324, a distribution chamber 326, and a permeable plate 334 coupled to the distribution chamber 326. The permeable plate 334 may include a sintered metal. Gas enters the manifold inlet 324, as generally indicated by arrow 330, and then flows through the distribution chamber 326, as generally indicated by arrows 332, and permeates through the plate 334 to fluidize the flow of solid particles. The nozzle mount 298 may be secured to the elbow body 250 as described above. Indeed, also as above, multiple nozzle mounts 298 may be secured to the elbow body 258.

[0058] FIGS. 6-23 illustrate various embodiments of the fluidization elbow 12 configured to fluidize the solid feedstock and to provide a uniform and homogenous flow of gas and feedstock particles to the conveyance system 244. For example, FIGS. 6-9 illustrate one embodiment of the fluidization elbow 12. FIG. 6 is a perspective view of an embodiment of the fluidization elbow 12. The fluidization elbow 12 includes the elbow inlet 246, the elbow outlet 248 downstream from the elbow inlet 246, and the elbow body 250 disposed between the elbow inlet 246 and the elbow outlet 248. The elbow inlet 246 includes an annular opening 342 for receiving the solid feedstock from the solid feed pump 10. As illustrated, the elbow body 250 turns, as generally indicated by arrow 253, and converges from the elbow inlet 246 toward the elbow outlet 248 (see FIG. 8). The elbow body 250 includes a topside portion 344 and a bottom side portion 346 (see FIG. 9) that converge or taper towards the elbow outlet 248. In addition, the elbow body 250 includes side portions 348 and 350 (see FIG. 9) that converge or taper towards the elbow outlet 248. The elbow outlet 248 extends from the elbow body 250 and is configured to couple with the conveyance system 244, e.g., a pipeline. A width 352 of the elbow body 250 increases from a top portion 354 to a bottom portion 356 of the elbow body 250. The increase in the width 352 provides sufficient space for the routing of the solid feedstock from the solid feed pump 10 to the conveyance system 244 to avoid pile up of solid feedstock within the fluidized elbow 12. A length 358 (see FIG. 8) of the elbow body 250 is configured to avoid low velocity zones while also providing a smooth transition for the solid feedstock. The length 358 of the elbow body 250 also increases from the top portion 354 to the bottom portion 356 of the elbow body. Thus, the elbow body 250 expands out from the elbow inlet 246 from the top portion 354 to the bottom portion 356 of the body 250. Also, a backside portion 360 of the elbow body 250 includes rounded corners 362 and 364 to smooth the transition of the solid feedstock flow as well as to avoid low velocity zones. Backside portions 366 and 360 of the elbow inlet 246 and the elbow body 250, respectively, include openings 368 for multiple gas nozzles 264.

[0059] FIG. 7 is a rear view of an embodiment of the fluidization elbow 12 shown in FIG. 6. The backside portion 366 of the elbow inlet 246 includes a set 378 of openings 368 for a set of gas nozzles 264 disposed in alignment along a width 380 of the backside portion 366 of the inlet 246. The backside portion 360 of the elbow body 250 also includes sets 382 and 384 of openings 368 for sets of gas nozzles 264 disposed in alignment along the width 352 of the elbow body 250. The openings 368 are also aligned in columns 388, 390, 392, 394, and 396 in a vertical direction along a total length 398 of the backside portions 360 and 366. As illustrated, the sets 378, 382, and 384 of openings 368 include 3, 3, and 5 openings, respectively, for a total of 11 openings 368 for 11 fuel nozzles 364. However, in other embodiments, the number of openings 368 in each set 378, 382, and 384, the number of sets, the total number openings 368, and the arrangement of the openings 368 may vary. For example, the number of openings 368 in each set may range from 1 to 10, the number of sets may range from 1 to 10, and the total number of openings 368 may range from 1 to 100. Also, the openings 368 may not be aligned in sets or rows or columns.

[0060] FIG. 8 is a cross-sectional side view of an embodiment of the fluidization elbow 12 shown in FIG. 6. As described above, the elbow body 250 turns, as generally indicated by arrow 253, and converges from the elbow inlet 246 toward the elbow outlet 248. The elbow body 250 includes inner bend portion 256 and outer bend portion 258. Turning of the elbow body 250 may range from approximately 45 to 90 degrees, 50 to 80 degrees, or 60 to 70 degrees. For example, the elbow body 250 may turn at least approximately 45, 50, 55, 60, 65, 70, 75, 80, 85, or 90 degrees, or any angles therebetween. As illustrated, multiple gas nozzles 264 are disposed along the outer bend portion 258. The multiple gas nozzles 264 are coupled to the openings 368. Each illustrated gas nozzle 264 may represent a set of gas nozzles 264. Both the openings 368 and their respective gas nozzles 264 are oriented towards the elbow outlet 248. As a result, the gas nozzles 264 include injection axes 408 that generally converge toward the elbow outlet 248, e.g., outlet axis 249. For example, opening 410 and gas nozzle 412 are oriented at a greater angle than opening 414 and gas nozzle 416. Also, opening 414 and gas nozzle 416 are oriented at a greater angle than opening 418 and gas nozzle 420. Accordingly, the gas nozzles 264 are arranged to avoid low velocity zones in the flow of the solid feedstock.

[0061] As mentioned above, the gas nozzles **264** are configured to fluidize the solid feedstock to provide a uniform and homogenous flow as well as to converge and accelerate the flow towards the elbow outlet **248**. As previously mentioned, the fluidized elbow **12** also includes at least one baffle **263** disposed in the elbow body **250** configured to guide the flow of solid feedstock around the turn in the elbow body **250**. In certain embodiments, one or more baffles **263** may include gas nozzles **264** to assist in converging the flow towards the elbow outlet **248**.

[0062] FIG. **9** is a cross-sectional top view of an embodiment of the fluidization elbow **12** shown in FIG. **6**. FIG. **9** illustrates the convergence of side portions **348** and **350** and bottom side portion **346** towards the elbow outlet **248**. Also, as previously mentioned, the corners **362** and **364** of the backside portion **360** of the elbow body **250** are rounded to avoid low velocity regions as well as to smoothly transition the flow of the solid feedstock towards the elbow outlet **248**. Additionally, the openings **368**, as illustrated by set **384**, are oriented to allow their respective fuel nozzles **364** to converge the flow of the solid feedstock towards the elbow outlet **248**, as generally indicated by arrows **430** directed toward outlet axis **249**.

[0063] FIGS. **10-13** illustrate another embodiment of the fluidization elbow **12**. FIG. **10** is a perspective view of an embodiment of the fluidization elbow **12**. The fluidization elbow **12** includes the elbow inlet **246**, the elbow outlet **248** downstream from the elbow inlet **246**, and the elbow body **250** disposed between the elbow inlet **246** and the elbow outlet **248**. The elbow inlet **246** includes the annular opening **342** for receiving the solid feedstock from the solid feed pump **10**. As illustrated, the elbow body **250** turns, as generally indicated by arrow **253**, and converges from the elbow inlet **246** toward the elbow outlet **248** (see FIG. **12**). The elbow body **250** includes the topside portion **344** and the bottom side portion **346** (see FIG. **13**) that converge or taper towards the elbow outlet **248**. In addition, the elbow body **250** includes the side portions **348** and **350** (see FIG. **14**) that converge or taper towards the elbow outlet **248**. The elbow outlet **248** extends from the elbow body **250** and is configured to couple with the conveyance system **244**, e.g., a pipeline. The width **352** of the elbow body **250** increases from the top portion **354** to the bottom portion **356** of the elbow body **250**. The increase in the width **352** provides sufficient space for the routing of the solid feedstock from the solid feed pump **10** to the conveyance system **244** to avoid pile up of solid feedstock within the fluidized elbow **12**. The length **358** (see FIG. **12**) of the elbow body **250** is configured to avoid low velocity zones while also providing a smooth transition for the solid feedstock. The length **358** of the elbow body **250** also increases from the top portion **354** to the bottom portion **356** of the elbow body **250**. Thus, the elbow body **250** expands out from the elbow inlet **246** from the top portion **354** to the bottom portion **356** of the body **250**. Also, the backside portion **360** of the elbow body **250** includes rounded corners **362** and **364** to smooth the transition of the solid feedstock flow as well as to avoid low velocity zones. In addition, the backside portion **360** of the elbow body **250** bows or curves away from backside portion **366** of the inlet **246**, as generally indicated by arrow **440**. The bowing or curving **440** increases the space for the routing of the solid feedstock by the fluidization elbow **12**. Backside portions **366** and **360** of the elbow inlet **246** and the elbow body **250**, respectively, include openings **368** for multiple gas nozzles **264**.

[0064] FIG. **11** is a rear view of an embodiment of the fluidization elbow **12** shown in FIG. **10**. The backside portion **366** of the elbow inlet **246** includes the set **378** of openings **368** for the set of gas nozzles **264** generally disposed in alignment along the width **380** of the backside portion **366** of the inlet **246**. The backside portion **360** of the elbow body **250** also includes sets **382** and **384** of openings **368** for sets of gas nozzles **264** disposed in alignment along the width **352** of the elbow body **250**. The openings **368** are also aligned in columns **388**, **390**, **392**, **394**, and **396** in a vertical direction along the total length **398** of the backside portions **360** and **366**. As illustrated, the sets **378**, **382**, and **384** of openings **368** include 3, 3, and 5 openings, respectively, for a total of 11 openings **368** for 11 fuel nozzles **364**. However, in other embodiments, the number of openings **368** in each set **378**, **382**, and **384**, the number of sets, the total number openings **368**, and the arrangement of the openings **368** may vary. For example, the number of openings **368** in each set may range from 1 to 10, the number of sets may range from 1 to 5, and the total number of openings **368** may range from 1 to 30. Also, the openings **368** may not be aligned in sets or rows or columns. In certain embodiments, instead of openings **368**, the permeable plate **334** is attached to the elbow **12**.

[0065] FIG. **12** is a cross-sectional side view of an embodiment of the fluidization elbow **12** shown in FIG. **10**. As described above, the elbow body **250** turns, as generally indicated by arrow **253**, and converges from the elbow inlet **246** toward the elbow outlet **248**. The elbow body **250** includes the inner bend portion **256** and the outer bend portion **258**. Turning of the elbow body **250** may range from approximately 45 to 90 degrees, 50 to 80 degrees, or 60 to 70 degrees. For example, the elbow body **250** may turn at least approximately 45, 50, 55, 60, 65, 70, 75, 80, 85, or 90 degrees, or any degrees therebetween. As illustrated, multiple gas nozzles **264** are disposed along the outer bend portion **258**. The multiple gas nozzles **264** are coupled to the openings **368**. Each illustrated gas nozzle **264** may represent a set of gas nozzles **264**. Both the openings **368** and their respective gas nozzles **264** are oriented towards the elbow outlet **248**. As a result, the gas nozzles **264** include injection axes **408** that generally converge toward the elbow outlet **248**. For example, opening **410** and gas nozzle **412** are oriented at a greater angle than opening **414** and gas nozzle **416**. Also, opening **414** and gas nozzle **416** are oriented at a greater angle than opening **418** and gas nozzle **420**. As mentioned above, the backside portion **360** of the elbow body **250** is bowed or curved, as indicated by arrow **440**. The bowed or curved backside portion **360** may allow the injection axes **408** of the multiple gas nozzles **264** to generally converge toward the elbow outlet **248** without having to angle the nozzles **264**. In other words, the multiple gas nozzles **264** may be perpendicularly installed with respect to the backside portion **360** of the elbow body **250**. Accordingly, the gas nozzles **264** are arranged to avoid low velocity zones in the flow of the solid feedstock.

[0066] As mentioned above, the gas nozzles **264** are configured to fluidize the solid feedstock to provide a uniform and homogenous flow as well as to converge and accelerate the flow towards the elbow outlet **248**. As previously mentioned, the fluidized elbow **12** also includes at least one baffle **263** disposed in the elbow body **250** configured to guide the flow of solid feedstock around the turn in the elbow body **250**. In certain embodiments, one or more baffles **263** may include gas nozzles **264** to assist in converging the flow towards the elbow outlet **248**.

[0067] FIG. **13** is a cross-sectional top view of an embodiment of the fluidization elbow **12** shown in FIG. **10**. FIG. **13** illustrates the convergence of side portions **348** and **350** and bottom side portion **346** towards the elbow outlet **248**. Also, as previously mentioned, the corners **362** and **364** of the backside portion **360** of the elbow body **250** are rounded to avoid low velocity regions as well as to smoothly transition the flow of the solid feedstock towards the elbow outlet **248**. Additionally, the openings **368**, as illustrated by set **384**, are oriented to allow their respective fuel nozzles **364** to converge the flow of the solid feedstock towards the elbow outlet **248**, as generally indicated by arrows **430** directed toward outlet axis **249**.

[0068] FIGS. **14-17** illustrate a further embodiment of the fluidization elbow **12**. FIG. **14** is a perspective view of an embodiment of the fluidization elbow **12**. The fluidization elbow **12** includes the elbow inlet **246**, the elbow outlet **248** downstream from the elbow inlet **246**, and the elbow body **250** disposed between the elbow inlet **246** and the elbow outlet **248**. Generally, the elbow inlet **246**, the elbow outlet **248**, and the elbow body **250** include an annular shape. The elbow inlet **246** includes the annular opening **342** for receiving the solid feedstock from the solid feed pump **10**. As illustrated, the elbow body **250** turns, as generally indicated by arrow **253**, and converges from the elbow inlet **246** toward the elbow outlet **248** (see FIG. **16**). The elbow inlet **246** includes a top portion **450** and a bottom portion **452** that includes width **380** that gradually decreases from the top portion **450** to the bottom portion **452** (see FIG. **15**). The elbow body **250** includes the topside portion **344** and the bottom side portion **346** (see FIG. **17**) that converge or taper towards the elbow outlet **248**. In addition, the elbow body **250** includes the side portions **348** and **350** (see FIG. **17**) that converge or taper towards the elbow outlet **248**. Also, the elbow body **250** includes a conical portion **448** that extends towards the elbow outlet **248**. The elbow outlet **248** extends from the elbow body **250** and is configured to couple with the conveyance system **244**, e.g., a pipeline. The width **352** of the elbow body **250** gradually decreases from the top portion **354** to the bottom portion **356** of the elbow body **250**. The length **358** (see FIG. **16**) of the elbow body **250** is configured to avoid low velocity zones while also providing a smooth transition for the solid feedstock. The backside portion **360** of the elbow body **250** curves towards the elbow outlet **248** and eliminates the possibility for settling of solid feedstock towards the backside portion **360** of the body **250**. Backside portions **366** and **360** of the elbow inlet **246** and the elbow body **250**, respectively, include openings **368** for multiple gas nozzles **264**.

[0069] FIG. **15** is a rear view of an embodiment of the fluidization elbow **12** shown in FIG. **14**. The backside portion **366** of the elbow inlet **246** includes a single opening **368** (i.e., **454**) centrally located at the bottom portion **452** of the inlet **246** for the gas nozzle **264**. The opening **454** forms a part of the set **378** of openings **368**. In some embodiments, the opening **454** may be centrally located at the top portion **354** on the backside portion **360** of the elbow body **250** as part of the set **378** of openings **368**. The backside portion **360** of the elbow body **250** also includes sets **378**, **382**, and **384** of openings **368** for sets of gas nozzles **264** generally disposed in alignment along the width **352** of the elbow body **250**. The openings **368** are also aligned in columns **388**, **390**, and **392** in a vertical direction along the total length **398** of the backside portions **360** and **366**. As illustrated, the sets **378**, **382**, and **384** of openings **368** include 3, 3, and 3 openings, respectively, for a total of 9 openings **368** for 9 fuel nozzles **364**. However, in other embodiments, the number of openings **368** in each set **378**, **382**, and **384**, the number of sets, the total number openings **368**, and the arrangement of the openings **368** may vary. For example, the number of openings **368** in each set may range from 1 to 10, the number of sets may range from 1 to 10, and the total number of openings **368** may range from 1 to 100. Also, the openings **368** may not be aligned in sets or rows or columns. In certain embodiments, instead of openings **368**, the permeable plate **334** is attached to the elbow **12**.

[0070] FIG. **16** is a cross-sectional side view of an embodiment of the fluidization elbow **12** shown in FIG. **14**. As described above, the elbow body **250** turns, as generally indicated by arrow **253**, and converges from the elbow inlet **246** toward the elbow outlet **248**. The elbow body **250** includes inner bend portion **256** and outer bend portion **258**. The outer bend portion **258** includes the wall portion **260** that curves in a downstream direction, as generally indicated by arrow **253**, from the elbow inlet **246** toward the elbow outlet **248** to help accelerate the flow of the solid feedstock as well as to eliminate any cavity for settling of the feedstock as described above. Turning of the elbow body 250 may range from approximately 45 to 90 degrees, 50 to 80 degrees, or 60 to 70 degrees. For example, the elbow body **250** may turn at least approximately 45, 50, 55, 60, 65, 70, 75, 80, 85, or 90 degrees, or any angle therebetween. As illustrated, multiple gas nozzles **264** are disposed along the outer bend portion **258**. The multiple gas nozzles **264** are coupled to the openings **368**. Each illustrated gas nozzle **264** may represent a set of gas nozzles **264**. Both the openings **368** and their respective gas nozzles **264** are oriented towards the elbow outlet **248**. As a result, the gas nozzles **264** include injection axes **408** that generally converge toward the elbow outlet **248**, e.g., outlet axis **249**. For example, opening **410** and gas nozzle **412** are oriented at a greater angle than opening **414** and gas nozzle **416**. Also, opening **414** and gas nozzle **416** are oriented at a greater angle than opening **418** and gas nozzle **420**. Accordingly, the gas nozzles **264** are arranged to avoid low velocity zones in the flow of the solid feedstock.

[0071] As mentioned above, the gas nozzles **264** are configured to fluidize the solid feedstock to provide a uniform and homogenous flow as well as to converge the flow towards the elbow outlet **248**. As previously mentioned, the fluidized elbow **12** also includes at least one baffle **263** disposed in the elbow body **250** configured to guide the flow of solid feedstock around the turn in the elbow body **250**. In certain embodiments, one or more baffles **263** may include gas nozzles **264** to assist in converging the flow towards the elbow outlet **248**.

[0072] FIG. **17** is a cross-sectional top view of an embodiment of the fluidization elbow **12** shown in FIG. **14**. FIG. **17** illustrates the convergence of side portions **348** and **350** and bottom side portion **346** towards the elbow outlet **248**. Additionally, the openings **368**, as illustrated by set **384**, are oriented to allow their respective fuel nozzles **364** to converge the flow of the solid feedstock towards the elbow outlet **248**, as generally indicated by arrows **430** directed toward outlet axis **249**.

[0073] FIGS. **18-21** illustrate a still further embodiment of the fluidization elbow **12**. FIG. **18** is a perspective view of an embodiment of the fluidization elbow **12**. The fluidization elbow **12** includes the elbow inlet **246**, the elbow outlet **248** downstream from the elbow inlet **246**, and the elbow body

250 disposed between the elbow inlet **246** and the elbow outlet **248**. Generally, the elbow inlet **246**, the elbow outlet **248**, and the elbow body **250** include an annular shape. The elbow inlet **246** includes the annular opening **342** for receiving the solid feedstock from the solid feed pump **10**. As illustrated, the elbow body **250** turns, as generally indicated by arrow **253**, and converges from the elbow inlet **246** toward the elbow outlet **248** (see FIG. **20**). The elbow body **250** includes the topside portion **344** and the bottom side portion **346** (see FIG. **21**) that converge or taper towards the elbow outlet **248**. In addition, the elbow body **250** includes the side portions **348** and **350** (see FIG. **21**) that converge or taper towards the elbow outlet **248**. The elbow body **250** also includes side portions **464** and **466** that bow or curve out from near the top portion **354** to a mid-portion **468** of the body **250**. Then, the side portions **464** and **466** curve back in from the mid-portion **468** to the bottom portion **356** of the elbow body **250**. The bowing of the side portions **348** and **350** provides sufficient space for the routing of the solid feedstock from the solid feed pump **10** to the conveyance system **244** to avoid pile up of solid feedstock within the fluidized elbow **12**. Also, the elbow body **250** includes a conical portion **448** that extends towards the elbow outlet **248**. The elbow outlet **248** extends from the elbow body **250** and is configured to couple with the conveyance system **244**, e.g., a pipeline. The width **352** of the elbow body **250** increases from the top portion **354** to the mid-portion **468** and decreases from the mid-portion **468** to the bottom portion **356** of the elbow body **250**. The length **358** (see FIG. **20**) of the elbow body **250** is configured to avoid low velocity zones while also providing a smooth transition for the solid feedstock. The backside portion **360** of the elbow body **250** also bows out (see FIG. **20**) to provide more space for the flow of the solid feedstock through the fluidization elbow **12**. Backside portions **366** and **360** of the elbow inlet **246** and the elbow body **250**, respectively, include openings **368** for multiple gas nozzles **264**.

[0074] FIG. **19** is a rear view of an embodiment of the fluidization elbow **12** shown in FIG. **18**. As mentioned above, FIG. **19** illustrates the bowing of the elbow body **250**. Also, the backside portion **360** of the elbow body **250** also includes sets **378**, **382**, and **384** of openings **368** for sets of gas nozzles **264** generally disposed in alignment along the width **352** of the elbow body **250**. The openings **368** are also aligned in columns **388**, **390**, and **392** in a vertical direction along a length **398** of the backside portions **360**. As illustrated, the sets **378**, **382**, and **384** of openings **368** include 3, 3, and 3 openings, respectively, for a total of 9 openings **368** for 9 fuel nozzles **364**. However, in other embodiments, the number of openings **368** in each set **378**, **382**, and **384**, the number of sets, the total number openings **368**, and the arrangement of the openings **368** may vary. For example, the number of openings **368** in each set may range from 1 to 10, the number of sets may range from 1 to 10, and the total number of openings **368** may range from 1 to 100. Also, the openings **368** may not be aligned in sets or rows or columns. In certain embodiments, instead of openings **368**, the permeable plate **334** is attached to the elbow **12**.

[0075] FIG. **20** is a cross-sectional side view of an embodiment of the fluidization elbow **12** shown in FIG. **18**. As described above, the elbow body **250** turns, as generally indicated by arrow **253**, and converges from the elbow inlet **246** toward the elbow outlet **248**. The elbow body **250** includes inner bend portion **256** and outer bend portion **258**. The outer bend portion **258** includes the wall portion **260** that curves in a downstream direction, as generally indicated by arrow **253**, from the elbow inlet **246** toward the elbow outlet **248** to help accelerate the flow of the solid feedstock. Turning of the elbow body **250** may range from approximately 45 to 90 degrees, 50 to 80 degrees, or 60 to 70 degrees. For example, the elbow body **250** may turn at least approximately 45, 50, 55, 60, 65, 70, 75, 80, 85, or 90 degrees, or any angle therebetween. As illustrated, multiple gas nozzles **264** are disposed along the outer bend portion **258**. The multiple gas nozzles **264** are coupled to the openings **368**. Each illustrated gas nozzle **264** may represent a set of gas nozzles **264**. Both the openings **368** and their respective gas nozzles **264** are oriented towards the elbow outlet **248**. As a result, the gas nozzles **264** include injection axes **408** that generally converge toward the elbow outlet **248**, e.g., outlet axis **249**. For example, opening **410** and gas nozzle **412** are oriented at a greater angle than opening **414** and gas nozzle **416**. Also, opening **414** and gas nozzle **416** are oriented at a greater angle than opening **418** and gas nozzle **420**. Accordingly, the gas nozzles **264** are arranged to avoid low velocity zones in the flow of the solid feedstock.

[0076] As mentioned above, the gas nozzles **264** are configured to fluidize the solid feedstock to provide a uniform and homogenous flow as well as to converge and accelerate the flow towards the elbow outlet **248**. As previously mentioned, the fluidized elbow **12** also includes at least one baffle **263** disposed in the elbow body **250** configured to guide the flow of solid feedstock around the turn in the elbow body **250**. In certain embodiments, one or more baffles **263** may include gas nozzles **264** to assist in converging the flow towards the elbow outlet **248**.

[0077] FIG. **21** is a cross-sectional top view of an embodiment of the fluidization elbow **12** shown in FIG. **18**. FIG. **21** illustrates the convergence of side portions **348** and **350** and bottom side portion **346** towards the elbow outlet **248**. Additionally, the openings **368**, as illustrated by set **384**, are oriented to allow their respective fuel nozzles **364** to converge the flow of the solid feedstock towards the elbow outlet **248**, as generally indicated by arrows **430** directed toward outlet axis **249**.

[0078] FIGS. **22** and **21** illustrate yet a further embodiment of the fluidization elbow **12**. FIG. **22** is a perspective view of an embodiment of the fluidization elbow **12**. The fluidization elbow **12** includes the elbow inlet **246**, the elbow outlet **248** downstream from the elbow inlet **246**, and the elbow body **250** disposed between the elbow inlet **246** and the elbow outlet **248**. Generally, the elbow inlet **246** includes a cylindrical shape and the elbow body **250** includes a conical shape. In certain embodiments, the position of the elbow inlet **246** may vary along the length **358** of the elbow body **250**. As illustrated, the elbow inlet **246** is disposed near the backside portion **360** of the elbow body **250**. In other embodiments, the elbow inlet **246** may be more centrally disposed between the backside portion **360** of the elbow body **250** and the elbow outlet **248**. The length **358** of the elbow body **250** is configured to avoid low velocity zones while also providing a smooth transition for the solid feedstock. The elbow inlet **246** includes the annular opening **342** for receiving the solid feedstock from the solid feed pump **10**. As illustrated, the elbow body **250** converges from the elbow inlet **246** toward the elbow outlet **248** in a downstream direction, generally indicated by arrow **486** to accelerate the flow of the solid feedstock from the elbow inlet **246** towards the elbow outlet **248**. In particular, the elbow body **250** includes an annular wall **480**

(e.g., conical wall) that converges from the backside portion **360** towards the elbow outlet **248**. The elbow outlet **248** extends from the elbow body **250** and is configured to couple with the conveyance system **244**, e.g., a pipeline.

[0079] A diameter **482** of the elbow body **250** decreases from the backside portion **360** towards the elbow outlet **248**. The backside portion **360** of the elbow body **250** has an elliptical shape (e.g., circular shape). The backside portion **360** of the elbow body **250** includes openings **368** for multiple gas nozzles **264** disposed proximate to a circumference **484** of the backside portion **360**. As illustrated, the openings **368** are equally spaced in an annular arrangement. As illustrated, the backside portion includes **8** total openings **368** for 8 fuel nozzles **264**. However, in other embodiments, the number of openings **368** and the arrangement of the openings **368** may vary. For example, the number of openings **368** may range from 1 to 100, 5 to 50, or 10 to 20. Also, the openings **368** may not be disposed proximate to the circumference **484** of the backside portion **360**, but nearer to the center of the backside portion **360**. Further, the openings **368** may not be equally spaced or arranged in an annular arrangement. In certain embodiments, instead of openings **368**, the permeable plate **334** is attached to the elbow **12**.

[0080] FIG. **23** is a cross-sectional side view of an embodiment of the fluidization elbow **12** shown in FIG. **22**. As illustrated, multiple gas nozzles **264** are disposed on the backside portion **360**. The multiple gas nozzles **264** are coupled to the openings **368**. In certain embodiments, a portion of or the entire backside portion **360** of the elbow body may include nozzle assembly **296** as described above. Both the openings **368** and their respective gas nozzles **264** are oriented towards the elbow outlet **248**. As a result, the gas nozzles **264** include injection axes **408** that generally converge toward the elbow outlet **248**, e.g., outlet axis **249**. For example, opening **488** and gas nozzle **490** are oriented at a greater angle than opening **492** and gas nozzle **494**. The gas nozzles **264** are arranged to avoid low velocity zones in the flow of the solid feedstock.

[0081] As mentioned above, the gas nozzles **264** are configured to fluidize the solid feedstock to provide a uniform and homogenous flow as well as to converge the flow towards the elbow outlet **248**. As illustrated, a cross-sectional area **496** of the elbow body **250** decreases from the backside portion **360** towards the elbow outlet **248**. As previously mentioned, the fluidized elbow **12** also includes at least one baffle **263** disposed in the elbow body **250** configured to guide the flow of solid feedstock within the elbow body **250**. In certain embodiments, one or more baffles **263** may include gas nozzles **264** to assist in converging the flow towards the elbow outlet **248**. As illustrated, the elbow outlet **248** is disposed at an angle **498** relative to an axis **500** extending from the bottom side portion **346** of the elbow body **250**. In certain embodiments, the angle **498** may range from approximately 0 to 45, 10 to 30, or 15 to 25 degrees. For example, the angle **498** may be approximately 0, 5, 10, 15, 20, 25, 30, 35, 40, or 45 degrees, or any angle therebetween.

[0082] Technical effects of the disclosed embodiments include providing systems with fluidization elbows **12** configured to establish a substantially uniform and homogenous flow of gas and solid particles that is coming out from the solid feed pump **10** to the gasifier **106** via a high pressure conveyance system, while avoiding pile ups of the solid particles in the fluidization elbow **12**. The location of the fluidization elbow **12** below the outlet **202** of the solid feed pump **10** allows the solid particles to flow into the elbow **12** downward and to be promptly discharged. However, the location of the fluidization elbow **12** does not need to be located below the outlet of the solid feed pump **10**. The convergence of the elbow body **250** from the elbow inlet **246** to the elbow outlet **248** accelerates the flow of the solid particles and reduces the residence time in the elbow **12** to less than approximately 1 second. In addition, the location of the fluidization elbow **12** allows the elbow **12** to include sufficient space for routing the solid particles from the solid feed pump **10** to the conveyance system **244**. The design of the fluidization elbow **12** also allows for easy installation and maintenance as well as simple operability since the elbow **12** is independent of the solid feed pump **10**.

[0083] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

1. A system, comprising:
- a solid feed pump having a pump inlet and a pump outlet, wherein the solid feed pump is configured to transport a solid feedstock; and
- a fluidization elbow disposed below the pump outlet, wherein the fluidization elbow comprises:
  - an elbow inlet coupled to the pump outlet;
  - an elbow outlet downstream from the elbow inlet;
  - an elbow body disposed between the elbow inlet and the elbow outlet, wherein the elbow body turns and converges from the elbow inlet toward the elbow outlet; and
  - a plurality of gas nozzles coupled to the elbow body, wherein the plurality of gas nozzles are configured to fluidize solid feedstock.

2. The system of claim **1**, wherein the plurality of gas nozzles comprise injection axes that generally converge toward the elbow outlet.

3. The system of claim **1**, comprising a controller configured to separately control gas flow through each gas nozzle of the plurality of gas nozzles.

4. The system of claim **1**, comprising at least one baffle disposed in the elbow body, wherein the at least one baffle is configured to guide the solid feedstock around a turn in the elbow body.

5. The system of claim **1**, wherein the plurality of gas nozzles is configured to inject a plurality of gas jets with different flow rates at different regions along the elbow body.

6. The system of claim **5**, wherein the plurality of gas nozzles comprises different nozzle diameters.

7. The system of claim **1**, comprising a nozzle assembly comprising a nozzle mount supporting at least two gas nozzles of the plurality of gas nozzles, wherein the nozzle mount is configured to secure the at least two gas nozzles to the elbow body.

8. The system of claim **7**, wherein the nozzle mount comprises a manifold having a manifold inlet, a distribution chamber, and the at least two gas nozzles coupled to the distribution chamber.

9. The system of claim **1**, comprising a nozzle assembly comprising a nozzle mount supporting a permeable plate.

10. The system of claim **1**, comprising a gasifier coupled to the elbow outlet.

11. A system, comprising:

a fluidization elbow, comprising:

an elbow inlet;

an elbow outlet downstream from the elbow inlet;

an elbow body disposed between the elbow inlet and the elbow outlet, wherein the elbow body turns and converges from the elbow inlet toward the elbow outlet; and

a plurality of gas nozzles coupled to the elbow body, wherein the plurality of gas nozzles comprise injection axes that generally converge toward the elbow outlet.

12. The system of claim **11**, comprising a controller configured to separately control gas flow through each gas nozzle of the plurality of gas nozzles.

13. The system of claim **11**, comprising at least one baffle disposed in the elbow body, wherein the at least one baffle is configured to guide a flow around a turn in the elbow body.

14. The system of claim **11**, wherein the plurality of gas nozzles is configured to inject a plurality of gas jets with different flow rates at different regions along the elbow body.

15. The system of claim **11**, wherein the fluidization elbow is configured to flow a solid feedstock with a residence time of less than approximately **1** second.

16. The system of claim **11**, comprising at least one of a posimetric pump or a gasifier coupled to the fluidization elbow.

17. A system, comprising:

a fluidization elbow, comprising:

an elbow inlet;

an elbow outlet downstream from the elbow inlet;

an elbow body disposed between the elbow inlet and the elbow outlet, wherein the elbow body turns and converges from the elbow inlet toward the elbow outlet; and

a plurality of gas nozzles coupled to the elbow body;

a controller configured to separately control gas flow through each gas nozzle of the plurality of gas nozzles.

18. The system of claim **17**, wherein the elbow body turns at least approximately 60 degrees, the elbow body comprises an inner bend portion and an outer bend portion, and the plurality of gas nozzles are disposed along the outer bend portion.

19. The system of claim **18**, wherein the plurality of gas nozzles comprises a first set of gas nozzles and a second set of gas nozzles disposed at different positions along a gas flow path through the elbow body.

20. The system of claim **18**, wherein the outer bend portion comprises a wall portion that curves in a downstream direction from the elbow inlet toward the elbow outlet.

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