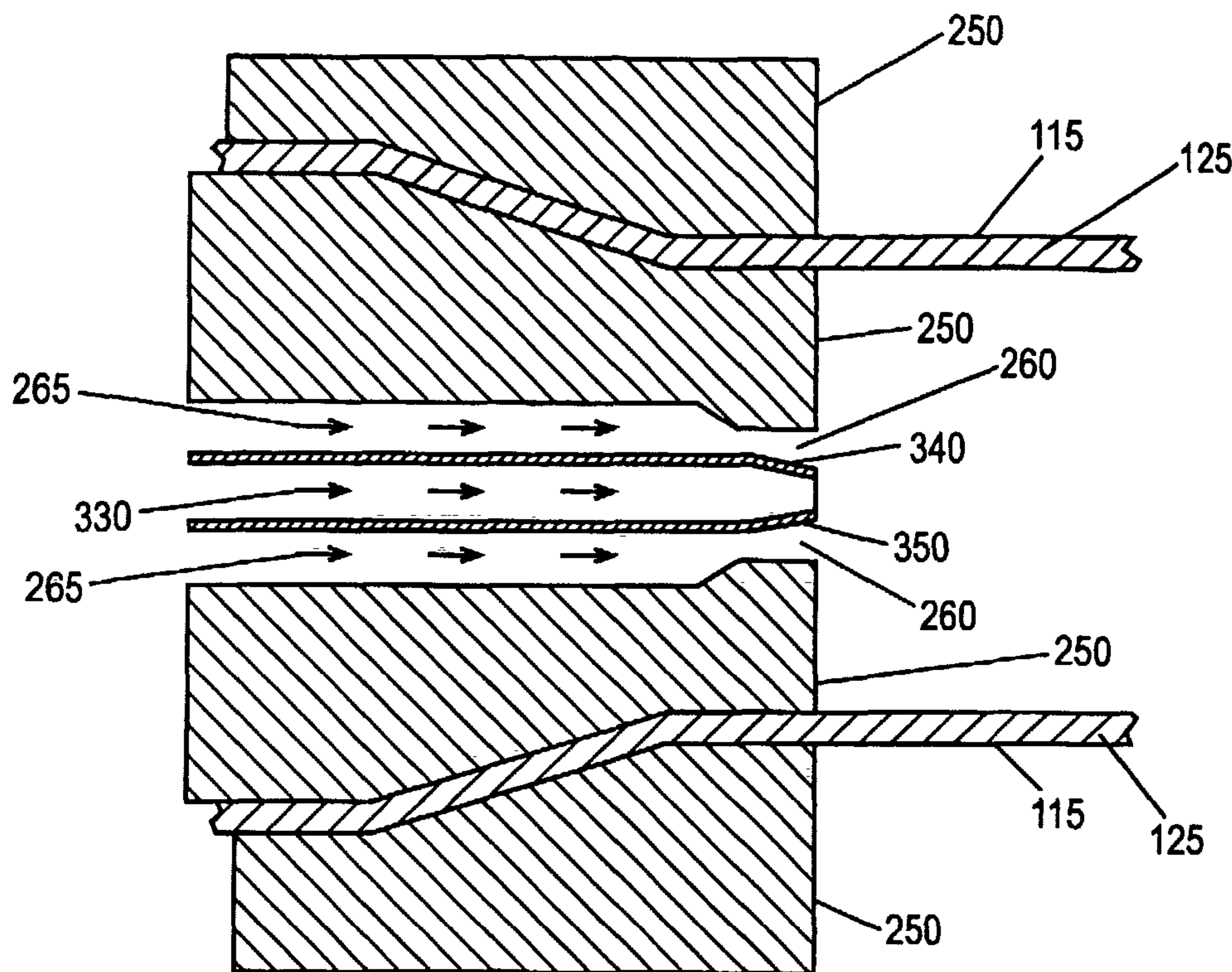




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 (71) Demandeur/Applicant:
 THE COCA-COLA COMPANY, US
 (72) Inventeurs/Inventors:
 PALANIAPPAN, SEVUGAN, US;
 ZHOU, SHENGYING, US;
 CHEN, YOU LUNG, US
 (74) Agent: SIM & MCBURNEY

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A coating device for coating an interior surface of a continuous tube (125) of material with a fluid. The coating device includes an extruder die (250) for forming the continuous tube of material and a fluid delivery system (310). The fluid delivery system (310) is positioned within the extruder die (250) so as to introduce the fluid (330) onto the interior surface (115) of the continuous tube of material (125).

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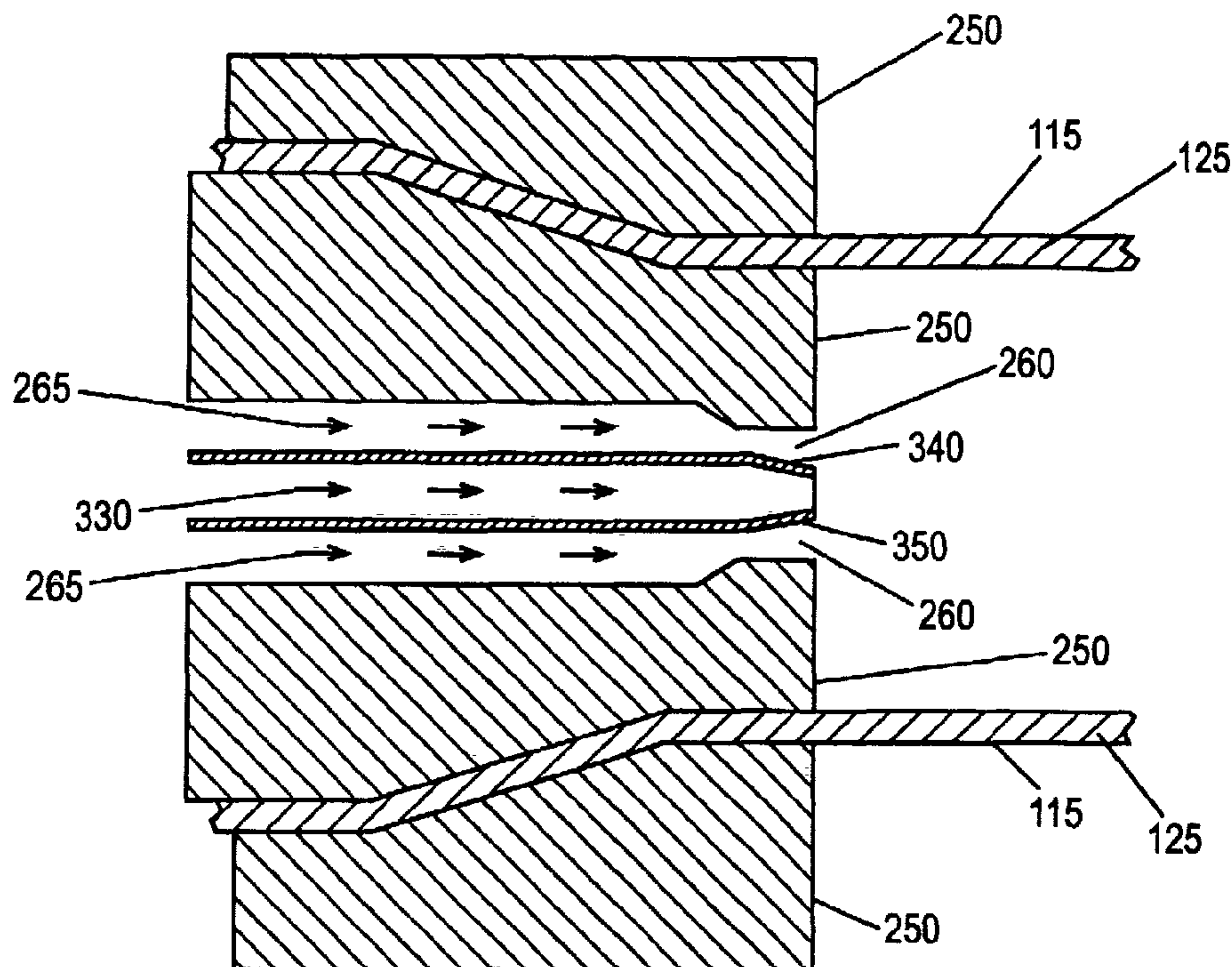
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- (71) Applicant: **THE COCA-COLA COMPANY** [US/US];
Patent Department, One Coca-Cola Plaza, NW, Atlanta,
GA 30313 (US).
- (72) Inventors: **PALANIAPPAN, Sevugan**; 4523 Castlewood
Street, Sugar Land, TX 77479 (US). **ZHOU, Shengying**;
3881 Emerald Estates Circle, Apopka, FL 32703 (US).
- CHEN, You, Lung; 518 Heatheroak Cove, Altamonte
Springs, FL 32714 (US).
- (74) Agents: **WARREN, Daniel, J.** et al.; Sutherland Asbill &
Brennan, L.L.P., 999 Peachtree Street, NE, Atlanta, GA
30309-3996 (US).
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(54) Title: METHOD AND APPARATUS FOR COATING THE INTERIOR SURFACE OF A STRAW



(57) Abstract: A coating device for coating an interior surface of a continuous tube (125) of material with a fluid. The coating device includes an extruder die (250) for forming the continuous tube of material and a fluid delivery system (310). The fluid delivery system (310) is positioned within the extruder die (250) so as to introduce the fluid (330) onto the interior surface (115) of the continuous tube of material (125).



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METHOD AND APPARATUS FOR COATING THE INTERIOR SURFACE OF A STRAW

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Technical Field

The present invention relates generally to extrusion techniques for polymers and more particularly relates to a method and an apparatus for extruding a polymer straw and coating an interior surface of the straw with a substance.

10

Background of the Invention

Various types of "flavored" drinking straws are known. By the term "flavored", we mean that an additional substance of some nature has been placed within the drinking straw such that the substance comes into contact with the beverage as the drinker sucks the beverage through the straw. The additional substance may be placed within the straw by various types of inserts, various types of internal coating methods, or various types of external structures that communicate with the interior of the straw.

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There are several disadvantages, however, with these known straws. First, the flow of the beverage through the straw may be obstructed when the additional substance is added as part of an internal insert. The insert may cause difficulty or require additional force as the user tries to suck the beverage through the insert. In the case of the interior coating methods, the straw is generally coated after the manufacturing process is complete. This extra coating step, however, may add considerable time and expense to the manufacturing process. Finally, the cost in terms of manufacture and materials is often prohibitive with the use of the known external structures.

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What is desired, therefore, is a method and an apparatus for coating the interior surface of a straw with an additional substance. Preferably the method and the apparatus should not materially increase the time of manufacture, increase the cost of manufacture, or decrease the production capacity. Further, the method and the apparatus should coat

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the additional substance on the interior surface of the straw in a substantially uniform manner.

Summary of the Invention

5 The present invention thus provides a coating device for coating an interior surface of a continuous tube of material with a fluid. The coating device includes an extruder die for forming the continuous tube of material and a fluid delivery system. The fluid delivery system is positioned within the extruder die so as to introduce the fluid onto the
10 interior surface of the continuous tube of material.

 Specific embodiments include the fluid delivery system having one or more fluid conduits extending through the extruder die. The fluid conduits may include an orifice about a first end. The fluid delivery system may have a flow rate of about 10 to about 500 milliliters
15 per minute.

 The coating device further may have an air delivery system. The air delivery system is positioned within the extruder die so as to introduce an air stream within the continuous tube of material. The fluid conduits are positioned within the air delivery system.

20 The coating device further may include a nozzle positioned within the extruder die. The fluid conduits may be positioned within the nozzle. The nozzle includes a face and the conduits lead to fluid apertures in the face. The fluid conduits may include a central conduit and a number of angled delivery conduits. The angled delivery conduits
25 may include four (4) to eight (8) delivery conduits, diameters of about 0.3 to about 0.6 millimeters, and angles of about ten (10°) to about sixty degrees (60°). The air delivery system includes a number of air conduits within the nozzle leading to a number of air apertures within the face. The air conduits may include a first section parallel to the fluid conduits
30 and a second section angled towards the fluid conduits. The second angled section may have an angle of about ten (10°) to about sixty degrees (60°) and a circular or a square shape. The nozzle also may include a deflector plate attached thereto.

 The coating device also may include an electrostatic device
35 positioned in communication with the extruder die. The electrostatic device includes a first charging device surrounding the continuous tube

and a second charging device in communication with the fluid delivery system.

A method of the present invention provides for coating the interior surface of a continuous tube of material with a fluid. The method includes the steps of extruding the continuous tube of material through an extruder die, providing a stream of air into the continuous tube of material through the extruder die, and providing a stream of the fluid through the extruder die so as to coat the continuous tube with the fluid.

A further embodiment of the present invention provides a coating device for coating an interior surface of a continuous tube of material with a fluid. The device includes an extruder die for forming the continuous tube of material, a nozzle positioned within the extruder die, a number of air delivery conduits positioned within the nozzle so as to produce an air stream within the continuous tube, and a number of fluid delivery conduits positioned within the nozzle so as to introduce the fluid onto the interior surface of the continuous tube of material.

A further embodiment of the present invention provides a coating device for coating an interior surface of a continuous tube of material with a fluid. The device includes an extruder die for forming the continuous tube of material, an air delivery system positioned within the extruder die so as to produce an air stream, and a fluid delivery system positioned within the air delivery system so as to introduce the fluid and coat the interior surface of the continuous tube of material.

25 Brief Description of the Drawings

Fig. 1 is a perspective view of a straw.

Fig. 2 is schematic view of a straw extrusion process for use with the present invention.

Fig. 3 is a side cross-sectional view of a hopper and a screw of an extruder.

Fig. 4 a side cross-sectional view of an extruder head.

Fig. 5 is a schematic view of the extruder of the present invention.

Fig. 6 is a side cross-sectional view of an extruder die of the present invention.

Fig. 7 is a cross-sectional view of a straw as coated.

Fig. 8 is a schematic view of an alternative embodiment of the present invention using an electrostatic device.

Fig. 9 is a plan view of a nozzle for use with the present invention.

5 Fig. 10 is a side cross-sectional view of the nozzle of Fig. 9.

Fig. 11 is a plan view of an alternative embodiment of a nozzle for use with the present invention.

Fig. 12 is a side cross-sectional view of the nozzle of Fig. 11

10 Fig. 13 is a plan view of an alternative embodiment of a nozzle for use with the present invention.

Fig. 14 is a plan view of an alternative embodiment of a nozzle for use with the present invention.

Fig. 15 is a side cross-section view of an alternative embodiment of a nozzle for use with the present invention.

15

Detailed Description

Referring now to the drawings, in which like numerals refer to like elements throughout the several views, the figures show a straw apparatus **100** for use with the present invention. The straw apparatus
20 **100** may manufacture a typical straw **110**. As is shown in Fig. 1, the straw **110** may be made out of a polymer such as polypropylene or similar types of materials. The straw **110** has an interior wall surface **115**. The straw **110** may be a conventional elongated tube, a “U”-shaped straw with a crimp towards one end so as to permit bending, a telescoping
25 straw, or any other type of conventional design. If the straw **110** is used with a typical juice box, a pouch, or a fountain drink, the straw **110** may have a wall thickness of about 0.2 to 0.4 millimeters and an inside diameter of about three (3) to four (4) millimeters. Any desired thickness or diameter, however, may be used. The straw **110** also may have any
30 desired length.

The Straw Apparatus

As is shown in Fig. 2, the straw apparatus **100** may include a number of elements or stations so as to produce the straw **110**. Operation
35 of the elements or the stations of the straw apparatus **100** may be controlled and monitored by a controller **117**. The straw apparatus **100**

may include an extruder **120**. The extruder **120** may be largely of conventional design. The components within the extruder **120** will be described in more detail below. In general, the extruder **120** takes pellets or other forms of a polymer or a similar material and processes the material into a fluid stream such that the material may be shaped as desired. The extruder **120** may produce about 10,000 to 100,000 straws **110** per hour.

In the case of the straw **110**, the extruder **120** generally produces a continuous tube **125** of the polymer material. The continuous tube **125** of the polymer material may extend out of the extruder **120**. By way of example, the continuous tube **125** may have a diameter of about six (6) to about ten (10) millimeters and a thickness of about 0.4 to about one (1) millimeters as the tube **125** exits the extruder **120**.

The continuous tube **125** may extend from the extruder **120** through an adjacent cooling trough **140**. The cooling trough **140** may extend for several meters in length. The cooling trough **140** may be made out of any desired material. The cooling trough **140** may contain water or any other type of fluids or other substances so as to chill the continuous tube **125**. For example, if the continuous tube **125** of the polymer material exits the extruder **120** at about 140 to 175 degrees Celsius, the continuous tube **125** may be lowered in temperature by the time it reaches the end of the cooling trough **140** to about twenty (20) to about forty (40) degrees Celsius. The drop in the temperature may vary upon the temperature of the water or other cooling medium, the length of the cooling trough **140**, the extrusion flow rate, and the nature of the polymer material.

The continuous tube **125** may extend through the cooling trough **140** to a stretching device **150**. The stretching device **150** may be of conventional design. The stretching device **150** may be pulley driven or driven by a conventional drive means. The stretching device **150** may pull on the continuous tube **125** of the polymer material and stretch it such that the wall thickness of the continuous tube **125** may be reduced from about one (1) millimeter to about 0.2 to 0.4 millimeters. This results in reducing the outside diameter of the continuous tube **125** to about three (3) to four (4) millimeters. Any desired diameter or wall thickness,

however, may be used. The stretching device may be positioned elsewhere within the straw device **100**.

The continuous tube **125** of the polymer material then may extend out of the stretching device **150** and towards a cutting device **160**.
5 The cutting device **160** may be of conventional design. The cutting device **160** may cut the continuous tube **125** of the polymer material into the individual straws **110** of any desired length.

Each individual straw **110** may then be further processed as desired. For example, the straw **110** may enter a corrugation machine
10 **170**. The corrugation machine **170** may be of conventional design. The corrugation machine **170** may score one end of the straw **110** so as to produce a "U"-shaped straw. The straw **110** then may be wrapped and/or packed as appropriate and shipped to the consumer or other end user.

15 **The Extruder**

Figs. 3 and 4 show the internal workings of the extruder **120**. As is well known, the extruder **120** may include a hopper **180**. The pellets or other forms of the polymer material may be loaded in the hopper **180**. The hopper **180** may lead to a screw **190**. The screw **190**
20 may be of conventional design. The screw **190** may be driven by a drive system **200**. The drive system **200** may be of conventional design. The polymer material may be heated and ground by the screw **190** into a molten polymer stream. The hopper **180**, the screw **190**, the drive system **200**, and the other elements of the extruder **120** may have any desired size
25 or configuration.

Positioned adjacent to the screw **190** may be an extruder head **210**. The extruder head **210** may include a mixer **220**. The mixer **220** may be of conventional design. The mixer **220** may rotate so as to mix the molten polymer stream. Positioned adjacent to the mixer **220**
30 may be a bore **230**. An outer wall **235** may define the bore **230**. The bore **230** may have any desired size or shape. A separator **240** may be positioned within the bore **230**. The separator **240** may have any desired size or shape. The separator **240** separates the molten polymer stream such that the molten polymer stream is forced between the wall **235** of the
35 bore **230** and the separator **240**. The separator **240** thus starts to form the molten polymer stream into the continuous tube **125**.

Positioned adjacent to the separator **240** may be an extruder die **250**. The extruder die **250** may be of conventional design. The extruder die **250** forces the molten polymer stream into the desired shape. In this example, the extruder die **250** may be largely cone shaped and may force the molten polymer stream into the continuous tube **125** of the polymer material with the desired dimensions.

The extruder head **210** also may include an air conduit **260**. The air conduit **260** may define an airflow path from outside the extruder **120** into and through the extruder separator **240** and the extruder die **250**. The air conduit **260** may end about with the extruder die **250**. The air conduit **260** may be made out of steel or similar types of materials. The air conduit **260** may allow a flow of air **265** into the continuous tube **125** of the polymer material as the tube **125** exits the extruder **120**. The air flow may assist in maintaining the interior shape of the continuous tube **125**.

Although the air conduit **260** generally may have an inside diameter of about two (2) millimeters for most extruders, an inside diameter of about 1.6 or 1.8 millimeters may be used herein at least at the end of the conduit **260**. The smaller inside diameter may provide for the increased air flow and the pressure desired for atomizing the fluid as described below. Any desired diameter, however, may be used.

The air conduit **260** may be attached to a source of pressurized air **270**. Air or other gases such as nitrogen, helium, or mixtures thereof also may be used. The air source **270** may be of conventional design. The air source **270** may provide the flow of air **265** through the air conduit **260** at any desired pressure. The air pressure may range from about 0.35 kilogram per square centimeter (kg/cm^2) to about $3.5 \text{ kg}/\text{cm}^2$ (about five (5) to about fifty (50) pounds per square inch (psi)). The flow rate of the air flow **265** may be about 5,663 to about 142,000 milliliters per minute (about 0.2 to about five (5) standard cubic feet per minute (scfm)). Any desire flow rate may be used.

Fluid Delivery System

Figs. 5 and 6 show an extruder **300** of the present invention. The extruder **300** may be substantially identical to the extruder **120** described in detail above. The extruder **300**, however, also may include a

fluid delivery system **310**. The fluid delivery system **310** may include a source of a fluid **320**. The fluid source **320** may be a pressurized container of conventional design. Alternatively, the fluid source **320** also may depend on a pump, gravity feed, or a siphoning action. One or more
5 heat sources also may be used.

The fluid source **320** may include a fluid **330** to be applied to the interior wall surface **115** of the straw **110**. The fluid **330** may contain a flavoring agent, such as citric acid; a coloring agent; a source of carbonation; any type of nutrient; any type of product additive; a
10 preservative; or any other type of fluid or combination thereof. The fluid **330** may include a measure of a surfactant so as to act as a wetting agent. The surfactant may include lecithin or similar types of materials. The fluid **330** also may include an adhesive agent such as a gum to aid in the “stickiness” of the fluid **330** with respect to the internal wall surface **115**
15 of the continuous tube **125**. The gum may include maltodextrin, alginate, or similar types of materials. A plasticizer also may be used. The fluid **330** may be heated to provide a uniform flow. The scope of the invention is not limited by the nature of the fluid **330**.

The fluid source **320** may be connected to the extruder head
20 **210** via a fluid conduit **340**. The fluid conduit **340** may be made out of steel, stainless steel, plastic materials, or similar types of materials. The fluid conduit **340** may extend into and through the extruder head **210** within the air conduit **260**. Alternatively, the fluid conduit **340** and the air conduit **260** may be separate passageways for part or substantially all
25 of their lengths. The fluid conduit **340** may end at about the same location or point where the air conduit **260** ends. The fluid conduit **340** may have a restricted orifice **350** at one end so as to increase the pressure of the fluid **330** therein. Given an air conduit **260** with an inside diameter of about 1.6 or 1.8 millimeters, the orifice **350** may have an outside
30 diameter of about one (1) to about 1.2 millimeters and an inside diameter of about 0.3 to about 0.8 millimeters.

As the fluid **330** exits the restricted orifice **350**, the fluid **330** may mix with the air flow **265** exiting the air conduit **260**. The flow of the air **265** may largely atomize the flow of the fluid **330** so as to form a
35 spray or a mist. The fluid **330** may have a pressure of about 0.2 to about 10.5 kg/cm² (about three (3) to 150 psi) and a flow rate of about 10 to

about 1,000 milliliters per minute. Any desired pressure or flow rate may be used. Modifications in the air pressure and flow rate may impact on the fluid pressure and flow rate as well as the atomization of the fluid **330**.

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In Use

In use, the extruder **300** cooperates with the other elements of the straw apparatus **100** as is described above so as to turn the pellets of the polymer material into the continuous tube **125** and the straw **110**.
10 As the continuous tube **125** of the polymer material exits the extruder head **210** of the extruder **300**, the fluid delivery system **310** delivers a stream of the fluid **330** through the orifice **350** of the fluid conduit **340**. The fluid **330** then may be mixed with the air flow **265** from the air source **270** and the air conduit **260**. The fluid **330** is preferably atomized
15 within the flow of air **265** and extends down the continuous tube **125** in a spray or a mist.

Based upon flow rates, surface energy, surface tension, particle size, and/or temperature differences, the atomized fluid **330** may coat the interior wall surface **115** of the continuous tube **125** of the
20 polymer material. As is shown in Fig. 7, the fluid **330** may form a substantially uniform coating **360** along the continuous tube **125**. This coating **360** should bind to the interior wall surface **115** of the continuous tube **125** as the atomized fluid **330** dries (cures) and the tube **125** cools in the cooling trough **140** and beyond.

25 By way of example, a straw **110** used with a typical pouch or box drink may have a length of about 135 to about 160 millimeters, with an internal diameter of about two (2) to about five (5) millimeters (about three (3) to about four (4) millimeters used for this example) and a thickness of about 0.2 millimeters to 0.4 millimeters. The beverage may
30 have an acid content of about 0.4 percent by weight. It may be desired to increase the acid content of the beverage to about 1.2 percent for the first five (5) sips or so of the beverage. If each sip contains about seven (7) milliliters of the beverage, the amount of citric acid originally in the first thirty-five (35) milliliters would be about 0.14 grams (by dry weight).

35 To increase the acid content to about 1.2 percent, we would need to add about another 0.28 grams of citric acid to the straw **110**.

Assuming one hundred percent (100%) recovery, 0.28 grams of the citric acid may be needed per straw **110**. The fluid **330** thus may have a citric acid solution of about five (5%) to about ninety-nine percent (99%) depending on the volume required, water solubility, viscosity, melting temperature, particle size, dripping, and the pumping capability (flow rate and pressure) of the fluid delivery system **310** and the air source **270**. If the fluid **330** has a ninety percent (90%) citric acid solution, about 0.31 grams of the fluid **330** should be used.

In this example, the air conduit **260** may have an inner diameter of about 1.6 millimeters and the air source **270** may deliver the flow of air **265** with a pressure of about 1.4 kg/cm² (about twenty (20) psi) and a flow rate of about 1700 milliliters per minute (about 0.6 scfm). The orifice **350** may have an outer diameter of about 1.2 millimeters and an inner diameter of about 0.4 millimeters. The fluid source **320** may deliver the fluid **330** with a pressure of about 1.8 kg/cm² (about twenty-five (25) psi) and a flow rate of about two hundred (200) to about three hundred (300) milliliters per minute. The continuous tube **125** may exit the extruder die **250** at about 150 degrees Celsius and may be traveling at about 350 centimeters per second.

Once the fluid delivery system **310** has delivered the fluid **330** to the inner wall surface **115** of the continuous tube **125** of the polymer material and the fluid **330** dries, the coating **360** of about 0.3 grams may remain along the length of the straw **110**. The coating **360** becomes bound to the continuous tube **125** as the polymer material cools.

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Electrostatic Device

Fig. 8 shows an alternative embodiment of the present invention. This embodiment involves the use of an electrostatic device **400**. The electrostatic device **400** may be of conventional design. The electrostatic device **400** may be used with the straw apparatus **100** as described above. The electrostatic device **400** may include a charging device **410**. The charging device **410** may be an electrically conducting conduit positioned on either side of the cooling trough **140** or elsewhere along the path of the straw apparatus **100**. The charging device **410** may encircle the continuous tube **125** of the polymer material. The electrostatic device **400** also may include an opposite charging device

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420. The opposite charging device 420 may be positioned about the fluid 330 and the fluid source 320. The opposite charging device 420 may charge the fluid 330 with an opposite charge to that of the charging device 110. As such, when the fluid 330 extends through the restricted orifice 350, the charge of the fluid 330 and the charge of the charging device 410 encircling the continuous tube 125 of the polymer material attract each other such that the fluid 330 binds to the interior wall surface 115 of the straw 110 so as to form the uniform coating 360.

10 Nozzle Design

Figs. 9 through 15 show further alternative embodiments of the present invention. In these embodiments, the extruder head 210 may include a nozzle 500 instead of or in addition to the orifice 350. The nozzle 500 may communicate with the air conduit 260 and the fluid conduit 340. The nozzle 500 may be made out of steel, stainless steel, plastic materials, or similar types of materials. The nozzle 500 may have a face 510 with a number of apertures 520 therethrough. Each nozzle 500 also may include an extended body portion 530 with a number of conduits 540 therein. The nozzle 500 may be about thirty (30) to about sixty (60) millimeters in length depending upon the size of the extruder head 210. The number, size, positioning, and angle of the apertures 520 may vary depending upon the nature of the fluid 330 and/or other variables as described in more detail herein.

For example, Figs. 9 and 10 show one embodiment of the nozzle 500, in this case a low loading application nozzle 550. The low loading application nozzle 550 may have an internal fluid conduit 560. The internal fluid conduit 560 may be in communication with the fluid conduit 340 described above. The internal fluid conduit 560 may be about thirty (30) to about sixty (60) millimeters in length. The internal fluid conduit 560 also may be in communication with a fluid aperture 570 on the face 510 of the nozzle 550. The internal fluid conduit 560 may have an inside diameter of about 0.1 to about three (3) millimeters. The diameter may narrow as the conduit 560 extends towards the face 510 such that the stream of the fluid 330 exits the aperture 570 under pressure. The fluid aperture 570 may have an inside diameter of about 0.1 to about

0.6 millimeters. The conduit **560** and the aperture **570** may be circular, square, or have any convenient shape.

Surrounding the internal fluid conduit **560** may be a number of internal air conduits **580**. The internal air conduits **580** may be enclosed structures or chambers defined by a number of splines. The internal air conduits **580** may be in communication with the air conduit **260** described above. The internal air conduits **580** may be about thirty (30) to about sixty (60) millimeters in length. The internal air conduits **580** also may be in communication with a number of air apertures **590** positioned on the face **510** of the nozzle **550**. The internal air conduits **580** may have an inside diameter of about 0.2 to about 0.8 millimeters. The air apertures **590** may have a similar internal diameter. The conduits **580** and the apertures **590** may be circular, square, or have any convenient shape.

The internal air conduits **580** may extend in a largely parallel direction with the internal fluid conduit **560** until about seventy (70) to about 120 millimeters from the face **510**. The internal air conduits **580** then may continue in a largely parallel direction with the fluid conduit **560** towards the air apertures **590** or the air conduits **580** may angle downward towards the fluid aperture **570**. The angle of the air conduits **580** towards the internal fluid conduit may be about ten (10°) to about sixty degrees (60°) from the horizon. The air apertures **590** may have a similar internal angle. In this example, four (4) air conduits **580** and four (4) air apertures **590** are used. Any number, size, angle, or positioning of the conduits **580** and the apertures **590**, however, may be used.

The air conduits **580** and apertures **590** may be used for lower flow rate application, i.e., a flow rate of about ten (10) to about (100) milliliters per minute. The conduits **580** and apertures **590** may be angled such that the air flow intersects the stream of fluid **330** as it leaves the fluid aperture **570**. The air conduits **580** and the air apertures **590** allow the air flow to atomize the stream of fluid **330**. Low flow applications may include color, flavor, etc. where atomizing or misting of the fluid **330** is sufficient to apply the fluid **330** to the continuous tube **125**. The eventual drying of the water within the fluid **330** produces the dry coated straws **110**.

For example, the internal fluid conduit **560** and the fluid aperture **570** may have a diameter of about 0.3 millimeters. The air conduits **580** and the air apertures **590** may have a diameter of about 0.6 millimeters. The fluid **330** may include blue dye, deionized water, glycerin, monoglyceride, and sodium alginate. The fluid **330** may have a flow rate of about 25 milliliters per minute at a pressure of about 3.5 kg/cm² (about 50 psi). The air flow may have a flow rate of about 28,000 milliliters per minute at a pressure of about 1.4 kg/cm² (about 20 psi). The fluid **330** thus may coat the inner wall surface **115** of the continuous tube **125** with about twenty-five (25) milligrams of the coating **360** along the length of a straw **110** about 150 millimeters long.

Figs. 11 and 12 show a further embodiment of the nozzle **500**, in this case a high load application nozzle **600**. The high load application nozzle **600** also may include an internal fluid conduit **610**. The internal fluid conduit **610** may be in communication with the fluid conduit **340** described above. The internal fluid conduit **610** may be about thirty (30) to about sixty (60) millimeters in length and may have an inside diameter of about 0.3 to about three (3) millimeters. The internal fluid conduit **610** may split into a number of angled delivery conduits **620**. Each angled delivery conduit **620** may be about 0.5 to about four (4) millimeters in length and may have an inside diameter of about 0.3 to about 0.6 millimeters. Although four (4) angled delivery conduits **620** are used in this embodiment, any number of conduits **620** may be used. The number of the conduits **620** used may vary with the diameter of each conduit **620**. The angle of the delivery conduits **620** may be between about ten (10°) and sixty degrees (60°) off of the center of the internal fluid conduit **610**.

Each angled delivery conduit **620** may communicate with a fluid aperture **630** positioned within the face **510**. Each fluid aperture **630** may have about the same internal angle and size as the accompanying delivery conduit **620**. The delivery conduit **620** and the aperture **630** may direct a flow of the fluid **330** towards the walls of the continuous tube **125** at the given angle. The conduits **620** and the apertures **630** may be circular, square, or have any convenient shape. One or more circular or semicircular slits also may be used instead of the multiple fluid apertures **630**. The slits may be about 0.2 to about 0.5

millimeters wide and angled at about ten (10°) to about sixty degrees (60°) off of the center of the internal fluid conduit **610**. Other shapes also may be used.

Surrounding the internal fluid conduit **610** and the angled
5 delivery conduits **620** may be one or more internal air conduits **640**. The
internal air conduits **640** each may have a diameter of about 0.2 to about
0.8 millimeters and may be about thirty (30) to about sixty (60)
millimeters in length. The internal air conduits **640** may be in
communication with the air conduit **260** described above. The internal air
10 conduits **640** may lead to a number of air apertures **650** on the face **510**.
The air conduits **640** and the air apertures **650** may be circular, square, or
have any convenient shape. The air conduits **640** and the air apertures
650 also may be angled. Any number of air conduits **640** and air
apertures **650** may be used. Certain application may not require the use
15 of the air conduits **640** and the apertures **650**.

The angled delivery conduits **620** and/or the internal air
conduits **640** also may extend beyond the face **510** by about five (5) to ten
(10) millimeters or so. Other distances also may be used. Likewise, the
face **510**, the conduits **620**, **640**, and the apertures **630**, **650** may terminate
20 before the end of the extruder head **210**. Different flow patterns and
coatings **360** may be provided by varying the positioning of these
elements.

As described above, the number, size, and angle of the fluid
apertures **570**, **630** may be varied. In the example of Figs. 11 and 12,
25 four (4) angled delivery conduits **620** and four (4) fluid apertures **630**
may be used. The conduits **620** and the apertures **630** may have a
diameter of about 0.6 millimeters and may extend about thirty degree
(30°) from the center of the internal fluid conduit **610**.

Fig. 13 shows a further nozzle **660**. The nozzle **660** is
30 similar to the high load application nozzle **600**, but has six (6) fluid
apertures **670** and six (6) angled delivery conduits **620**. The apertures
670 and the conduits **620** may be positioned about ten (10°) to about
thirty degrees (30°) off of the center of the internal fluid conduit **610**.
The apertures **670** and conduits **620** may have an internal diameter of
35 about 0.5 millimeters.

Fig. 14 shows a further nozzle **700**. The nozzle **700** is similar to the high load application nozzle **600**, but with eight (8) fluid apertures **710**. The fluid apertures **710** may be fed by eight (8) angled delivery conduits **620**. The delivery conduits **620** may be angled at about
5 ten (10°) to about thirty degrees (30°) off of the center of the internal fluid conduit **610**. The apertures **710** and the conduits **620** each have an inside diameter of about 0.4 millimeters.

As is seen in the figures above, the size of each aperture **630**, **670**, **710** and each conduit **620** may vary according to the number of
10 apertures **630**, **670**, **710** and conduits **620** used. The more apertures **630**, **670**, **710** and conduits **620** used, the smaller the apertures **630**, **670**, **710** and the conduits **620** may be. Likewise, the angle and positioning of the apertures **630**, **670**, **710** and the conduits **620** may vary with size. The number, size, and angle of the air conduits **640** and air apertures **650** also
15 may be varied.

The high load application nozzle **600** may be utilized for high flow applications where evaporating water from the flow of the fluid **330** may not be possible, i.e., about fifty (50) to about 1,000 milliliters per minute. This application may use a coating formulation that solidifies
20 as soon as the continuous tube **125** and the fluid **330** exit the extruder head **210**. This solidification, setting, or jelling of the fluid **330** may occur by means of rapid cooling, chemical formation, or by curing. It is understood that the term "fluid **330**" may refer to a fluid, a particle slurry, a fluid/solid slurry, an emulsion, a fluid/gas/solid slurry, or any other type
25 of flowable material. The nozzle **600** thus may be utilized for applications such as acid coating where large amounts of a coating ingredient may be required or desired in the end product.

For example, six (6) angled delivery conduits **620** and six (6) apertures **630** each may have a diameter of about 0.5 millimeters. The
30 conduits **620** and the apertures **630** may have an angle of about fifteen (15) degrees. Four (4) internal air conduits **640** and four (4) air apertures **650** each may have a diameter of about 0.5 millimeters. The fluid **330** may include citric acid anhydrous and/or phosphoric acid, deionized water, glycerin, and monoglyceride. The fluid **330** may have a flow rate
35 of about 300 milliliters per minute at a pressure of about 1.4 kg/cm² (about 20 psi). The air flow may have a flow rate of about 7000

milliliters per minute at a pressure of about 0.35 kg/cm^2 (about five (5) psi). The fluid **330** thus may coat the inner wall surface **115** of the continuous tube **125** with about 350 milligrams of the coating **360** along the length of each straw **110**.

5 Fig. 15 shows a further embodiment of the present invention, a nozzle **750**. The nozzle **750** may include an internal fluid conduit **760** and a fluid aperture **770**. The nozzle **750** also further may include a deflector plate **780** attached to the face **510** via a number of prongs **790**. The deflector plate **780** may be spaced from the face **510** by a sufficient
10 distance such that the fluid exiting the fluid aperture **770** may strike the deflector plate **780** and spray uniformly onto the inner surface of the continuous tube **125**. The deflector plate **780** may be about one (1) to about four (4) millimeters in diameter. The deflector plate **780** may be positioned about two (2) to about twenty (20) millimeters away from the
15 face **510**. The positioning of the deflector plate **760** may vary with the flow rate of the fluid **330**.

A number of internal air conduits **800** and accompanying air apertures **810** also may be present. The air conduits **800** and the apertures **810**, however, may not be needed. The angled delivery conduits **620** also
20 may be used with a number of the fluid apertures **630** as is shown in Figs. 11 and 12.

CLAIMS

We claim:

- 5 1. A coating device for coating an interior surface of a continuous tube of material with a fluid, comprising:
 an extruder die for forming the continuous tube of material;
and
 a fluid delivery system;
10 said fluid delivery system positioned within said extruder die so as to introduce the fluid onto the interior surface of the continuous tube of material.
2. The coating device of claim 1, wherein said fluid
15 delivery system comprises one or more fluid conduits extending through extruder die.
3. The coating device of claim 2, wherein said one or
20 more fluid conduits comprise an orifice about a first end.
4. The coating device of claim 2, further comprising an
 air delivery system, said air delivery system positioned within said
 extruder die so as to introduce an air stream within the continuous tube of
 material.
25
5. The coating device of claim 4, wherein said one or
 more fluid conduits are positioned within said air delivery system.
6. The coating device of claim 4, further comprising a
30 nozzle positioned within said extruder die.
7. The coating device of claim 6, wherein said one or
 more fluid conduits are positioned within said nozzle.

8. The coating device of claim 7, wherein said nozzle comprises a face and wherein said one or more fluid conduits lead to one or more fluid apertures in said face.

5 9. The coating device of claim 7, wherein said one or more fluid conduits comprise a central conduit and a plurality of angled delivery conduits.

10 10. The coating device of claim 9, wherein said plurality of angled delivery conduits comprises four (4) to eight (8) delivery conduits.

15 11. The coating device of claim 9, wherein said plurality of angled delivery conduits comprises a diameter of about 0.3 to about 0.6 millimeters.

20 12. The coating device of claim 9, wherein said plurality of angled delivery conduits comprises an angle of about ten (10°) to about sixty degrees (60°).

25 13. The coating device of claim 6, wherein said air delivery system comprises a plurality of air conduits within said nozzle leading to a plurality of air apertures within said face.

30 14. The coating device of claim 13, wherein said plurality of air conduits comprises a first section parallel to said one or more fluid conduits.

35 15. The coating device of claim 14, wherein said plurality of air conduits comprises a second section angled towards said one or more fluid conduits.

16. The coating device of claim 15, wherein said second angled section comprises an angle of about ten (10°) to about sixty degrees (60°).

17. The coating device of claim 6, wherein said nozzle comprises a deflector plate attached thereto.

18. The coating device of claim 1, further comprising an
5 electrostatic device positioned in communication with said extruder die.

19. The coating device of claim 18, wherein said electrostatic device comprises a first charging device in communication with the continuous tube and a second charging device surrounding said
10 fluid delivery system.

20. A method for coating the interior surface of a continuous tube of material with a fluid, comprising:
extruding the continuous tube of material through an
15 extruder die;
providing a stream of air into the continuous tube of material through said extruder die; and
providing a stream of the fluid through said extruder die so as to coat the continuous tube with the fluid.

20

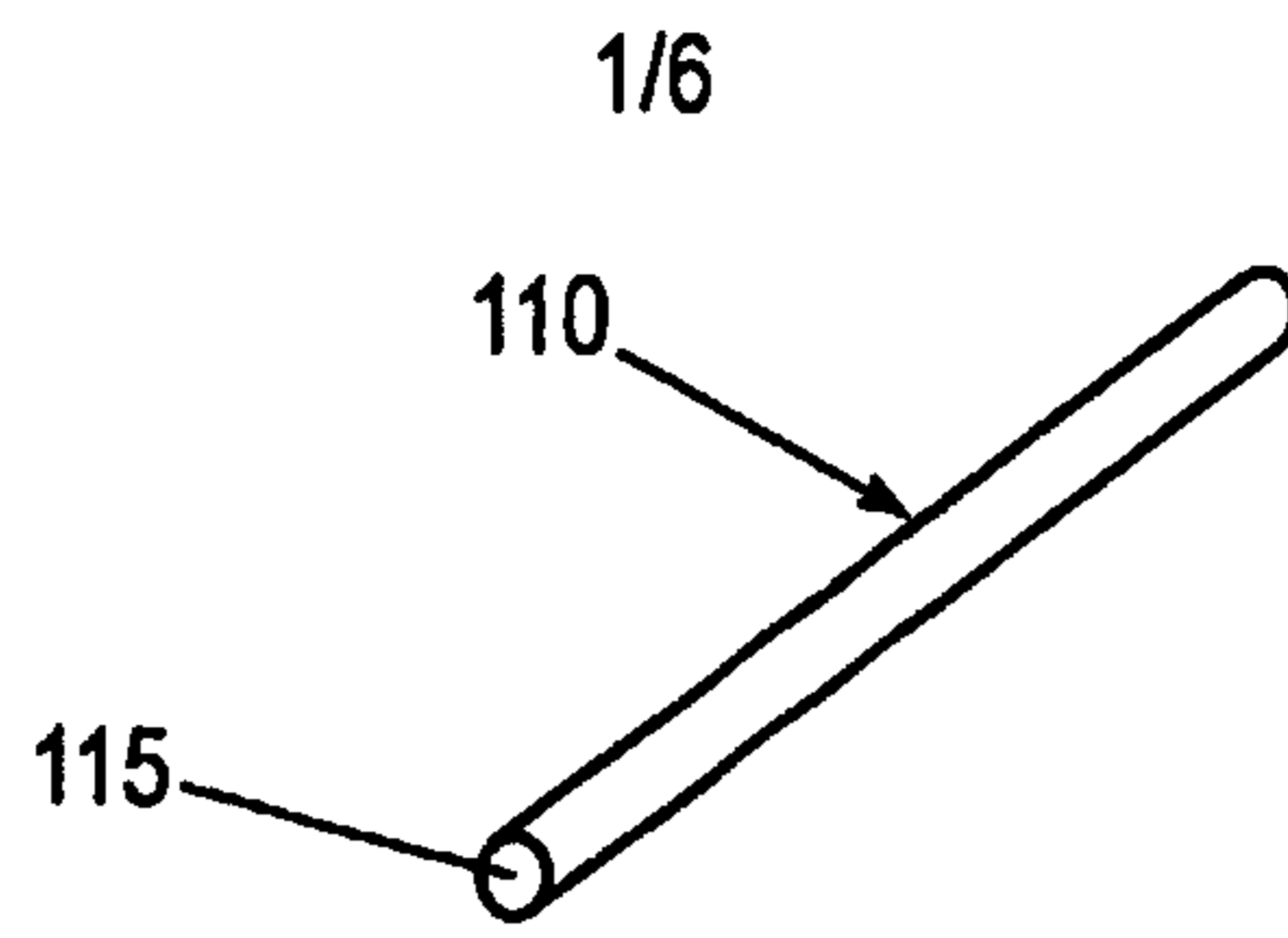


Fig. 1

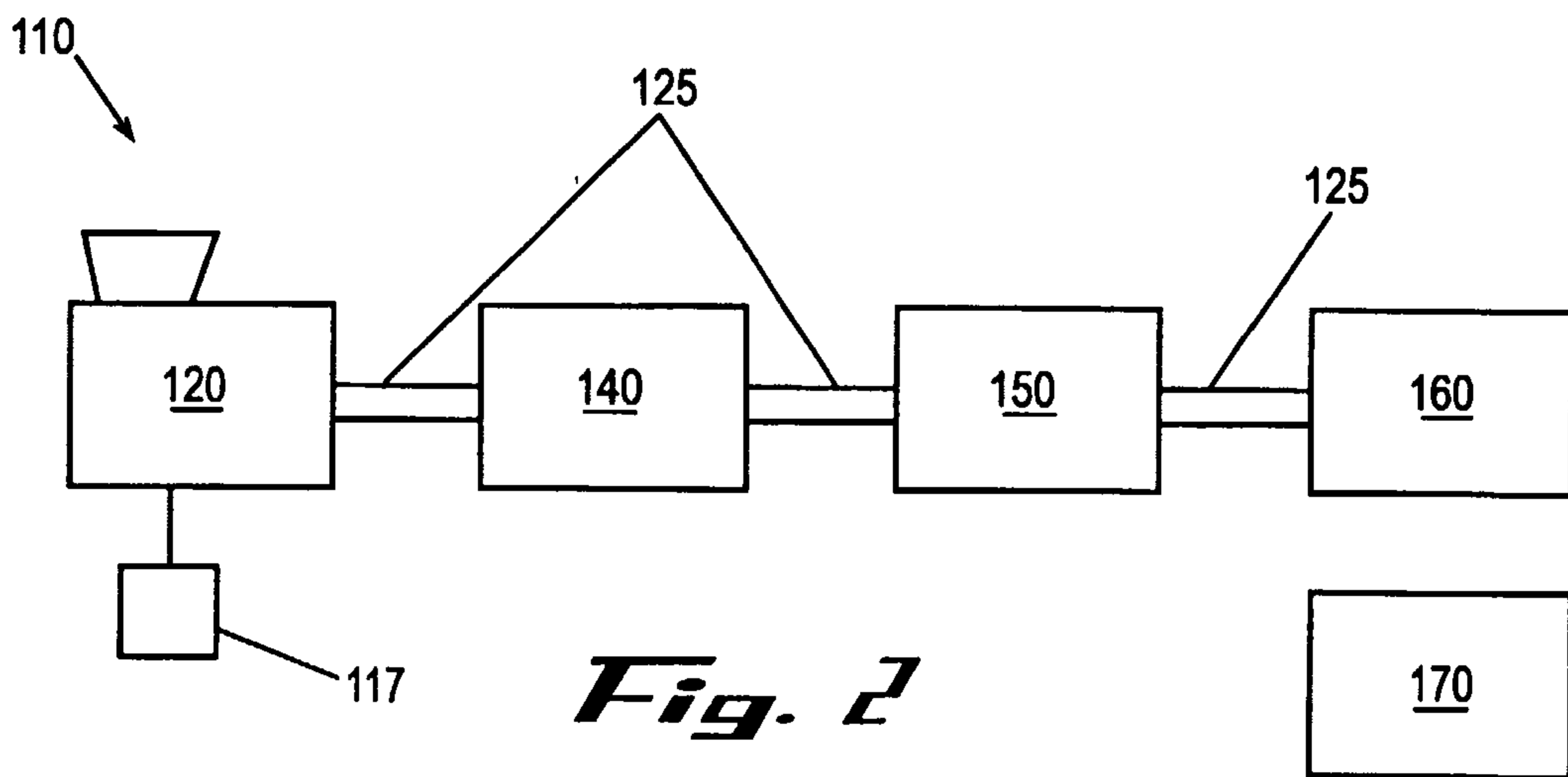


Fig. 2

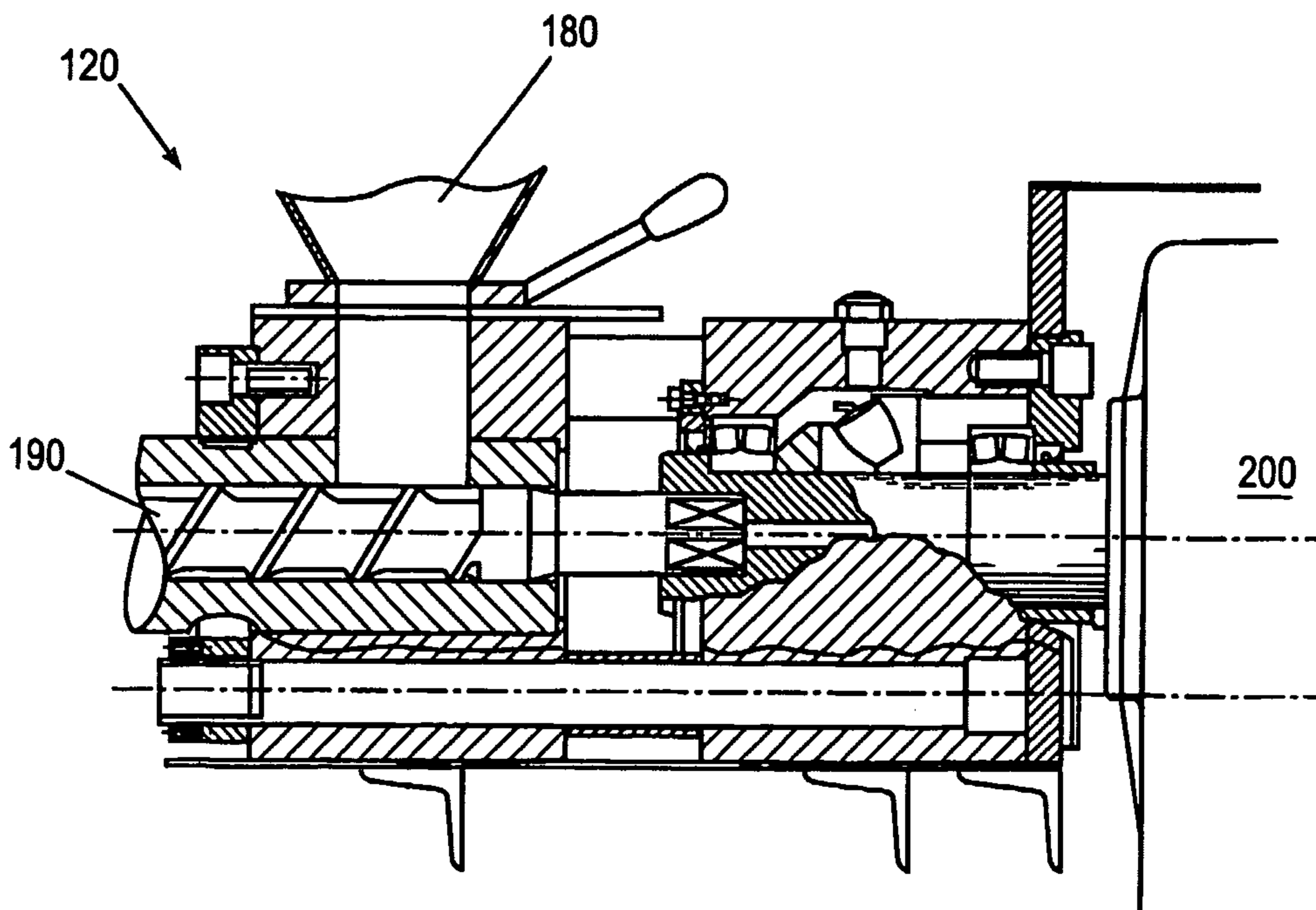


Fig. 3

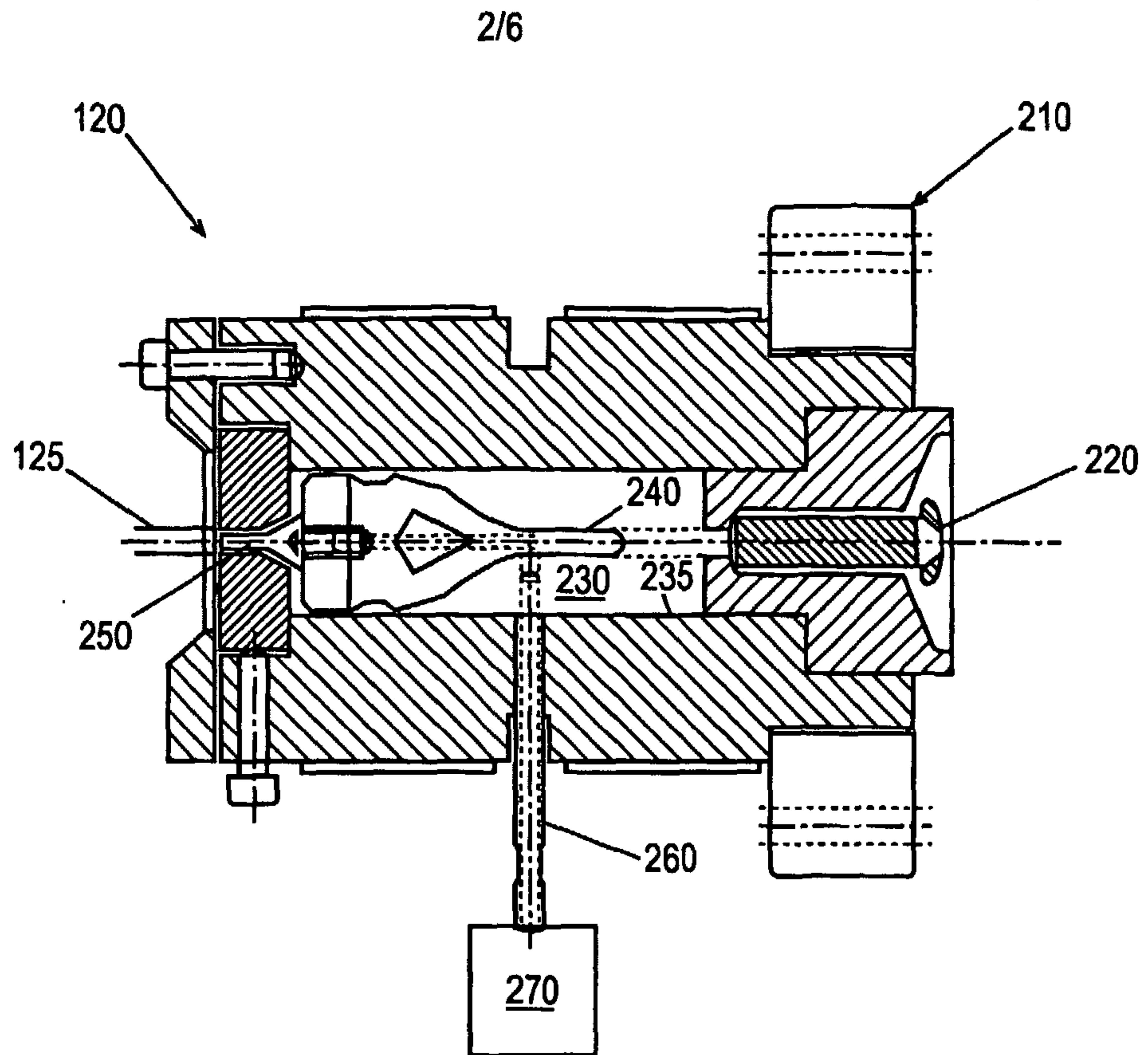


Fig. 4

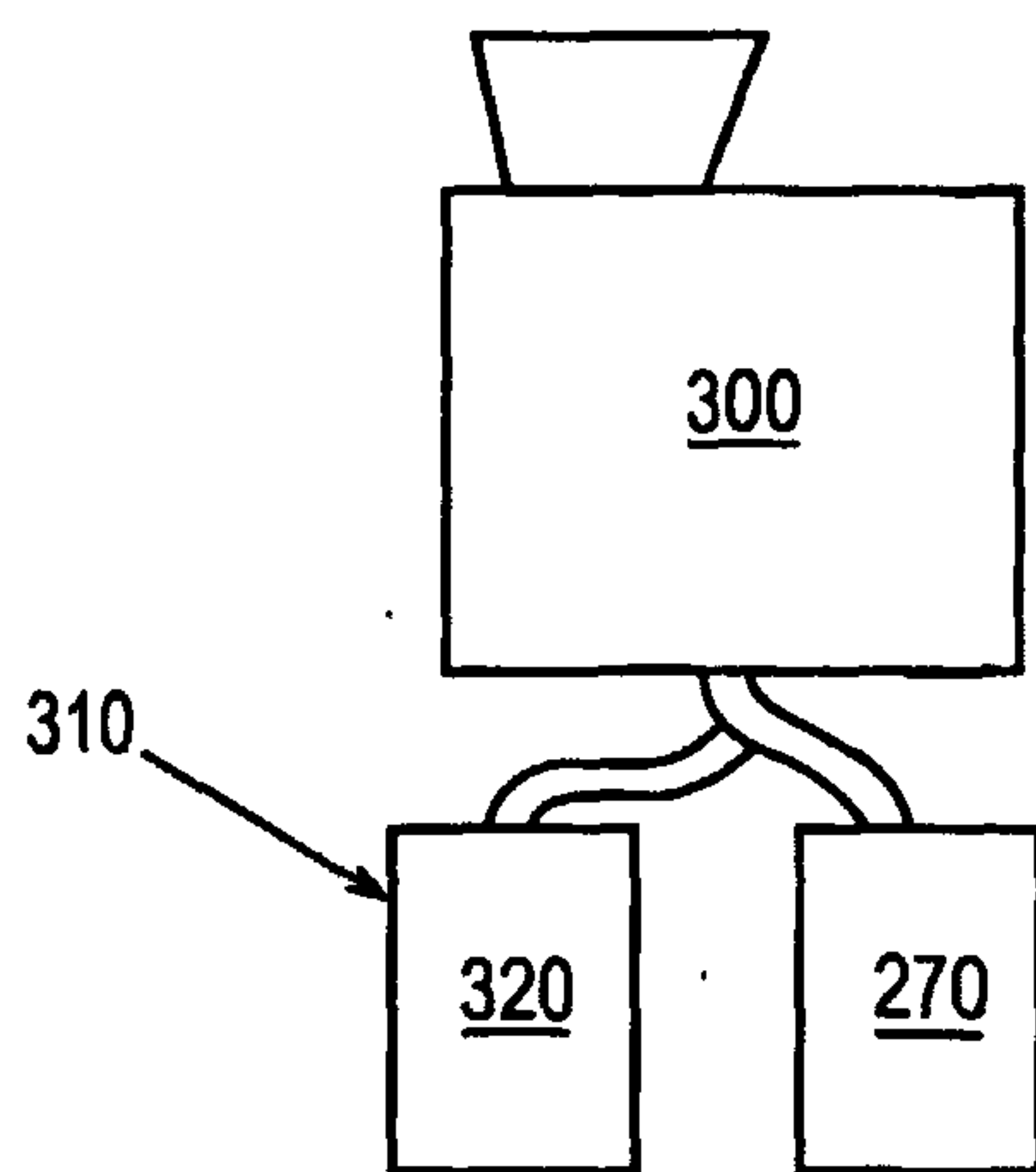


Fig. 5

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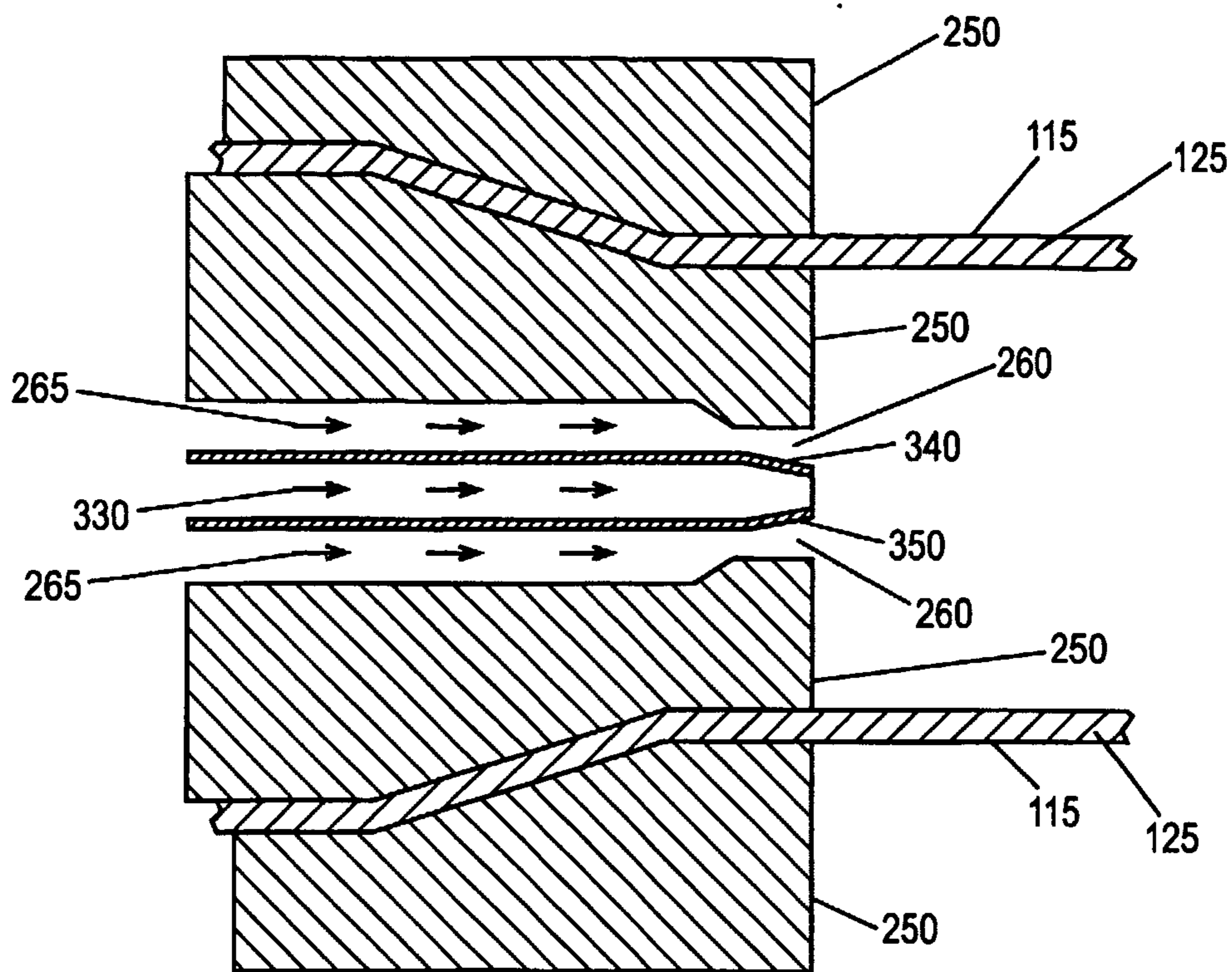


Fig. 6

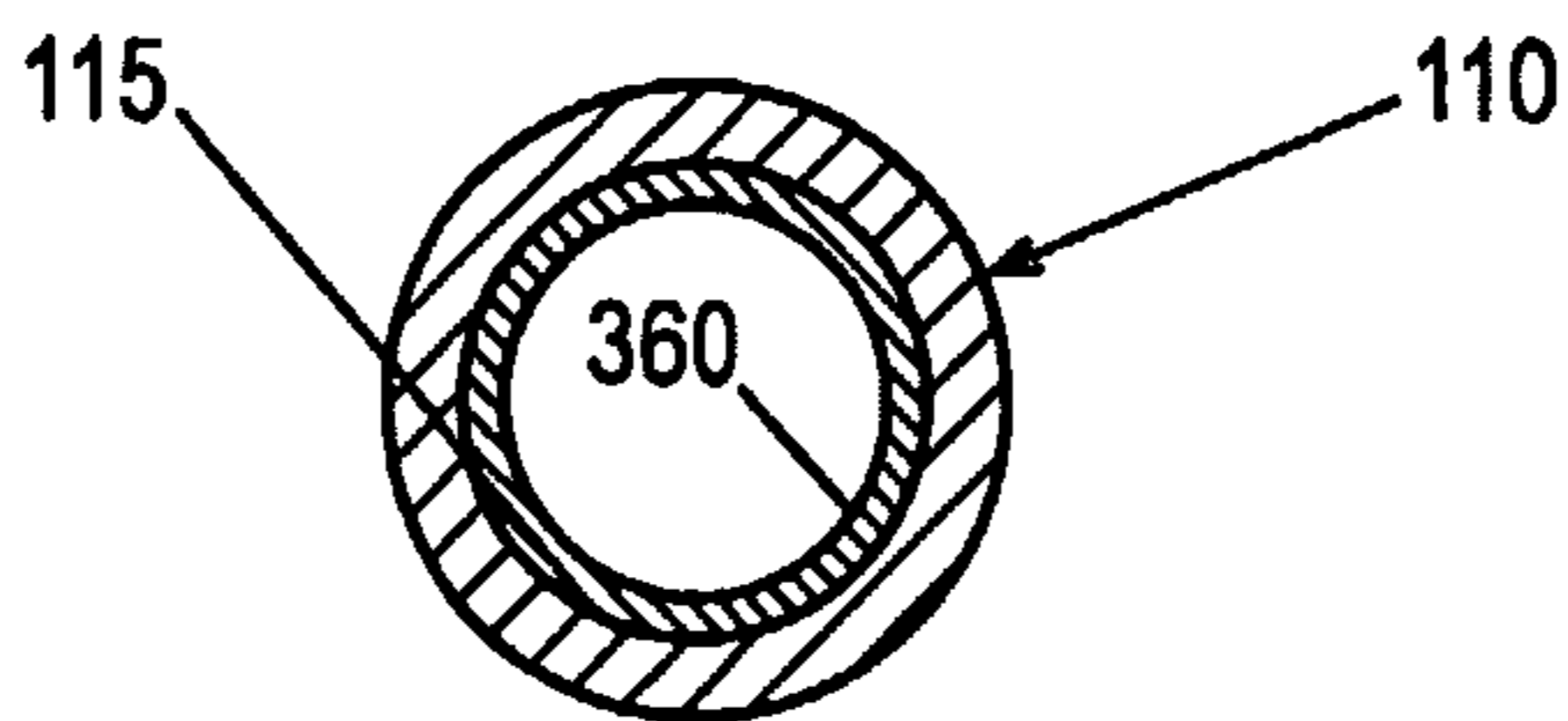


Fig. 7

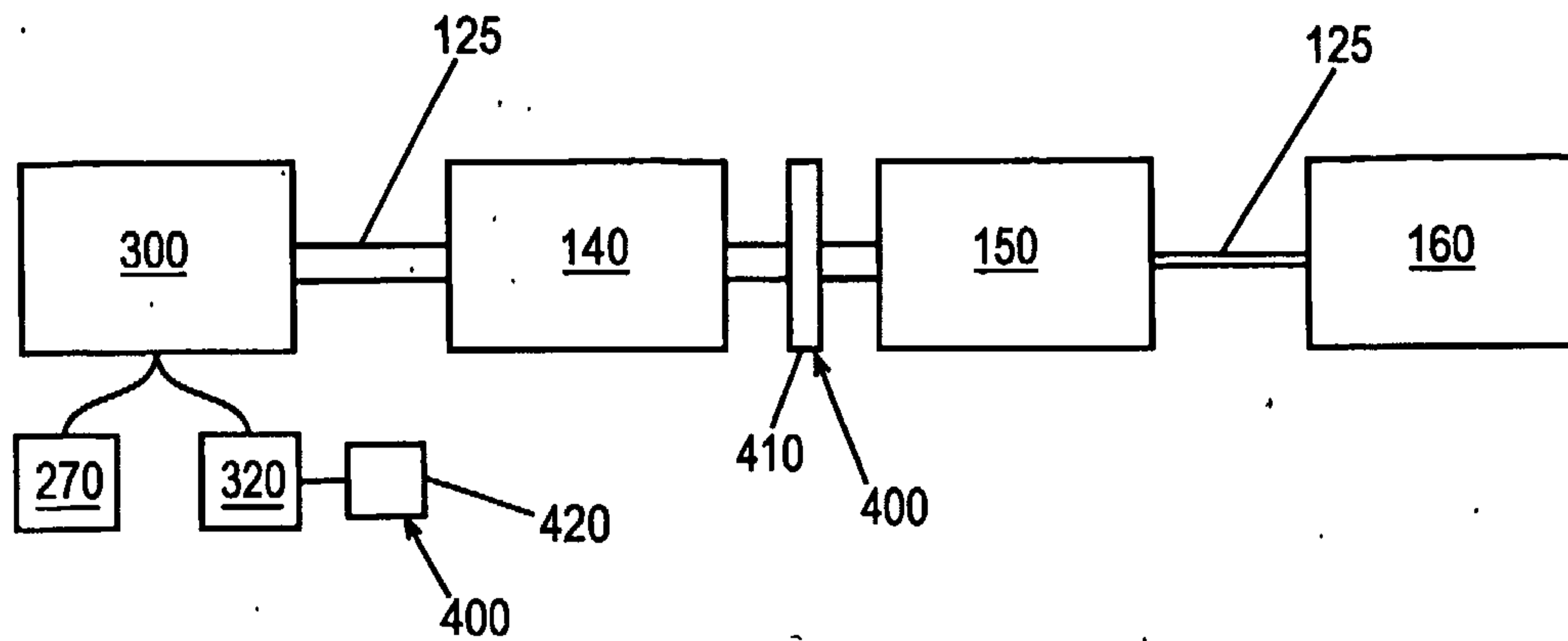


Fig. 8

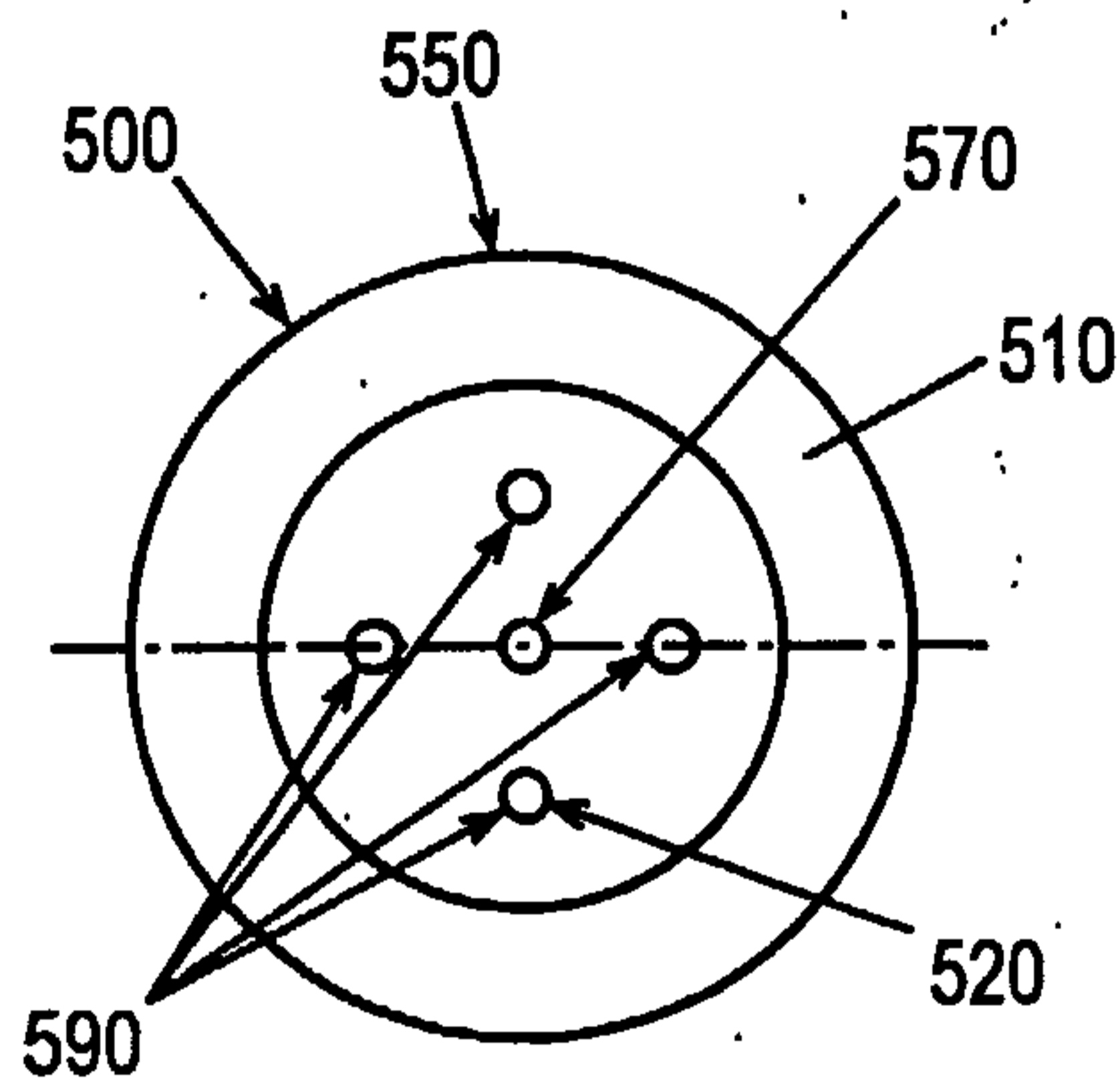
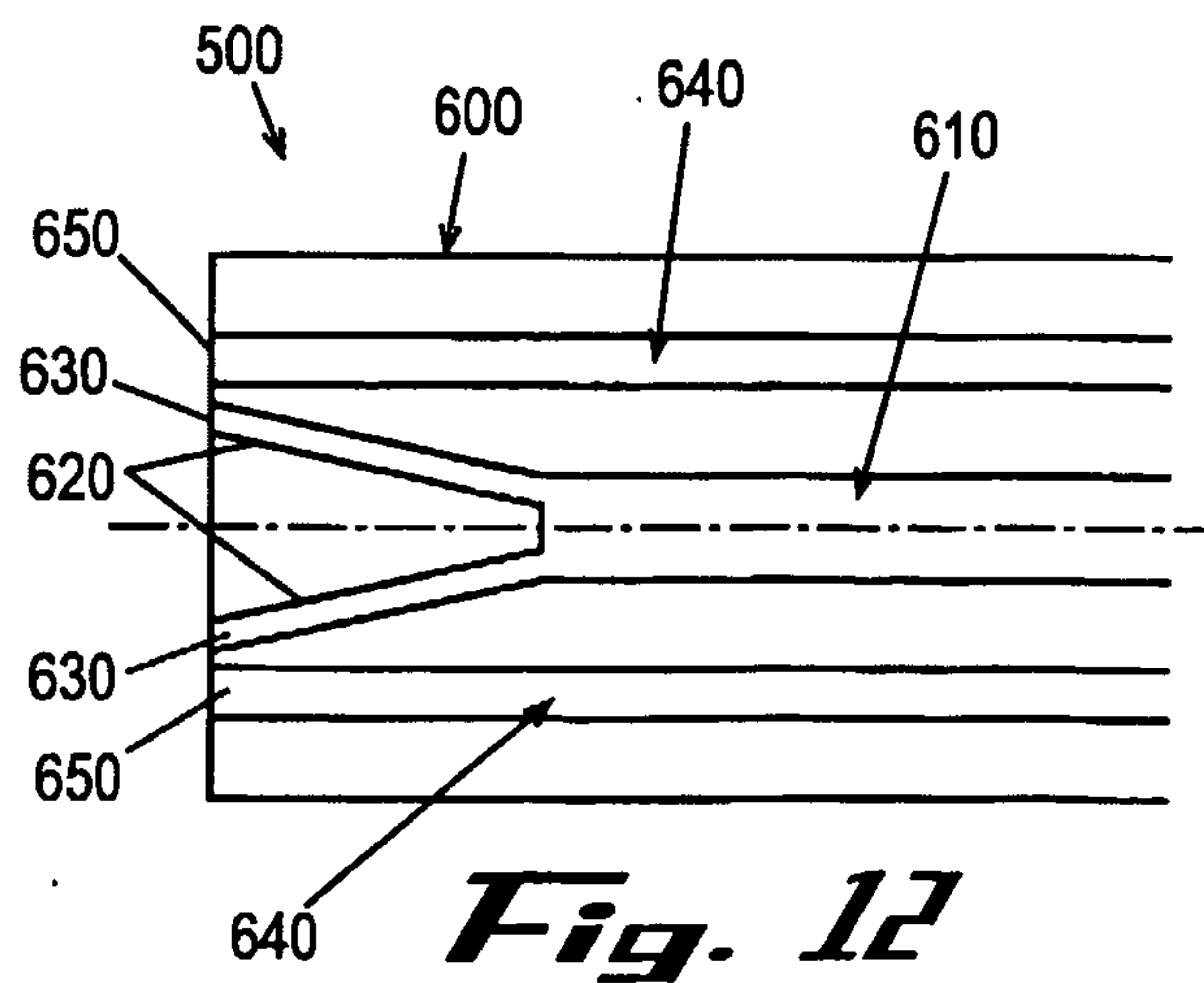
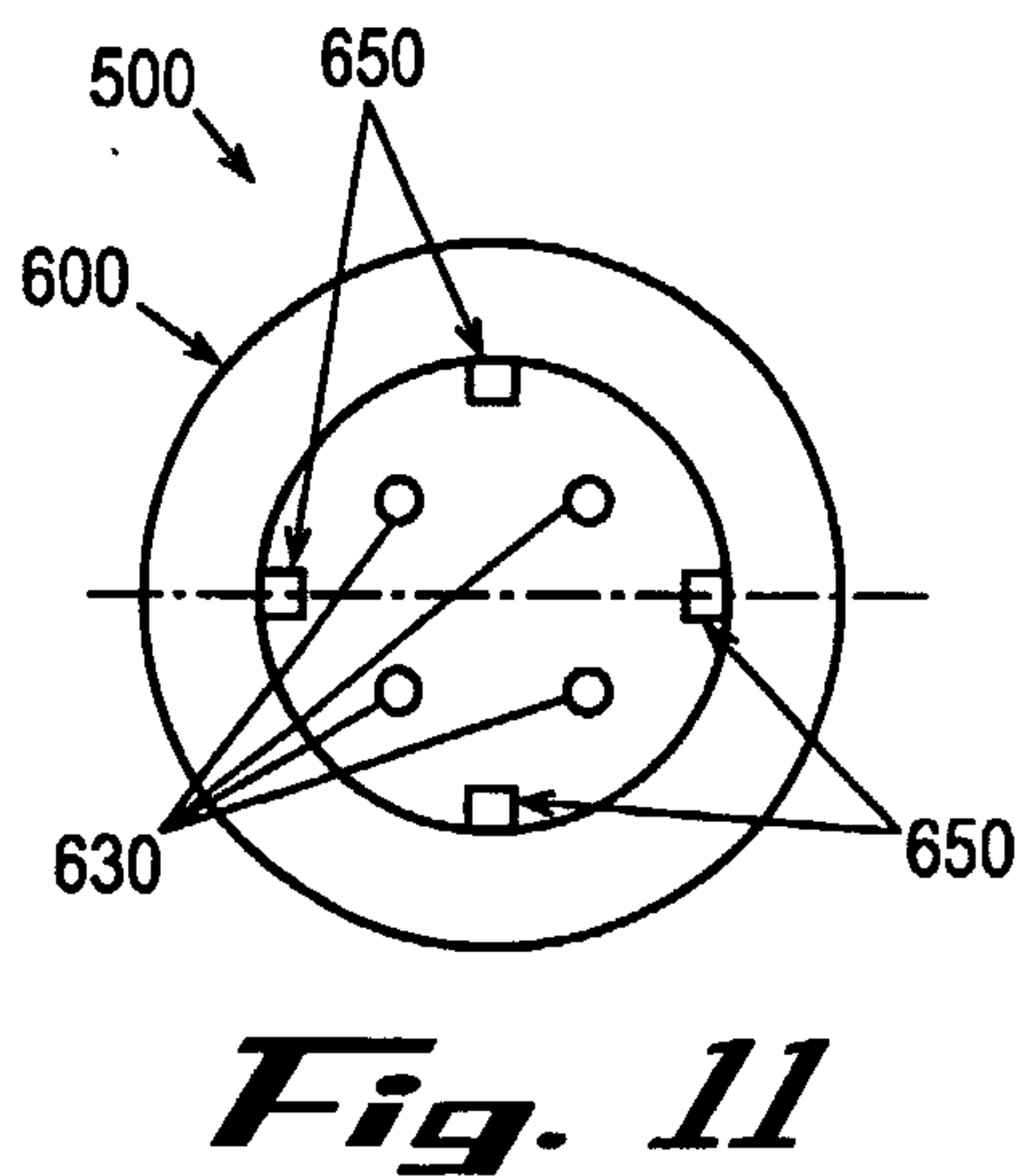
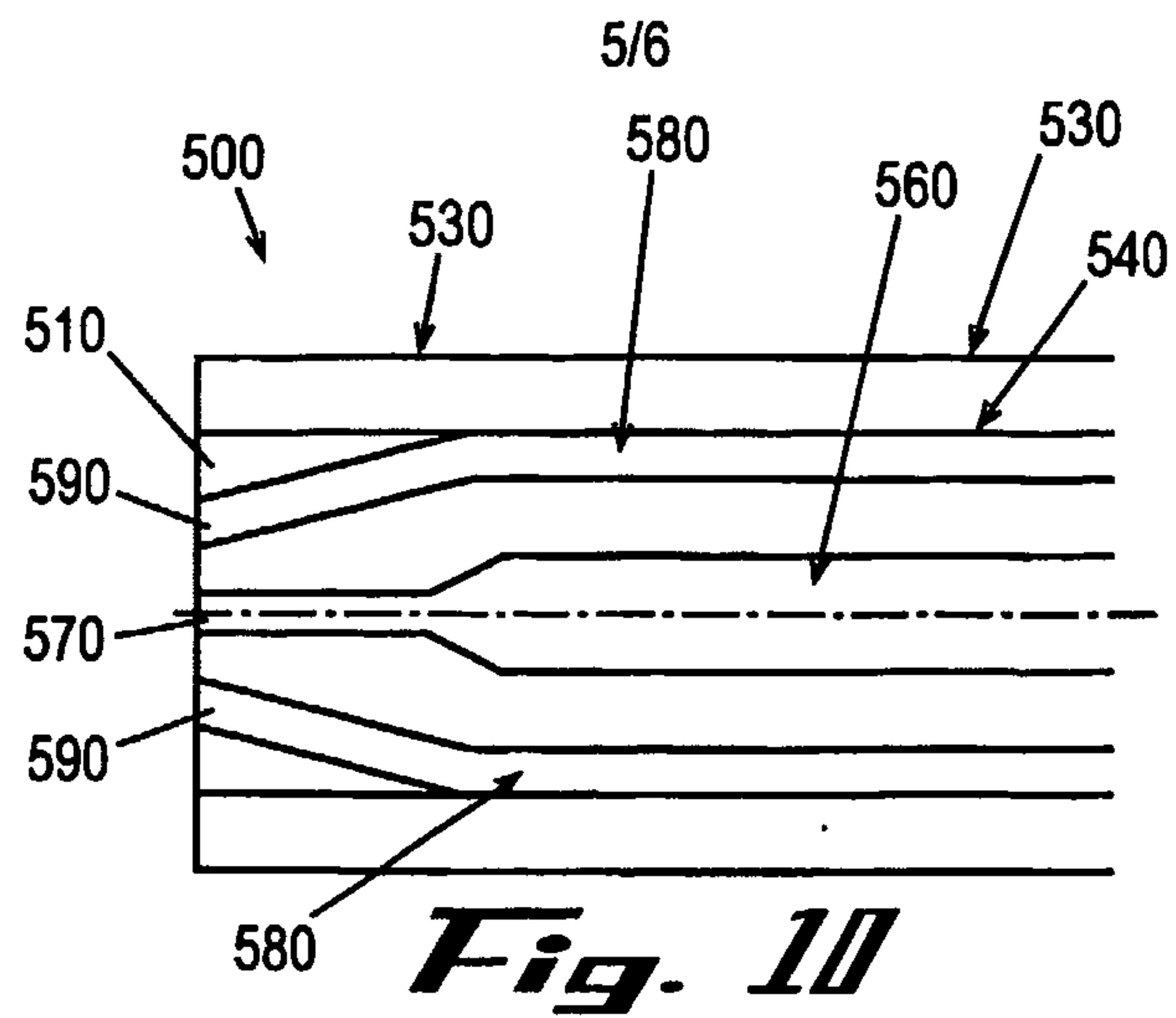


Fig. 9



6/6

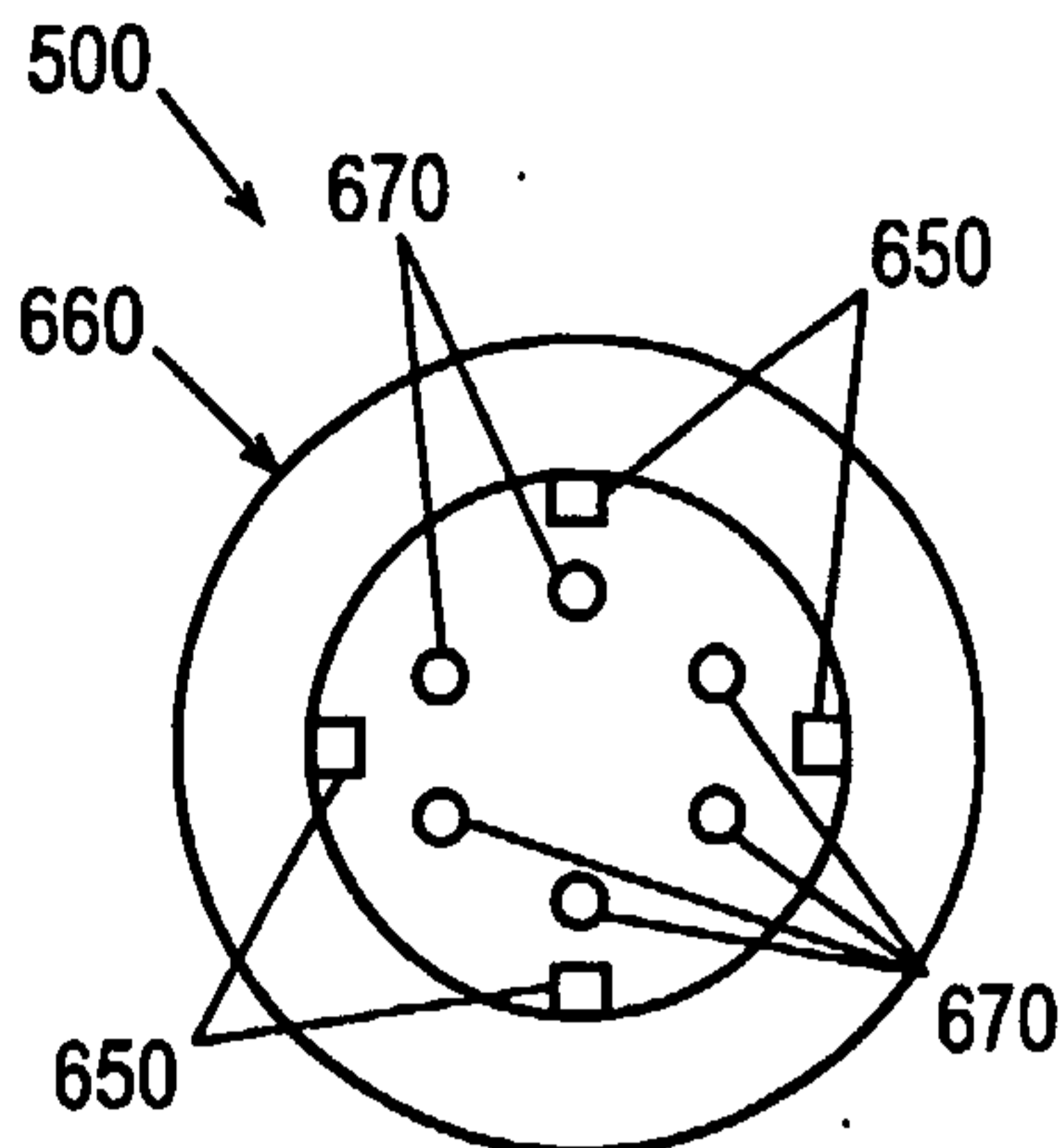


Fig. 13

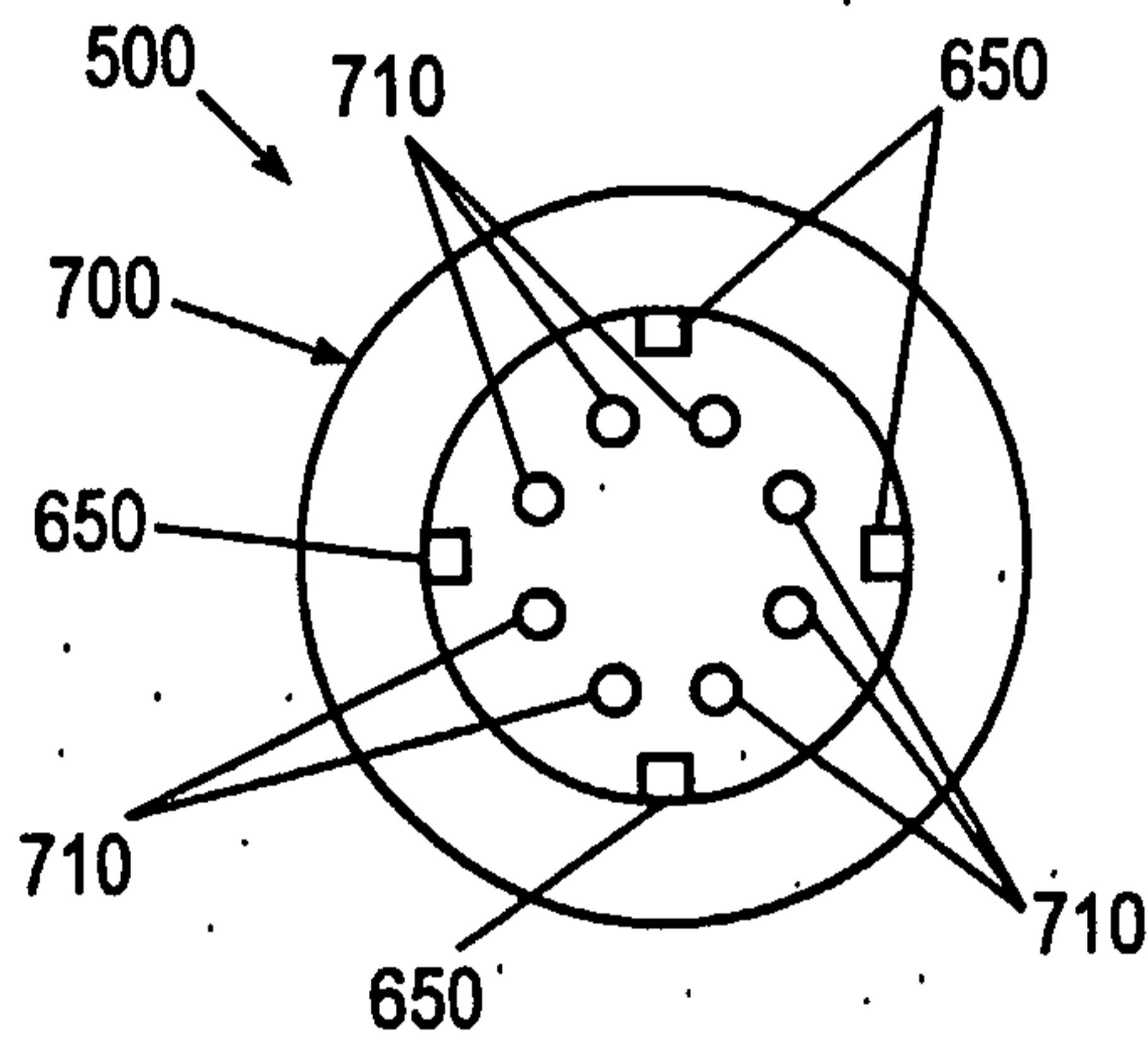


Fig. 14

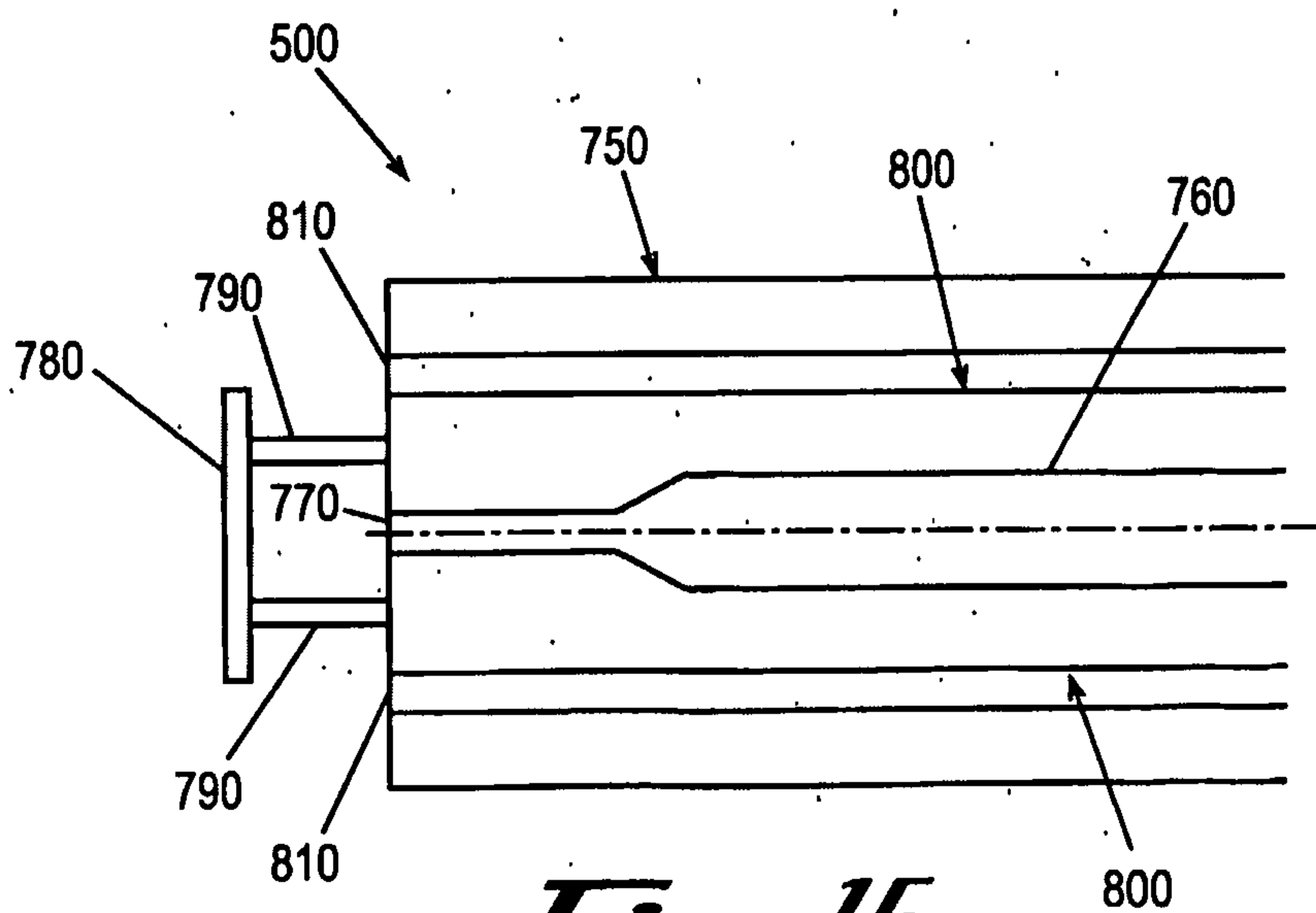


Fig. 15

