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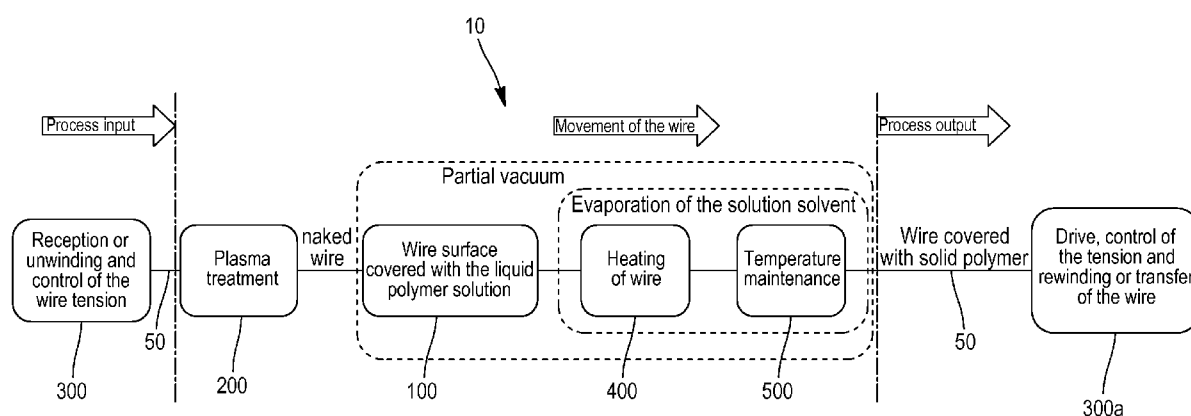


FIG. 1

(57) Abstract: The invention relates to a process for coating the surface of a moving wire (50) with a thin solid polymer layer. The process includes the step of providing a deposition device (100) having two wheels that include an upper wheel (114) and a lower wheel (114') having circumferential grooves (114b, 114b') in which the two rings (110) are lodged. A predetermined contact force between the wheels (114, 114') and the wire (50) makes it possible, by friction, to rotate the wheels (114, 114') and the rings (110). The device also includes a tank (106) containing a liquid polymer solution (75). The wire (50) is conveyed at a predetermined constant speed, and the rotatable rings (110) are rotated, these conveying an amount of the liquid polymer solution (75). The process also includes the step of simultaneously creating a partial vacuum in the spaces passed through by the wire (50). The temperature of the wire (50) is increased in a heating device (400) and its temperature is maintained by a temperature maintaining device (500) until the complete evaporation of the solvent is obtained.

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PROCESS FOR COVERING A WIRE
WITH A LAYER OF POLYMER

TECHNICAL FIELD

5 The invention relates generally to a process for covering the surface of wire moving continuously at constant speed with a thin solid polymer layer using a liquid polymer solution.

CONTEXT

10 The coating of the surface of a wire with a material of different nature in order to modify or improve certain properties thereof is known and widely used in industry. Depending on the nature and the use of the wire, the coating may be used for example to improve corrosion resistance, to provide electrical insulation, to modify tribological properties, to enable adhesion to another material or simply for
15 decoration. In many cases, the coating material is deposited in the liquid state and then undergoes a treatment or a transformation intended to convert it to the solid state such as, for example, a temperature change, a polymerization, the evaporation of a solvent or other. In the case of a coating deposited in the liquid state, which requires an increase in the temperature to change to the solid state, it is sometimes
20 preferable to increase the temperature of the wire rather than the ambient temperature around the wire in order to increase the temperature of the coating. In this case, the problem to be solved is to transmit the energy needed to increase its temperature to a continuously moving wire covered with a thin layer of a material in the liquid state. The nature of the wire and the nature of the liquid are chosen as
25 a function of the desired final characteristics. For the invention described here, the term “wire” applies to wires having properties of electrical conductors and the term “liquid” applies to a liquid polymer solution dissolved in a solvent.

SUMMARY

30 The invention relates to a process for coating the surface of a moving wire with a thin solid polymer layer. The process includes the following steps:
providing a deposition device having a compartment of a chamber that contains two rotatable rings and two wheels that include an upper wheel and a lower wheel having circumferential grooves in which the two rings are lodged, and in which

compartiment the wheels are placed vertically on either side of the wire by means of the grooves such that a predetermined contact force between the wheels and the wire makes it possible, by friction, when the wire moves at constant speed, to rotate the wheels and, by means of the lower wheel, the rings too, and a tank
5 containing a liquid polymer solution; conveying the wire at a predetermined constant speed; rotating the rotatable rings, these rings convey an amount of the liquid polymer solution, and these rings bring it to a point of tangential contact between the grooves of the wheels and the wire, which at the same time passes
10 through an orifice formed by the grooves and located between the grooves, in order to coat the surface of the wire while it is moving; creating a partial vacuum simultaneously in the spaces passed through by the wire of a deposition device, of a heating device and of a temperature maintaining device; increasing the temperature of the wire in the heating device in order to initiate the evaporation of the solvent from the liquid polymer solution deposited at the surface of the wire;
15 and maintaining the temperature of the wire with the temperature maintaining device until the complete evaporation of the solvent is obtained.

In certain embodiments, the process also includes the following steps: providing, in the heating device, a heating circuit having an induction coil and a capacitor connected in parallel and that form a resonant circuit; powering the
20 heating circuit with a DC supply voltage; measuring the current consumed by the power supply of the heating circuit; calculating the power provided by the power supply of the heating circuit; estimating the temperature of the wire; and establishing a control period in order to slave the temperature of the wire to the predetermined setpoint temperature. In certain embodiments, the control period is
25 established every 100 ms.

In certain embodiments, a surplus of the polymer solution is conveyed to the tank by the rotation of the rings and by the effect of gravity.

In certain embodiments, the process also includes the step of calibrating the thickness of the deposited layer of the polymer solution by means of a calibration
30 bushing provided with an orifice at its centre and mounted in the compartment of the chamber in order to make the surplus of the polymer solution fall into the tank.

In certain embodiments, the temperature of the wire is increased in the heating device until an evaporation temperature of the solvent is attained.

In certain embodiments, the process also includes the dipping of a lower

portion of each ring in the polymer solution by means of an opening in the bottom of the compartment of the chamber that corresponds with at least one portion of the tank.

In certain embodiments, the process also includes the step of carrying out a plasma surface treatment of the wire before the step of depositing a layer of the polymer solution on the surface of the wire.

The invention also relates to a system for producing a wire coated with a layer of solid polymer using a chosen polymer dissolved in a liquid solvent. The system includes a series of devices that together make it possible to carry out processes as described.

The invention also relates to a wire coated according to processes as described.

Other aspects of the present invention will become obvious by means of the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The nature and various advantages of the present invention will be better understood from reading the detailed description which follows, and from studying the attached drawings, in which the same reference numerals denote identical parts throughout, and in which:

Figure 1 represents a schematic view of an embodiment of a process for covering a wire.

Figure 2 represents a front view, in the direction of movement of a wire, of a device for depositing liquid on the surface of a wire of the process from Figure 1.

Figure 3 represents a side view of the deposition device from Figure 2.

Figure 4 represents a cross-sectional view of the deposition device from Figure 2 along the line A-A.

Figure 5 represents a cross-sectional view of the deposition device from Figure 3 along the line B-B.

Figure 6 represents an enlarged view of the portion I from Figure 5.

Figure 7 represents a rear view of the deposition device from Figure 3, with the wall 108b removed.

Figure 8 represents an embodiment of the coil of a heating device of the process from Figure 1.

Figure 9 represents an embodiment of a heating circuit having the induction coil from Figure 8 and a capacitor.

Figure 10 represents an embodiment of a partial vacuum of the process from Figure 1.

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DETAILED DESCRIPTION

Detailed reference will now be made to some embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is given for the purposes of explaining, rather than limiting, the invention described. A person skilled in the art will appreciate that various modifications and alternative forms may be made to the invention without departing either from the scope or from the spirit of the invention. Thus, provision is made for the invention to cover these modifications and alternative forms in so far as they fall within the scope of the attached claims and equivalents thereof.

15 With reference now to the figures, in which the same numerals identify elements that are identical, Figure 1 represents an example of a process 10 that enables the homogeneous and continuous coverage of the surface of a wire 50, in particular a wire having a small diameter, for example a diameter of the order of 0.2 mm to 1 mm) with a thin solid polymer layer using a solution of polymer in the liquid state. In the process 10, a wire 50 is obtained from a reel or another process and moves continuously and at constant speed and tension through a succession of devices that carry out the operations necessary for obtaining a wire covered with a thin solid polymer layer so that the wire has the desired properties, which properties are variable and can be adapted depending on the subsequent use of the wire. The movement of the wire 50 at a constant speed and the adjustment of its tension are carried out by means of an unwinding, conveying and tension adjusting system 300 selected from varieties of systems that are commercially available and known by a person skilled in the art. In certain embodiments, the wire may move at a speed of several metres per minute up to 100 metres per minute.

30 The constituents of the polymer solution in the liquid state that is deposited on the wire, and the respective proportions thereof, must be chosen and respectively adjusted in order to obtain the deposition conditions (for example the viscosity) that enable a complete final coating of the desired thickness on the wire.

With reference again to Figure 1, a wire 50 obtained from the system 300 is

transported to a plasma treatment device 200. The plasma treatment device 200 is an element of the process 10 that carries out a surface treatment of the wire 50. The plasma treatment modifies the surface properties of the wire 50 in order to improve its wettability and the subsequent adhesion of the polymer to the surface of the wire. The plasma treatment device may be selected from varieties of devices that are commercially available and the plasma treatments are known by a person skilled in the art.

With reference again to Figure 1 and to Figures 2 to 7, a wire 50 obtained from the plasma treatment device 200 is transported to a deposition device 100. The deposition device 100 enables the homogeneous and continuous deposition of a thin layer of liquid polymer solution on a wire moving at constant speed that has a small diameter.

The device 100 for depositing a thin layer of liquid on a wire 50 moving linearly at constant speed includes at least one bottle 102 having a predetermined volume for storing a liquid 75. The bottle 102 has an open end 102a where a valve 104, with a relief valve 104a, establishes fluid communication with a tank 106. The valve 104 regulates the supply of the liquid 75 between the bottle 102 and the tank 106 in order to preserve a minimum level of liquid 75 in the tank during the deposition (see Figures 4 and 5). During the deposition, it is necessary to respect an upper limit and a lower limit of the level 75a of liquid 75 in order to ensure the complete coverage of the wire 50.

The valve 104 is fastened to the bottle 102 by means of the cap 102b which has a thread adapted to that of the bottle 102. The valve 104 enables the removable fastening of the bottle 102 to the tank 106. Thus, the bottle 102 is easily replaceable in order to re-establish the level 75a of the liquid 75 if required, or in order to change the chosen liquid.

In addition to establishing fluid communication with the bottle 102, the tank 106 containing the liquid 75 is surmounted by a chamber 108 having two compartments 108d' and 108d''. The compartment 108d' contains two rotatable rings 110. The chamber 108 has a front cover 108a, a rear cover 108b, side walls 108c and an internal wall 108d that together define the internal volumes of the two compartments 108d' and 108d''. The side walls 108c of the chamber 108 are opposed to one another and include an inlet wall 108c' for the wire 50 and an outlet wall 108c'' for the wire. At the bottom of the compartment 108d', there is an

opening 108e corresponding with at least one portion of the tank 106 so that the dipping of a lower portion 110a of each ring 110 in the liquid 75 is ensured.

With reference again to Figures 2 to 7, the wire 50 enters the compartment 108d' by passing through an assembly 112 that is mounted on the outside of the inlet wall 108c'. The assembly 112 includes a barrel 112a that engages a tightening screw 112b (for example via known complementary threads). The wire 50 passes through an opening along the tightening screw 112b, and is guided to the internal volume of the compartment 108d' by at least one tightness bushing 112c.

By additionally referring to Figures 4, 5 and 6, there are two rings 110 that are rotated by the lower wheel 114' of the set of two wheels that include an upper wheel 114 and a lower wheel 114'. Each wheel 114, 114' has a respective circumferential periphery 114a, 114a' having grooves 114b, 114b' in which the two rings 110 are lodged and also a central groove 114c, 114c' that forms an orifice 126 for the passage of the wire 50. The wheels 114, 114' may have identical diameters, although this feature is not essential, in order to ensure uniform and reproducible performances during the deposition of the liquid.

The wheels 114, 114' are placed vertically on either side of the wire 50 and in tangential contact with the wire by means of the grooves 114c, 114c'. The shafts 116, 116', on which the wheels 114, 114' are fastened, support the rotational movement of these wheels by turning about an axis of rotation defined by the bearings 118, 118' that are fastened in cages 120, 120'. The cage 120' is rigidly fastened to the wall 108d of the compartment 108d'' and imposes a fixed position on the lower wheel 114'. The cage 120 is fastened to the wall 108d of the compartment 108d'' by an axle 121 which allows the cage 120 a degree of rotational freedom about the axle 121. The wheels 114, 114' are arranged so that their rotational axes are parallel to one another.

With reference to Figures 4 to 7, a predetermined contact force between the wheels 114, 114' and the wire 50 is provided by a tension spring 122 that tends to move the mobile cage 120 closer to the fixed cage 120' (see Figure 7). The strength of the tension spring 122 enables the wire 50, when it moves at constant speed (as indicated by the arrow A in Figures 3, 4 and 7), to rotate the wheels 114, 114' (as indicated by the arrows B, B' in Figure 4) by means of the frictional force that exists at the tangential contact points between the wire 50 and the grooves 114c, 114c' of the wheels 114, 114'.

By friction also at their common tangential contact points, the lower wheel 114' rotates the two rings 110 that pass through spaces 124 created by the grooves 114b, 114b' (see figure 6 which represents the portion I from Figure 5). The rings 110 turn in the direction of the arrow B' from Figure 4 and convey a certain
5 amount of liquid to the point of contact between the wheels 114, 114' and the wire 50, which passes through an orifice 126 between the grooves 114c, 114c'. The liquid coats the wire 50 and the surplus liquid is conveyed to the tank 106 by the rotation of the rings 110 and by the effect of gravity.

A uniform coating thickness is obtained on the wire 50 by the combined
10 effects of the surface tension and the viscosity of the liquid on the one hand, and the surface energy of the wire on the other hand. The thickness of the layer of liquid measured on the wire 50, at the end of the liquid deposition process, mainly depends on the viscosity of the liquid and on the run speed of the wire 50. In some embodiments, it is preferable for the thickness to be very fine (for example around
15 10 μm), but the thickness of the liquid depends on the use for which the wire is intended.

If necessary, a calibration bushing 128 provided with an orifice at its centre may be mounted in the compartment 108d' of the chamber 108 downstream of and as close as possible to the wheels 114, 114', in order to calibrate the thickness of
20 the coating. In this case, the bushing 128 is "floatably" mounted in a housing 117 which blocks it in the direction of movement of the wire 50 but leaves it free in all directions perpendicular to the movement of the wire. The hydrodynamic bearing effect ensures the centring of the calibration bushing 128 around the wire when the latter moves through the orifice of the calibration bushing. The diameter of the
25 orifice is determined as a function of the final coating thickness that it is desired to obtain. The liquid removed by the calibration bushing falls back into the tank 106 by the effect of gravity.

At the inlet of the process 10, there are two different materials: a wire provided by a system 300 and a liquid polymer solution 75 provided in a bottle
30 102. At the outlet of the process 10, a wire covered with a thin solid polymer layer is obtained. Besides the fact that it completely covers the wire, the polymer layer has a certain degree of adhesion to the surface of the wire.

With reference to Figure 1, the wire 50 obtained from the deposition device 100 (by passing through the outlet wall 108c'') is transported to a heating device

400, the role of which is to raise the temperature of the layer of polymer solution in order to initiate the evaporation of the solvent that it contains. In the present invention, the evaporation of the solvent is obtained by the combined use of an increase in the temperature and a reduction in the pressure in the space surrounding the wire by the creation of a partial vacuum (typically between 10 mbar and 500 mbar) by means of an industrial vacuum pump (not represented). The partial vacuum makes it possible, on the one hand, to lower the boiling point of the solution, therefore the evaporation temperature of the solvent and, on the other hand, to suck up the solvent vapours in order to pass them, for example, into a condensation device and thus recover them for subsequent recycling.

To produce the partial vacuum, the wire circulates in a network of glass tubes 418 connected directly and in a leaktight manner to the outlet wall 108c'' of the chamber 108. The network of glass tubes 418, which may be a single tube or several tubes connected to one another in a leaktight manner, forms a tubular chamber of length L_{418} inside which the pressure will be able to be reduced. The tubular chamber is common to the heating device 400 and to the temperature maintaining device 500 and passes through both devices. The length L_{418} of the tubular chamber breaks down into two sections of respective lengths L_{418}' and L_{418}'' . The section L_{418}' bears the heating device 400 and the section L_{418}'' bears the temperature maintaining device 500. The two sections L_{418}' and L_{418}'' are separated by a section L_{419} in which a branch connection 420 makes it possible to connect the industrial vacuum pump in order to create the partial vacuum in the tubular chamber. Glass is chosen to make the tubes since it is not an electrical conductor, and also because it has excellent chemical resistance and good temperature resistance. The tubes could nevertheless be made from other materials having the same features.

The existence of a partial vacuum limits the effectiveness of a transmission of the energy needed to increase the temperature of the polymer solution by convection with a hot gas, for example. To overcome this difficulty, the temperature of the wire is increased by means of an induction coil positioned around the section L_{418}' of the tube network 418 in which the wire 50 circulates and which implements the principle of induction heating. This heating means makes it possible to rapidly increase the temperature of the moving wire 50 without physical contact therewith and does not require the presence of a gaseous

medium for transmitting the energy to the wire.

With reference to Figures 8 and 9, the induction heating is composed of an electronic control board supplying an induction coil 412 and a capacitor 411. The temperature of the wire 50 is increased by means of the induction coil 412 placed
 5 around the wire 50. The material of the wire 50 has an electrical conductivity and a resistance that are dependent on the temperature. The resistance of the material may be calculated by means of the electrical conductivity given that the resistance and the conductivity are inversely proportional.

When the induction coil 412, inside which the wire 50 to be heated passes,
 10 is powered by an electrical current, it creates a magnetic field. This magnetic field induces Foucault currents in the metal wire 50. It is the Joule effect, due to the Foucault currents, which is responsible for the increase in temperature of the object to be heated (i.e. the wire 50).

The electrical power consumed for heating an element that is a cylinder of
 15 material may be described as:

$$P = \pi \cdot d \cdot h \cdot H^2 \cdot \sqrt{\pi \cdot \rho \cdot \mu_0 \cdot \mu_r \cdot f} \cdot C \cdot F$$

where:

- d: Diameter of the cylinder [m]
- 20 h: Height of the cylinder [m]
- H: Intensity of the magnetic flux [A/m]
- ρ : Resistivity [$\Omega \cdot m$] of the conductive material of the element
- μ_0 : Magnetic permeability of the vacuum ($4\pi \cdot 10^{-7}$ H/m)
- μ_r : Relative permeability of the conductive material of the element
- 25 f: Frequency [Hz]
- C: Coupling factor that decreases with the length of the inductor
- F: Power transmission factor

It is observed that the heating power depends on the resistance of the cross
 30 section of the element to be heated (i.e. the wire 50).

Figure 9 represents the wiring diagram of the induction furnace which is represented by a heating circuit 402. The heating circuit 402 is powered by a DC supply voltage (Ubus). The DC supply voltage is then split by electronic transistors 408 in order to form an AC voltage at the terminals of the coil 412 (i.e. an ideal
 35 inductor 404 and a resistor inductor 410) and of the capacitor 411 (i.e. an ideal

capacitor 406 and a resistor capacitor 407), and this voltage is measured by a voltage (V) measurement 414. The supply voltage of the heating circuit is indeed direct, that of the coil is alternating and has a frequency close to the resonance frequency.

5 The supply voltage of the induction furnace is controlled by the electronic board and its amplitude is therefore known. The power provided by the heating may therefore be known by measuring the current that passes through the circuit by means of a current sensor (see the measurement of the current (A) 413 in Figure 9) and by multiplying this current by the amplitude of the heating circuit supply
10 voltage. The fact of being at a frequency close to the resonance frequency makes it possible to minimize the supply power.

Specifically, to the first order, the power supply of the induction furnace only needs to compensate for the losses of the system. These losses are mainly the Foucault current losses in the element to be heated. The Foucault current losses
15 depend on the resistance of the wire to be heated, a resistance that increases with the increase in its temperature. By increasing the temperature of the wire, the losses and therefore the power to be provided by the supply are increased.

By measuring the power provided by the heating, it is therefore possible, correspondingly, to know the temperature of the wire 50. It is thus possible, by an
20 appropriate regulation, to precisely control the temperature of the wire 50 in order, for example, not to degrade the mechanical properties of the wire.

The heating circuit 402 is powered, continuously, by a DC voltage (U_{bus}). During a first heating phase, the coil (412) and the capacitor (411) are supplied, over a predetermined time, with a sinusoidal voltage resulting from the splitting of
25 the DC voltage by the transistors 408. This time is predetermined by the heating regulator, and this time depends, amongst others, on the temperature error (setpoint-measurement). During this phase, the current consumed by the heating circuit 402 is measured. Owing to the knowledge of the supply voltage (U_{bus}) of the heating circuit (412), the power consumed by the heating circuit is determined
30 therefrom as is the temperature of the wire 50.

Next, the power supply of the induction coil 412 and of the capacitor 411 is cut off. After this cut-off, the portion of the heating circuit 402 that includes an inductor-capacitor circuit (412 and 411) continues to oscillate at the resonance frequency of the circuit. It is at this moment that the resonance frequency is

measured by means of the voltage measurement 414, mainly for process controls.

Finally, by knowing the temperature of the wire, a controller determines the heating time for a control period in order to slave the temperature of the wire 50 to the setpoint temperature. In one embodiment, a control period is established every
5 100 ms. The value of the control period may be different; likewise, in the case cited here, the heating time varies between 5 and 95 ms. In another embodiment, the control period is established every 250 ms, and the heating time varies between 5 and 245 ms. If a different control period is chosen, the heating time will vary.

The temperature control of the wire 50 is carried out by varying the heating
10 time calculated by the controller during the control period (for example, the heating time calculated by the controller every 100 ms, every 250 ms, etc.). The wire 50 (or a wire portion considered) enters the coil 412 with a temperature equal to the ambient temperature. Each wire portion considered moves by advancing through the coil 412, and each portion undergoes heating. At the outlet 412b of the
15 coil 412 the temperature of the wire 50 has reached the setpoint temperature.

The temperature is maintained over the entire length of the wire, or for the entire time needed for the process. The temperature controller will calculate, at every control period (for example, every 100 ms), the heating time which will be dependent on the temperature error. In some embodiments, several control periods
20 are carried out with, at each time, a different heating time and a decreasing temperature error. The control operates all the time, and the temperature is being maintained all the time. If the temperature is close to the setpoint, slight heating is carried out, and if the temperature is far from the setpoint more heating is carried out.

25 The run speed must be constant in order to be able to measure the temperature. The geometry of the wire 15 must also be constant, that is to say that the cross section of the wire must be constant along its length. The electrical resistivity and the magnetic permeability of the wire 50 must be stable for a given temperature.

30 From the moment it leaves the induction coil 412, a given portion of the wire 50 begins to cool down by radiation, by convection with the residual ambient atmosphere and optionally by the presence of solvent that might not have evaporated over the length L_{412} of the induction coil 412. In this case, the solvent may continue its evaporation by taking the energy accumulated in the wire at the

outlet of the coil 412.

The present invention therefore provides an additional supply of energy after the device 400 for the duration needed to obtain the complete evaporation of the residual solvent. The wire obtained from the heating device 400 is thus
5 transported to a temperature maintaining device 500, the role of which is to provide the necessary energy to the solvent so that it finishes evaporating. This external energy supply is transmitted to the surface of the wire by radiation and by convection of the residual molecules in the partial vacuum and is carried out by heating elements 510 that are commercially available and known to a person
10 skilled in the art. These heating elements are fastened directly to the section $L_{418''}$ of the tube network 418. The length $L_{418''}$ depends on the speed of travel of the wire and on the amount of residual solvent in the layer deposited at the surface of the wire at the outlet of the heating device 400.

The creation of a partial vacuum makes it necessary to achieve a tightness
15 seal at the inlet and at the outlet of the devices passed through by the wire 50. For practical reasons, it is difficult to achieve this tightness seal when the wire is covered with a solution of polymer in the liquid state. This is the case for the section of wire that is downstream of the inlet of the deposition device 100 and upstream of the outlet of the temperature maintaining device 500. This is why the
20 three devices 100, 400 and 500 are connected together in a leaktight manner by a network of glass tubes and the tightness seals necessary for the creation of the partial vacuum are positioned at the inlet of the deposition device 100 (tightness seal on the bare wire) and at the outlet of the temperature maintaining device 500 (tightness seal on the wire covered with solid polymer). The tightness seal 515 at
25 the outlet of the temperature maintaining device 500 is of similar design to that of the assembly 112 of the deposition device 100.

The invention disclosed describes a continuous process, which means that all the steps are carried out without interruption on a wire, the speed of travel of which is constant. This process may be placed upstream or downstream of any
30 other process that aims to carry out an operation prior or subsequent to the covering of the wire with a thin layer of solid polymer on condition that the speed of travel of the wire is common to all of the processes.

The process 10 may follow a programmed formula. For example, a central control centre may have been programmed with data (formulae) established for a

plurality of polymer solutions and a plurality of wire sizes. One or more sensors and/or sensor types may potentially be used, including, without limitation, environmental sensors (for example for detecting atmospheric conditions such as temperature, pressure and/or humidity during the course of the process) and
5 checking sensors (for example for detecting a deviation in relation to a setpoint value). In this way, the invention makes it possible to treat a large variety of wires as a function of the targeted application.

At least some of the various techniques may be implemented in relation to hardware or software or, if justifiable, a combination of the two. As used here, the
10 terms “method” or “process” may encompass one or more steps performed at least by an electronic or computer-based apparatus having a processor used to execute instructions that carry out the steps.

The terms “at least one” and “one or more” are used interchangeably. The ranges given as lying “between a and b” encompass the values of “a” and “b”.

15 Although particular embodiments of the disclosed device have been illustrated and described, it will be appreciated that various changes, additions and modifications can be made without departing from either the spirit or scope of the present description. Thus, no limitation should be imposed on the scope of the invention described, except for the limitations set out in the attached claims.

CLAIMS

1. A process for coating the surface of a moving wire (50) with a thin solid polymer layer, wherein the process comprises the following steps:
- providing a deposition device (100) having a compartment (108d') of a
5 chamber (108) that contains two rotatable rings (110) and two wheels that
comprise an upper wheel (114) and a lower wheel (114') having circumferential
grooves (114b, 114b') in which the two rings (110) are lodged, and in which
compartment the wheels (114, 114') are placed vertically on either side of the wire
10 (50) by means of the grooves (114c, 114c') such that a predetermined contact force
between the wheels (114, 114') and the wire (50) makes it possible, by friction,
when the wire (50) moves at constant speed, to rotate the wheels (114, 114') and,
by means of the lower wheel (114'), the rings (110) too, and a tank (106)
containing a liquid polymer solution (75);
- conveying the wire (50) at a predetermined constant speed;
- 15 rotating the rotatable rings (110), these rings convey an amount of the
liquid polymer solution (75), and these rings bring it to a point of tangential
contact between the grooves (114c, 114c') of the wheels (114, 114') and the wire
(50), which at the same time passes through an orifice (126) formed by the grooves
(114c, 114c') and located between the grooves (114b, 114b'), in order to coat the
20 surface of the wire (50) while it is moving;
- creating a partial vacuum simultaneously in the spaces passed through by
the wire (50) of a deposition device (100), of a heating device (400) and of a
temperature maintaining device (500);
- increasing the temperature of the wire (50) in the heating device (400) in
25 order to initiate the evaporation of the solvent from the liquid polymer solution
(75) deposited at the surface of the wire (50); and
- maintaining the temperature of the wire (50) with the temperature
maintaining device (500) until the complete evaporation of the solvent is obtained.
- 30 2. A process according to claim 1, additionally comprising the following
steps:
- providing, in the heating device (400), a heating circuit (402)
comprising an induction coil (412) and a capacitor (411) connected in parallel and

that form a resonant circuit;

powering the heating circuit (402) with a DC supply voltage (U_{bus});

measuring the current consumed by the power supply of the heating circuit (402);

5 calculating the power provided by the power supply of the heating circuit (402);

estimating the temperature of the wire (50); and

establishing a control period in order to slave the temperature of the wire (50) to the predetermined setpoint temperature.

10

3. A process according to claim 2, wherein the control period is established every 100 ms.

4. A process according to any one of claims 1 to 3, wherein a surplus of the
15 polymer solution (75) is conveyed to the tank (106) by the rotation of the rings (110) and by the effect of gravity.

5. A process according to claim 4, additionally comprising a step of:
calibrating the thickness of the deposited layer of the polymer solution
20 (75) by means of a calibration bushing (128) provided with an orifice at its centre and mounted in the compartment (108d') of the chamber (108) in order to make the surplus of the polymer solution (75) fall into the tank (106).

6. A process according to any one of claims 1 to 5, wherein the temperature of
25 the wire (50) is increased in the heating device (400) until an evaporation temperature of the solvent is attained.

7. A process according to any one of claims 1 to 6, additionally comprising the dipping of a lower portion (110a) of each ring (110) in the polymer solution
30 (75) by means of an opening (108e) in the bottom of the compartment (108d') of the chamber (108) that corresponds with at least one portion of the tank (106).

8. A process according to any one of claims 1 to 7, additionally comprising the step of carrying out a plasma surface treatment of the wire (50) before the step

of depositing a layer of the polymer solution on the surface of the wire (50).

9. A system for producing a wire (50) coated with a layer of solid polymer using a chosen polymer dissolved in a liquid solvent, the system comprising a series of devices (100, 400, 500) that together make it possible to carry out a process according to any one of claims 1 to 8.

10. A system according to claim 9, wherein the series of devices (100, 400, 500) comprises:

- 10 the impregnation device (100) that carries out a process for depositing liquid polymer solution on the surface of the wire (50) while it is moving;
- the heating device (400) that increases the temperature of the wire (50) to initiate the evaporation of the solvent from the layer of liquid polymer solution (75) deposited on the wire (50) while the wire (50) is moving; and
- 15 the temperature maintaining device (500) that regulates the temperature of the wire (50) at a temperature for evaporating the solvent from the liquid polymer solution (75) deposited at the surface of the wire (50).

11. A wire (50) coated according to a process according to any one of Claims 1 to 8.

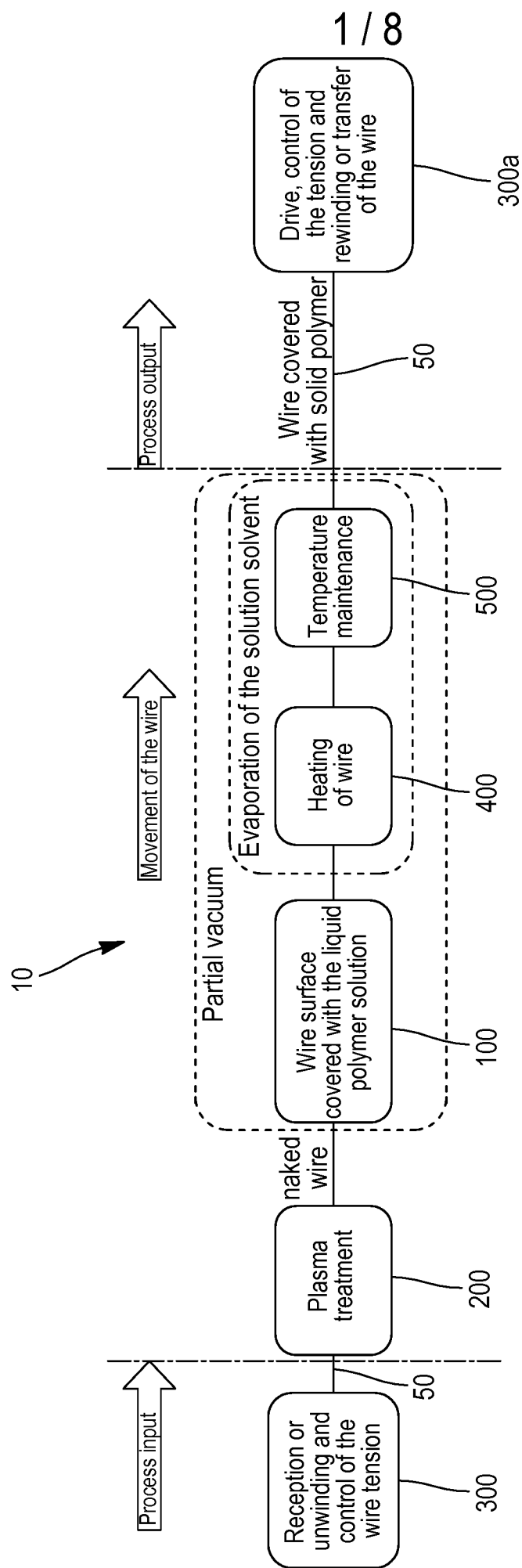


FIG. 1

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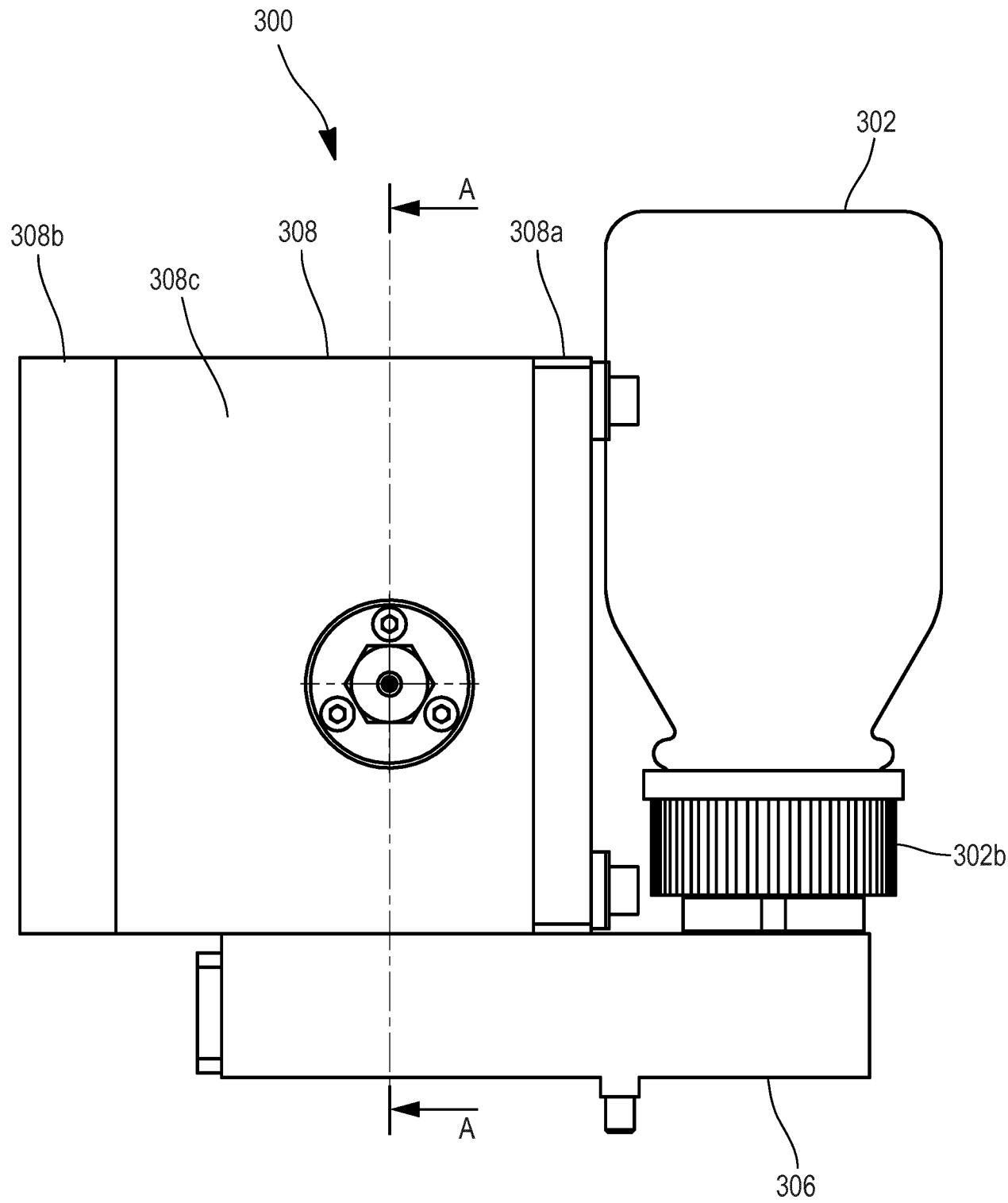
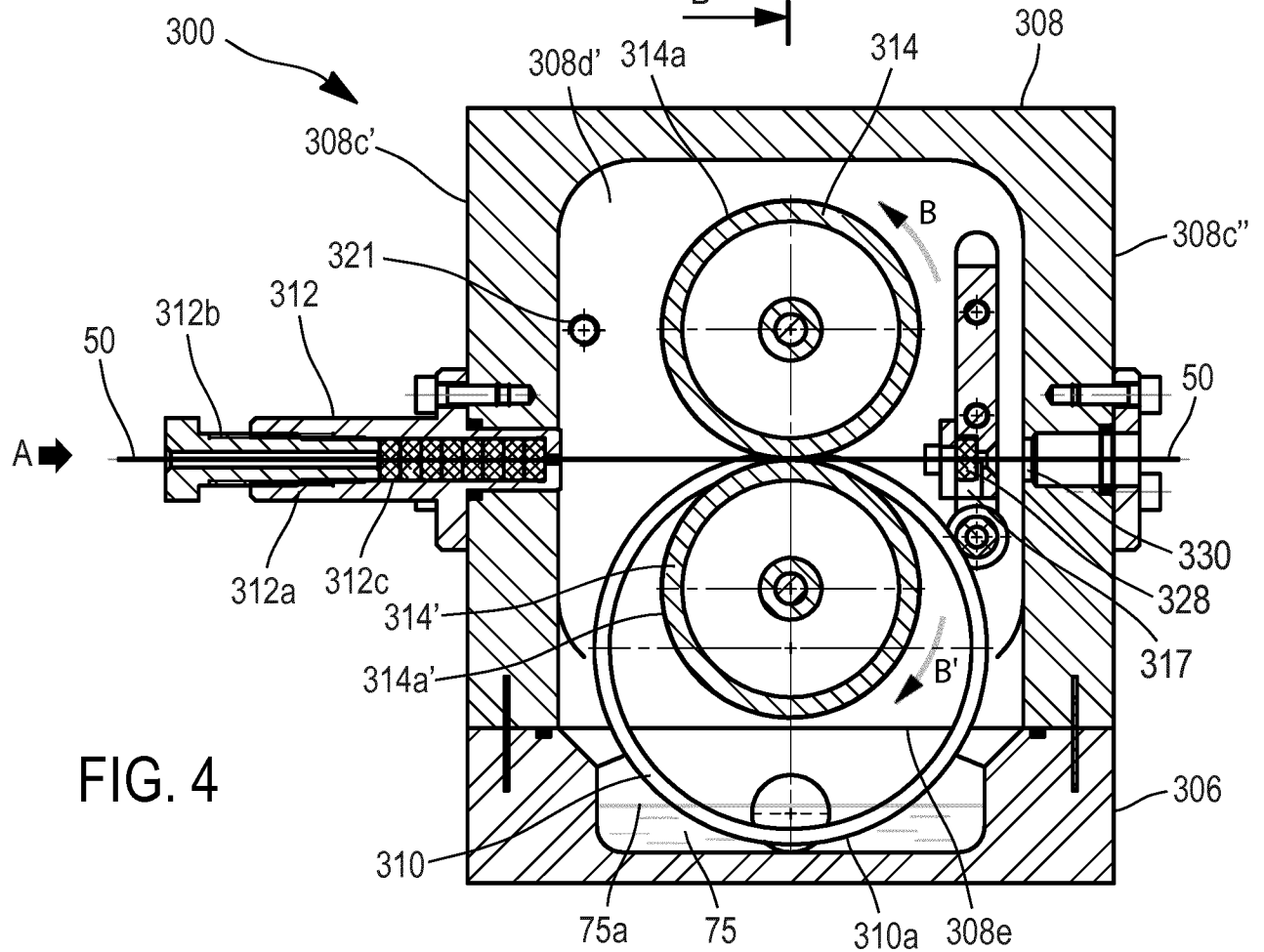
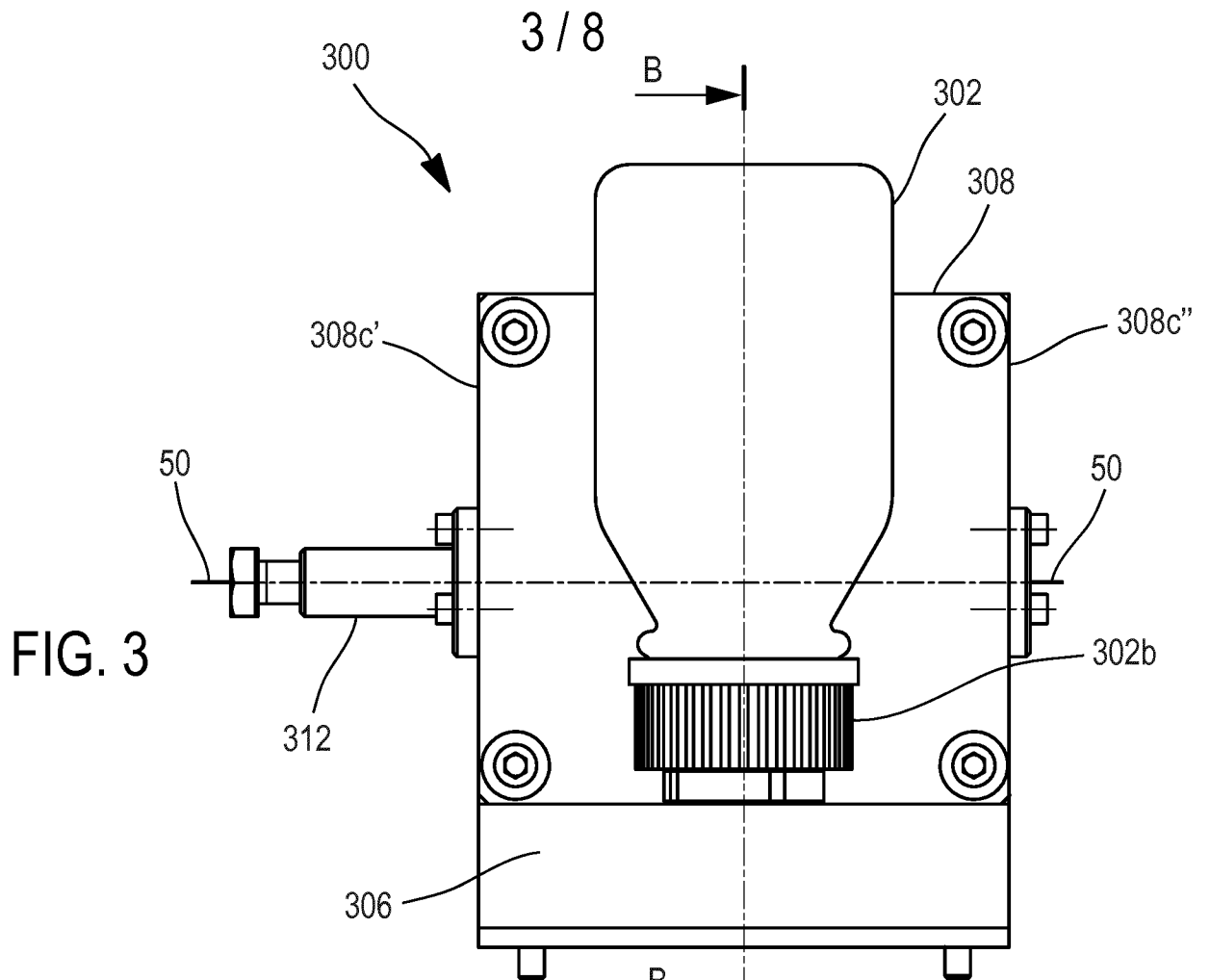


FIG. 2



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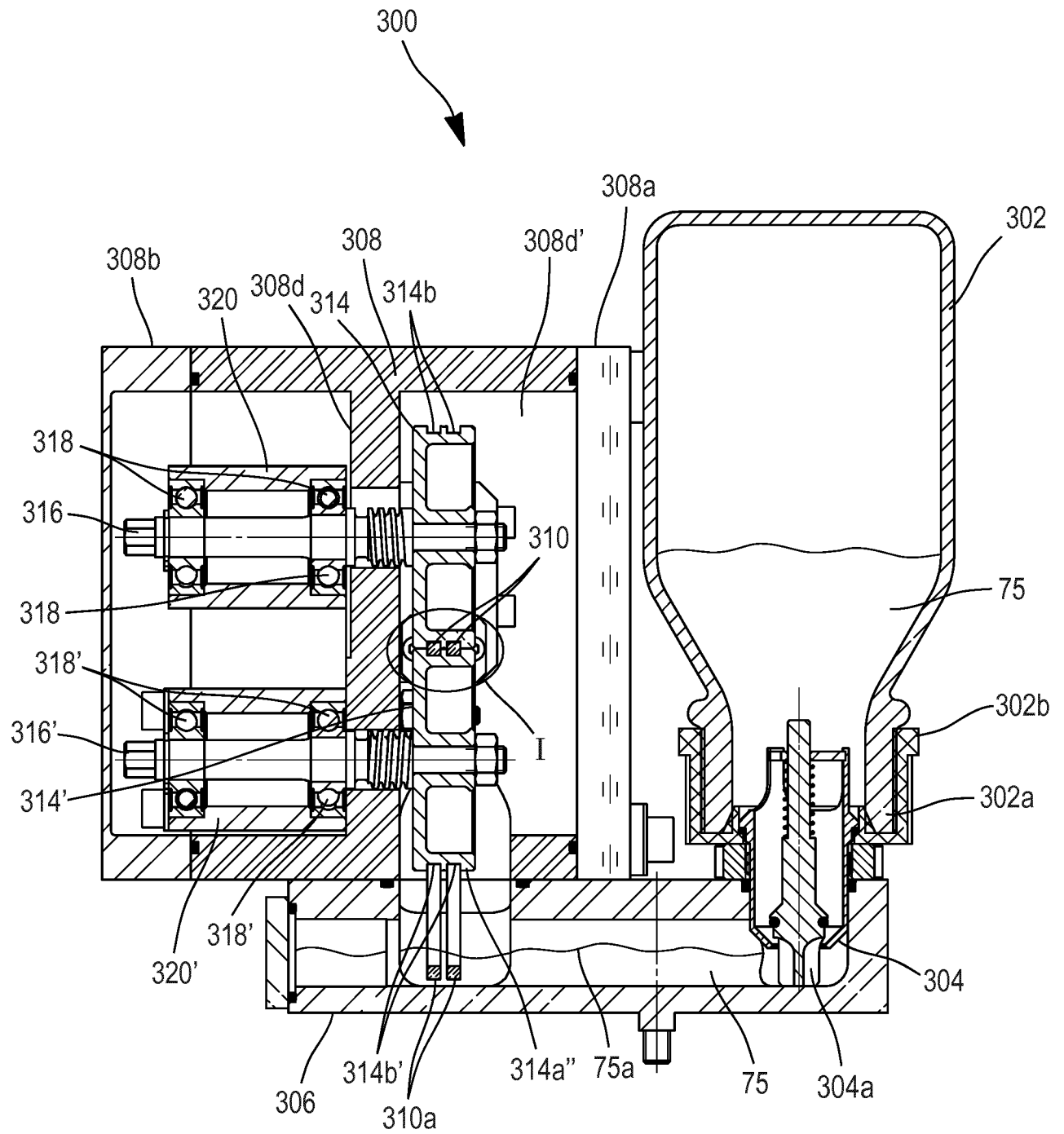


FIG. 5

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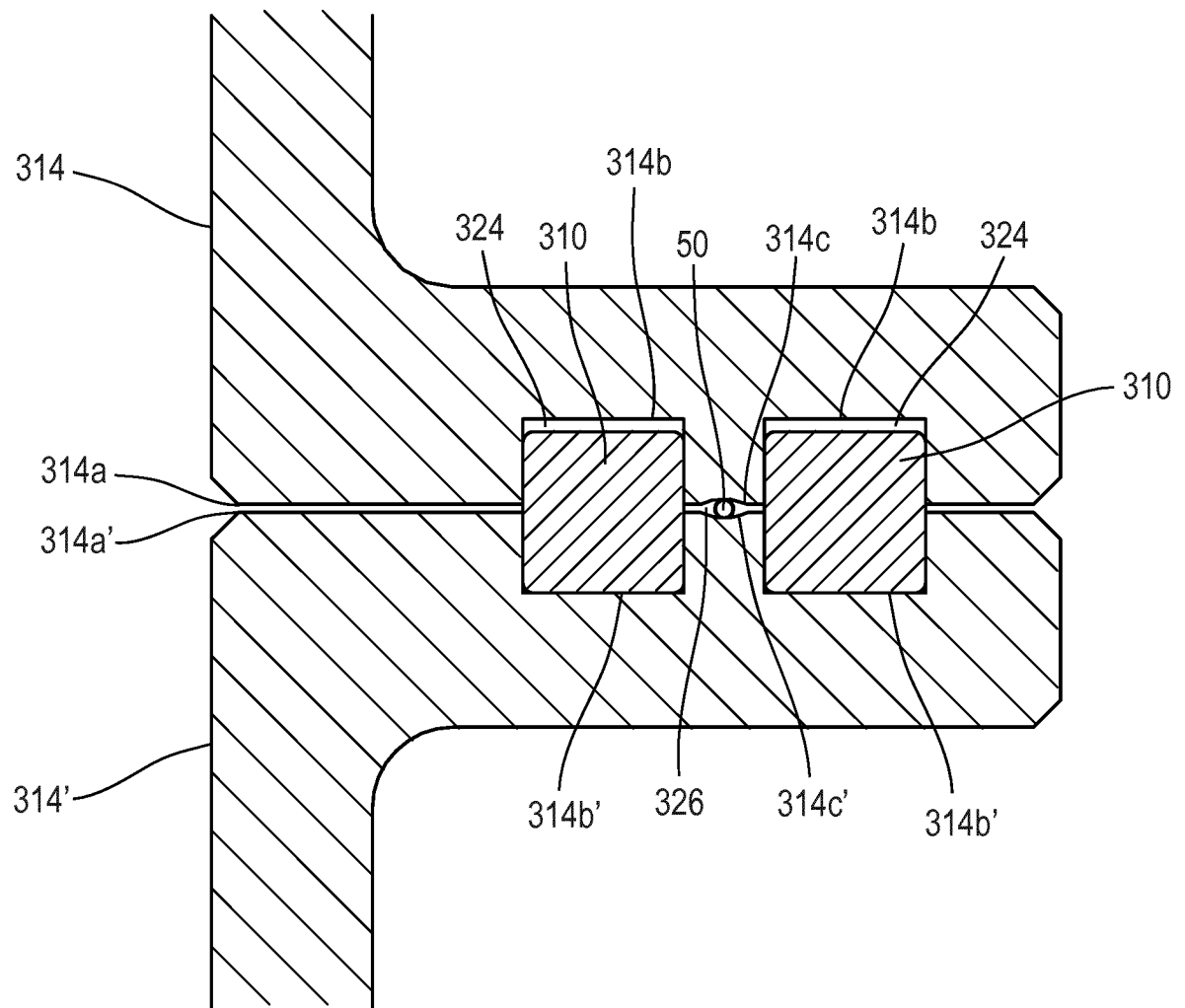


FIG. 6

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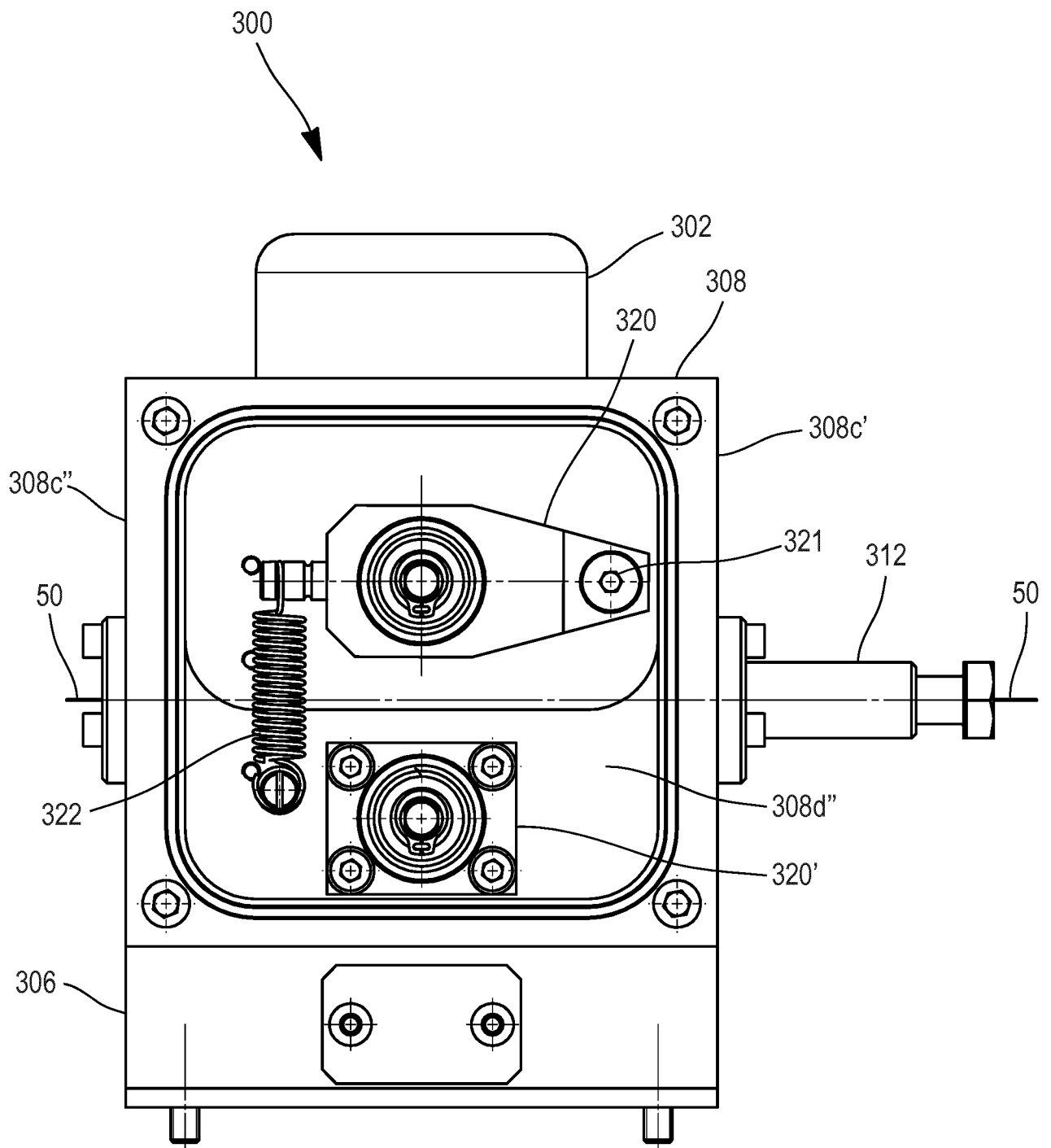


FIG. 7

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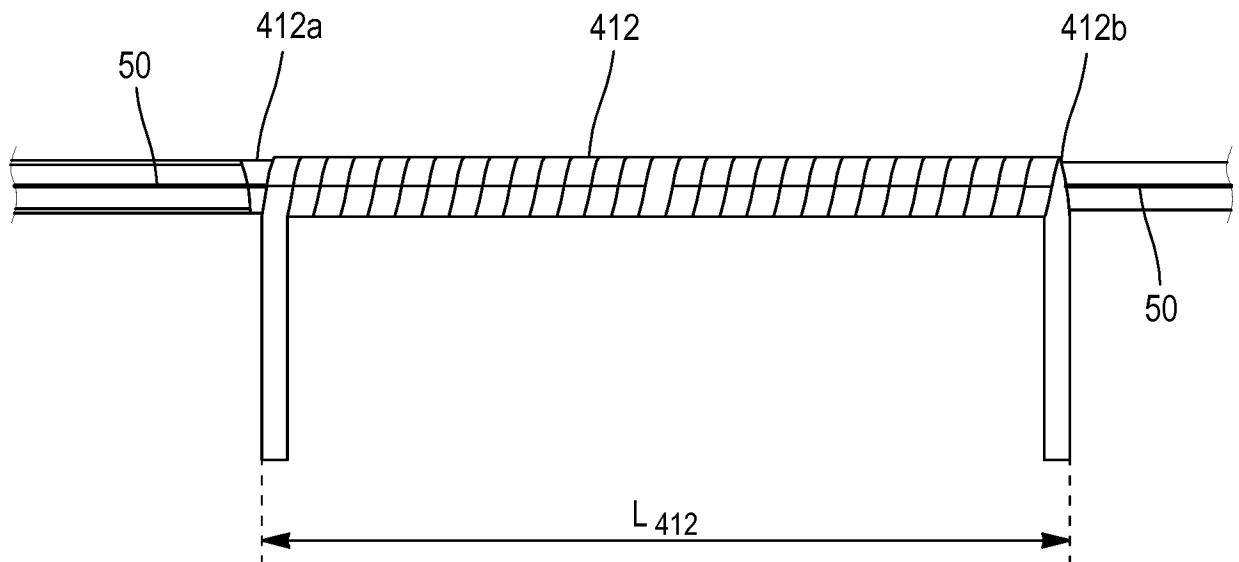


FIG. 8

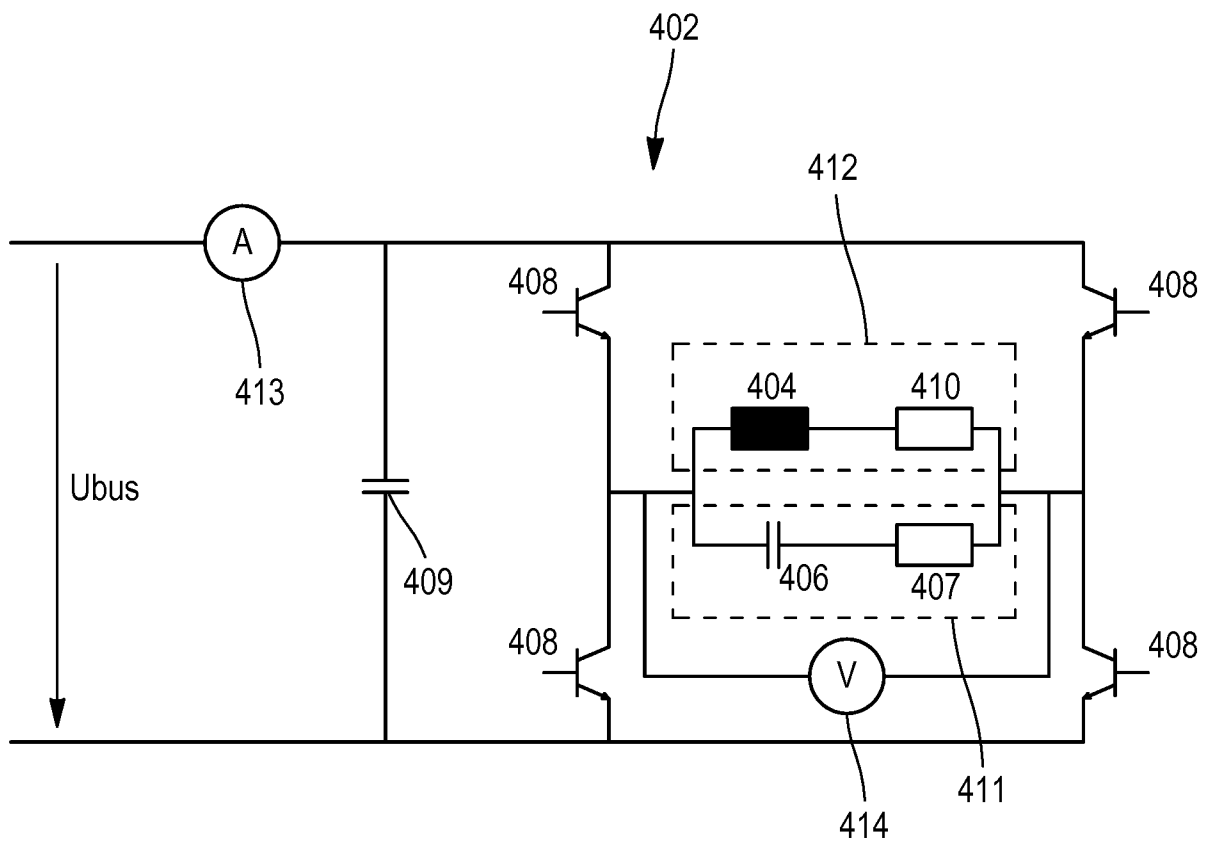


FIG. 9

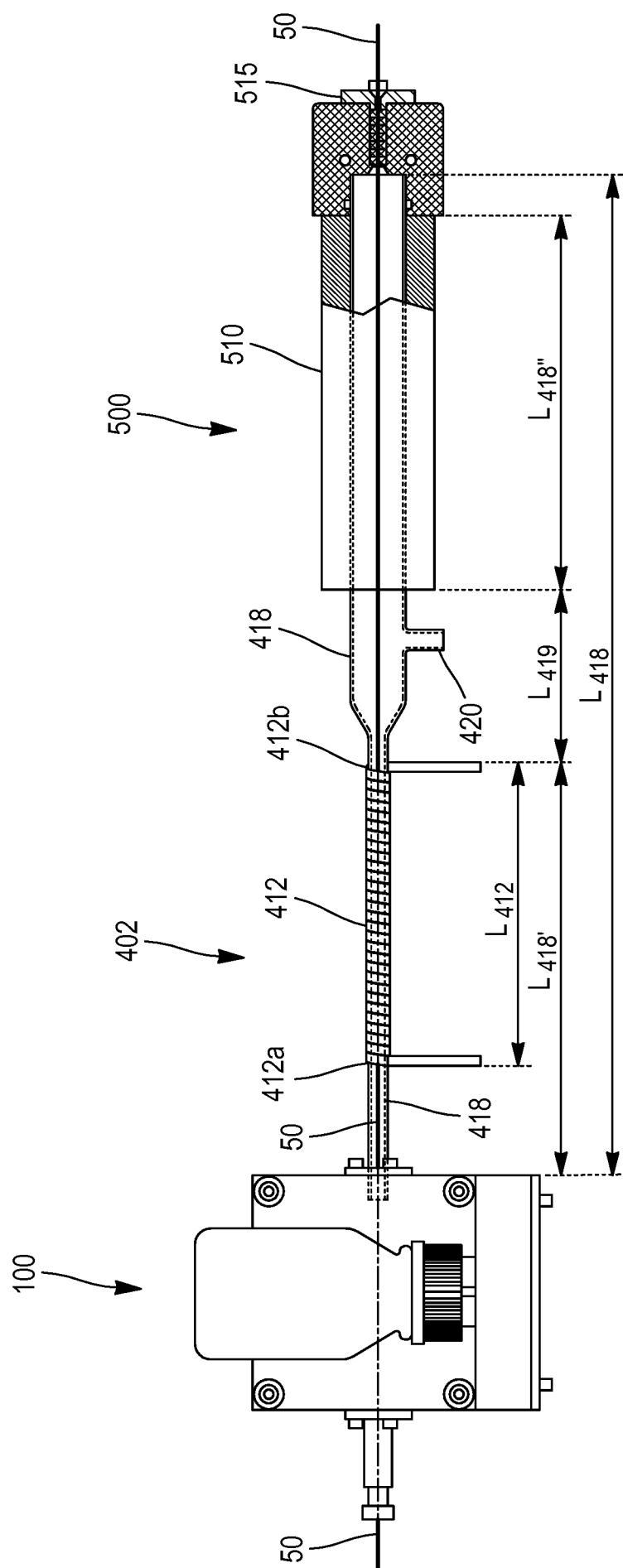


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/078550

A. CLASSIFICATION OF SUBJECT MATTER INV. B05C1/08 B05D1/28 B05D7/20 D06B1/14 D07B7/14 B29B15/14 B05D3/02 H01B13/06 B05D3/04 B05C9/14 ADD. B05C3/12 B05C11/02		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) B05C B65H D07B D06B B05D H01B B29B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	BE 624 114 A (MANUFACTURE D' EPINGLES ET D'AIGUILLES) 15 February 1963 (1963-02-15) page 2 - page 4; figures -----	11 1,9
X A	FR 1 384 410 A (THOMSON HOUSTON COMP FRANCAISE) 4 January 1965 (1965-01-04) page 2, left-hand column, last line - page 2, right-hand column, paragraph 2; figures 1-2 -----	11 1,9
X A	US 2014/110147 A1 (ELIE LARRY DEAN [US] ET AL) 24 April 2014 (2014-04-24) paragraphs [0035] - [0038]; figures 3-5 -----	11 1,9
<input style="width: 20px; height: 20px; margin-right: 5px;" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" style="width: 20px; height: 20px; margin-right: 5px;" type="checkbox"/> See patent family annex.		
* Special categories of cited documents :		
"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
Date of the actual completion of the international search 29 January 2018	Date of mailing of the international search report 07/02/2018	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Brévier, François	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/078550

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
BE 624114	A	15-02-1963	NONE	
FR 1384410	A	04-01-1965	NONE	
US 2014110147	A1	24-04-2014	NONE	