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The invention relates to a dispensing device for the dispensing of liquids, particularly liquid medicaments to persons according to the preamble of claim 1. Furthermore, the invention relates to a covering cap according to the preamble of claim 25. Finally, the invention relates to a method for the determination and validation of the fill level of a container according to the preamble of claim 32.

The invention can in particular be used in health care, for example, in medical devices, pharmaceutical technology and biotechnology, medicine and nursing, studies, etc. for the monitoring of the dispensing of medicaments to patients.

Various devices for the dispensing of liquids are known from the prior art, for example the patent application WO 2014/052997 A1, in which the amount of the dispensed liquid or the amount of liquid present in the dispensing device is determined capacitively. The object of the present invention is to effectively detect malfunctions in capacitive fill level detections and allow for an invalidation of capacitive fill level measurement results. It is a further object of the invention to obtain the best and most reliable results possible.

The invention achieves this object with a dispensing device of the type mentioned at the outset with the characterising feature of claim 1.

In addition, the object of the invention is achieved with a method of the type mentioned at the outset having the feature of the characterising portion of claim 25. In addition, the object of the invention is achieved with a method of the type mentioned at the outset having the feature of the characterising portion of claim 32. According to the invention, a dispensing device for the dispensing of liquids, particularly liquid medicaments to persons, comprises:

- a container filled with the liquid and having an opening formed therein on one end to dispense the liquid, and
- at least one pair of capacitive measuring electrodes arranged in the outer area, in particular on the wall, of the container opposite one another, to determine the permittivity of the respective medium in the space between

the measuring electrodes. A stable and precise determination of the liquid fill level in the container is achieved according to the invention.

Advantageously, it can be provided that the measuring electrodes are surrounded by a shield that is arranged around the container. Disturbances which are caused by contact with the container during the measurement process due to capacitive effects are effectively prevented with the invention. In particular, measures according to the invention can enable the prevention of a contact with the measuring electrodes by the hands of a person or a distortion of the electrical field in the area of the measuring electrodes by the hands of a person or other electrically-conducting objects that lead to changes in the fill level measurement value.

An advantageous protection of the measuring electrodes can be produced through one of the measuring electrodes and jacket-like covering cap that surrounds the container.

To produce a protection of the measuring electrodes that is simultaneously mechanically and electrically effective, it can be provided that the shield is integrated into the covering cap or applied to the surface of the covering cap.

Alternatively it can be provided for the same purpose that the wall of the covering cap surrounds the measuring electrodes and that the outer wall or outer surface of the covering cap is at a distance of at least 5 mm, in particular of at least 1 cm from the measuring electrodes and/or prevents an access to and a contact with the measuring electrodes.

Advantageously, the shield can be formed as a film coated with conductive paths of electrically conductive material. In a preferred embodiment, this film is arranged or wound around the container and/or surrounds same. Such a shield prevents the distortion of measurement results in a particularly advantageous manner.

To obtain good measurement results, it can be provided that the area between the liquid and the measuring electrodes is free of the shield.

To avoid a deterioration of the measurement results due to the effects of the shield, it can be provided that the shield is spaced apart from the measuring electrodes in the radial direction.

To achieve an improved shielding and at the same time to enable an attachment of a semiconductor chip and an antenna in the region of the shield or on the film, it can be provided that the shield is formed as a film coated with conductors in the form of conductive paths, in particular wound around the container, wherein preferably a capacitance measurement circuit, a computing unit, and a communication controller, in particular in the form of a semiconductor chip, and an antenna are applied to the film.

To prevent the radio communication with the antenna from impairing changes in the electromagnetic field generated by an external data communication device and simultaneously to enable a good electrical shielding of the measuring electrodes, it can be provided that the conductors are loop-free and/or free of closed conductor loops.

For a good shielding effect, it can be provided that the conductors have a width of at most 5 mm, in particular of between 0.1 mm and 3 mm, and a thickness of at most 3 mm, in particular of between 10 μm and 150 μm.

An electronically advantageous implementation of the detection of the fill level in a container is provided in that a communications controller and/or a number of capacitance measuring devices for determining the capacitance between the measuring electrodes and/or a computing unit and/or an antenna for transmitting measurement values determined by the measuring electrodes or values derived therefrom, in particular the fill level values, are arranged on the film and in that these units arranged on the film are preferably integrated in a common housing of a semiconductor chip.

A particularly advantageous design of a shield, which can be used simultaneously for contact detection, and also enables a radio communication with an antenna applied to the shield, provides that three separate conductors are formed on the film, wherein the first and the second conductor are formed as interengaging comb conductors and the third conductor is formed to be meandering between the two comb conductors.

A preferred measure for determining the liquid fill level inside the container provides that the two opposite-facing measuring electrodes are connected to a capacitance measuring device.

For the simple determination of the fill level, it can be provided that the capacitance value detected by the capacitance measuring device is fed to a computing unit which determines the liquid fill level of the container based on the determined capacitance value by means of a predetermined stored calibration and keeps same available in the output thereof.

A particularly effective shield with good shielding effect can be achieved in that one of the three conductors, in particular the second conductor formed as a comb conductor, is connected to the earth connection of the capacitance measuring device.

To advantageously detect contacts or distortions of the capacitance measurement, a contact sensor, in particular capacitive, arranged outside or in the region of the shield can be provided.

A variant that is simple to manufacture from the production technology standpoint can be provided wherein the contact sensor comprises the first comb conductor and the meandering conductor of the shield as sensor electrodes.

In this way, for the detection of contacts, it can be provided that the sensor electrodes of the contact sensor are connected to a further capacitance measuring device, and that preferably the further capacitance value determined by the further capacitance measuring device is fed to the computing unit, and if the determined further capacitance value exceeds a specified threshold value, the computing unit suppresses or marks as invalid the forwarding of the fill level established thereby.

An advantageous container for the uptake of liquids which can be easily emptied and for which the fill level can be easily determined provides that the container has an internal volume which, apart from the region of the opening, has a constant inner cross-section, wherein a piston is provided that closes off and seals the container and the liquid contained therein, where the outer cross-section of said piston corresponds to the cross-section of the inner volume of the container and is slidably arranged in the interior of the container, so that the liquid is delivered from the container through the opening upon a feed of the piston towards the opening.

For the more precise determination of the fill level, it is provided that a plurality of pairs of additional measuring electrodes are arranged on the container, wherein in particular for each pair of additional measuring electrodes, an additional capacitance measuring device is provided downstream of the pairs of additional measuring electrodes, and the determined capacitance value is output to the computing unit.

An advantageous electrode arrangement which enables an accurate fill level determination, provides that the respective mutually paired measuring electrodes face one another in the circumferential direction of the container, in particular diametrically opposite one another and in particular in the feed direction of the piston at the same height.

For improving the detection accuracy, it can also be provided that adjacent pairs of measuring electrodes in the feed direction of the piston are arranged to be spaced apart and/or that the width of the measuring electrodes in the feed direction of the piston corresponds to the width of the piston in the feed direction.

Preferred embodiments of the measuring electrodes with a simple construction provide,

- that the measuring electrodes are arranged two-dimensionally on the outer surface of the container and in particular have the shape of a rectangle, a triangle, a trapezoid or a parallelogram, and/or
- that each two of the measuring electrodes associated with one another in pairs are formed by two interengaging comb conductors that are arranged in the outer area, in particular on the outer wall, of the container.

To enable a simple exchange of the container, it can be provided that outside the container, between the container and the shield, the measuring electrodes are arranged on a support, wherein the support preferably abuts the container, and/or that the measuring electrodes are arranged on the wall of the support abutting the container, wherein in particular a part of the housing of the dispensing device is formed as a support or the support is connected to the housing.

Advantageously, the determined fill level can be transmitted to an external communication device. It can be provided that a communication controller with an antenna downstream thereof is connected to the computing unit. Provision can advantageously be made for a space-saving arrangement in which the antenna is arranged in the outer area of the shield or directly on the shield but not electrically conductively connected thereto.

A simply constructed dispensing device having a reusable covering cap for fill level measurement and optional fill level display provides that the covering cap has a number of electrical contacts, each of which is electrically conductively connected to one of the measuring electrodes of the container, in particular via connector contacts arranged on the covering cap.

A solution that is simple from the production technology standpoint provides that the shield and/or the conductors, the capacitance measuring devices and/or the further capacitance measuring device and/or the computing unit and/or the communication controller and/or the antenna and/or a power supply are integrated into the covering cap.

To enable a good grip between the covering cap and the body of the dispensing device, it can be provided

- that in the area of the opening of the container the covering cap has a continuous recess for the dispensing of liquid through the covering cap through which, optionally, an injection needle in contact with the liquid is passed, and/or
- that the covering cap surrounds the container, and in particular surrounds an injection needle in contact with the liquid, and/or
- that the covering cap is, in particular multiply detachably, connectable to the container and/or with a housing part adjoining the container, and/or
- that the cap is formed as a sleeve which is open at the end of the injection needle.

To be able to observe the container during dispensing and/or measurement and to be able to detect any turbidity of the liquid or foreign bodies in the container, it can be provided that in the support body is provided a viewing window through which the liquid is visible, wherein optionally in the region of the viewing window, the covering cap has a further viewing window through which the liquid is visible and/or

that a display unit is provided in the outer region of the covering cap, which in particular displays the fill level of the liquid in the interior of the container.

The invention furthermore relates to a covering cap for covering and shielding a liquid-filled container, said covering cap having a number of measuring electrodes, comprising

- connector contacts for electrical contact with the measuring electrodes being arranged on the cap, in particular on the inside thereof,
- at least one capacitance measuring device connected to the connector contacts. With such a reusable covering cap a multiple measurement can

be made of different containers in different support bodies. In particular, in sets with multiple containers, a multiple implementation of a measuring device on all support bodies can be avoided.

A particularly advantageous arrangement provides for a shield running along the inside of the covering cap or on the surface thereof, which in particular is connected to a further capacitance measuring device.

An advantageous covering cap, with which an automatic further processing of data directly on the covering cap is possible, provides the following: a computing unit downstream from the capacitance measuring device(s) and/or the further capacitance measuring device, and optionally a communication controller downstream from the computing unit, in particular connected to an antenna.

Advantageously, a voltage supply arranged on or in the covering cap can be provided, which voltage supply is connected to the capacitance measuring device and optionally to the further capacitance measuring device and/or the computing unit and/or the communication controller and supplies them with electrical energy. To advantageously enable a dispensing of liquid from the container, it can be provided that a continuous recess for dispensing liquid through the covering cap, in particular in the region of the opening of the container, is provided through the covering cap, and/or that the covering cap is formed in the form of a sleeve which is open to one side.

To ensure a multiple use of the covering cap, it can be provided that the covering cap is formed for, in particular multiple, detachable connection with the container or a housing part connected thereto.

To be able to observe the container during dispensing and/or measurement and to be able to detect any turbidity of the liquid or foreign bodies in the container, it can be provided that a viewing window is provided through which the liquid present in the interior of the covering cap and the container is visible from the outside.

Alternatively or additionally, it can be provided that a display unit is provided in the outer region of the covering cap, which in particular displays the fill level of the liquid in the interior of the container.

The invention further relates to a method for determining and validating the fill level in a container arranged in particular in a dispensing device, wherein at least one pair of measuring electrodes for the measuring of capacitance is arranged opposite to one another in the outer area of the container and in particular provided with an outer shield, wherein the capacitance between the two measurement electrodes is determined and a fill level value is determined based on the determined capacitance according to a given calibration function.

According to the invention, it is provided with such a method,

- that a further capacitance is determined using conductors arranged in the outer area of the measuring electrodes in the area of the shield, in particular on the shield,
- that the further capacitance is compared with a threshold value, and
- that the fill level is only considered valid if the further capacitance is below the threshold value.

With such a method, it can be easily checked whether the determined fill level value has been distorted by the fact that a person has contacted the measuring electrodes or the shield in the region of the measuring electrodes or has come sufficiently close to the measuring electrodes to cause a distortion.

For the precise determination of the fill level, it can be provided that the fill level value and/or information regarding the validity of the fill level value is transmitted to an external data communications device by encoded electromagnetic data transmission, in particular through load modulation.

For the same purpose, it can be provided that the respective capacitances of a plurality of, in particular three, pairs of measuring electrodes, which are associated to be opposed to one another on the outside of the container, and the fill level value is determined on the basis of capacitance.

A particularly precise detection is possible in that

a) respective reference vectors comprising the capacitances between the individual pairs of measuring electrodes are made available as components for a number of fill levels, and
b) a fill level is associated with each of these vectors,
c) a vector containing the individual determined capacitances is determined,
d) a number of reference vectors that are at the smallest, in particular Euclidean, distance from the vector is sought,
e) an interpolation function is formed that, when applied to the reference vectors found in step b), provides the fill levels associated with these reference vectors, and
f) the interpolation function is applied to the vector and the result is used as the fill level.

Several preferred embodiments of the invention will be explained in more detail with reference to the following drawing figures.

Fig. 1 shows a side view of a first embodiment of a dispensing device according to the invention. **Fig. 2** shows a side view of a completely filled container in the form of an ampoule. **Fig. 3** shows a side view of a partially emptied container. **Fig. 4** shows a side view of a completely emptied container. **Fig. 5** shows an alternative embodiment of a container with three pairs of measuring electrodes. **Fig. 6** shows a second embodiment of the invention with one single pair of measuring electrodes. **Fig. 7** shows a further embodiment of the invention with one pair of measuring electrodes arranged to be comb-shaped. **Fig. 8** shows a further embodiment of the invention with three pairs of measuring electrodes arranged to be comb-shaped.

Figs. 9a through 12d show further embodiments of containers with electrodes running obliquely. **Fig. 13** shows an embodiment of a device according to the invention in cross-section B-B. **Fig. 13a** shows a detail Z from **Fig. 1. Fig. 14** and

Fig. 15 show two devices for determining the fill level within the container and for transferring the determined fill level to an external data communication device.

Fig. 16 shows a shield in the form of a film having conductors arranged thereon.

Fig. 17 shows the theoretical course of the individual partial capacitances during the emptying of the container in the embodiment depicted in **Fig. 15**. **Figs. 18 and 19** show the embodiments depicted in **Figs. 14 and 15**, wherein an additional contact detection is provided.

Fig. 20 shows a further embodiment of the invention with a covering cap. **Fig. 21** shows an exterior view of the embodiment depicted in **Fig. 20**. **Fig. 22** shows a further embodiment of a container with obliquely running electrodes corresponding to **Figs. 10a-d**. **Fig. 23** shows detail from **Fig. 20. Figs. 24 and 25** show cross-sections through the embodiment of the invention depicted in **Fig. 20**.

Fig. 26 shows a further embodiment of the invention which omits the shield.

Fig. 1 depicts a side view of a first embodiment of a dispensing device 100 according to the invention. The dispensing device 100 shown comprises a container 1 which is filled with a liquid medicament 12. Insulin is used as the liquid medicament 12 in the present case, but it is also possible to fill the container 1 with other liquid medicaments 12, such as hormone preparations (for example, growth hormones, etc.), biopharmaceuticals, or medicaments used in the course of therapeutic measures in reproductive medicine, and then to administer these in the same way.

The dispensing device 100 has the shape of a pen or ball-point pen and can be easily held in the hand by a patient during administration of the liquid 12 present in the container 1. The container 1 has the form of a cartridge or ampoule and is located in an end portion 102 of the dispensing device 100.

At one end, which is located in this end region 102 of the dispenser 100, the container 1 which is depicted in detail in **Fig. 2**, has an opening 11 for dispensing the liquid 12. At the opposite end, the container 1 has a piston 13 which is slidably mounted in the container 1. For this purpose, the container has an internal volume which, apart from the region of the opening 11, has a constant cross-section. The piston 13 closes off the container 1 from the opening 11 on the opposite side, so that the liquid 12 contained in the container 1 is tightly enclosed in the container 1 and can escape only through the opening 11. In the present embodiment, the inner area of the container 1 and the piston 13 have a circular cross-section and have available a substantially cylindrical inner wall or outer wall. The piston 13 is pushed or advanced into the container 1, so that the liquid 12 contained in the container 1 can escape from the container 1 through the opening 11. When the piston 13 is fed in the direction of the opening 11, the liquid 12 is discharged through the opening 11 of the container 1. Prior to use, however, the opening 11 of the container 1 is closed by means of a sealing element 14, as shown in Fig. 2, so that the liquid 12 cannot escape from the container 1.

Fig. 3 shows the container 1 depicted in **Fig. 2** after a portion of the liquid 12 was applied through the opening 11 via an injection needle 103.

Fig. 4 shows the container 1 depicted in **Fig. 2** after the liquid 12 has been completely emptied out of container 1 through the opening 11 via an injection needle 103.

The piston is in a middle position or in a final position, in the depictions in **Fig. 3** and **Fig. 4**, i.e., the container 1 is partially **(Fig. 3)** or completely **(Fig. 4)** emptied. Air is located in the area 15 behind the piston 13. In the region of the opening 11 of the container 1, the dispensing device 100 further has an injection needle 103 that, on the one hand, penetrates the sealing element 14 and projects into the interior of the container 1, and on the other part, protrudes from the dispensing device 1.

As depicted in **Fig. 1**, the injection needle 103 in this exemplary embodiment is connected with a housing 104 which is screwed onto the dispensing device 100. The dispensing device 100 has an external thread 105 which is shaped to be adapted to a diametrically opposed mating internal thread of the housing 104. When the piston 13 as depicted in **Fig. 3**, is advanced in the direction of the opening 11, the liquid contained inside the container 1 can be administered to the respective patient through the opening 11 and the injection needle 103. The housing of the dispensing apparatus 100 has two viewing ports 108, to visually determine the fill level F of the liquid 12 remaining in the container 1, or to be able to detect any turbidity or foreign bodies of the liquid.

In addition, the dispensing device 100 (**Fig. 1**) a setting unit 106, which can be preset with a certain feed of the piston 13 and – corresponding therewith – a certain amount of liquid 12 to be dispensed. After adjustment of the amount of liquid 12 to be dispensed, a feed element 109 is pressed against the piston 13 of the container 1 by the patient by means of a pressure actuator on an actuating unit 107. The piston 13 is pushed into the container 1 and the liquid 12 in the container 1 is administered to the patient via the injection needle 103. The feed element 109 is secured against a reset opposite to the feed direction V of the piston 13, that is, away from the opening 11, so that the piston 13 can be only moved further in the direction of the opening 11.

Especially advantageous is the use of a container 1 having three pairs of measuring electrodes, as is depicted in **Fig. 5**. As shown in **Fig. 5**, the container 1 has three pairs of measuring electrodes 21–26. All the measuring electrodes 21–26 are arranged in the outer region of the container 1, in the present case on the outer wall of the container 1. In this preferred embodiment of the invention, each two of the associated measuring electrodes 21–26 lie opposite one another in the circumferential direction spaced apart on the outer wall of the container 1. The individual pairs of mutually associated measuring electrodes 21–26 are spaced apart from each other in the feed direction V of the piston 13. The measuring electrodes 25, 26 of the third pair lie furthest away from the opening 11 of the container 1. The measuring electrodes 21, 22 of the first pair lie closest to the opening 11. The measuring electrodes 23, 24 of the second electrode pair – viewed in the feed direction V of the piston 13 – are located between the measuring electrodes 21, 22; 25, 26 of the first and third pairs. The measuring electrodes 21–26 lie flat against the container 1 in an area of the outer wall thereof. In the exemplary embodiment depicted in **Fig. 5**, the measuring electrodes 21–26 exhibit a rectangular shape. The measuring electrodes 21–26 extend over the entire feed range of the piston 13. If a plurality of electrode pairs is used, it may be advantageous if the extension of an electrode pair in the feed direction V of the piston 13 corresponds to the extension of the piston 13 in the feeding direction V thereof.

Alternatively, other electrode shapes such as circular or comb-like electrode shapes can be used for the measuring electrodes 21–26. The use of multiple pairs of measuring electrodes 21–26 is basically advantageous in the sense of accurate measurement of the liquid content or liquid level in the elongated containers 1, but is not required for short or compact containers 1. In an alternative exemplary embodiment of a container 1 depicted in **Fig. 6**, only a single pair of measurement electrodes 21, 22 is provided, these being elongated and formed to extend over the entire feed range. The two measuring electrodes 21, 22 face one another circumferentially with respect to the same height or position with respect to the feed direction V of the piston 13.

Moreover, it is also possible to use different shapes of measuring electrodes 21–26. An advantageous embodiment provides that the measuring electrodes 21–26 are designed as comb electrodes or interdigital electrodes. The measuring electrodes 21–26 are associated in pairs with one another and have a comb structure, wherein the teeth of the mutually associated measuring electrodes 21, 22; 23, 24; 25, 26 interengage with one another. As depicted in **Fig. 7 and Fig. 8**, comb electrodes are used both for an arrangement with one **(Fig. 7)** and with a plurality of pairs of measuring electrodes 21, 22; 23, 24; 25, 26.

Depending on the application, it is also possible to provide differently sized measuring electrodes 21–26 to enable a particularly advantageous determination of the fill level F in the container 1. Particularly advantageous is the use of parallelogram-shaped or triangular measuring electrodes 21–26, in which the electrodes are separated from one another by separation regions 27, which extend in the feed direction V of the piston or along the longitudinal axis of the container 1 at an angle, for example, at an angle of 45°. Such an arrangement results in a smooth transition so that a particularly accurate determination of the fill level F is possible. **Fig. 9a through 12d** show four different embodiments with separation regions 27 between the measuring electrodes 21–26 which are at an angle to the feed direction V. In these embodiments, furthermore, an axis-parallel separation area 28 is provided to separate the mutually assigned respective pairs of measuring electrodes 21, 22; 23, 24; 25, 26 from one another.

With all such electrode arrangements, it is possible to close off at the fill level F of the container 1 due to the capacitance between the measuring electrodes 21–26. To enable a most precise possible measurement of the individual capacitances C_1, C_2, C_3, and thus to be able to draw a conclusion as to the fill level F of the container 1, the invention provides for a dispensing device to have an electrical shield 3 for electric fields outside the measuring electrodes 21–26 which is arranged jacket-like around the container 1. **Fig. 13** depicts a cross-section through the container 1 that shows the shield 3, the measuring electrodes 21, 22, the wall of the container, and the liquid 12 inside the container 1. The shield 3 acts to ensure that the capacitance measured between the electrodes 21, 22 is not distorted, or only so to a negligible extent, when a person contacts or comes close to the dispensing device 100, thereby changing the prevailing electrical field conditions on the measuring electrodes 21, 22. In a first embodiment of the invention, the shield 3 is formed as a film of electrically conductive material, for example, as copper film having a thickness of 50 µm, which is wrapped around the container 1 and measuring electrodes 21, 22 like a jacket. The measuring electrodes 21, 22 and the shield 3 are separated from one another and are not connected with one another in an electrically conductive manner. The shield 3 is used for suppressing the influence of external influences such as changes in the permittivity and electrical fields in the immediate outer region of the measuring electrodes 21, 22. The shield 3 surrounds both the measuring electrodes 21, 22 as well as the container 1, and is advantageously not located between the measuring electrodes and the container 1. In particular, it is advantageous for the shield 3 to have a radial separation from the electrodes. Furthermore, it is not necessary to embody the shielding 3 as a full-surface electrically conductive film, but it is also possible to implement the shielding 3 in the form of a non-electrically conducting support material, e.g., a non-electrically conductive film arranged with individual conductive paths.

Fig. 13a shows a close-up from **Fig. 1** along the section B-B from **Fig. 13**. Clearly visible – even though not correctly to scale – is the arrangement of the wall of the container 1 with respect to the electrodes 21, 23, 25, and the shield 3. The individual conductors 32–34 on the film 3 are shown in cross-section. Outside the shield 3 is the housing of the dispensing device 100.

Alternatively, it is also possible for the shield 3 to be arranged just outside the outer wall of the dispensing device 100 and/or outside of a support 31 at least partly surrounding the container 1. At the same time, the support 31 in this case serves for the radial separation between the shield 3 and the measuring electrodes 21, 22.

For determining the instantaneous fill level F of the liquid 12 in the container 1, the capacitance present between the measuring electrodes 21, 22 is first determined. In **Fig. 14** depicts a measuring arrangement for determining the capacitance of a single pair of measurement electrodes 21, 22. **Fig. 15** shows a measuring arrangement with the use of a plurality of pairs of measuring electrodes 21–26. In **Fig. 14 and 15**, a respective computing unit 6 is provided in the form of a microcontroller upstream from the one or three capacitance measuring devices 41, 42, and 43. Each pair of sensor electrodes 21–26 is respectively associated with one of the capacitance measuring devices 41, 42, 43 shown in **Fig. 15**. The measuring electrodes 21–26 are respectively connected to the connectors of the capacitance measuring devices 41, 42, 43. The output of the capacitance measuring devices 41, 42, 43 is one of the respective proportional measured capacitance values C_1, C_2, C_3 corresponding to the respective capacitance for the electrode pair, which is transmitted to the computing unit 6. The computing unit 6 uses the individual transmitted capacitance measurement values C_1, C_2, C_3 to determine a value for the liquid fill level F using a calibration operation to be described later. The computing unit 6 keeps this value available in its output. Upon request, in particular via an antenna 62 (not shown) downstream from the computing unit 6, this value can be transmitted to an external data communication device.

Of course, the number of pairs of the measuring electrodes 21–26 used can be adapted to the requirements for the measurement accuracy. In particular, it is also possible to use a single pair of measurement electrodes 21, 22, and to use only the value C_1 determined between these measuring electrodes 21, 22 for determining the fill level F. **(Fig. 15).**

Downstream from the computing unit 6 is a communications controller 61, which is connected to an antenna 62. The communication controller 61 enables the transmission of the determined fill level F to an external data communication device. Obviously, as an alternative to the wireless transmission of data relating to the fill level to an external data communication device, a hard-wired transmission according to the prior art is possible, e.g., such as a USB. In addition it can also be provided that the external data communication device can also transmit electrical energy via the antenna 62 to the communication controller 61, the computing unit 6, and the capacitance measuring devices 41–43, so that the entire circuit depicted in **Fig. 14 or Fig. 15** requires no separate power supply.

Hereinafter, the specific determination of the fill level F of the liquid 12 in the container 1 is depicted in more detail using the determined capacitance values C_1, C_2, C_3. **Fig. 17** depicts the respective dependence of the fill level F on the individual capacitance values C_1, C_2, C_3, in the embodiment of a container 1 according to the invention as depicted schematically in **Fig. 5**. At the beginning of the process of emptying the container 1, the liquid 12 is at first located exclusively between the measuring electrodes 21–26. In the course of the emptying, the piston 13 first passes into the intermediate region between the measuring electrodes

21, 22 of the first measuring electrode pair, so that the because of the lower permittivity of the piston 13 compared to the liquid 12, a continuous drop in the measured capacitance value C_1 is observed in the first measuring electrode pair. After the piston 13 has been pushed through the intermediate region between the measuring electrodes 21, 22 of the first measuring electrode pair, air 15 is present between the two measuring electrodes 21, 22 of the first measuring electrode pair. Due to the even lower permittivity of the air between the two measuring electrodes 21, 22 of the first measuring electrode pair, the measured capacitance value C_1 measured between these measuring electrodes 21, 22 falls even further. A similar behaviour is also observed for the measured capacitance values C_2, C_3 between the measuring electrodes 23–26 of the second and third measurement electrode pairs during emptying of the container 1.

In a particular embodiment of the invention, the total sum C_{sum} of the individual capacitance values C_1, C_2, C_3 can be used to determine the fill level F. By determining a calibration curve, a number of different fill levels can be used for determining the associated sum C_{sum} of the respective individual measured capacitance values C_1, C_2, C_3, wherein a sum C_{sum} is assigned to each fill level F. The thus created individual data records each comprising a measured capacitance value C_{sum} and a fill level F are stored in a calibration memory in the computing unit 6. Alternatively, it is also possible for the individual data records each comprising a measured capacitance value C_{sum} and a fill level F to be kept available outside the dispensing device, for example, in an external data communications device, for later determination of the fill level.

After the measurement and determination of the individual capacitance values C_1, C_2, C_3, the sum thereof C_{sum} is determined and compared with the individual C_{sum} values stored in the calibration memory. One electrode pair is selected for which the associated sum C_{sum} best matches the sum determined for the measured capacitance values C_1, C_2, C_3. With the best matching sum C_{sum} for the respectively assigned fill level that is taken as the fill level F for the container 1, the computing unit 6 keeps this fill level F available in its output, and outputs the fill level F upon request via an antenna 62, or independently without such a request, to an external data communications device as described above.

It becomes apparent in practice that, apparently due to complex capacitive coupling phenomena, the curves for the measured capacitances C_1, C_2, C_3 for the measuring electrodes 21–26 exhibit strong deviations from one another as a function of the fill level F, and also deviate significantly from the theoretically expected curves shown in **Fig. 17**. However, the measurable curves are highly reproducible and show different slopes in different curve sections and fill level regions for each capacitance C_1, C_2, C_3, wherein, contrary to theoretical expectations, the greatest steepness of the curve and the largest change in capacitance does not necessarily occur between those measuring electrodes 21–26 between which the liquid fill level happens to be located. Since a larger curve slope means better measurement resolution/accuracy, a weighted sum can alternatively be used to form a simple sum of the three individual measured capacitance values for the calculation of the fill level, wherein a distinct weight is determined separately for each of the three terms in each curve section separately during the calibration.

A calibration is performed to achieve a conversion between individual capacitances C_1, C_2, C_3 and a fill level F, in which the container 1 is filled with the medicament, or a structurally identical reference container is emptied. The respective fill level F as well as the individual capacitances C_1, C_2, C_3 are determined during the emptying. Thus, individual capacitance values C_1, C_2, C_3 are available each of the fill levels F obtained during the emptying. In the present exemplary embodiment, 30 equidistant fill levels F are obtained during the emptying, wherein the initial state is indicated by a 1 and the completely emptied state is indicated by a 0. The capacitance values of C_1, C_2, C_3 are each stored in a reference vector V_{ref}, which is assigned to the respective fill level F as well as to the respective weights a, b, c. Thus, a reference vector V_{ref} is available for each fill level F. The weights are determined through optimisation in such a way that the weighted sum of $a.C_1 + b.C_2 + c.C_3$ represents a linear approximation for the fill level F.

If one wishes to determine the actual fill level F based on capacitance values C_1, C_2, C_3 determined by measurement, this can be carried out using the weights determined during calibration, wherein for each measurement there are as many weights available as capacitance values C_1, C_2, C_3 which were determined. First, a vector V_{mess} [C_1, C_2, C_3] is created based on the determined or measured capacitance values C_1, C_2, C_3 which has the capacitance values C_1, C_2, C_3 as components. Subsequently, the vector V_{mess} is compared with the determined reference vectors V_{ref} and the one reference vector having the shortest distance from the vector V_{mess} is sought. In the present exemplary embodiment, the Euclidean distance is used as the distance dimension. Subsequently, those reference vectors V_{ref} are determined which have the respective next shortest distance from the vector V_{mess}. It is an interpolating function, for example, a linear interpolation function, which, when applied to the reference vectors V_{ref} determined by calibration, returns the respective fill level F assigned thereto. The capacitance values C_1, C_2, C_3 are used in the interpolation function and one obtains an averaged fill level value.

For reasons of space, the antenna 62 can advantageously be arranged outside on the shield 3. To ensure an advantageous combination, the shield 3 has a film 31 made of an electrically and magnetically non-conductive material, such as plastic. Conductors 32–34 are applied to the film 31, depicted in **Fig. 16**, in the form of conductive paths. If the conductors 32–34 are formed on the film 31 such that no large area closed conductor loops exist in which eddy currents can form, the magnetic fields output from the external data communication device will not be significantly affected by the shield 3 and can be received by the antenna 62. Furthermore, it is also possible thereby to transfer energy to the antenna 62 in the form of electromagnetic waves, which is sufficient to supply components connected to the antenna electrical with sufficient energy.

If additional precision in the determination of the fill level F is required in the interior of the container 1, it can be provided that a measured value for the fill level F is invalidated or is declared void if the electric field in the outer region of the container 1 is distorted, for example, through contact with or proximity to the electrically conductive body or bodies having a high dielectric permittivity.

The shield 3 has an electrically and magnetically non-conductive film 31 on which a plurality of conductors 32, 33, 34 are formed by coating. The film 31 in the present embodiment is composed of flexible plastic. The conductive paths have a layer thickness of about 50 μm and a width of about 1000 μm. The conductors 32–34 advantageously have widths of 100 μm between and 3000 μm.

To avoid the formation of eddy currents and thus an impairment of inductively coupled contact communication, in particular NFC communication, the width of the conductors 32–34 can be limited to less than 3 mm. In addition, the conductors 32–34, as depicted in **Fig. 16**, can be formed to be loop-free, i.e., free of closed conductive loops, i.e., that do not comprise closed loops, to prevent the formation of eddy currents to a sufficient degree and to avoid an impairment of an NFC communication, while at the same time to avoid capacitive effects on the measuring electrodes 21–26 located inside the shield 3.

In this particular exemplary embodiment of the invention, therefore, two of the three conductors 32, 33 are formed as interengaging comb conductors 32, 33, the third conductor 34 meandering between the two comb conductors 32, 33. In addition to this exemplary embodiment, there are of course a variety of other exemplary embodiments of the loop-free arrangement of a plurality of conductive paths or electrodes which are not electrically connected with one another and are on the surface of a film 31 or inside or between the individual layers of a film with a multilayer construction. Also, both front and back of the film 31 can be printed with conductors 32–34. Alternatively, several meandering conductors 34 can be arranged to be adjacent to one another between the comb conductors 32, 33, or several conductors 34 can be spirally arranged on the film 31.

Two conductive paths, namely one of the two comb conductors 33 and the meandering conductor 34 are used as a contact sensor 5. The second comb conductor 32 is set to a predetermined earth potential and serves as an electrical shield. If a person contacts the shield 3 or the person comes into proximity with the shield 3, the capacitance between the conductors 33, 34 of the contact sensor 5 changes due to the change in the permittivity of the environment. The change in this capacitance between the conductors 33, 34 can be determined by means of a further capacitance measuring device 44, the conductors 33, 34 of the shield 3 and the contact sensor 5 being connected to the measurement connections of the further capacitance measuring device 44. This additional capacitance measuring device 44 determines a further capacitance value C' and passes this on to the computing unit **6**, as depicted in **Fig. 18 or Fig. 19**. If the change in the further measured capacitance value C' that has been determined exceeds a given threshold T, it is presumed that the determined fill level F based on the measured capacitance values C_1, C_2, C_3 is in error due to the contact. The determine fill level F is invalidated.

In the present exemplary embodiment of the invention, a shield 3 which is used also functions as a contact-sensitive detection 5 and consists of the comb conductor 32 and the meandering conductor 34. From a physical and functional standpoint, however, electrical shielding 3 and contact detection 5 can be realised as two completely separate and distinct units, which is particularly advantageous through the concrete arrangement depicted in **Fig. 16**, namely, which can be produced in a plane by printing. This functional separation of electrical shielding 3 and contact detection 5 is of course readily possible. Only for ease of depiction, the conductors 32, 33, 34 lying in the plane of the film 31 are depicted in **Figs. 14, 15, 18, 19** side by side with the shield 3 or the contact detection 5.

An alternative embodiment of the invention enables the removal of the container 1 from the dispensing device 100 through an exchange. A support (not shown) is arranged outside the container 1 between the container 1 and the shield 3. On this is located measuring electrodes 21–26. The support bears against the container 1 and is advantageously formed by a part of the housing of the dispensing device 100. The measuring electrodes 21–26 are arranged on the wall of the support bearing against container 1. The housing of the dispensing device 100 can be opened and the container 1 can be removed from the housing of the dispensing apparatus 100. The support forms a part of the dispensing apparatus 100.

Advantageously, the communication controller 61, the computing unit 6, the capacitance measuring devices 41–44, and the antenna 62 can be arranged on the film 31.

A further preferred embodiment of the invention, which is depicted in **Fig. 20**, shows a dispensing device with a covering cap 9. This embodiment corresponds essentially to the embodiment depicted previously, wherein only the differences from the foregoing embodiment will be shown in more detail in the following.

The covering cap 9 is detachably connected to the support body 200 of the dispensing device by means of one or more fixing elements 109. The covering cap 9 surrounds the container 1 and the measuring electrodes 21–26 arranged the container 1 in a jacket-like manner. Unlike the previous embodiment, the shield 3 and the contact sensor 5 are arranged in the body of the covering cap 9. Provided that the covering cap 9 is placed on the support body 200, the measuring electrodes 21–26 are shielded by the shield 3. In the present embodiment, the shield 3 is cast in the body of the covering cap 9, and is enclosed on all sides by the latter. As also in the present embodiment, the shield 3 is arranged on a film which is surrounded on all sides or enclosed by the covering cap 9. In the present case, the shield 3 surrounds the measuring electrodes 21–26 in the end region of the covering cap 9 which faces the injection needle 103. It is alternatively also possible that the film and/or the shield 3 is arranged on the outside of the covering cap 9.

In this end region, the covering cap 9 has a recess 99 as a through-hole for the injection needle 103. Alternatively, it is also possible that the injection needle 103 is completely surrounded by the housing of the covering cap 9.

In a second alternative, the covering cap 9 is in the form of a sleeve which is open at the end of the injection needle 103. Thus, an injection or administration of the liquid is even possible with a fitted covering cap. Overall, it is therefore not necessary that the covering cap covers the injection needle 103 or the container 1 from all sides.

In order to enable a view of the viewing ports 108 in the support body 200 of the dispensing device, the covering cap 9 has respective further viewing ports 98 at positions upstream from the viewing ports.

Fig. 21 shows the dispensing device 100 from the outside. Also seen in this depiction is a display unit 90 which is connected to the computing unit 6 (**Figs. 23, 25**) and is controlled thereby. The connection lines of the display unit 90 extend in the interior of the covering cap 9 outside the shield 3.

Figs. 22a-d show one possible embodiment of the electrodes 21–26. The individual measuring electrodes 21–26 are guided via electrically conductive connections with connection contacts 211, 221, 231, 241, 251, 261. Like the measuring electrodes 21–26 and the terminals 211, 221, 231, 241, 251, 261, these connections are advantageously arranged as conductor layers on the inside or outside of container 1.

In principle, it is possible here to use all of electrode types depicted in **Fig. 9a through 12d**, wherein the respective measuring electrodes 21–26 are each guided via a line which is associated with the electrode 21–26 and extends in the outer region of the container 1 to the container-side connection contacts 211, 221, 231, 241, 251, 261. Provided that only two measurement electrodes are used, as depicted in **Fig. 9a-d**, only two connection contacts 211, 221 are present.

Fig. 23 shows a cross-sectional view along the section B-B from **Fig. 20**. The support body 200 of the dispensing device 100 has a respective through-connection 212, 222, 232, 242, 252, 262, for each of the connection contacts 211, 221, 231, 241, 251, 261, which is guided on the outer surface of the support body 200 and is arranged to be tappable and electrically contactable from the outside.

As can be seen from **Fig. 25**, the covering cap 9 has, at the open end region thereof which faces the support body 200, a number of connection contacts 91, 92, 93, 94, 95, 96, which are electrically conductively connectable via the through-contacts 212, 222, 232, 242, 252, 262. To avoid confusion, the fixing elements 109 can be formed such that a locking is possible only in a single position, wherein each of the through-contacts 212, 222, 232, 242, 252, 262 respectively contacts one of the connection contacts 91, 92, 93, 94, 95, 96 of the cover cap 9. All the terminals 211, 221, 231, 241, 251, 261 and through-contacts 212, 222, 232, 242, 252, 262, and connection contacts 91, 92, 93, 94, 95, 96 of the covering cap 9 are formed from electrically conductive material, particularly from copper. Each of the connection contacts 91, 92, 93, 94, 95, 96 is connected to one connection of a capacitance measuring unit 41, 42, 43, so that the respective capacitance measurement unit 41, 42, 43, determines the respective capacitance between each pair of oppositely arranged measuring electrodes 21, 22; 23, 24; 25, 26. The capacitance measuring units 41, 42, 43 are connected to the computing unit 6.

The antenna 62 depicted in **Fig. 23** is arranged outside the shield 3 on or in the covering cap 9. In the present embodiment, the antenna 62 as well as the shield 3 are cast with the covering cap 9 and are completely surrounded by the body of the covering cap 9. The antenna 9 is preferably arranged on a film which is arranged on the outside of the film of the shield 3, wherein both films are completely surrounded by the body of the cover cap.

The antenna 62 is connected to a communication controller, which is connected to the computing unit 6. Two of the three conductors 32, 33, 34 of the shield 3 are electrically conductively connected with the further capacitance measuring device 44, which is connected to the computing unit 6.

The capacitance measuring devices 41, 42, 43, the further capacitance measuring device 44, the communication controller 61, and optionally still a further battery (not shown in the figures) are integrated into a common housing 60 which is arranged in the interior of the covering cap 9, preferably cast therewith.

Fig. 24 shows a section CC normal to the feed direction in the end region of the container 1. Here it can be seen that the shield 3 arranged in the covering cap 9 surrounds the measuring electrode 21–26. Reference is also made to the description of **Fig. 13**.

Fig. 26 shows a further embodiment of the invention which, however, omits a shield 3. Nevertheless, to ensure an accurate measurement, an enlarged covering cap 9 is provided which limits access to the measuring electrodes 21–26 to less than 10 mm. In this embodiment, in the absence of a shield, no extra capacitance measuring device is provided.

Patentkrav

1. Udleveringsapparat (100) til udlevering af væsker (12), især af flydende medikamenter til personer, med et niveaumålesystem med en genanvendelig tildækningskappen omfattende

- en med væsken (12) fyldt beholder (1), som ved en ende har en åbning (11) til udleveringen af væsken (12),
- i det mindste et par kapacitive måleelektroder (21, 22), som er anbragt over for hinanden i beholderens (1) ydre område, især liggende an imod væggen, og som er indrettet til bestemmelse af væskens (12) niveau (F) i beholderen (1),
- en elektrisk afskærmning (3), som omgiver måleelektroderne (21, 22) og beholderen (1) på kappeformet måde, og som består af lederbaner (32, 33, 34), som er anbragt på en folie (31),
- en på folien (31) anbragt kommunikationsstyreindretning (61),
- i det mindste en på folien (31) anbragt kapacitetsmåleindretning (41) til konstatering af kapaciteten imellem måleelektroderne (21, 22),
- en på folien (31) anbragt regneenhed (6),
- en antenne (62) til overføring af måleværdier eller heraf afledte værdier, især niveauværdier (F), som er konstateret med måleelektroderne (21, 22),
- en ved hjælp af en udløselig forbindelse på udleveringsapparatet (100) koblet tildækningskappe (9), som omgiver måleelektroderne (21, 22) og beholderen (1) på kappeformet måde, **kendetegnet ved,** at den elektriske afskærmning (3), kapacitetsmåleindretningen (41), regneenheden (6) og antennen (62) er integreret i tildækningskappen (9), hvorved afskærmningen (3) omgiver måleelektroderne (21, 22) og beholderen (1) på kappeformet måde,

hvorved afskærmningen (3) er realiseret i form af enkelte lederbaner, som er anbragt på en ikke elektrisk ledende folie,
og at afdækningskappen (9) omfatter et antal elektriske kontakter, som hver for sig er forbundet elektrisk ledende med en af måleelektroderne (21, 22).

2. Udleveringsapparat ifølge krav 1, **kendetegnet ved,** at lederen (32, 33, 34) er tildannet sløjfefri og/eller fri for lukkede ledersløjfer og/eller at lederen (32, 33, 34) har en tykkelse på højst 3 mm, især på imellem 50 µm og 150 µm.

3. Udleveringsapparat ifølge et af de foregående krav, **kendetegnet ved,** at der på folien (31) er tildannet tre separate ledere (32, 33, 34), hvorved den første og den anden leder (32, 33) er tildannet som ind i hinanden gribende kamledere, og den tredje leder (34) ligger meanderformet tildannet imellem de to kamledere (32, 33).

4. Udleveringsapparat ifølge et af de foregående krav, **kendetegnet ved,** at de to over for hinanden beliggende måleelektroder (21, 22) er tilsluttet en kapacitetsmåleindretning (41), og at fortrinsvis den af kapacitetsmåleindretningen (41) konstaterede kapacitetsværdi (C_1) tilføres en regneenhed (26), som på basis af den konstaterede kapacitetsværdi (C_1) bestemmer væskens (12) niveau (F) i beholderen (1) ved hjælp af en på forhånd givet gemt kalibreringsfunktion og holder den til rådighed ved sin udgang.

5. Udleveringsapparat ifølge krav 4, **kendetegnet ved,** at en af de tre ledere (32, 33, 34), især den som kamleder tildannede anden leder (33), er forbundet med kapacitetsmåleindretningens (41) måletilslutning.

6. Udleveringsapparat ifølge et af de foregående krav, **kendetegnet ved** en uden for eller inden for området af afskærmningen (3) anbragt, især kapacitiv, berøringsføler (5), hvorved fortrinsvis berøringsføleren (5) omfatter afskærmningens (3) første kamleder (32), og den meanderformede leder (34) som føleelektroder.

7. Udleveringsapparat ifølge krav 6, **kendetegnet ved,** at berøringsfølerens (5) følerelektroder er tilsluttet en yderligere kapacitetsmåleindretning (44), og at fortrinsvis den af den yderligere kapacitetsmåleindretning (44) konstaterede yderligere kapacitetsværdi (C’) tilføres regneenheden (6), og regneenheden (6) i det

tilfælde at den konstaterede yderligere kapacitetsværdi (C') overstiger en på forhånd givet tærskelværdi (T) undertrykker videreføringen af det af denne konstaterede niveau (F) eller kendetegner det som ugyldigt.

8. Udleveringsapparat ifølge et af de foregående krav, **kendetegnet ved,** at der på beholderen (1) er anbragt et antal af par af yderligere målelektroder (23, 24; 25, 26), hvorved der især på hvert par af yderligere måleelektroder (23, 24; 25, 26) er tilvejebragt en respektiv yderligere efterindkoblet kapacitetsmåleindretning (42, 43) efter parret af yderligere måleelektroder (23, 24; 25, 26), og som udleverer den konstaterede kapacitetsværdi (C_2, C_3) til regneenheden (6).

9. Udleveringsapparat ifølge et af de foregående krav, **kendetegnet ved,** at de hver for sig efter hinanden parvist anbragte måleelektroder (21, 22; 23, 24; 25, 26) ligger indbyrdes i samme højde i beholderens (1) periferiretning, især diametralt over for hinanden og især i retning af stemplets (13) fremføring.

10. Udleveringsapparat ifølge et af de foregående krav, **kendetegnet ved,** at tildækningskappen (9) inden for området af beholderens (1) åbning (11) har en gennemgående fordybning (99) til udlevering af væsken igennem tildækningskappen (9).

11. Udleveringsapparat ifølge et af de foregående krav, **kendetegnet ved,** at tildækningskappen (9) indeholder et batteri, som er tilsluttet kapacitetsmåleindretningen (41, 42, 43), den yderligere kapacitetsmåleindretning (44), regneenheden (6) og kommunikationsstyreindretningen (61) og forsyner disse med elektrisk energi, og
at batteriet, kapacitetsmåleindretningen (41, 42, 43) og kommunikationsstyreindretningen (61) er integreret i et fælles hus (60).

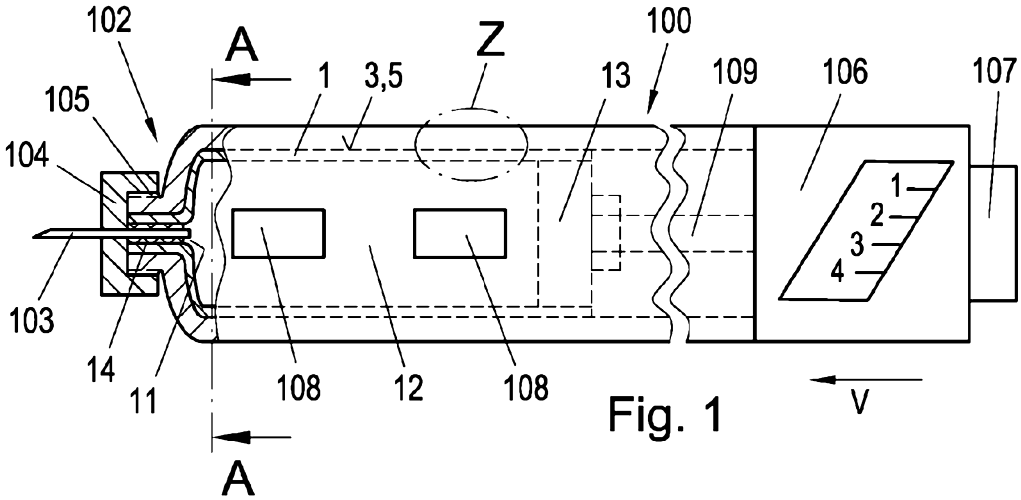

Fig. 1

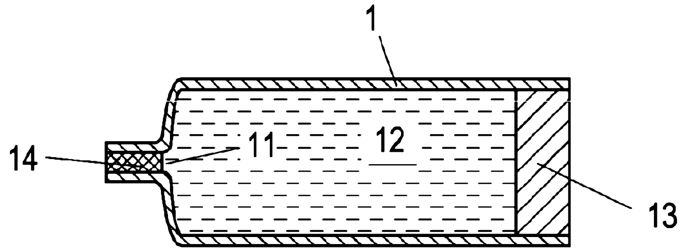

Fig. 2

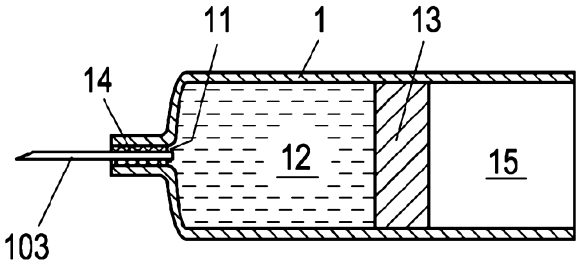

Fig. 3

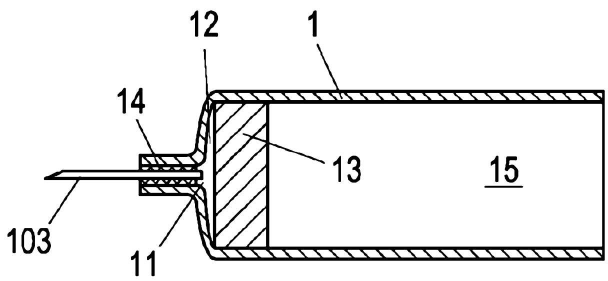

Fig. 4

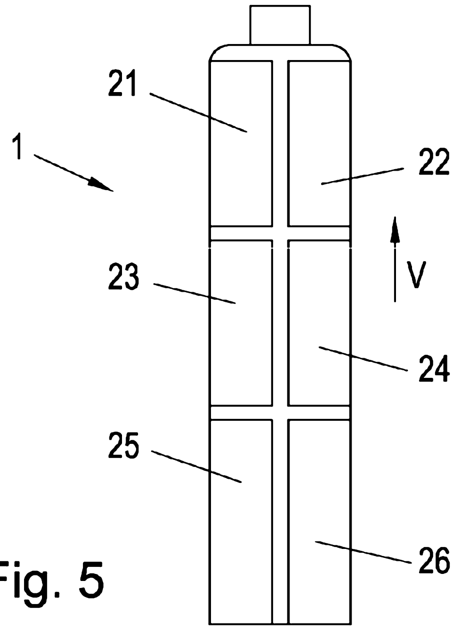

Fig. 5

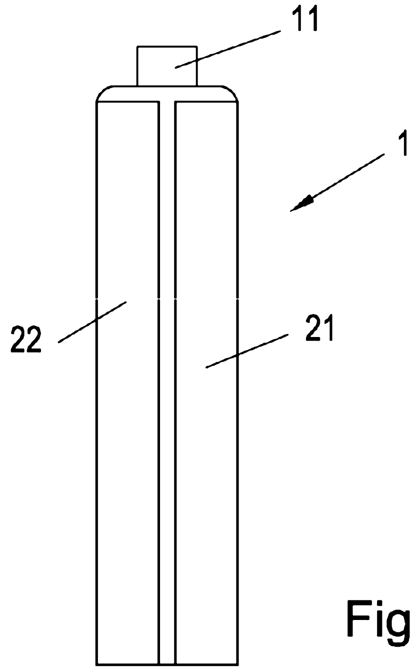

Fig. 6

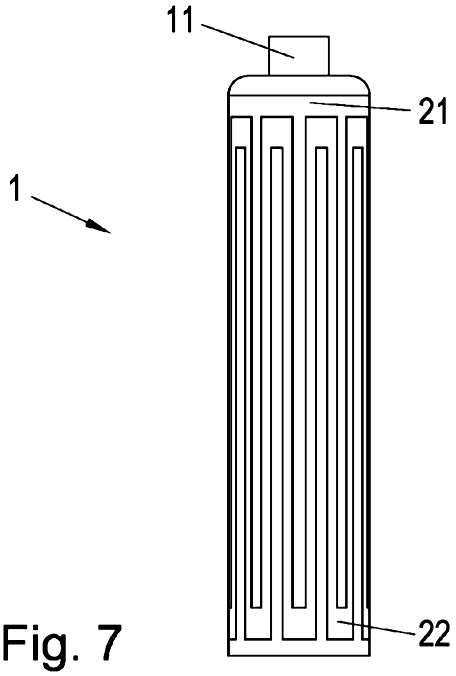

Fig. 7

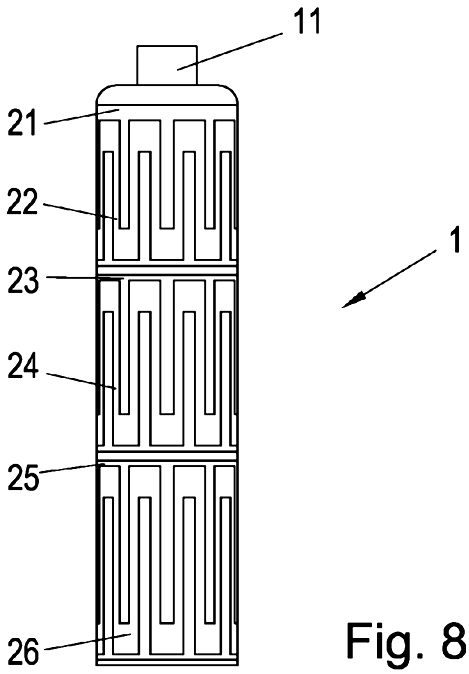

Fig. 8

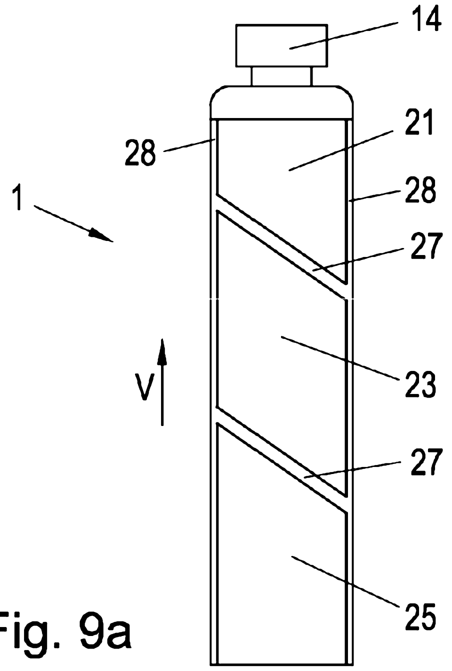

Fig. 9a

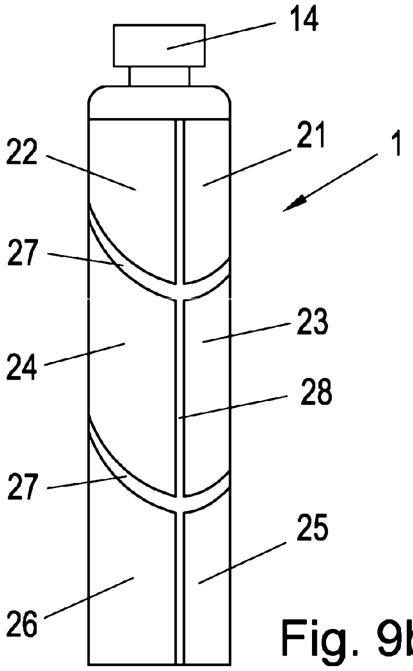

Fig. 9b

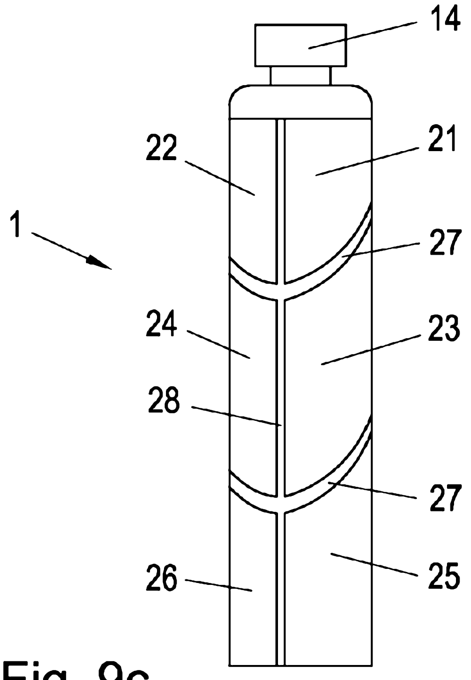

Fig. 9c

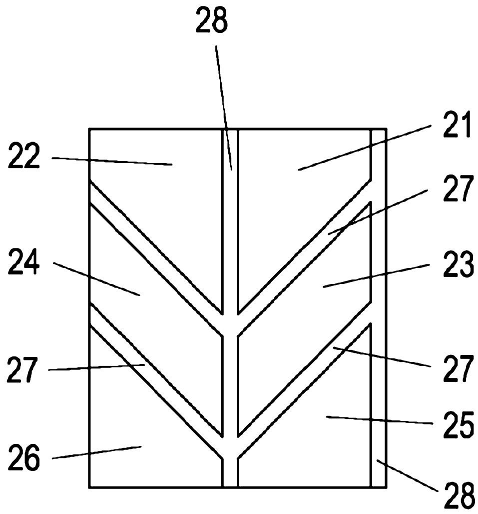

Fig. 9d

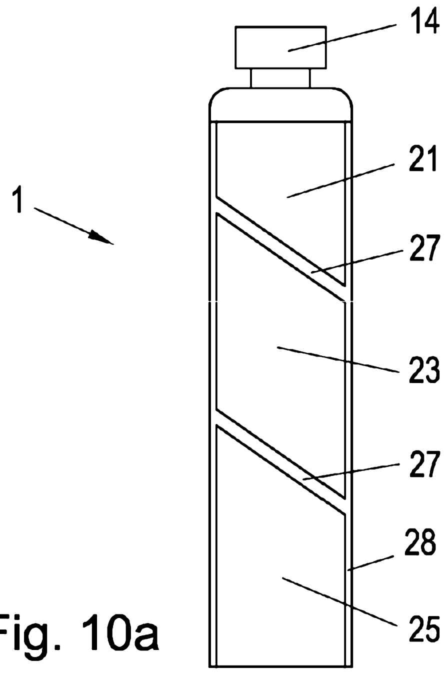

Fig. 10a

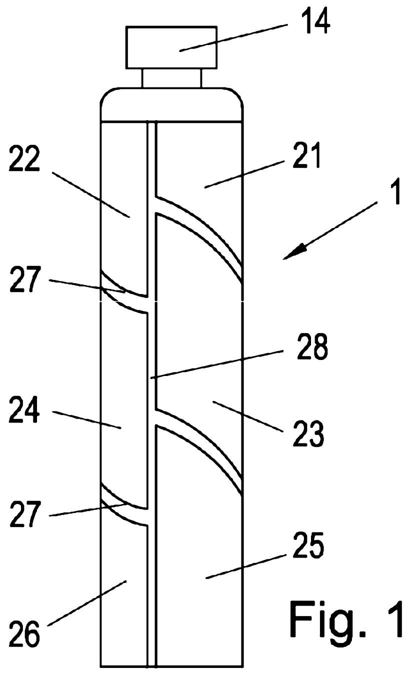

Fig. 10b

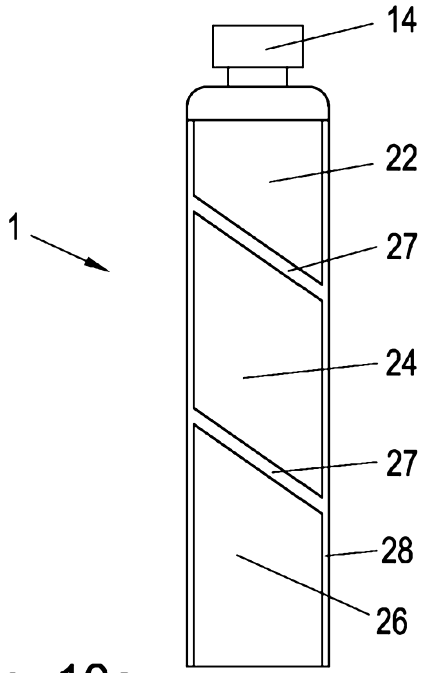

Fig. 10c

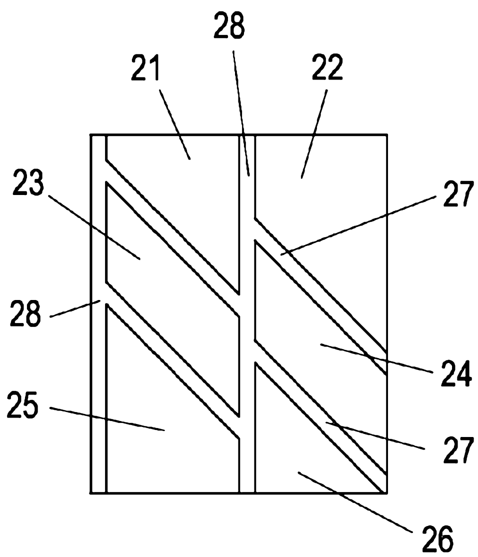

Fig. 10d

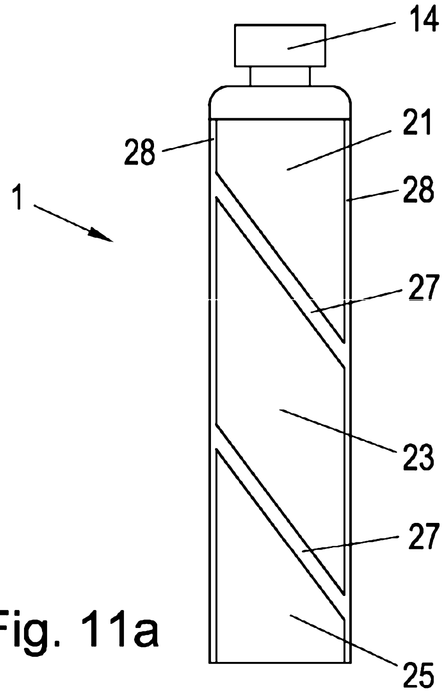

Fig. 11a

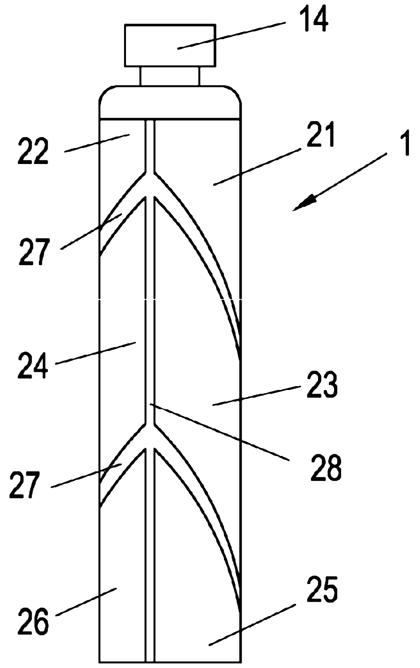

Fig. 11b

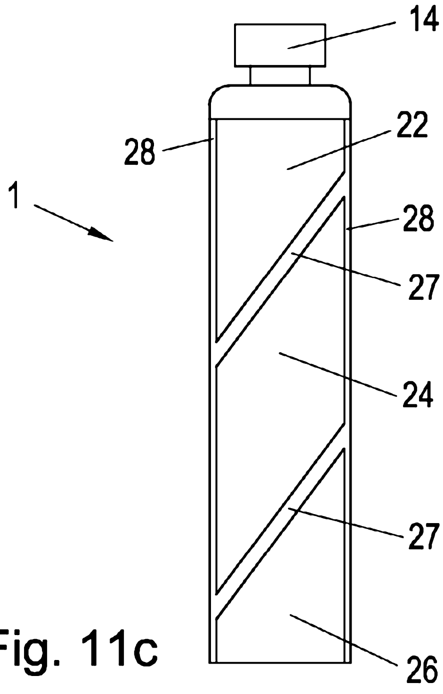

Fig. 11c

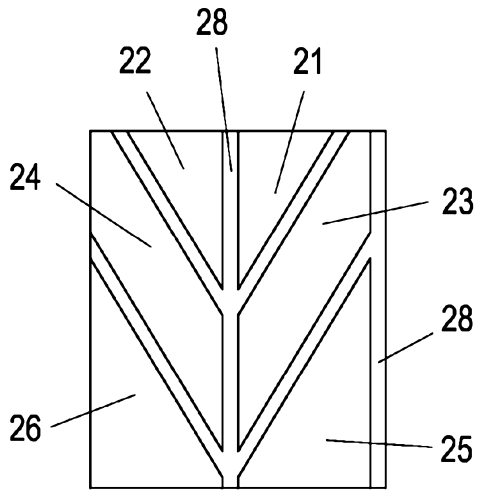

Fig. 11d

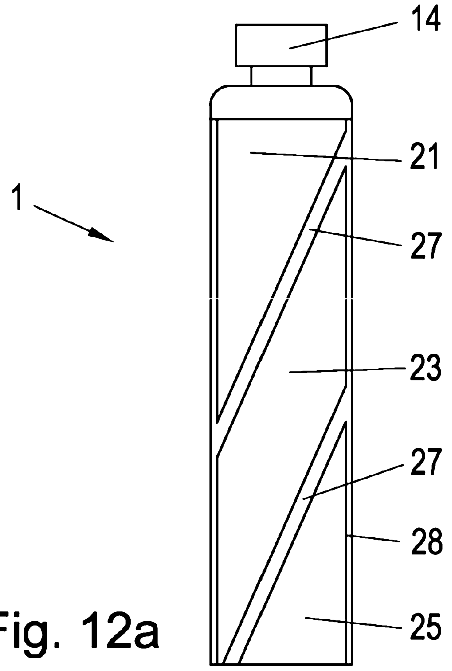

Fig. 12a

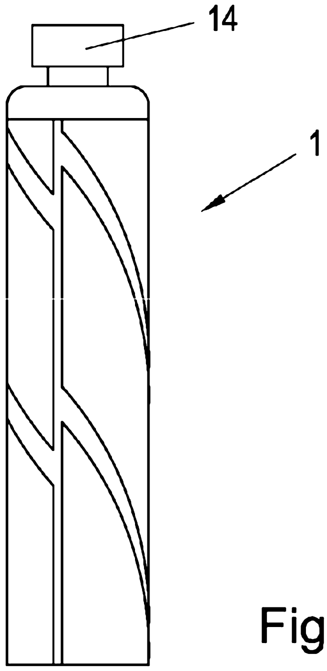

Fig. 12b

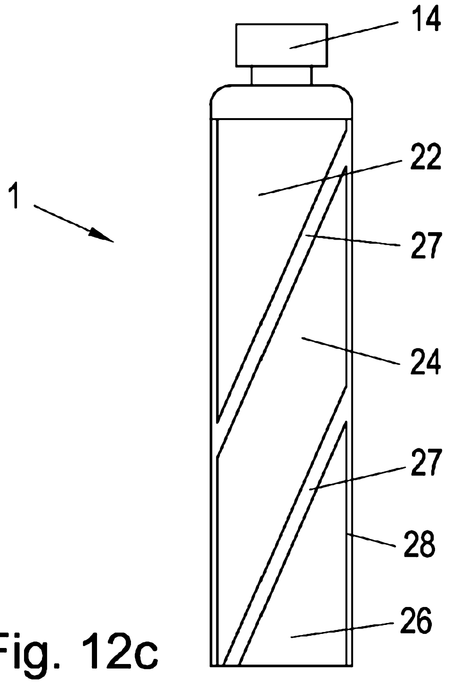

Fig. 12c

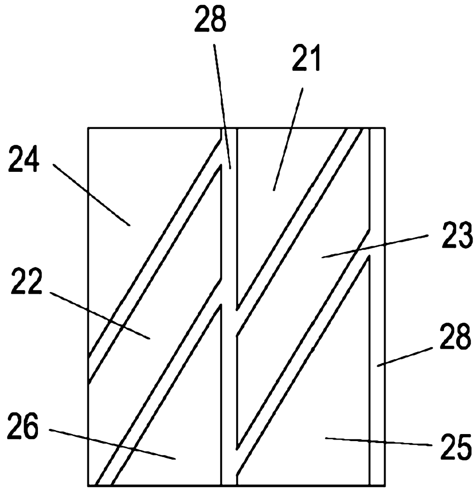

Fig. 12d

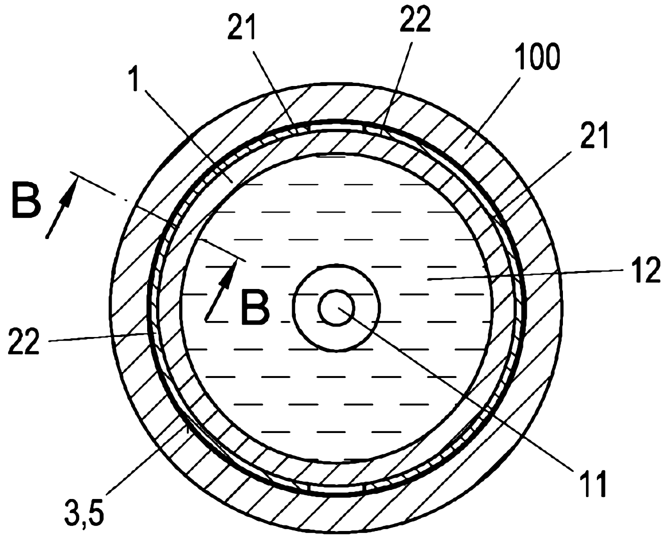

Fig. 13

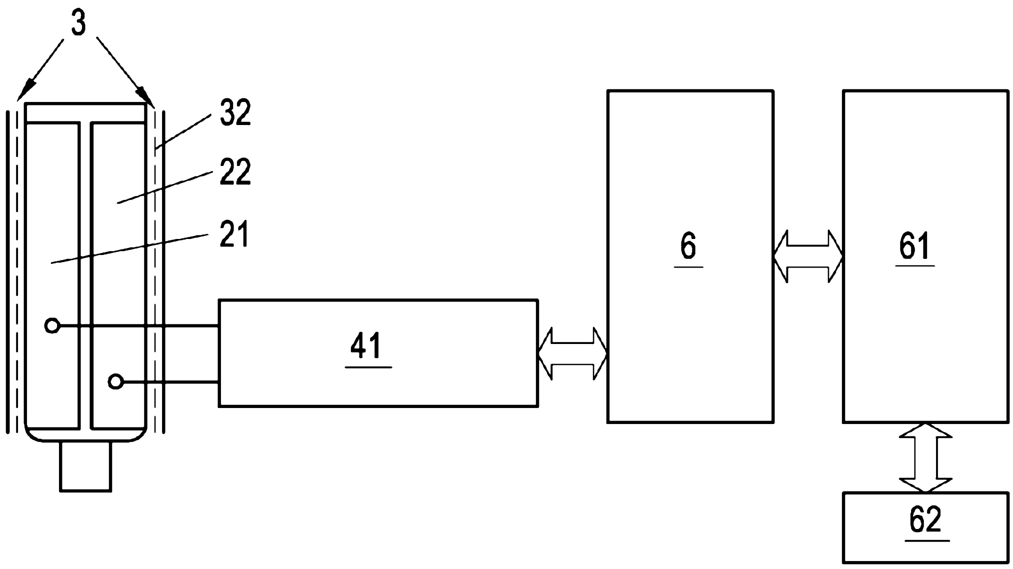

Fig. 14

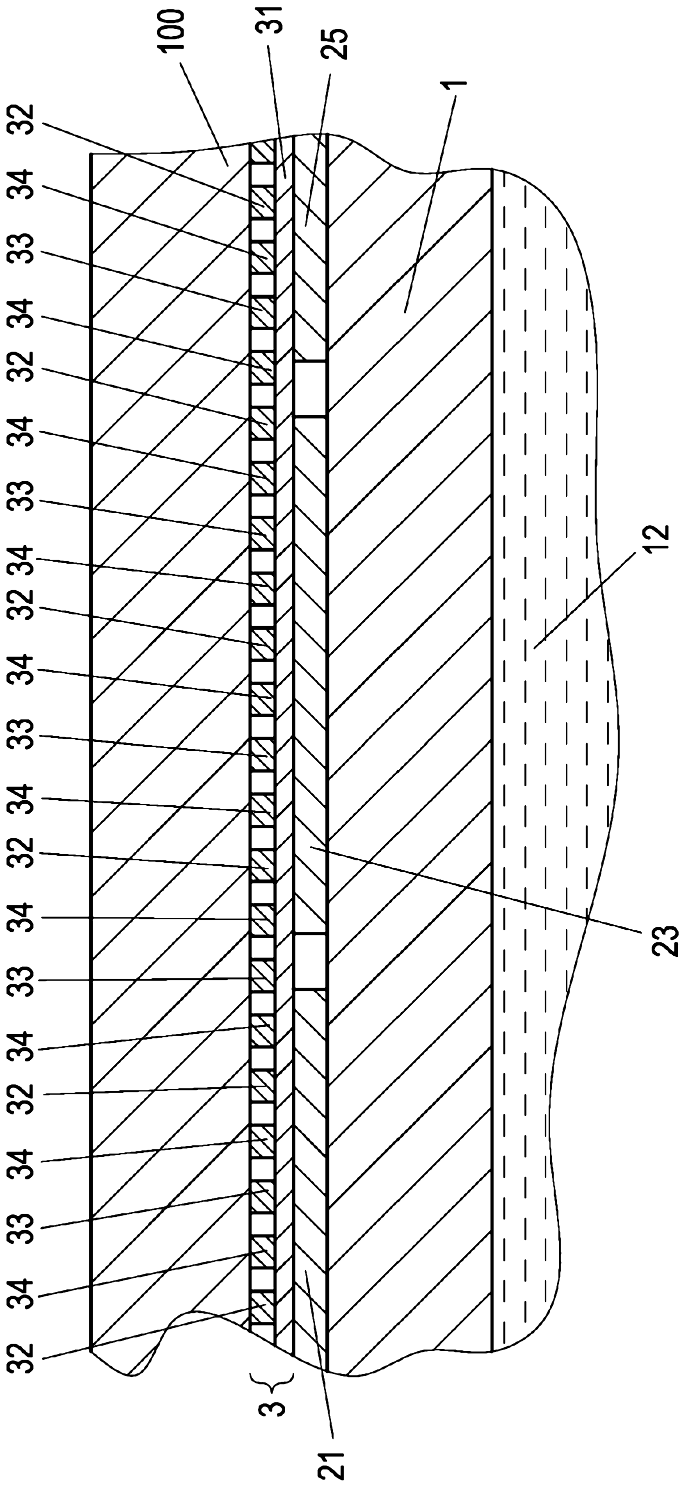
32
34
33
34
32
34
33
34
32
34
33
34
32
34
33
34
32
34
33
34
32
100
31
25
1
12
23
3
21

Fig. 13a

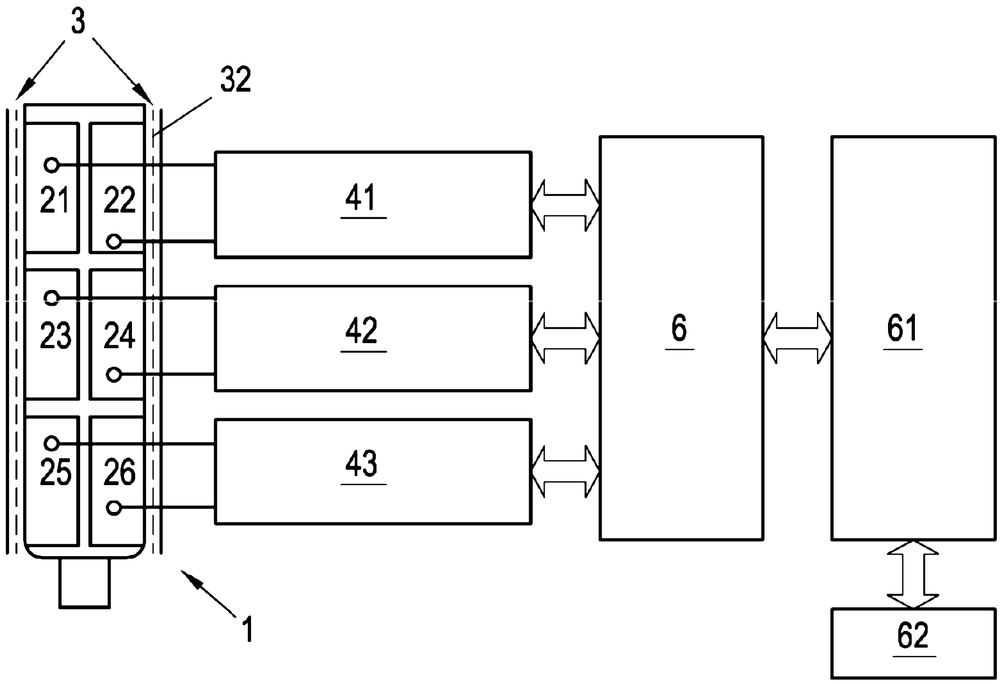

Fig. 15

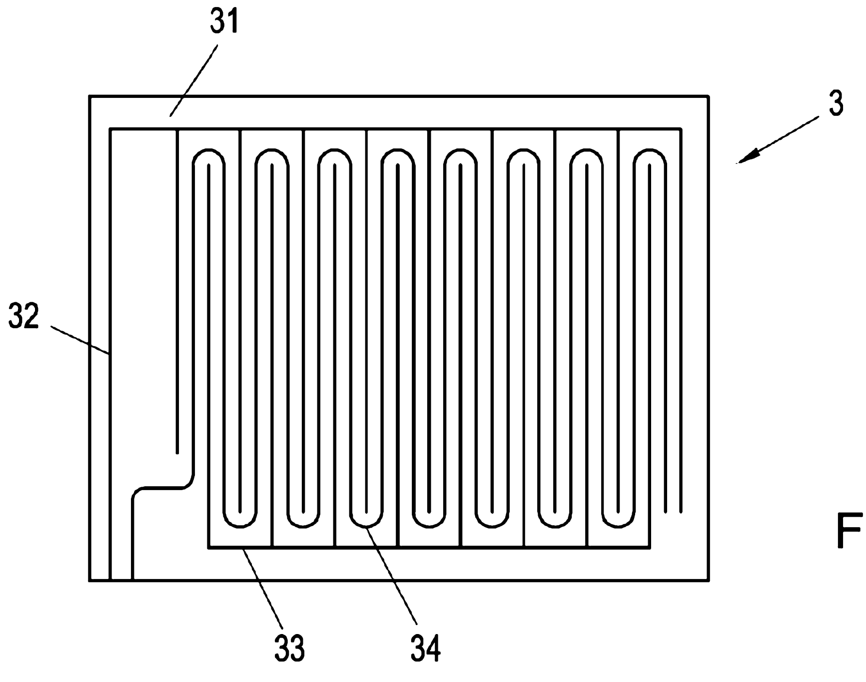

Fig. 16

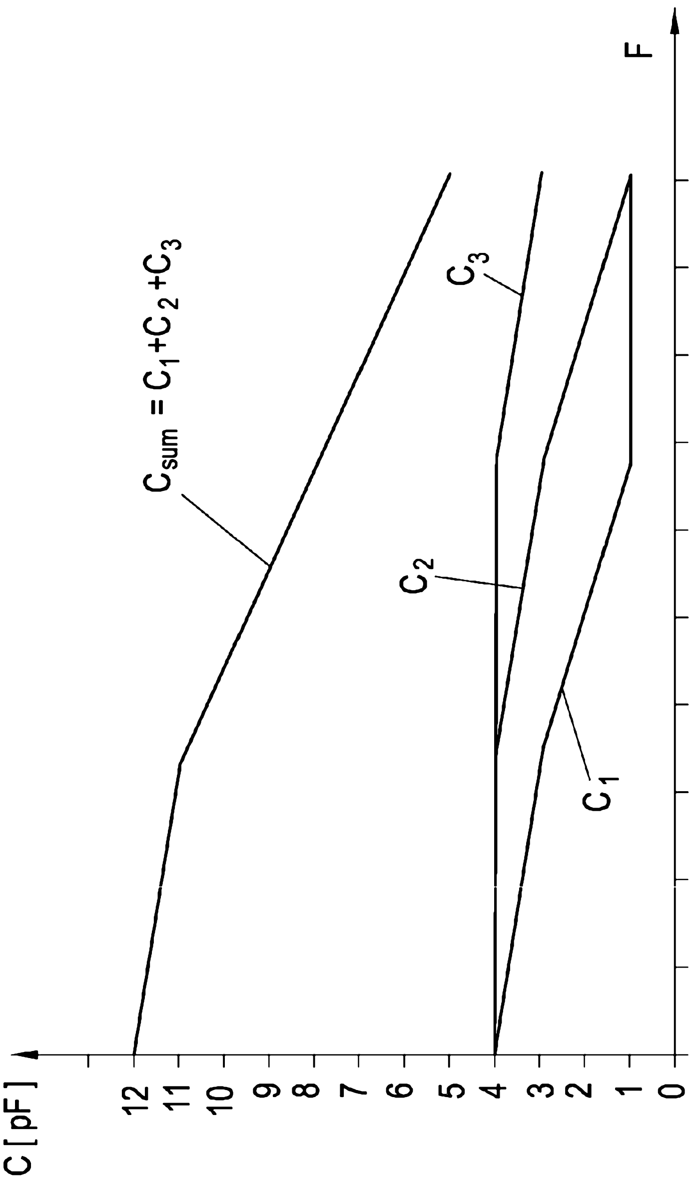
C [pF]
12
11
10
9
8
7
6
5
4
3
2
1
0
F
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1
C_sum = C_1+C_2+C_3
C_3
C_2
C_1

Fig. 17

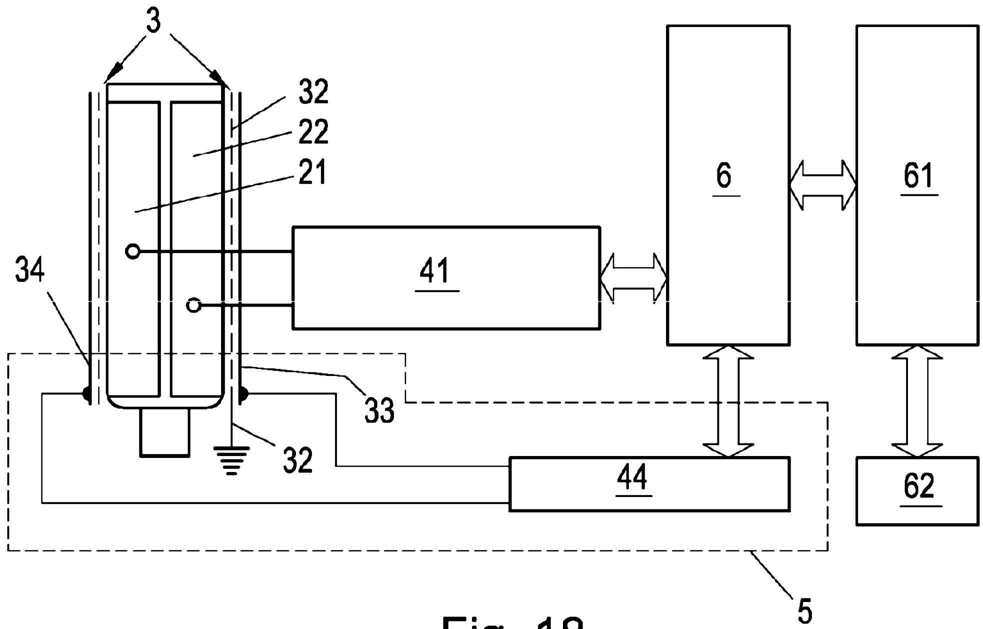
3
32
22
21
34
6
61
41
33
32
44
62
5

Fig. 18

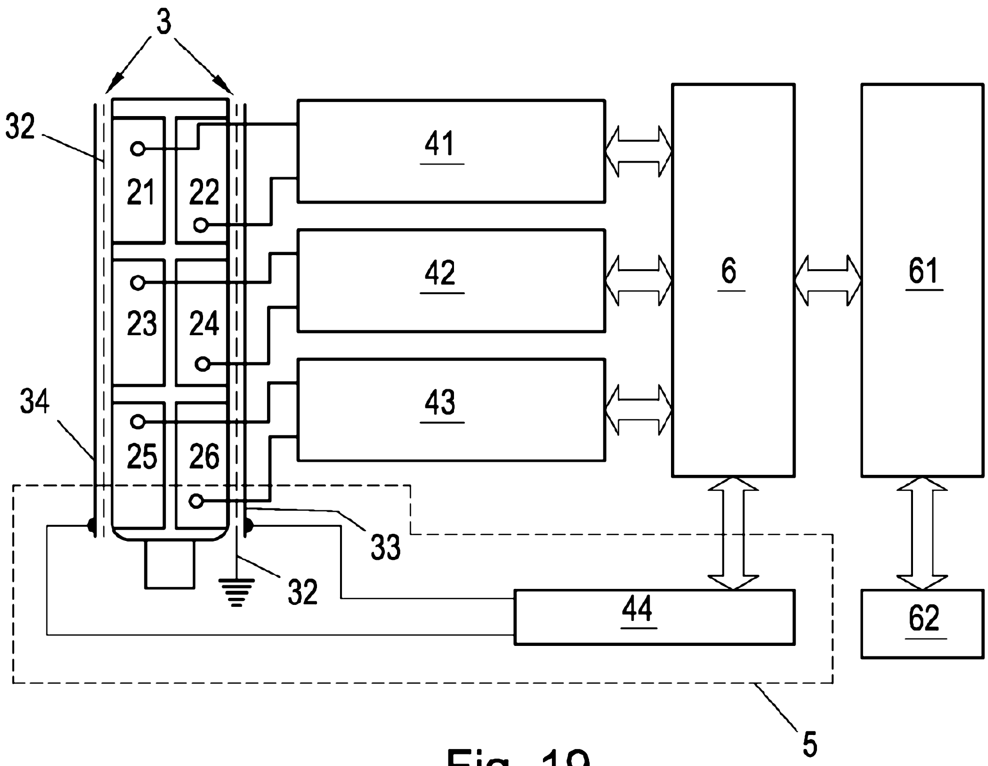
3
32
21
22
41
23
24
42
6
61
34
25
26
43
33
32
44
62
5

Fig. 19

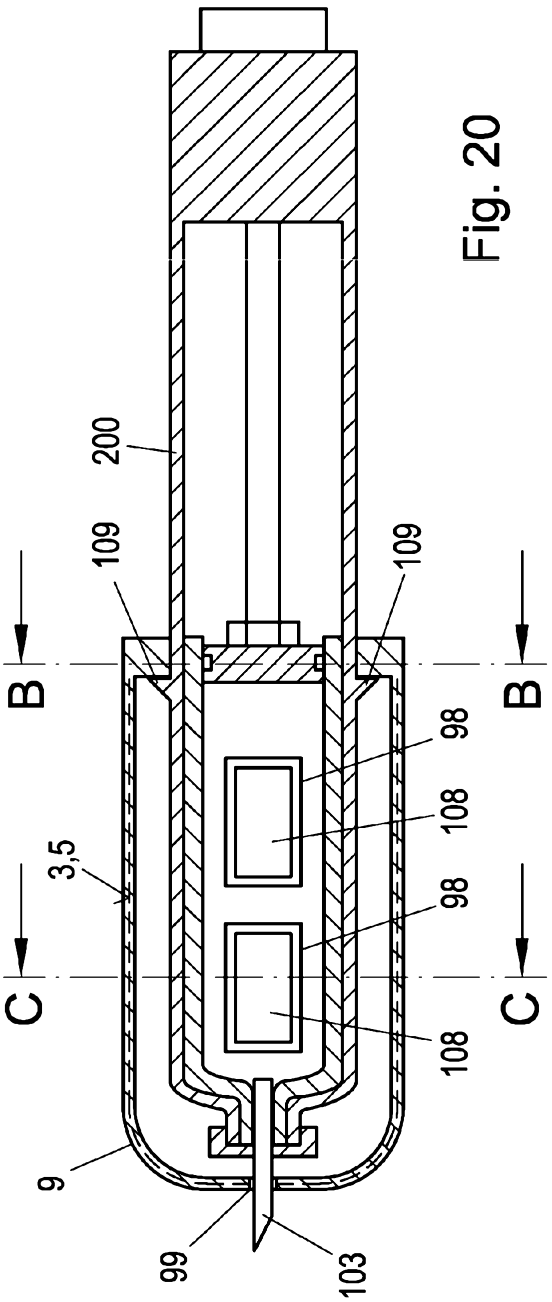
200
109
109
B
B
98
108
3,5
98
C
C
108
9
99
103

Fig. 20

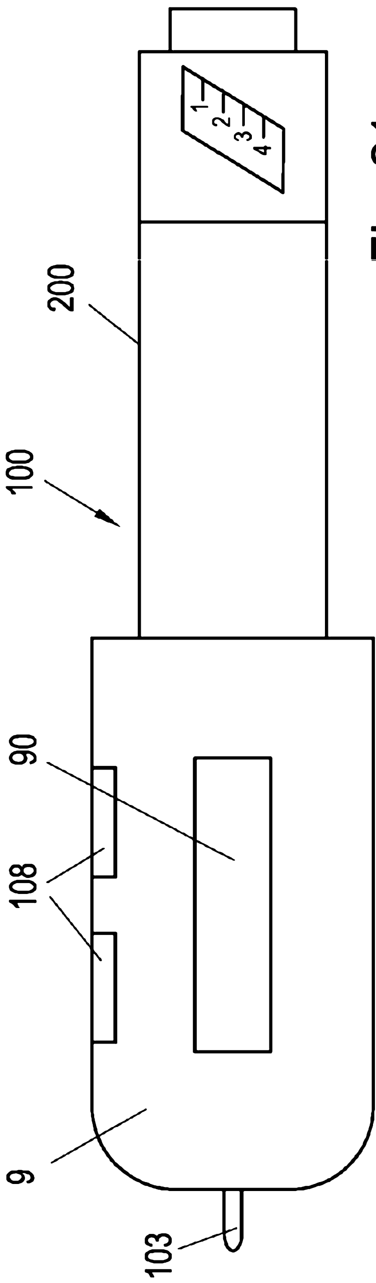
1
2
3
4
200
100
90
108
9
103

Fig. 21

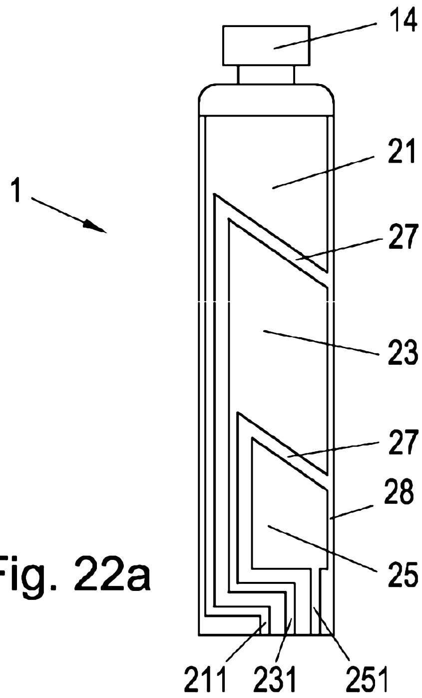

Fig. 22a

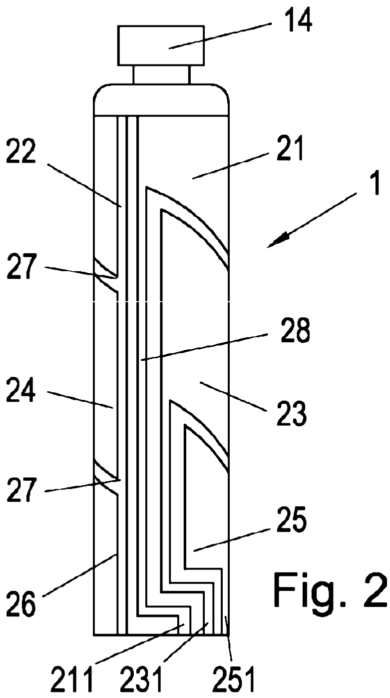

Fig. 22b

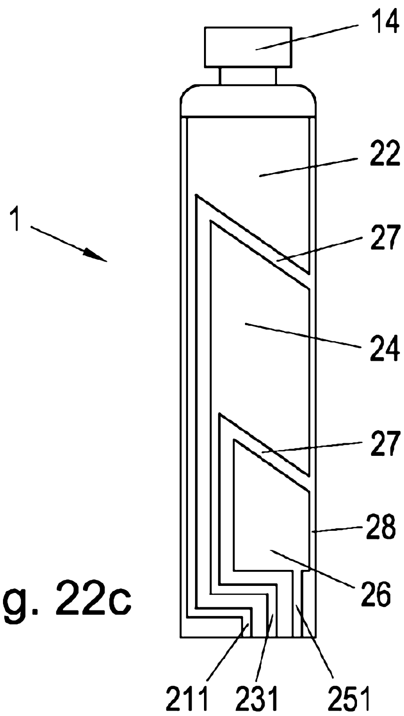

Fig. 22c

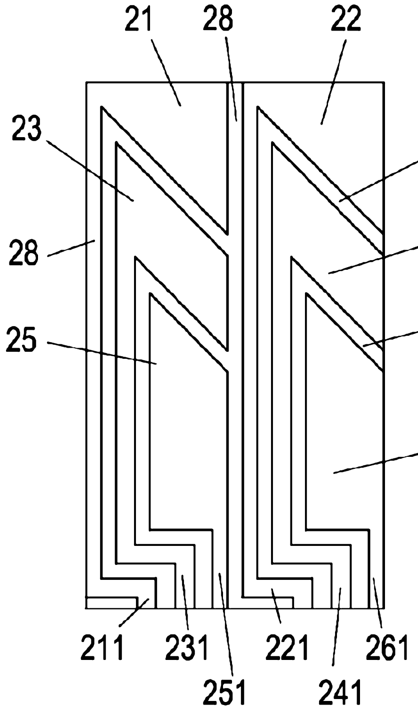

Fig. 22d

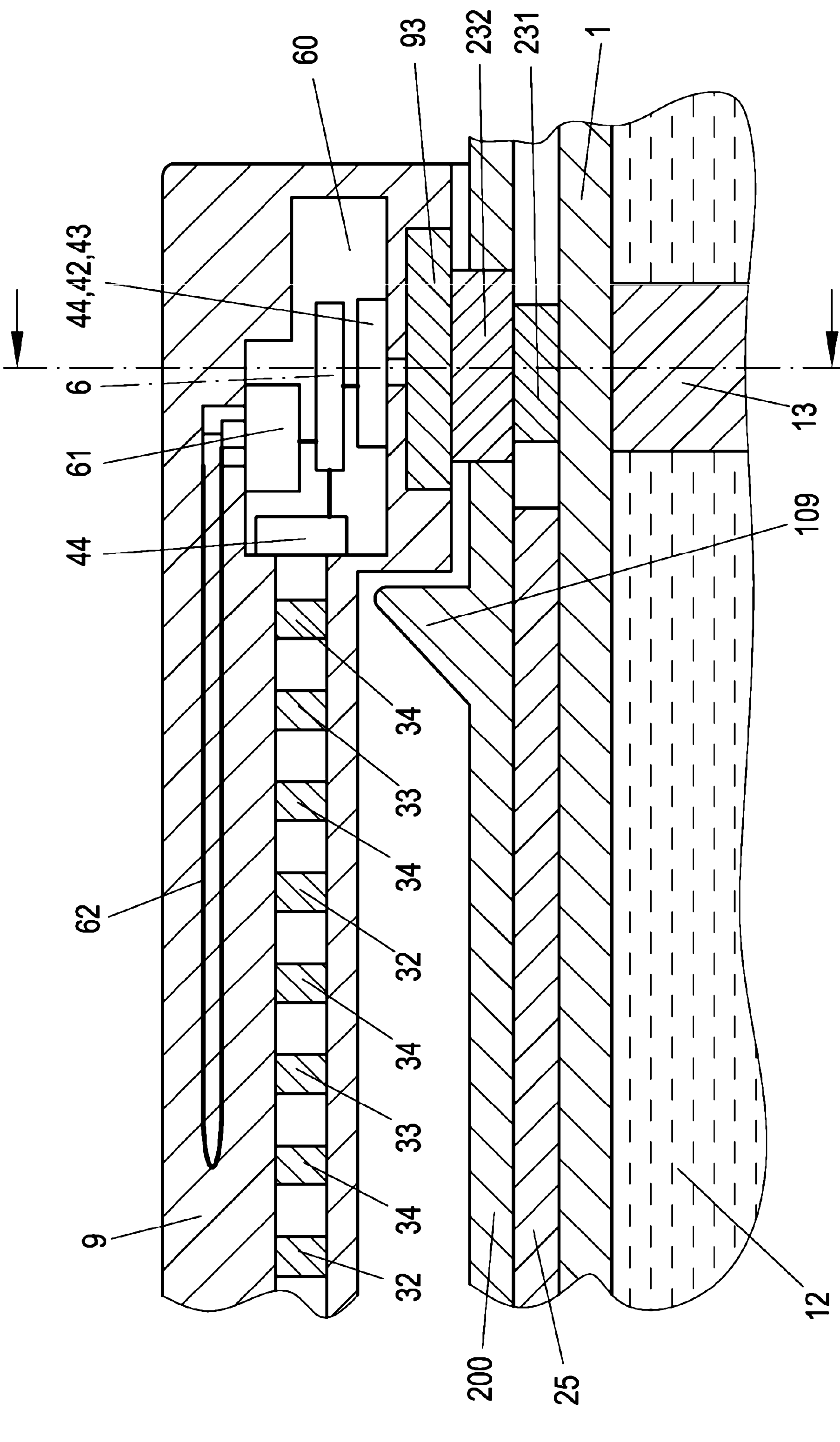
60
93
232
231
1
44,42,43
6
61
44
62
9
34
33
34
32
34
33
34
32
109
13
200
25
12

Fig. 23

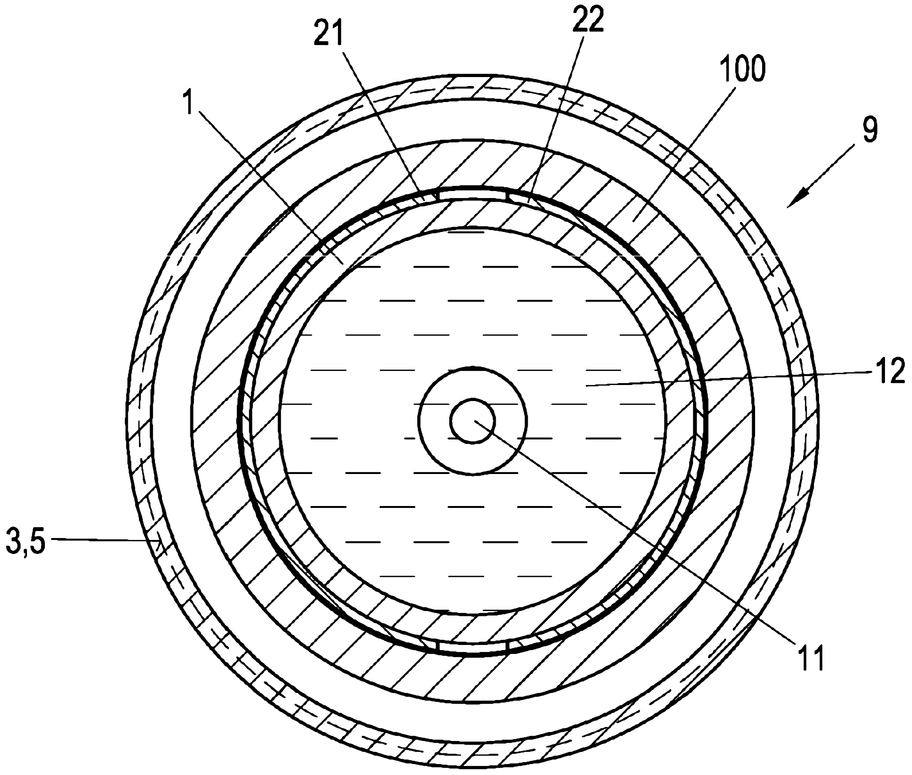

Fig. 24

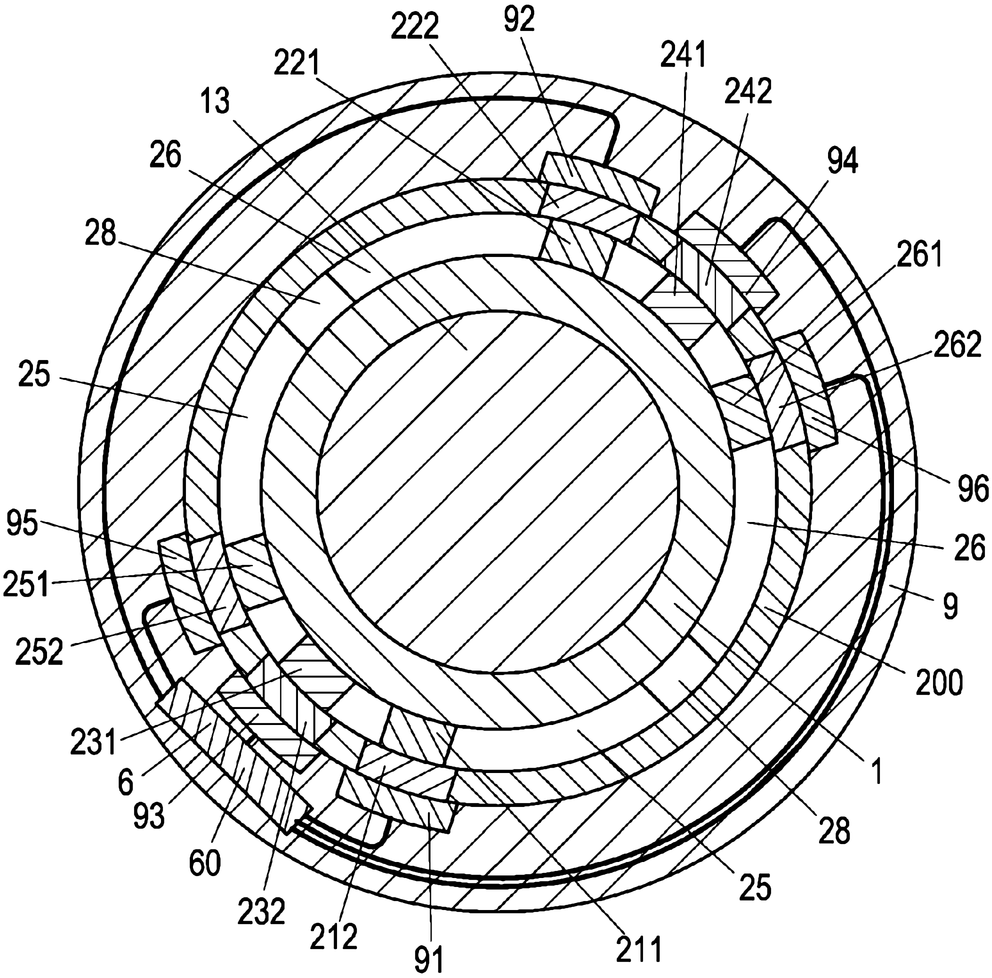
222
92
221
241
13
242
26
94
28
261
262
25
96
95
26
251
9
252
200
231
1
6
93
28
60
25
232
212
91
211

Fig. 25

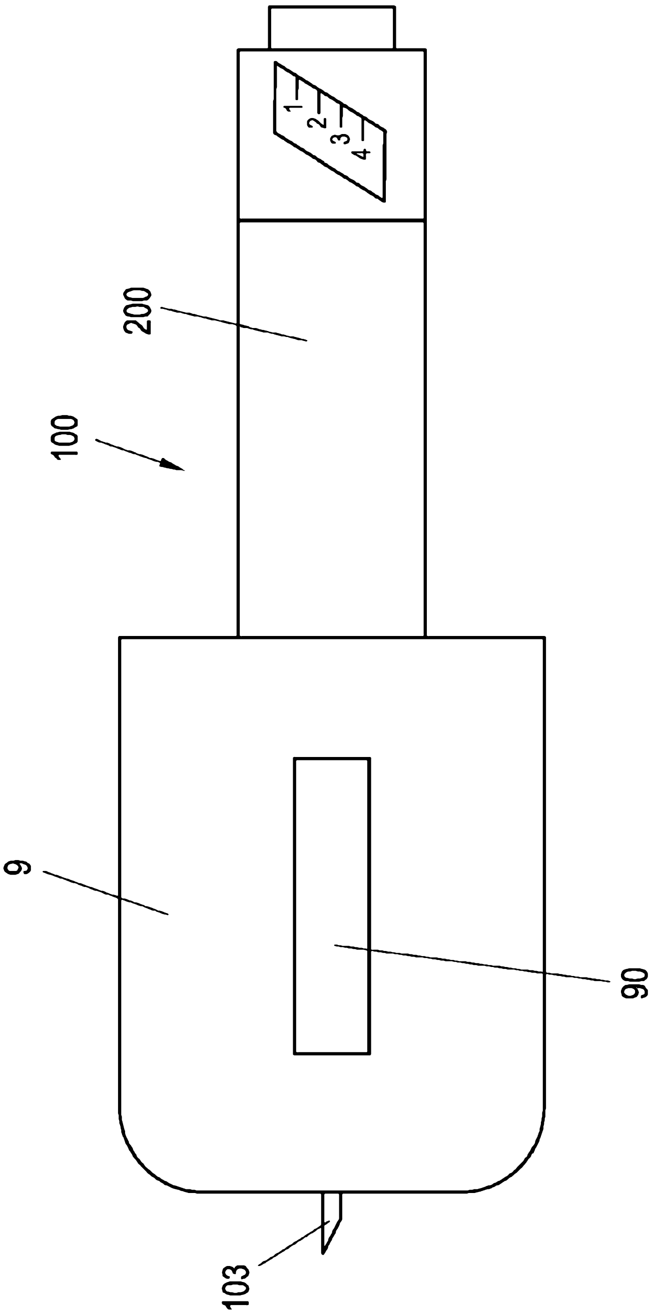

Fig. 26