



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.03.2013 Bulletin 2013/10

(51) Int Cl.:
H01F 38/24 (2006.01) H01F 38/26 (2006.01)

(21) Application number: **12460050.3**

(22) Date of filing: **08.08.2012**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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(30) Priority: **31.08.2011 PL 12030211**
05.12.2011 PL 39724111

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(54) **High voltage coil**

(57) The invention deals with an HV voltage coil which is an element of a voltage transformer used in a combined instrument transformer applicable in high voltage electric power measuring systems. The voltage coil comprises a magnetic core (16), a primary winding (13) wound onto a secondary winding (14) and surrounded by an upper screen (17), a bushing of a high voltage instrument transformer in the form of a conducting rod (21) placed in insulating material (23) with equipotential screens (25), the primary winding together with the upper screen being located in the coil insulation (24) which is covered by an external screen (26). The voltage coil according to the invention is characterized in that the upper screen (17) has the shape of a ring with a gap (18), which is integrated with a connecting element (19) in the form of a truncated cone. This base of the cone which has the larger diameter is situated on the external surface of the ring, and the cone has an axial opening (20) into which a threaded end of the conducting rod (21) is screwed. Equipotential screens (25) are situated centrally around the rod (21) and they have overlapping longitudinal edges which do not touch one another in any point. A copper tape (27) is wound on the insulation (23) and on the external screen (26) of the voltage coil.

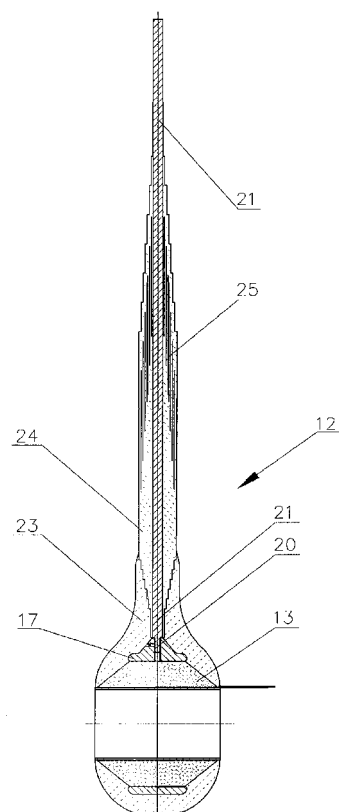


Fig. 2

Description

[0001] The invention deals with a high voltage voltage coil which is an element of a voltage transformer used in a combined instrument transformer which comprises of a current transformer and a voltage transformer located in a common enclosure. A combined instrument transformer is applicable in high voltage electric power measuring systems.

[0002] A combined instrument transformer known from patent description PL193711 comprises an inductive toroidal core type current transformer and an inductive three-leg core type potential transformer, located in the upper and lower parts of the combined instrument transformer, respectively, in metal enclosures and it has an insulator filled with insulating medium in which equipotential screens of an electrically conductive material are located. The primary winding of the voltage transformer and the secondary winding of the voltage transformer are wound on a cylindrical tube of an insulating material, located on the central column of the core which is a composition of two rectangular cores. The equipotential screens are built into an insulating material spread over the high voltage output lead of the voltage transformer and they are connected with the equipotential screens built into the insulating material spread over the tube with the output leads of the secondary windings of the current transformer. The insulating medium is located in the space between the insulated windings of the current and voltage transformers and their metal enclosures as well as in the space between the insulated input leads of the windings of the transformers running along the insulator and the internal surface of the insulator.

[0003] There is known a combined instrument transformer of a similar design, JUK123 made by ABB Sp.z o.o., in which the current coil of the current transformer, which surrounds the current lead, is located in a metal enclosure. Output leads of the windings of the current coil are taken through a current bushing in the form of a metal tube to a terminal box connected to the casing of the voltage transformer. The current bushing is connected with the metal enclosure through a screw joint in which the external thread is made at the end of the bushing tube, and the internal thread is made in the opening of a joining sleeve which is tightly fitted in the opening made in the metal casing of the current coil. The screw joint of the current bushing with the joining sleeve enables the appearance of blades of the protruding thread and edges of the sleeve, which may weaken the strength of the paper-and-oil insulation at the place where bushing joins the current coil enclosure. The voltage transformer comprises a voltage coil in which the primary winding is wound on the secondary winding, which are wound on a cylindrical tube of an insulating material. Inside the tube there are the columns of two magnetic cores which form a jacket core system for the windings of the voltage transformer. At the bottom, the voltage transformer is closed by the bottom part of the metal casing with four openings

used to fasten the transformer to the frame by means of bolts.

[0004] In the JUK 123 combined instrument transformer known from ABB catalogs, the voltage coil windings are provided with an upper screen located inside the voltage coil in the shape of a cylinder and covering the final layer of the winding, made from a copper sheet with wires soldered to the edges of the sheet to avoid sharp edges. The output lead of the voltage coil is the high voltage bushing of the coil, which is located in an insulating material with equipotential screens made from aluminum sheets which after being wound into the insulating material form cylindrical covers situated centrically around the longitudinal axis of the voltage bushing.

[0005] In the presented JUK 123 instrument transformer, the external screen of the voltage coil was formed of aluminum foil and was connected with the final aluminum screen situated on the voltage bushing. There is also known an external screen made of black semiconducting paper which is located outside the voltage coil and which is electrically connected with the final, wound on the largest diameter, aluminum screen situated on the voltage bushing.

[0006] The essence of the high voltage voltage coil comprising a magnetic core, a primary winding wound onto the secondary winding and surrounded by an upper screen to which there is fixed a bushing of a high voltage instrument transformer in the form of a conducting rod placed in insulating material in which cylindrical, axial equipotential screens are situated on different levels, the primary winding together with the upper screen being located in the coil insulation which is covered by an external screen is that the upper screen has the shape of a ring with a gap, integrated with the connecting element in the form of a truncated cone. The larger base of the truncated cone is situated on the external surface of the ring. The cone has an axial opening into which the threaded end of the rod is screwed. The equipotential screens are situated centrically around the conducting rod and they have overlapping longitudinal edges which do not touch one another in any point. Moreover, a copper tape is wound on the voltage coil insulation and on the external screen of the voltage coil.

[0007] Preferably, the internal and external edges of the ring of the upper screen are rounded, and the rounding radius "R1" of the external edge is larger than the rounding radius "R2" of the internal edge.

[0008] Preferably, the upper screen is made as an aluminum cast.

[0009] Preferably the equipotential screens of the bushing are situated in relation to the rod axis in such way that the line connecting the upper edges of the screens located in the insulating material is situated at an acute angle to the rod axis and at the same time it is parallel to the line connecting the bottom edges of these screens.

[0010] Preferably, the angle " α " of the mutual overlapping of the longitudinal edges of the equipotential screens

of the bushing is less than 60° .

[0011] Preferably, the insulating material of the bushing is paper insulation whose bands are wound stepwise on the bushing rod, narrowing towards both ends of the rod.

[0012] Preferably, the final bushing screen made of conducting material is permanently connected with the copper tape on the external side outline of the voltage coil.

[0013] Preferably, the output leads of the copper tape are the end of the band in the form of copper plaiting which is permanently fixed to an insulating connector.

[0014] Preferably, the external screen of the coil, which reflects the outer surface of the coil, is made of a semi-conducting paper.

[0015] Preferably, the coil according any of the claims 1 through 9 is an element of a voltage transformer which together with a current transformer and an insulator make a combined instrument transformer.

[0016] The invention is presented as an example of an embodiment in the drawing, where fig. 1 shows the combined instrument transformer in half-view and in broken-out frontal half section showing the insulator in section, fig. 2 - the voltage coil in side section, fig. 3 - the voltage coil in frontal view partially broken-out, fig. 4 - the upper screen of the voltage coil in frontal view, fig. 5 - the upper screen of the voltage coil in side view, fig. 6 - the voltage bushing with indicated equipotential screens in half-view and in half section, fig. 7 - the voltage bushing with the equipotential screens from fig. 6 in cross-section along line C-C, fig. 8 - the insulation of the voltage coil with the external screen in frontal projection on the side where the copper belt is taken outside, fig. 9 - the insulation of the voltage coil with the external screen from fig. 8 in end elevation, fig. 10 - the insulation of the voltage coil with the external screen in frontal projection on the side where the copper belt is taken outside, and fig. 11 - the insulation of the voltage coil with the external screen from fig. 10 in end elevation.

[0017] The combined instrument transformer comprises a current transformer 1 and a voltage transformer 2 located in the upper and lower parts of the transformer, respectively, in metal enclosures 1a and 2a, 2b and it has an insulator 3 filled with an insulating medium 4. The current transformer 1 is located in a metal head 5 in which there is at least one cylindrical core 6. Secondary windings 7 of the current transformer 1 are wound on the core 6. The windings 7 with the core 6 are located in a metal enclosure 8. A primary winding 9 whose terminal is connected to the metal head 5 of the instrument transformer runs through the center of the cores. The output leads of the secondary windings 7 of the instrument transformer 1 are brought into a metal tube 10 which is a current bushing of the transformer 1, which is located inside the insulator 3. The output leads of the secondary windings 7 are brought outside the tube 10 at its other end and they are connected with the external terminals located in a terminal box attached to the lower part of the enclosure

2b of the voltage transformer 2, which is not shown in the drawing. In the upper part of the enclosure 1a of the current transformer there is located a compensatory bellows 11 used to compensate variations in the volume of the insulating medium 4 which can be insulating oil, sulfur hexafluoride, or nitrogen. The voltage transformer comprises a voltage coil 12 with a primary winding 13 wound onto a secondary winding 14, which are wound on a cylindrical tube 15 of insulating material. Inside the tube 15 there are placed the columns of two magnetic cores 16 which make a jacket-core system for the windings of the voltage transformer 2. In side section, the windings of the coil 12 have the shape of a trapeze, which is shown in fig. 2. The shorter base of the trapeze is galvanically connected with the inner surface of the upper screen 17 of the voltage coil. The upper screen 17 is formed in the shape of a metal ring with a gap 18 which prevents the formation of a shorted coil, and it comprises a connecting element 19 which has the shape of a truncated cone whose larger-diameter base is situated on the external surface of the ring. In the cone axis there is a threaded port 20 into which the threaded end of a conducting rod 21 constituting the voltage bushing of the voltage coil is screwed. The whole upper screen 17 is made as an aluminum casting. The ring edges are rounded, and the radius of the rounding of the external edge R1 is bigger than the radius of the rounding of the internal edge R2, which allows to minimize the intensity of the electric field on the edges of the screen 17. The connecting element 20 contains also a transverse port 22 which is used to introduce a set screw into it. The windings of the voltage transformer 2 with the upper screen 17 are insulated with insulating material 23 in the form of paper-and-oil insulation. The conducting rod 21 that is screwed into the port 20 is situated along its own length in the bushing insulation 24 in the form of paper bands wound onto the rod 21. In the insulation 24 there are axial equipotential screens 25 in the form of sheets of conducting material, forming cylindrical screens of equal length, with the exception of a shorter external screen, which are situated parallel to one another and to the axis of the rod 22. The line joining the upper edges of the equipotential screens, with the exception of the external screen which is shorter than the other screens, is situated at an acute angle to the axis of the rod 21 and at the same time parallel to the line connecting the bottom edges of the equipotential screens. After the formation of the cylindrical screens, the longitudinal edges of the equipotential screens overlap one another, which is shown in fig. 7, but these edges do not touch because there is a layer of a thickness of one insulation paper sheet between the overlapping screen layers. The angle α at which the edges of the screens overlap should not exceed 60° , and preferably it should be within the range of $15-45^\circ$. The presented system of cylindrical equipotential screens 25, made of aluminum foil, and their mutual position in the paper insulation 24 enable the achievement of considerable homogeneity of the electric field in the voltage bushing of

the voltage coil, which greatly improves the quality of the combined instrument transformer. The insulation of the bushing 24 is gradated on both sides, i.e. the upper and the lower sides, and it is connected with the insulation material 23 of the voltage coil forming the main insulation of the voltage transformer 2, in which the lower gradated side of the insulation 24 is comprised.

[0018] On the lower part of the main insulation of the voltage transformer there is an external screen 26, of a shape reflecting the coil surface. A conducting copper tape 27 is evenly wound onto the external screen 26, which is shown in fig. 8, 9, 10 and 11. The tape 27 twists around the front surfaces of the coil and covers the outer side outline of the coil, the sections of the band that intersect on the side outline of the coil being permanently joined with one another e.g. by soldering. One end of the band 27 is taken outside the insulation and it is fixed to the insulating connector 28, to which also the end of the band 29 in the form of a copper plaiting, constituting the conducting outlet of the external screen 26, is fixed. The final, shorter screen 25 of the conducting material is permanently connected with the copper tape 27, which is not shown in the drawing. To facilitate equal distribution of the band 27 on the external screen, pressboard disks 30 through which the band is threaded are fixed to both sides of the voltage coil. The function of the copper tape 27 is to conduct an electric charge to earth and to equalize potentials on the voltage coil. The use of the copper tape 27 permits an even distribution of the potential on the voltage coil. At the bottom, the combined instrument transformer is closed by the lower part of the casing 2b with four openings used to fix the transformer to the frame by means of bolts, not shown in the drawing. In the combined instrument transformer, the equipotential screens 25 built into the insulation 24 surrounding the conducting rod 21 of the voltage transformer are not galvanically connected. The design and shape of the upper screen 17 located in the voltage coil 12 in the paper-and-oil insulation 23, as well as the way of connecting it with the voltage bushing wound on the metal rod 21 where the thread of the metal rod 21 is completely hidden in the connecting element 19, and the shape of the primary winding of the voltage transformer 13 ensure the optimum distribution of the electric field. Moreover, the upper screen 17 functions as a support structure for the bushing of the voltage coil. The threaded connection can be a metric thread, a unified screw thread, or any other thread depending on the design needs. The system of the screens 25 of a design in which the longer sides of the screens overlap ensures an even distribution of voltage gradients at the ends of the screens. Also the use of the external screen 26 of semiconducting paper and the use of the copper tape 27 coiling around this screen ensures an even potential distribution on the voltage coil. All the above mentioned new features of the voltage coil contribute to an increase in the quality of the voltage transformer and greater operating safety of the combined instrument transformer.

List of markings in the drawing

[0019]

- | | |
|----|--|
| 5 | 1. current transformer |
| | 1 a - current transformer casing
voltage transformer |
| 10 | 2. voltage transformer |
| | 2a - voltage transformer casing
2b - voltage transformer casing |
| 15 | 3. insulator |
| | 4. insulating medium |
| | 5. metal head |
| | 6. cylindrical core of the current transformer |
| | 7. secondary windings of the current transformer |
| 20 | 8. metal enclosure of the current coil |
| | 9. primary winding of the current transformer |
| | 10. metal tube |
| | 11. compensatory bellows |
| 25 | 12. voltage coil |
| | 13. primary winding of the voltage transformer |
| | 14. secondary winding of the voltage transformer |
| | 15. cylindrical tube of insulating material |
| | 16. magnetic core of the voltage transformer |
| | 17. upper screen of the voltage coil |
| 30 | 18. gap in the upper screen |
| | 19. connecting element |
| | 20. port |
| | 21. conducting rod |
| | 22. transverse port |
| 35 | 23. insulating material |
| | 24. bushing insulation |
| | 25. equipotential screens |
| | 26. external screen |
| | 27. copper tape |
| 40 | 28. insulating connector |
| | 29. end of copper tape |
| | 30. pressboard disk |

45 Claims

- | | |
|----|---|
| 50 | 1. High voltage voltage coil comprising a magnetic core, a primary winding wound onto a secondary winding and surrounded by an upper screen to which there is fixed a bushing of a high voltage instrument transformer in the form of a conducting rod placed in insulating material in which cylindrical, axial equipotential screens are situated on different levels, the primary winding together with the upper screen being located in the coil insulation which is covered by an external screen, characterized in that the upper screen has the shape of a ring with a gap (18), integrated with the connecting element (19) in the form |
| 55 | |

of a truncated cone whose larger base is situated on the external surface of the ring, the cone having an axial opening (20) into which a threaded end of the conducting rod is screwed (21), and equipotential screens (25) situated centrically around the rod (21) have overlapping longitudinal edges which do not touch one another in any point, and moreover, a copper tape (27) is wound on the insulation (23) and on the external screen (26) of the voltage coil.

2. A coil according to claim 1, **characterized in that** the internal and external edges of the ring of the upper screen (17) are rounded and the rounding radius (R1) of the external edge is larger than the rounding radius (R2) of the internal edge.
3. A coil according to claim 2, **characterized in that** the upper screen (17) is made as an aluminum cast.
4. A coil according to claim 1, **characterized in that** equipotential screens (25) are situated in relation to the rod axis in such way that the line connecting the upper edges of the screens (25) located in the insulating material (24) is situated at an acute angle to the rod axis (21) and at the same time parallel to the line connecting the bottom edges of these screens.
5. A coil according to claim 4, **characterized in that** the angle (α) of the mutual overlapping of the longitudinal edges of the equipotential screens (25) is less than 60° .
6. A coil according to claim 1, **characterized in that** the insulating material (24) of the coil bushing is paper insulation whose bands are wound stepwise on the rod (21), narrowing towards both ends of the rod.
7. A coil according to claim 1, **characterized in that** the last screen of conducting material (25) is permanently connected with the copper tape (27) wound onto the external side outline of the voltage coil.
8. A coil according to claim 1, **characterized in that** the output leads of the copper tape (27) are the end of the band (29) in the form of copper plaiting which is permanently fixed to an insulating connector (28).
9. A coil according to claim 1-8, **characterized in that** external screen (26) which reflects the outer surface of the coil is made of a semiconducting paper.
10. A coil according to any claim from 1 through 9, **characterized in that** it is an element of the voltage transformer (2) which together with the current transformer (1) and the insulator (3) make a combined instrument transformer.

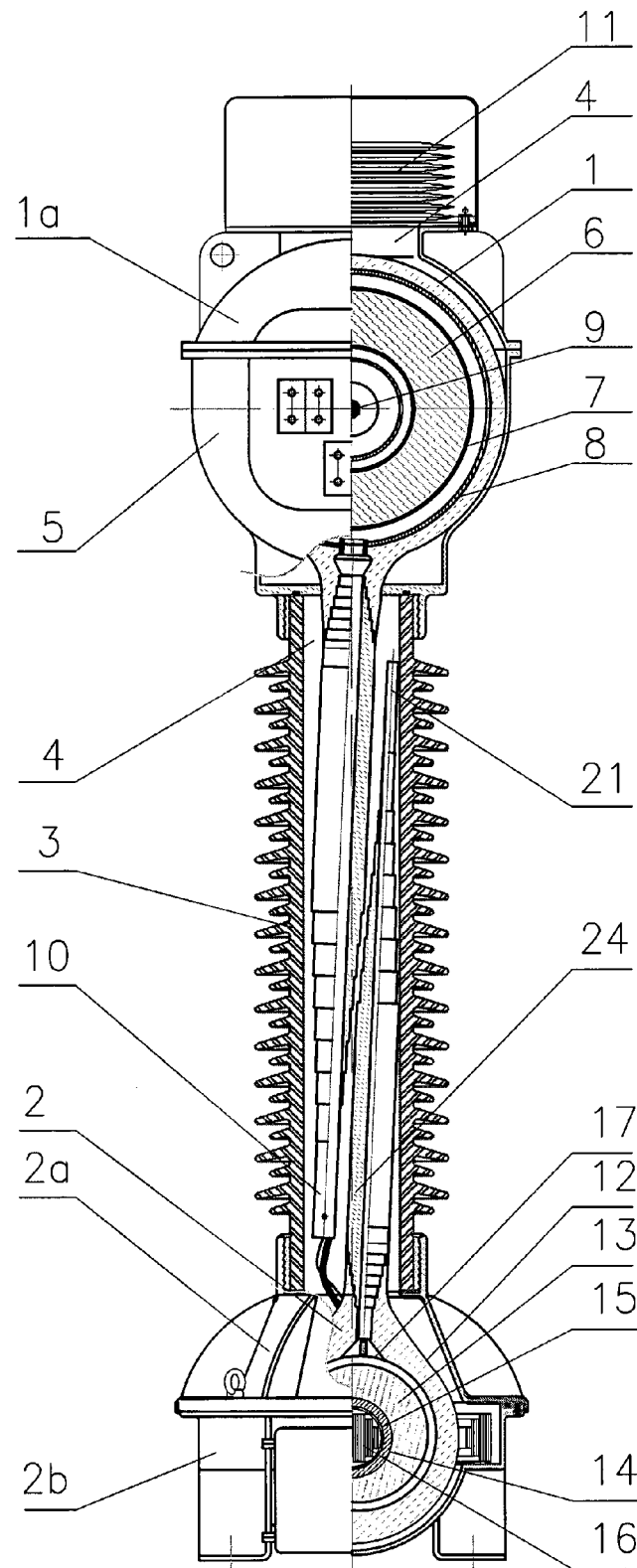


Fig. 1

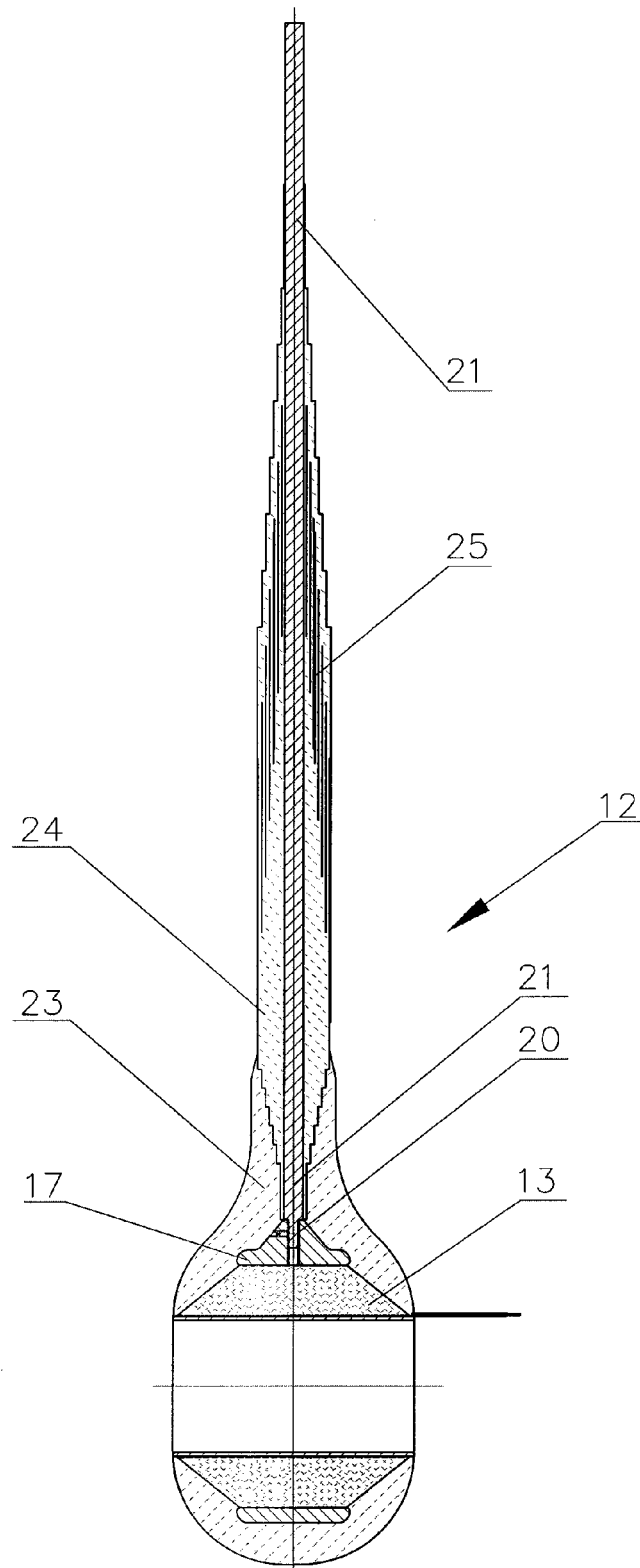


Fig. 2

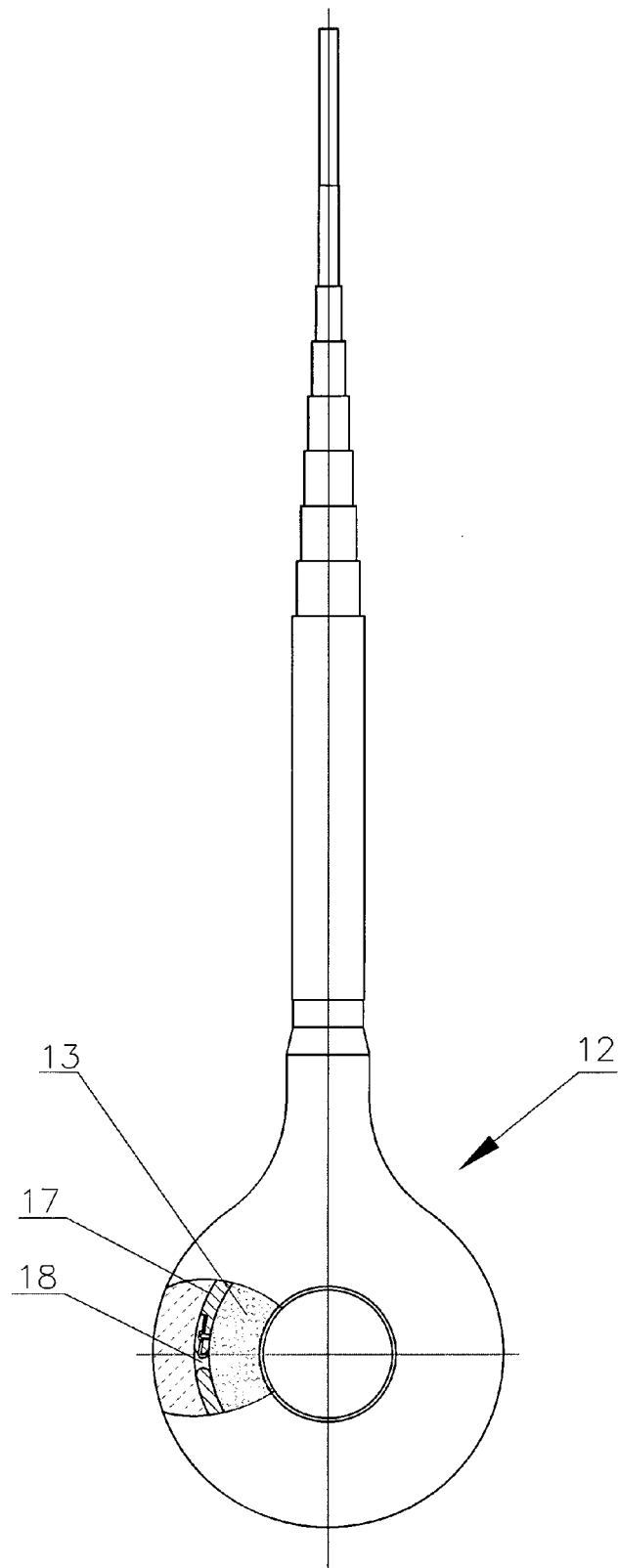


Fig. 3

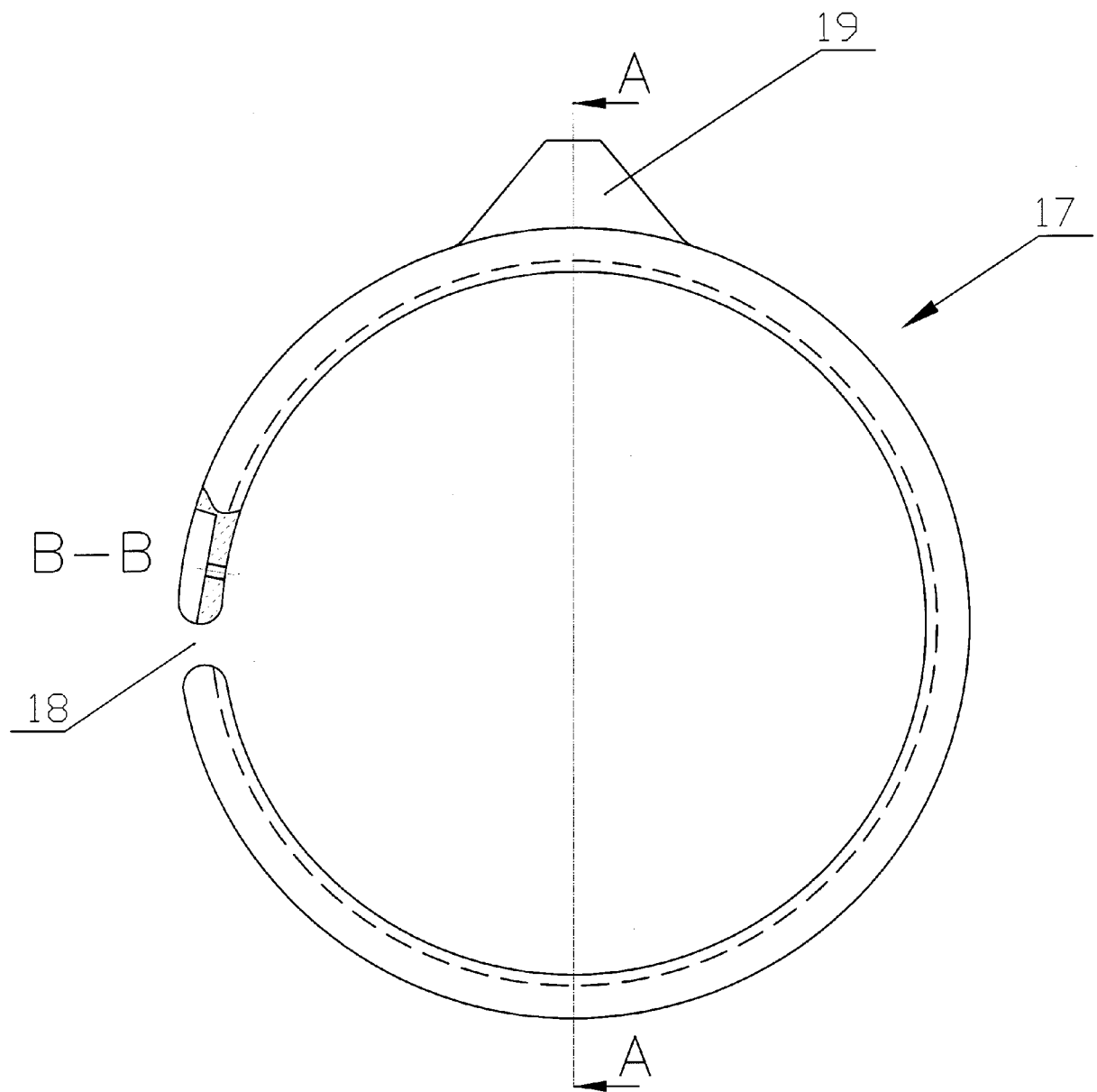


Fig. 4

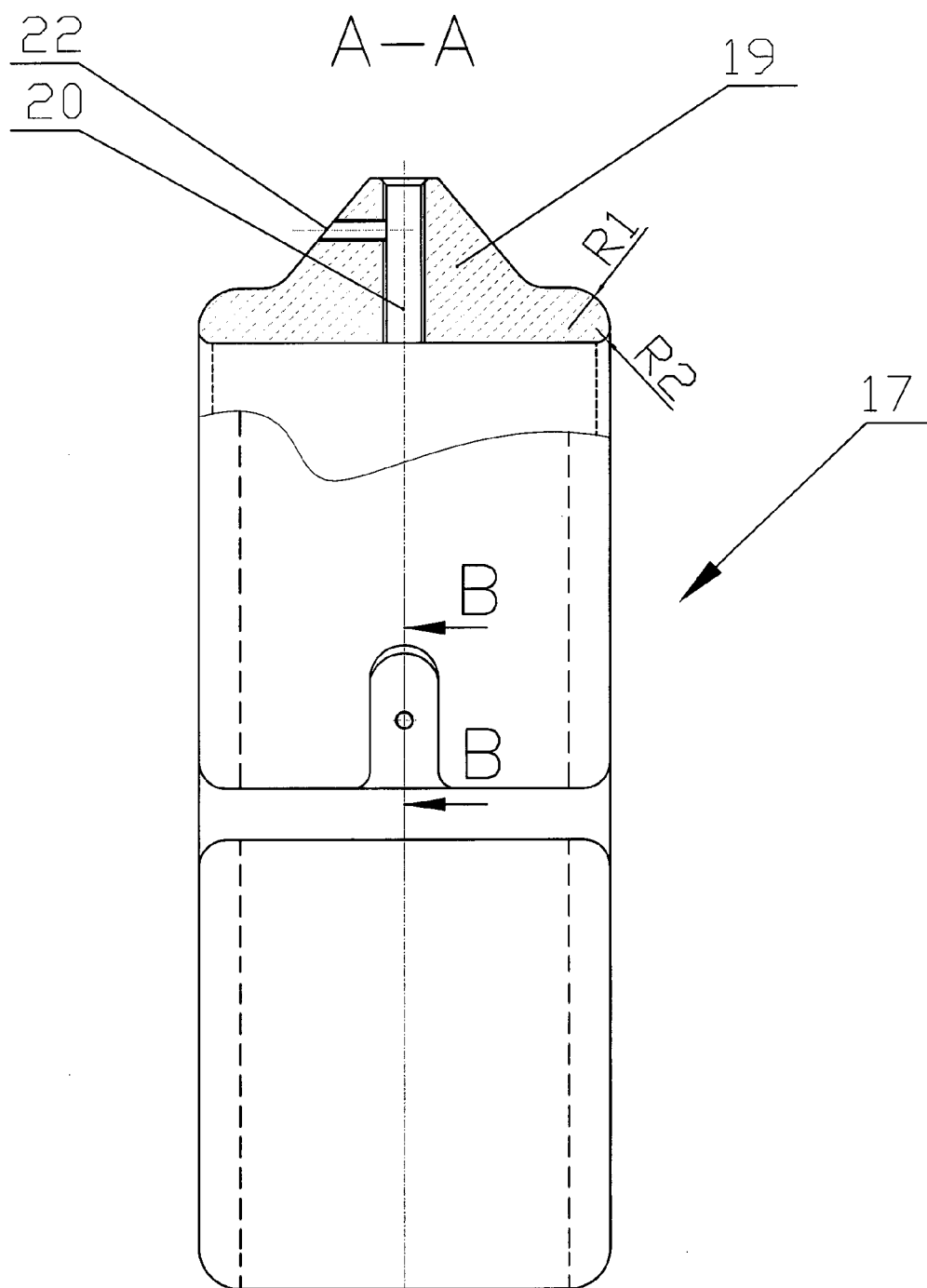


Fig. 5

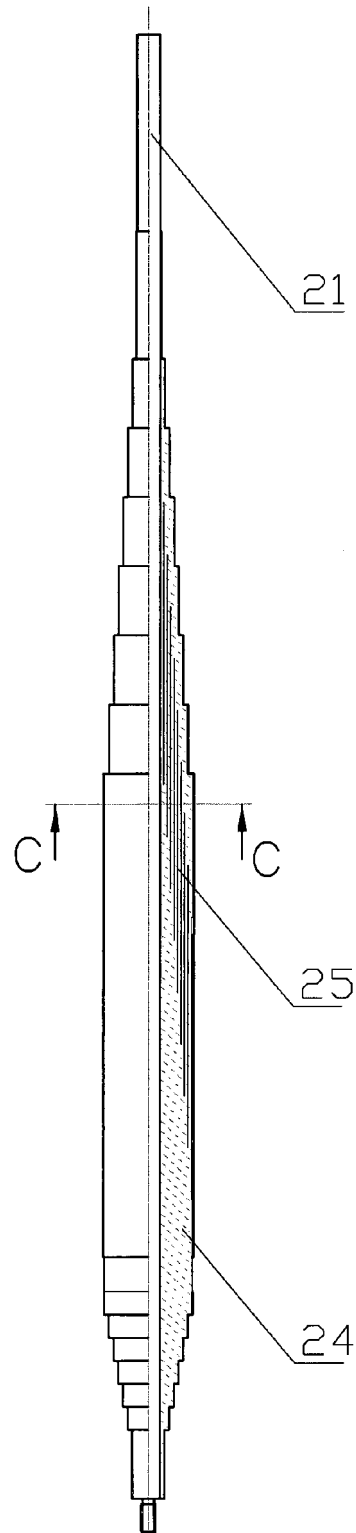


Fig. 6

C—C

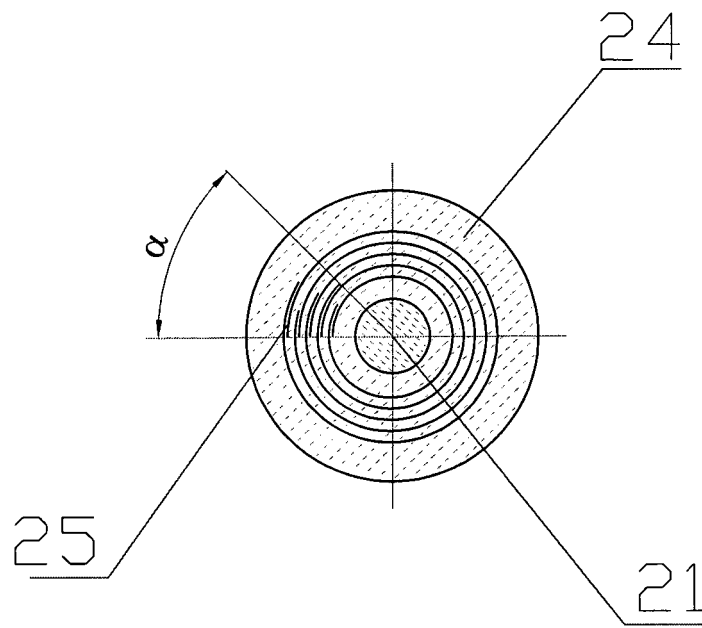


Fig. 7

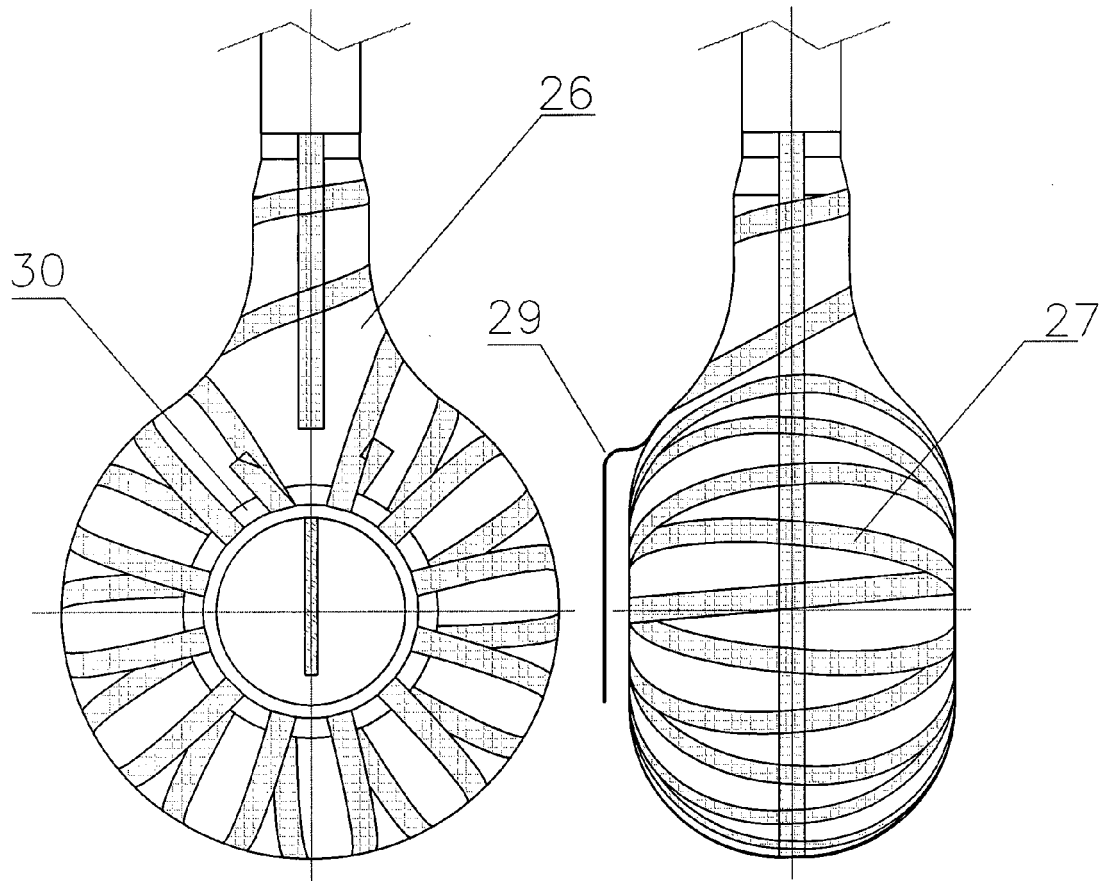


Fig. 8

Fig. 9

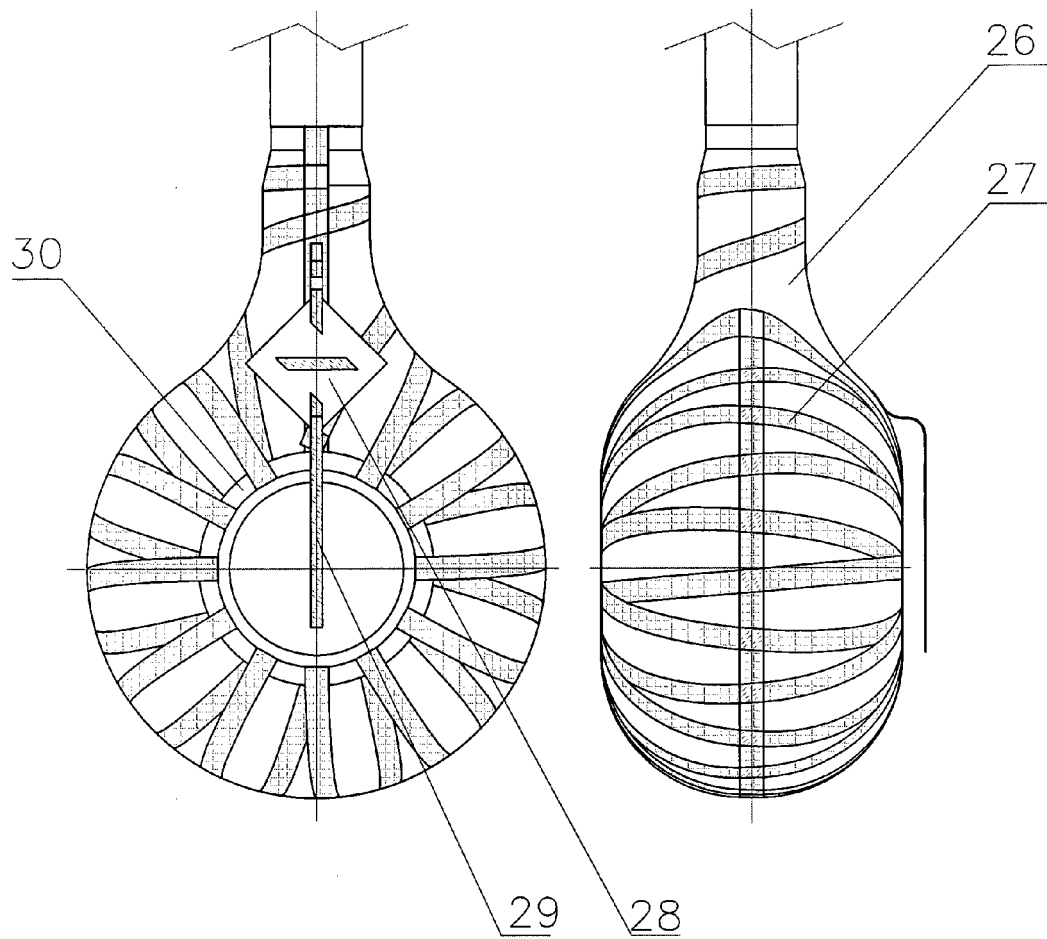


Fig. 10

Fig. 11

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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