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(54) Combustion apparatus

(57) A heat-exchanger element (1; 20) suitable for enabling the circulation within it of a heat-exchanging fluid, said heat-exchanger element (1; 20) being provid-

ed with at least an inlet (7; 8) and with at least an outlet (7; 8) for said fluid, inside said heat-exchanger element (1; 20) a path (5; 19; 22) is defined for the circulation of said fluid.

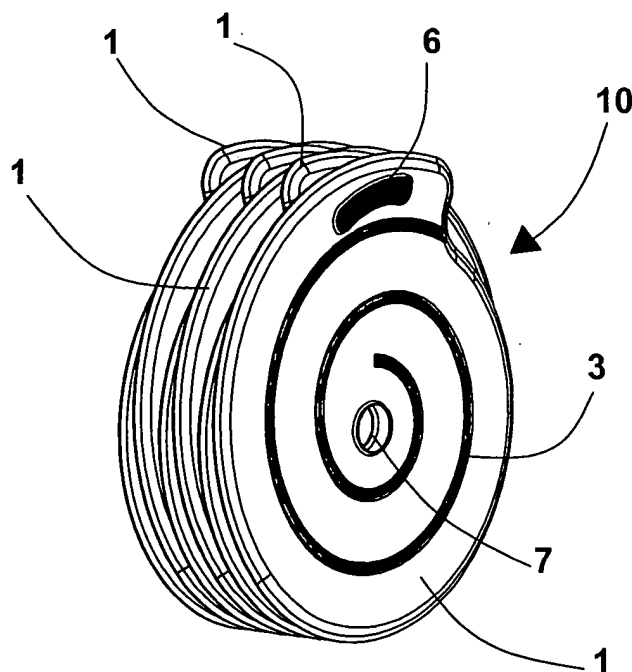


Fig. 8

## Description

**[0001]** The present invention relates to a combustion apparatus with high specific power, in particular a burner and heat-exchanger assembly having limited overall dimensions in relation to the thermal power developed by the burner.

**[0002]** The need is currently increasingly felt to develop high-power boilers, with power for example up to 90kW, with reduced overall dimensions.

**[0003]** The present invention proposes providing a combustion unit with high specific power that is suitable for compact boilers.

**[0004]** According to the present invention, a heat exchanger is provided that is suitable for enabling the circulation within it of a heat-exchanging fluid, said exchanger comprising a plurality of exchanger elements connected with one another and each provided with at least an inlet and at least an outlet for said fluid, characterised that inside each said heat exchanger elements at least a path is defined for the circulation of said fluid, the total cross section of said at least a path being significantly less than the maximum cross section of the heat-exchanger element.

**[0005]** Said at least a path enables the heat-exchange surface to be maximised in proportion to the external dimensions of the exchanger, inasmuch as substantially the entire surface of each heat-exchanger element is exploited for the transmission of the heat to the fluid circulating therein.

**[0006]** Furthermore, by appropriately selecting the section of the path defined for the fluid inside each heat-exchanger element it is possible to set the fluid speed substantially at all the points of the heat-exchanger element, in particular it is possible to select a speed value that enables the heat transmission parameters to be optimised and high specific power to be obtained for the heat exchanger.

**[0007]** According to a preferred embodiment, each heat-exchanger element comprises a pair of shells facing each other, between which at least a path for said fluid is defined, the paths of adjacent elements being able to be connected together serially or in parallel.

**[0008]** This enables the elements of the heat exchanger to be made simply and cheaply from the constructional point of view.

**[0009]** According to a further aspect of the present invention, a combustion unit comprising a burner and a heat exchanger is provided, characterised in that said burner externally surrounds the exchanger at least in part.

**[0010]** The fact that the burner at least partially surrounds the heat exchanger enables the heat exchange between the fumes produced by the burner and the fluid that circulates inside the exchanger to be improved further.

**[0011]** The invention will now be disclosed below, purely by way of non-limitative example, with reference

to the attached drawings, in which:

Figure 1 is an exploded view of a heat-exchanger element according to the invention, consisting of two shells, which are brought together;

Figure 2 is a frontal view of the assembled heat-exchanger element in Figure 1;

Figure 3 is the section III-III of Figure 2;

Figure 3a is an enlarged detail of Figure 3 that shows the joint between the two shells of the heat-exchanger element;

Figures 4, 4a, 5, 5a, 6, 6a, 7, 7a, are views of certain embodiments of shells of the heat-exchanger element according to the invention;

Figure 8 is a perspective view of a heat exchanger according to the invention, constituted by a plurality of heat exchanger elements;

Figure 9 is a frontal view of the heat exchanger in Figure 8;

Figure 10 is the section X-X in Figure 9;

Figure 11 is the left-hand view of Figure 9;

Figure 12 is a frontal view of a shell of a version of a heat-exchanger element according to the invention;

Figure 13 is a left-hand view of Figure 12

Figure 14 illustrates a heat exchanger according to the invention, inserted into a combustion chamber with corresponding burner;

Figure 15 is a schematic cross section of figure 14; Figures 16 and 16a show two shells of a further version of a heat-exchanger element according to the invention;

Figure 17 shows a still further version of a heat-exchanger element according to the invention;

Figure 18 is the section XVII-XVII of Figure 16;

Figure 19 is a perspective view of the burner associated with the heat exchanger shown in Figures 14 and 15.

**[0012]** With reference to Figure 1, 1 shows a heat-exchanger element according to the invention constituted by a first shell 2 and by a second shell 2a in each of which a spiral-shaped respective seat 3, 3a, is obtained by drawing. The seats 3 and 3a substantially mirror each other. Between the seats 3 and 3a a sheet-metal or plastics material strip 4 is inserted which, when the two shells 2 and 2a are brought up and fixed together, defines a spiral path 5 inside the heat-exchanger element 1. In each shell 2, 2a, at the ends of said spiral path 5, a drawn element 6, 6a is obtained. In one of the two drawn elements 6, 6a an opening 7, 8 is obtained. In a first shell 2 the opening 7 is obtained in a central position, at a first end of the spiral path 5, whereas in the other shell 2a the opening 8 is obtained in a peripheral position at the end of the spiral path 5 opposite said first end. The two openings 7 and 8 act as an inlet and outlet for a heat-exchanging fluid, for example water, intended to circulate inside the heat-exchanger element 2 along

said spiral path 5.

**[0013]** The two openings 7 and 8 furthermore make adjacent heat exchanger elements 2 communicate together when a plurality of said elements 2 is assembled to constitute a heat exchanger.

**[0014]** In a pair of shells 2, 2a, an opening in a shell corresponds to a drawn element without opening in the other shell.

**[0015]** The drawn elements 6 and 6a and correspondingly the openings 7 and 8 may for example have a circular or buttonhole shape, the latter being preferable for reducing the load loss that occurs during circulation of the heat-exchanging fluid inside the heat-exchanger element 2.

**[0016]** Two shells 2, 2a are assembled together to constitute a heat-exchanger element 2, by superimposing peripheral edges 9, 9a, of respectively the two shells (Figure 3a) that are then fixed together by fusion welding, braze welding, or mechanical joining with seal in order to make a sealed peripheral joint between the two shells 2, 2a. In particular, by using the technique of braze welding the risk of creating oxidation points is eliminated, which during operation of the heat-exchanger element can rapidly lead to local breaks in the joint, with the consequent need to replace the heat-exchanger element.

**[0017]** Figures 4, 4a, 5, 5a, 6, 6a, 7, 7a show different possible combinations of the drawn elements 6, 6a and of the openings 7, 8.

**[0018]** Figures 4, 4a show the shells 2, 2a of a first embodiment of a heat-exchanger element 2 according to the invention. The shell 2 shown in Figure 4 shows an opening 8 with a substantially circular shape at the outer end of the spiral path 5 and an oblong-shaped drawn element 6a at the internal end of the spiral path 5. The shell 2a shown in Figure 4a has, at the external end of the spiral path 5, a substantially circular-shaped drawn element 6, and at the internal end of the spiral path 5, a slot-shaped opening 7 having a shape that is substantially the same as that of the drawn element 6a.

**[0019]** By connecting together the shells 2 and 2a a heat-exchanger element 2 with a central opening 8 and a peripheral opening 7 is obtained for the entry and exit of a heat-exchanging fluid in the heat-exchanger element 2. Fluid entry in the heat-exchanger element 2 can occur through the opening 8 and the exit can occur through the opening 7, or vice versa.

**[0020]** Figures 5 and 5a show the shells 2 and 2a of a second embodiment of a heat-exchanger element 2 according to the invention, in which the opening 8 has a buttonhole shape, the opening 7 is circular in shape, the drawn element 6 has an elongated shape corresponding to that of the opening 8 and the drawn element 6a is circular in shape.

**[0021]** Figures 6 and 6a show the shells 2 and 2a of a third embodiment of a heat-exchanger element 2 according to the invention, in which the openings 7 and 8 and the drawn elements 6, 6a all have a substantially

circular shape.

**[0022]** Figures 7 and 7a show the shells 2 and 2a of a fourth embodiment of a heat-exchanger element 2 according to the invention, in which the openings 7 and 8 have a buttonhole shape and the drawn elements 6, 6a have an elongated shape substantially corresponding to that of the openings 7 and 8.

**[0023]** Figures 8-11 show a heat exchanger 10 made by assembling together a plurality of heat exchanger elements 1. As can be easily appreciated from Figures 8, 10, 11, the heat exchanger elements 1 are assembled in such a way as to constitute a sort of compact "pack" in which between pairs of adjacent elements 1 passages 11 are defined through which the exhaust gases can pass that are produced by a burner associated with the heat exchanger, which in this case touch both faces of each heat-exchanger element 1. All this enables the heat-exchange surface of the exchanger 10 to be maximised per unit of volume of the exchanger, thus obtaining an exchanger 10 with great specific power and very reduced dimensions. The path of the heat-exchanging fluid that circulates in the exchanger 10 is indicated by the arrows F in Figure 10.

**[0024]** Figures 12 and 13 show a version of a shell 12 of a heat-exchanger element.

**[0025]** In this version, the shell 12 is provided, on the face intended to be turned to the outside of the heat-exchanger element, with spacer means 13, for example in the form of projections intended to keep the heat exchanger elements spaced apart at a preset distance when they are assembled to form a heat exchanger 10. This enables passages 11 to be obtained in the heat exchanger 10 that have preset and constant dimensions for the passage of the fumes produced by the burner associated with the heat exchanger.

**[0026]** Figures 14 and 15 show a combustion chamber 14, inside which a heat exchanger 10 according to the invention is arranged. The upper part of the combustion chamber 14 is closed by a burner 15, substantially having the shape of a cylindrical sector with a concave-shaped diffuser 16 facing inside the combustion chamber 14, that at least partially surrounds the heat exchanger 10. A burner of this type has been disclosed in Italian patent application M02004A000031 of the same applicant, to which reference is made, for a detailed description of the burner 15. The burner 15 is shown schematically in Figure 19.

**[0027]** The heat-exchanging fluid is taken to the exchanger 15 by an inlet conduit 25, connected to the inlet opening 8 of a first heat-exchanger element 1 of the exchanger 10, placed at a first end of the exchanger 10, and exits from the exchanger through an outlet conduit 25 connected to the outlet opening 7 of a last heat-exchanger element 1 of the heat exchanger 10, placed at a second end of the exchanger 10 opposite said first end.

**[0028]** The burner 15 shuts the combustion chamber 14 at the top, surrounding part of the heat exchanger

10. The fumes produced by the combustion of a mixture of air and fuel taken to the burner 10 touch the external surface of each heat-exchanger element 1 and are discharged through a discharge conduit 27 communicating through an opening 28 with the combustion chamber 14.

[0029] In Figure 15, the path of the fumes in the combustion chamber and in the discharge conduit is indicated by the arrows F2, F3, and F4. The inlet and outlet of the heat-exchanging fluid are indicated by the arrows F5 and F6.

[0030] As can be seen by Figures 14 and 15, the heat exchanger 10 according to the invention enables an extremely compact combustion chamber to be made with extremely reduced overall dimensions. In fact, the high specific power of the exchanger according to the invention is translated into a reduction of the overall dimensions of the heat exchanger compared with a prior-art exchanger of equal power.

[0031] The combination, shown in Figure 14, between a heat exchanger according to the invention and a burner like the one in Figure 18 is purely by way of non-limitative example. In fact, a heat exchanger according to the invention can be combined with any other type of burner.

[0032] Figures 16 and 16a show a further variation of a heat-exchanger element according to the invention. The heat-exchanger element consists of two shells 17, 17a having an approximately square shape with curved sides. Inside each of the two shells 17, 17a seats 18, 18a are obtained by drawing that are respectively spiral-shaped. Between the seats 18 and 18a the sheet metal or plastics material strip 4 is inserted which, when the two shells 17 and 17a are brought and fixed together to constitute a heat-exchanger element, defines a spiral path 19 inside the heat-exchanger element.

[0033] The shape of the shells 17, 17a enables the heat-exchange surface of a heat-exchanger element obtained with them to be significantly increased, increasing the overall external dimensions to a limited extent.

[0034] Figures 17 and 18 show a still further version of a heat-exchanger element 20 according to the invention consisting of two shells 21 and 21a. In this version, inside the heat-exchanger element 20 a spiral path 22 is defined for a heat-exchanging fluid by spiral-shaped drawn elements 23 and 24 obtained in the shells 21 and 21a. The depth of the drawn elements 23 and 24 is such that their internal walls are very close or in contact with one another, together constituting the walls that delimit the spiral path 22.

[0035] In the practical embodiment, the materials, dimensions and practical details may be different from those shown but be technically equivalent to them without falling outside the legal scope of the present invention.

## Claims

1. Heat-exchanger element (1; 20) suitable for permitting the circulation in its interior of a heat-exchanging fluid, said heat-exchanger element (1; 20) being provided with at least an inlet (7; 8) and with at least an outlet (7; 8) for said fluid, **characterised in that** inside said heat-exchanger element (1; 20) at least a path (5; 19; 22) is defined for the circulation of said fluid, said at least a path having a total cross section that is noticeably less than the maximum cross section of said heat-exchanger element (1; 20).
2. Heat-exchanger element (1; 20) according to claim 1, **characterised in that** said path (5; 19; 22) has a substantially spiral shape.
3. Heat-exchanger element (1; 20) according to claim 1, or 2, **characterised in that** it consists of two shells (2, 2a; 12; 17, 17a; 21, 21a) inside which said path (5; 19; 22) is defined.
4. Heat-exchanger element (1) according to claim 3, wherein in each of said shells (2, 2a; 12; 17, 17a) a respective seat (3, 3a; 18, 18a) is obtained, said seats (3, 3a; 18, 18a) substantially mirroring one another, between said seats (3, 3a; 18, 18a) a strip means (4) being insertable that delimits said path (5; 19).
5. Heat-exchanger element (1) according to claim 4, wherein said strip means (4) is made of metal or plastics material.
6. Heat-exchanger element (20) according to claim 3, wherein in each of said shells (21, 21a) a respective drawn element (23, 24) is obtained that is substantially spiral-shaped, said drawn elements (23, 24) substantially mirroring one another and being made in such a way that their inner walls are very near, or in contact with one another, in such a way as to delimit said path (22).
7. Heat-exchanger element (1; 20) according to any one of claims 2 to 6, wherein in each of said shells (2, 2a; 12; 17, 17a; 21, 21a) a first drawn element (6) is obtained at a first end of said spiral path (5; 22) and a second drawn element (6a) at a second end of said spiral path (5; 22) opposite said first end.
8. Heat-exchanger element (1; 20) according to claim 7, wherein said first drawn element (6) has a substantially circular shape, or elongated shape.
9. Heat-exchanger element (1; 20) according to claim 7, or 8, wherein said second drawn element (6a) has a substantially circular or elongated shape.

10. Heat-exchanger element (1; 20) according to any one of claims 7 to 9, wherein in one of said drawn elements (6, 6a) an opening (7; 8) is obtained.
11. Heat-exchanger element (1; 20) according to claim 10, wherein said opening (7; 8) has a shape substantially corresponding to the shape of the drawn element (6; 6a) in which it is obtained. 5
12. Heat-exchanger element (1; 20) according to claim 10, or 11, wherein in a first shell (2; 12; 17; 21) of said shells (2, 2a; 12; 17, 17a; 21, 21a) said opening (8) is obtained in said first drawn element (6). 10
13. Heat-exchanger element (1; 20) according to any one of claims 10 to 12, wherein in a second shell (2a; 12; 17a; 21a) of said shells (2, 2a; 12; 17, 17a; 21, 21a) said opening (7) is obtained in said second drawn element (6a). 15
14. Heat-exchanger element (1; 20) according to any preceding claims, wherein said shells (2, 2a; 12; 21, 21a) have an external profile that is substantially spiral-shaped. 20
15. Heat-exchanger element according to claim 14, wherein said seats (3, 3a) are substantially spiral-shaped. 25
16. Heat-exchanger element (1; 20) according to any one of claims 1 to 13, wherein said shells (17, 17a) have a noticeably quadrangular shape, with curved sides 30
17. Heat-exchanger element (1; 20) according to claim 16, wherein said seats (18, 18a) are constituted by a series of consecutive portions that are substantially parallel to said sides. 35
18. Heat-exchanger element (1; 20) according to any preceding claims, wherein each of said shells (12) is provided, on its outer surface, with spacer elements (13). 40
19. Heat-exchanger element (1; 20) according to any preceding claims, wherein said shells (2, 2a; 12; 17, 17a; 21, 21a) are connected together along respective peripheral edges (9; 9a) by fusion welding. 45
20. Heat-exchanger element (1; 20) according to any one of claims 1 to 18, wherein said shells (2, 2a; 12; 17, 17a; 21, 21a) are connected together along respective peripheral edges (9; 9a) by braze welding. 50
21. Heat-exchanger element (1; 20) according to any one of claims 1 to 18, wherein said shells (2, 2a; 12; 17, 17a; 21, 21a) are connected together along respective peripheral edges (9, 9a), by a mechanical joint with seal. 55
22. Heat-exchanger element (1; 20), according to any one of claims 19 to 21, wherein the peripheral edge (9) of a first shell (2) is shaped in such a way as to be superimposable on the corresponding peripheral edge (9a) of the second shell (2a).
23. Heat exchanger (10) comprising a plurality of elements (1; 20) which are connectable to one another serially or in parallel, **characterised in that** said heat exchanger elements (1; 20) are heat exchanger elements according to any one of claims 1 to 22.
24. Heat exchanger (10) according to claim 23, **characterised in that** between a heat-exchanger element (1; 20) and the elements (1; 20) adjacent thereto passages (11) are defined suitable for allowing the passage of fumes produced by a burner.
25. Combustion unit comprising a burner (16) and a heat exchanger (10) insertable in a combustion chamber (14), **characterised in that** the heat exchanger (10) is a heat exchanger (10) according to claim 22, or 23.
26. Combustion unit according to claim 25, wherein said burner (16) has a cylindrical sector shape with a diffuser with a concave shape facing said heat exchanger (10), that at least partially surrounds the heat exchanger (10).

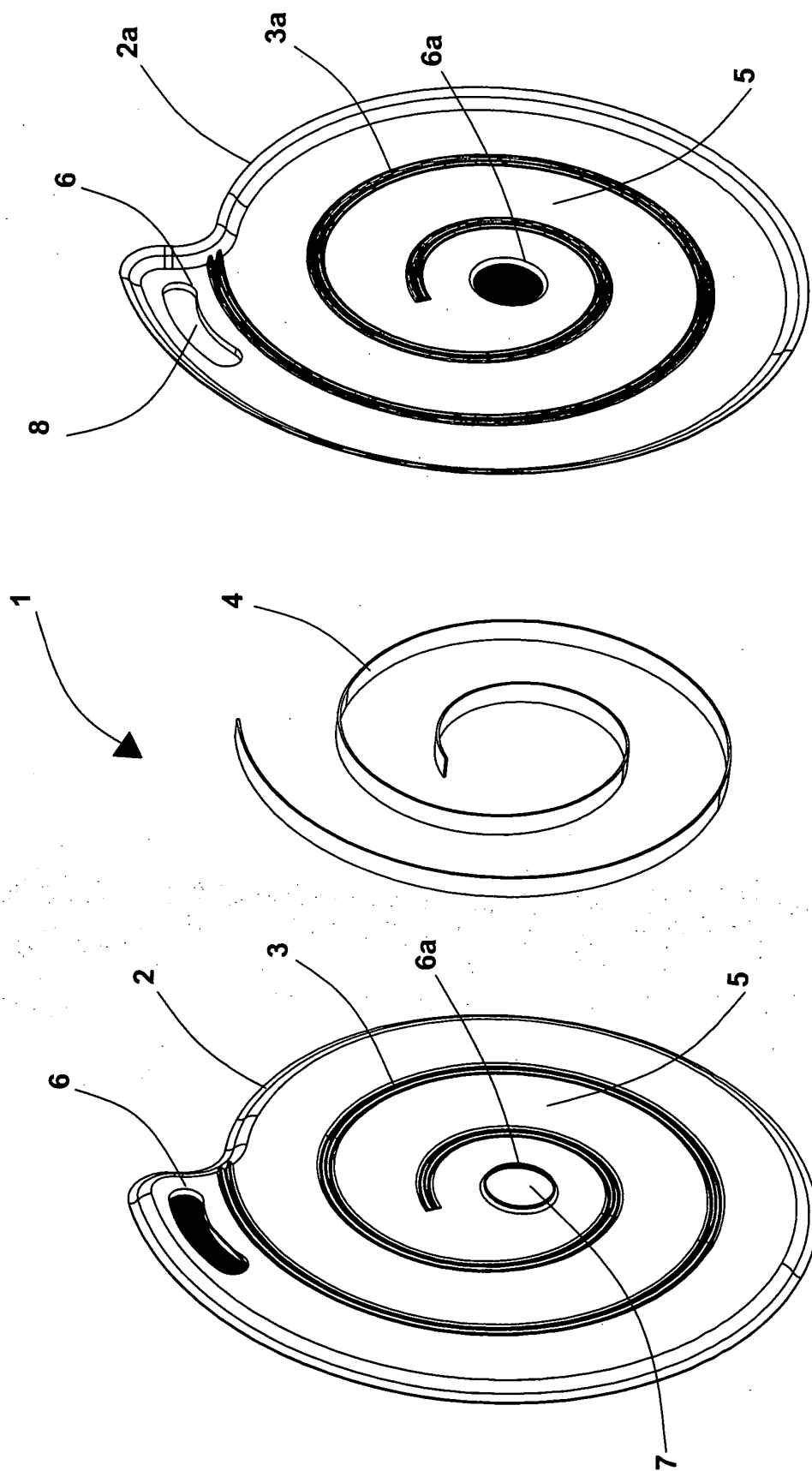
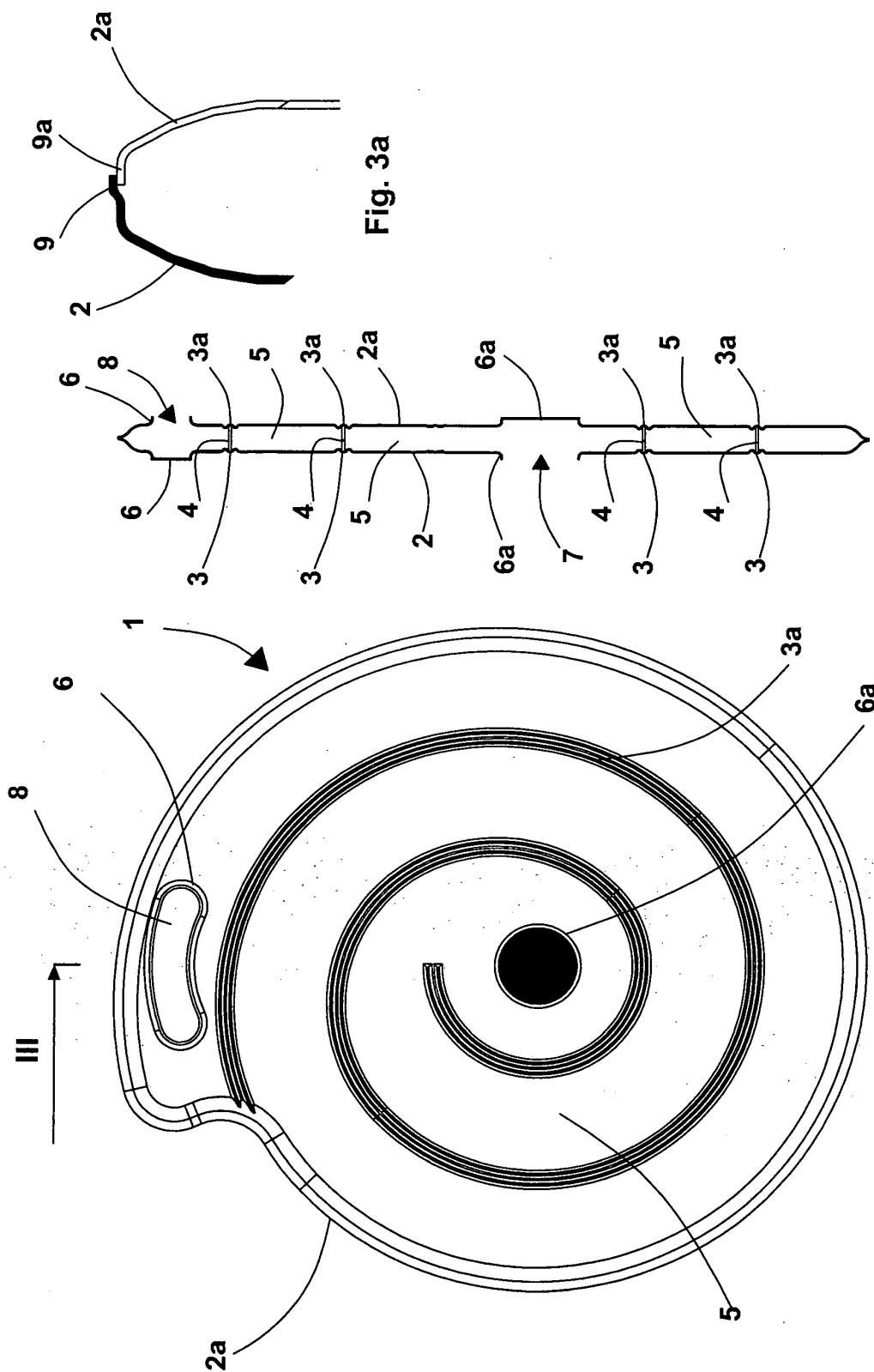


Fig. 1



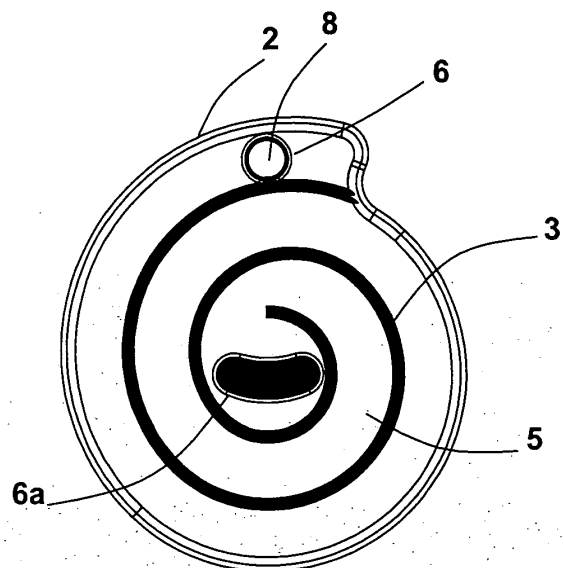


Fig. 4

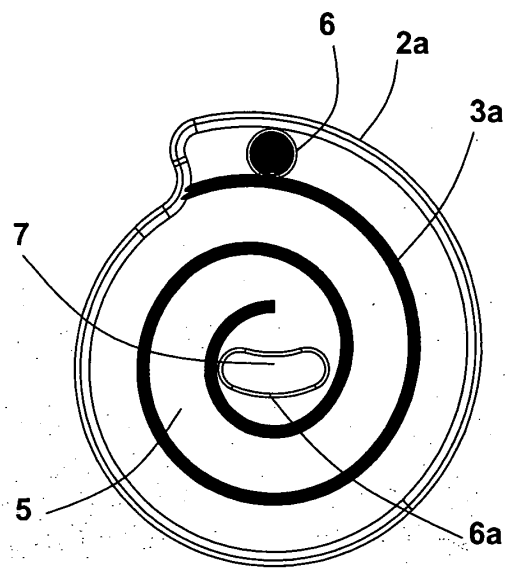


Fig. 4a

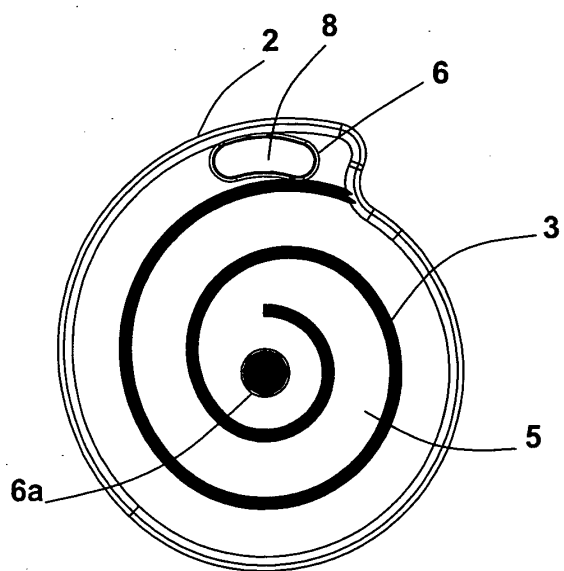


Fig. 5

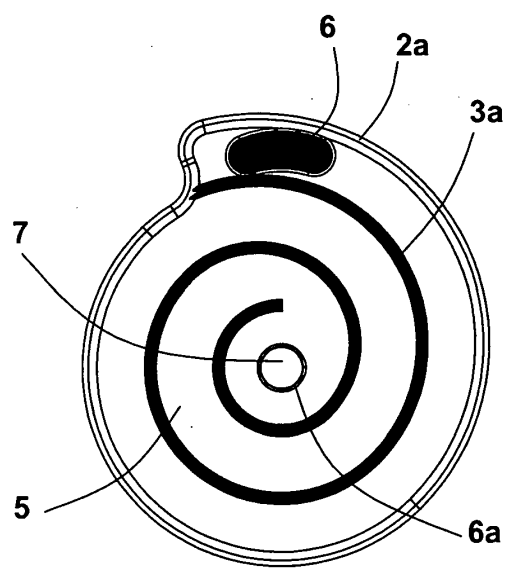


Fig. 5a

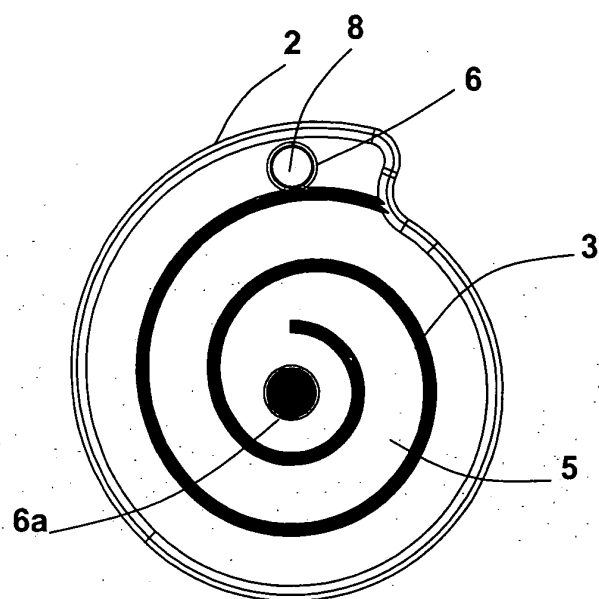


Fig. 6

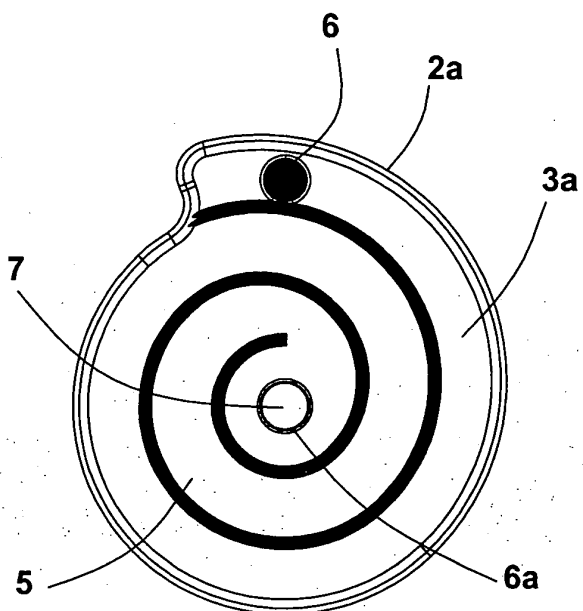


Fig. 6a

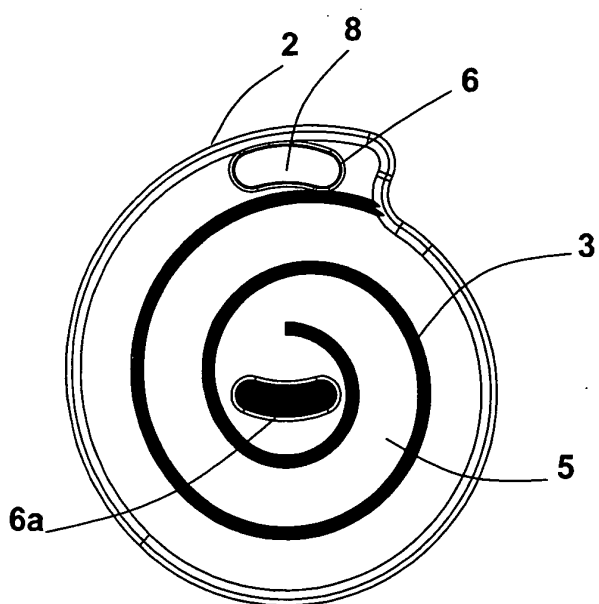


Fig. 7

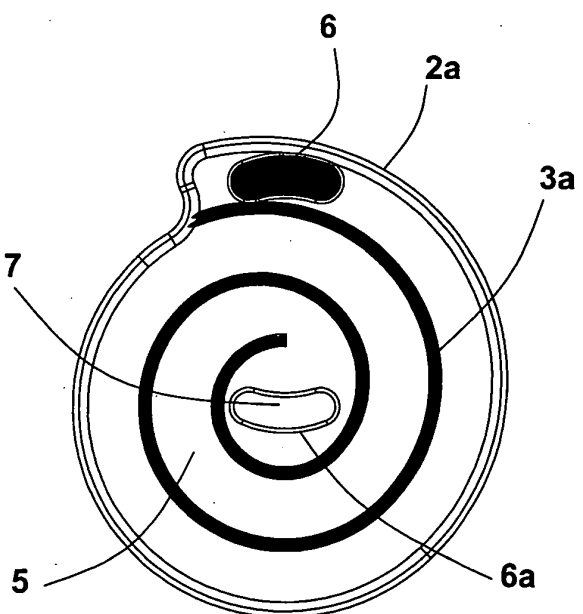


Fig. 7a

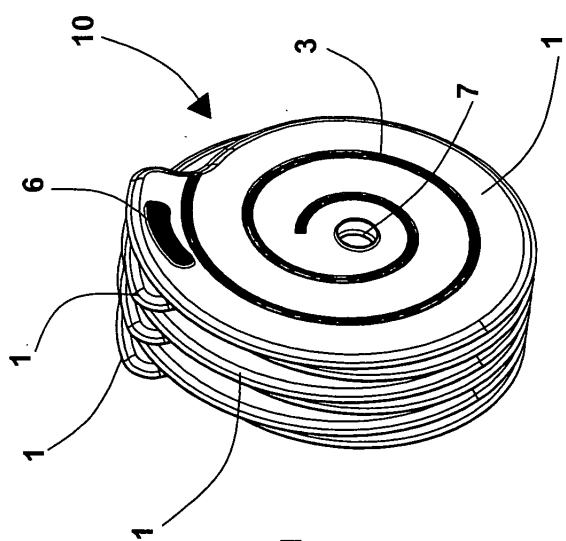


Fig. 8

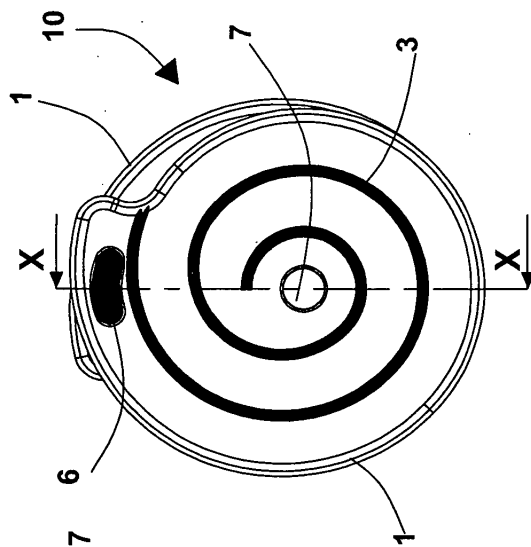


Fig. 9

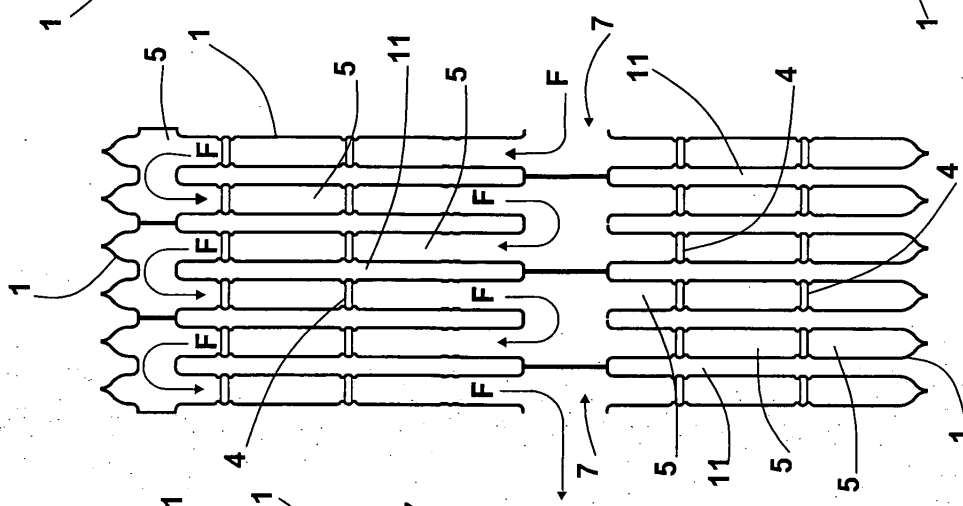


Fig. 10

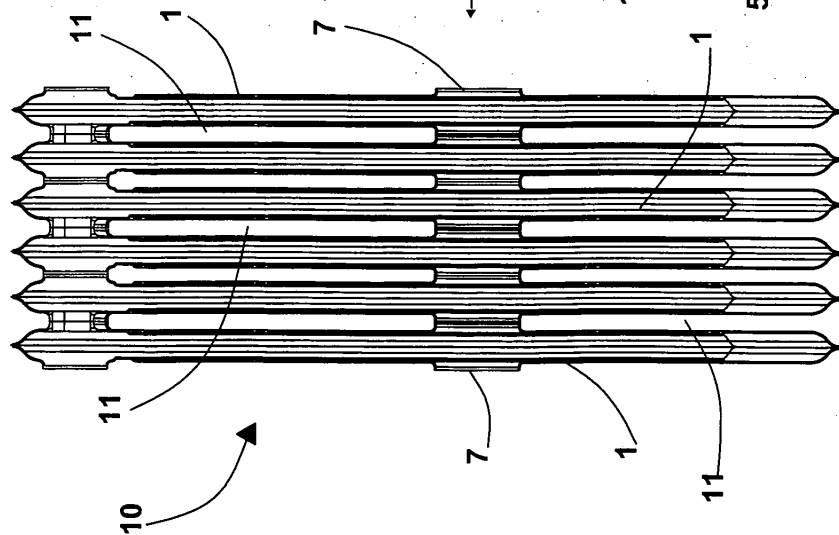


Fig. 11

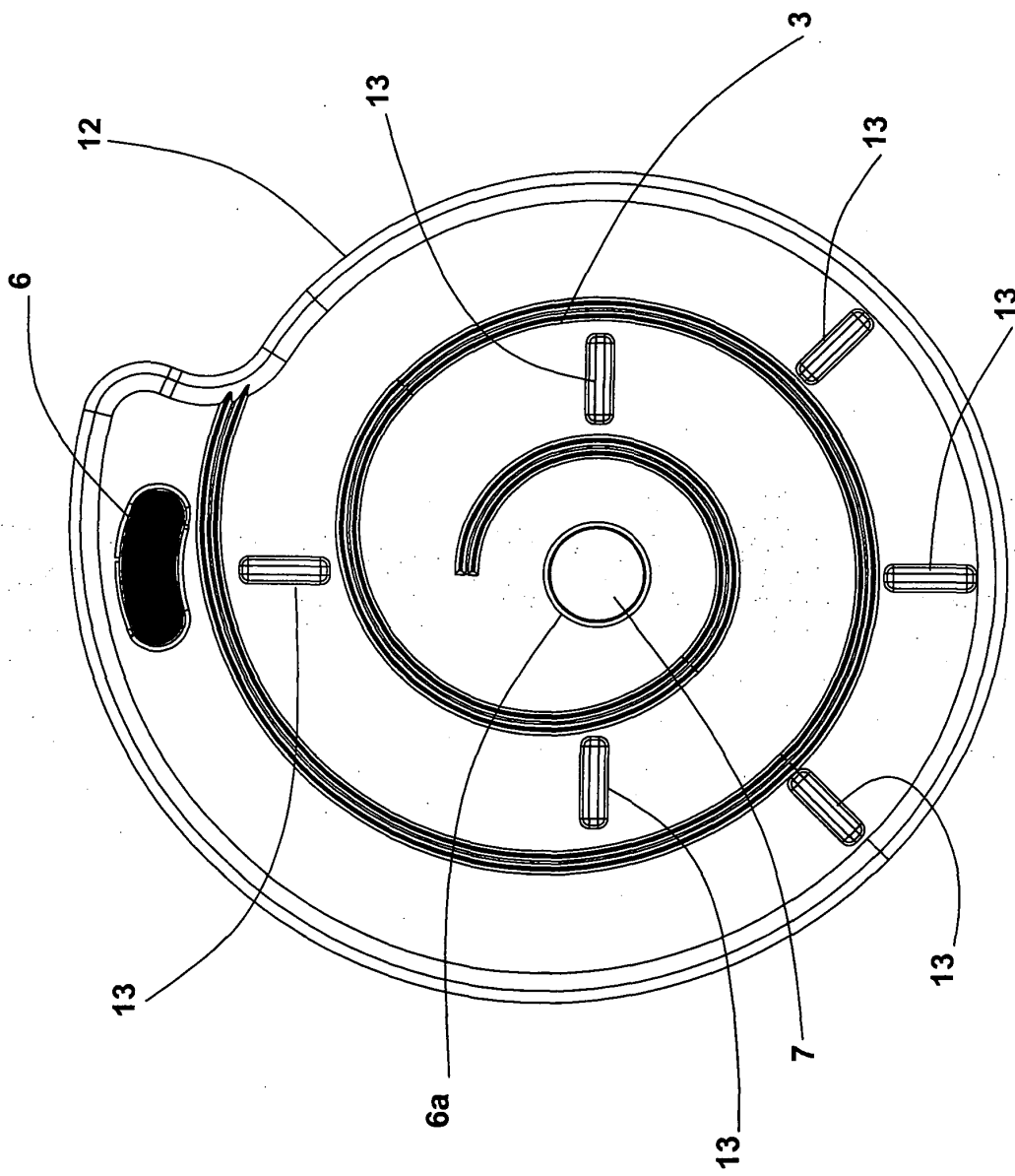


Fig. 12

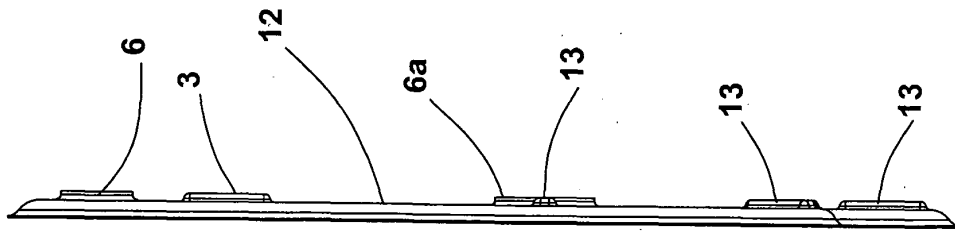


Fig. 13

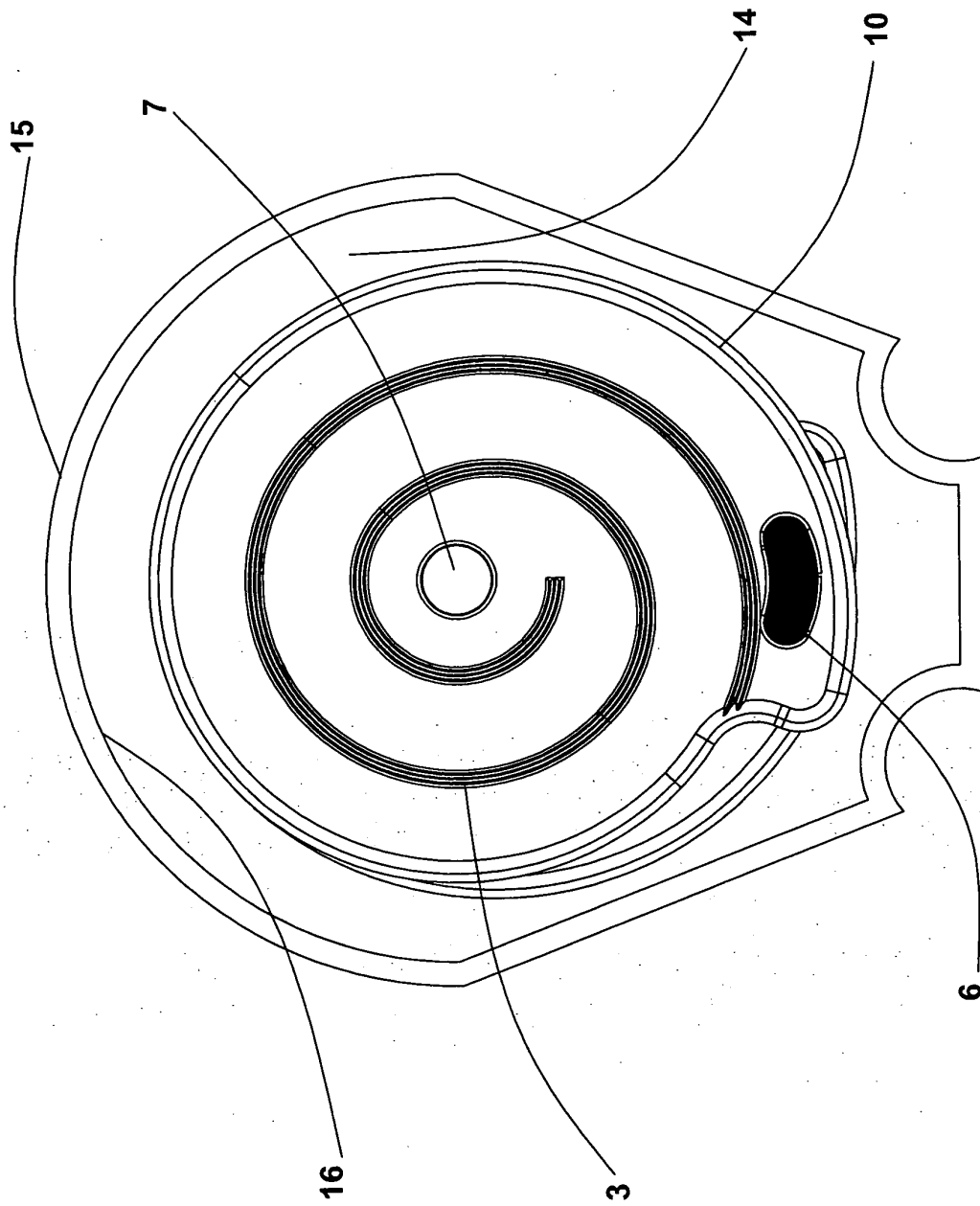


Fig. 14

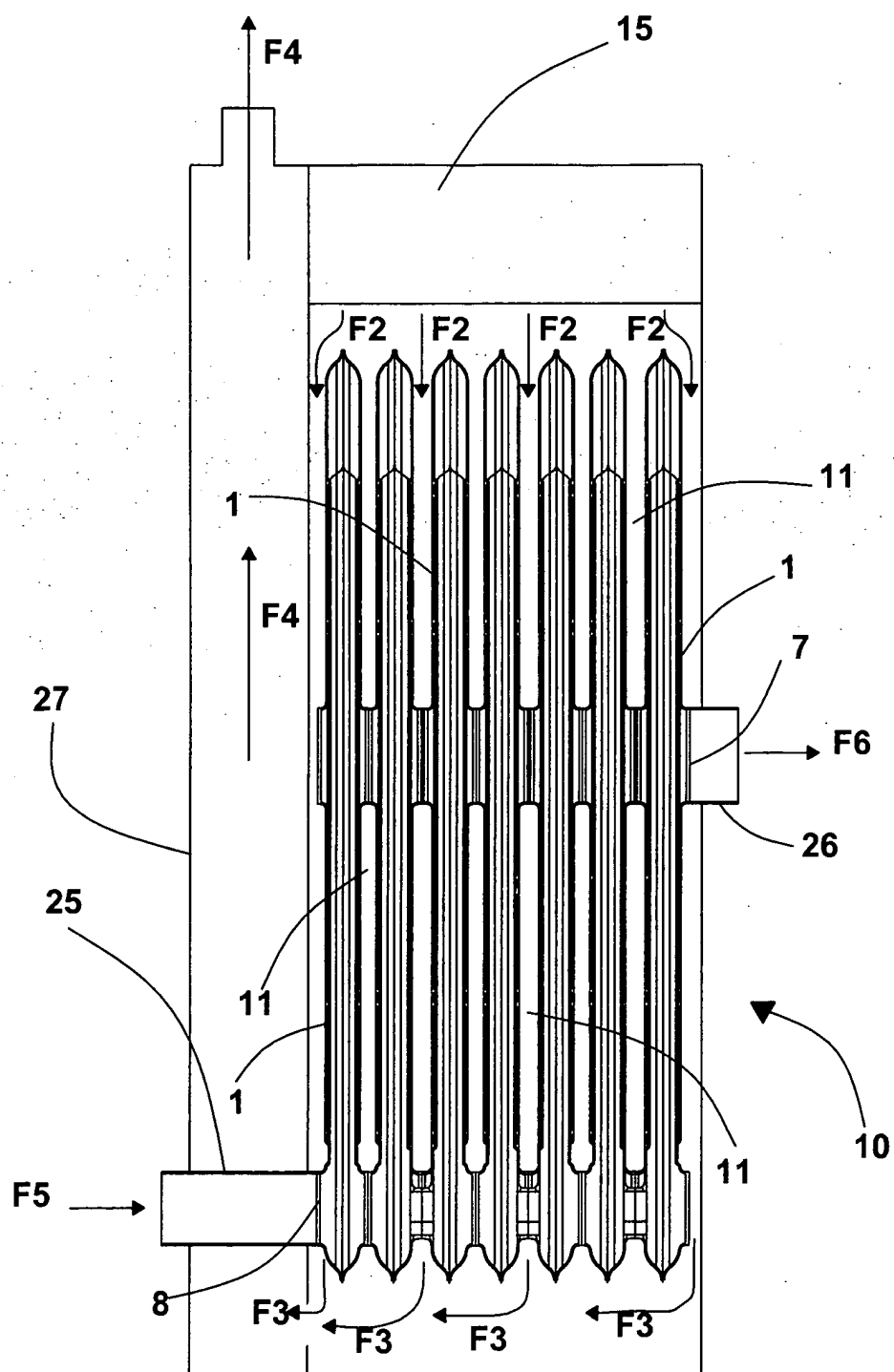


Fig. 15

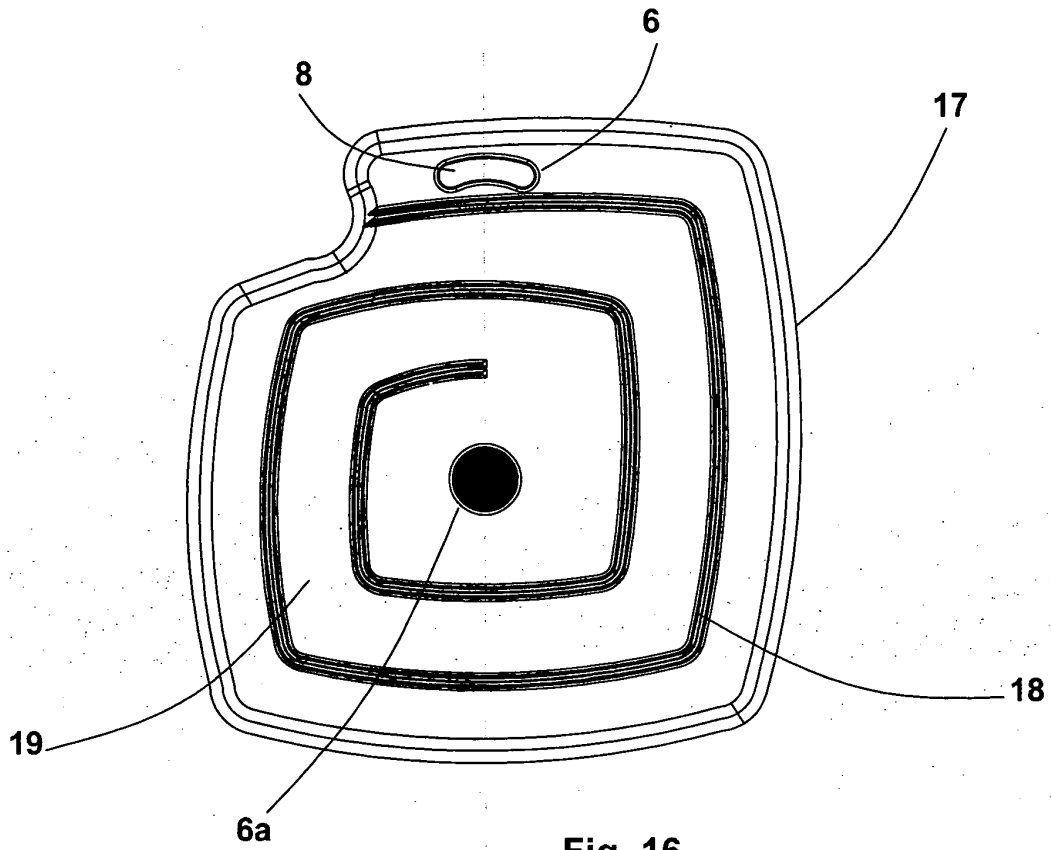


Fig. 16

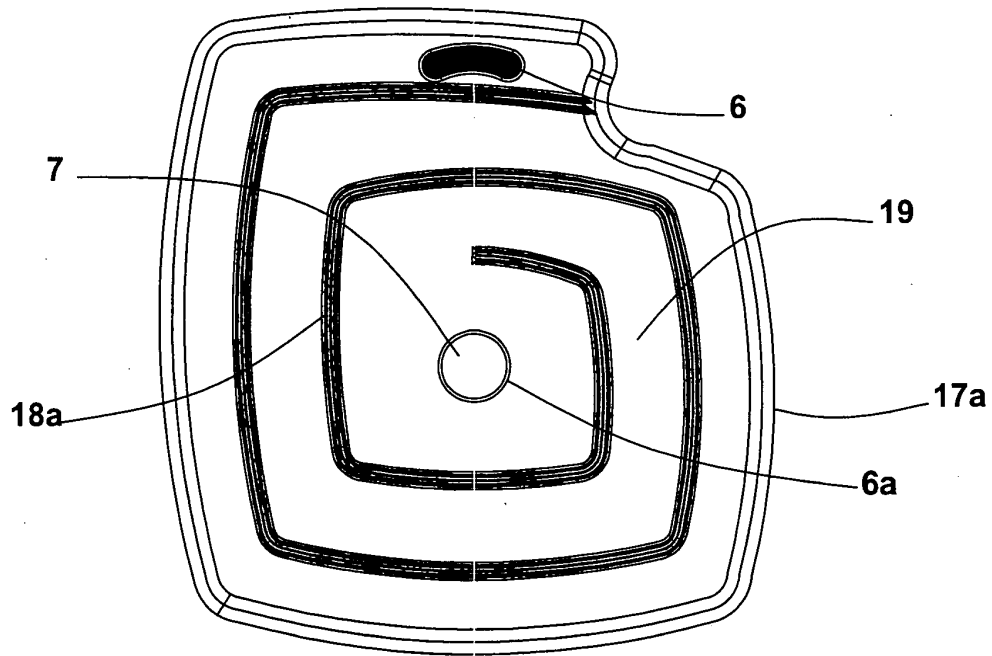


Fig. 16a

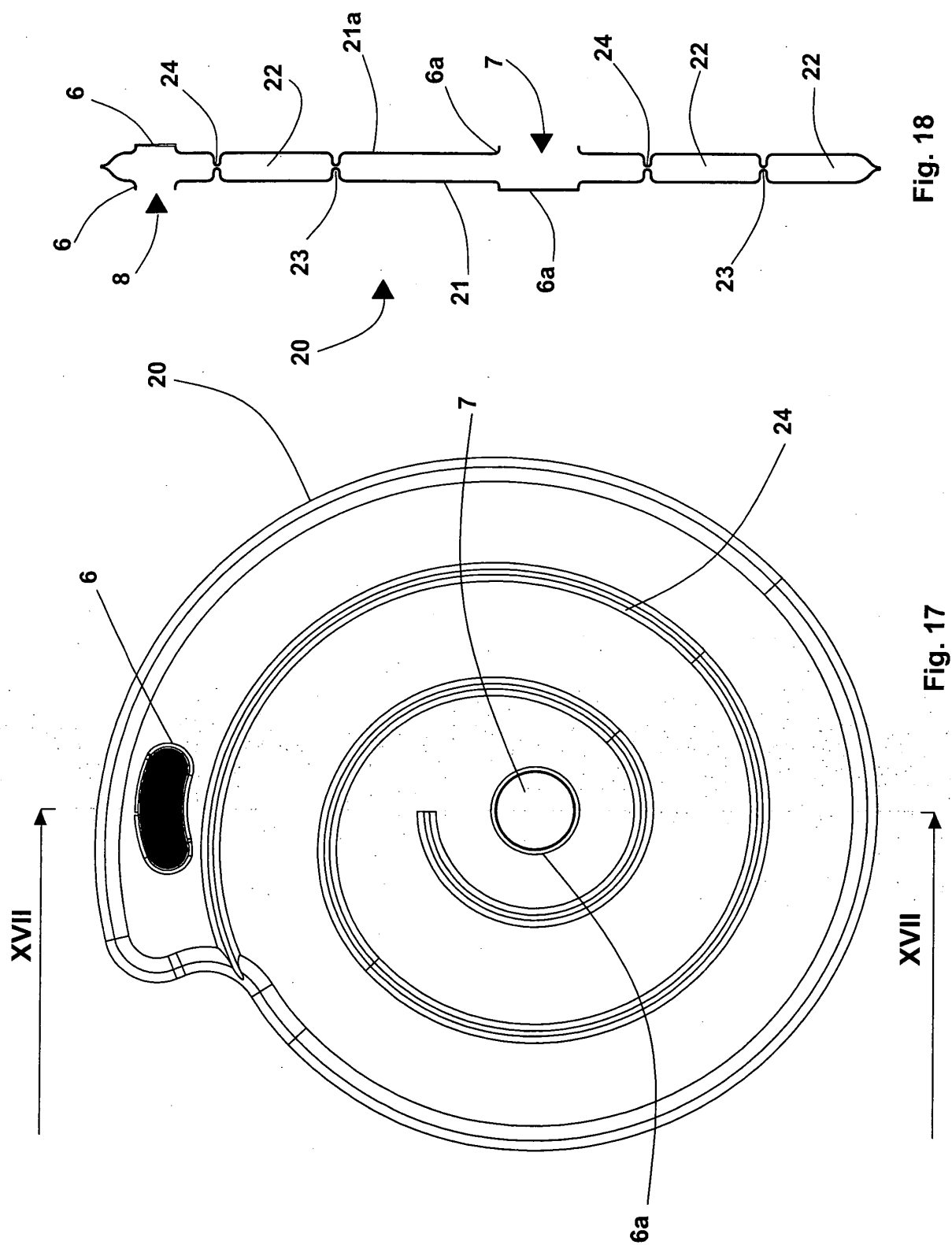
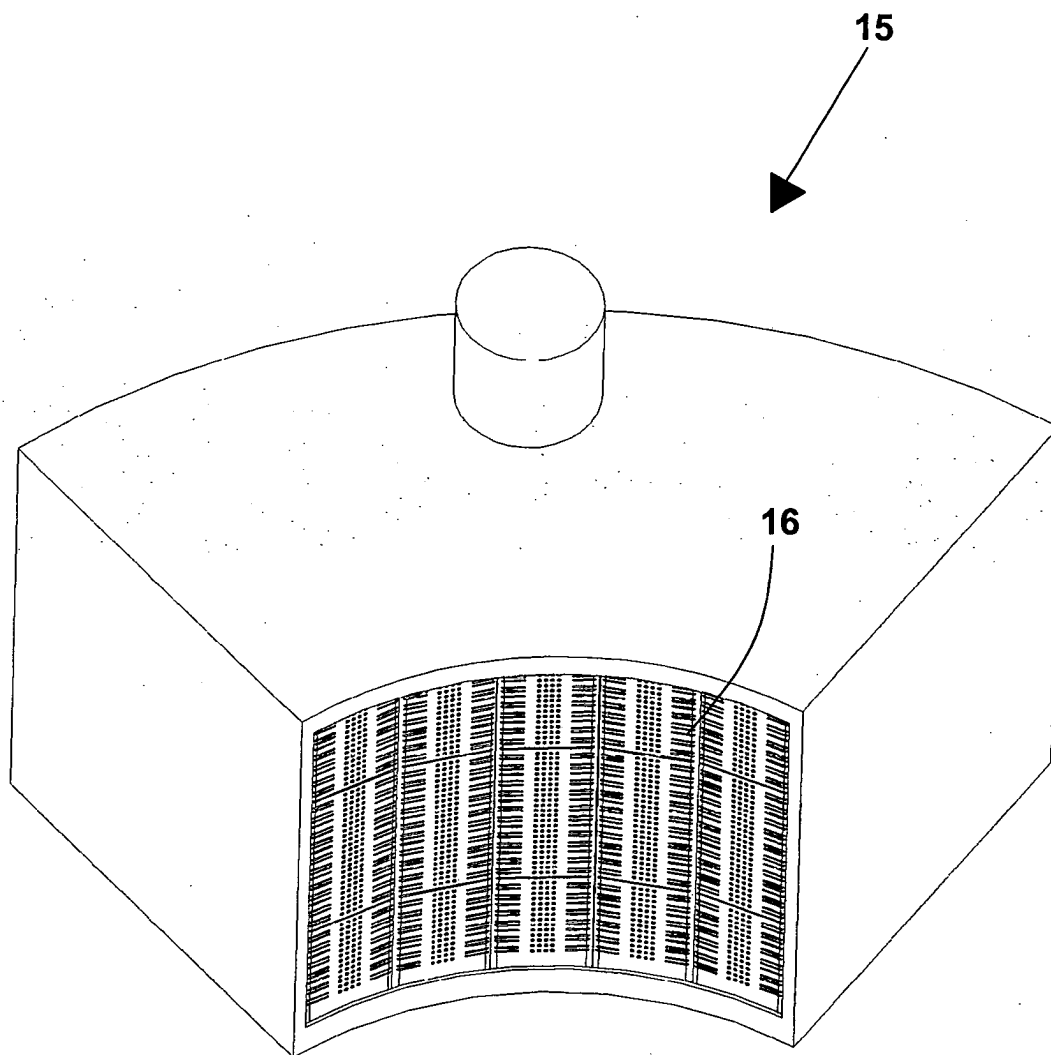


Fig. 18

Fig. 17



**Fig. 19**