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(54) **A SPACER DEVICE FOR PRODUCING WOUND HEATING ELEMENTS AND A WOUND HEATING ELEMENT**

(57) The invention relates to a spacer device (13) for producing wound heating elements (31), the spacer device (13) comprising a windable carrier (75) with spacer elements (9) arranged thereon, wherein the spacer elements (9) have a base by which the spacer elements (9) are connected to the carrier (75), or wherein the carrier (75) is formed by adjacent bases contacting each other,

and wherein in unwound condition a gap (73) is formed between adjacent spacer elements (9) in winding direction of the carrier (75). The invention further relates to a wound heating element (31) comprising such spacer devices (13) and a heat exchanger comprising the wound heating element (31).

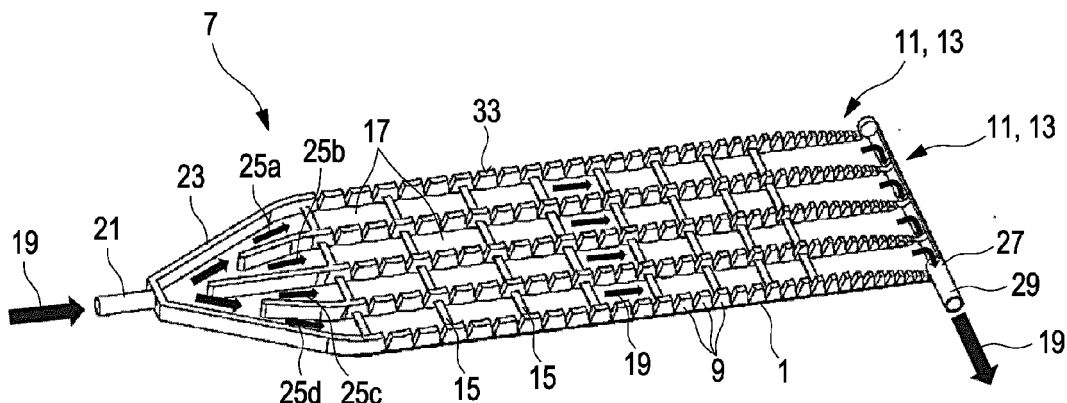


Fig. 2

Description

[0001] The invention relates to a spacer device for producing wound heating elements and a wound heating element comprising a heating film and such spacer devices.

[0002] Wound heating elements comprising a heating film particularly can be used for heating a fluid by electrical energy where heating elements with a large surface are to be placed in a compact installation space. Common applications where such heating elements may be used are, for example, air-conditioning systems in vehicles, tanks for operating liquids in vehicles, or heating devices to heat a battery of an electric vehicle to bring the battery to operating temperature.

[0003] For heating a tank for operating liquids, it is for example known from DE 10 2013 210 742 A1 to provide a heating mat which is arranged on elevations on the bottom of the tank.

[0004] Devices for heating a secondary battery module are disclosed for example in US 2006/0210868 A1 or DE 10 2016 121 838 A1. Here, positive temperature coefficient (PTC) heaters are used for heating a heat transfer medium which is used for heating the battery.

[0005] Presently, particularly PTC heaters made of ceramic are used. Due to their form and size, these PTC heaters cannot provide large surfaces for heat transfer and, further, it is not possible to form PTC heaters efficient regarding the flow of the heat transfer medium.

[0006] For placing a large heating film into a compact installation space, DE 10 2015 203 665 A1 describes wound heating elements which may be used in air-conditioning systems of vehicles. The heating element comprises a heating film with an electrically insulating carrier material and at least one electrical conductive heating path. To provide a distance between layers of the heating film, spacer elements are used, the spacer elements being arranged between the layers of the heating film.

[0007] A spirally wound heating film in a cylindrical housing is described in EP 3 731 596 A2. Here, the heating film comprises PTC (positive temperature coefficient) resistor elements. Further, the heating film is arranged in such a way that a first spiral-shaped flow channel section is formed which winds inwards around the cylinder axis of the housing with decreasing distance from the cylinder axis and a second spiral-shaped flow channel section is formed which winds outwardly around the cylinder axis of the housing with increasing distance from the cylinder axis.

[0008] It is an object of the present invention to provide a spacer device for producing wound heating elements which allows an easier assembly of the heating elements and by which further the flow of a heating medium can be adjusted.

[0009] This object is achieved by a spacer device for producing wound heating elements, the spacer device comprising a windable carrier with spacer elements ar-

ranged thereon, wherein the spacer elements have a base by which the spacer elements are connected to the carrier, or wherein the carrier is formed by adjacent bases contacting each other, and wherein in unwound condition a gap is formed between adjacent spacer elements in winding direction of the carrier.

[0010] To achieve a defined height of a channel formed between two adjacent layers of a heating film in the wound heating element, usually at least two lines of spacer elements are necessary. For this purpose, it is either possible to fix at least two spacer devices with each comprising one line of spacer elements on an upper surface of the heating film or to fix one spacer device on the upper surface of the heating film, if the spacer device comprises at least two lines of spacer elements on a carrier.

[0011] The spacer devices comprising the windable carrier and the spacer elements can be easily fixed on the upper surface of the heating film and subsequently the heating film is wound to produce the wound heating element. By winding, a bottom surface of the heating film comes into contact with upper sides of the spacer elements. Thus, by the spacer elements a predefined distance between adjacent layers of the heating film is set, the distance between the adjacent layers corresponding to the height of the spacer elements.

[0012] By the geometry of the spacer elements, particularly the length of the base in winding direction, the height of the spacer elements and the geometry of the gap between two adjacent spacer elements, the geometry of the wound heating element is defined. If all spacer elements have the same geometry, the cross-sectional shape of the wound heating element usually is cylindrical. However, besides a cylindrical cross-sectional shape, also an oval shape, an elliptical shape or any other shape may be possible.

[0013] To allow winding of the heating film with the spacer device fixed thereon, it is necessary that the gap is formed between adjacent spacer elements. Particularly for the innermost spacer elements after winding, i.e. the spacer elements at the position where winding of the heating film with the spacer device is started, the winding radius is defined by the shape of the spacer elements and the distance between the upper sides of adjacent spacer elements.

[0014] Further, by the shape of the spacer elements and the arrangement of the spacer devices on the heating film, it is possible to define the flow of the fluid to be heated in the channel formed by the spacer elements and the heating film in the wound heating element.

[0015] It is for example possible that all spacer elements arranged in one line have the same width perpendicular to the winding direction and are arranged in parallel. In this case the cross-sectional geometry of the channel being enclosed from the spacer elements and the heating film remains constant in winding direction and, thus, in flow direction of the fluid to be heated. On the other hand, it may be suitable to design the channel being enclosed from the spacer elements and the heating

film in such a way that the cross-sectional area increases or decreases. This may be achieved for example by using spacer elements with increasing or decreasing width in the winding direction. If spacer elements with decreasing width in winding direction are used and the spacer devices are arranged in parallel the cross-sectional area of the channel increases. Accordingly, if the width of the spacer elements increases in winding direction the cross-sectional area of the channel decreases.

[0016] If the spacer elements in one line have different widths a parallel arrangement of adjacent lines of spacer elements means that the lines connecting the center of the basis of the first spacer element and the center of the basis of the last spacer element in each line of spacer elements are parallel.

[0017] Besides using spacer elements having different widths for providing increasing or decreasing cross-sectional areas of the channels being enclosed by the spacer elements and the heating film, it is further possible to fix the spacer devices in such a way that the distance of the spacer elements increases or decreases in winding direction.

[0018] Further, depending on the shape of the gap, it is possible to avoid a cross-flow between adjacent channels or to allow such a cross-flow. For avoiding a cross-flow, the gap is shaped in such a way that adjacent faces of spacer elements are in contact after winding along their total height. If a cross-flow is allowed, the gaps are shaped such that there is still a gap after winding.

[0019] Usually, to avoid a cross-flow and to achieve closed channel walls, the gaps between adjacent spacer elements are V-shaped. If a cross-flow is allowed or intended, the gaps for example may have a U-shape or any other shape. Further, for allowing a cross-flow, there may be holes in the spacer elements or the gaps may have a shape that such holes are formed after winding.

[0020] To avoid a cross-flow and to achieve an essentially fluid-tight connection of adjacent spacer elements, it is further possible that one side of the spacer element oriented perpendicular to the winding direction of the carrier comprises a groove and another side of the spacer element oriented perpendicular to the winding direction of the carrier comprises a tongue, such that in wound condition the tongue of one spacer element engages in the groove of an adjacent spacer element. By the engagement of the tongue into the groove an essentially fluid-tight connection is achieved and a closed wall is formed by the spacer elements.

[0021] Alternatively or additionally for varying the cross-sectional area of the channel formed between the spacer elements and the heating film, it is also possible to vary the height of the spacer elements in one line. With an increasing height, also the cross-sectional area of the channel increases and with a decreasing height, the cross-sectional area of the channel decreases.

[0022] If the channel is designed in such a way that the cross-sectional area varies, generally, the variation is such that the cross-sectional area of the channel in-

creases along the whole length of the channel in the winding direction of the carrier, or, alternatively, that the cross-sectional area of the channel decreases along the whole length of the channel in the winding direction of the carrier. This means, that the height and/or the width of the spacer elements increases or decreases from the first spacer element to the last spacer element in one line.

[0023] In the context of the present invention, "length" refers to the extension in winding direction, "width" refers to the extension perpendicular to the winding direction parallel to the carrier or heating film and "height" refers to the extension perpendicular to the plane of the carrier or heating film.

[0024] To achieve a spacer device having at least one line of spacer elements, the spacer device comprises the carrier onto which the spacer elements are arranged. If the spacer device comprises only one line of spacer elements, the carrier for example may be a ribbon onto which the spacer elements are arranged. Even though the ribbon may have a width differing from the width of the spacer elements, it is preferred that the width of the ribbon corresponds to the width of the spacer elements.

[0025] As an alternative, the spacer device may comprise at least two lines of spacer elements. In this case, the carrier preferably is a film with the at least two lines of spacer elements, the lines of spacer elements being arranged at a distance from each other.

[0026] Regardless of whether the carrier is a ribbon or a film, the carrier is configured such that the spacer device can be wound. Suitable materials, the ribbon or film can be made of are for example metal films or polymer films. Preferably, the carrier is made in one piece. The material is preferably thermoplastic, elastomer-modified plastic or a multi-component part. The manufacturing technologies are preferably injection molding (with film hinges), multi-component injection molding (e.g. with rotary tool, transfer technique), injection molding, blow molding, deep drawing.

[0027] Besides using a ribbon or a film, it is also possible to connect the bases of adjacent spacer elements, for example by short film sections or hinges.

[0028] The spacer elements can be fixed to the film or ribbon or to the short film sections or hinges by any suitable method known to the skilled person. Preferably, the spacer elements are fixed to the film, the ribbon or to the film sections or hinges by gluing or welding. As an alternative, particularly if the spacer elements and the carrier are made of a polymer material, it is possible to form the spacer elements and the carrier integrally as one piece.

[0029] After connecting the spacer elements to the carrier, there may be a distance between the bases of two adjacent spacer elements or alternatively, the bases of two adjacent spacer elements are in contact with each other. Preferably, the bases of two adjacent spacer elements are in contact with each other. Particularly if a channel wall is formed by the spacer elements and the channel wall shall be fluid-tight, it is mandatory that the bases of adjacent spacer elements are in contact with

each other.

[0030] The spacer device is used for producing a heating element. The heating element comprises a heating film and at least one spacer device, if the carrier is a film with at least two lines of spacer elements, or at least two spacer devices being arranged at a distance from each other, if the carrier is a ribbon, being arranged on an upper surface of the heating film, the heating film being wound in such a way that upper sides of the spacer elements are in contact with a bottom surface of the heating film.

[0031] Due to this construction, at least one channel is formed which is enclosed by two adjacent lines of spacer elements the upper surface of the heating film and the bottom surface of the heating film which is in contact with the upper sides of the spacer elements. As the heating element is wound, each channel forms a spiral. The fluid to be heated in the heating element usually is fed at one end into the channel and leaves the channel on the other end. Thus, one connection for feeding or withdrawing the fluid to be heated is at the center of the wound heating element and one connection for withdrawing or feeding the fluid to be heated is at the outer end of the wound heating film.

[0032] Before winding the heating film, the spacer devices are fixed on the heating film. The spacer devices may be fixed on the heating film for example by welding or gluing. Preferably, the spacer is clipped to the heating film at the inner end (beginning of the winding) or held in position with centering pins in openings of the heater, but it can also be riveted, screwed, glued or welded. As an alternative, it is also possible that the spacer device is an integral part of the heating film. In this case, the heating film simultaneously also is the carrier of the spacer device and the spacer elements are fixed on the heating film or are integrally formed with the heating film.

[0033] For improving the heat transfer, it is possible to arrange the heating film as described for example in EP 3 731 596 A2. In this case, one half of the heating film comprises the spacer devices on the bottom surface and the other half of the heating film comprises the spacer devices on the upper surface, the heating film being folded such that the upper surface of that half having the spacer devices arranged on the bottom surface lies on the spacer elements of that half having the spacer devices arranged on the upper surface, the thus formed folded heating film having a bended area on one side and free ends of the heating film on the side opposite to the bended area, wherein the folded heating film then is wound such that the spacer elements of that half having the spacer devices arranged on the bottom surface are in contact with the bottom surface of that half having the spacer elements arranged on the upper surface and connections for feeding and withdrawing a fluid to be heated are arranged at the bending area.

[0034] For producing the wound heating element, it is possible to start winding of the folded heating film either with the free end so that the free ends are in the center

of the wound heating element and the bended area on the outside, or, alternatively, to start winding with the bended area so that the bended area is in the center of the wound heating element and the free ends are outside. By this design a first channel section is formed extending from the bended area to the free ends and a second channel section which extends from the free ends to the bended area.

[0035] Regardless of whether the free ends are in the center of the wound heating element or at the outside of the heating element, to allow a flow of the fluid to be heated through the whole channel it is necessary that the connections for feeding the fluid to be heated and for withdrawing the fluid to be heated both are at the bended area. In both cases the side with the free ends is designed such that the fluid to be heated leaves the first channel section, flows around one free end and enters the second channel section for flowing back to the bended area where it is withdrawn through the connection for withdrawing the fluid to be heated.

[0036] For setting the flow of the fluid to be heated in the channel being enclosed by the spacer elements, the bottom surface of the heating film and the top surface of the heating film, or, if the heating film is folded in the first and second channel sections, it may be suitable to vary the cross-sectional area. Increasing the cross-sectional area may be obtained by increasing the height of the spacer elements in one line and/or by decreasing the width of the spacer elements in one line. Accordingly, for decreasing the cross-sectional area of the channel, the height of the spacer elements in one line may decrease and/or the width of the spacer elements in one line may increase.

[0037] Further, a decrease of the cross-sectional area of one channel may be obtained by arranging two adjacent lines of spacer elements, which form the wall of the channel, in such a way that the distance of the lines of spacer elements decreases and, accordingly, an increase of the cross-sectional area of one channel may be obtained by arranging the two lines forming the walls of the channel in such a way that the distance of the spacer elements in the adjacent lines increases.

[0038] Particularly if spacer devices are used which have only one line of spacer elements, it is preferred to arrange distance pieces between the adjacent spacer devices for setting the distance between the adjacent spacer devices.

[0039] For heating the fluid to be heated, a heat exchanger is produced which comprises the heating element. Usually, for producing the heat exchanger, the heating element is placed in a housing. The heat exchanger comprises a heating element as described above, wherein the heating element is arranged such that the heating fluid flows in the at least one channel being formed between the upper surface and the bottom surface of the wound heating film by the spacer devices.

[0040] Embodiments of the invention are shown in the figures and described in more detail in the description

below.

[0041] In the figures:

- Figure 1 shows a heating film;
- Figure 2 shows an unwound heating element based on a heating film as shown in figure 1;
- Figure 3 shows the heating element of figure 2 in wound condition;
- Figure 4 shows spacer devices arranged on a heating film in a second embodiment;
- Figure 5 shows a wound heating element using the heating film as shown in figure 4
- Figure 6 shows an unwound heating element in a third embodiment;
- Figure 7 shows an exploded view of a heat exchanger using the heating element of figure 6;
- Figure 8 shows the assembled heat exchanger of figure 7;
- Figure 9 shows an unwound heating element in a fourth embodiment;
- Figure 10 shows an exploded view of a heat exchanger using the heating element of figure 9;
- Figure 11 shows the assembled heat exchanger of figure 10;
- Figure 12 shows an unwound heating element in a fifth embodiment;
- Figure 13 shows the wound heating element of figure 12;
- Figure 14 shows a heating film with spacer elements on the upper surface of one half of the heating film for forming a folded heating film;
- Figure 15 shows the heating film of figure 14 in folded condition;
- Figure 16 shows the heating film of figure 15 with spacer device on the bottom surface of the second half of the heating film;
- Figure 17 shows a cross-sectional view of a wound heating element using the heating film of figures 14 to 16;
- Figure 18 shows spacer elements for forming a closed channel wall;

Figure 19 shows the spacer elements of figure 18 in top view;

Figure 20 shows a section of a wound spacer device comprising the spacer elements of figures 18 and 19;

Figure 21 shows spacer elements with a U-shaped gap between adjacent spacer elements;

Figure 22 shows a section of a wound spacer device comprising the spacer elements of figure 21;

Figure 23 shows spacer elements for forming channel walls with openings;

Figure 24 shows a section of a wound spacer device comprising the spacer elements of figure 23.

[0042] Figure 1 shows a heating film 1. The heating film 1 comprises a first section 3 with increasing width for forming a fluid distributor for distributing a fluid to be heated in a heat exchanger using the heating film 1, and a second section 5 with a constant width which forms a wound heating element after winding. The heating film can be any heating film known to a skilled person. Usually, the heating film comprises an electrical heater, for example at least electrically connectable wire which is arranged in an insulating film, for example a polymer film. As an alternative, the heating film may comprise an electrically conductive film which is enclosed by an electrically insulating material. However, the heating film can be any windable heating film known to a skilled person.

[0043] An unwound heating element 7 on the basis of the heating film 1 of figure 1 is shown in figure 2. The heating element 7 comprises the heating film 1 and spacer elements 9 arranged on the heating film 1. The spacer elements 9 are arranged in lines 11, where each of the lines 11 may be one inventive spacer device 13, or where the spacer device comprises at least two of the lines 11, preferably all lines 11.

[0044] Particularly if each line 11 is one spacer device 13, it is preferred to arrange distance pieces 15 between the lines 11 to set defined distances. In the embodiment shown here, the distances between adjacent spacer devices 13 are equal and remain constant.

[0045] In the heating element 7 channels 17 are formed between the lines 11 of spacer elements 9. In operation of a heat exchanger using the heating element 7, a fluid to be heated flows along the channels 17. The flow of the fluid to be heated is shown by arrows 19.

[0046] The fluid to be heated enters the heating element through a connection 21 for feeding the fluid to be heated into a fluid distributor 23. In the fluid distributor 23 the fluid to be heated is distributed into several streams 25a, 25b, 25c, 25d. Each of the streams 25a,

25b, 25c, 25d enters one channel 17 in which the respective stream 25a, 25b, 25c, 25d is heated by heat transfer from the heating film 1. At the end of each channel 17, the fluid to be heated is collected in a collector tube 27 and withdrawn from the heating element via a connection 29 for withdrawing the fluid to be heated.

[0047] For setting the height of each channel 17, the height of the spacer elements 9 decreases at that end of the heating film which is connected to the collector tube 27 and which forms the center of the wound heating element 31, which is shown in figure 3.

[0048] While winding the heating element 7, the bottom surface of the heating film 1 comes into contact with the upper sides 33 of the spacer elements 9, thus forming a closed spiral channel, which is enclosed by the upper surface of the heating film 1 forming the bottom of the channel, two adjacent lines of spacer elements 9 forming the side walls of the channel 17 and the bottom surface of the heating film 1 forming the cover of the channel 17.

[0049] Figure 4 shows a heating element 7 in a second embodiment in unwound condition and figure 5 the wound heating element 31 which differs from the embodiment shown in figures 1 to 3 by the design of the fluid distributor 23.

[0050] In difference to the fluid distributor 23 of the embodiment shown in figures 1 to 3 having an increasing width, in the embodiment shown in figures 4 and 5, the fluid distributor 23 comprises baffles 35, by which the fluid to be heated is turned by 90°. This design of the fluid distributor 23 allows for an arrangement of the connection 21 for feeding the fluid to be heated and the connection 29 for withdrawing the fluid to be heated on the same side of the wound heating element 31 and, thus, on the same side of a heat exchanger comprising the heating element 31.

[0051] Besides a design shown in figures 1 to 5 comprising a fluid distributor 23 for distributing the fluid to be heated into streams 25a, 25b, 25c, 25d, which flow through parallel channels 17 from one end of the heating element 7 to the other end of the heating element 7, it is also possible to arrange the spacer devices 13 or the lines 11 of spacer elements 9 of one spacer device in such a way that the fluid to be heated is not separated into several streams but flows through the channel in a meandering manner. An unwound heating element 7 with such an arrangement of spacer elements 9 is shown in figure 6.

[0052] For providing the meandering channel, only the outermost lines 37 of spacer elements 9 extend from one end of the heating film 1 to the opposite end of the heating film 1 for forming a closed outer wall in the wound heating element 31. To provide a meandering channel, the lines 11 of spacer elements 9 between the outermost lines 37 each end alternately before a first end 39 or a second end 41 of the heating element 7, so that the fluid to be heated can flow around the wall formed by the spacer elements 9.

[0053] If the number of lines 11 of spacer elements 9

is uneven, the connections 21, 29 for feeding and withdrawing the fluid to be heated can be arranged at the same end of the heating element. If the number of lines 11 of spacer elements 9 is even, one connection 21, 29 for feeding or withdrawing the fluid to be heated is arranged at one end 39, 41 and the other connection 29, 21 for withdrawing or feeding the fluid to be heated is arranged at the other end 41, 39 of the heating element 7.

[0054] An exploded view of a heat exchanger with the heating element of figure 6 is shown in figure 7 and the respective heat exchanger in figure 8.

[0055] A heat exchanger 43 comprising a wound heating element 31 comprises a first housing part 45 and a second housing part 47. For producing the heat exchanger 43, the wound heating element 31 is placed in the first and second housing parts 45, 47 and then the first and second housing parts 45, 47 are connected. For connecting the first and second housing parts 45, 47, each housing part 45, 47 may have a flange as shown here and the housing parts 45, 47 then can be connected with screws or clips or any other connecting type known to the skilled person.

[0056] Besides providing the connections 21, 29 for feeding and withdrawing the fluid to be heated at that end which ends on the outside of the wound heating element 31 as shown in figures 6 to 8, the connections 21, 29 also can be arranged on that end of the heating element 7 which forms the center of the wound heating element 31. Such an arrangement is shown in figure 9. An exploded view of a heat exchanger comprising a wound heating element 31 with connections 21, 29 in the center is shown in figure 10 and the respective assembled heat exchanger in figure 11.

[0057] In difference to the embodiment shown in figures 7 and 8, the housing of the heat exchanger shown in figures 10 and 11 comprises a first half shell 49 and a second half shell 51, which both have the shape of a cup. In this case, the connections 21, 29 for feeding and withdrawing the fluid to be heated are in the center of the bottom of the cup-shaped half shells 49, 51.

[0058] However, besides the cup-shaped half shells 49, 51, in case of the connections 21, 29 for feeding and withdrawing the fluid to be heated, also housing parts as shown in figures 7 and 8 can be used. In this case, each housing part comprises a cutout through which the connections 21, 29 can be lead through after assembling the housing.

[0059] Figure 12 shows a further alternative for an unwound heating element 7. Here, each line 11 comprises spacer elements 53, which are longer. By this arrangement and shape of the spacer elements 9, 53 a wound heating element 31 is formed, which has an oval shape. The respective wound heating element 31 is shown in figure 13.

[0060] Besides embodiments with feeding the fluid to be heated at one end of the heating element and withdrawing the fluid to be heated at the other end so that the fluid is either fed at the center of the wound heating

element and withdrawn at the outside of the heating element or the fluid is fed at the outside of the wound heating element and withdrawn at the center as in the embodiments of figures 1 to 5, or 12 and 13 or the fluid flows in a meandering manner like in the embodiments 6 to 11, it is also possible to form the wound heating element in such a way that a first channel segment is formed through which the fluid to be heated flows to the center of the wound heating element, flows around the heating film and into a second channel segment and back to the outside. Alternatively, the fluid is fed in the center of the wound heating element flows through the first channel segment to the outside, around the heating film and back to the center of the wound heating element, where the fluid to be heated is withdrawn. Such an embodiment with connections for feeding and withdrawing the fluid to be heated at the center of the wound heating element and the arrangement of the spacer devices on the heating film for producing the wound heating element are shown in figures 14 to 17.

[0061] For producing such a wound heating element, spacer devices 13 are fixed on a first section 54 of an upper surface 55 of the heating film 1 as shown in figure 14. Afterwards, a second section 56 of the heating film 1 is folded such that the upper surface 55 of the second section 56 comes into contact with the upper sides 33 of the spacer elements 9. The thus obtained folded heating element comprises a bended area 59 on one end and free ends 61 on the side opposite the bended area 59 as shown in figure 15.

[0062] On the bottom surface 57 of the second section 56 further spacer devices 13 are fixed as shown in figure 16. The spacer devices 13 which are fixed on the bottom surface 57 of the second section 56 of the heating film 1 may be mounted as shown here after having folded the heating film 1 or, alternatively, before folding the second section such that the upper surface 55 of the second section 56 comes into contact with the upper sides 33 of the spacer elements 9.

[0063] After having fixed the spacer devices 13 to the upper surface 55 of the first section 54 and the bottom surface 57 of the second section 56 and having formed the folded heating element as shown in figure 16, the folded heating element is wound forming a wound heating element 31 as shown in figure 17 with the bended area 59 in the center and the free ends 61 at the outside of the wound heating element 31. In this case, the connections for feeding and withdrawing the fluid to be heated are located in the center of the wound heating element 31 so that the fluid to be heated is fed into a first channel section 63, flows along the first channel section 63 into the direction to the free ends 61, leaving the first channel section 63 at the end 65 of the first channel section 63, flows around the free end into a second channel section 67, through the second channel section 67 to the center and is withdrawn from the second channel section 67 at the center through a connection for withdrawing the fluid to be heated. For closing the section of the wound heating

element 31 where the fluid flows around the free end 61, the housing of an heat exchanger with the wound heating element 31 is designed accordingly.

[0064] As an alternative, it is also possible to locate the free ends 61 in the center of the wound heating element 31. Also in this case the connections for feeding and withdrawing the fluid to be heated are located at the bended area and, thus, at the outside of the wound heating element. In this case the center needs to be designed in such a way that the fluid can flow from the exit of the first channel section around the free end of the heating film into the second channel section.

[0065] Regardless of the embodiment of the wound heating element 31, it is preferred to provide a tube 27 at that end of the heating film, which is in the center of the wound heating element as shown in figures 2, 4, 6, 9 and 16. Due to the openings in the tube and to keep the cross-sectional area of the channels 17 essentially constant, the spacer elements 9 adjacent to the tube 27 have a lower height and the height increases with increasing distance from the tube 27 to the maximum height.

[0066] If the wound heating element has a shape different from a circular shape, for example the oval shape as shown in figure 13, only a section of a tube may be used at the end of the heating film 1 which will form the center of the wound heating element, or, if the wound heating element has any other shape, the tube may have any other suitable shape for forming the center of the wound heating element.

[0067] Further, besides five lines 11 of spacer elements 9 as shown here, the wound heating element 31 may have any other number of lines 11 of spacer elements 9. The number of lines 11 of spacer elements 9 generally depends on the width of the heating film 1 and/or the intended width of the channels 17 through which the fluid to be heated flows. Besides the five lines 11 of spacer elements 9, the wound heating element 31 may comprise for example two, three or four lines 11 or even more than five lines 11 of spacer elements 9.

[0068] Examples for different shapes of spacer elements and gaps between the spacer elements in unwound condition are shown in figures 18 to 24.

[0069] Figures 18 to 20 show spacer elements with which fluid-tight walls between the channels can be formed. For forming a fluid-tight wall, each spacer element 9 comprises a tongue 69 on one side and a groove 71 on the opposite side such that when winding the heating element the tongue 69 of one spacer element 9 is introduced into the groove 71 of the adjacent spacer element. The respective spacer elements in unwound condition are shown in figure 18 in a three dimensional view and in figure 19 in a top view. Figure 20 shows a section of a wound spacer device 13 comprising the spacer elements 9 with tongue 69 and groove 71.

[0070] In unwound condition, a gap 73 is formed between adjacent spacer elements 9. In the embodiment shown in figure 18, the gap is V-shaped. Therefore, in

the wound heating element, the gap 73 is closed.

[0071] An alternative design of spacer elements is shown in figure 21 in unwound condition and in figure 22 as a section of a wound heating element. In difference to the embodiment shown in figures 18 to 20, here the gaps 73 are U-shaped.

[0072] For forming the spacer device 13, the spacer elements 9 are fixed on a carrier 75 and the spacer device 13 comprising the carrier 75 and the spacer elements 9 is fixed on the heating film 1.

[0073] Due to the U-shaped gaps 73, only the upper sides 33 of the spacer elements 9 are in contact in wound condition and there are formed holes 77 between the adjacent spacer devices 9 such that there can be a cross-flow between adjacent channels in the wound heating element.

[0074] A further alternative for providing holes in the walls between the channels formed by the spacer elements 9 in the wound heating element is shown in figures 23 and 24.

[0075] Here there are cutouts 79 in the sides of the spacer elements, so that in wound condition as shown in figure 24 openings 81 are formed in the wall formed by the spacer elements. In this case, also V-shaped gaps 73 are provided between adjacent spacer devices 9 in unwound condition.

[0076] Besides the embodiments shown here, with spacer elements 9 having such a shape that circular or oval wound heating elements 31 are produced, the spacer elements 9 may have any other shape or different shapes in one line to produce wound heating elements with any other cross-sectional shape. Further, it is also possible to use spacer elements, where adjacent spacer elements are not in contact at their upper side. In this case, there still remains a gap between adjacent spacer elements in the wound heating element.

[0077] However, preferably, the spacer elements are shaped as shown here in the figures such that the wound heating elements 31 either have a circular cross-sectional shape or an oval cross-sectional shape.

Claims

1. A spacer device (13) for producing wound heating elements (31), the spacer device (13) comprising a windable carrier (75) with spacer elements (9) arranged thereon, wherein the spacer elements (9) have a base by which the spacer elements (9) are connected to the carrier (75), or wherein the carrier (75) is formed by adjacent bases contacting each other, and wherein in unwound condition a gap (73) is formed between adjacent spacer elements (9) in winding direction of the carrier (75).
2. The spacer device according to claim 1, wherein the gap (73) is a U-shaped gap or a V-shaped gap.

3. The spacer device according to claims 1 or 2, wherein the spacer elements (9) have a constant width perpendicular to the winding direction of the carrier (75).
4. The spacer device according to claims 1 or 2, wherein the width of the spacer elements (9) increases or decreases in the winding direction of the carrier (75).
5. The spacer device according to any of claims 1 to 4, wherein the carrier (75) is a ribbon on which one line (11) of spacer elements (9) is arranged or wherein the carrier (75) is a film with at least two lines (11) of spacer elements (9), the lines (11) of spacer elements (9) being arranged at a distance from each other.
6. The spacer device according to any of claims 1 to 5, wherein the bases of two adjacent spacer elements (9) are in contact with each other.
7. The spacer device according to any of claims 1 to 6, wherein one side of the spacer element (9) oriented perpendicular to the winding direction of the carrier (75) comprises a groove (71) and another side of the spacer element (9) oriented perpendicular to the winding direction of the carrier (75) comprises a tongue (69), such that in wound condition the tongue (69) of one spacer element (9) engages in the groove (71) of an adjacent spacer element (9).
8. A heating element comprising a heating film (1) and at least one spacer device (13) according to any of claims 1 to 7, if the carrier (75) is a film with at least two lines (11) of spacer elements (9), or at least two spacer devices (13) according to one of claims 1 to 7 being arranged at a distance from each other, if the carrier (75) is a ribbon, being arranged on an upper surface (55) of the heating film (1), the heating film (1) being wound in such a way that upper sides (33) of the spacer elements (9) are in contact with a bottom surface (57) of the heating film (1).
9. The heating element according to claim 8, wherein the spacer device (13) is an integral part of the heating film (1).
10. The heating element according to claims 8 or 9, wherein one half of the heating film (1) comprises the spacer devices (13) on the bottom surface (57) and the other half of the heating film (1) comprises the spacer devices (13) on the upper surface (55), the heating film (1) being folded such that the upper surface (55) of that half having the spacer devices (13) arranged on the bottom surface (57) lies on the spacer elements 89) of that half having the spacer devices (13) arranged on the upper surface (55), the thus formed folded heating film having a bended area

(59) on one side and free ends (61) of the heating film on the side opposite to the bended area (59), wherein the folded heating film then is wound such that the spacer elements (9) of that half having the spacer devices (13) arranged on the bottom surface (57) are in contact with the bottom surface (57) of that half having the spacer elements (9) arranged on the upper surface (55) and connections (21, 29) for feeding and withdrawing a fluid to be heated are arranged at the bending area (59).

11. The heating element according to claim 10, wherein the free ends (61) of the heating film (1) are in the center of the wound heating element (31).
12. The heating element according to claim 10, wherein the bended area (59) is in the center of the wound heating element (31).
13. The heating element according to any of claims 8 to 12, wherein the spacer devices (13) are arranged such that the cross-sectional area of channels (17) formed between the spacer elements (9) and the heating film (1) increases or decreases and/or wherein the width of the spacer elements (9) in one line (11) and/or the height of the spacer elements (9) in one line (11) increases or decreases so that the cross-sectional area of the channels (17) increases or decreases.
14. The heating element according to any of claims 8 to 13, wherein for setting the distance between adjacent spacer devices (13) distance pieces (15) are arranged between the adjacent spacer devices (13).
15. A heat exchanger for heating a fluid comprising a heating element (31) according to any of claims 8 to 14, wherein the heating element (31) is arranged such that the fluid to be heated flows in the at least one channel (17) being formed between the upper surface (55) and the bottom surface (57) of the wound heating film by the spacer devices (13).

Amended claims in accordance with Rule 137(2) EPC.

1. A spacer device (13) for producing wound heating elements (31), the spacer device (13) comprising a windable carrier (75) with spacer elements (9) arranged thereon, wherein the spacer elements (9) have a base by which the spacer elements (9) are connected to the carrier (75), or wherein the carrier (75) is formed by adjacent bases contacting each other, and wherein in unwound condition a gap (73) is formed between adjacent spacer elements (9) in winding direction of the carrier (75), wherein the carrier (75) is a ribbon on which one line (11) of spacer

elements (9) is arranged or wherein the carrier (75) is a film with at least two lines (11) of spacer elements (9), the lines (11) of spacer elements (9) being arranged at a distance from each other.

2. The spacer device according to claim 1, wherein the gap (73) is a U-shaped gap or a V-shaped gap.
3. The spacer device according to claims 1 or 2, wherein the spacer elements (9) have a constant width perpendicular to the winding direction of the carrier (75).
4. The spacer device according to claims 1 or 2, wherein the width of the spacer elements (9) increases or decreases in the winding direction of the carrier (75).
5. The spacer device according to any of claims 1 to 4, wherein the bases of two adjacent spacer elements (9) are in contact with each other.
6. The spacer device according to any of claims 1 to 5, wherein one side of the spacer element (9) oriented perpendicular to the winding direction of the carrier (75) comprises a groove (71) and another side of the spacer element (9) oriented perpendicular to the winding direction of the carrier (75) comprises a tongue (69), such that in wound condition the tongue (69) of one spacer element (9) engages in the groove (71) of an adjacent spacer element (9).
7. A heating element comprising a heating film (1) and at least one spacer device (13) according to any of claims 1 to 6, if the carrier (75) is a film with at least two lines (11) of spacer elements (9), or at least two spacer devices (13) according to one of claims 1 to 7 being arranged at a distance from each other, if the carrier (75) is a ribbon, being arranged on an upper surface (55) of the heating film (1), the heating film (1) being wound in such a way that upper sides (33) of the spacer elements (9) are in contact with a bottom surface (57) of the heating film (1).
8. The heating element according to claim 7, wherein the spacer device (13) is an integral part of the heating film (1).
9. The heating element according to claims 7 or 8, wherein one half of the heating film (1) comprises the spacer devices (13) on the bottom surface (57) and the other half of the heating film (1) comprises the spacer devices (13) on the upper surface (55), the heating film (1) being folded such that the upper surface (55) of that half having the spacer devices (13) arranged on the bottom surface (57) lies on the spacer elements (9) of that half having the spacer devices (13) arranged on the upper surface (55), the thus formed folded heating film having a bended area

(59) on one side and free ends (61) of the heating film on the side opposite to the bended area (59), wherein the folded heating film then is wound such that the spacer elements (9) of that half having the spacer devices (13) arranged on the bottom surface (57) are in contact with the bottom surface (57) of that half having the spacer elements (9) arranged on the upper surface (55) and connections (21, 29) for feeding and withdrawing a fluid to be heated are arranged at the bending area (59).

10. The heating element according to claim 9, wherein the free ends (61) of the heating film (1) are in the center of the wound heating element (31).
11. The heating element according to claim 9, wherein the bended area (59) is in the center of the wound heating element (31).
12. The heating element according to any of claims 7 to 11, wherein the spacer devices (13) are arranged such that the cross-sectional area of channels (17) formed between the spacer elements (9) and the heating film (1) increases or decreases and/or wherein the width of the spacer elements (9) in one line (11) and/or the height of the spacer elements (9) in one line (11) increases or decreases so that the cross-sectional area of the channels (17) increases or decreases.
13. The heating element according to any of claims 7 to 12, wherein for setting the distance between adjacent spacer devices (13) distance pieces (15) are arranged between the adjacent spacer devices (13).
14. A heat exchanger for heating a fluid comprising a heating element (31) according to any of claims 7 to 13, wherein the heating element (31) is arranged such that the fluid to be heated flows in the at least one channel (17) being formed between the upper surface (55) and the bottom surface (57) of the wound heating film by the spacer devices (13).

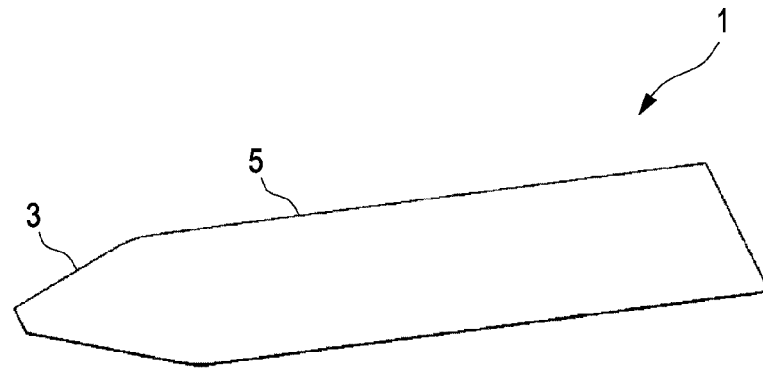


Fig. 1

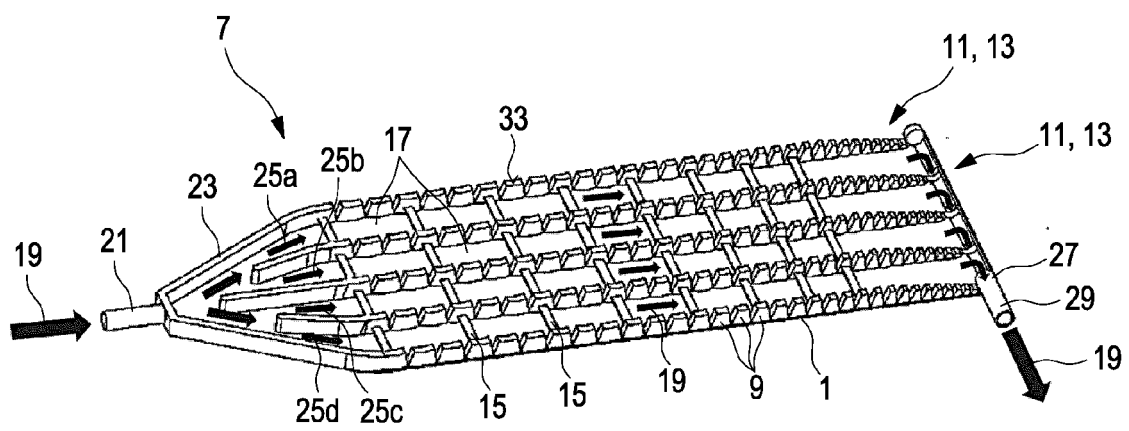


Fig. 2

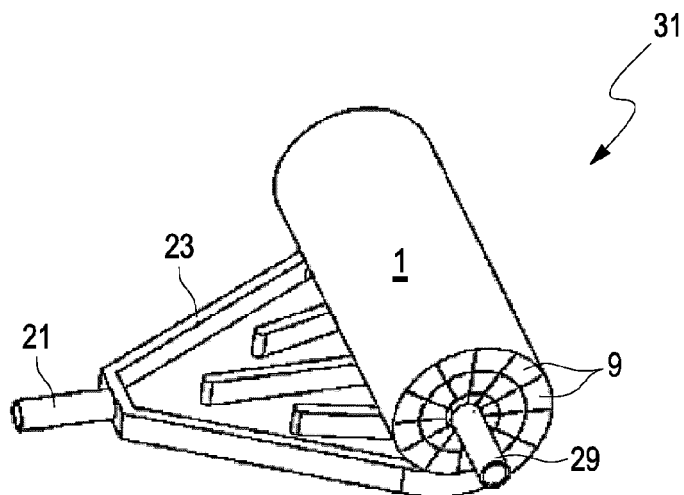


Fig. 3

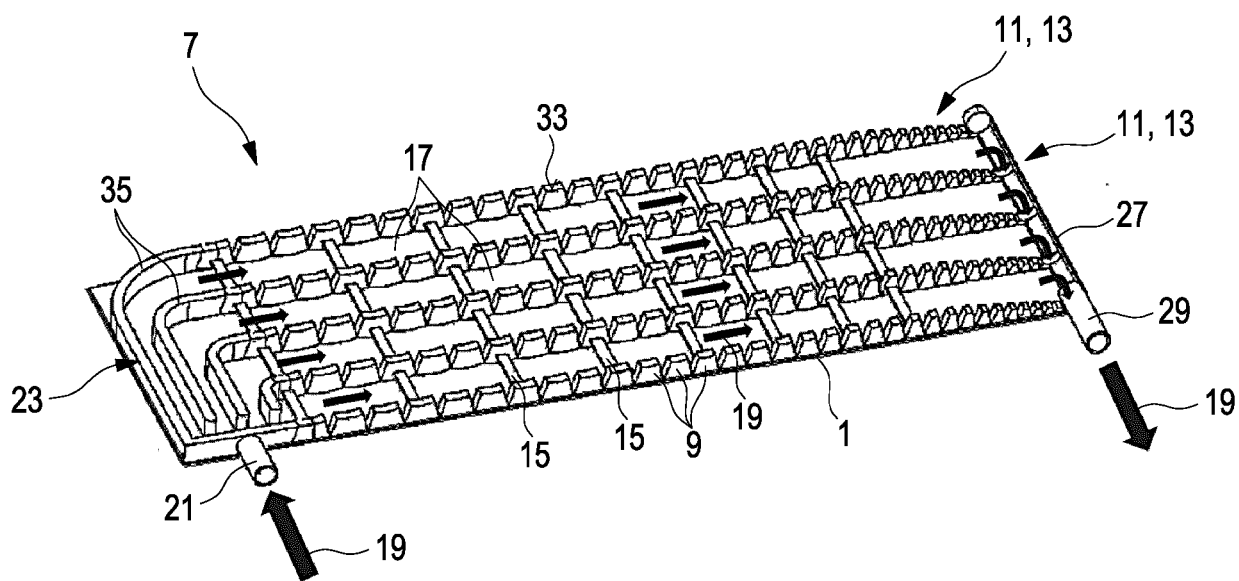


Fig. 4

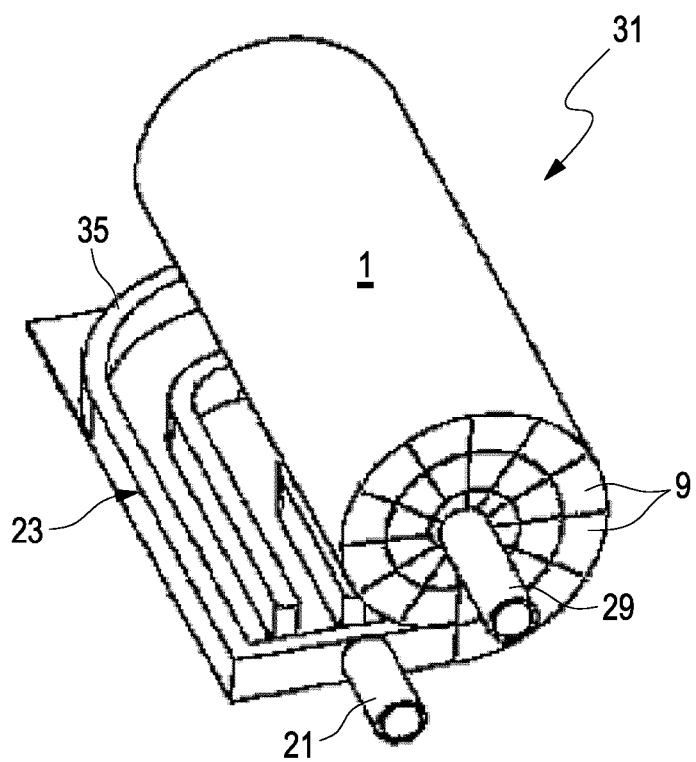


Fig. 5

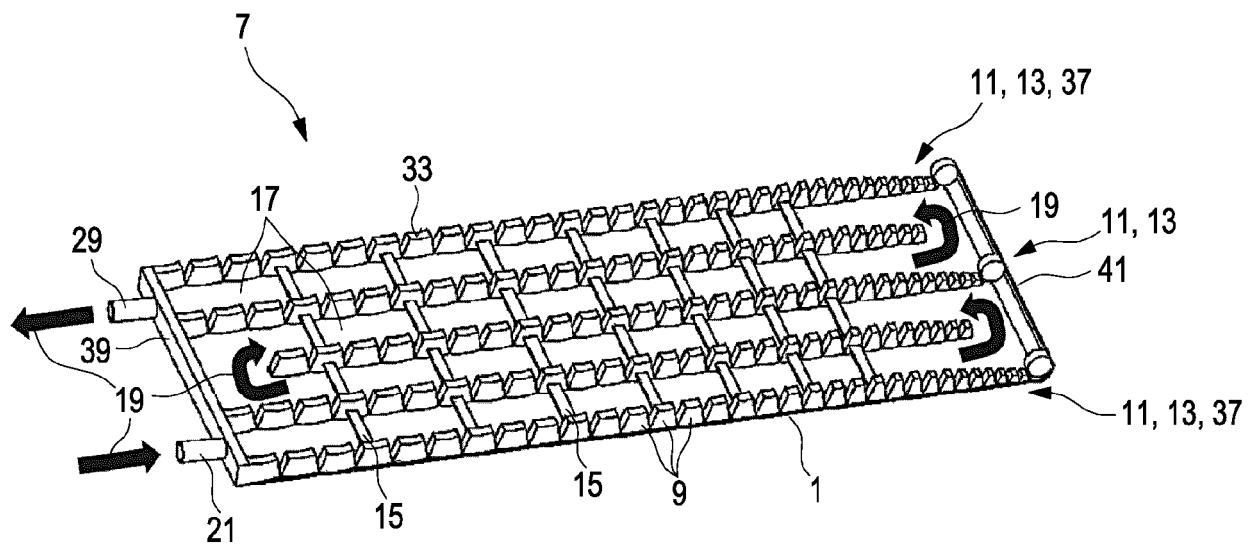


Fig. 6

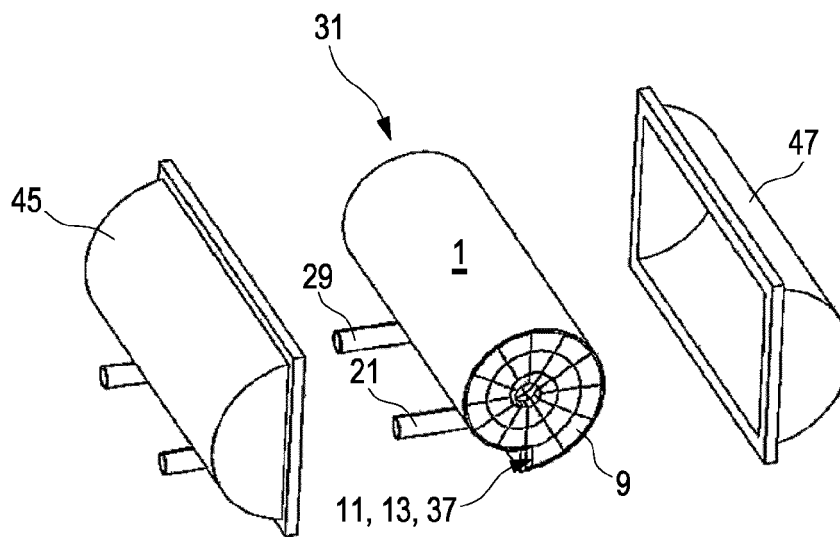


Fig. 7

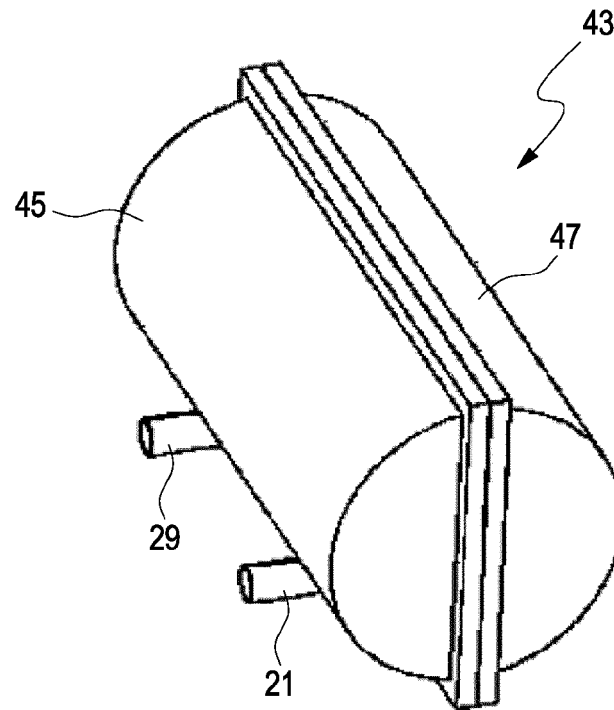


Fig. 8

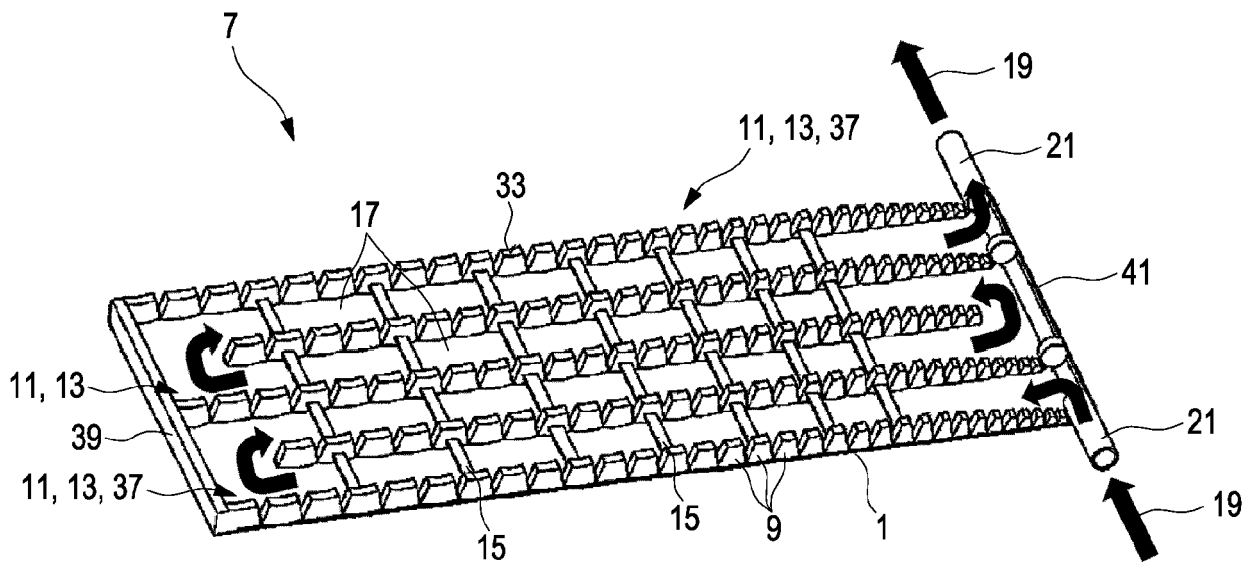


Fig. 9

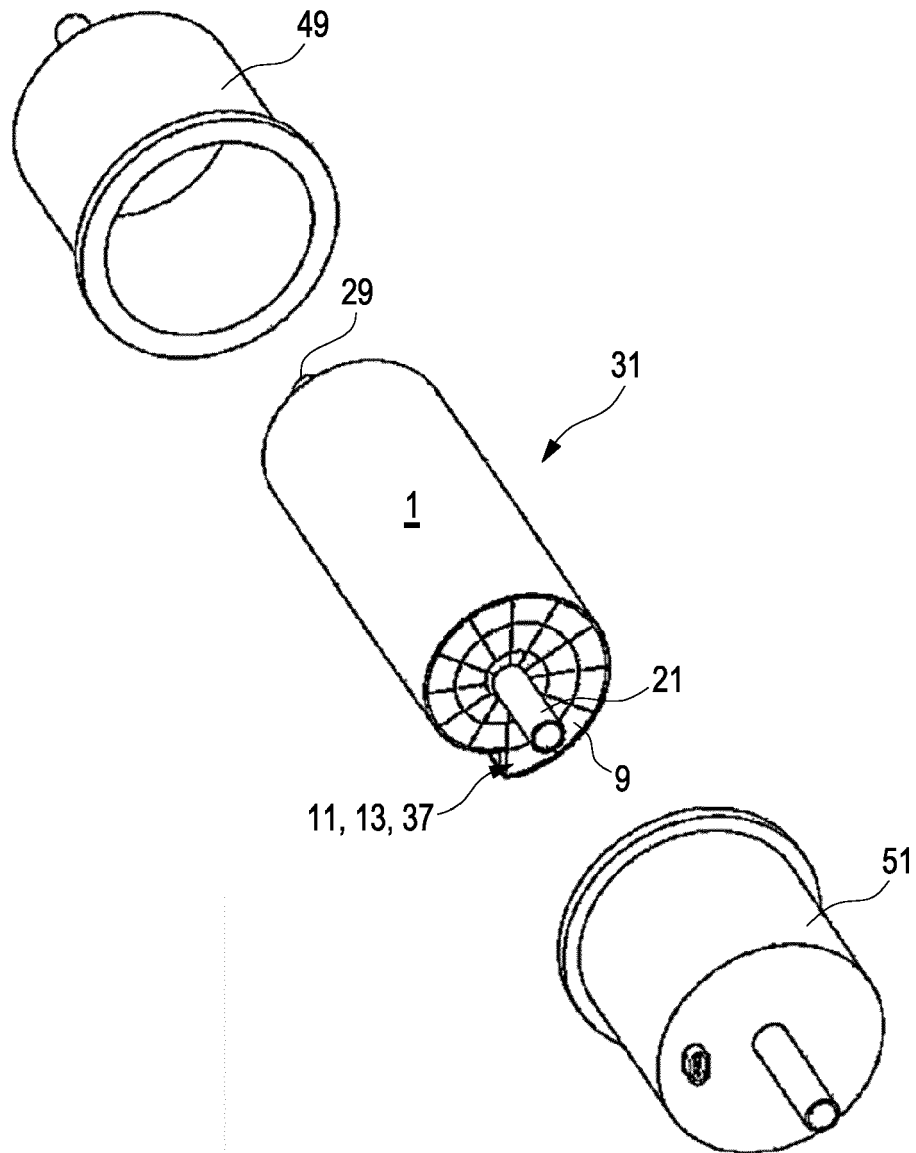


Fig. 10

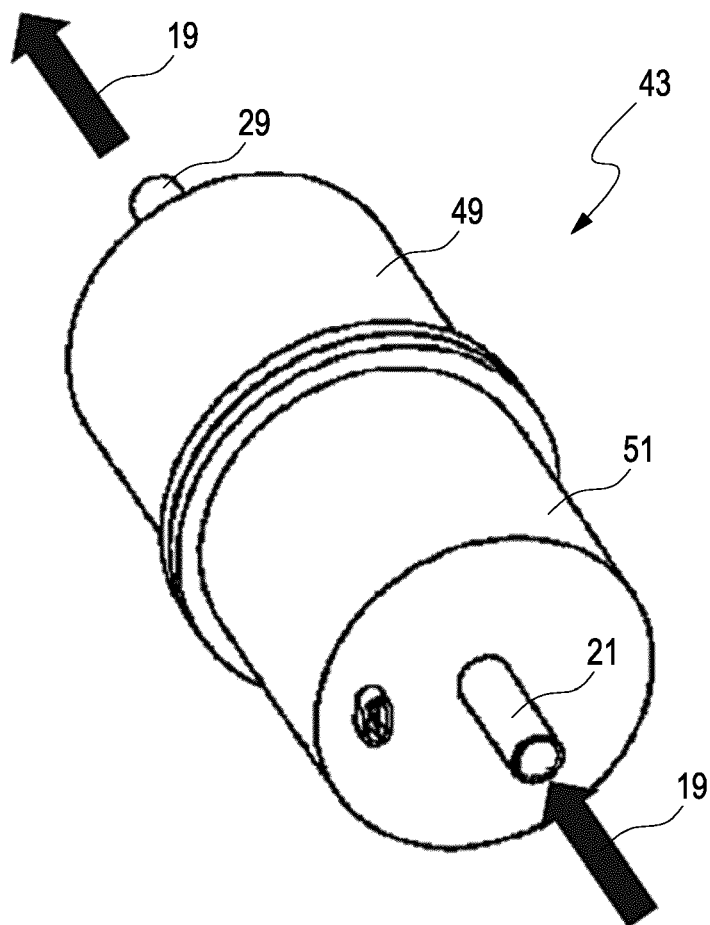


Fig. 11

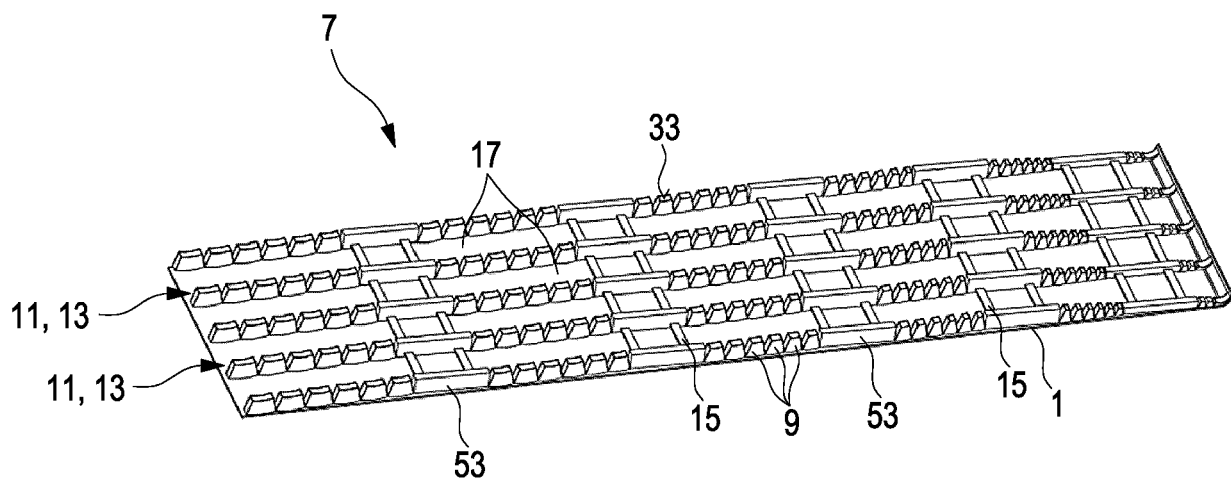


Fig. 12

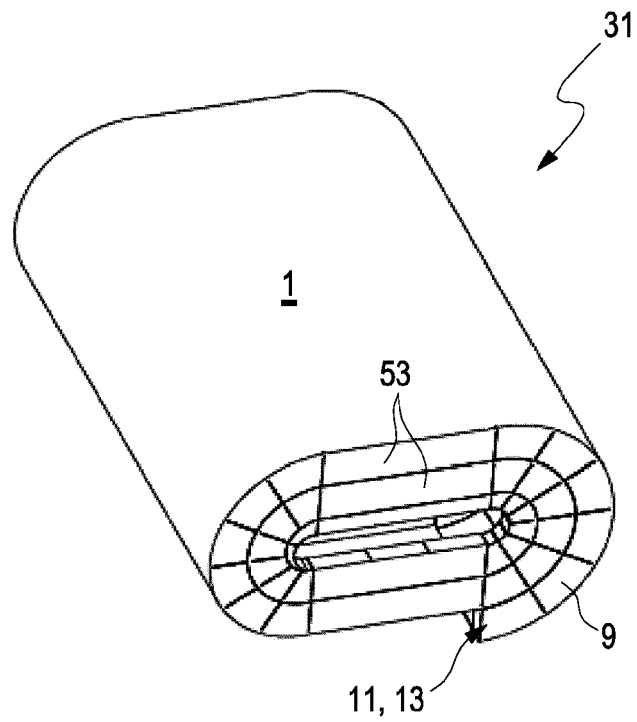


Fig. 13

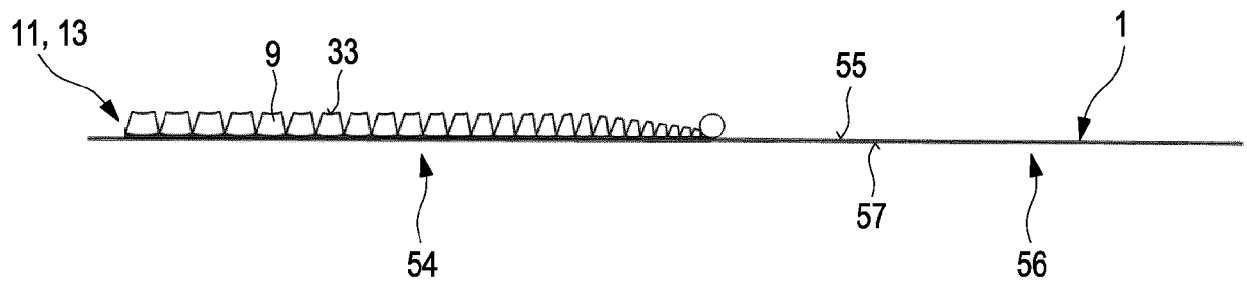


Fig. 14

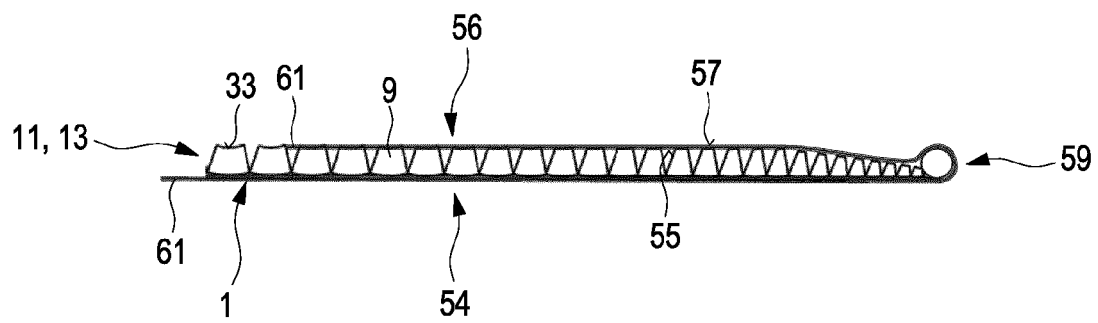


Fig. 15

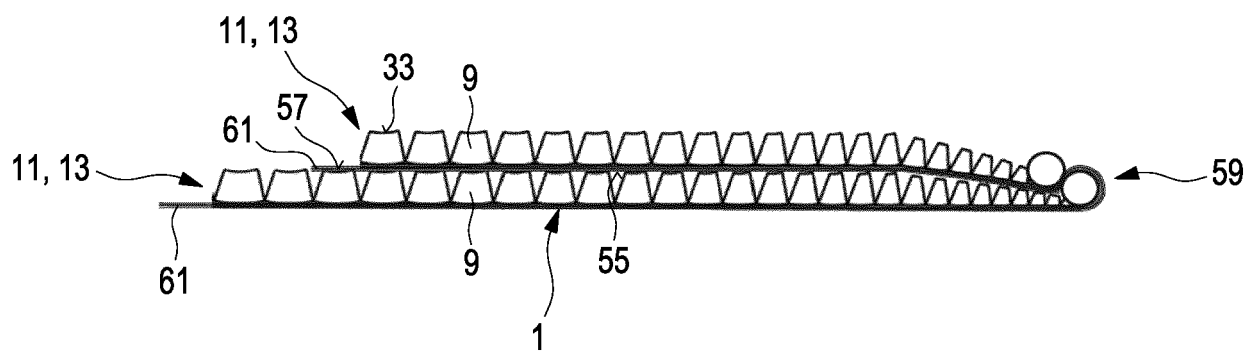


Fig. 16

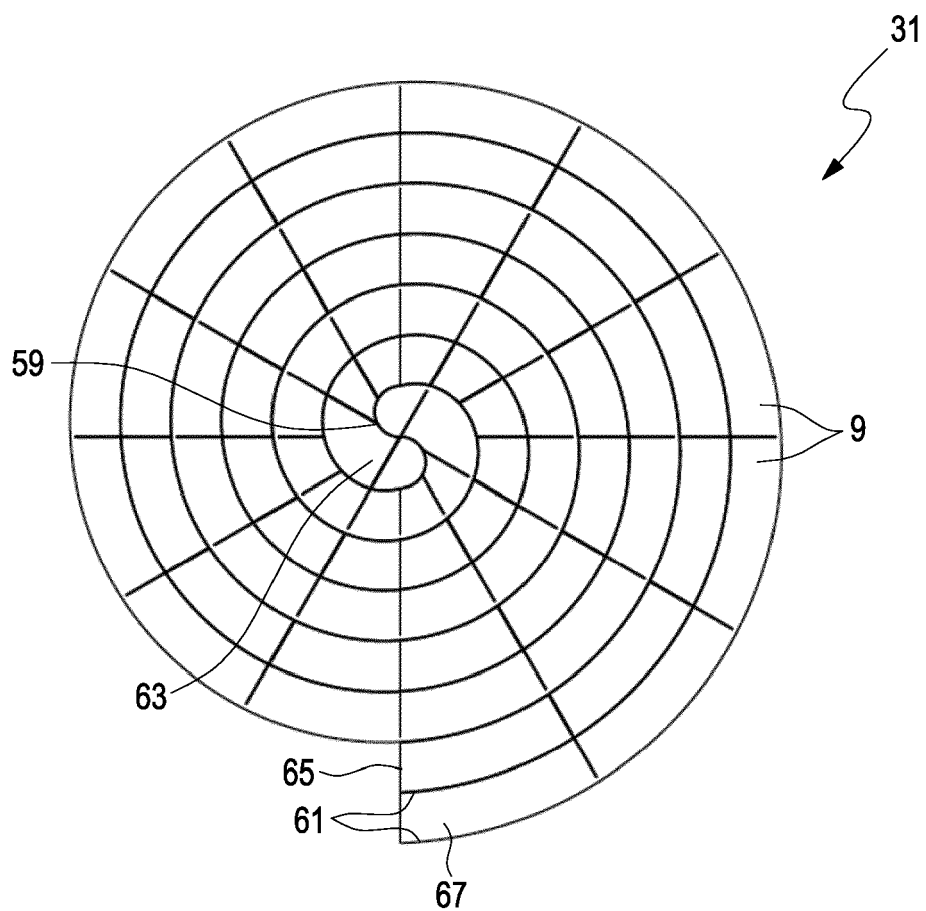


Fig. 17

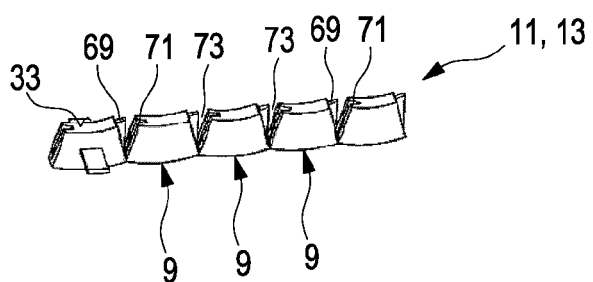


Fig. 18

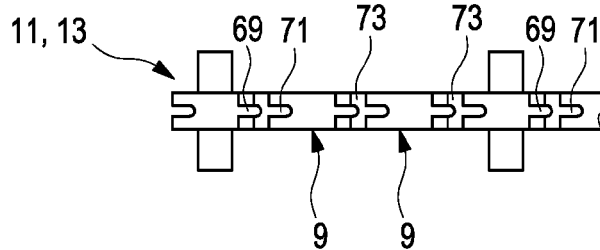


Fig. 19

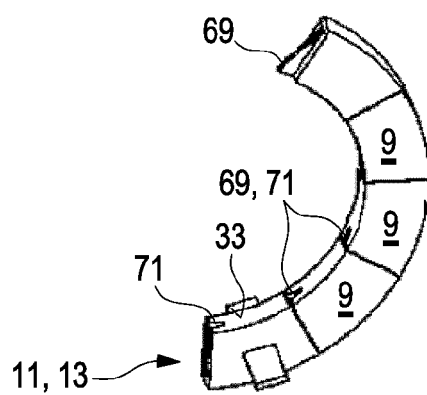


Fig. 20

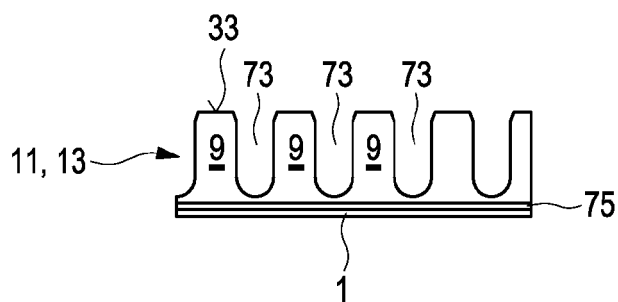


Fig. 21

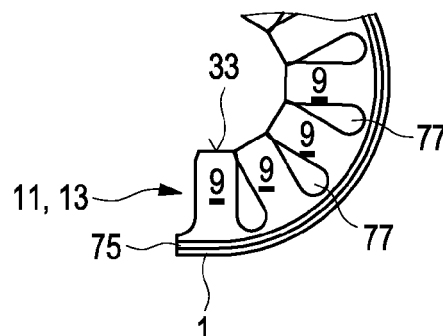


Fig. 22

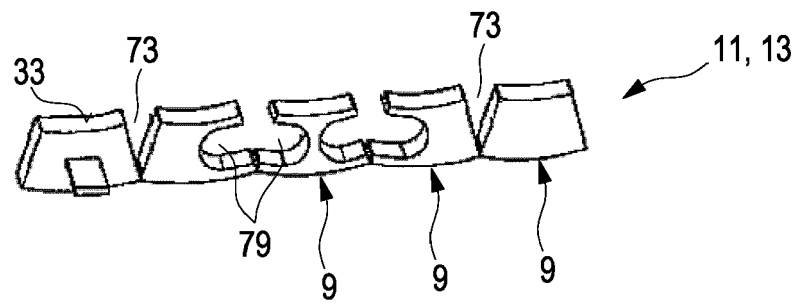


Fig. 23

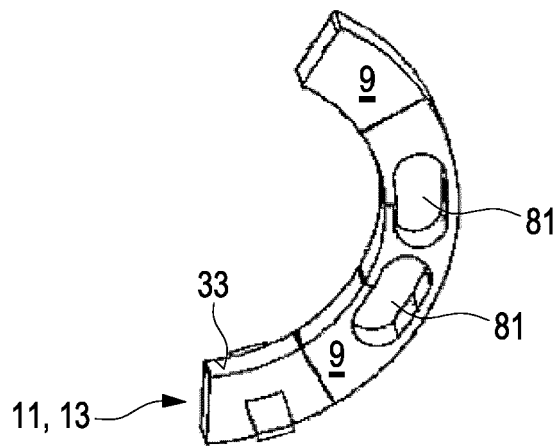


Fig. 24



EUROPEAN SEARCH REPORT

Application Number

EP 23 15 7218

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EPO FORM 1503 03.82 (P04C01)

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X	US 2003/037674 A1 (ALLIE MARK C [US] ET AL) 27 February 2003 (2003-02-27)	1-6	INV. H05B3/34
A	* paragraph [0042]; figure 5 * * paragraph [0043]; figure 8 * * paragraph [0045]; figures 5-8 * -----	7-15	
X	US 5 562 885 A (BAYER JUERGEN [DE] ET AL) 8 October 1996 (1996-10-08)	1-6	
A	* column 1, line 14 - line 20 * * column 6, line 6 - line 14; figures 2,3 * * column 6, line 23 - line 26; figures 1-3 * -----	7-15	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			H05B
Place of search		Date of completion of the search	Examiner
Munich		20 July 2023	Barzic, Florent
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

**ANNEX TO THE EUROPEAN SEARCH REPORT
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