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(54) Title: A BIMETAL THERMAL ELEMENT AND THE MANUFACTURING METHOD THEREOF

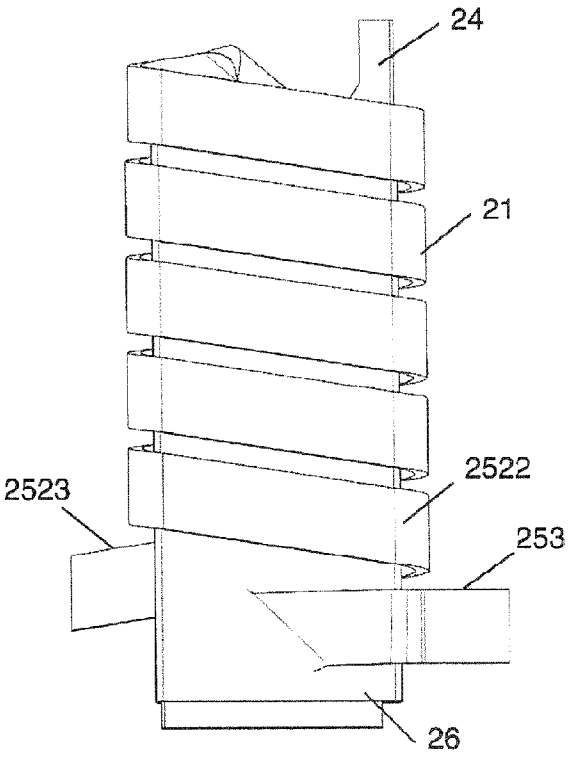


Fig.2A

(57) Abstract: This invention discloses a bimetal thermal element adapted to assembling into a support. The bimetal thermal element includes a bimetal strip (24) having a first end (241) and a second end (242) opposite to the first end, and a notch (243) formed at the first end; a heater (25) made of a resistant strip including a linear portion (251) and a wound portion (252), wherein the linear portion is straight and extending from a first end positioned near the second end of the bimetal in the direction parallel to the bimetal and the wound portion is wound around the bimetal strip and the linear portion; an insulating device (26) to insulate the bimetal strip from the heater. By use of this invention, there is also no current within the bimetal strip and its support, so the deflection of the bimetal strip is generated only by the temperature - rise coming from the resistant strip, therefore, it can realize long tripping time.

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Specification

A bimetal thermal element and the manufacturing method thereof

Technical Field

This application relates to a bimetal thermal element and the method to manufacture the said bimetal thermal element.

Technical Background

In motor application field, overload relays are used to protect the motor windings from over heating.

The principle of these overload relays consists in detecting the overload currents through the deflection of one or more bimetal strip thanks to the temperature rise provided by the current. The motor current either directly goes through the bimetal strip and or through a heater made of an appropriate resistant strip wound around it. The subassembly made of the bimetal strip, the heater and the insulating sheath is called bimetal thermal element.

Relay designed for long tripping times are dedicated for some applications where the loads driven by the motors are huge and so the starting durations to get their full speeds are long.

Overload relay tripping times may refer to the classes defined within the international standards, for instance the standard IEC 60947-4. For example, if the tripping time under 7.2In (In= nominal current) is in between 6 and 20s starting from cold state, a relay is marked class 20.

The structure of conventional bimetal thermal element 11 can be seen from Fig. 1. As shown in Fig. 1, it is made of following components: a bimetal strip 14; a heater 15 made of a resistant strip wound around the bimetal strip 14 with several turns according to the electrical resistance to be obtained and it's welded on the bimetal strip 14 and the end portion is connected to a terminal in the relay case (not shown in Fig. 1); an insulating sheath 16 to electrically insulate the heater 15 from the bimetal strip 14. The bimetal element 11 is assembled with a support 12 by different techniques such as riveting or laser welding and an input wire 13 connected with a motor is connected with the support 12.

As can be seen from above description, the current is flowed via following path: from the input wire 13 to the bimetal support 12; from the bimetal support 12 to an first end of the bimetal strip 14 welded with the support 12; from the first end to a second end of the bimetal strip 14 opposite to the first end; from the second end of the bimetal strip 14 to the resistant strip 15

through the welding point between the resistant strip 15 and the bimetal strip 14; finally crossing all the turns of the resistant strip 15 around the bimetal strip 14 and reaching the relay terminal welded to. Therefore there is current in both the bimetal strip 14 and the bimetal support 12. For this configuration, since there is current in both the bimetal strip 14 and the bimetal support 12, the deflection of bimetal strip 14 is generated by the temperature-rise coming from the heater 15 as well as from the bimetal strip 14 and the bimetal support 12, it is hard to realize long tripping time.

For the situation where long tripping time is needed, usually a multi-strip heater made of several very thin and flexible strips in parallel welded together at their both ends is used. This heater can be either in one short length or made of one or two go and return portions so as to increase the heater length. In the second case, the go and return lengths are insulated with thin insulating strips. One of the multi-strip heater ends is either welded on the bimetal strip or directly to the input depending of the current path desired. The other end is generally welded on the terminal of the relay. Finally the multi-strip heater is fixed along the bimetal strip thanks to staples to ensure a good thermal intimacy. Between the heater and bimetal strip, another insulating strip is placed. But for this kind of heater, the thickness of the bimetal thermal element will increase since several layers of heater are used. In many situations, the thickness of bimetal thermal element is limited to size of the product casing, such multi-strip heater can not be fitted into the casing.

Therefore, there exists the requirement to improve bimetal thermal element to realize longer tripping time while maintaining small volume, especially small width to fit for many applications.

Summary of the Invention

This invention aims to solve the above-mentioned problems. The object of this invention is to provide bimetal thermal element used for long tripping time applications and having relatively smaller volume and simple manufacturing process, thereby eliminate or at least partially alleviate the problems lie in the prior arts.

In order to realize the object of this invention, this invention is to use as much as possible the common winding technique providing wound heater which are easy to manufacture and to define a current path in a such a way that the current doesn't go through both the bimetal strip and its support or only low current goes though the bimetal strip and its support.

According to one aspect of this invention, a bimetal thermal element is provided. The bimetal thermal element is adapted to assembling into a support. The bimetal thermal element

includes a bimetal strip, a heater and an insulating device. The bimetal strip has a first end and a second end opposite to the first end, and a notch formed at the first end. The heater is made of a resistant strip including a linear portion and a wound portion, wherein the linear portion is straight and extending from a starting position near the second end of the bimetal strip toward the notch in the direction parallel to a side of the bimetal strip and the wound portion is wound around the bimetal strip and the linear portion. The insulating device is to insulate the bimetal strip from the heater.

According to one aspect of this invention, a method for manufacturing a bimetal thermal element is provided. The method comprises the following steps of:

preparing a bimetal strip including a notch at a first end thereof;

positioning a resistant strip parallel to a side of the bimetal strip with a starting position of a first portion thereof adjacent a second end of the bimetal strip opposite to the first end;

extending the first portion of the resistant strip from the starting position toward the notch;

enclosing the bimetal strip and the resistant strip with an insulating sheath;

folding the first portion of the resistant strip along an edge of the notch of the bimetal strip with a linear portion parallel to the side of the bimetal strip;

winding a wound portion of the first portion of the resistant strip around the linear portion of the first portion of the resistant strip and the bimetal strip at a predetermined winding angle.

By use of this invention, there is also no current within the bimetal strip and its support or only low current goes though the bimetal strip and its support, so the deflection of the bimetal strip is generated only by the temperature-rise coming from the resistant strip, therefore, it can realize long tripping time. And since there is no current in the bimetal strip, it can be made of two layers instead of three layers when low electrical resistance is required.

As the thermal conduction coefficient of two layers bimetal strip is lower than the one of three layers bimetal strip, in the bimetal strip made of two layers, the temperature-rise generated by the resistant strip will move slower and will reach the bottom of the bimetal strip later. Since the bottom of the bimetal strip is the most effective portion for deflection, so the bimetal thermal element of this embodiment can realize long tripping time. Additionally, since there is only one welding operation by resistance, the process of assembling become simpler.

Description of the Figures

Other aspects, features and merits of this invention will be more easily understood and determined with the reference to the figures and detailed description below.

Fig. 1 shows the structure of the conventional bimetal thermal element;

Fig. 2A shows the structure of the bimetal thermal element according to embodiment 1 of this invention;

Fig. 2B shows the structure of the blank bimetal strip according to embodiment 1 of this invention;

Fig. 2C illustrates the structure of the resistant strip of the bimetal thermal element according to embodiment 1 of this invention;

Fig. 2D illustrates the structure of the insulating sheet of the bimetal thermal element according to embodiment 1 of this invention;

Figs. 3A-3D illustrate the dimensions of the bimetal strip and the resistant strip of the bimetal thermal element according to embodiment 1 of this invention;

Figs. 4A-4F illustrate the manufacturing process of the bimetal thermal element according to embodiment 1 of this invention;

Figs. 5A-5C illustrate the process to assemble the bimetal thermal element with the support according to embodiment 1 of this invention;

Figs. 6A-6B illustrate steps 3 and 4 of the manufacturing process of the bimetal thermal element according to embodiment 2 of this invention.

The figures mean to describe the illustrative embodiments of this invention, they shall not be understood as define the scope. Except pointed explicitly, the figures shall not be deemed to be drawn in scale.

Description of the preferred embodiments

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. The invention includes any alterations and further modifications in the illustrated devices and described methods and further applications of the principles of the invention that would normally occur to one skilled in the art to which the invention relates.

Now, preferred embodiments are described with reference to the figures.

Embodiment 1

This embodiment provides a bimetal thermal element including a bimetal strip, a heater and an insulating device. The bimetal strip is either bonded by two metal strips or bonded by three

metal strips. The bimetal strip bonded by three metal strips is made of two layers of same metal strips and there is a third layer of metal strip between the above-mentioned two layers. The third layer is made of nickel or copper in order to reduce the electrical resistivity and to increase the thermal conductivity. The bimetal thermal element is adapted to assembling with a support and the heater is adapted to connecting with a terminal of the support and an input wire connected with a motor. The complete set of bimetal thermal element with the support is adapted to being inserted into an overload relay case.

In this embodiment, the current path within the resistant strip is to be fully insulated from the bimetal strip. There is no welding point between the bimetal strip and the resistant strip.

As shown in Fig. 2A, a bimetal thermal element 21 is provided. The bimetal thermal element 21 includes a bimetal strip 24, a heater 25 and an insulating device 26 to insulate the bimetal strip 24 from the heater 25. As shown in Fig. 2B, the bimetal strip 24 has a first end 241 and a second end 242 opposite to the first end 241, and the bimetal strip 24 has two sides, one side with higher expansion coefficient and the other side with lower expansion coefficient opposite to the one with higher expansion coefficient. The bimetal strip 24 has a notch 243 at the first end 241, and it also has a protrusion 244 for action on the tripping bar at the first end 241. Preferably, the bimetal strip 24 has a little cutting 245 near its second end 242. The cutting 245 serves as a depth stop for its entrance into the support 22 (not shown in Fig. 2B).

Fig. 2C illustrates the structure of the resistant strip of the bimetal thermal element according to embodiment 1 of this invention. In the status shown in Fig. 2C, the resistant strip 25 is not wound round the bimetal strip 24 yet. As shown in Fig. 2C, the heater 25 is made of a resistant strip 25 which includes a linear portion 251 and a wound portion 252. The linear portion 251 is straight and from a position (referred as "starting position") near the second end 242 of the bimetal strip 24, extending to the notch 243 in a direction parallel to a side of the bimetal strip 24. The wound portion 252 is wound around the bimetal strip 24 and the linear portion 251. The starting position of the linear portion 251 is decided by the position of the terminal at the support 22 (not shown in Fig. 2C).

As shown in Fig. 2A and Fig. 2C, the wound portion 252 includes a first portion 2521 and a second portion 2522. The first portion 2521 has a length "A" to allow it to be folded around the notch 243 of the bimetal strip 24 from the linear portion 2521. The second portion 2522 is wound the bimetal strip 24 and the linear portion 251. The second portion 2522 has a length proportional to the number of turns of the heater to be wound around the bimetal strip 24. The second portion 2522 of the wound portion 252 starts from the opposite side of the bimetal strip 24 to the side of bimetal strip 24 where the linear portion 251 is set. And the second portion

2522 of the wound portion 252 is connected with the linear portion 251 by the first portion 2521 of the wound portion 252. Preferably, the resistant strip 25 further includes a terminal end 2523 stretching from the second portion 2522 of the wound portion 252 for connecting with a terminal in the relay case (not shown in Fig. 2C).

The linear portion 251 of the resistant strip 25 is preferably set on the lower expansion side of the bimetal strip 24 so as to warm up that side of the bimetal strip 24 first which is non-operant in the deflection process.

As shown in Fig. 2A and Fig. 2C, the resistant strip 25 further includes a folded portion 253, folded from the starting position of the linear portion 251 with a folding angle. Preferably, the folding angle is 45° so as to get a right angle between the linear portion 251 and the folded portion 253. The folded portion 253 is adapted to welding with the terminal of the support 22 and the input wire 23 at an end of the folded portion 253.

In the present embodiment shown in Fig. 2A, the insulating device 26 includes insulating sheet 261 (not shown in Fig. 2A) and insulating sheath 262.

Fig. 2D illustrates the structure of the insulating sheet 261 of the bimetal thermal element 21 according to embodiment 1 of this invention. In the status shown in Fig. 2D, the insulating sheet 11 is just inserted between the bimetal strip 24 and the linear portion 251 of the resistant strip 25 and the wound portion 252 is not wound round the bimetal strip 24 yet. As shown in Fig. 2D, the insulating sheet 261 is between the resistant strip 25 and bimetal strip 24. The insulating sheet 261 has a shape designed to cover the incline edge of the notch 243 of the bimetal strip 24 after folding so as to ensure no electrical contact between the bimetal strip 24 and the resistant strip 25. In the present embodiment, the insulating sheet 261 is made of a kind of Nomex material. It can also be made of other insulating materials, as long as the dielectric strength, the thermal conductivity are equivalent.

The insulating sheath 262 is slid around the linear portion 251 of the resistant strip 25 and the bimetal strip 24. The second portion 2522 of the wound portion 252 is wound around the insulating sheath 262 to prevent the second portion 2522 of the wound portion 252 from touching the linear portion 251 of the resistant strip 25 and the bimetal strip 24. The insulating sheath 262 is partially cut to allow one end of the folded portion 253 to get out from the insulating sheath 262. The material of insulating sheath 262 is glass fiber; it can also be made of other insulating materials, such as Nomex type materials.

The form and configuration of the insulating device 26 are not limited to the above-mentioned ones, any types of insulating device 26 able to insulate the resistant strip 25 from the bimetal strip 24 can be used here. And in case the resistant strip 25 is made of a

material having a very low resistivity such as copper, the insulating sheet 261 between the bimetal strip 24 and the linear portion 251 of the resistant strip 25 can be omitted.

It is preferred to design the dimension of bimetal strip and resistant strip as follows. Fig. 3A illustrates relation between the dimension of the bimetal strip 24 and the dimension of the resistant strip 25. Referring to Fig. 3A, suppose the length of the edge of the notch 243 around which the first portion 2521 of the wound portion 252 is folded is D. The incline angle of above-mentioned edge of the notch 243 is β. Preferably, the linear portion 251 of the resistant strip 25 is parallel with planes of the bimetal strip 24 which connect the first end 241 and the second end 242. In this situation, since the resistant strip need to fold around the incline edge of the notch, so D shall satisfy the following condition:

$D > W/\cos\beta$, wherein W is the width of the resistant strip.

Suppose the length of the first portion 2521 of the wound portion 252 of the resistant strip 25 is A, so A shall satisfy the following condition:

$A = W \cdot \tan\beta$, wherein W is the width of the resistant strip.

Fig. 3B and Fig. 3C illustrate relation between the incline angle of above-mentioned edge of the notch β and a winding angle α of the resistant strip. Fig. 3B and Fig. 3C are two possible layouts of the resistant strip 25 and the bimetal strip 24. In Fig. 3B, the protrusion 244 is on the left of the notch 243, and in Fig. 3C, the protrusion 244 is on the right of the notch 243. As can be seen both from Figs. 3B and 3C, β is linked to the winding angle α by the following formula:

$\beta = (90^{\circ} - \alpha)/2$, wherein α is a winding angle of the resistant strip 25.

Winding angle α depends on the number of turns desired for the wound portion. As shown in Fig. 3D, the winding angle α is calculated by the following formula:

$\alpha = \arcsin(H/L)$, wherein, L is efficient winding length of the resistant strip 25, H is winding height.

To explain the configuration of bimetal thermal element 21 more clearly, now the specific steps of manufacturing process of the bimetal thermal element 21 are explained with reference to Figs. 4A-4F.

Step 1: Preparing a bimetal strip 24 including a notch 243 and a protrusion 244 for action on the tripping bar at its first end, as shown in Fig. 4A.

Step 2: Preparing a resistant strip 25, folding the resistant strip 25 to have a first portion and a second portion, as shown in Fig. 4B. The angle between these two portions are substantially 90°. The first portion is to be divided into a linear portion 251 and a wound

portion 252 in later steps, the second portion here is adapted to be the folded portion 253.

Step 3: Positioning the resistant strip 25 parallel to a side of the bimetal strip 24 with a connecting portion 2512 between the first portion and the second portion located at a position (starting position) near the second end 242 of the bimetal strip 24 and extending the first portion from the connecting portion 2512 toward the notch 243, as shown in Fig. 4B. The position of the connecting portion 2512 between the first portion and the second portion is decided by the position of the terminal at the support 22.

As mentioned before, the folded portion 253 of the resistant strip 25 can be omitted in some situations. So the step 2 can be omitted. In this situation, step 3 can be described as follows: preparing a resistant strip 25 having a first portion, positioning the resistant strip 25 parallel to a side of the bimetal strip 24 with a starting position of a first portion of the resistant strip 25 near the second end 242 of the bimetal strip 24 and extending the first portion from the starting position toward the notch 243.

Step 4: Putting an insulating sheet 261 between the bimetal strip 24 and the first portion of the resistant strip 25 with a part having a specific shape at the head thereof, as shown in Fig. 4C. The specific shape at the head of the sheet 261 will be folded later to cover the edge of the notch 243 around which the resistant strip 25 will be folded.

Step 5: Positioning the bimetal strip 24, insulating sheet 261 and resistant strip 25 into an insulating sheath 262, as shown in Fig. 4D. The sheath 262 is partially cut to allow the end of the resistant strip 25 to get out from the sheath 262.

Step 6: Folding the resistant strip 25 along the edge of the notch 243 of the bimetal strip 24, as shown in Fig. 4E. The part having the specific shape of the insulating sheet 261 will also be folded with the resistant strip to cover the edge of the notch 243 of the bimetal strip 24. Therefore the resistant strip 25 is insulated from the bimetal strip 24 thanks to the rectangular pre-cut shape made within the insulating sheet 261. After this step, the first portion of the resistant strip 25 is divided into linear portion 251 and wound portion 252.

Step 7: Winding the wounded portion of the resistant strip 25 around the bimetal strip and the linear portion the number of turns defined by the winding angle α, as shown in Fig. 4F. The number of turns will define the final vertical position of the wound portion 252 of the resistant strip 25. After this step, the wound portion 252 is divided into the first portion 2521 and the second portion 2522.

It is preferably to include the step of cutting the resistant strip 25 according to a dimension allowing a final good positioning for the resistance welding with a terminal in the relay case which is adapted to connecting with the resistant strip 25. After this step, the terminal end 2523

of the resistant strip 25 is formed.

After that, the bimetal thermal element 21 made of the bimetal strip 24, the insulating device 26 and the resistant strip 25 is finished and ready to be assembled with its support 22 thanks to a laser welding or other methods, such as riveting.

As mentioned before, since the insulating sheet 261 can be omitted in case the resistant strip 25 is made of a material having a very low resistivity such as copper. In this situation, step 4 can be omitted, too.

Now, the process to assemble the bimetal element with the support is explained with reference to Figs. 5A-5C.

Step 8: Positioning the bimetal thermal element 21 with its support 22 for the laser welding operation, as shown in Fig. 5A. A jig allows a right positioning within all X, Y, and Z directions.

Step 9: Laser welding between bimetal strip 24 and the support 22, as shown in Fig. 5B.

Step 10: Resistance welding of the support 22, the input wire 23 and the resistant strip 25, as shown in Fig. 5C.

After that, the complete thermal element after resistance welding is inserted within an overload relay case, and then the terminal end of the resistant strip 25 is welded to the terminal in the relay case.

Some steps of the manufacturing process of the bimetal thermal element of present embodiment are the same for conventional bimetal thermal element, the process mainly differs in:

1) getting the bimetal strip prepared with a notch for wound portion of the resistant strip to wind around.

2) getting the resistant strip prepared with a linear portion and positioning the bimetal strip and the linear portion at right position before winding.

As can be seen from above description, the bimetal thermal element provided by present embodiment has the following advantages over conventional bimetal thermal element:

1) The way of getting the resistant strip around the bimetal strip without any current neither within both the bimetal strip and nor within its support allows to warm up the bimetal strip only thanks to radiation and conduction to the resistant strip in the transient state (time < 10s). So the deflection of the bimetal strip is generated only by the temperature-rise coming from the resistant strip, therefore, it can realize long tripping time.

2) Since there is only one welding operation by resistance (step 10), the process of assembling become simpler.

3) Since there is no current in the bimetal strip, it can be made of two layers instead of three layers when low electrical resistance is required. The two-layer bimetal strip can be AS type of Imphy (TM) company or 155 type of Kanthal (TM) company or L1 type of EMS(TM) company. The bimetal strip made of two layers is cheaper than the one made of three layers, the cost of the whole element will be reduced.

4) The deflection coefficient of bimetal strip made of two layers are higher than the one made of three layers, so the bimetal strip can have more deflection and it is easier to adjust current tripping.

5) As the thermal conduction coefficient of two-layer bimetal strip is lower than the one of three-layer bimetal strip. Comparing to the bimetal strip made of three layers, in the bimetal strip made of two layers, the temperature-rise generated by the resistant strip will move slower and will reach the bottom of the bimetal strip later. Since the bottom of the bimetal strip is the most effective portion for deflection, so the bimetal thermal element of this embodiment can realize long tripping time.

Embodiment 2

The structure of bimetal thermal element of embodiment 2 is mostly the same as that of embodiment 1. The main difference lies in that there is a fixing point realized by welding between the linear portion of the resistant strip and the bimetal strip.

The specific steps of manufacturing process of the bimetal thermal element of embodiment 2 are mostly the same as that of embodiment 1. The main difference lies in step 3 and step 4. The steps 3&4 of embodiment 2 are as follows:

Step 3: Positioning the resistant strip 25 parallel to a side of the bimetal strip 24 with a connecting portion 2512 between the first portion and the second portion located at a position near the second end 242 of the bimetal strip 24 and the first portion extending from the connecting portion toward the notch 243, as shown in Fig. 6A. The position of the connecting portion 2512 between the first portion and the second portion is decided by the position of the terminal at the support 22. Same as in Embodiment 1, in the situation step 2 is omitted, the step 3 can be described as follows: preparing a resistant strip 25 having a first portion, positioning the resistant strip 25 parallel to a side of the bimetal strip 24 with a starting position of a first portion of the resistant strip 25 near the second end 242 of the bimetal strip 24 and extending the first portion from the starting position toward the notch 243. Then, fixing the linear portion 251 of the resistance strip 25 and bimetal strip 24 by a resistance welding operation at a position near the connecting portion 2512. In Fig. 6A, “B” is referred to the fixing point.

Step 4: Folding the resistant strip 25 to have a small gap for the insulating sheet 261 to insert, and then putting the insulating sheet 261 between the bimetal strip 24 and the resistant strip 25 to touch the step made in the resistant strip, as shown in Fig. 6B. Since the linear portion 251 is weld to bimetal strip 24 at the point "B", the resistant strip 25 needs to fold to have a small gap for the insulating sheet 261 to insert.

In this situation, there is a low current within the portion made by the bimetal strip 24 and its support 22. The whole bimetal thermal element 21 equals two current branches connected in parallel, the two terminals of these two branches are the welding point between the linear portion 251 of the resistant strip 25 and the bimetal strip 24 and the welding point between input wire 23, the support 22 and the folded portion 253 of the resistant strip 25. One branch is made by the support 22 and the bimetal strip 24, the other branch is made by the resistant strip 25.

The electrical resistance in the branch made by the support 22 and the bimetal strip 24 is greatly higher than the one made by the resistant strip 25 between the two terminals. The current flowing within the branch is inversely proportional to those electrical resistances ratio. Therefore, there is only very little current in the bimetal strip 24 and the support 22. There will be little heat produced due to current in the bimetal strip 24 and the support 22. So the tripping performance will be almost the same as that of the bimetal element 21 of embodiment 1.

Besides the advantage described in embodiment 1, embodiment 2 further has the following advantage: thanks to the welding point, relative positioning of bimetal strip and resistant strip is fixed, the manipulation become much easier.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character. It should be understood that only the preferred embodiments have been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected.

Claims

1. A bimetal thermal element adapted to assembling into a support, including:

a bimetal strip having a first end, a second end opposite to the first end, and a notch formed at the first end;

a heater made of a resistant strip including a linear portion and a wound portion, wherein the linear portion is straight and extending from a starting position near the second end of the bimetal strip toward the notch in a direction parallel to a side of the bimetal strip and the wound portion is wound around the bimetal strip and the linear portion; and

an insulating device to insulate the bimetal strip from the heater.

2. The bimetal thermal element according to claim 1, wherein:

the wound portion of the resistant strip includes a first portion folded around the notch of the bimetal strip and a second portion wound around the bimetal strip and the linear portion of the resistant strip;

the second portion of the wound portion of the resistant strip starts from a side of the bimetal strip opposite to where the linear portion is set; and

the second portion of the wound portion of the resistant strip is coupled to the linear portion of the resistant strip via the first portion of the wound portion.

3. The bimetal thermal element according to claim 2, the dimensions of the bimetal strip and the resistant strip satisfying the following condition:

$D > W/\cos\beta$,

wherein, D is the length of an edge of the notch around which the first portion of the wound portion of the resistant strip is folded , W is the width of the resistant strip, β is the incline angle of the edge of the notch.

4. The bimetal thermal element according to claim 2, the dimensions of the bimetal strip and the resistant strip satisfying the following condition:

$A = W \cdot \tan\beta$,

wherein, A is the length of the first portion of the wound portion of the resistant strip, W is the width of the resistant strip, β is the incline angle of an edge of the notch around which the first portion of the wound portion of the resistant strip is folded.

5. The bimetal thermal element according to claim 2, wherein the dimension of the bimetal strip and the resistant strip satisfying the following condition:

$\beta = (90^{\circ} - \alpha) /2,$

wherein, β is the incline angle of an edge of the notch around which the first portion of the wound portion of the resistant strip is folded, α is a winding angle of the wound portion of the resistant strip.

6. The bimetal thermal element according to claim 2, wherein the resistant strip further includes a folded portion folded from the starting position of the linear portion with a folding angle.

7. The bimetal thermal element according to claim 6, wherein the folding angle is 45° to result in a right angle between the linear portion and the folded portion of the resistant strip.

8. The bimetal thermal element according to claim 2, wherein the resistant strip further includes terminal portion stretching from the second portion of the wound portion of the resistant strip.

9. The bimetal thermal element according to claim 1, wherein the insulating device includes a sheath adapted to preventing the second portion of the wound portion of the resistant strip from touching the linear portion of the resistant strip and the bimetal strip.

10. The bimetal thermal element according to claim 9, wherein the insulating device further includes a sheet adapted to insulating the linear portion and the first portion of the wound portion of the resistant strip from the bimetal strip.

11. The bimetal thermal element according to claim 1, wherein the insulating device completely insulates the bimetal strip from the resistant strip.

12. The bimetal thermal element according to claim 1, further including a fixing point between the bimetal strip and linear portion of the resistant strip, near the starting position of the linear portion.

13. The bimetal thermal element according to claim 12, wherein the insulating device insulates the bimetal strip from the resistant strip except the portion adjacent the fixing point.

14. The bimetal thermal element according to claim 1, wherein the bimetal strip is made of two layers.

15. The bimetal thermal element according to claim 1, wherein the bimetal strip has a first side with higher thermal expansion coefficient and a second side with lower thermal expansion coefficient, the linear portion of the resistant strip is set on the second side of the bimetal strip .

16. A method for manufacturing a bimetal thermal element, comprising the following steps of:

preparing a bimetal strip including a notch at a first end thereof;

positioning a resistant strip parallel to a side of the bimetal strip with a starting position of a first portion thereof adjacent a second end of the bimetal strip opposite to the first end;

extending the first portion of the resistant strip from the starting position toward the notch;

enclosing the bimetal strip and the resistant strip with an insulating sheath;

folding the first portion of the resistant strip along an edge of the notch of the bimetal strip with a linear portion parallel to the side of the bimetal strip;

winding a wound portion of the first portion of the resistant strip around the linear portion of the first portion of the resistant strip and the bimetal strip at a predetermined winding angle.

17. The method according to claim 16, further comprising the step of fixing the linear portion of the resistant strip and bimetal strip at a position adjacent the starting position of the first portion of the resistant strip before enclosing the bimetal strip and the resistant strip with the insulating sheath.

18. The method according to claims 16 or 17, further comprising the step of putting an insulating sheet between the bimetal strip and the linear portion of the resistant strip with a part having a specific shape at the head of the insulation sheet adapted to being folded later to cover an edge of the notch before enclosing the bimetal strip and the resistant strip with the insulating sheath.

19. The method according to claims 16 or 17, further including the step of folding a resistant strip at a folding angle to divide the resistant strip into the first portion and a second portion before positioning the resistant strip parallel to the side of the bimetal strip with the starting position of the first portion of the resistant strip near the second end of the bimetal strip opposite to the first end.

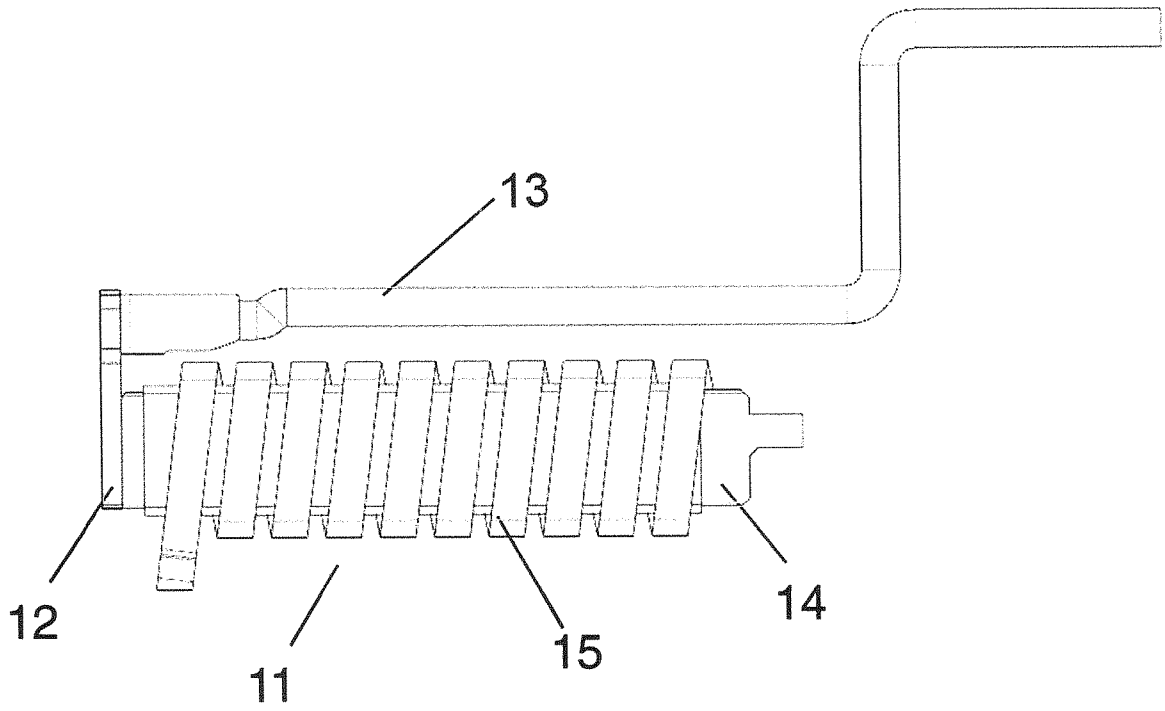


Fig.1

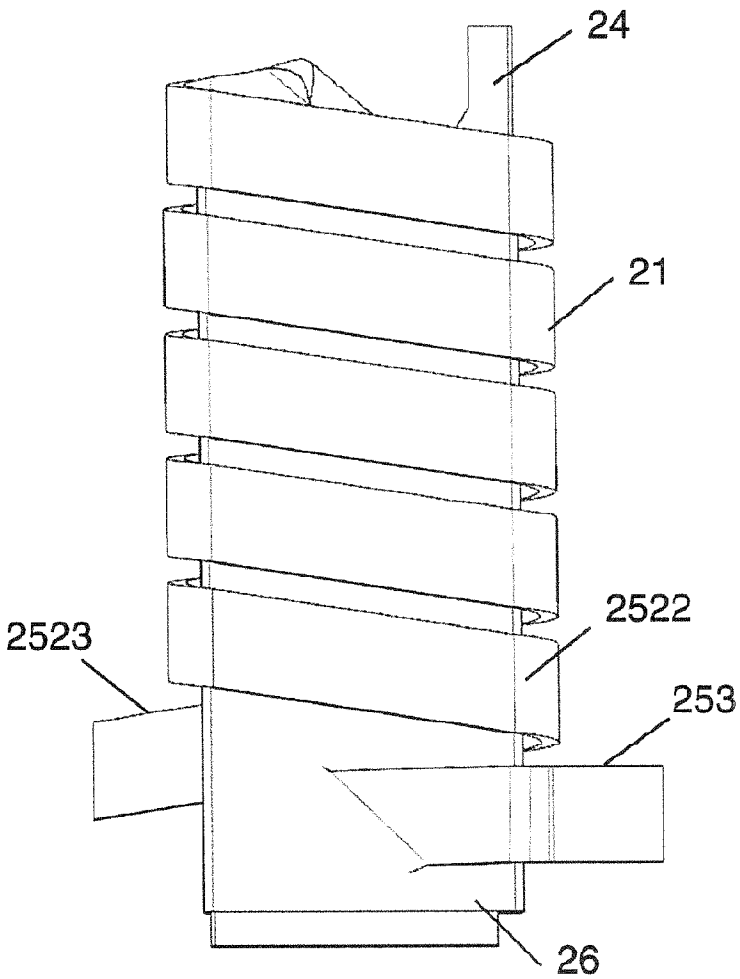


Fig.2A

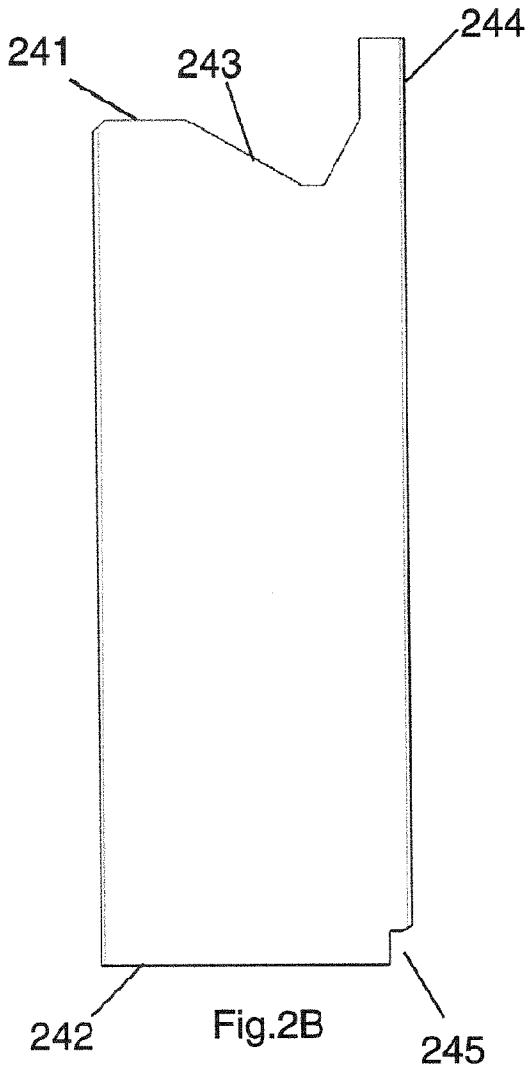


Fig.2B

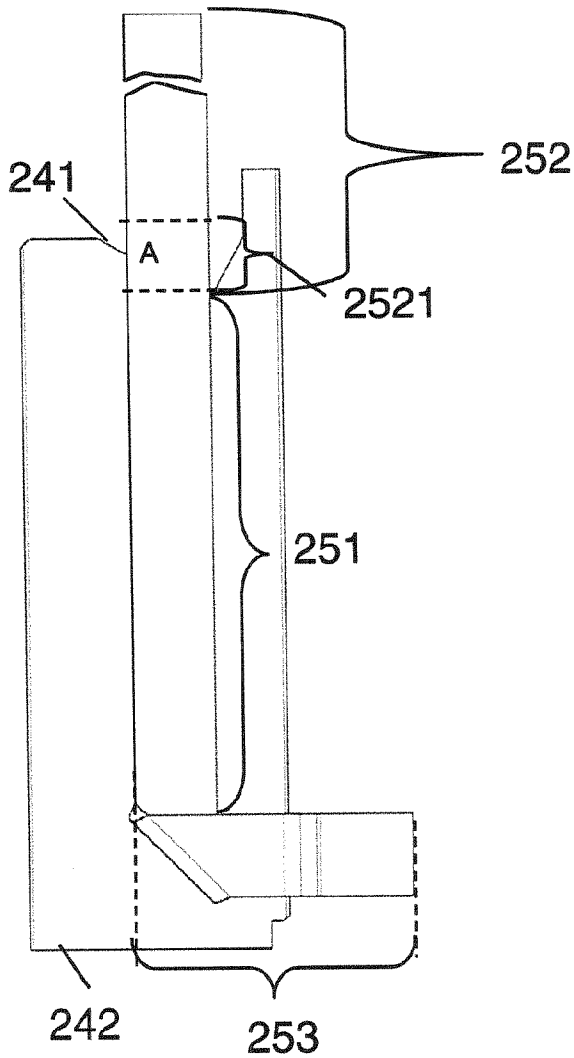


Fig.2C

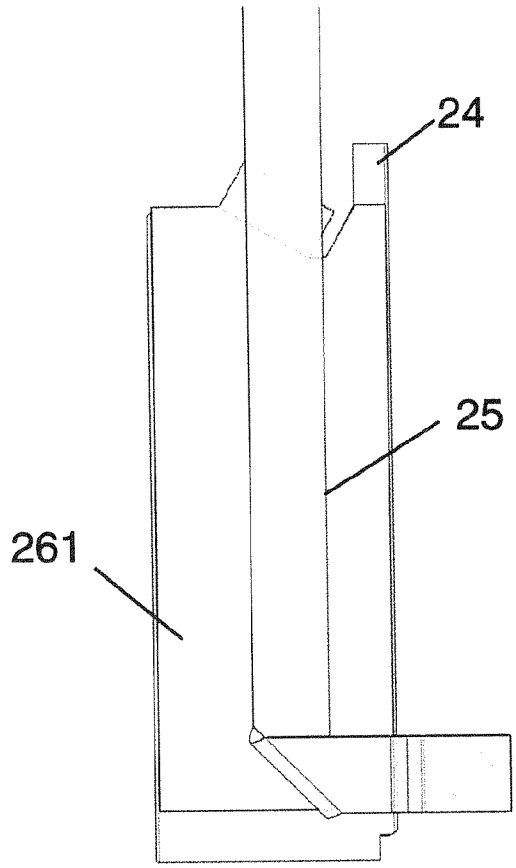


Fig.2D

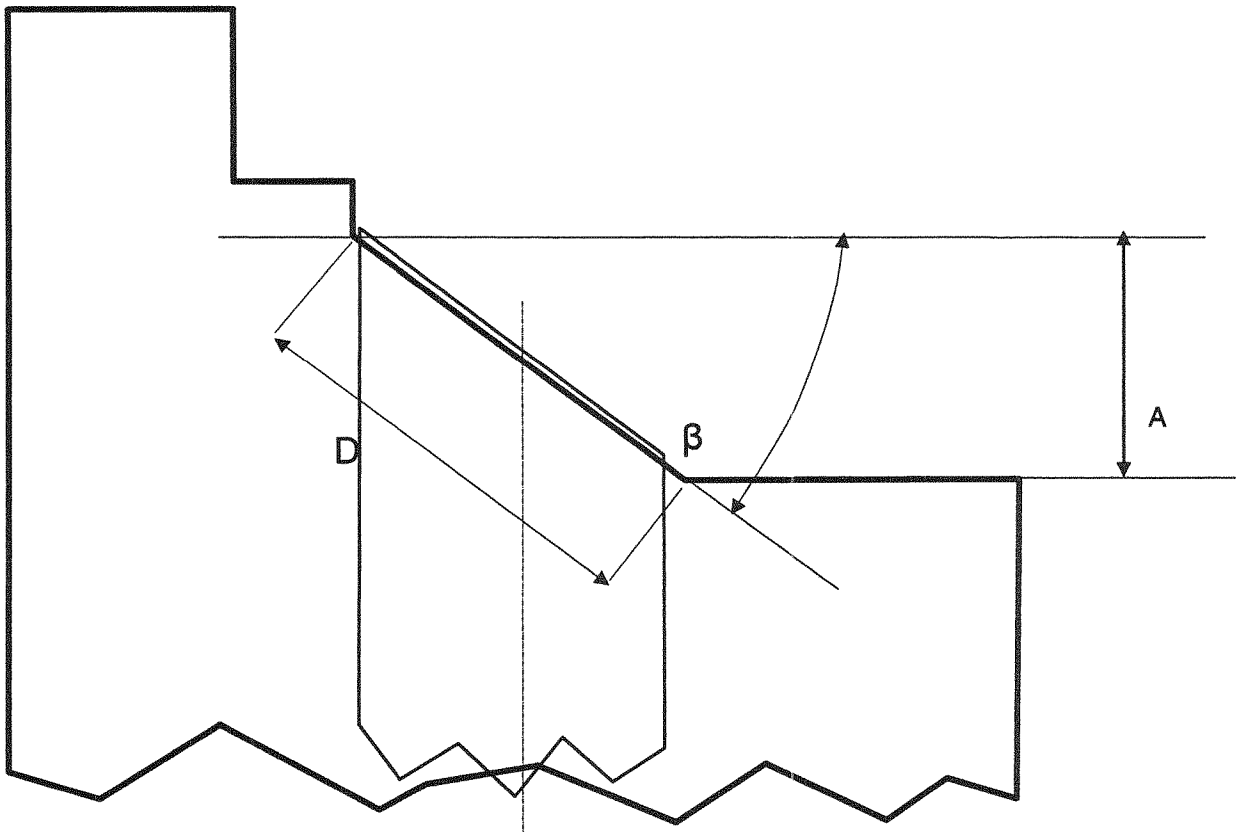


Fig.3A

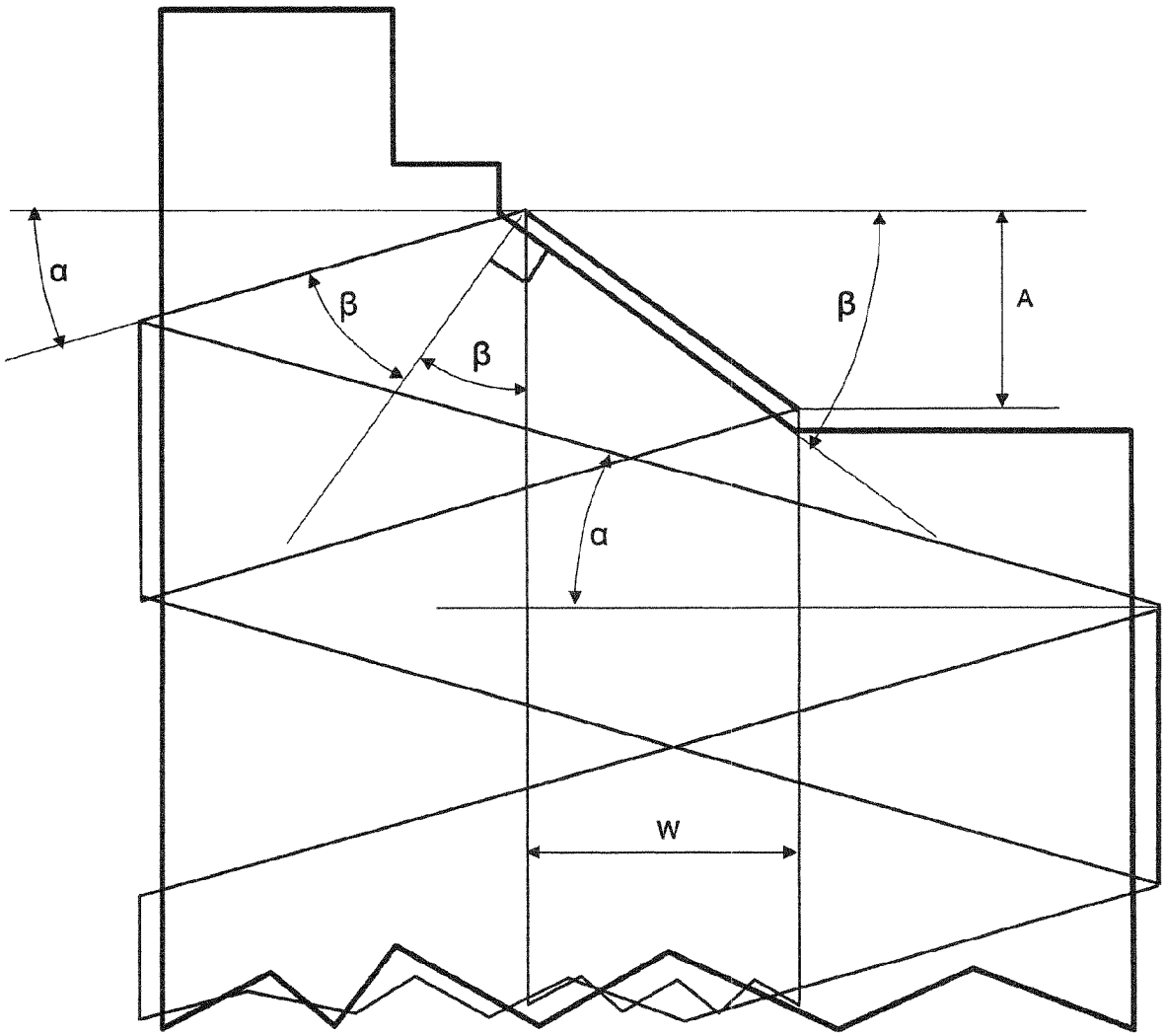


Fig. 3B

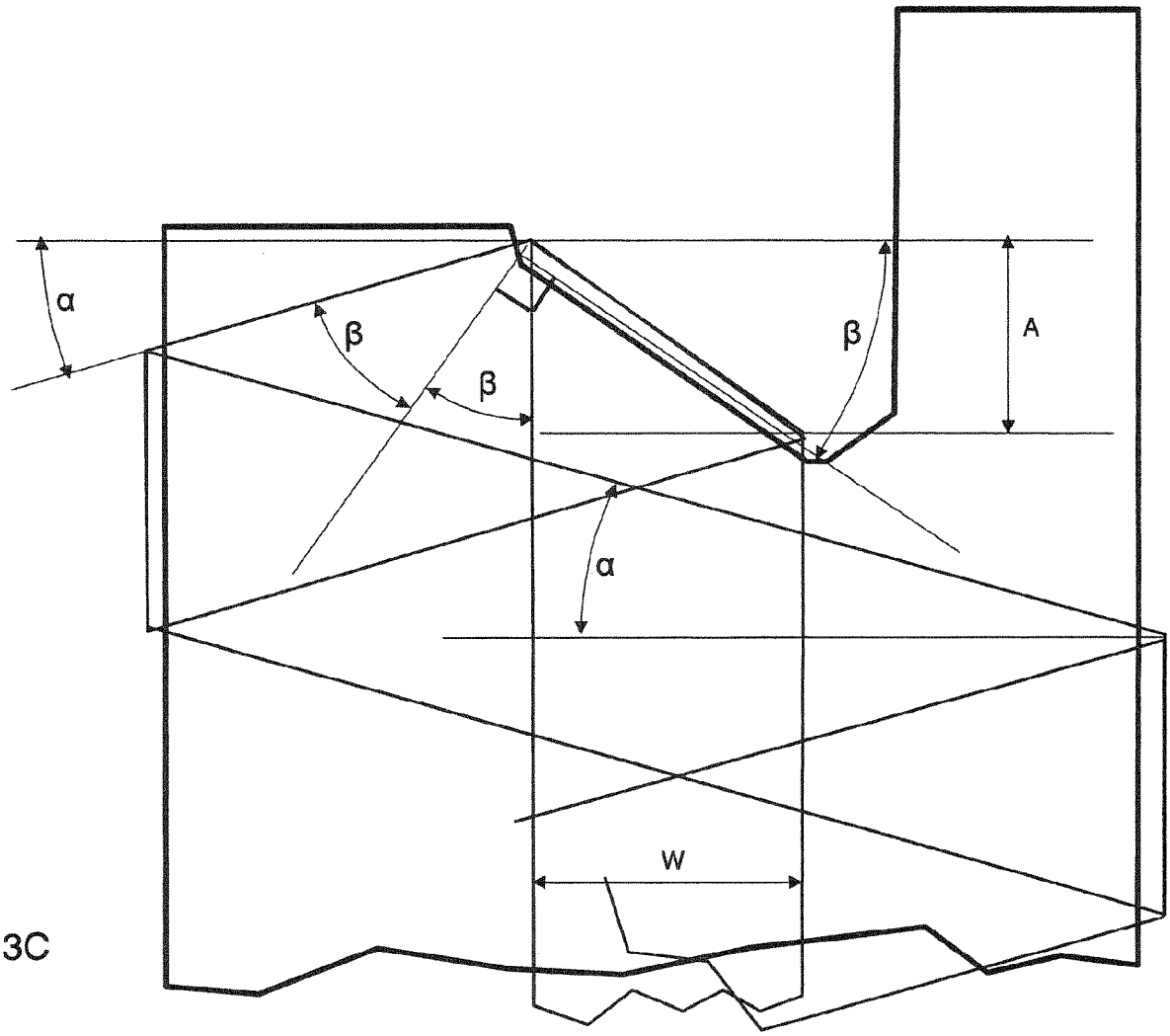


Fig.3C

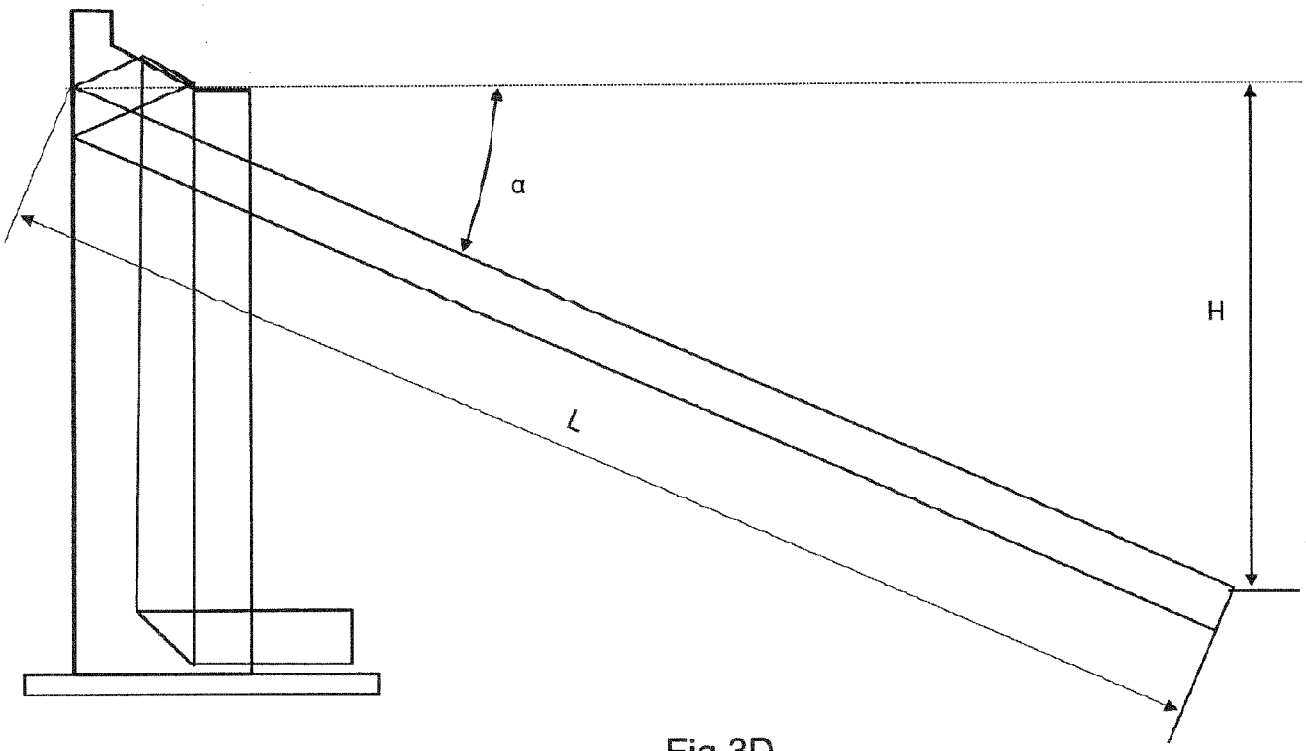


Fig.3D

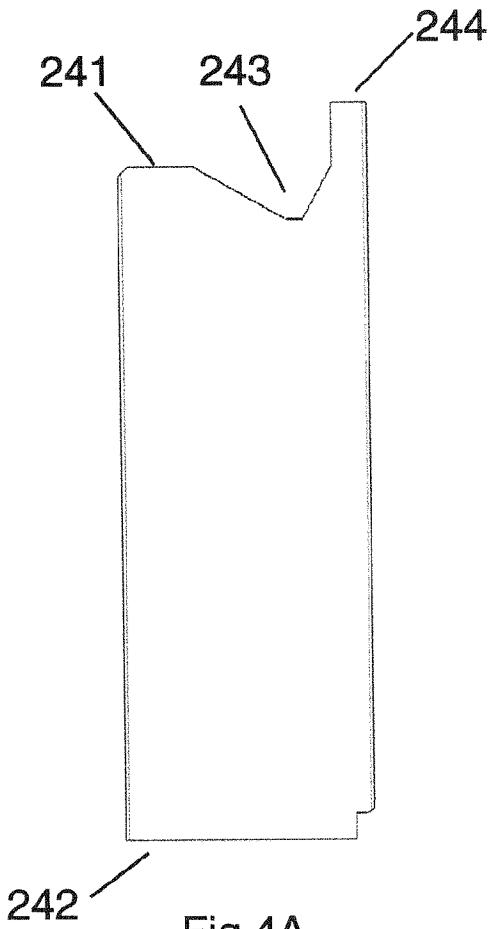


Fig.4A

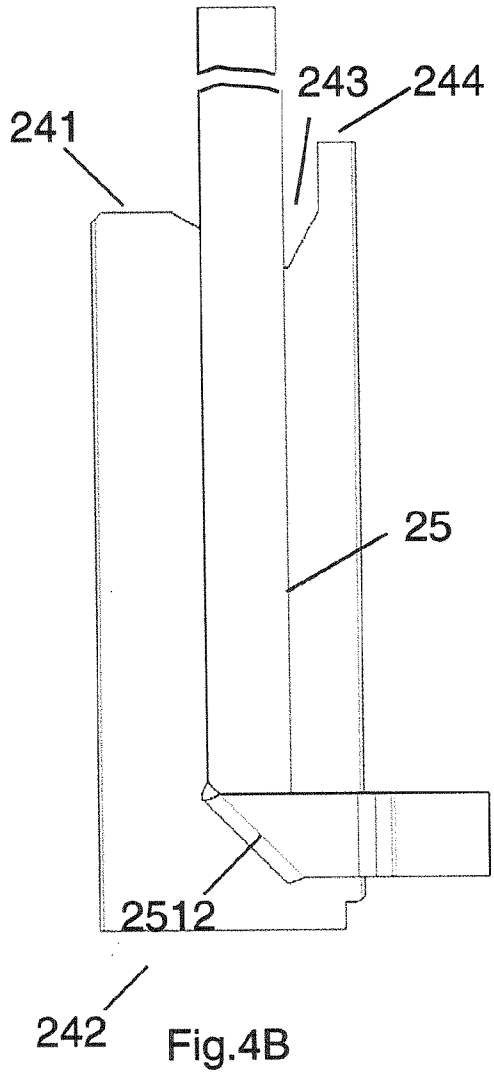


Fig.4B

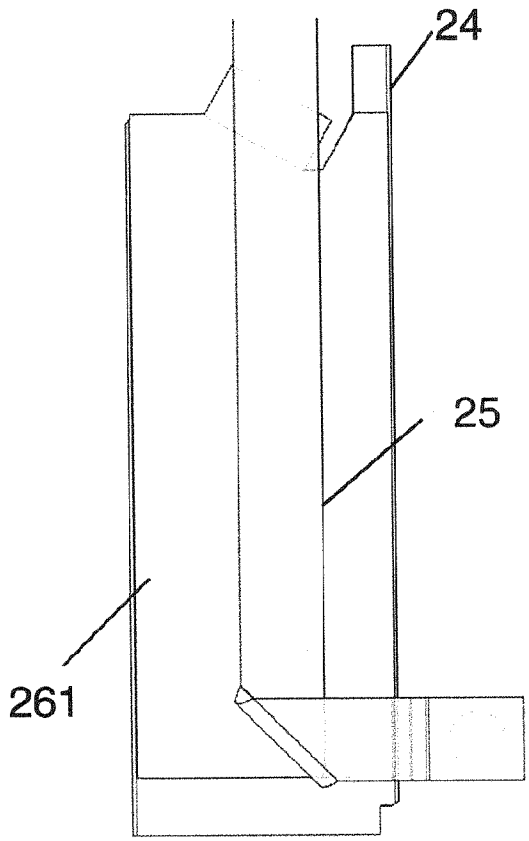


Fig.4C

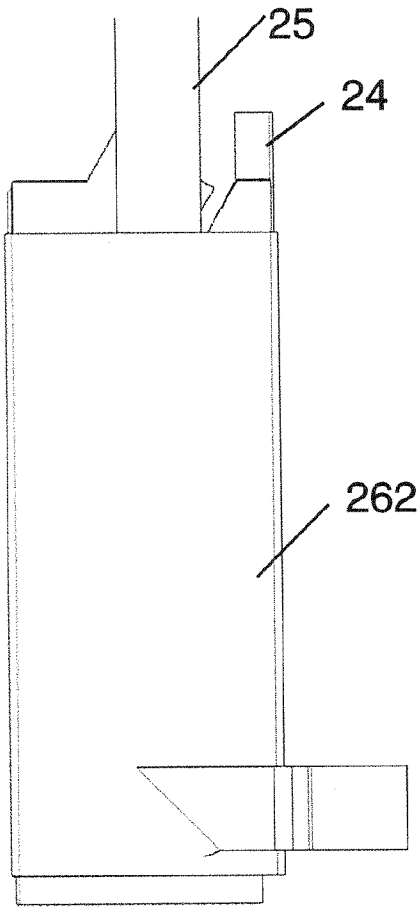


Fig.4D

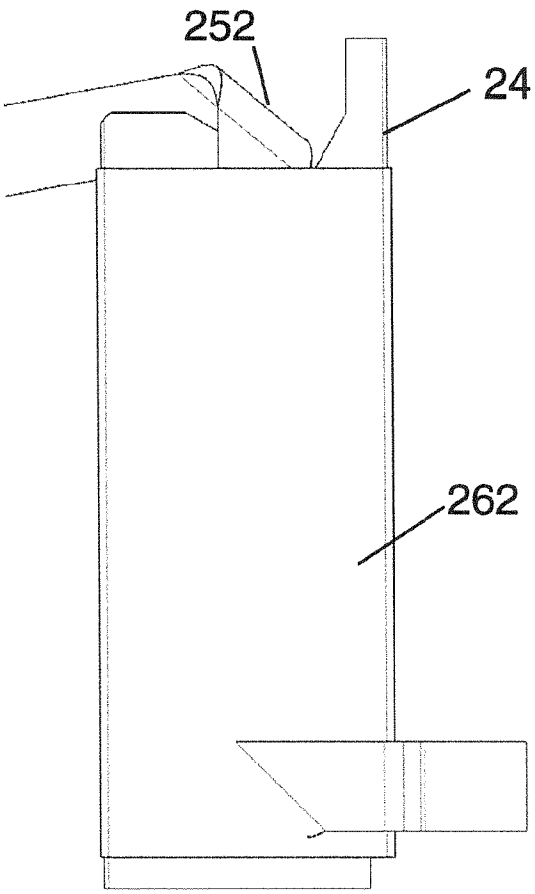


Fig.4E

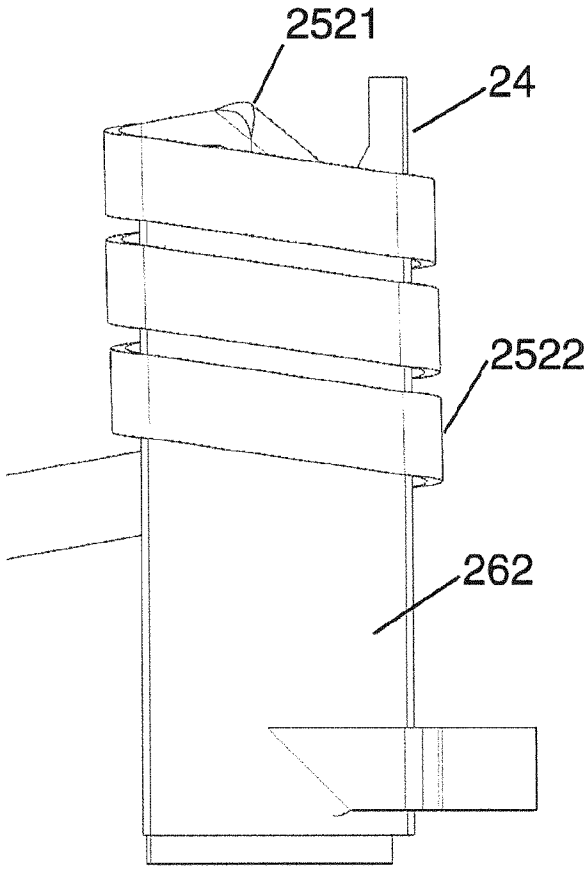


Fig.4F

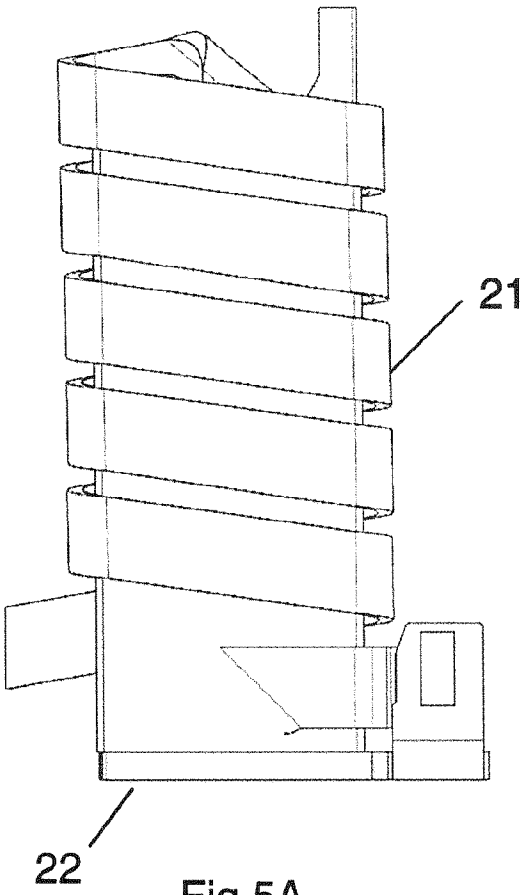


Fig.5A

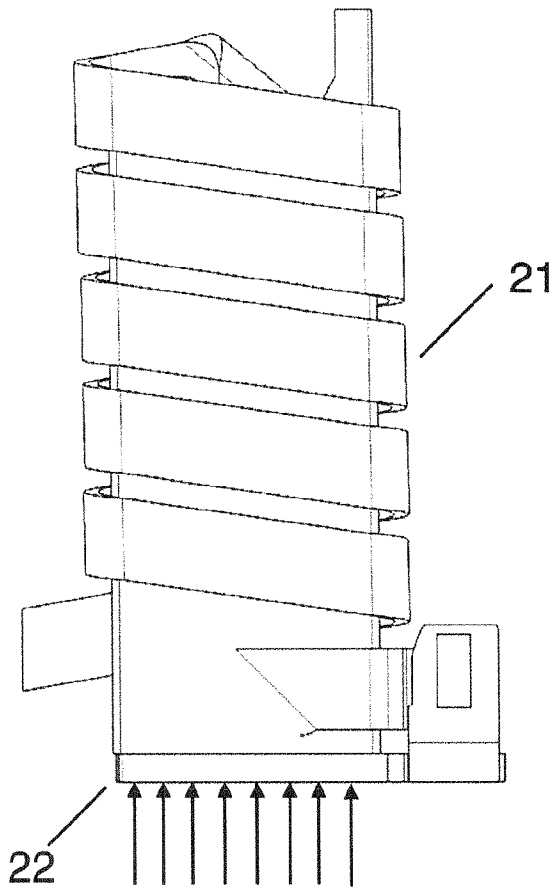


Fig.5B

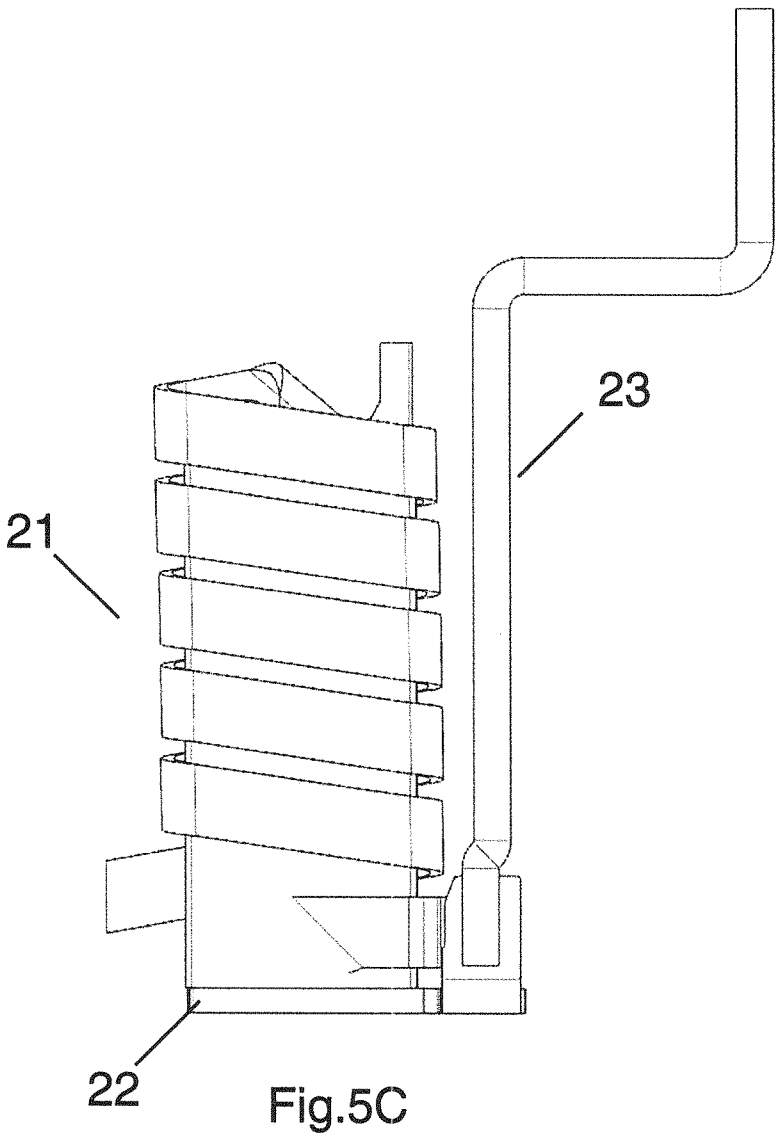


Fig.5C

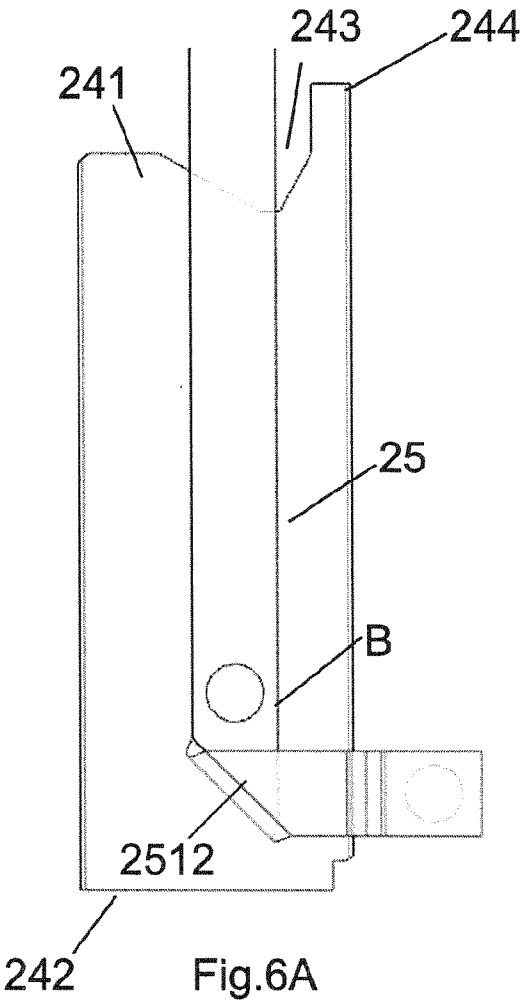


Fig.6A

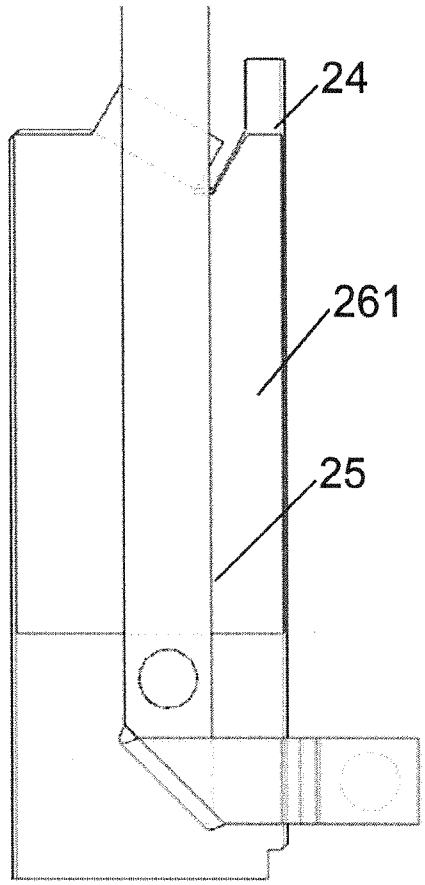


Fig.6B

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/053814

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01H71/16
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 196 46 003 C1 (SIEMENS AG [DE]) 20 November 1997 (1997-11-20) column 1, lines 51-60; figure 2	1-19
A	CH 232 754 A (HERMES PATENTVERWERTUNGS GMBH [DE]) 15 June 1944 (1944-06-15) the whole document	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 May 2012	08/06/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Simonini, Stefano

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2012/053814

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 19646003 C1	20-11-1997	NONE	
CH 232754 A	15-06-1944	NONE	