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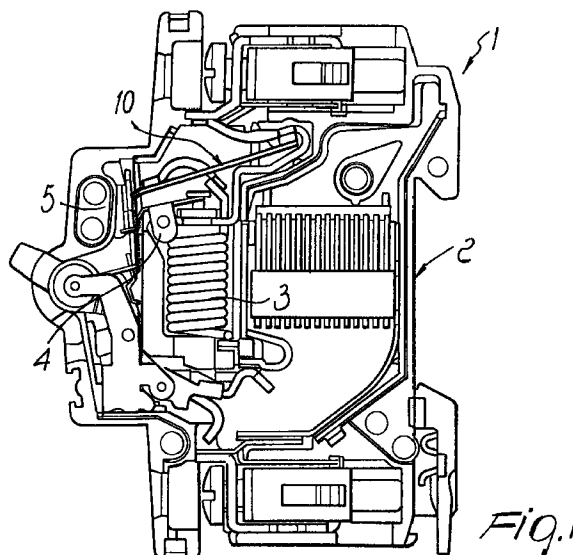
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(54) **Magnetothermal low voltage circuit breaker with sensitive element made from shape-memory material**

(57) The present invention relates to a magnetothermal low voltage circuit breaker with sensitive element made from shape-memory material which comprises a coil traversed by current and operationally interconnected with a magnetic trip device for instantaneously breaking the flow of current for short-circuit and a thermal trip device for breaking the flow of current for overload. The aforesaid thermal trip device consists of an element made from a shape-memory material. The novel feature of the invention consists in the fact that the aforesaid shape-memory material exhibits a temperature of transition between the martensite phase and the austenite phase of greater than 90°C and a thermal shock resistance temperature of greater than 600°C.



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Description

The present invention relates to a magnetothermal low voltage circuit breaker with sensitive element made from shape-memory material.

As is known, magnetothermal low voltage circuit breakers are made with two separate trip devices, more precisely a thermal trip device that is time-dependent and trips in the event of a current overload and a time-independent or instantaneous electromagnetic trip device which trips in the event of short-circuit.

In the most embodiments the thermal trip device is made with a bimetallic strip which exhibits considerable limits of applicability, on account of its poor versatility for being adapted to protection for the various uses.

Moreover, with a bimetallic strip it is not possible to obtain repeatability of tripping performances and it is necessary to carry out very complex and expensive calibration operations.

In order to overcome the above undesirable drawback, magnetothermal circuit breakers have already been introduced in which the thermal trip device is made from a shape-memory material which is used instead of the bimetallic strip and which is normally obtained from NiTi alloys or alloys based on CuNiTi which are made with different structural configuration.

The principle of operation is conceptually similar to the bimetallic-based low voltage circuit breakers: the current passes through the shape-memory material and when the current exceeds the rated value, the overheating produced by the Joule effect on the material heats it above the temperature of activation (or phase-transition) in a time which depends on the magnitude of the current, so that the circuit is opened.

The shape-memory materials currently available on the market, although they have afforded improvements relative to previous solutions, have the drawback of being subject to ageing with consequent loss of their response characteristics over time and are moreover rather unstable to thermal shocks associated with short-circuit currents, with the consequent risk of irreversible damage of the material ("loss of memory").

Consequently it is necessary to introduce devices for protection from short-circuit currents and therefore the resulting mechanisms are not always reliable and are moreover bulky and expensive.

Another drawback is that shape-memory materials generally have transition temperatures which close to ambient temperature; it is therefore difficult to guarantee that operation is always efficient and correct.

The task addressed by the invention is precisely that of eliminating the above undesirable drawbacks, by making a magnetothermal low voltage circuit breaker with sensitive element made from shape-memory material which affords the possibility of considerably simplifying all the constructional aspects, without having the need to provide devices for protection against short-circuit currents.

Within the scope of the aforesaid task a particular objective of the invention is that of making a thermal trip device which is very stable, having an activation temperature considerably above ambient temperature.

Another objective of the present invention is that of making a magnetothermal circuit breaker in which the thermal trip device is able to afford the widest guarantees of reliability and safety during use.

Not the last objective of the present invention is that of making a magnetothermal low voltage circuit breaker which is of simplified structure and which, moreover, is advantageous from a purely cost point of view.

The aforesaid task as well as the objectives cited, are achieved by a magnetothermal low voltage circuit breaker with sensitive element made from shape-memory material

comprising a coil traversed by current and operationally interconnected with a magnetic trip device for instantaneously breaking the flow of current for short-circuit and a thermal trip device for breaking the flow of current for overload, the said thermal trip device consisting of an element made from shape-memory material, characterised in that the said shape-memory material exhibits a temperature of transition between the martensite phase and the austenite phase of greater than 90°C and a thermal shock resistance temperature of greater than 600°C.

Further characteristics and advantages will emerge from the description of a preferred but non-exclusive embodiment of a magnetothermal low voltage circuit breaker with sensitive element made from shape-memory material, shown as a non-limiting example in the appended drawings in which:

Figure 1 represents diagrammatically a magnetothermal low voltage circuit breaker;

Figure 2 represents diagrammatically a possible embodiment of the thermal trip device under rest conditions;

Figure 3 represents the thermal trip device activated.

With reference to the above mentioned figures, the magnetothermal low voltage circuit breaker, according to the invention, which is denoted in its entirety by the reference number 1, comprises a boxlike body 2 with a configuration which is known per se, inside which is provided a coil 3 traversed by the current and operationally interconnected with a magnetic trip device 4 which acts on the trigger device 5 of the circuit breaker, opening the contacts and breaking the flow of current.

In addition to the magnetic trip device, there is provided a thermal trip device 10 which, in the embodiment shown in Figure 1, consists of a strip made from shape-memory alloy which is represented under rest conditions in the martensite phase. The shape-memory material strip is to modify its shape so that a portion of it acts on the trigger mechanism of the circuit breaker. At

the moment of activation, the shape-memory alloy is subject to phase transition to the austenite phase and the strip returns to an initial memorised curved shape in which the left end, referring to the drawing, is raised and acts on the opening mechanism. An important novel feature of the invention consists in the fact that the alloy used exhibits a temperature of transition between the martensite phase and the austenite phase which is greater than 90°C and has a thermal shock resistance temperature which is greater than 600°C.

Advantageously a preferred but non-limiting embodiment provides for the use of an alloy based on hafnium; more specifically, in a preferred formulation thereof, the alloy consists of nickel from 30 to 51%, titanium from 20 to 66.5% and hafnium from 3.5 to 40% as, for example, explained in patent US 5114504.

By using an alloy of this type it is possible to make a strip with smaller dimensions than those which are typical of bimetallic strips, by virtue of the fact that it is possible to obtain large deformations at the moment of transition when the "memorised shape" is recovered.

The use of a strip of this type affords the possibility of considerably increasing the compactness of the device, with constructional simplification and complete integration of all the components of the circuit breaker.

The device can also be provided with a system for restoring the shape typical of the rest condition when the shape-memory material has reverted to the martensite phase; the restoring mechanism can be incorporated within the manual resetting mechanism of the circuit breaker, thus further increasing the compactness of the circuit breaker.

The thermal trip device described above can be provided with external means of restoring the typical rest shape in the martensite phase such as for example return springs or the like, or can be made in such a way that the material recovers its typical rest shape at the change of phase (austenite to martensite), so that the material is defined as having a 2-way shape memory.

Obviously the type of actuation can also be modified in any way to suit differing operational requirements.

According to a different embodiment the shape-memory material, instead of acting directly on the trigger mechanism, acts on an actuator which can engage with the trigger mechanism. In such a case the thermal trip device is able to adopt a first configuration in which it latches the actuator, and a second configuration in which it unlatches the actuator.

For example, with reference to Figures 2 and 3, the shape-memory material thermal trigger element made with an alloy containing hafnium, provides for a retention device referenced with 20, which under rest conditions exhibits a contracted configuration so that an actuating actuator 21, thrust by a spring 22, counteracts with it. When the transition temperature is reached the deformable element 20 changes its shape by expanding and allows the movement of the actuator 21 which

thrust by the spring passes through the retention device and interacts with the trigger mechanism.

In the embodiment shown in Figures 2 and 3 the retention device 20 is a shape-memory alloy based ring whose internal diameter in the austenite phase is greater than the external diameter of the actuator 21. In the rest condition (Fig. 2) the element 20 is in the martensite phase and has a contracted configuration. In the activated condition (Fig. 3) the element 20 is in the austenite phase and has recovered its memorised configuration thus unlatching the actuator 21.

In practice the plunger is always subject to the thrust of the spring, so that when the deformable shape-memory element 20 is subject to phase transition to the austenite phase said element 20 recovers its memorised configuration, thus unlatching the actuator (or plunger) that interacts with the trigger mechanism.

A simple mechanism connected to the resetting mechanism of the circuit breaker, which operates the resetting of the spring 22, is sufficient for performing reclosure.

From the foregoing description it is therefore clear how the invention achieves the proposed objectives and in particular it is pointed out that the invention allows considerable improvements to be made to thermal trip devices for magnetothermal circuit breakers, overcoming all the drawbacks associated both with bimetallic strips and with existing devices made from shape-memory alloy, by using a particular shape-memory alloy based on hafnium which allows a transition phase which is very far from ambient temperature and moreover allows a particularly high resistance to thermal shocks from short-circuit currents, so that it does not suffer irreversible damage.

The invention thus devised is capable of numerous modifications and variations all within the scope of the inventive concept. Moreover, all the details can be substituted with other technically equivalent elements. In practice the configurations employed as well as the dimensions and contingent shapes can widely be varied according to requirements.

Claims

1. A magnetothermal low voltage circuit breaker with sensitive element made from shape-memory material comprising a coil traversed by current and operationally interconnected with a magnetic trip device for instantaneously breaking the flow of current for short-circuit and a thermal trip device for breaking the flow of current for overload, the said thermal trip device consisting of an element made from shape-memory material, characterised in that the said shape-memory material exhibits a temperature of transition between the martensite phase and the austenite phase of greater than 90°C and a thermal shock resistance temperature of greater than 600°C.

2. A magnetothermal low voltage circuit breaker according to claim 1, characterised in that the shape-memory material is an alloy containing hafnium. 5
3. A magnetothermal low voltage circuit breaker according to any of the preceding claims, characterised in that the said shape-memory material is an alloy containing nickel, titanium and hafnium. 10
4. A magnetothermal low voltage circuit breaker according to one or more of the preceding claims, characterised in that the said shape-memory material is an alloy containing nickel from 30 to 51% titanium from 20 to 66.5% and hafnium from 35 to 40%. 15
5. A magnetothermal low voltage circuit breaker according to one or more of the preceding claims, characterised in that the said thermal trip device comprises a strip made from the said shape-memory material and able to modify its shape so that a portion of it acts on the trigger mechanism of the said magnetothermal circuit breaker. 20
6. A magnetothermal low voltage circuit breaker according to one or more of the preceding claims, characterised in that the said thermal trip device made from shape-memory material acts on an actuator which can engage with the trigger mechanism, the said thermal trip device being able to adopt a first configuration in which it latches the said actuator, and a second configuration in which it unlatches the said actuator. 25
7. A magnetothermal low voltage circuit breaker according to claim 6, characterised in that the said thermal trip device comprises a shape memory alloy retention device which, in a first contracted configuration, latches the said actuator, and in a second expanded configuration, in unlatches the said actuator. 30
8. A magnetothermal low voltage circuit breaker according to one or more of the preceding claims, characterised in that it comprises a mechanism for restoring the shape typical of the rest condition of the thermal trip device made from the said shape-memory material, said mechanism being incorporated within the resetting mechanism of the circuit breaker. 35
9. A magnetothermal low voltage circuit breakers according to one or more of the preceding claims, characterised in that it comprises a mechanism for restoring the original shape of the thermal trip device made from shape-memory material, said mechanism being obtained from a 2-way shape- 40

memory material able to restore its typical shape under rest conditions upon the return to the temperature corresponding to the martensite phase.

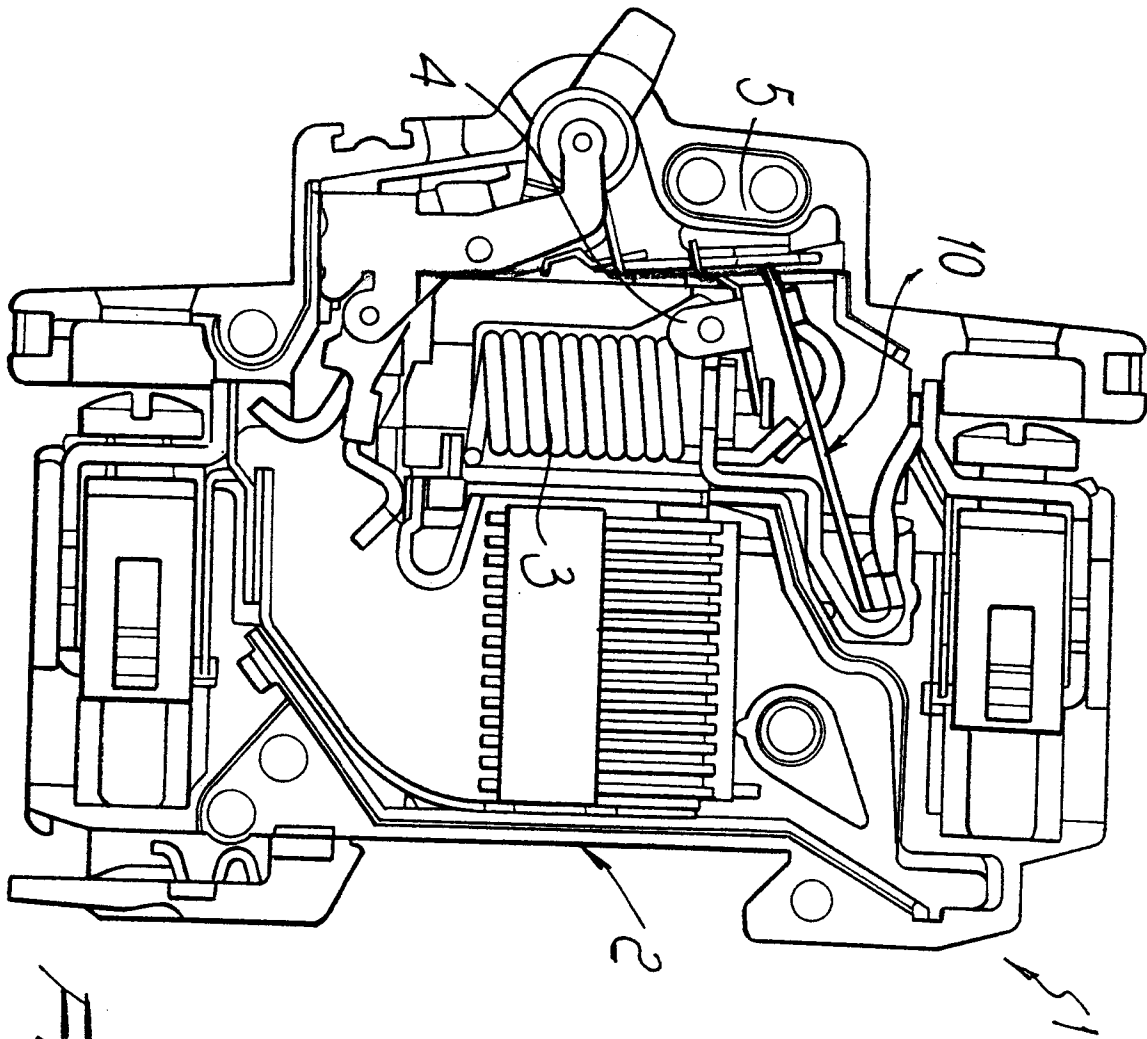


Fig. 1

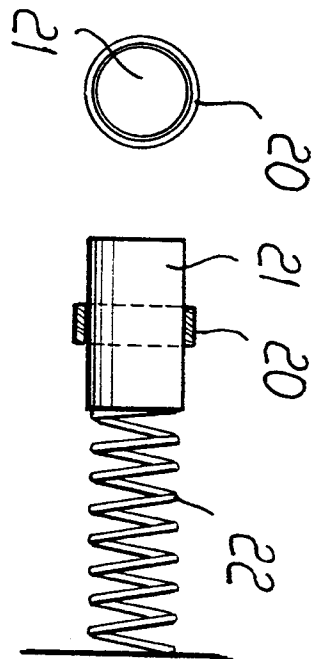


Fig. 2

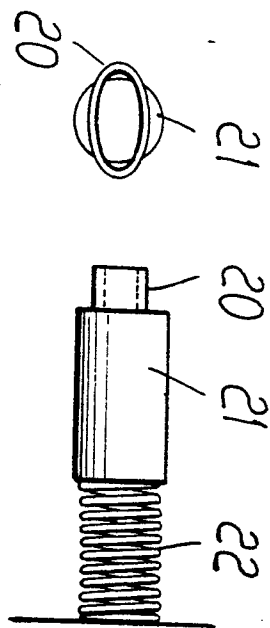


Fig. 3