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(54) **Titre : RELAIS ELECTROMAGNETIQUE**
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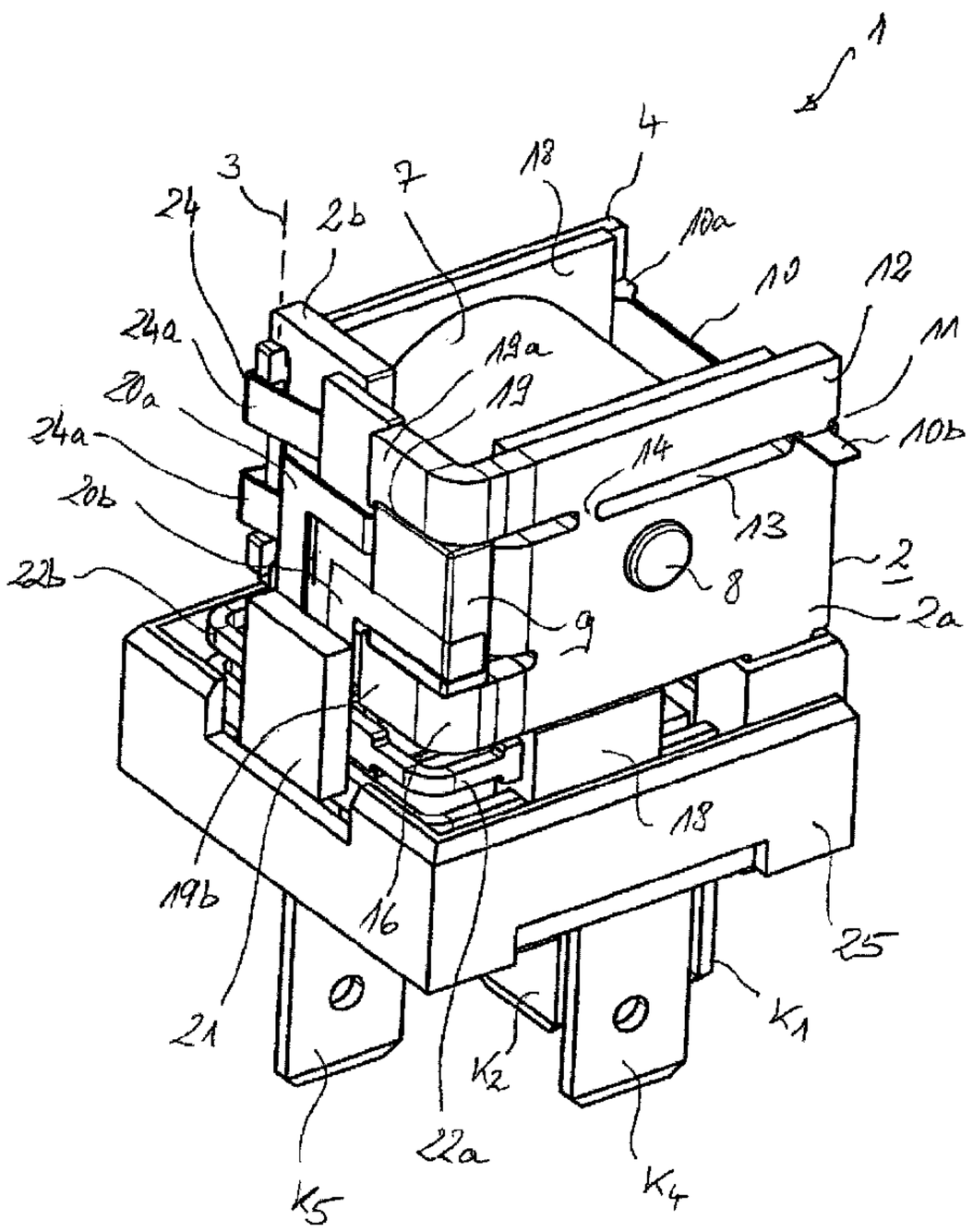

(57) **Abrégé/Abstract:**
The invention relates to an electromagnetic relay (1), in particular a motor vehicle relay, comprising a magnet yoke (2), a relay coil (7), a hinged armature (4) which is pivotable about an axis of rotation (3) and on which a moving contact (5), as working or switchover contact, is retained relative to at least one fixed contact (6a), and comprising a piezo actuator (9), which keeps the working or switchover contact (5, 6a, 6b) closed when the relay coil (7) is de-energised as a result of the actuation of said piezo actuator.

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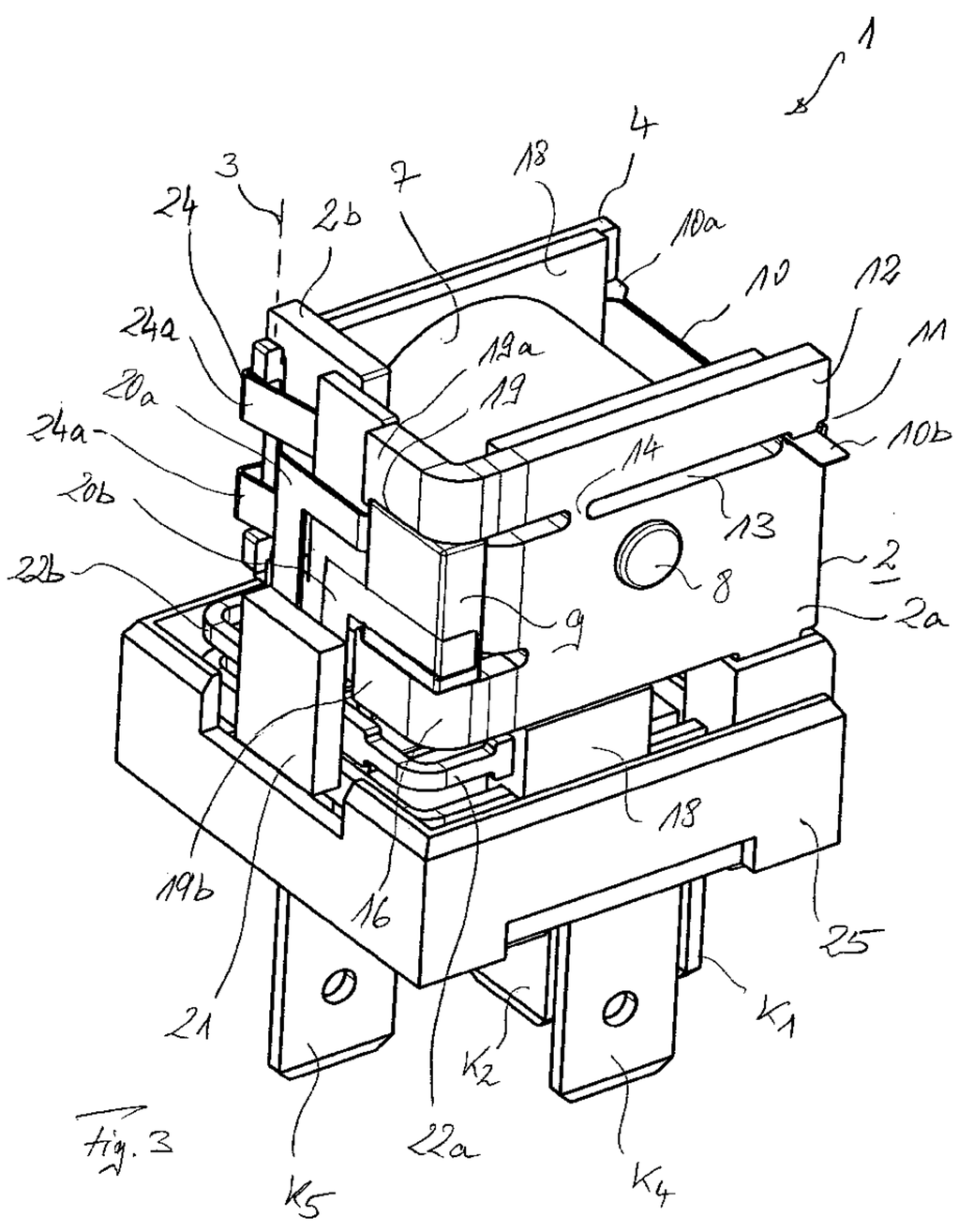

fig. 3

(57) Abstract: The invention relates to an electromagnetic relay (1), in particular a motor vehicle relay, comprising a magnet yoke (2), a relay coil (7), a hinged armature (4) which is pivotable about an axis of rotation (3) and on which a moving contact (5), as working or switchover contact, is retained relative to at least one fixed contact (6a), and comprising a piezo actuator (9), which keeps the working or switchover contact (5, 6a, 6b) closed when the relay coil (7) is de-energised as a result of the actuation of said piezo actuator.

(57) Zusammenfassung: Die Erfindung betrifft ein elektromagnetisches Relais (1), insbesondere Kraftfahrzeug-Relais, mit einem Magnetjoch (2), mit einer Relaisspule (7), mit einem um eine Drehachse (3) schwenkbaren Klappanker (4), an dem als Arbeits- oder Umschaltkontakt ein Bewegkontakt (5) gegenüber mindestens einem ersten Festkontakt (6a) gehalten ist, sowie mit einem Piezoaktor (9), der infolge dessen Ansteuerung den Arbeits- bzw. Umschaltkontakt (5, 6a, 6b) bei stromloser Relaisspule (7) geschlossen hält.

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Description

Electromagnetic relay

The invention relates to an electromagnetic relay, in particular a motor vehicle relay, comprising a magnet yoke and comprising a relay coil and also comprising a hinged armature which can be pivoted about a rotation axis and on which a moving contact, as an operating or switchover contact, is held relative to at least a first fixed contact.

A relay, as also used in many instances as an electromagnetic switch in a motor vehicle in particular, is activated by means of a control circuit in which the relay coil is situated and usually switches at least one further circuit in which, for example, an electric motor, a gasoline pump or often also safety-relevant vehicle components, for example a fuel injection system, are connected.

In principle, a distinction is drawn between monostable and bistable relays. A monostable relay requires a permanent flow of current through the relay coil (field winding) in order to pull in and also to hold the armature, for the purpose of assuming and maintaining the operating position (ON). If the flow of current is interrupted, the relay autonomously returns to its inoperative position (OFF). A bistable relay can have two different stable states in the deenergized state, and therefore, when a current pulse is generated in the control circuit, it switches over to the respectively other switching state and maintains this switching state until the next control pulse. The bistable relay therefore has to be actively actuated in order to reach a defined switching position.

Relays which have as low a power as possible and can be actuated in a power-saving manner are desired or

required particularly in the motor vehicle sector, especially since power losses and in particular permanent losses result in correspondingly elevated CO_2 emissions by the motor vehicle.

In order to provide low-power relays, DE 43 25 619 A1 discloses connecting two relays in parallel in a first phase, in which a comparatively large pull-in voltage for the armature is required, and, after the operating circuit contact is closed, connecting said two relays in series in a second phase in which only a comparatively low holding voltage is required.

In a relay which is known from DE 44 10 819 A1, a switch bridges a holding resistor which adjusts the holding current of the field winding of the relay. As a result of the resistor being bridged, a comparatively large pull-in current is available at the first moment at which the field winding is connected.

DE 10 2005 037 410 A1 discloses reducing the voltage supply to a minimum, which holds the working contact, in the field circuit by means of a microcontroller after the relay has been pulled in.

In a relay which is known from DE 10 2008 023 626 A1, when the relay is supplied with current by means of a switch, the relay controller is designed to control the field current in such a way that a pull-in current initially flows through the field winding and, after a pull-in time has elapsed, a holding current which is smaller than the pull-in current flows through said field winding.

It is also known, for example from DE 92 12 266 U1, to reduce the power loss in the relay coil by pulse-width

modulation of the coil current following the pull-in time when a relay is controlled.

The invention is based on an object of specifying an electromagnetic relay, which is suitable preferably as a motor vehicle relay, which operates with as low a power as possible, in particular in the holding mode (ON).

According to the invention, this object is achieved by the features described herein. Advantageous refinements, developments and variants are also described herein.

According to an aspect of the invention, there is provided an electromagnetic relay, in particular motor vehicle relay, comprising a magnet yoke and comprising a relay coil and also comprising a hinged armature which can be pivoted about a rotation axis and on which a moving contact is held relative to at least a first fixed contact,
characterized by
a piezo actuator which, as a result of being actuated, keeps the moving contact closed when the relay coil is deenergized.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein,
characterized by
a piezo stack actuator, the force stroke direction of which runs parallel to the rotation axis of the hinged armature as a result of the actuation.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein,
characterized by
a lever transmission means for converting a force stroke, which is generated by the piezo actuator as a result of being actuated, into a clamping stroke for fixing a tension element, which is held on the hinged armature side and/or on the moving contact side, in a releasable and clamped manner.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized
in that the tension element, which is held on one side of the hinged armature, is routed by way of its free side into a clamping gap and, as a result of the piezo actuator being actuated, is held in the clamping gap in a force-fitting manner.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized
in that the magnet yoke has a clamping lever which pivots about a rotation or tilting point, has a lever arm which is acted on by the piezo actuator, and has a clamping arm which is routed to the clamping gap.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized
in that the clamping lever is produced by a radial slot which is made in the magnet yoke, in particular in the pole limb of said magnet yoke, and which is formed by a material web which represents the rotation point.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized
in that the clamping arm is longer than, in particular at least twice as long as, the lever arm.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized
in that the tension element is oriented axially, and the clamping gap is oriented radially, in relation to the relay coil.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized
in that the magnet yoke has a supporting limb which is spaced apart from the clamping lever and on which the piezo actuator, which operates the clamping lever as a result of being actuated, is supported.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized
in that the distance between the clamping lever and the supporting limb is matched to the actuator height which runs in the stroke direction of the piezo actuator.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized by
an L-shaped magnet yoke comprising, in relation to the relay coil, a radial pole limb and an axial functional limb to which the hinged armature is connected in an articulated manner by means of the rotation axis.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized
in that the functional limb has a U-shaped receiving pocket for the piezo actuator, wherein the U-limbs, which are parallel to one another, merge with the clamping limb and, respectively, with the supporting limb of the pole limb.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized
in that the relay coil has a magnet core which is surrounded by a field winding and is routed toward the hinged armature and is fastened to the magnet yoke.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized
in that the clamping gap is formed by a clamping cam, which is preferably provided on the clamping lever, and a bead-like clamping groove in which the clamping cam engages so as to secure the tension element against pivoting radially outward.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized
in that the moving contact is designed as a spring contact for generating a spring return force which acts on the hinged armature.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized
in that an approximately L-shaped spring element of the spring contact is bent in such a way that one of the offset spring limbs is fixed to the functional limb of the magnet yoke, and the further spring limb is fixed to the hinged armature.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, characterized
in that a second fixed contact is connected to a non-reactive resistor, which is connected in parallel with the piezo actuator, so as to form the switchover contact.

According to another aspect of the invention, there can be provided the electromagnetic relay described herein, comprising a control electronics system for actuating both the relay coil and also the piezo actuator.

According to another aspect of the invention, there is provided an electromagnetic relay comprising:

a magnet yoke;

a relay coil; and

a hinged armature which can be pivoted about a rotation axis and on which a moving contact is held relative to at least a first fixed contact,

wherein a piezo actuator is provided which, as a result of being actuated, keeps the moving contact closed when the relay coil is deenergized.

According to another aspect of the present invention, there is provided an electromagnetic relay, comprising:

a magnet yoke having a clamping gap formed therein;

a relay coil;

a moving contact;

a first fixed contact;

a hinged armature being pivotable about a rotation axis and on which said moving contact being held relative to at least said first fixed contact;

a piezo actuator which, as a result of being actuated, keeps said moving contact closed when said relay coil is de-energized;

a tension element having a free side, said tension element being held on one side of said hinged armature, and being routed by way of said free side into said clamping gap and, as a result of said piezo actuator being actuated, is held in said clamping gap in a force-fitting manner; and

a lever transmission device for converting a force stroke, which is generated by said piezo actuator as a result of being actuated, into a clamping stroke for fixing said tension element, which is held on a hinged armature side and/or on a moving contact side, in a releasable and clamped manner.

According to another aspect of the present invention, there is provided an electromagnetic relay, comprising:

a relay coil;

a moving contact;

a first fixed contact;

a hinged armature being pivotable about a rotation axis and on which said moving contact being held relative to at least said first fixed contact;

an L-shaped magnet yoke containing, in relation to said relay coil, a radial pole limb and an axial functional limb to which said hinged armature is connected in an articulated manner by means of said rotation axis;

a piezo actuator which, as a result of being actuated, keeps said moving contact closed when said relay coil is de-energized;

said radial pole limb having a supporting limb and a clamping limb; and

said axial functional limb having a U-shaped receiving pocket for said piezo actuator, wherein said U-shaped receiving pocket has U-limbs, which are parallel to one another, merge with said clamping limb and, respectively, with said supporting limb of said radial pole limb.

To this end, the relay points a the moving or switchover contact and therefore forms a hybrid system with monostable behavior with only a very low level of current consumption. When the field winding is deenergized, the moving or switchover contact is held closed by the piezo actuator, preferably indirectly by means of the hinged armature against which the moving contact bears in a spring-prestressed manner in the form of a spring contact.

Therefore, although the relay according to the invention is comparable to a bistable system according to the principle of the holding mode, the relay coil or field winding is deenergized in the holding mode, in contrast to a conventional monostable relay. The piezo actuator requires a brief flow of current only when it

is actuated, whereas a voltage only has to be applied following this brief flow of current given an only very small leakage current (holding mode). Since the piezo actuator therefore operates virtually without power and the relay coil is deenergized, the relay according to the invention likewise operates virtually without power in the holding mode.

The hybrid piezo relay system which is provided as a result is particularly suitable for reliable switching. The monostable behavior ensures that the piezo relay leads to a defined state in a reliable and autonomous manner in the event of a loss of voltage, in particular in the event of a loss of the on-board electrical system voltage of a motor vehicle. Since the piezo actuator only maintains the contact closure for as long as the actuation voltage of said piezo actuator is supplied in the holding mode and when the relay coil is deenergized, the contact opens spontaneously in the event of a loss of the actuation voltage as a result of the loss of the supply or on-board electrical system voltage.

On account of the holding or inoperative state which is maintained virtually without power, the relay according to the invention is extremely advantageous, particularly in the motor vehicle sector, since the low power loss is accompanied by a corresponding CO_2 saving by the motor vehicle. In addition, the temperature development of the relay coil of the hybrid piezo relay system according to the invention, that is to say the operating temperature, is considerably lower than in conventional relays and is approximately room temperature. This provides the considerable advantage of a particularly flexible and variable design of the installation space for the piezo relay.

Although it is known, in principle, to equip a relay with a piezo actuator (piezoelectric elongator), a piezo actuator, which is designed in particular as a piezoelectric bending tranducer, replaces the field winding or coil and acts directly on the operative contact in the case of said relays, as are known, for

example, from DE 36 03 020 C2, from WO 89/02659, from DE 198 13 128 A1 or DE 10 2006 018 669 A1.

A piezo actuator which acts on the hinged armature with direct mechanical contact is also used in a residual current release which is known from DE 41 18 177 A1. However, in addition or as an alternative to a field winding which surrounds the pole limb of a U-shaped magnet yoke, the piezo actuator serves to lift off the hinged armature from the pole surface, in order to assist a mechanical return spring, which acts on the hinged armature, to overcome an undesired adhesion force.

The piezo actuator of the relay according to the invention is preferably designed as a (piezo) stack actuator (stack), the force stroke direction of which runs parallel to the rotation axis of the hinged armature. In order to increase the force stroke which is generated by the piezo actuator as a result of being actuated, a lever transmission means is suitably provided, said lever transmission means converting the force stroke into a clamping stroke for releasably fixing a tension element which is held on the hinged armature or moving contact side. The transmission ratio is suitably 2:1, so that a force stroke of the piezo actuator of, for example, $\geq$ 15 µm leads to a clamping stroke of $\geq$ 30 µm.

In an advantageous refinement, the tension element, which is held on one side of the hinged armature or moving contact (changeover or switchover contact), is routed by way of its free side into a clamping gap and held there in a force-fitting manner as a result of the piezo actuator being actuated.

The clamping gap is preferably provided on the magnet yoke. To this end, a slot, which is produced by a material cutout and which runs radially in relation to the relay coil and is interrupted or closed at a suitable point by a narrow web which is formed by the magnet yoke material, is provided in the pole limb, which is parallel to the hinged armature, of the suitably L-shaped magnet yoke. As a result, starting from a rotation or tilting point, which is formed by the material web, a lever arm which is acted on by the piezo actuator is formed in the direction of the piezo actuator and a clamping arm of a clamping lever which pivots about the rotation point is formed in the other direction toward the clamping gap. In this case, the length of the clamping arm is preferably greater than, preferably at least twice the size of, the length of the lever arm.

In the mounted state, the piezo actuator which acts on the clamping lever is supported on a supporting limb, the distance of said supporting limb from the clamping lever being matched to the height of the piezo actuator. An axial functional limb, which runs at a right angle to the radial pole limb and which preferably has a U-shaped receiving pocket for the piezo actuator, is provided relative to the relay coil. The U-limbs, which are parallel to one another, merge with the supporting limb and, respectively, with the clamping limb of the pole limb.

The hinged armature is connected in an articulated manner to the functional limb by means of the rotation axis. In addition, a magnet core, which is surrounded by the field winding, of the relay coil is ideally routed on one side toward the hinged armature and fastened, for example riveted, on the other side to the

magnet yoke, that is to say to the pole limb which is situated opposite the hinged armature.

In order to reliably prevent the tension element from sliding (radially) out of the open clamping gap, said clamping gap is formed by a bead-like clamping groove in which the tension element is securely situated. A clamping cam which engages in the clamping groove is expediently provided on the clamping lever, whereas the clamping groove is then located on the remaining pole limb of the magnet yoke on the opposite gap side.

The moving contact is preferably designed as a spring contact for generating a spring return force which acts on the hinged armature. To this end, an approximately L-shaped spring element is suitably bent or shaped, wherein one of the offset spring limbs is fixed to the functional limb of the magnet yoke, and the further spring limb is fixed to the hinged armature.

Since, as is known, the piezo actuator behaves in a similar manner to a capacitor in the event of current consumption, a flow of current is required firstly only at the moment at which the clamping force is generated. Secondly, in order to reliably release the clamping in the event of a loss of the control voltage for actuating the piezo actuator, said piezo actuator is connected in parallel with a suitable non-reactive resistor. This ensures that the relay reliably moves to the prespecified state, in particular by correspondingly reliable opening of the operative contact or by a contact changeover in the case of a switchover contact.

The components of the relay according to the invention are preferably assembled in a reliably sealed manner in a relay housing which is formed from a device base and

a housing cap. In this case, both the relay coil and also the piezo actuator have an associated, preferably common, control electronics system within the housing. Operating or switchover contacts and also the control contacts for the electronics system are routed out of the housing base in the form of flat plug connections. The connections of the piezo actuator are connected to the electronics system within the housing.

Exemplary embodiments of the invention will be explained in greater detail below with reference to a drawing, in which:

figure 1 schematically shows an electromagnetic relay comprising a relay coil in a magnet yoke with a hinged armature, which can be pivoted on said magnet yoke, and a piezo actuator which keeps an operating or switchover contact closed by means of a tension element when the field winding is deenergized,

figure 2 shows a side view of a detail of the magnet yoke with a pole limb which is slotted so as to form a clamping lever,

figure 3 shows a perspective view of a detail of the electromagnetic relay looking at the piezo actuator with the housing open,

figure 4 shows a further perspective view of the electromagnetic relay looking at the operating or switchover contact and the tension element,

figure 5 shows a first exploded illustration of the relay with the housing base partially mounted, a separate yoke and relay coil and also a housing cap,

figure 6 shows a different exploded illustration of the relay, and

figure 7 shows a circuit diagram of the electromagnetic relay.

Parts which correspond to one another are provided with the same reference symbols throughout the figures.

Figure 1 schematically shows the relay 1 comprising a magnet yoke 2 with a hinged armature 4 which can be pivoted about a rotation axis 3 on said magnet yoke and on which a moving contact 5 is held. The moving contact 5 is in the closed position with a fixed contact (inoperative contact) 6a, and in the open position to a further fixed contact (operative contact) 6b, so that a changeover or switchover contact is formed overall.

The relay coil 7, which is also called a field winding in the text which follows, together with its magnet core 8 is located between the hinged armature 4 and a pole limb 2a, which is parallel to said hinged armature, of the L-shaped magnet joke 2. The magnet core 8 and a functional limb 2b of the magnet yoke 2 run in axial direction x in relation to the relay coil 7, whereas the hinged armature 4 and the pole limb 2a of the magnet yoke 2 runs in the radial direction y in this respect. A piezo actuator 9 is located in the vicinity of the functional limb 2b or the junction between said functional limb and the pole limb 2a of the magnet yoke 2. Said piezo actuator is designed as a piezo stack actuator (stack).

A tension element 10, which is also called a clamping spring in the text which follows, is located opposite the functional limb 2b of the magnet yoke 2, said tension element spanning the open side of the U-shaped magnet yoke 2 and being held on one side on the hinged armature 4 and on the other side on the pole limb 2a of the magnet yoke 2. The spring end 10a, which is

associated with the hinged armature 4, of the tension element 10 is held in a captive manner on the hinged armature 4, whereas the opposite clamping end 10b of the tension element 10 is fixed in a clamping manner in a clamping gap 11 (figure 2), which is provided in the pole limb 2a, when the hinged armature 4 is pulled in and therefore contacts 5, 6a are closed. In this state, the relay coil 7 can be controlled without power, without the hinged armature 4 dropping out and accordingly the contact 5, 6a opening.

As a result, a hybrid piezo relay system for reliable switching with monostable behavior and an extremely low level of current consumption is provided. Since the relay coil 7 is deenergized in the shown holding mode and the piezo actuator 9 requires only the necessary actuation voltage in order to maintain the clamping force F_K, which is generated as a result of said piezo actuator being actuated or voltage being applied to said piezo actuator and which holds the tension element 10 when the armature 4 is pulled in, and the leakage currents in a piezo stack actuator 9 of this kind are extremely low, the contacts 5, 6a can be closed virtually without power. This is extremely advantageous, particularly in the motor vehicle sector, since the power loss of a relay with each watt of electrical power is accompanied by a correspondingly elevated CO_2 emission by the motor vehicle.

Figure 2 shows, in a side view of the pole limb 2a of the magnet yoke 2, a clamping lever 12 which is formed on the pole limb 2a and is formed by a longitudinal slot 13, which runs in the radial direction y, in the pole limb 2a. A material web 14, which forms a rotation point about the rotation axis 15 (which is indicated by a dashed line) and virtually locally closes the longitudinal slot 13, is present or remains along the

longitudinal slot (material or radial slot) 13. Therefore, a lever arm a is produced between the rotation point or rotation axis 15 and the location of the piezo actuator 9, whereas a clamping arm b is produced between the rotation point 14 and the clamping gap 11. In this case, the clamping arm b is approximately twice as long as the lever arm a ($b \geq 2a$) in the exemplary embodiment.

A supporting limb 16, on which the piezo actuator 9 which operates the clamping lever 12 as a result of being actuated is supported, is inserted into the magnet yoke 2 spaced apart from the clamping lever 12 by the height h, which runs in the z-direction, of the piezo actuator. According to the illustrated Cartesian coordinate system, the clamping force F_K, which is generated by the piezo actuator 9, and the stroke direction of said clamping force run in the z-direction, whereas the longitudinal slot 13, which forms the clamping lever 12, runs in the radial direction y.

Figure 2 comparatively clearly also shows the configuration of the clamping gap 11. A clamping groove 11a, in which the clamping end 10b of the tension element 10 is situated and therefore secured against pivoting out in radial direction y, is made in the pole limb 2a of the magnet yoke 2 in the region of the clamping gap 11. A clamping cam 11b, which is integrally formed on the clamping lever 12 and there on the free end of the clamping arm b of said clamping lever, engages in the clamping groove 11a with the interposition of the clamping end 10b of the tension element 10.

Figures 3 to 6 show a preferred embodiment of the relay 1 according to the invention in various perspective

views (figures 3 and 4) and also in exploded illustrations of different details (figures 5 and 6).

Figure 3 comparatively clearly shows the tension element 10 which is situated in the clamping gap 11 and is clamped at its clamping end 10d. Said figure also shows the magnet core 8 which is riveted to the pole limb 2a, which passes through the relay coil or field winding 7 and is supported (figure 4) on a coil former 18 on the armature side by way of a head 17 (figure 6).

In order to arrange the piezo actuator 9 in a particularly functional and space-saving manner, a U-shaped receiving pocket 19 is made in the functional limb 2b of the magnet yoke 2. The U-limbs 19a and 19b, which are parallel to one another, of said U-shaped receiving pocket merge with the (upper) clamping limb 12 and, respectively, with the (lower) supporting limb 16 of the pole limb 2a.

Contact elements 20a, 20b, which for their part are connected to an electronics system 21 for the purpose of relay control, make contact with the piezo actuator 9. Contact elements 22a, 22b with which the winding ends of the relay coil 7 make contact (in a manner not illustrated in any detail) are also connected to the electronics system 21. Said contact elements 22a, 22b are fixed in the coil former 18, as shown in figure 6.

The electronics system 21 is additionally connected to control connections 23a, 23b which are illustrated in figure 6.

As shown comparatively clearly in figures 4 and 6, the moving contact 5 is designed as a spring contact. To this end, an L-shaped spring element 24 has a spring limb 24a, which is held on the functional limb 2b of the magnet yoke, and also a further spring limb 24b,

which is routed on the outer face, which is averted from the relay coil 7, of the hinged armature 4 and there is connected to said hinged armature. The spring element 24 and therefore the spring or moving contact 5 creates a return force F_R on the hinged armature 4 in the x-direction, so that said hinged armature drops out in a manner assisted by the corresponding spring force when both the relay coil 7 is deenergized and the piezo actuator 9 is free of voltage and therefore the clamping gap 1 is open.

The illustrated and described components and elements of the relay 1 are mounted on a housing base 25 which, in the final assembled state, is covered by means of a housing cap 26, preferably in a dirt- and moisture-tight manner. Contact connections K_1, K_2 (operating or inoperative contact connection) of the fixed contacts 6a (inoperative contact) and, respectively, 6b (operative contact), at least one contact connection K_3 (control connection 23a and/or 23b) of the electronics system 21, at least one contact connection K_4 (coil contact connection) of the relay coil 7 and also a contact connection K_5 (changeover contact connection) of the moving or changeover or switchover contact 5 are routed out of the bottom of the housing base 25 which has an approximately square cross section.

Figure 7 shows a circuit diagram of the electromagnetic piezo relay 1 according to the invention. A switching circuit or path 27, in which a load 28, for example a gasoline pump or an electric motor, is connected in series with the operative contact 6b between the positive pole and the negative pole or ground of a supply voltage U_V, is electrically conductively disconnected from a control circuit or path 29 of the relay 1. Whereas figure 4 shows the electromagnetic

relay 1 in the switched-on state (ON), figure 7 shows the switched-off state (OFF).

The electronics system 21 is supplied with a control voltage U_S which, in the case of a motor vehicle, is obtained from the on-board electrical system voltage of said motor vehicle. A non-reactive resistor R is connected electrically in parallel with the piezo actuator 9 in order to reliably break the clamping of the tension element 10 in the clamping gap 11 in the event of a loss of the control voltage U_S. In the case of a fault of this kind, the moving contact 5 moves from the shown closed or operating state to the safe changeover state by making contact with the changeover contact 6b.

The invention is not restricted to the above-described exemplary embodiment. Rather, other variants of the invention can also be derived from said exemplary embodiment by a person skilled in the art, without departing from the subject matter of the invention. In particular, all of the individual features described in connection with the exemplary embodiment can furthermore also be combined with one another in a different way, without departing from the subject matter of the invention.

List of reference symbols

1	Relay
2	Magnet yoke
2a	Pole limb
2b	Functional limb
3	Rotation axis
4	Hinged armature
5	Moving contact
6a	Operative contact
6b	Inoperative contact
7	Relay coil
8	Magnet core
9	Piezo actuator
10	Tension element
10a	Spring end
10b	Clamping end
10d	Clamping end
11	Clamping gap
11a	Clamping groove
11b	Clamping cam
12	Clamping lever
13	Longitudinal slot
14	Material web
15	Rotation axis/point
16	Supporting limb
18	Coil former
19	Receiving pocket
19a	U-limb
19b	U-limb
20a	Contact element
20b	Contact element
21	Electronics system
22a	Contact element
22b	Contact element
23a	Control connection
23b	Control connection

24	Spring element
24a	Spring limb
24b	Spring limb
25	Housing base
27	Switching circuit/path
28	Load
29	Control circuit/path
a	Lever arm
b	Clamping arm
h	Actuator height
F_K	Clamping force
F_R	Spring return force
K_1	Operative contact connection
K_2	Inoperative contact connection
K_3	Coil contact connection
K_4	Coil contact connection
K_5	Changeover contact connection
U_S	Control voltage
U_V	Supply voltage
X	Axial direction
y	Radial direction

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An electromagnetic relay, comprising:

a magnet yoke having a clamping gap formed therein;

a relay coil;

a moving contact;

a first fixed contact;

a hinged armature being pivotable about a rotation axis and on which said moving contact being held relative to at least said first fixed contact;

a piezo actuator which, as a result of being actuated, keeps said moving contact closed when said relay coil is de-energized;

a tension element having a free side, said tension element being held on one side of said hinged armature, and being routed by way of said free side into said clamping gap and, as a result of said piezo actuator being actuated, is held in said clamping gap in a force-fitting manner; and

a lever transmission device for converting a force stroke, which is generated by said piezo actuator as a result of being actuated, into a clamping stroke for fixing said tension element, which is held on a hinged armature side and/or on a moving contact side, in a releasable and clamped manner.

2. The electromagnetic relay according to claim 1, wherein said magnet yoke has a clamping lever which pivots about a rotation or rotation point, a lever arm which is acted on by said piezo actuator, and a clamping arm which is routed to said clamping gap.

3. The electromagnetic relay according to claim 2, wherein:

said magnet yoke has a radial slot formed therein; and

said clamping lever is produced by said radial slot in said magnet yoke, and said clamping lever is formed by a material web which represents said rotation point.

4. The electromagnetic relay according to claim 3, wherein said magnet yoke has a pole limb and said clamping lever is formed in said pole limb.

5. The electromagnetic relay according to any one of claims 2 to 4, wherein said clamping arm is longer than said lever arm.

6. The electromagnetic relay according to any one of claims 2 to 5, wherein said clamping arm is at least twice as long as said lever arm.

7. The electromagnetic relay according to any one of claims 2 to 6, wherein said tension element is oriented axially, and said clamping gap is oriented radially, in relation to said relay coil.

8. The electromagnetic relay according to any one of claims 2 to 7, wherein said magnet yoke has a supporting limb which is spaced apart from said clamping lever and on which said piezo actuator, which operates said clamping lever as a result of being actuated, is supported.

9. The electromagnetic relay according to claim 8, wherein a distance between said clamping lever and said supporting limb is matched to an actuator height which runs in a stroke direction of said piezo actuator.

10. The electromagnetic relay according to claim 2, wherein:
said clamping lever has a clamping cam;

said magnet yoke has a bead-shaped clamping groove formed therein; and

said clamping gap is formed between said clamping cam and said bead-shaped clamping groove, said clamping cam engaging in said bead-shaped clamping groove so as to secure said tension element against pivoting radially outward.

11. The electromagnetic relay according to any one of claims 1 to 10, further comprising:

a non-reactive resistor; and

a second fixed contact connected to said non-reactive resistor, said non-reactive resistor connected in parallel with said piezo actuator, so as to form a switchover contact.

12. The electromagnetic relay according to any one of claims 1 to 11, wherein the electromagnetic relay is a motor vehicle relay.

13. An electromagnetic relay, comprising:

a relay coil;

a moving contact;

a first fixed contact;

a hinged armature being pivotable about a rotation axis and on which said moving contact being held relative to at least said first fixed contact;

an L-shaped magnet yoke containing, in relation to said relay coil, a radial pole limb and an axial functional limb to which said hinged armature is connected in an articulated manner by means of said rotation axis;

a piezo actuator which, as a result of being actuated, keeps said moving contact closed when said relay coil is de-energized;

said radial pole limb having a supporting limb and a clamping limb; and

said axial functional limb having a U-shaped receiving pocket for said piezo actuator, wherein said U-shaped receiving pocket has U-limbs, which are parallel to one another, merge with said clamping limb and, respectively, with said supporting limb of said radial pole limb.

14. The electromagnetic relay according to claim 13, wherein said moving contact is a spring contact for generating a spring return force which acts on said hinged armature.

15. The electromagnetic relay according to claim 14, wherein said spring contact has a generally L-shaped spring element being bent in such a way to have offset spring limbs with one of said offset spring limbs fixed to said axial functional limb of said magnet yoke, and another of said offset spring limbs fixed to said hinged armature.

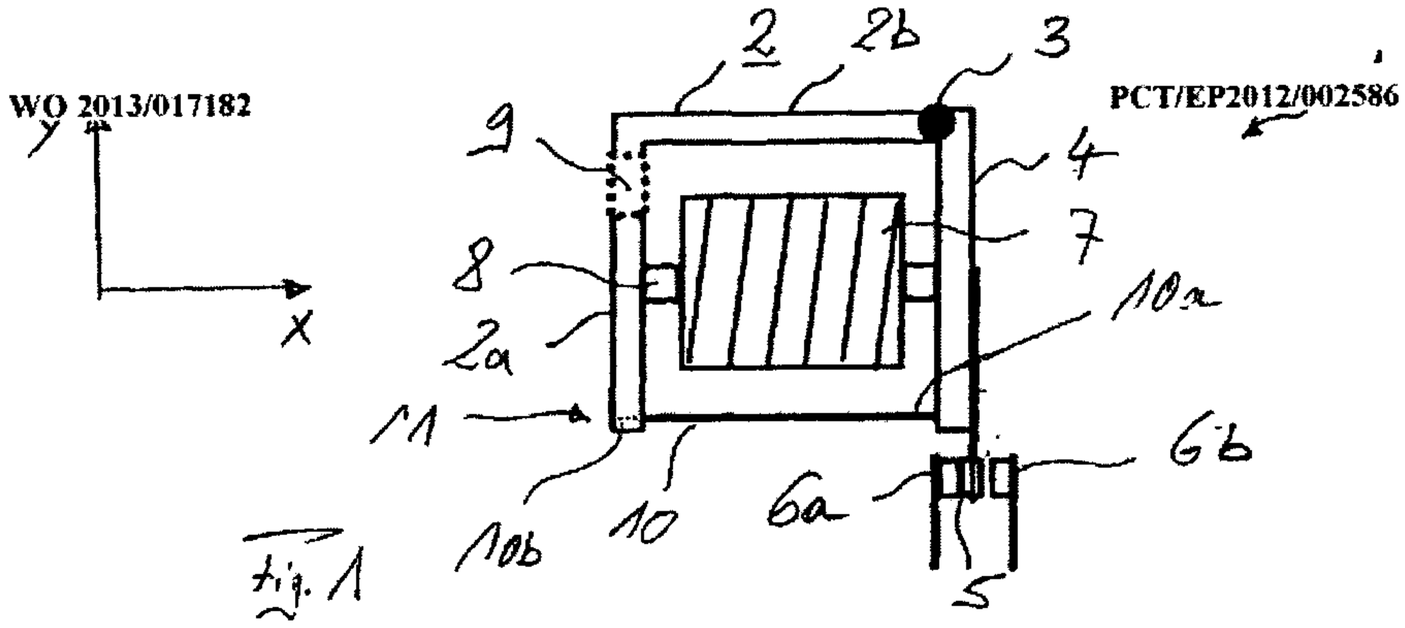


fig. 1

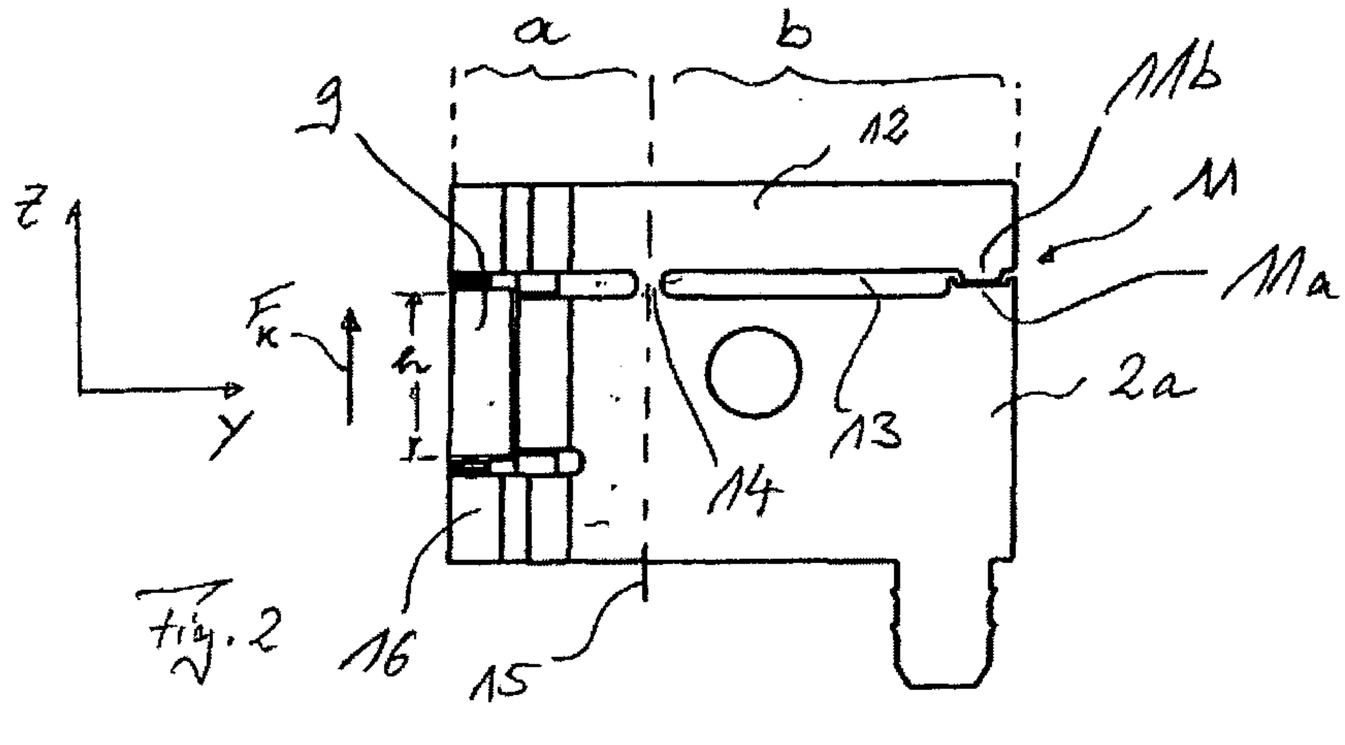


fig. 2

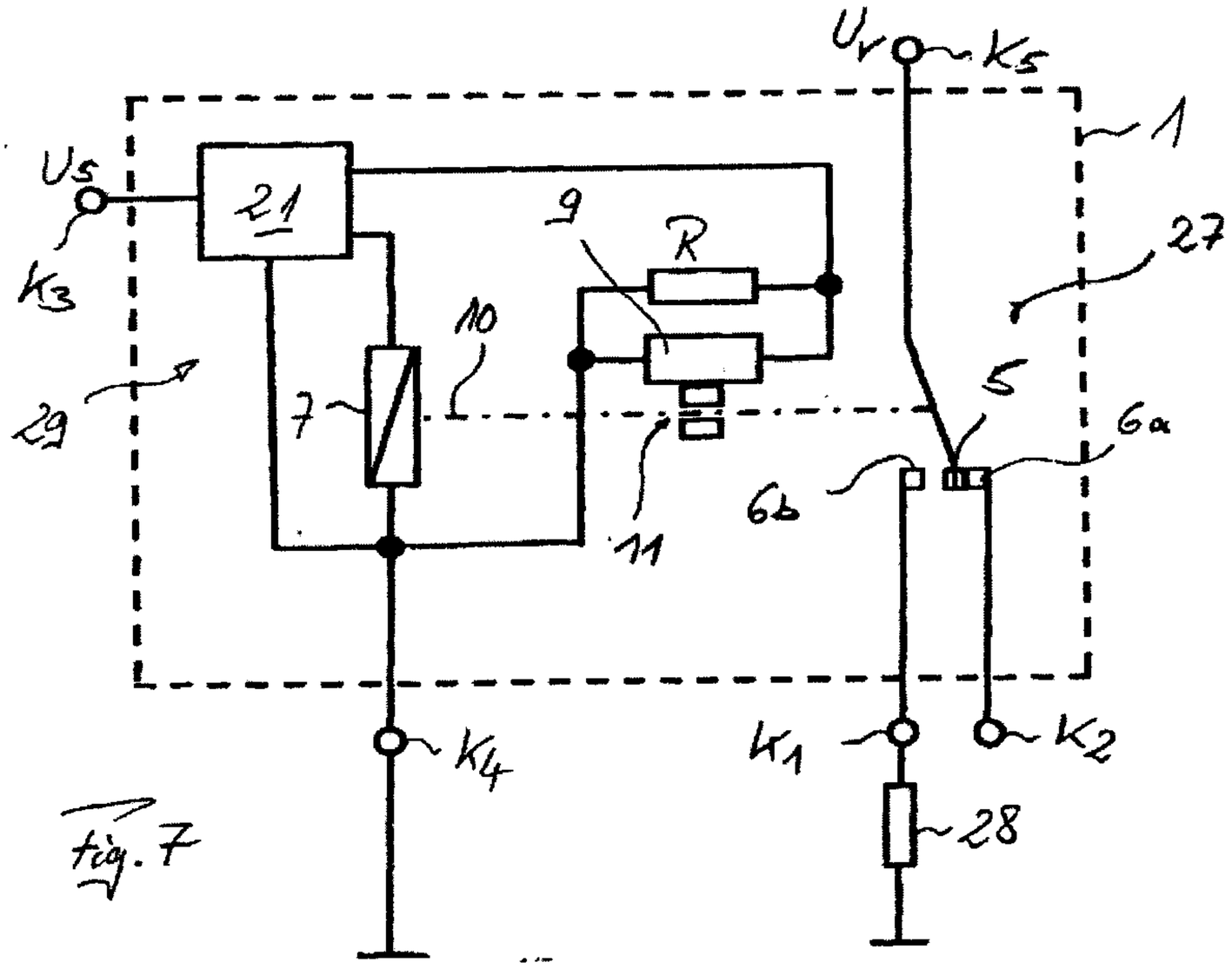
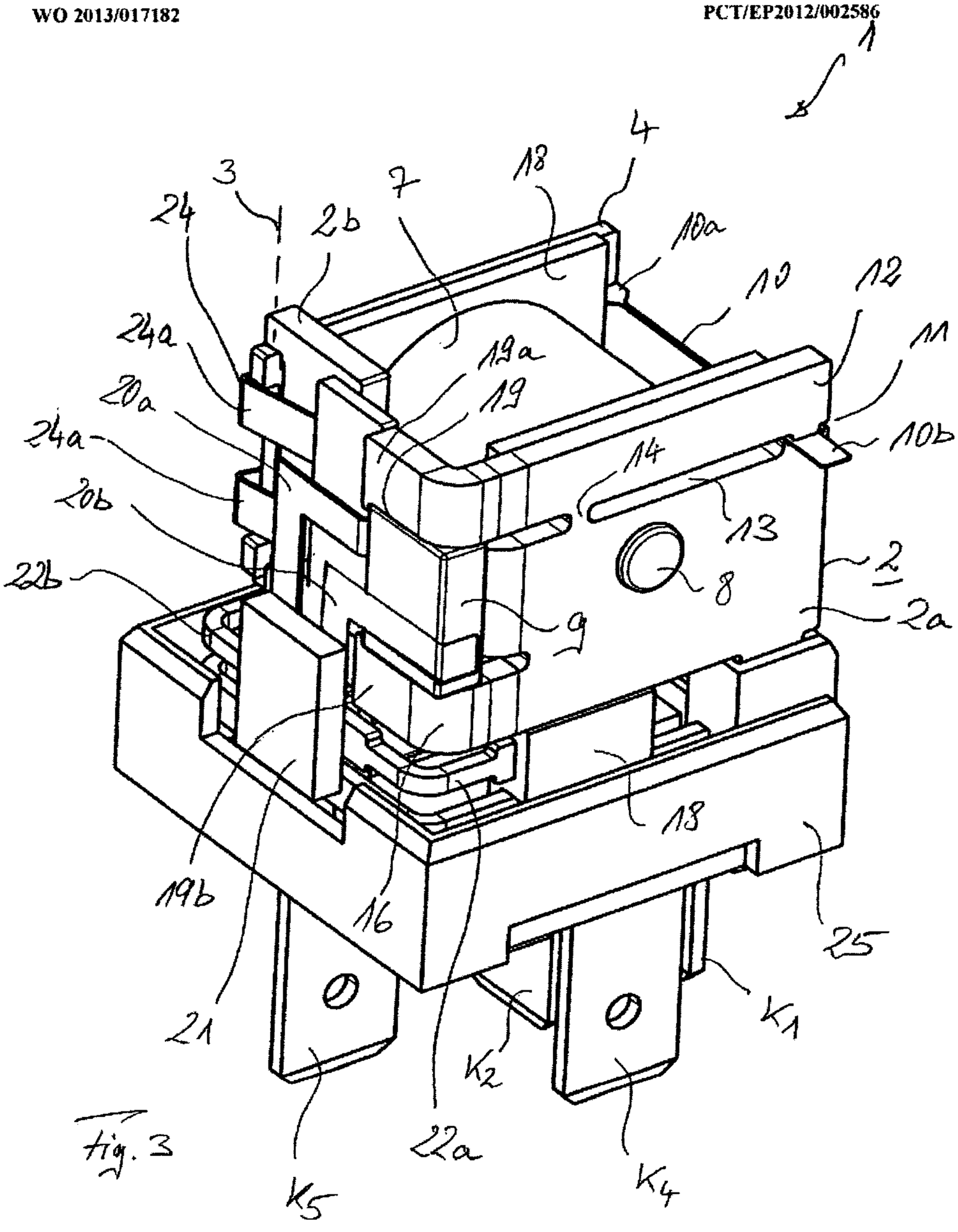


fig. 7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K1
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22a
K4

fig. 3

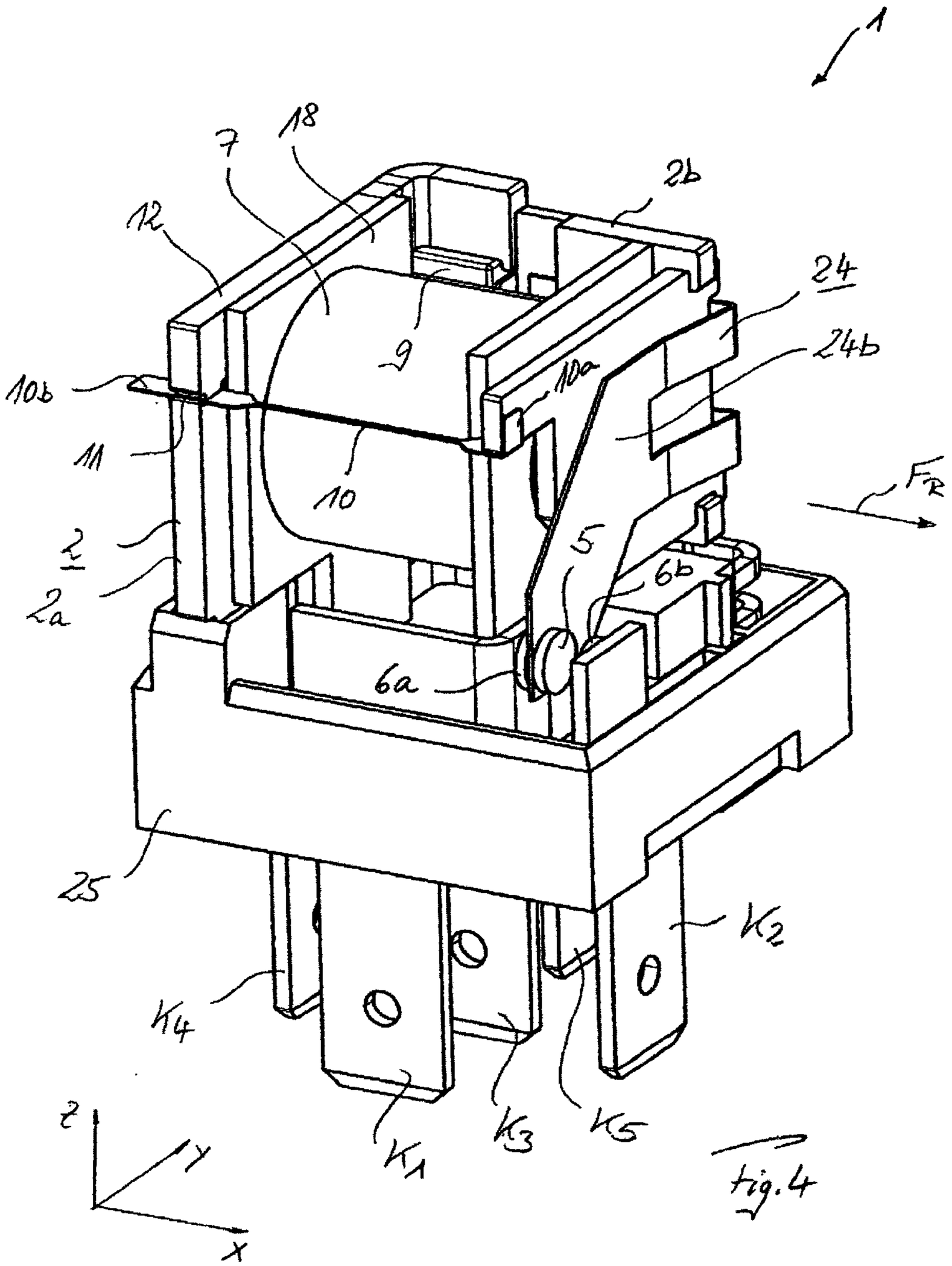


fig. 4

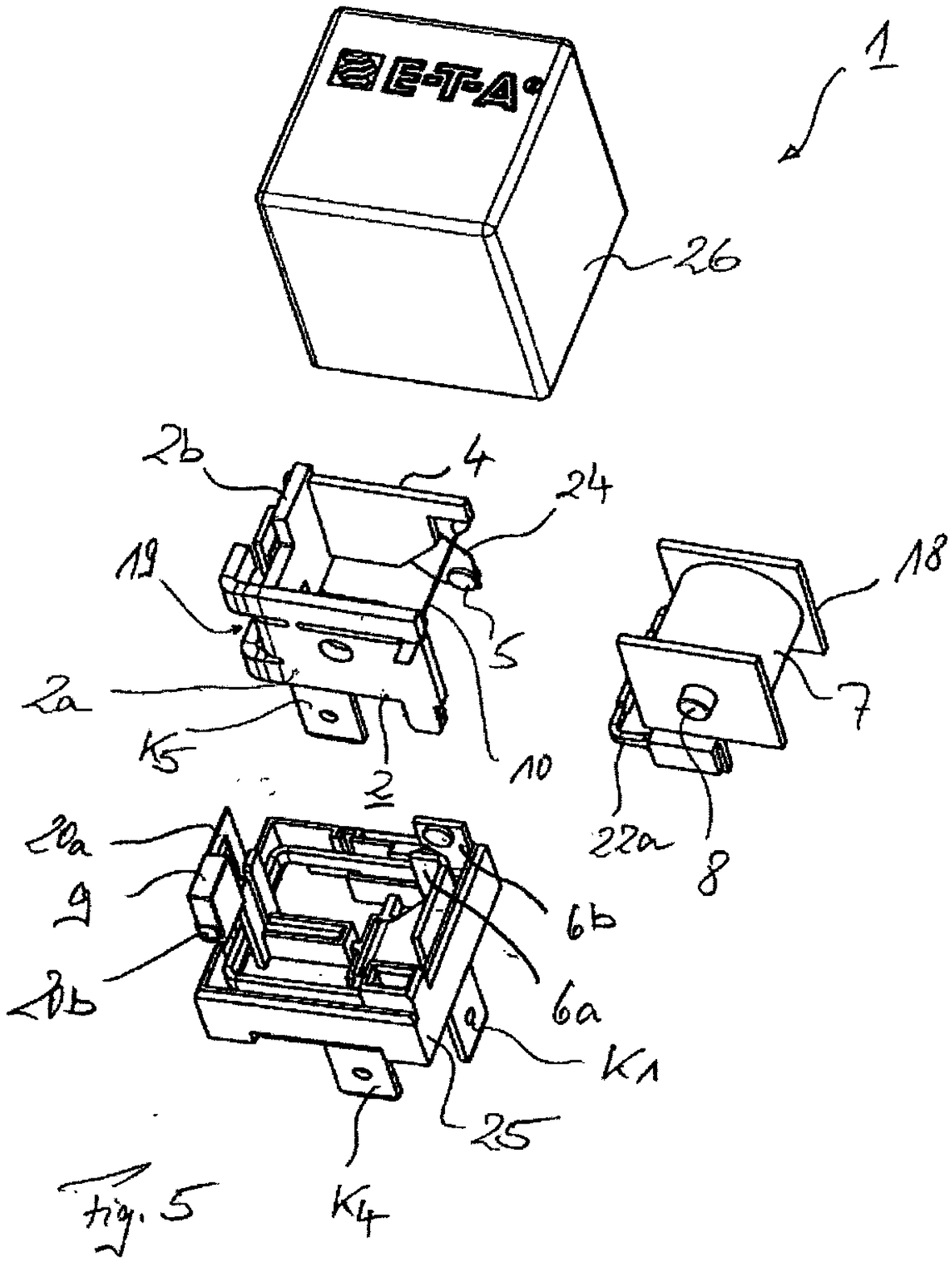
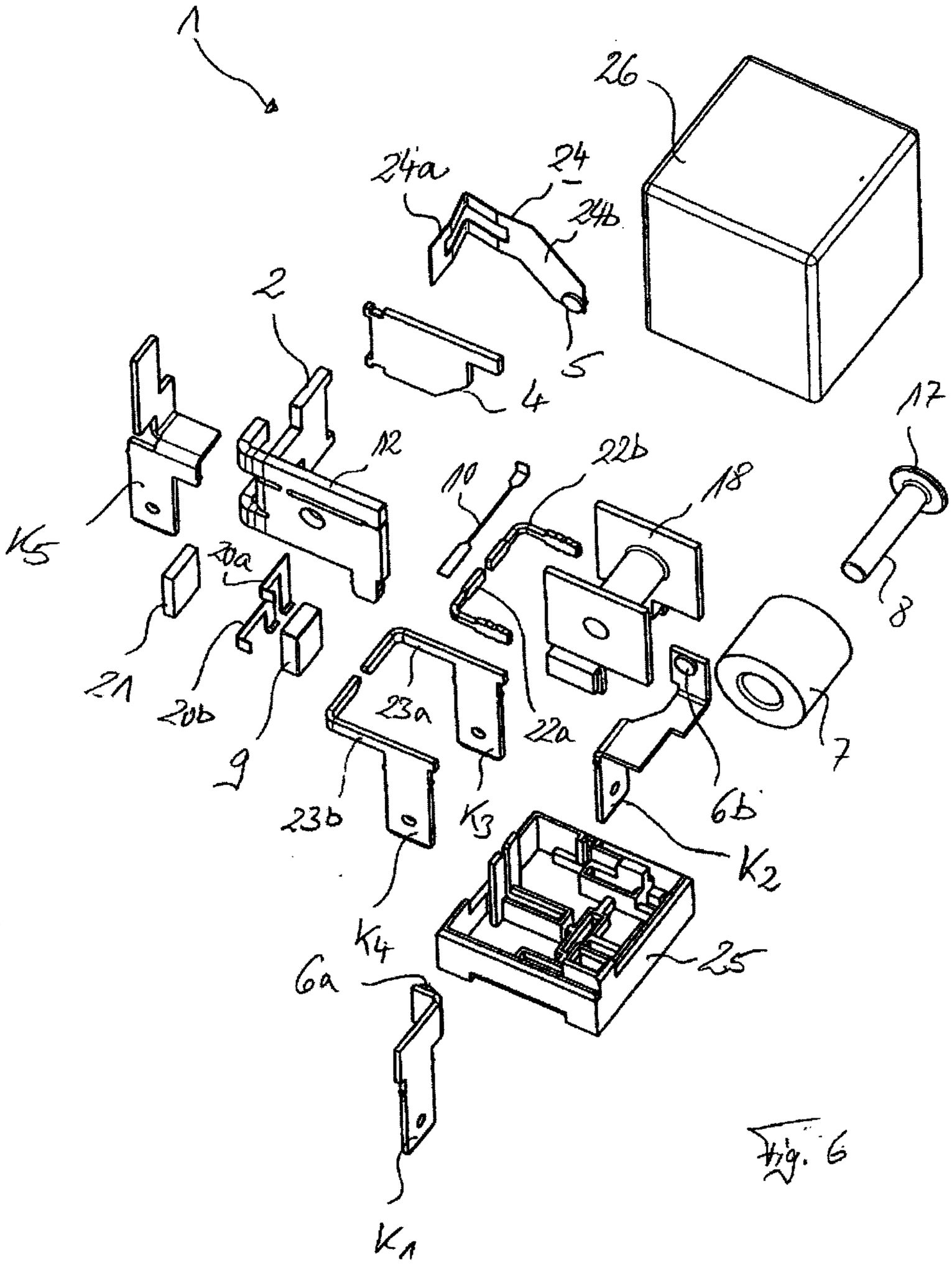


fig. 5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K3
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K4
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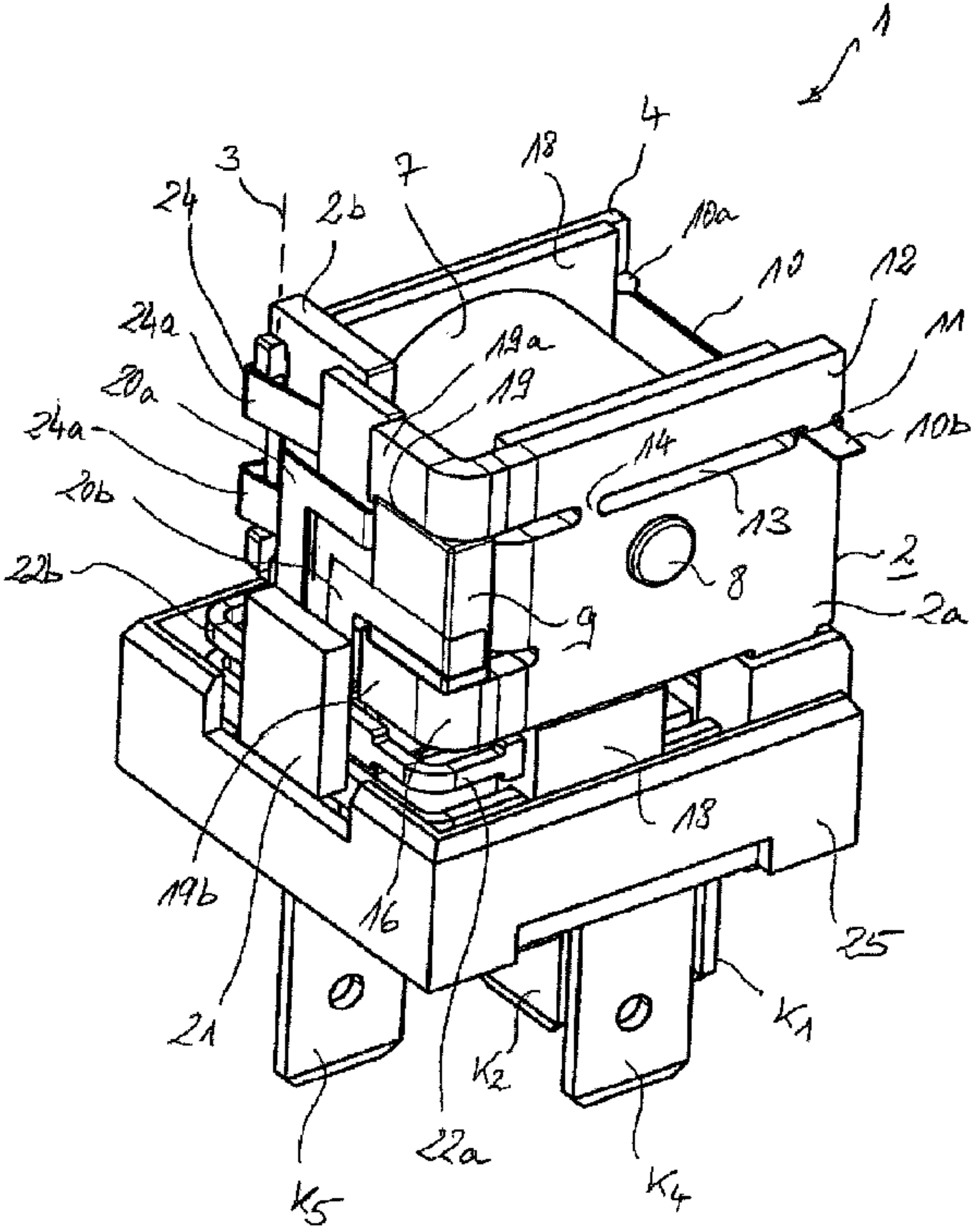
6a
K1

Fig. 6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