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(54) **ELECTROMAGNETIC RELAY, IN PARTICULAR FOR INTERRUPTION OF AN ELECTRIC CIRCUIT IN THE CASES OF DIFFERENTIAL CIRCUIT, AND A SWITCH COMPRISING SUCH RELAY**

ELEKTROMAGNETISCHES RELAIS, INSBESONDERE ZUR UNTERBRECHUNG EINER ELEKTRISCHEN SCHALTUNG IM FALLE VON EINER DIFFERENTIALSCHALTUNG, UND SCHALTER MIT EINEM SOLCHEN RELAIS

RELAIS ÉLECTROMAGNÉTIQUE, EN PARTICULIER POUR L'INTERRUPTION D'UN CIRCUIT ÉLECTRIQUE DANS LES CAS DE CIRCUIT DIFFÉRENTIEL, ET COMMUTATEUR COMPORTANT UN TEL RELAIS

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(56) References cited:  
**EP-B1- 0 508 052 ES-A1- 2 107 935**

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## Description

**[0001]** The invention refers to an electromagnetic relay, which is used for the purposes of interrupting an electric circuit in the case of differential current between a phase conductor and a neutral conductor.

**[0002]** In accordance with the International patent Classification, such invention belongs to electricity and in such context to basic electric elements, namely to relays and switches, which include a permanent magnet and which are intended to protect electric circuits. Optionally, such invention can also refer to construction details of electromagnetic relays.

**[0003]** The purpose of the invention is to create an electromagnetic relay, in particular a relay for a switch used in interrupting of an electric circuit in the case of differential current within the conductors thereof, in which despite to essentially simplified technology used in manufacturing thereof required magnetic properties could be achieved, so that the sensibility and reactivity of such relay even by detecting extremely low differential currents could be assured. Correspondingly, a further purpose of invention is to improve a switch, in which such relay can be integrated.

**[0004]** An electromagnetic relay is described in EP 0 508 052 B1 and consists of a casing, within which an electromagnetic inductive coil is placed and is due to triggering at a low electric power electrically interconnected with a phase conductor and a neutral conductor via a passive electronic circuit and an electric transformer. A yoke is placed within a core of said coil and is connected with a so-called L-yoke comprising a first arm, which extends in a direction of said yoke of the coil, and a second arm, which extends perpendicular in a direction away from the coil. A further S-yoke is foreseen adjacent to said L-yoke and consists of central region as well as of two arms. The first arm of said S-yoke extends parallel with said first arm of the L-yoke, while the central region of the S-yoke extends perpendicular with respect to said first arm and in a direction away from the coil. The second arm of said S-yoke extends parallel with respect to the first arm and at a distance apart from the coil. A permanent magnet is inserted between the second arm of said L-yoke and the central region of the S-yoke. An armature is placed over the coil and the second arm of the S-yoke, and is supported in a pivot point, which is located on the second arm of the S-yoke on the side opposite to the yoke of the coil. The coil is therefore with respect to said pivot point in the area of its one end portion supported by means of the yoke of the coil, while on its other end portion it is connected with a tension spring, which is on the other hand attached to said casing. A triggering needle is mounted on the coil.

**[0005]** A magnetic field, which is thanks to said permanent magnet permanently available within such relay, maintains the armature in its position where it abuts the yoke of the coil and also the second arm of the S-yoke against the force of the spring, which expresses tendency

of rotating the armature around the pivot point and displacing it apart from the yoke of the coil together with displacing said triggering needle, which is rest on the armature. Maintaining the armature in its previously described position must be reliable just in order to prevent undesired triggering due to mechanical influences like vibrations or the like. Whenever the electric circuit is operating regularly and the current in the phase conductor is equal to the current in the neutral conductor, the differential current does not exist, and the permanent magnet produces a force, which is stronger than the force produced by the spring, by which the armature is maintained in the described position. In the case of differential current between the phase conductor and the neutral conductor, another magnetic field is generated within the coil, which acts opposite to the previously mentioned magnetic field, and the effectiveness of the permanent magnet is correspondingly reduced, so that the force produced by the s-spring is then stronger than the magnetic force, upon which the armature is pivoted around its the pivot point, and the needle is triggered for the purposes of interrupting the electric circuit, in which the differential current is detected.

**[0006]** Such concept generally enables operating of the relay, but due to such concept and due to arrangement of the yoke and the armature including its pivot point, a relatively high magnetic density of the permanent magnet is required, which then in the practice leads to a relatively high power required for the purposes of triggering such relay, and which is normally between 120 and 150  $\mu$ VA, and should preferably be essentially lower.

**[0007]** On the other hand, such concept leads to pretty undesired acting of forces. The magnetic force is namely acting at a relatively small distance apart from the pivot point, so that a relatively strong magnetic field must be established by the permanent magnet for the purposes of producing a sufficient magnetic force, and a relatively large difference of current is then required for the purposes of reducing said magnetic force, so that such switch is correspondingly insufficiently sensitive with respect to lower current differences.

**[0008]** In addition to that, manufacturing of such relay is extremely complicated from quite technological point of view and is connected with high risk of providing dimensions within the ranges, which are required for the purposes of regular operation. The yoke namely consists of two parts, which are welded to each other, wherein in the welded area the magnetic properties are difficultly maintained within a very narrow range. Moreover, a thin recess of approx. 50  $\mu$ m has to be assured between the first arm of the L-yoke and the first arm of the S-yoke, which is filled with a diamagnetic film, wherein the manufacturing of such recess and finalization thereof in combination with problems related to the previously mentioned weld area leads to essential risk in respect to achieving each required characteristic of the final product

**[0009]** The present invention refers, on the one hand, to a switch for interruption of an electric circuit in the case

of differential current, which is intended for integration into an electric circuit, which is formed by appropriate direct voltage or alternating voltage or combined voltage source together with at least one load, as well as by a phase conductor and a neutral conductor, which are connected to said source via the said switch, such switch comprising

- a differential transformer, in which its primary winding is formed by the phase conductor and the neutral conductor extending through a core thereof, and its secondary winding comprises two electric connectors;
- a passive electronic circuit, comprising two pairs of connectors, between which a capacitor is serially connected to other parallel connected components and is adapted to be energized by means of electric voltage, which is induced in the secondary winding of the transformer, since said circuit is by means of said connectors electrically interconnected with the connectors of said secondary winding of said transformer;
- a relay, which in the electrical context represents a resistance and inductivity of a coil, via which said relay is electrically interconnected with a passive electronic circuit and indirectly also with a differential transformer which is intended for detection of a differential electric current in the area of said conductors, so that in the case of difference between currents in said conductors due to the voltage generated in the differential transformer and in the passive electronic circuit a corresponding magnetic flux is generated in said coil, and wherein such relay in the mechanical contexts consists of a yoke, which comprises said inductive coil and a permanent magnet for providing a desired magnetic flux in the area of said yoke, as well as of an armature, which is pivotally interconnected with said yoke in a pivot point and is, depending on energizing the coil, either by means of said permanent magnet rest onto said yoke, or is by means of a force of a spring pivoted away from the yoke towards the actuating mechanism, which is located at appropriate distance apart from the yoke and is intended for activation of the switch in the sense of interrupting the electric circuit through said conductors.

**[0010]** In accordance with the invention, said switch includes a relay comprising a yoke, which is uniformly conceived and is cut or punched out of a plate or a strip consisting of steel or any other metallic alloy with predetermined magnetic properties and comprises three arms, which are spaced apart from each other and protrude towards the armature, wherein their lengths are adjusted for the purposes of simultaneously abutment of said armature to all of them, and wherein

- the first arm is adapted to receive the coil, which is

mounted on it in such a manner that said first arm extends throughout the coil and is surrounded by the winding of the coil extending along it;

- the second arm is adapted to receive a permanent magnet, which permanently generates a magnetic flux and consequently a magnetic force, which is required for the purposes of abutment of the armature towards the said arms of the yoke and which is acting in a direction opposite to the force of said spring;
- the third arm is intended to support the armature and to provide a pivot point, around which the armature can be pivoted from its first position of abutment towards said arms of the yoke to its second position, in which it abuts the actuating mechanism, which is located at appropriate distance apart from the yoke, and wherein furthermore the armature is uniformly conceived and is made of a plate or a strip or a wire or any other rolled semi-product of a hot or cold formed preform consisting of steel or any other metallic alloy having pre-determined magnetic properties, and is in the pivot point pivotally interconnected with the yoke and comprises the first area, which is located in the one side of said pivot point and is adapted for simultaneously abutment towards all three arms of the yoke, as well as the second cantilevered area, which is located on the other side of said pivot point and protrudes away from the yoke and in which a spring is mechanically connected to the armature.

**[0011]** In a preferred embodiment of the switch in accordance with the present invention, said permanent magnet is wedge-like shaped and is adapted for inserting into a wedge-shaped trapezoidal recess in the second arm of the yoke, which is converging away from the first arm. Besides, the armature is furnished with a supplemental protrusion, which is firmly attached thereto and protrudes at least approximately perpendicularly from its cantilevered portion, so that the spring is mechanically connected therewith.

**[0012]** Upon inserting said permanent magnet into the second arm of the yoke in such switch according to the invention, a magnetic field is generated, which in the case, when the coil on the first arm is not energized and the armature is simultaneously abutting all three arms of the yoke, consists of

- the first magnetic flux, which extends throughout the permanent magnet, the second arm of the yoke, the armature and through the first arm of the yoke towards the permanent magnet;
- the second magnetic flux, which extends throughout the permanent magnet, the second arm of the yoke, the armature and through the third arm of the yoke back towards the permanent magnet; and
- the third magnetic flux, which extends throughout the permanent magnet, the second arm of the yoke and through the third arm of the yoke back towards

the permanent magnet, wherein by energizing the coil by means of a voltage on the connectors thereof an additional magnetic field is generated therein with a magnetic flux, which is acting in the opposite direction as the said first magnetic flux, by which at least the first magnetic flux of the permanent magnet in the first arm is then reduced i.e. at least essentially neutralized.

**[0013]** Said permanent magnet in the relay of the switch according to the invention is preferably designed in such a manner that upon inserting it into the area of said second arm of the yoke in the case, when the coil is not energized, the torque produced by magnetic force due to at least the first magnetic flux in the area of the first arm of the yoke with respect to the pivot point of the armature, which is simultaneously abutting all three arms, is greater than the torque produced by the force of the spring acting on the armature, while on the contrary, when the coil is energized by means of voltage produced by the passive electronic circuit and the additional magnetic flux is generated, which is acting opposite to at least the first magnetic flux of the permanent magnet in the first arm, the torque produced by magnetic forces is reduced below the value of the torque produced by the force of the spring acting to the armature.

**[0014]** In addition, the ratio between the first magnetic flux and the third magnetic flux in said relay of the switch according to the invention can be determined in advance by means of defining the shape and dimensions of the recess and/or of each permanent magnet, which is insertable therein.

**[0015]** The invention preferably provides that the primary winding of the differential transformer comprises a single turn.

**[0016]** On the other hand, the invention also refers to a relay, which in the electrical context represents a resistance and inductivity of a coil, via which said relay is electrically interconnected with a passive electronic circuit and indirectly also with a differential transformer which is intended for detection of a differential electric current in the area of said conductors, so that in the case of difference between currents in said conductors due to the voltage generated in the differential transformer and in the passive electronic circuit a corresponding magnetic flux is generated in said coil, and wherein such relay in the mechanical contexts consists of a yoke, which comprises said inductive coil and a permanent magnet for providing a desired magnetic flux in the area of said yoke, as well as of an armature, which is pivotally interconnected with said yoke in a pivot point and is, depending on energizing the coil, either by means of said permanent magnet rest onto said yoke, or is by means of a force of a spring pivoted away from the yoke towards the actuating mechanism, which is located at appropriate distance apart from the yoke and is intended for activation of the switch in the sense of interrupting the electric circuit through said conductors.

**[0017]** In accordance with the invention, said relay comprises a yoke, which is uniformly conceived and is cut or punched out of a plate or a strip consisting of steel or any other metallic alloy with pre-determined magnetic properties and comprises three arms, which are spaced apart from each other and protrude towards the armature, wherein their lengths are adjusted for the purposes of simultaneous abutment of said armature to all of them, and wherein

- the first arm is adapted to receive the coil, which is mounted on it in such a manner that said first arm extends throughout the coil and is surrounded by the winding of the coil extending along it;
- the second arm is adapted to receive a permanent magnet, which permanently generates a magnetic flux and consequently a magnetic force, which is required for the purposes of abutment of the armature towards the said arms of the yoke and which is acting in a direction opposite to the force of said spring;
- the third arm is intended to support the armature and to provide a pivot point, around which the armature can be pivoted from its first position of abutment towards said arms of the yoke to its second position, in which it abuts the actuating mechanism, which is located at appropriate distance apart from the yoke,

and wherein furthermore the armature is uniformly conceived and is made of a plate or a strip or a wire or any other rolled semi-product of a hot or cold formed preform consisting of steel or any other metallic alloy having pre-determined magnetic properties, and is in the pivot point pivotally interconnected with the yoke and comprises the first area, which is located in the one side of said pivot point and is adapted for simultaneous abutment towards all three arms of the yoke, as well as the second cantilevered area, which is located on the other side of said pivot point and protrudes away from the yoke and in which a spring is mechanically connected to the armature.

**[0018]** In a preferred embodiment of the relay in accordance with the present invention, said permanent magnet is wedge-like shaped and is adapted for inserting into a wedge-shaped trapezoidal recess in the second arm of the yoke, which is converging away from the first arm. Besides, the armature is furnished with a supplemental protrusion, which is firmly attached thereto and protrudes at least approximately perpendicularly from its cantilevered portion, so that the spring is mechanically connected therewith.

**[0019]** Upon inserting said permanent magnet into the second arm of the yoke in such relay according to the invention, a magnetic field is generated, which in the case, when the coil on the first arm is not energized and the armature is simultaneously abutting all three arms of the yoke, consists of

- the first magnetic flux, which extends throughout the

- permanent magnet, the second arm of the yoke, the armature and through the first arm of the yoke towards the permanent magnet;
- the second magnetic flux, which extends throughout the permanent magnet, the second arm of the yoke, the armature and through the third arm of the yoke back towards the permanent magnet; and
  - the third magnetic flux, which extends throughout the permanent magnet, the second arm of the yoke and through the third arm of the yoke back towards the permanent magnet,

wherein by energizing the coil by means of a voltage on the connectors thereof an addition magnetic field is generated therein with a magnetic flux, which is acting in the opposite direction as the said first magnetic flux, by which at least the first magnetic flux of the permanent magnet in the first arm is then reduced i.e. at least essentially neutralized.

**[0020]** Said permanent magnet in the relay according to the invention is preferably designed in such a manner that upon inserting it into the area of said second arm of the yoke in the case, when the coil is not energized, the torque produced by magnetic force due to at least the first magnetic flux in the area of the first arm of the yoke with respect to the pivot point of the armature, which is simultaneously abutting all three arms, is greater than the torque produced by the force of the spring acting on the armature, while on the contrary, when the coil is energized by means of voltage produced by the passive electronic circuit and the additional magnetic flux is generated, which is acting opposite to at least the first magnetic flux of the permanent magnet in the first arm, the torque produced by magnetic forces is reduced below the value of the torque produced by the force of the spring acting to the armature.

**[0021]** In addition, the ratio between the first magnetic flux and the third magnetic flux in said relay according to the invention can be determined in advance by means of defining the shape and dimensions of the recess and/or of each permanent magnet, which is insertable therein.

**[0022]** The invention will be described in more detail on the basis of an embodiment, which is presented in the accompanying drawing, wherein

- Fig. 1 is a schematically shown electric switch with integrated relay according to the invention;
- Fig. 2 is a relay in its opened state;
- Fig. 3 is a relay in its opened state, wherein the coil is not energized; and
- Fig. 4 is a relay in its closed state by energizing the coil and just prior to opening the relay i.e. prior to transition into a state according to Fig. 2.

**[0023]** An electric switch is schematically shown in Fig. 1, which is intended for interruption of an electric circuit as soon as a differential current would occur between a phase conductor P and a neutral conductor N, which can

e.g. arise due to mechanical damage of at least one of said conductors N, P or due to corrosion e.g. in junctions where said conductors N, P arc connected.

**[0024]** Said switch S can be integrated into each electric circuit together with at least one load 4 and essentially consists of a differential transformer 1, a passive electric circuit 2 and the relay 3 according to the invention. Said differential transformer 1 consists of a primary winding N1, which is formed by a neutral conductor N and the phase conductor P which extend throughout a core, as well as by a secondary winding N2, which is by means of its connectors 11, 12 electrically interconnected with connectors 21', 22' of said passive electronic circuit 2, which comprises a still further pair of connectors 21", 22", with which the relay 3 according to the invention is electrically interconnected by means of its connectors 30', 30".

**[0025]** In the shown embodiment, the passive electronic circuit 2 comprises two parallel connected diodes D<sub>1</sub> and D<sub>2</sub>, a capacitor c<sub>p</sub> which is parallel connected therewith, and a further capacitor c<sub>s</sub>, which is serially interconnected with said diodes D<sub>1</sub>, D<sub>2</sub> and the previously mentioned capacitor c<sub>p</sub>.

**[0026]** In the context of the previously mentioned electric circuit, said relay 3 is formed by serially interconnected coil L<sub>R</sub> and resistance R<sub>R</sub>, while its mechanical concept and the operation will be detailed described later-on.

**[0027]** As soon as the switch S is integrated into a desired electric circuit, and the conductors N, P extending through the core are supplied with the electric voltage, during the regular operation the electric current in the neutral conductor N should generally be equal to the electric current in the phase conductor P. Whenever an irregularity appear, e.g. by damaging one of said conductors N or P, the difference between said electric currents in both conductors N, P and consequently also in the primary winding N1 of the differential transformer 1, where the number of turns is 1, so that the voltage is induced in the secondary winding N2 of said differential transformer 1, to which then the passive electronic circuit 2 is exposed, which is electrically interconnected with said secondary winding N2. This leads to energizing of the capacitor c<sub>s</sub> of the passive electronic circuit 2, which is re-polarized during the next semi-period of differences between the electric current in the phase conductor P and the neutral conductor N, which results in a correspondingly strong current impulse through the coil L<sub>R</sub> of the relay 3, by which in such situation the actuating mechanism 5 is triggered, by means of which then the switch S is deactivated (Fig. 1) and the electric circuit through the conductors N, P is interrupted.

**[0028]** The invention provides that the primary winding N1 of said differential transformer 1 consists of a single turn. On such a basis, the sensibility of the relay 3 is namely essentially improved, since in such single turn in the primary winding N1 of the differential transformer 1 just a minor difference between the electric currents in the conductors N and P is then able to induce in the sec-

ondary winding N2 a sufficiently high electric voltage for the purposes of generating an impulse in said passive electronic circuit 2, by which the relay 3 can then be triggered.

**[0029]** As mentioned, in the context of electricity, said relay 3 requires just a conductivity and resistance  $R_R$  of the coil  $L_R$ . Said coil  $L_R$  having the resistance  $R_R$  is electrically interconnected with the passive electronic circuit 2, in which a voltage impulse is generated under certain conditions, namely by occurring a differential electric current in the conductors N, P, by which a magnetic field i.e. the magnetic flux  $\Phi_1$  (Fig. 4) is generated within the coil  $L_R$ .

**[0030]** A mechanical concept of the relay 3 is shown in Figs. 2 - 4. In this, the relay 3 essentially consists of a yoke 31, on which said inductive coil  $L_R$  is placed and via its connectors 30', 30" electrically interconnected with the said passive electronic circuit 2, and furthermore of a permanent magnet 32 as well as of an armature 33, which is pivotally around a pivot point 333 attached to said yoke 31 and by means of a spring 34 pivotable at least in the area between said yoke 31 and the actuating mechanism 5, which is located at appropriate distance apart from said yoke 31 and is intended for mechanical triggering the switch S for the purposes of interrupting the electric circuit through the conductors N, P.

**[0031]** The yoke 31 is according to the invention uniformly conceived and is made of a plate consisting of steel or any other metallic alloy having pre-determined magnetic properties, and may be quite precisely manufactured by means of cutting or punching the plate or a strip consisting of previously mentioned material, which may lead to essential benefits in particularly in the mass production. In this, the previously mentioned yoke 31 comprises three arms 311, 312, 313, which are spaced apart from each other and all protrude in the same direction towards the armature 33 and are moreover with respect to their length adapted for simultaneously abutting the armature, wherein the first arm 311 is adapted to receive said coil  $L_R$ , the second arm 312 is adapted to receive a permanent magnet 32, and the third arm 313 is adapted for establishing interconnection between the yoke 31 and the armature 33 at least in the previously mentioned pivot point 333. The coil  $L_R$  is placed on the first arm 311 of the yoke 31 such that said first arm 311 extends throughout the passage within the coil  $L_R$  and is therefore surrounded by the winding of the coil  $L_R$  extending along it.

**[0032]** In order to enable mounting of a permanent magnet 32, said second arm 312 is furnished with a wedge-like trapezoidal recess 3121, which converges in a direction apart from the first arm 311 and into which said permanent magnet 32 is then inserted. Said magnet 32 is maintained within said recess due to its magnetism, and is therefore upon insertion and without any other supplemental interconnection with the yoke 31 thanks to the previously described shape of the recess 3121 positioned in a quite satisfactory manner.

**[0033]** The third arm 313 is essentially intended to support the armature 33 and comprises a pivot point 333, around which the armature 33 can be pivoted relatively to the yoke 31 at least in the area between its first position of simultaneous abutment towards all three arms 311, 312, 313 of the yoke 31 and its second position of abutment the actuating mechanism 5, which is located at appropriate distance apart from the yoke 31 (Fig. 2) and apart from the pivot point 33, and is adapted to interrupt the electric through the conductors N, P whenever appropriate, and in particular when the differential electric current occurs.

**[0034]** The armature 33 is generally also uniformly conceived and is made of a plate or a strip or a wire or any other rolled semi-product of a hot or cold formed preform consisting of steel or any other metallic alloy having pre-determined magnetic properties, and is moreover adapted for simultaneously abutment towards all three arms 311, 312, 313 of the yoke 31, wherein the pivot point 333, around which the armature 33 is allowed to swivel relatively to the yoke 31, is arranged on the third arm 313 of the yoke 31. By taking into consideration said pivot point 333, the armature 33 comprises two areas 331, 332, namely the first area 331 which is adapted to be rest on said three arms 311, 312, 313 of the yoke 31, and the second area 332 in the form of cantilever protruding apart from the third arm 313 of the yoke 31. A tension spring 34 is mechanically interconnected with the armature 33 in said second area 332 thereof in order to generate a permanent force due to tendency of rotating the armature 33 apart from the yoke 31 i.e. towards the actuating mechanism 5. For the purposes of attachment of said spring 34, the armature 33 is optionally furnished with a further appropriately rigid cantilever protrusion 3321, which is located on said second area 332 and preferably extends perpendicularly with respect to the armature 33 itself, by which the lever between the pivot point 333 of the armature 33 and the force of the spring 34 can be additionally extended and adjusted to each required conditions.

**[0035]** When the coil  $L_R$  is via both connectors 30', 30" electrically interconnected with said passive electronic circuit 2, and the permanent magnet 32 is inserted within the recess 3121, the armature 33 can be pivoted around the pivot point in order to assure simultaneous abutment thereof towards all three arms 311, 312, 313 of the yoke 31.

**[0036]** As shown in Fig. 3, the permanent magnet 32 generates a first magnetic flux  $\Phi_1$  throughout the magnet 32, the second area 312, the armature 33 and the first arm 311 of the yoke 31, and also a second magnetic flux  $\Phi_2$  throughout the permanent magnet 32, the second arm 312, the armature 32 and the third arm 313 of the yoke 31. In such a state of the relay 3, the coil  $L_R$  is not energized by the voltage of the passive electronic circuit 2, and the armature 33 is pressed towards the arms 311, 312, 313 of the yoke 31 by means of the force resulting from said magnetic flux  $\Phi_1$ ,  $\Phi_2$  and acting opposite with

respect to said force of the tension spring 34. The majority of torque, by which the armature 33 is pressed towards the yoke 31, results from the force, which is generated by the first magnetic flux  $\Phi_1$  through the first arm 311 of the yoke 31 and which is located at larger distance apart from the pivot point 333. Said torque results from the magnetic forces, by which, depending on the density of the magnetic field of the permanent magnet 32 and/or the coil  $L_R$ , the yoke 31 adheres the armature 33 in the area of its arms 311, 312, 313, and can be therefore appropriately adjusted among others also by means of determining each desired cross-sections of the arms 311, 312, 313 of the yoke 31.

**[0037]** The ratio between the first magnetic flux  $\Phi_1$  and the third magnetic flux  $\Phi_3$  can be determined in advance by means of defining appropriate shape and dimensions of the recess 3121 and/or of the permanent magnet 32, which is insertable therein.

**[0038]** As soon as differential current occurs in the conductors N, P, voltage is generated on the connectors 30', 30" thanks to the differential transformer 1 and the passive electronic circuit 2, which has already been described, so that a magnetic field i.e. the fourth magnetic flux  $\Phi_4$  is generated within the coil  $L_R$ , which is acting opposite to the previously mentioned first magnetic flux  $\Phi_1$  of the permanent magnet 32 extending through the first and the second arm 311, 312 of the yoke 31. Consequently, the magnetic force generated by the first magnetic flux  $\Phi_1$  of the permanent magnet 32 is herewith eliminated, and the torque adhering the armature 33 towards the yoke 31 is reduced below the value of the torque, by which the force of the tension spring 34 insists in rotating the armature 33 around the pivot point 333 in a direction apart from the yoke 31 i.e. towards the actuating mechanism 5. In such situation, due to energizing the coil  $L_R$  and thanks to the fourth magnetic flux  $\Phi_4$  generated therein, the armature 33 is swiveled around the pivot point 333 into a position according to Fig. 2 in order to abut the actuating mechanism, upon which the electric circuit through the conductors N, P is interrupted by the switch S, wherein the third magnetic flux  $\Phi_3$  still persists through the permanent magnet 32, the second arm 312 and the third arm 313 of the yoke 31 (Fig. 1). The switch S, which is during the regular operation of the electric circuit through the conductors N, P closed, is in Fig. 1 merely for illustrative purposes shown in its opened state upon interrupting said electric circuit, which essentially corresponds to the position of the armature 33 as soon as said armature 33 abuts the actuating mechanism 5.

**[0039]** The relay 3 in accordance with the previously described mechanical concept can be despite to quite simple manufacturing technology extremely precisely manufactured within each pre-determined range of dimensions, which is of a crucial importance with respect to magnetic properties, which are required for the purposes of reliable operation thereof, whereas due to improved sensibility and reactivity of the relay 3 in the case of differential current also the reliability of the complete

switch S, in which it is integrated together with each corresponding conductors N, P, in comparison with the existing switches may be essentially improved.

## Claims

1. Relay (3), which is in particular intended to be integrated into a switch (S) used for the purposes of interrupting an electric circuit in the case, when a difference between electric current in conductors (N, P) occurs, wherein such relay (3) in the electrical context represents a resistance ( $R_R$ ) and inductivity of a coil ( $L_R$ ), via which the relay (3) is electrically interconnected with a passive electronic circuit (2) and indirectly also with a differential transformer (1) intended for indication of a differential electric current in the area of said conductors (N, P), so that in the case of difference between currents in said conductors (N, P) due to the voltage generated in the differential transformer (1) and in the passive electronic circuit (2) a corresponding magnetic flux ( $\Phi_4$ ) is generated in said coil ( $L_R$ ), and wherein such relay (3) in the mechanical contexts consists of a yoke (31), which comprises said inductive coil (LR) and a permanent magnet (32) for providing a desired magnetic flux ( $\Phi_1, \Phi_2, \Phi_3$ ) in the area of said yoke (31), as well as of an armature (33), which is pivotally interconnected with said yoke (31) in a pivot point (333) and is, depending on energizing the coil ( $L_R$ ), either by means of said permanent magnet (32) rest onto said yoke (31), or is by means of a force of a spring (34) pivoted away from the yoke (31) towards the actuating mechanism (5), which is located at appropriate distance apart from the yoke (31) and is intended for activation of the switch (S) in the sense of interrupting the electric circuit through said conductors (N, P), **characterized in that** the yoke (31) is uniformly conceived and is cut or punched out of a plate or a strip consisting of steel or any other metallic alloy with pre-determined magnetic properties and comprises three arms (131, 132, 133), which are spaced apart from each other and protrude towards the armature (33), wherein their lengths are adjusted for the purposes of simultaneously abutment of said armature (3) to all of them, and wherein

- the first arm (131) is adapted to receive the coil ( $L_R$ ), which is mounted on it in such a manner that said first arm (131) extends throughout the coil ( $L_R$ ) and is surrounded by the winding of the coil ( $L_R$ ) extending along it;
- the second arm (132) is adapted to receive a permanent magnet (32), which permanently generates a magnetic flux and consequently a magnetic force, which is required for the purposes of abutment of the armature (33) towards the said arms (131, 132, 133) of the yoke (31) and

which is acting in a direction opposite to the force of said spring (34);

- the third arm (133) is intended to support the armature (33) and to provide a pivot point (333), around which the armature (33) can be pivoted from its first position of abutment towards said arms (131, 132, 133) of the yoke (31) to its second position, in which it abuts the actuating mechanism (5), which is located at appropriate distance apart from the yoke (31),

**and in that** the armature (33) is uniformly conceived and is made of a plate or a strip or a wire or any other rolled semi-product of a hot or cold formed preform consisting of steel or any other metallic alloy having pre-determined magnetic properties, and is in the pivot point (333) pivotally interconnected with the yoke (31) and comprises the first area (331), which is located in the one side of said pivot point (333) and is adapted for simultaneously abutment towards all three arms (131, 132, 133) of the yoke (31), as well as the second cantilevered area (332), which is located on the other side of said pivot point (333) and protrudes away from the yoke (31) and in which a spring (34) is mechanically connected to the armature (33).

2. Relay according to Claim 1, **characterized in that** the permanent magnet (32) is wedge-like shaped and is adapted for inserting into a wedge-shaped trapezoidal recess (3121) in the second arm (312) of the yoke (31), which is converging away from the first arm (311).
3. Relay according to Claim 1 or 2, **characterized in that** the armature (33) is furnished with a supplemental protrusion (3221), which is firmly attached thereto and protrudes at least approximately perpendicularly from its cantilevered portion (332), so that the spring (34) is mechanically connected therewith.
4. Relay according to anyone of Claims 1 - 3, **characterized in that** upon inserting said permanent magnet (32) into the second arm (312) of the yoke (31) a magnetic field is generated, which in the case, when the coil ( $L_R$ ) on the first arm (311) is not energized and the armature (33) is simultaneously abutting all three arms (131, 132, 133) of the yoke (31), consists of

- the first magnetic flux ( $\Phi_1$ ), which extends throughout the permanent magnet (32), the second arm (312) of the yoke (31), the armature (33) and through the first arm (311) of the yoke (31) towards the permanent magnet (32);

- the second magnetic flux ( $\Phi_2$ ), which extends throughout the permanent magnet (32), the second arm (312) of the yoke (31), the armature

(33) and through the third arm (311) of the yoke (31) back towards the permanent magnet (32); and

- the third magnetic flux ( $\Phi_3$ ), which extends throughout the permanent magnet (32), the second arm (312) of the yoke (31) and through the third arm (313) of the yoke (31) back towards the permanent magnet (32),

wherein by energizing the coil ( $L_R$ ) by means of a voltage on the connectors (30', 30") thereof an addition magnetic field is generated therein with a magnetic flux ( $\Phi_4$ ), which is acting in the opposite direction as the said first magnetic flux ( $\Phi_1$ ), by which at least the magnetic flux ( $\Phi_1$ ) of the permanent magnet (32) in the first arm (131) is then reduced i.e. at least essentially neutralized.

5. Relay according to anyone of Claims 1 - 4, **characterized in that** the permanent magnet (32) is designed in such a manner that upon inserting it into the area of said second arm (132) of the yoke (31) in the case, when the coil ( $L_R$ ) is not energized, the torque produced by magnetic force due to at least the first magnetic flux ( $\Phi_1$ ) in the area of the first arm (131) of the yoke (31) with respect to the pivot point (333) of the armature (32), which is simultaneously abutting all three arms (131, 132, 133), is greater than the torque produced by the force of the spring (34) acting on the armature (33), while on the contrary, when the coil ( $L_R$ ) is energized by means of voltage produced by the passive electronic circuit (2) and the additional magnetic flux ( $\Phi_4$ ) is generated, which is acting opposite to at least the first magnetic flux ( $\Phi_1$ ) of the permanent magnet (32) in the first arm (131), the torque produced by magnetic forces is reduced below the value of the torque produced by the force of the spring (34) acting to the armature (33).
6. Relay according to anyone of Claims 1 - 5, **characterized in that** the ratio between the first magnetic flux ( $\Phi_1$ ) and the third magnetic flux ( $\Phi_3$ ) is determined in advance by means of defining the shape and dimensions of the recess (3121) and/or of each permanent magnet (32), which is insertable therein.
7. Switch for interruption of an electric circuit in the case of differential current, which comprises a relay (3) according to anyone of Claims 1 - 6 and is intended for integration into an electric circuit, which formed by appropriate direct voltage (DC) or alternating voltage (AC) or combined (AC/DC) voltage source together with at least one load (4) as well as with a phase conductor (P) and a neutral conductor (N), which are connected to said source via the said switch (S), such switch (S) comprising

- a differential transformer (1), in which its primary winding (N1) is formed by the phase conductor (P) and the neutral conductor (N) extending through a core thereof, and its secondary winding (N2) comprises two electric connectors (11, 12);
- a passive electronic circuit (2), comprising two pairs of connectors (21', 22' and 21'', 22''), between which a capacitor (C<sub>s</sub>) is serial connected to other parallel connected components (C<sub>p</sub>, D<sub>1</sub>, D<sub>2</sub>) and is adapted to be energized by means of electric voltage, which is induced in the secondary winding (N2) of the transformer (1), since said circuit (2) is by means of said connectors (21', 22') electrically interconnected with the connectors (11, 12) of said secondary winding (N2) of said transformer (1).
8. Switch according to Claim 7, **characterized in that** the permanent magnet (32) is wedge-like shaped and is adapted for inserting into a wedge-shaped trapezoidal recess (3121) in the second arm (312) of the yoke (31), which is converging away from the first arm (311).
9. Switch according to Claim 7 or 8, **characterized in that** the armature (33) is furnished with a supplemental protrusion (3221), which is firmly attached thereto and protrudes at least approximately perpendicularly from its cantilevered portion (332), so that the spring (34) is mechanically connected therewith.
10. Switch according to anyone of Claims 7 - 9, **characterized in that** upon inserting said permanent magnet (32) into the second arm (312) of the yoke (31) a magnetic field is generated, which in the case, when the coil (L<sub>R</sub>) on the first arm (311) is not energized and the armature (33) is simultaneously abutting all three arms (131, 132, 133) of the yoke (31), consists of

- the first magnetic flux (Φ<sub>1</sub>), which extends throughout the permanent magnet (32), the second arm (312) of the yoke (31), the armature (33) and through the first arm (311) of the yoke (31) towards the permanent magnet (32);
- the second magnetic flux (Φ<sub>2</sub>), which extends throughout the permanent magnet (32), the second arm (312) of the yoke (31), the armature (33) and through the third arm (311) of the yoke (31) back towards the permanent magnet (32); and
- the third magnetic flux (Φ<sub>3</sub>), which extends throughout the permanent magnet (32), the second arm (312) of the yoke (31) and through the third arm (313) of the yoke (31) back towards the permanent magnet (32), wherein by energizing the coil (L<sub>R</sub>) by means of a voltage on the

connectors (30', 30'') thereof an additional magnetic field is generated therein with a magnetic flux (Φ<sub>4</sub>), which is acting in the opposite direction as the said first magnetic flux (Φ<sub>1</sub>), by which at least the magnetic flux (Φ<sub>1</sub>) of the permanent magnet (32) in the first arm (131) is then reduced i.e. at least essentially neutralized.

11. Switch according to anyone of Claims 7 - 10, **characterized in that** the permanent magnet (32) is designed in such a manner that upon inserting it into the area of said second arm (132) of the yoke (31) in the case, when the coil (L<sub>R</sub>) is not energized, the torque produced by magnetic force due to at least the first magnetic flux (Φ<sub>1</sub>) in the area of the first arm (131) of the yoke (31) with respect to the pivot point (333) of the armature (32), which is simultaneously abutting all three arms (131, 132, 133), is greater than the torque produced by the force of the spring (34) acting on the armature (33), while on the contrary, when the coil (L<sub>R</sub>) is energized by means of voltage produced by the passive electronic circuit (2) and the additional magnetic flux (Φ<sub>4</sub>) is generated, which is acting opposite to at least the first magnetic flux (Φ<sub>1</sub>) of the permanent magnet (32) in the first arm (131), the torque produced by magnetic forces is reduced below the value of the torque produced by the force of the spring (34) acting to the armature (33).
12. Switch according to anyone of Claims 7 - 11, **characterized in that** the primary winding (N1) of the differential transformer (1) comprises a single turn.
13. Switch according to anyone of Claims 7 - 12, **characterized in that** the ratio between the first magnetic flux (Φ<sub>1</sub>) and the third magnetic flux (Φ<sub>3</sub>) is determined in advance by means of defining the shape and dimensions of the recess (3121) and/or of each permanent magnet (32), which is insertable therein.

#### Patentansprüche

1. Relais (3), das insbesondere in einen Schalter (S) integriert werden soll, der zur Unterbrechung einer elektrischen Schaltung für den Fall verwendet wird, dass in Leitern (N, P) unterschiedliche elektrische Ströme auftreten, wobei ein solches Relais (3) in einer elektrischen Kontext einen Widerstand (R<sub>R</sub>) und eine Induktivität einer Spule (L<sub>R</sub>) darstellt, über die das Relais (3) elektrisch mit einer passiven elektronischen Schaltung (2) und indirekt auch mit einem Differentialtransformator (1) zur Anzeige eines elektrischen Differentialstroms in dem Bereich der Leiter (N, P) verbunden ist, so dass für den Fall einer Differenz zwischen Strömen in den Leitern (N, P) infolge der in dem Differenzialtransformator (1) und in

der passiven elektronischen Schaltung (2) erzeugten Spannung ein entsprechender magnetischer Fluss ( $\Phi_4$ ) in der Spule ( $L_R$ ) erzeugt wird, und wobei dieses Relais (3) in einer mechanischen Kontext aus einem Joch (31) besteht, das die induktive Spule ( $L_R$ ) und einen Dauermagneten (32) zum Bereitstellen eines gewünschten magnetischen Flusses ( $\Phi_1$ ,  $\Phi_2$ ,  $\Phi_3$ ) in dem Bereich des Jochs (31) umfasst, sowie aus einem Anker (33), der schwenkbar mit dem Joch (31) in einem Schwenkpunkt (333) verbunden ist und in Abhängigkeit von der Stromversorgung der Spule ( $L_R$ ) entweder mittels des Dauermagneten (32) auf dem Joch (31) ruht oder mittels der Kraft einer Feder (34) von dem Joch (31) weg in Richtung zum Betätigungsmechanismus (5) geschwenkt wird, der sich in einem geeigneten Abstand entfernt von dem Joch (31) befindet und zur Aktivierung des Schalters (S) im Sinne einer Unterbrechung der elektrischen Schaltung durch die Leiter (N, P) gedacht ist, **dadurch gekennzeichnet, dass** das Joch (31) einheitlich konzipiert und aus einer Platte oder einem Streifen aus Stahl oder einer anderen metallischen Legierung mit vorbestimmten magnetischen Eigenschaften ausgeschnitten oder ausgestanzt ist und drei Arme (131, 132, 133) aufweist, die voneinander beabstandet sind und in Richtung zum Anker (33) vorragen, wobei ihre Längen so eingestellt sind, dass der Anker (3) gleichzeitig an ihnen allen anliegt, und wobei

- der erste Arm (131) ausgestaltet ist, um die Spule ( $L_R$ ) aufzunehmen, die darauf so befestigt ist, dass der erste Arm (131) durch die Spule ( $L_R$ ) verläuft und von der Wicklung der Spule ( $L_R$ ), die daran entlang verläuft, umgeben ist;
- der zweite Arm (132) ausgestaltet ist, um einen Dauermagneten (32) aufzunehmen, der permanent einen magnetischen Fluss und infolgedessen eine Magnetkraft erzeugt, die zum Anliegen des Ankers (33) an den Armen (131, 132, 133) des Jochs (31) erforderlich ist und die in einer zur Kraft der Feder (34) entgegengesetzten Richtung wirkt;
- der dritte Arm (133) dafür gedacht ist, den Anker (33) zu stützen und einen Schwenkpunkt (333) bereitzustellen, um den der Anker (33) aus seiner ersten Position des Anliegens an den Armen (131, 132, 133) des Jochs (31) in seine zweite Position geschwenkt werden kann, in der er an dem Betätigungsmechanismus (5) anliegt, der sich in einem passenden Abstand zu dem Joch (31) befindet,

**und dadurch, dass** der Anker (33) einheitlich konzipiert und aus einer Platte oder einem Streifen oder einem Draht oder einem sonstigen gewalzten Halbzeug aus einem warm- oder kaltumgeformten Rohling aus Stahl oder einer anderen metallischen Le-

gierung mit vorbestimmten magnetischen Eigenschaften hergestellt ist, und in dem Schwenkpunkt (333) schwenkbar mit dem Joch (31) verbunden ist und den ersten Bereich (331) aufweist, der sich auf der einen Seite des Schwenkpunkts (333) befindet zum gleichzeitigen Anliegen an allen drei Armen (131, 132, 133) des Jochs (31) ausgestaltet ist, sowie den zweiten, auskragenden Bereich (332), der sich auf der anderen Seite des Schwenkpunkts (333) befindet und von dem Joch (31) weg hervorragt und in dem eine Feder (34) mit dem Anker (33) mechanisch verbunden ist.

2. Relais gemäß Anspruch 1, **dadurch gekennzeichnet, dass** der Dauermagnet (32) keilförmig gebildet und zum Einführen in eine keilförmige Trapezausnehmung (3121) in dem zweiten Arm (312) des Jochs (31) ausgebildet ist, die von dem ersten Arm (311) weg verläuft.

3. Relais gemäß Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** der Anker (33) mit einem zusätzlichen Vorsprung (3221) ausgestattet ist, der daran fest angebracht ist und zumindest annähernd senkrecht von seinem auskragenden Abschnitt (332) vorsteht, so dass die Feder (34) mechanisch damit verbunden ist.

4. Relais gemäß einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** nach dem Einfügen des Dauermagneten (32) in den zweiten Arm (312) des Jochs (31) ein Magnetfeld erzeugt wird, das in dem Fall, wenn die Spule ( $L_R$ ) auf dem ersten Arm (311) nicht mit Strom versorgt wird und der Anker (33) gleichzeitig an allen drei Armen (131, 132, 133) des Jochs (31) anliegt, folgendes umfasst:

- den ersten magnetischen Fluss ( $\Phi_1$ ), der durch den Dauermagneten (32), den zweiten Arm (312) des Jochs (31), den Anker (33) und durch den ersten Arm (311) des Jochs (31) zum Dauermagneten (32) verläuft;
- den zweiten magnetischen Fluss ( $\Phi_2$ ), der durch den Dauermagneten (32), den zweiten Arm (312) des Jochs (31), den Anker (33) und durch den dritten Arm (311) des Jochs (31) zurück zum Dauermagneten (32) verläuft; und
- den dritten magnetischen Fluss ( $\Phi_3$ ), der durch den Dauermagneten (32), den zweiten Arm (312) des Jochs (31) und durch den dritten Arm (313) des Jochs (31) zurück zum Dauermagneten (32) verläuft,

wobei durch Versorgen der Spule ( $L_R$ ) mit Strom mittels einer Spannung an deren Anschlüssen (30', 30") darin ein zusätzliches Magnetfeld mit einem Magnetfluss ( $\Phi_4$ ) erzeugt wird, der in der entgegengesetzten Richtung wie der erste magnetische Fluss ( $\Phi_1$ ) wirkt, wodurch dann we-

nigstens der magnetische Fluss ( $\Phi_1$ ) des Dauermagneten (32) im ersten Arm (131) reduziert, d.h. mindestens wesentlich neutralisiert wird.

5. Relais gemäß einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** der Dauermagnet (32) derart ausgestaltet ist, dass nach seinem Einführen in den Bereich des zweiten Arms (132) des Jochs (31) in dem Fall, wenn die Spule ( $L_R$ ) nicht mit Strom versorgt wird, das von der Magnetkraft erzeugte Drehmoment, das infolge wenigstens des ersten magnetischen Flusses ( $\Phi_1$ ) in dem Bereich des ersten Arms (131) des Jochs (31) im Hinblick auf den Schwenkpunkt (333) des Ankers (32) entsteht, der gleichzeitig an allen drei Armen (131, 132, 133) anliegt, größer ist als das Drehmoment, das von der Kraft der Feder (34) erzeugt wird, die auf den Anker (33) wirkt, während dagegen, wenn die Spule ( $L_R$ ) mittels der durch die passive elektronische Schaltung (2) erzeugten Spannung mit Strom versorgt wird und der zusätzliche magnetische Fluss ( $\Phi_4$ ), der entgegengesetzt zu dem wenigstens ersten magnetischen Fluss ( $\Phi_1$ ) des Dauermagneten (32) in dem ersten Arm (131) wirkt, erzeugt wird, das durch die Magnetkräfte erzeugte Drehmoment unter den Wert des von der Kraft der Feder (34), die auf den Anker (33) wirkt, erzeugten Drehmoments reduziert wird.

6. Relais gemäß einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** das Verhältnis zwischen dem ersten magnetischen Fluss ( $\Phi_1$ ) und dem dritten magnetischen Fluss ( $\Phi_3$ ) im Voraus durch Festlegen der Form und der Abmessungen der Ausnehmung (3121) und/oder jedes Dauermagneten (32), der dort eingeführt werden kann, bestimmt wird.

7. Schalter zum Unterbrechen einer elektrischen Schaltung im Falle eines Differenzialstroms, der ein Relais (3) gemäß einem der Ansprüche 1 bis 6 aufweist und zum Integrieren in eine elektrische Schaltung gedacht ist, die durch eine geeignete Gleichspannungs- (DC) oder Wechselspannungs-(AC) oder kombinierte Gleichspannungs-/Wechselspannungsquelle (AC/DC) zusammen mit mindestens einer Last (4) sowie mit einem Phasenleiter (P) und einem neutralen Leiter (N) gebildet ist, die mit der Quelle über den Schalter (S) verbunden sind, wobei der Schalter (S) folgendes umfasst:

- einen Differenzialtransformator (1), in dem seine Primärentwicklung (N1) durch den Phasenleiter (P) und den sich durch einen Fern davon erstreckenden neutralen Leiter (N) gebildet ist, und seine zweite Wicklung (N2) zwei elektrische Anschlüsse (11,12) umfasst;
- eine passive elektronische Schaltung (2), die zwei Paare von Anschlüssen (21', 22' und 21",

22") aufweist, zwischen denen ein Kondensator ( $C_S$ ) an anderen parallelgeschalteten Bauteilen ( $C_P$ ,  $D_1$ ,  $D_2$ ) in Reihe angeschlossen und ausgestaltet ist, um mittels der elektrischen Spannung, die in der sekundären Wicklung (N2) des Transformators (1) induziert wird, mit Strom versorgt zu werden, da die Schaltung (2) mittels der Anschlüsse (21', 22') elektrisch mit den Anschlüssen (11,12) der Sekundärwicklung (N2) des Transformators (1) verbunden ist.

8. Schalter gemäß Anspruch 7, **dadurch gekennzeichnet, dass** der Dauermagnet (32) keilförmig gebildet und zum Einführen in eine keilförmige Trapezausnehmung (3121) in dem zweiten Arm (312) des Jochs (31) ausgebildet ist, die von dem ersten Arm (311) weg verläuft.

9. Schalter gemäß Anspruch 7 oder 8, **dadurch gekennzeichnet, dass** der Anker (33) mit einem zusätzlichen Vorsprung (3221) ausgestattet ist, der daran fest angebracht ist und zumindest annähernd senkrecht von seinem auskragenden Abschnitt (332) vorsteht, so dass die Feder (34) mechanisch damit verbunden ist.

10. Schalter gemäß Anspruch 7 bis 9, **dadurch gekennzeichnet, dass** nach dem Einfügen des Dauermagneten (32) in den zweiten Arm (312) des Jochs (31) ein Magnetfeld erzeugt wird, das in dem Fall, wenn die Spule ( $L_R$ ) auf dem ersten Arm (311) nicht mit Strom versorgt wird und der Anker (33) gleichzeitig an allen drei Armen (131, 132, 133) des Jochs (31) anliegt, folgendes umfasst:

- den ersten magnetischen Fluss ( $\Phi_1$ ), der durch den Dauermagneten (32), den zweiten Arm (312) des Jochs (31), den Anker (33) und durch den ersten Arm (311) des Jochs (31) zum Dauermagneten (32) verläuft;
- den zweiten magnetischen Fluss ( $\Phi_2$ ), der durch den Dauermagneten (32), den zweiten Arm (312) des Jochs (31), den Anker (33) und durch den dritten Arm (311) des Jochs (31) zurück zum Dauermagneten (32) verläuft; und
- den dritten magnetischen Fluss ( $\Phi_3$ ), der durch den Dauermagneten (32), den zweiten Arm (312) des Jochs (31) und durch den dritten Arm (313) des Jochs (31) zurück zum Dauermagneten (32) verläuft, wobei durch Versorgen der Spule ( $L_R$ ) mit Strom mittels einer Spannung an deren Anschlüssen (30', 30") darin ein zusätzliches Magnetfeld mit einem Magnetfluss ( $\Phi_4$ ) erzeugt wird, der in der entgegengesetzten Richtung wie der erste magnetische Fluss ( $\Phi_1$ ) wirkt, wodurch dann wenigstens der magnetische Fluss ( $\Phi_1$ ) des Dauermagneten (32) im ersten Arm (131) reduziert, d.h. mindestens wesentlich

neutralisiert wird.

11. Schalter gemäß einem der Ansprüche 7 bis 10, **dadurch gekennzeichnet, dass** der Dauermagnet (32) derart ausgestaltet ist, dass nach seinem Einführen in den Bereich des zweiten Arms (132) des Jochs (31) in dem Fall, wenn die Spule ( $L_R$ ) nicht mit Strom versorgt wird, das von der Magnetkraft erzeugte Drehmoment, das infolge wenigstens des ersten magnetischen Flusses ( $\Phi_1$ ) in dem Bereich des ersten Arms (131) des Jochs (31) im Hinblick auf den Schwenkpunkt (333) des Ankers (32) entsteht, der gleichzeitig an allen drei Armen (131, 132, 133) anliegt, größer ist als das Drehmoment, das von der Kraft der Feder (34) erzeugt wird, die auf den Anker (33) wirkt, während dagegen, wenn die Spule ( $L_R$ ) mittels der durch die passive elektronische Schaltung (2) erzeugten Spannung mit Strom versorgt wird und der zusätzliche magnetische Fluss ( $\Phi_4$ ), der entgegengesetzt zu dem wenigstens ersten magnetischen Fluss ( $\Phi_1$ ) des Dauermagneten (32) in dem ersten Arm (131) wirkt, erzeugt wird, das durch die Magnetkräfte erzeugte Drehmoment unter den Wert des von der Kraft der Feder (34), die auf den Anker (33) wirkt, erzeugten Drehmoments reduziert wird.
12. Schalter gemäß einem der Ansprüche 7 bis 11, **dadurch gekennzeichnet, dass** die Primärwicklung ( $N_1$ ) des Differenzialtransformators (1) eine einzelne Windung aufweist.
13. Schalter gemäß einem der Ansprüche 7 bis 12, **dadurch gekennzeichnet, dass** das Verhältnis zwischen dem ersten magnetischen Fluss ( $\Phi_1$ ) und dem dritten magnetischen Fluss ( $\Phi_3$ ) im Voraus durch Festlegen der Form und der Abmessungen der Ausnehmung (3121) und/oder jedes Dauermagneten (32), der dort eingeführt werden kann, bestimmt wird.

## Revendications

1. Relais (3) qui est prévu en particulier pour être intégré dans un interrupteur (S) utilisé dans le but d'interrompre un circuit électrique dans le cas où il se produit une différence entre des courants électriques passant dans des conducteurs (N, P), où un tel relais (3), dans le contexte électrique, représente une résistance ( $R_R$ ) et l'inductance d'une bobine ( $L_R$ ) par laquelle le relais (3) est électriquement interconnecté à un circuit électronique passif (2) et, indirectement, également à un transformateur différentiel (1) prévu pour fournir une indication d'un courant électrique différentiel dans la zone desdits conducteurs (N, P), de sorte que dans le cas d'une différence entre des courants électriques passant dans lesdits conducteurs (N, P) due à la tension générée dans

le transformateur différentiel (1) et dans le circuit électronique passif (2), un flux magnétique correspondant ( $\Phi_4$ ) est généré dans ladite bobine ( $L_R$ ), et ou un tel relais (3), dans les contextes mécaniques, se compose d'une culasse (31) qui comprend ladite bobine inductive ( $L_R$ ) et un aimant permanent (32) pour fournir un flux magnétique souhaité ( $\Phi_1$ ,  $\Phi_2$ ,  $\Phi_3$ ) dans la zone de ladite culasse (31), ainsi que d'une armature (33) qui est interconnectée de façon pivotante à ladite culasse (31), au niveau d'un point pivot (333), et, en fonction de l'excitation de la bobine ( $L_R$ ), soit repose sur ladite culasse (31) au moyen dudit aimant permanent (32), soit pivote au moyen d'une force d'un ressort (34) en s'écartant de la culasse (31), en direction du mécanisme d'actionnement (5) qui est placé à une distance appropriée par rapport à la culasse (31) et qui est prévu pour l'activation de l'interrupteur (S) dans le but d'interrompre le circuit électrique traversant lesdits conducteurs (N, P),

**caractérisé en ce que** la culasse (31) est conçue de façon uniforme et est découpée ou estampée à partir d'une plaque ou d'une bande se composant d'acier ou de n'importe quel autre alliage métallique ayant des propriétés magnétiques prédéterminées et comprend trois bras (131, 132, 133) qui sont espacés les uns des autres et sont en saillie vers l'armature (33), où leurs longueurs sont ajustées dans le but que tous les bras viennent simultanément en butée sur ladite armature (3), et où

- le premier bras (131) est adapté pour loger la bobine ( $L_R$ ) qui est montée sur celui-ci, de manière telle que ledit premier bras (131) s'étende sur la totalité de la bobine ( $L_R$ ) et soit entouré par l'enroulement de la bobine ( $L_R$ ) s'étendant le long de celle-ci;

- le deuxième bras (132) est adapté pour loger un aimant permanent (32) qui, de façon permanente, génère un flux magnétique et, par conséquent, une force magnétique qui est nécessaire pour que l'armature (33) vienne en butée vers lesdits bras (131, 132, 133) de la culasse (31) et qui agit dans une direction opposée à celle de la force dudit ressort (34);

- le troisième bras (133) est prévu pour supporter l'armature (33) et pour fournir un point pivot (333) autour duquel l'armature (33) peut pivoter, passant de sa première position où elle vient en butée vers lesdits bras (131, 132, 133) de la culasse (31), à sa seconde position dans laquelle elle vient en butée sur le mécanisme d'actionnement (5) qui est placé à une distance appropriée par rapport à la culasse (31),

et **en ce que** l'armature (33) est conçue de façon uniforme et est constituée d'une plaque ou d'une bande ou d'un fil ou de n'importe quel autre semi-

produit laminé provenant d'une ébauche formée à chaud ou à froid et se composant d'acier ou de n'importe quel autre alliage métallique ayant des propriétés magnétiques prédéterminées et, au niveau du point pivot (333), est interconnectée de façon pivotante à la culasse (31) et comprend la première zone (331) qui est placée sur l'un des côtés dudit point pivot (333) et est adaptée pour venir simultanément en butée vers la totalité des trois bras (131, 132, 133) de la culasse (31), ainsi que la seconde zone en porte-à-faux (332) qui est placée de l'autre côté dudit point pivot (333) et dépasse de la culasse (31), seconde zone dans laquelle un ressort (34) est mécaniquement relié à l'armature (33).

2. Relais selon la revendication 1, **caractérisé en ce que** l'aimant permanent (32) est en forme de coin et est adapté pour une insertion dans un évidement trapézoïdal (3121) en forme de coin, dans le deuxième bras (312) de la culasse (31), deuxième bras qui est convergent à distance par rapport au premier bras (311).

3. Relais selon la revendication 1 ou 2, **caractérisé en ce que** l'armature (33) est fournie en ayant une partie saillante supplémentaire (3221) qui est solidairement fixée à ladite armature et est en saillie au moins approximativement de façon perpendiculaire à sa partie en porte-à-faux (332), de sorte que le ressort (34) est mécaniquement relié à celle-ci.

4. Relais selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** lors de l'insertion dudit aimant permanent (32) dans le deuxième bras (312) de la culasse (31), un champ magnétique est généré qui, dans le cas où la bobine ( $L_R$ ), sur le premier bras (311), n'est pas excitée et où l'armature (33) vient simultanément en butée sur la totalité des trois bras (131, 132, 133) de la culasse (31), se compose

- du premier flux magnétique ( $\Phi_1$ ) qui traverse la totalité de l'aimant permanent (32), le deuxième bras (312) de la culasse (31), l'armature (33) et traverse le premier bras (311) de la culasse (31) vers l'aimant permanent (32);

- du deuxième flux magnétique ( $\Phi_2$ ) qui traverse la totalité de l'aimant permanent (32), le deuxième bras (312) de la culasse (31), l'armature (33) et traverse le troisième bras (313) de la culasse (31) en revenant vers l'aimant permanent (32); et

- du troisième flux magnétique ( $\Phi_3$ ) qui traverse la totalité de l'aimant permanent (32), le deuxième bras (312) de la culasse (31) et traverse le troisième bras (313) de la culasse (31) en revenant vers l'aimant permanent (32), où, lors de l'excitation de la bobine ( $L_R$ ) au moyen d'une tension appliquée aux connecteurs (30', 30'') de

la bobine, un champ magnétique supplémentaire est généré dans ladite bobine, avec un flux magnétique ( $\Phi_4$ ) qui agit dans la direction opposée à celle dudit premier flux magnétique ( $\Phi_1$ ), flux magnétique supplémentaire par lequel au moins le flux magnétique ( $\Phi_1$ ) de l'aimant permanent (32), dans le premier bras (311), est ensuite réduit, c'est-à-dire au moins essentiellement neutralisé.

5. Relais selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** l'aimant permanent (32) est conçu de manière telle, que lors de son insertion dans la zone dudit deuxième bras (312) de la culasse (31), dans le cas où la bobine ( $L_R$ ) n'est pas excitée, le couple produit par une force magnétique due au moins au premier flux magnétique ( $\Phi_1$ ) dans la zone du premier bras (311) de la culasse (31), par rapport au point pivot (333) de l'armature (33) qui vient simultanément en butée sur la totalité des trois bras (131, 132, 133), soit supérieur au couple produit par la force du ressort (34) agissant sur l'armature (33), tandis qu'au contraire, quand la bobine ( $L_R$ ) est excitée au moyen d'une tension produite par le circuit électronique passif (2) et que le flux magnétique supplémentaire ( $\Phi_4$ ) est généré et qu'il agit en s'opposant au moins au premier flux magnétique ( $\Phi_1$ ) de l'aimant permanent (32) dans le premier bras (311), le couple produit par des forces magnétiques soit réduit, passant au-dessous de la valeur du couple produit par la force du ressort (34) agissant sur l'armature (33).

6. Relais selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** le rapport entre le premier flux magnétique ( $\Phi_1$ ) et le troisième flux magnétique ( $\Phi_3$ ) est déterminé à l'avance en définissant la forme et les dimensions de l'évidement (3121) et/ou de chaque aimant permanent (32) qui peut être inséré dans ledit évidement.

7. Interrupteur pour l'interruption d'un circuit électrique dans le cas d'un courant différentiel, interrupteur qui comprend un relais (3) selon l'une quelconque des revendications 1 à 6 et est prévu pour une intégration dans un circuit électrique qui est formé par une source appropriée de tension continue (c.c.) ou de tension alternative (c.a.) ou de tension combinée (c.c./c.a.) associée au moins à une charge (4) ainsi qu'à un conducteur de phase (P) et à un conducteur neutre (N) qui sont connectés à ladite source via ledit interrupteur (S), ledit interrupteur (S) comprenant

- un transformateur différentiel (1) dans lequel son enroulement primaire (N1) est formé par le conducteur de phase (P) et par le conducteur neutre (N) s'étendant à travers un noyau dudit transformateur, et son enroulement secondaire

- (N2) comprend deux connecteurs électriques (11, 12);  
 - un circuit électronique passif (2) comprenant deux paires de connecteurs (21', 22' et 21'', 22'') entre lesquels un condensateur ( $C_5$ ) est connecté en série à d'autres composants ( $C_p$ ,  $D_1$ ,  $D_2$ ) connectés en parallèle et est adapté pour être excité au moyen d'une tension électrique qui est induite dans l'enroulement secondaire (N2) du transformateur (1), étant donné que ledit circuit (2) est, au moyen desdits connecteurs (21', 22'), électriquement interconnecté aux connecteurs (11, 12) dudit enroulement secondaire (N2) dudit transformateur (1).
8. Interrupteur selon la revendication 7, **caractérisé en ce que** l'aimant permanent (32) est en forme de coin et est adapté pour une insertion dans un évidement trapézoïdal (3121) en forme de coin, dans le deuxième bras (312) de la culasse (31), deuxième bras qui est convergent à distance par rapport au premier bras (311).
9. Interrupteur selon la revendication 7 ou 8, **caractérisé en ce que** l'armature (33) est fournie en ayant une partie saillante supplémentaire (3221) qui est solidairement fixée à ladite armature et dépasse au moins approximativement de façon perpendiculaire à sa partie en porte-à-faux (332), de sorte que le ressort (34) est mécaniquement relié à celle-ci.
10. Interrupteur selon l'une quelconque des revendications 7 à 9, **caractérisé en ce que** lors de l'insertion dudit aimant permanent (32) dans le deuxième bras (312) de la culasse (31), un champ magnétique est généré qui, dans le cas où la bobine ( $L_R$ ), sur le premier bras (311), n'est pas excitée et où l'armature (33) vient simultanément en butée sur la totalité des trois bras (131, 132, 133) de la culasse (31), se compose
- du premier flux magnétique ( $\Phi_1$ ) qui traverse la totalité de l'aimant permanent (32), le deuxième bras (312) de la culasse (31), l'armature (33) et traverse le premier bras (311) de la culasse (31) vers l'aimant permanent (32);
  - du deuxième flux magnétique ( $\Phi_2$ ) qui traverse la totalité de l'aimant permanent (32), le deuxième bras (312) de la culasse (31), l'armature (33) et traverse le troisième bras (313) de la culasse (31) en revenant vers l'aimant permanent (32); et
  - du troisième flux magnétique ( $\Phi_3$ ) qui traverse la totalité de l'aimant permanent (32), le deuxième bras (312) de la culasse (31) et traverse le troisième bras (313) de la culasse (31) en revenant vers l'aimant permanent (32), où, lors de l'excitation de la bobine ( $L_R$ ) au
- moyen d'une tension appliquée aux connecteurs (30', 30'') de la bobine, un champ magnétique supplémentaire est généré dans ladite bobine, avec un flux magnétique ( $\Phi_4$ ) qui agit dans la direction opposée à celle dudit premier flux magnétique ( $\Phi_1$ ), flux magnétique supplémentaire par lequel au moins le flux magnétique ( $\Phi_1$ ) de l'aimant permanent (32), dans le premier bras (131), est ensuite réduit, c'est-à-dire au moins essentiellement neutralisé.
11. Interrupteur selon l'une quelconque des revendications 7 à 10, **caractérisé en ce que** l'aimant permanent (32) est conçu de manière telle, que lors de son insertion dans la zone dudit deuxième bras (132) de la culasse (31), dans le cas où la bobine ( $L_R$ ) n'est pas excitée, le couple produit par une force magnétique due au moins au premier flux magnétique ( $\Phi_1$ ) dans la zone du premier bras (131) de la culasse (31), par rapport au point pivot (333) de l'armature (33) qui vient simultanément en butée sur la totalité des trois bras (131, 132, 133), soit supérieur au couple produit par la force du ressort (34) agissant sur l'armature (33), tandis qu'au contraire, quand la bobine ( $L_R$ ) est excitée au moyen d'une tension produite par le circuit électronique passif (2) et que le flux magnétique supplémentaire ( $\Phi_4$ ) est généré et qu'il agit en s'opposant au moins au premier flux magnétique ( $\Phi_1$ ) de l'aimant permanent (32), dans le premier bras (311), le couple produit par des forces magnétiques soit réduit, passant au-dessous de la valeur du couple produit par la force du ressort (34) agissant sur l'armature (33).
12. Interrupteur selon l'une quelconque des revendications 7 à 11, **caractérisé en ce que** l'enroulement primaire (N1) du transformateur différentiel (1) comprend une seule spire.
13. Interrupteur selon l'une quelconque des revendications 7 à 12, **caractérisé en ce que** le rapport entre le premier flux magnétique ( $\Phi_1$ ) et le troisième flux magnétique ( $\Phi_3$ ) est déterminé à l'avance en définissant la forme et les dimensions de l'évidement (3121) et/ou de chaque aimant permanent (32) qui peut être inséré dans ledit évidement.

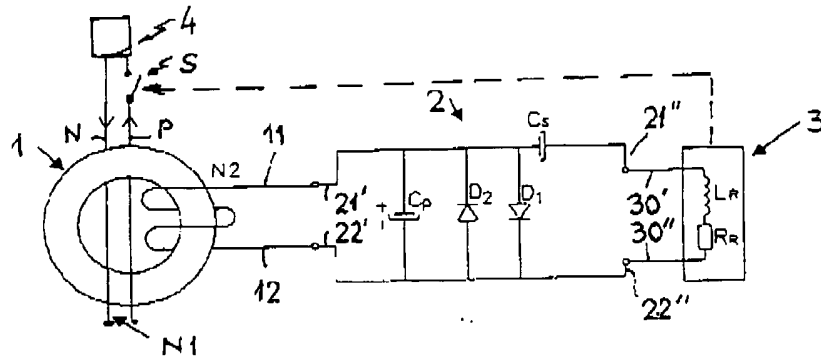


Fig. 1

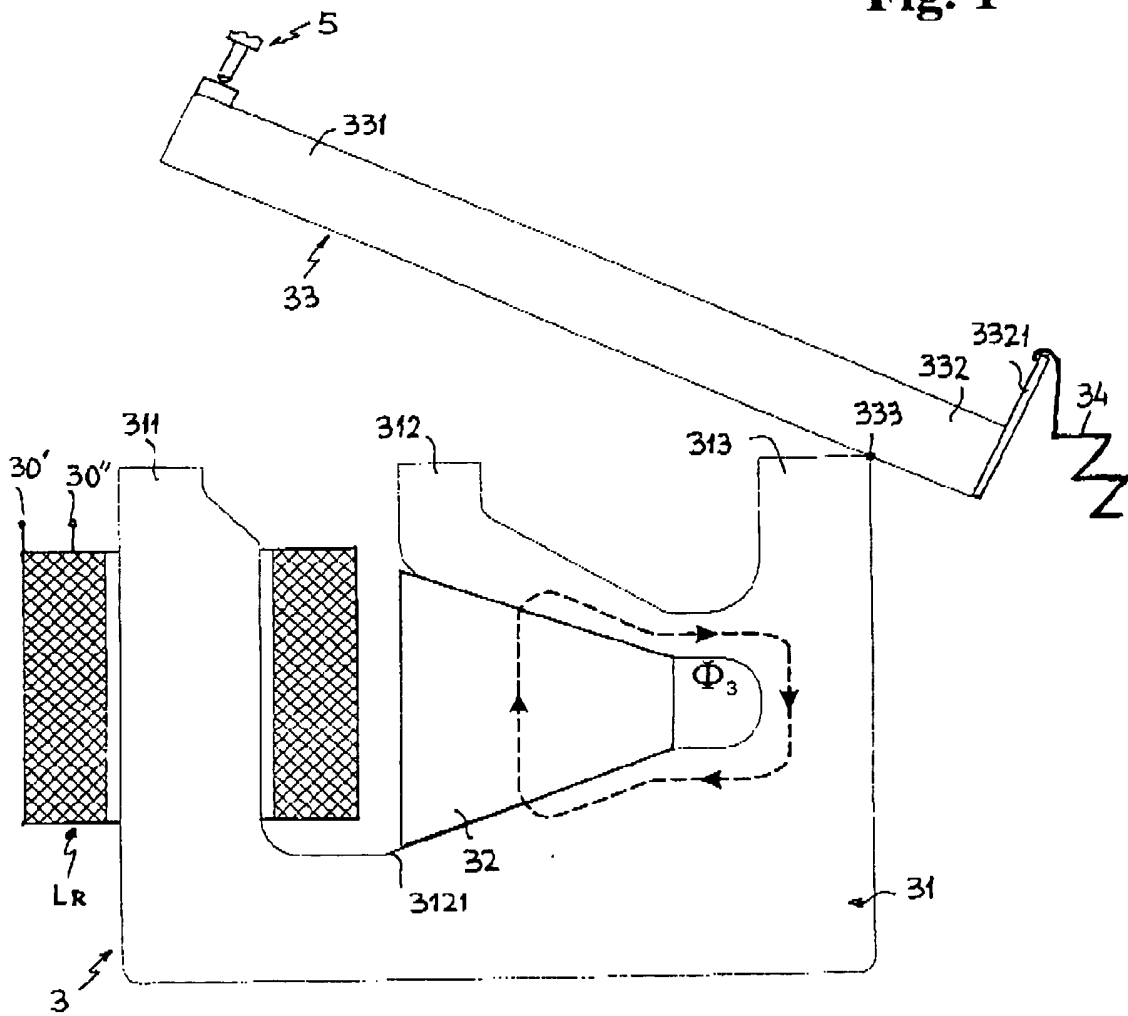


Fig. 2

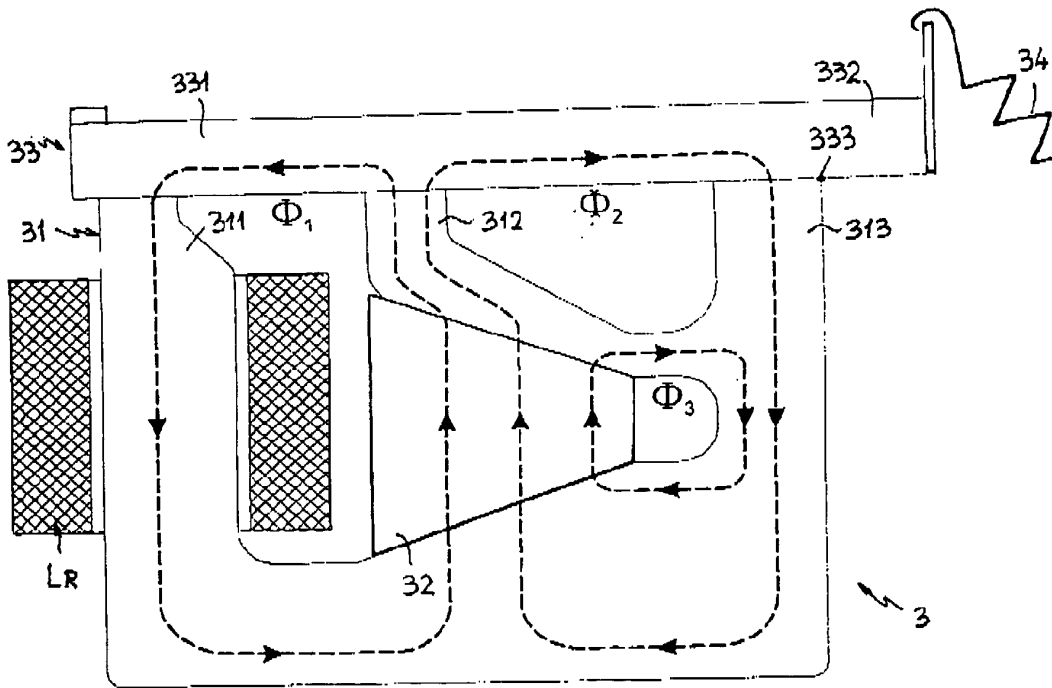


Fig. 3

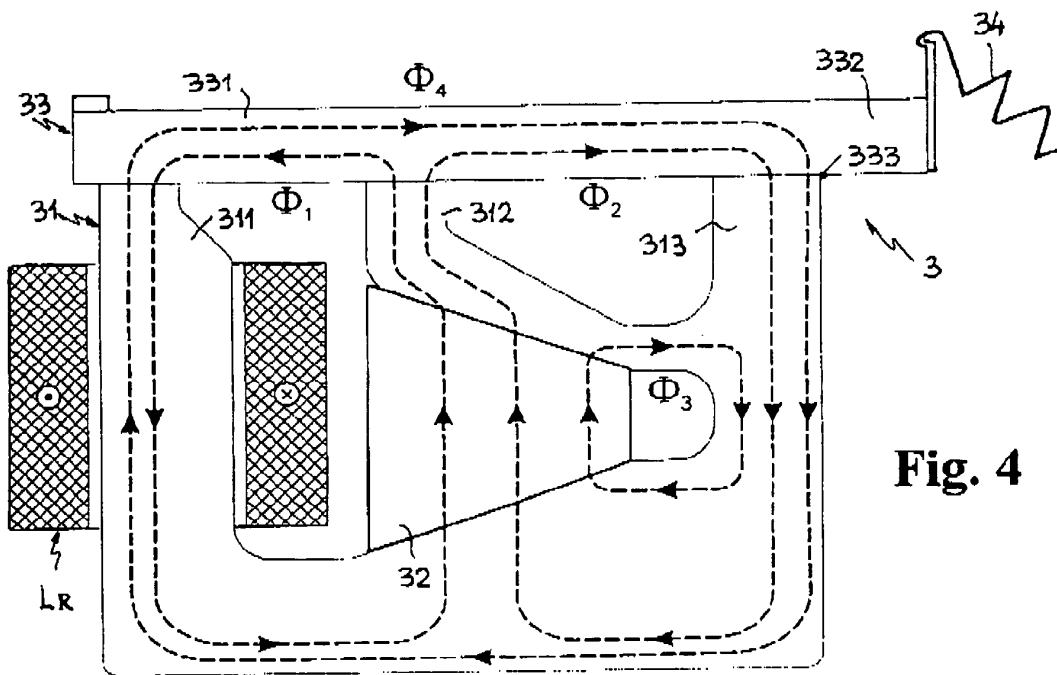


Fig. 4

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- EP 0508052 B1 [0004]