

- 1 -

Tripping device for an overcurrent release

The invention relates to a tripping device for an overcurrent release, such as a circuit breaker, comprising a tripping armature which operates a latching mechanism and can be operated by a coil through which a current to be monitored flows.

Overcurrent releases essentially use, on the one hand, fuse links - which can be used only for a single release process - and, on the other hand, automatic protection devices which can be switched on again and can thus be used more than once.

In an electrical system, overload protection of the described type is normally provided in the supply line, before this supply line splits into a multiplicity of circuits connected in parallel with one another. Dedicated protective devices - as a rule consisting of personnel protection (residual current devices or the like) and system protection (circuit breakers, fuse links or the like) are provided in each of these circuits. These circuits, for their part, may if required once again be split into further sub-circuits, which are likewise protected by protective devices.

In such a circuit structure, the protective devices in the supply line, circuit and sub-circuit form a series circuit.

If an unacceptably high current now occurs in a sub-circuit, then it is desirable for only the circuit breaker assigned to this sub-circuit to trip and thus to disconnect its sub-circuit from the mains, but for all the upstream circuit breakers to remain switched on, and thus for all the circuits and sub-circuits without defects to remain connected to the mains. Only if the overcurrent which occurs is so large that it can no longer be disconnected by the circuit breaker in the sub-circuit should the higher-level circuit breaker respond. Such time-delayed switching of the upstream circuit breaker is called "selectivity".

In the case of fuse links, this selectivity is

governed by the heat power which is required to melt the fuse wire and is proportional to the square of the current level and the time period for which the over-current acts.

As a rule, two tripping devices are provided in the field of circuit breakers. A first device is provided to disconnect overcurrents which are only slightly greater than the system rated current and act over relatively long time periods.

The second, so-called short-circuit current release is normally provided by a coil through which the current to be monitored flows and which has a moving armature that causes the disconnection. Thermal bimetallic strips through which the current to be monitored flows are used to model the delay, which has been explained in the context of fuse links and is dependent on the heat power and thus the current level and time. These bimetallic strips deform in an analogous manner to fuse wires, in proportion to the square of the current level and time, and enable the switching operation of the short-circuit current release, with a time delay, by means of this deformation.

These bimetallic strips are components which, on the one hand, must be mechanically adjusted exactly and, on the other hand, require additional electrical connections. Thus, in summary, they result in the circuit breaker design being made considerably more complex, and thus result in the functional reliability being reduced and in more complicated manufacture.

The object of the invention is to specify a tripping device of the type mentioned initially which has a selective tripping behaviour, but for this purpose has only a small number of insensitive components which are simple to install, in addition to the conventional tripping coil.

Further objects of the invention are to specify means that are as simple as possible for producing the said holding force, possibilities for adjusting the selectivity and design examples of the release device

according to the invention which can be implemented in practice and are functionally reliable. This is achieved by the measures quoted in the subclaims.

In the case of a tripping device for an over-current release, such as a circuit breaker, comprising a tripping armature which operates a latching mechanism and can be operated by a coil through which a current to be monitored flows, this object is achieved according to the invention in that the tripping armature can be operated indirectly by a magnet armature which can be moved directly by the coil and is connected to the tripping armature by means of at least one elastic coupling element and, possibly, one or more auxiliary armatures, and in that the tripping armature is held in its rest position by a holding force which can be preset.

The switching operation can thus be delayed in time by electromechanical measures or arrangements, this being considerably more functionally reliable than electrothermal-mechanical solutions.

According to a first variant of the invention, it is possible for the holding force to be a force produced by mechanical means, which leads to the tripping device according to the invention having a robust and compact structure.

In this context, it is possible for the holding force to be a static friction force which can be produced by components which are in contact with the tripping armature.

Varying the contact pressure exerted by the components on the tripping armature allows the holding force to be adjusted particularly easily.

According to another embodiment of the invention, it is possible for the holding force to be produced by sprung components which act on the tripping armature, such as a snap-action spring.

This allows relatively large holding forces and thus long time delays to be achieved in a simple manner.

According to a preferred embodiment of the invention, it is possible for the holding force to be a

magnetic force which is produced by at least one permanent magnet or electromagnet which acts on the tripping armature.

Such systems have magnetic characteristics which can be predicted relatively accurately and are constant with respect to environmental influences, so that tripping devices provided with them exhibit virtually constant time delays throughout their life.

It may be advantageous for the holding force which acts on the tripping armature to be variable since, in this way, the time delay of the tripping process is variable and the switching device provided with a tripping device according to the invention can be matched to the protective devices downstream from it.

In this context, it may be particularly advantageous for the holding force to be variable as a function of the level of the current to be monitored.

This allows the tripping device to have an adaptive behaviour; the relative release delay increases automatically depending on the magnitude of the short-circuit current.

In a development of the invention, it is possible for the holding force to be produced by an electromagnet through which a current flows which is directly proportional to the current to be monitored.

This allows the current-dependent holding force variation described above to be achieved in a particularly simple and functionally reliable manner.

A further feature of the invention may be for the at least one elastic coupling element to be formed by a helical spring, since such components occupy a small amount of space, while at the same time having good elasticity, which remains constant.

According to a particularly preferred embodiment of the invention, it is possible for at least parts of the magnet armature to be arranged in the interior of the coil.

The magnet armature can thus be moved in an accurately predictable manner by the magnetic forces of

the current to be monitored.

In a development of the above preferred embodiment, it is also possible for the tripping armature to be arranged in the interior of the coil, the tripping armature being formed from nonmagnetic material.

This results in the tripping device having a relatively compact physical size.

It is furthermore possible for the magnet armature to be designed as a tube closed at one end, and for the tripping armature and the at least one coupling element to be arranged at least partially inside the cavity formed by the magnet armature.

This allows a further reduction in the geometric size of the tripping device according to the invention, which is now dependent essentially only on the size of the coil and, apart from this, there are no other moving components.

In a further refinement of the invention, it is possible for the tripping armature to have an attachment which passes through the magnet armature and preferably runs parallel to the longitudinal axis of the coil, on which attachment the holding force acts.

The components which introduce the holding force can thus be arranged outside the coil, so that they do not in any way impede the freedom of movement of the components arranged in the interior of the coil.

The invention will be explained in more detail in the following text with reference to the attached drawings, in which:

Fig. 1 shows a schematic section illustration of a front elevation of a tripping device according to the invention;

Fig. 2 shows the tripping device according to Fig. 1 with an additional auxiliary armature;

Figs. 3a, b show the tripping device according to Fig. 1 with components for applying the holding force mechanically;

Fig. 4 shows a front elevation, in section, of one

possible specific version of the invention;

Fig. 5 shows a front elevation, in section, of another possible version of the tripping device according to the invention, and

Fig. 6 shows the version according to Fig. 5 supplemented by two possible variants of the electrical circuitry of the tripping device.

The tripping device illustrated in Fig. 1 for an overcurrent release, such as a circuit breaker, has a magnet armature 5 composed of a magnetic material such as iron, which magnet armature 5 can be moved directly by a coil 3. The current flowing through the coil 3 is actually the current to be monitored and possibly to be disconnected. Furthermore, a tripping armature 1 is provided which can operate a latching mechanism 20, which latching mechanism 20 opens the contacts 21 through which the current to be monitored flows. This operation may take place, as illustrated in the drawing, via a tripping pin 2 which is integrally formed on the tripping armature 1 but, as an alternative to this, it can also be carried out directly by the tripping armature 1 itself.

The tripping armature 1 and the magnet armature 5 are mechanically connected to one another by means of an elastic coupling element 4, which in the simplest case is formed by a helical spring. The tripping armature 1 is mounted such that it cannot move freely, but is held in its rest position by a holding force F_H which can be preset. In order to allow the tripping armature 1 to be moved back to its rest position again after tripping, a resetting spring 6 is provided which is supported on the one hand on the tripping armature 1 and on the other hand on the housing part 7, which is illustrated only symbolically.

This arrangement allows time-delayed tripping to be achieved if an unacceptably high overcurrent, which must thus be disconnected, occurs.

The said tripping can be split into two tripping phases, which are described below. In a first tripping phase, which immediately follows the overcurrent occur-

ring, the overcurrent produces, via the coil 3, a magnetic field which is proportional to the level of the said overcurrent and moves the magnet armature 5 in the direction of the tripping armature 1. This movement is transmitted via the elastic coupling element 4 to the tripping armature 1 which, however, temporarily - governed by the holding force F_H acting upon it - still remains in its rest position. As the deflection of the magnet armature 5 continues, the coupling element 4 is prestressed more and more, as a result of which the force acting on the tripping armature 1 increases. In this tripping phase, the magnet armature 5 and the coupling element 4 represent an oscillating system which is excited by the magnet force produced by the overcurrent. The time which the magnet armature 5 requires to prestress the coupling element until the holding force F_H is exceeded and the tripping armature 1 can be deflected from its rest position results in the time delay, the selectivity of the tripping device according to the invention.

The second tripping phase occurs when the force produced by the overcurrent exceeds the holding force F_H . In this case, the tripping armature 1 moves suddenly, as a result of which the latching mechanism 20 operates and, as the process continues, the contacts 21 of the overcurrent protective device are opened. In this tripping phase, the masses of the magnet armature 5 and the tripping armature 1, which are now coupled, represent an oscillating system, in conjunction with the resetting spring 6. This operates like a conventional magnetic release formed only from a coil and armature, the excitation force being produced from the resultant of the current force - holding force F_H force system.

Thus, in summary, tripping is not initiated by an armature which is operated directly by the overcurrent, but takes place indirectly as a result of the movement of the magnet armature 5, which can be moved directly by the coil 3 and is connected to the tripping armature 1 by means of the elastic coupling element 4.

The tripping time delay is essentially produced in the first tripping phase and is governed by the mechanical characteristics of the oscillating system - the magnet-armature mass, the spring characteristic of the coupling element 4 and the magnet-armature travel - and by the current force. As is known, the current force is proportional to the square of the current, as, in consequence, is the movement of the magnet armature 5 as well. The delay is thus also proportional to the square of the current, precisely in the same way as in the known, electrothermally operating delay devices mentioned initially.

Although this would make the design of the tripping device according to the invention more complex, it is also possible, as is illustrated in Fig. 2, to arrange an - possibly also more than one - auxiliary armature 11 between the magnet armature 5 and the tripping armature 1. These auxiliary armatures 11 are mechanically connected to one another via further elastic coupling elements 40, and holding forces F_H act on them in their rest positions, in an analagous manner to the tripping armature 1. Such a mechanical series circuit of a plurality of armatures leads to their holding forces F_H being added, as well as to an increase in the deflection movement which the magnet armature 5 has to carry out, and thus to the delay time being lengthened.

The described holding forces F_H can, in principle, be produced in any manner. Figs. 3a and 3b show examples for producing the holding force by mechanical means. According to Fig. 3a, the holding force F_H is a static friction force which is produced by components 8 which are in contact with the tripping armature 1 and clamp the tripping armature 1 between them.

The alternative according to Fig. 3b provides for the holding force F_H to be produced by sprung components 9 which act on the tripping armature 1, such as a snap-action spring. This snap-action spring 9 is designed as a leaf spring, which is clamped in on both sides and is prestressed against the movement direction of the trip-

ping armature 1. If the force acting on it is large enough, it bends in the opposite direction to that in which it is prestressed, and thus allows the tripping armature 1 to move.

One way of forming the holding force which is contrary to these mechanical solutions is for the holding force F_R to be a magnetic force which is produced by at least one permanent magnet or electromagnet which acts on the tripping armature 1. Examples of this can be seen in Figs. 4, 5 and 6. These drawings illustrate design variants of the invention which can be used in practice.

In this case, the coil 3 is arranged on a nonmagnetic winding former 10, parts of the magnet armature 5 being arranged in the interior of the coil 3. Furthermore, a yoke 23 made of magnetic material is provided, the majority of which runs outside the coil 3 and has an attachment 24 which projects into the coil 3 at the end of the latter that is closer to the latching mechanism 20. The magnetic field produced by a coil current passes via the yoke 23, the magnet armature 5, the operating airgap a and the yoke attachment 24.

This structure corresponds to the conventional, normal design of a magnetic release. The tripping armature 1 is also arranged in the interior of the coil 3, but for this purpose must be formed from nonmagnetic material, such as aluminium or plastic, in order that it is not moved by the magnetic forces produced by the coil 3.

The magnet armature 5 is designed as a tube closed at one end, the tripping armature 1 and the coupling element 4 being arranged within the cavity which is formed by the magnet armature 5.

The tripping armature 1 has a tripping pin 2 which extends out of the coil 3 and can be moved to its rest position by a resetting spring 6, in an analogous manner to the illustration according to Fig. 1.

In order to allow the holding force to act on the tripping armature 1, the latter has an attachment 12 which extends through the magnet armature 5 and prefer-

ably runs parallel to the longitudinal axis of the coil 3. This attachment 12 has sections which are freely accessible and on which forces can thus act.

It is not essential for the attachment 12 to be provided, and it is just as possible for the purposes of the invention for the holding forces F_H to be allowed to act directly on the tripping armature 1. However, to do this, the components required for this purpose would have to be arranged in the interior of the coil 3, and cutouts would possibly have to be provided for them in the magnet armature 5 in order that the freedom of movement of the latter is not impeded.

As already mentioned, the holding force F_H in this exemplary embodiment is produced by magnetic means, specifically by means of a permanent magnet 13. To this end, an armature 26 is fixed on the upper end of the attachment 12. Together with the yoke 25, which, according to Fig. 4, is at the same time used to hold the permanent magnet 13 mechanically, and the permanent magnet 13, the armature 26 forms a magnetic circuit for the magnetic field produced by the permanent magnet 13. The holding forces which are produced in this arrangement between the armature 26 and the yoke 25 hold the tripping armature 1 in the illustrated rest position.

In the said magnetic circuit - formed from the armature 26, the yoke 25 and the permanent magnet 13 - there are airgaps 27 between the armature 26 and the yoke 25, as well as an airgap 28 between the permanent magnet 13 and the armature 26. The holding forces F_H produced can be varied by varying the size of these airgaps 27, 28. The said airgap variation can be achieved, for example, by choosing the height of the permanent magnet 13, by inserts of various thicknesses arranged between the yoke 25 and the armature 27 and composed of nonmagnetic material, by varying the length of the yoke limbs, or by similar measures.

If a short-circuit current occurs, the strength of the magnetic field in the operating airgap a between the magnet armature 5 and the yoke attachment 24 is

increased, and thus the attraction forces which act between the magnet armature 5 and the attachment 24 are increased, as a result of which the magnet armature 5 is moved in the direction of the attachment 24. Since the tripping armature 1 is still stationary, the distance d between the magnet armature 5 and the tripping armature 1 is now reduced, the spring 4 being compressed. As soon as the forces which are transmitted via the spring 4 to the tripping armature 1 exceed the holding force F_H of the permanent magnet 13, the tripping armature 1 is also caused to move and, as a consequence of this, initiates the disconnection via the latching mechanism 20.

Should the total distance d be travelled by the magnet armature 5 without this producing any movement of the tripping armature 1, then the magnet armature 5 strikes against the tripping armature 1 and takes the latter with it during its further downward movement. This action of the two armatures striking against one another leads to a collision process in which kinetic energy is taken from the magnet armature 5, which once again delays the switching operation, and thus contributes to the selective disconnection behaviour of the arrangement.

The magnitudes of the distances a , b , c and d are important for correct operation of the described arrangement. In particular, the distance d between the magnet armature 5 and the tripping armature 1 must be less than the distance a between the magnet armature 5 and the yoke attachment 4, thus ensuring that, at the end of the possible movement distance of the magnet armature 5 - it then strikes the yoke attachment 24 - the tripping armature 1 has operated the latching mechanism 20. In this context, it is necessary for the movement distance of the tripping armature 5 to be sufficiently long to operate the latching mechanism 20. Furthermore, it must not be possible for the armature 26 to strike the winding former 10 during the movement of the tripping armature 1, and thus to stop the tripping armature 1. This is achieved by the distance c being greater than the distance b .

In summary, the following expressions may be quoted for the relationships between the distances a , b , c and d : $a > b$ and $a > d$, as well as $c > b$.

The particularly preferred exemplary embodiment according to Fig. 5 largely corresponds with that in Fig. 4, but in this case the permanent magnet 13 is replaced by an electromagnet - formed from the winding 15 and the yoke 25. As above, an armature 26 is provided which is connected to the attachment 12 and forms a magnetic circuit with the yoke 25. A separate component 14 is provided to hold the electromagnet mechanically. The magnitudes of the distances are governed by what was stated in the course of the description of Fig. 4.

Once again, the holding force F_H can be varied by adjusting the lengths of the airgaps 27, 28. In this case, it is particularly favourable not to provide the airgaps 27, that is to say to allow the armature 26 to rest on the yoke 25, and to design the section 25' of the yoke 25 which runs in the interior of the winding 25 to be displaceable in the longitudinal direction of the winding 15. The holding force F_H can thus be adjusted by mechanical means.

In addition to this capability to vary the holding force F_H mechanically, it can also be varied by varying the current flowing through the winding 15. However, the capability to vary the holding force F_H is not in any way limited to magnetic force production. The components 8 indicated in Fig. 3a can also be arranged displaceably, as a result of which it is possible to vary the contact pressure on the tripping armature 1, and thus the holding force F_H .

It is particularly favourable if the holding force F_H can be varied as a function of the level of the current to be monitored. In the design variant according to Fig. 5, this can be achieved particularly easily in that the current which flows through the winding 15 is directly proportional to the current to be monitored.

In order to keep the circuit complexity as low as possible, the said proportionality is most easily

achieved by the overcurrent itself flowing through the winding 15 of the electromagnet. To this end - as is illustrated in Fig. 6 by solid connecting lines 16, 17 - the coil 3 and the winding 15 are connected in series with one another. However, the coil 3 and the winding 15 could also be connected in parallel for the same purpose - see the dashed connecting lines 18, 19; in this case, series impedances may be connected in the path of the winding 15 in order to adjust the current flowing through the winding 15, and thus to adjust the holding force F_H produced.

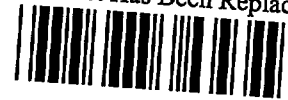
Although this would also result in a relatively large amount of additional complexity, it is just as possible for the purposes of the invention to apply to the winding 15 a current which has no direct-current connection to the current to be monitored, and, if required, also to vary this current via appropriate control circuits in proportion to the overcurrent.

One preferred field of application of the described tripping device according to the invention is for use in circuit breakers, although this is not intended to preclude application in other equipment for disconnecting overcurrents.



- 14 -

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PATENT CLAIMS

1. Tripping device for an overcurrent release, such as a circuit breaker, comprising a tripping armature (1) which operates a latching mechanism (20) and can be operated by a coil (3) through which a current to be monitored flows, **characterized** in that the tripping armature (1) can be operated indirectly by a magnet armature (5) which can be moved directly by the coil (3) and is connected to the tripping armature (1) by means of at least one elastic coupling element (4) and, possibly, one or more auxiliary armatures (11), and in that the tripping armature (1) is held in its rest position by a holding force (F_H) which can be preset.

2. Tripping device according to Claim 1, **characterized** in that the holding force (F_H) is a force produced by mechanical means.

3. Tripping device according to Claim 2, **characterized** in that the holding force (F_H) is a static friction force, which can be produced by components (8) which are in contact with the tripping armature (1).

4. Tripping device according to Claim 2, **characterized** in that the holding force (F_H) can be produced by sprung components (9) which act on the tripping armature (1), such as a snap-action spring.

5. Tripping device according to Claim 1, **characterized** in that the holding force (F_H) is a magnetic force which is produced by at least one permanent magnet or electromagnet (13; 14, 25) which acts on the tripping armature (1).

6. Tripping device according to one of Claims 1 to 5, **characterized** in that the holding force (F_H) which acts on the tripping armature (1) can be varied.

7. Tripping device according to Claim 6, **characterized** in that the holding force (F_H) can be varied as a function of the level of the current to be monitored.

8. Tripping device according to Claim 7,



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- 15 -

characterized in that the holding force (F_H) can be produced by an electromagnet through which a current flows which is directly proportional to the current to be monitored.

9. Tripping device according to one of Claims 1 to 8, characterized in that the at least one elastic coupling element (4) is formed by a helical spring.

10. Tripping device according to one of Claims 1 to 9, characterized in that at least parts of the magnet armature (5) are arranged in the interior of the coil (3).

11. Tripping device according to Claim 10, characterized in that the tripping armature (1) is also arranged in the interior of the coil, the tripping armature (1) being formed from nonmagnetic material.

12. Tripping device according to Claim 11, characterized in that the magnet armature (5) is designed as a tube closed at one end, and in that the tripping armature (1) and the at least one coupling element (4) are at least partially arranged inside the cavity formed by the magnet armature (5).

13. Tripping device according to Claim 10, 11 or 12, characterized in that the tripping armature (1) has an attachment (12) which passes through the magnet armature (5) and preferably runs parallel to the longitudinal axis of the coil (3), on which attachment (12) the holding force (F_H) acts.

14. Use of a tripping device according to one of the preceding claims as a short-circuit current tripping device in a circuit breaker.

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