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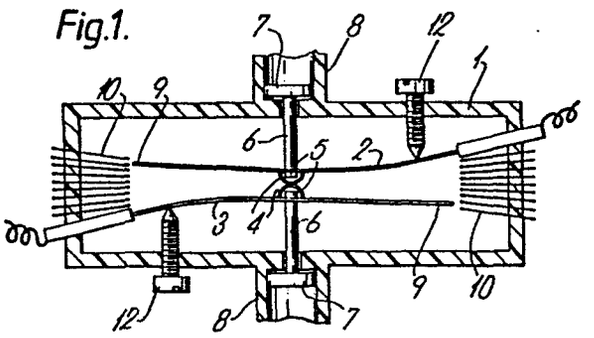
(54) Current limiting switch.

(57) An automatic current limiting device has contacts carried by leaf springs extending from opposite ends of a housing in a magnetic field, and normally biassed into engagement by the resilience of the springs. Each contact is movable away from the other into an open position against the spring bias on the occurrence of a fault current, but is restrained from movement, at least to any significant extent, in the opposite direction, and means are provided for delaying the return of each contact from the open to the engaged position. Any arc that is formed will be propelled rapidly away from the contacts by the magnetic field, conveniently to an arc chute.

Fig.1.



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Current Limiting Switch

This invention relates to automatic current limiting switches.

There is a need in power systems for such switches which open almost instantaneously upon the occurrence of a short circuit, and in so doing have an arc voltage which builds up sufficiently quickly and to such a high level that the prospective short circuit current never flows.

The invention is aimed particularly at alternating current supply systems in the few hundred volt range, i.e. the ultimate distribution voltage, although it can be applied at higher voltages.

In accordance with the invention an automatic current limiting switch comprises a support structure accommodating a pair of cantilever leaf springs, extending inwards in overlapping relationship from opposite ends of the structure, and carrying respective contacts normally biassed towards each other into a closed position by the resilience of the leaf springs, each contact being movable away from the other into an open position against the spring bias, but being restrained by stop means from moving in the opposite direction, at least to any significant extent, means for delaying the return of each contact

from the open to the closed position, and means for producing a steady magnetic field transverse to the contact springs.

In such a switch the passage of a high fault current will cause the springs to move in one or other direction, depending upon the instantaneous direction of current flow, due to the presence of the magnetic field. Accordingly one contact will move rapidly away from the other which will be arrested by the respective stop means, however the first contact will continue to move against the biassing force so drawing an arc initially between the contacts but which will be rapidly propelled away and extended by the magnetic field.

In the closed condition of the switch the contacts may be arranged to engage each other directly and in such a case the said other contact may follow the moving contact for a short distance, for example not more than a millimetre, before being arrested by the stop means. However the contacts may engage each other indirectly by bearing against a common central contact means as will subsequently be described.

Conveniently the free ends of the cantilever leaf springs extend beyond the respective contacts and terminate adjacent associated arc chutes, such that, on opening the contacts, the arc that is formed is propelled very rapidly to the respective arc chute, which can be of the usual form comprising a number of spaced conductive plates mutually insulated from each other, or be of any other suitable construction. Thus refractory splitter plates could alternatively be employed, and in some cases the plates may be coated with a material evolving an arc-suppressing gas on the formation of an arc.

Preferably also the leaf springs carry ferromagnetic elements adjacent the contacts asymmetrically disposed with respect to the permanent

magnetic field, in order to enhance the opening and closing speeds.

The means for delaying the return of the contacts from the open to the closed positions may be effected by dash-pots, or they may be arranged to be held in the open position, for example mechanically by a suitable latch until released.

It is also possible to arrange that the contacts may be opened if required by mechanisms which operate on the pins connected to the dash-pots so that the switch may be opened if required either manually or automatically when the current flowing is below that necessary to open the switch by self-action.

Means for opening the switch contacts automatically, albeit with some delay, in the low over-current region may be provided by a relay or like electromagnetically operated device appropriately linked to the switch contacts.

Means are preferably provided for adjusting the level of current at which the contacts of the switch open, either by varying the preloading of the cantilever leaf springs mechanically, or by varying of the strength of the applied magnetic field. Alternatively or additionally the relative positions of the ferromagnetic elements could be adjusted.

The stop means may be provided by a fixed contact means located between the two cantilever spring contacts and against which the latter are biassed by the resilience of the leaf springs. Such a contact means has the effect of reducing contact vibration under normal current conditions. Although this has the slight disadvantage of increasing contact dissipation it can be designed to provide a shorter high thermal conductivity path for heat to the exterior of the switch.

Such a fixed contact means preferably has extensions projecting in the same general directions

as the free ends of the cantilever leaf springs, so as to act, in effect, as centre fed arcing horns, which can improve the magnetic blowout effect in the switch.

One form of current limiting switch in accordance with the invention and a modification thereof will now be described by way of example with reference to Figures 1 to 3 of the accompanying schematic drawings, in which

Figures 1 and 2 represent a longitudinal section and a transverse section respectively through the first switch, and

Figure 3 represents a longitudinal section through the modified form of switch.

Thus, referring to Figures 1 and 2 of the drawings, the switch illustrated comprises a housing 1 accommodating a pair of contact springs 2, 3, for example of phosphor bronze or other suitably resilient material, each fixed at one end to opposite ends of the housing 1, and carrying engageable contacts 4 of silver cadmium oxide or similar non-welding material. The contacts 4 are of hollow part-cylindrical shape, preferably with a radius of approximately 6mm, and mounted within them are a pair of ferromagnetic elements 5 offset with respect to each other on opposite sides of the longitudinal axis of the switch, as shown in Figure 2.

The contact springs 2, 3 are biassed in such a manner that the two contacts 4 engage each other with a suitable pressure, conveniently of the order of tens to hundreds of grams.

Each contact spring 2, 3 has attached to its outwardly facing surface in the vicinity of the respective contact 4 a stem 6 terminating in the piston 7 of a dash-pot 8. This is arranged so that the respective contact is restrained from moving in the direction of the other by more than about one millimetre, but can move outwards a much greater

distance, for example between 5 and 10 millimetres, the return of the contact to its rest position, in the latter cases, being delayed by the dash-pot 8.

The free ends 9 of the contact spring extend beyond the respective contacts 4 to terminate adjacent respective arc chutes 10.

Pole pieces 11 of a permanent magnet are disposed on opposite sides of the switch as shown in Figure 2.

The device is arranged to operate by the force on the contact springs 2, 3 generated by the interaction of the short circuit current in the springs and the transverse steady magnetic field, e.g. of 3 to 5 kilogauss produced by the permanent magnet.

The instantaneous force per centimetre on the springs in a magnetic field of, say 5 kilogauss is given by

$F \simeq 5 \times 10^3 I$ Dynes, where I is the instantaneous current in Abamperes.

Thus when the instantaneous current is 1 Ampere,

$F \simeq 5 \times 10^3 \times 10^2 \times 10^{-6}$ kilogramme per centimetre,

$= \frac{1}{2}$ kilogramme/cm

In operation the build up of current in a short circuit (which may have a prospective value of tens of kiloamperes in a domestic/commercial 240 volt system) very rapidly opens the contacts 4, the direction of movement depending on the instantaneous polarity of the fault current. The very fast operation of the device compared with known devices is due to the opening force being proportional to the current, and acting from the instant that the current commences to flow. The contacts 4 initially move together until the "following" contact is arrested by its restraint, where upon the contacts separate, an arc is formed and propelled by the magnetic field very rapidly along the extension 9 of one or other of the springs 2, 3, which

acts as an arc runner to the relevant arc chute 10.

After the arc is extinguished the "leading" one of the contacts 4 returns to the closed position at a rate determined by the dash-pot 8. It may of course be held in the open position by a latch (not shown) which may be manually or electrically released.

This switch is intended to be used (but can of course be used in many ways) in the infeed circuit to a distribution unit. On the occasion of a short circuit, two things happen.

1. The build up of s/c current is detected in one out-going circuit.

2. The automatic switch in the infeed circuit opens.

Then, whilst it is still open, the off load switch in the outging circuit which is faulty opens, so that when the automatic switch recloses the system is re-energised but with the one faulty outgoing circuit isolated.

The level of current at which the automatic switch will open can be varied in a number of ways. Thus the preloading on the contact springs may be adjusted mechanically as by the use of loading screws as at 12 to pre-bend the contact springs, or by rotating the mounting points of the springs about the appropriate axes.

Alternatively the degree of asymmetry of the ferromagnetic inserts could be adjusted, or the strength of the applied magnetic field could be varied, for example by adjustment of the position of the pole pieces 11.

Adjustment could take place during use or during manufacture in the design of the switch, depending upon the method employed. Means should, in any case, be provided to prevent the contact springs 2, 3 being bent excessively in either the "forward" or "reverse" direction.

The modified switch illustrated in Figure 3 is similar to that of Figures 1 and 2, except that in the closed position the contacts 4 bear against opposite sides of a central fixed contact 13. The modified switch operates in a somewhat similar manner to the first switch, in that one or other of the contacts 4 moves away from the other on the occurrence of a short circuit current, in dependence upon the instant polarity of the fault current. However instead of the other contact following the moving contact until arrested by its restraining stem, its movement is arrested completely by the fixed contact 13. The latter has extensions as at 14 projecting in the same general direction as the free ends of the contact springs 2, 3 but flaring away from them to form arcing horns which provided an improved blowout effect. The fixed contact 13 may also extend transversely through the sides of the switch housing 1 so as to provide a high thermal conductivity path to the exterior of the switch.

Either of the two switches described may be associated with latches or other suitable means for holding the contacts open after short circuit operation, in which case the dash-pots 7 may be dispensed with. In such a case the contacts may be electrically or mechanically released when it is desired to re-close the switch. A mechanism may also be provided designed to open the switch contacts in a low over-current region if designed, the pins 6 being suitably coupled to the operating mechanism.

CLAIMS

1. An automatic current limiting switch comprising a support structure accommodating a pair of cantilever leaf springs, extending inwards in overlapping relationship from opposite ends of the structure, and carrying respective contacts normally biassed towards each other in a closed position by the resilience of the leaf springs, each contact being movable away from the other into an open position against the spring bias, but being restrained by stop means from moving in the opposite direction, at least to any significant extent, means for delaying the return of each contact from the open to the closed position, and means for producing a steady magnetic field transverse to the contact springs.

2. A switch according to Claim 1 wherein the free ends of the cantilever leaf springs extend beyond the respective contacts and terminate adjacent associated arc chutes, such that, on opening the contacts, the arc that is formed is propelled rapidly to the respective arc chute.

3. A switch according to Claim 1 or 2 wherein the leaf springs carry ferromagnetic elements adjacent the contacts asymmetrically disposed with respect to the permanent magnetic field such as to enhance the opening and closing speeds of the contacts.

4. A switch according to Claims 1, 2 or 3 wherein the means for delaying the return of the contacts from the open to the closed positions comprise dash-pots.

5. A switch according to Claims 1, 2 or 3 wherein the means for delaying the return of the contacts from the open to the closed positions comprise for each contact a releasable latch for holding the contact in the open position.

6. A switch according to any preceding Claim

wherein the stop means comprises a fixed contact means located between the two cantilever spring contacts, and against which the latter are biassed by the resilience of the leaf springs.

7. A switch according to Claim 6 wherein the fixed contact means has extensions projecting in the same general directions as the free ends of the cantilever leaf springs so as to act in effect as centre fed arcing horns.

8. A switch according to any preceding Claim including external means operable to open the contacts either manually or automatically.

9. A switch according to any preceding Claim including means for adjusting the level at which the switch contacts open under short circuit conditions.

10. A switch according to Claim 9 wherein said adjusting means comprises means for mechanically varying the preloading of the cantilever leaf springs or for varying the strength of the applied magnetic field.

~~11. An automatic current limiting switch substantially as shown in and as hereinbefore described with reference to Figures 1 and 2 or Figure 3 of the accompanying drawings.~~

Fig.1.

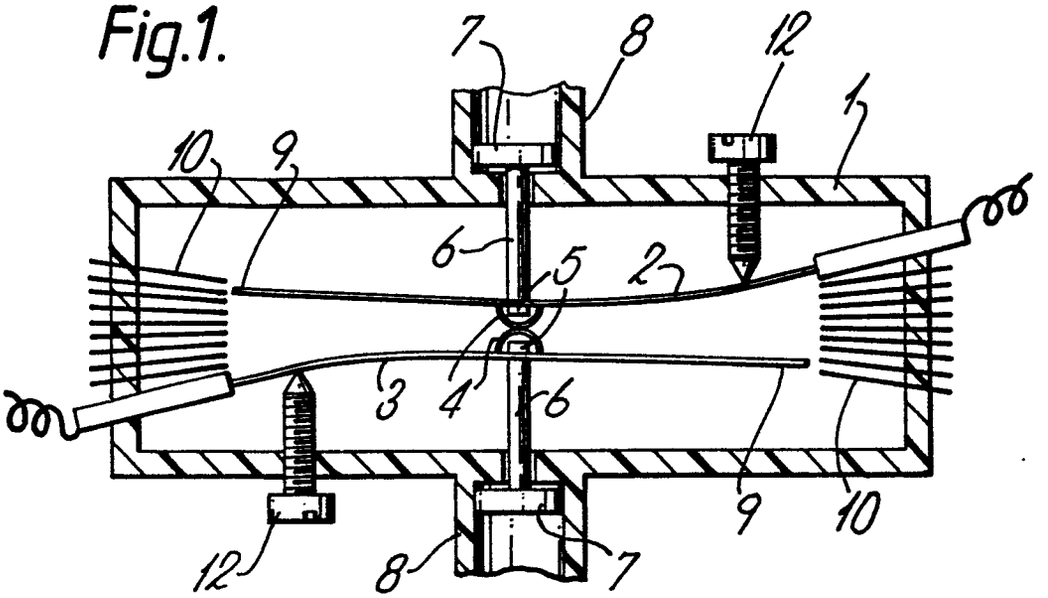

Fig.2.

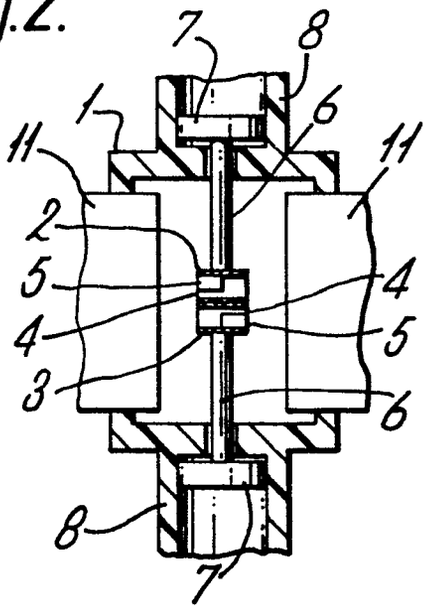

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Fig.3.