PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to Electrical Circuit Current Limiting Devices

We, MECCANO LIMITED, a British Company, of Binns Road, Liverpool, 13, Lancashire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the protection of electrical circuits against accidental current overload, and is more particularly concerned with an electro-magnetically operated current limiting device which is adapted for inclusion in an electrical circuit which is to be protected.

It is an object of the invention to provide an electro-magnetically operated current limiting device of compact and efficient construction which, when included in a circuit to be protected, will automatically allow the current flowing through said circuit to rise only to a predetermined maximum limit, for example upon the incidence of a fault such as a short-circuit.

It is another object of the invention to provide a current limiting device which will automatically re-set itself when the electrical supply to the circuit is interrupted, and, if required, auxiliary means associated with said device may indicate when such a fault exists.

It is a still further object of the invention to provide a current limiting device which is not operable by transients, such as momentary current overloads, or surges.

According to the present invention, an electro-magnetically operated current limiting device includes a substantially U-shaped yoke or core supported on a right-angle bracket and having one limb shorter than the other, a solenoid wound upon one of said limbs and adapted for connection in an electrical circuit to be protected, an electrical resistance or impedance element connected in series with said solenoid, at least one pair of normally closed break contacts carried on resilient blades extending longitudinally of said bracket adjacent the other limb, said contacts being connected across said resistance or impedance element so as normally to short-circuit said element, and an armature secured to the blade nearest the last-mentioned limb for movement towards and accommodation by adjacent free end regions of said core on energisation of said solenoid beyond a predetermined limit, whereby said contacts are opened and remove said short-circuit to make the series connection of said element with said circuit effective to limit the current flowing therethrough.

The resistance or impedance element is preferably also wound on the core or yoke, over the solenoid winding.

In order to make provision for pre-determining the current value at which the device shall operate, resilient means such as a further spring blade may be arranged to bear on the blade carrying the armature and may be pre-set so as to predetermine the value of the magnetic attraction to be exerted by the solenoid and yoke before the armature will move.

The spring blade carrying the aforementioned break contact and the armature, together with the preset resilient means and the armature itself, constitute a mechanical damping arrangement having a natural frequency of oscillation which preferably lies well outside the duration of any current transients which might be expected to arise in the circuit, whereby premature attraction of the armature to the core or yoke is avoided.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1 is a side elevation of the current limiting device constructed in accordance with the invention, and

Fig. 2 is a plan view of the current limiting device shown in Fig. 1.

As shown in the drawings, a core or yoke 1 is assembled from a series of juxtaposed laminated ferrous metal strips of substantially U-shaped configuration, supported on a right angle bracket 2, the solenoid forming an inner winding on one limb 3 of the core 1, and a resistance element forming an outer winding 4 on the same limb. The inner winding con-

[*Price 3s. 0d.*]

Price 25p

stituting the solenoid is connected in series with the circuit to be protected via a lead 5 terminating in a tag 5*a*, forming one external terminal of the device, the conductor forming the said winding being given a cross-sectional area suitable for carrying the maximum current which is to be permitted to flow in said circuit under normal operating conditions. It is preferable that the solenoid should present only a relatively small ohmic resistance, and should offer only a small impedance when the armature is not operated, in the event that the circuit and hence the current limiting device are energised by alternating current.

The outer winding 4 constituting the resistance element may consist of a number of turns of a metallic resistance wire, preferably a nickel-copper alloy such as constantan, and the winding may be referred to as a limiter winding. The limiter winding and the solenoid are connected together at a common tag 6*a*, by means of leads 6 and 7 respectively.

The remaining connection of the limiter winding into the circuit is by way of lead 8 and tag 8*a* forming the other external terminal of the device. The tag 6*a* is connected to or formed integrally with a spring blade 9, and the tag 8*a* is similarly connected at 8*b* to a spring blade 10, and it will be observed from the foregoing description that, whilst the limiter winding 4 is connected in series with the solenoid, it is normally short-circuited by a pair of break contacts 11*a*, 11*b*, carried on the free ends of the resilient blades 9 and 10.

Adjacent the free end thereof, the upper blade 9 carries an armature 12, and hence, should the armature be attracted towards limbs of the yoke to contact said yoke, the contacts 11*a*, 11*b* will open to remove the short circuit across the limiter winding.

The blades 9 and 10 carrying the break contacts are mounted at one end of the bracket 1 in a common spring assembly block 13, and in this assembly block there is also supported a flat spring blade 14, for example of phosphor-bronze, having a V-shaped indentation 15 adjacent its free extremity. This V-shaped indentation 15 is arranged to bear on the blade 9 carrying the armature and performs two functions. Firstly by exerting a mechanical force in a direction opposite to that of the magnetic force exerted by the yoke and solenoid when the latter is energised, the phosphor-bronze spring 14 serves as the controlling element which may be pre-set to determine the amount of current required to flow through the solenoid in order that the armature may be attracted thereto. It will likewise help to restore the break contacts 11*a*, 11*b* to their normal closed position when current ceases to flow in the solenoid. Thus the phosphor-bronze spring 14 in combination with the resilient contact blade 9 carrying the armature 12 and the armature itself constitute a mechanical couple having a definite moment, and provide a mechanical damping arrangement, the natural frequency of oscillation of which lies well outside the duration of any current transients which might otherwise tend to cause the armature to rise prematurely. The device is therefore prevented from operating on momentary current surges such as might arise where the device is used to protect a circuit containing an electric motor, or where the circuit is completed through a main control switch having sliding or rolling contacts.

In operation, the current flowing in the circuit which is being protected by the current limiting device passes through the solenoid, and should such current rise to a value which, as mentioned above, is predetermined by the setting of the phosphor-bronze spring 14, the armature 12 is attracted to the free end regions 1*a* and 1*b* of the yoke 1, thus causing the break contacts 11*a*, 11*b* to open. It will be observed that the end regions 1*a* and 1*b* of the yoke 1 are those regions which are immediately adjacent the armature, and against which the armature abuts when in its operated position. Since the movement of the armature into its operated position takes place along an arcuate path, it is displaced from its normally substantially upright disposition, and to accommodate this displacement the end regions 1*a* and 1*b* of the yoke are shaped so as squarely to receive the armature i.e. they are inclined relative to the normally horizontal and perpendicular faces which they respectively receive of said armature. The travel of the spring blades 9 and 10 carrying the contacts 11*a* and 11*b* is so adjusted that the latter remain closed until the armature has moved an appreciable distance towards the yoke faces, the blade 10 for this purpose being biased to exhibit the normal follow through motion when the contacts 11*a*, 11*b* are opened.

Thus, when finally the contacts 11*a*, 11*b* do open, the magnetic reluctance of the air gaps between the armature and the adjacent free end regions 1*a*, 1*b* of the limbs is considerably reduced. When the break contacts separate, the limiter winding 4 is introduced into the circuit and, being of comparatively high ohmic resistance, considerably reduces the current which is allowed to flow in said circuit. The armature 12, however, remains in the attracted position since, with the closure of the air gaps, the magnetic reluctance is so reduced that only a relatively small current is now required to keep the armature "held." It is preferable that both the solenoid and the limiter winding are connected so that their individual magneto-motive forces are additive. Clearly, breaking the electric circuit at any point, will ultimately restore the current limiting device to its normal position.

The arrangement described is clearly capable of variation to meet differing requirements in differing circuits. For instance, the

limiter winding 4 may take the form of a substantially sure inductance not having appreciable electrical resistance, and the reactance of which will vary considerably according to whether the air gaps are closed by the armature, or are open as is the case when the current limiting device is in the normal operating position. Thus, when used in an alternating current circuit of known frequency, the reactance of the limiter winding when the device is in the normal position with the air gaps open, may be designed to be only a fraction of an ohm, but when in the closed position the reactance will rise to many times this value. Again, the solenoid and limiter winding need not be wound concentrically, but may be disposed one on each of two limbs of a U-shaped yoke, or the limiter winding may even comprise a separate element. Similarly, the lower limb of the U-shaped yoke may be fitted with a copper slug to give a delayed restoring action.

To indicate when the current limiting device has operated, a lamp, bell or other appropriate audible or visual alarm of high electrical resistance or impedance relative to the limiter winding may be connected to tags 6*a* and 8*a*, in parallel with said limiter winding.

The current limiting device provided by the invention is particularly suitable for use in power packs designed to provide an output which is variable within predetermined limits.

What we claim is:—

1. An electro-magnetically operated current limiting device including a substantially U-shaped yoke or core supported on a right-angle bracket and having one limb shorter than the other, a solenoid wound upon one of said limbs and adapted for connection in an electrical circuit to be protected, an electrical resistance or impedance element connected in series with said solenoid, at least one pair of normally closed break contacts carried on resilient blades extending longitudinally of said bracket adjacent the other limb, said contacts being connected across said resistance or impedance element so as normally to short-circuit said element, and an armature secured to the blade nearest the last-mentioned limb for movement towards and accommodation by adjacent free end regions of said core on energisation of said solenoid beyond a predetermined limit, whereby said contacts are opened and remove said short-circuit to make the series connection of said element with said circuit effective to limit the current flowing therethrough.

2. A current limiting device as claimed in claim 1, in which the resistance or impedance element is a wire wound coaxially with the solenoid.

3. A current limiting device as claimed in claim 1 or 2 in which the resistance or impedance element is a wire wound upon the same limb as and on top of the solenoid.

4. A current limiting device as claimed in any of claims 1 to 3 in which the break contacts are secured at one end of the resilient blades and the armature is disposed substantially opposite the end faces of the yoke or core limbs on the blade adjacent thereto, and wherein resilient means are arranged to bear on said latter blade and are pre-set in order to pre-determine the force to be overcome by the attractive effort of the solenoid in moving said armature.

5. A current limiting device as claimed in claim 4, in which said resilient means is a further spring blade of phosphor-bronze or the like readily tensioned material, and has a substantially U-shaped indentation bearing on the armature-carrying blade.

6. A current limiting device as claimed in any of claims 1 to 5 in which the travel of the contact-carrying blades is so adjusted that the contacts thereon remain closed until the armature has moved an appreciable distance towards the yoke or core.

7. A current limiting device as claimed in claim 5 in which the contact-carrying blades and the phosphor-bronze or the like blade are all mounted, at the end of the bracket remote from the end faces of the core or yoke, in a common spring assembly block, and the armature, together with the blade on which it is carried and the phosphor-bronze or the like blade form a mechanical damping arrangement having a natural frequency of oscillation lying well outside that of any current transients expected to arise in the circuit.

8. An electro-magnetically operated current limiting device constructed and arranged as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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PROVISIONAL SPECIFICATION

Improvements in or relating to Electrical Circuit Current Limiting Devices

We, MECCANO LIMITED, a British Company, of Binns Road, Liverpool, 13, Lancashire, do hereby declare this invention to be described in the following statement:—

This invention relates to the protection of electrical circuits against accidental current overload, and is more particularly concerned with an electro-magnetically operated current limiting device which is adapted for inclusion in an electrical circuit which is to be pro-

tected.

It is an object of the invention to provide an electro-magnetically operated current limiting device which, when included in a circuit to be protected, will automatically allow the current flowing through said circuit only to rise to a predetermined maximum limit, for example upon the incidence of a fault such as a short-circuit.

It is another object of the invention to provide a current limiting device which will automatically re-set itself when the fault is removed, or when the electrical supply to the circuit is switched off, whereby, if required, auxiliary means associated with said device may indicate when such a fault exists.

It is a still further object of the invention to provide a current limiting device which is not operable by transients, such as momentary current overloads, or surges.

According to the present invention, an electro-magnetically operated current limiting device includes a resiliently arranged armature disposed adjacent a solenoid adapted for connection in an electrical circuit to be protected, an electrical resistance, impedance, or the like element connected in series with said circuit, and at least one pair of break contacts connected across said resistance, impedance or the like element so as normally to short-circuit said element, said contacts being operable by said armature on energisation of said solenoid beyond a predetermined limit, to open and remove said short-circuit, whereby the series connection of said element with said circuit becomes effective to limit the current flowing therethrough.

The solenoid is preferably wound on a magnetisable core or yoke which may be of substantially U-shaped configuration with one limb shorter than the other. The end faces of the limbs of the core or yoke may be shaped, for example by inclining them relative to the longitudinal axes of the limbs themselves, and may be adapted, on energisation of the solenoid beyond the predetermined limit, to receive and contact with the resiliently arranged armature.

In one preferred embodiment of the invention, wherein the core or yoke is assembled from a series of juxtaposed laminated ferrous metal strips of substantially U-shaped configuration, supported on a right-angle bracket, the solenoid forms an inner winding on one limb of the core, and a resistance element forms an outer winding on the same limb. The inner winding constituting the solenoid is connected in series with the circuit to be protected, the conductor forming the said winding being given a cross-sectional area suitable for carrying the maximum current which is to be permitted to flow in said circuit under normal operating conditions. It is preferable that the solenoid should present only a relatively small ohmic resistance, and should offer only a small impedance when the armature is not operated, in the event that the circuit and hence the current limiting device are energised by alternating current.

The outer winding constituting the resistance element may consist of a number of turns of a metallic resistance wire, preferably a nickel-copper alloy such as constantan, and the winding may be referred to as a limiter winding. The limiter winding is connected in series with the solenoid, but is normally short-circuited by a pair of break contacts carried on the bracket, the break contacts normally being closed and each comprising a resilient blade carrying at its free end, a metallic contact. The armature may be carried by one of the break contacts, adjacent the free end thereof, and hence, should the armature be attracted towards the yoke to contact said yoke, said contacts will open to remove the short circuit across the limiter winding.

Resilient blades carrying the break contacts are mounted at one end of the bracket in a common spring assembly block, and in this assembly block there is also supported a flat spring blade, for example of phosphor-bronze, having a V-shaped indentation ad jacent its free extremity. This V-shaped indentation is arranged to bear on that blade carrying the armature and performs two functions. Firstly, by exerting a mechanical force in a direction opposite to that of the magnetic force exerted by the yoke and solenoid when the latter is energised, the phosphor-bronze spring serves as the controlling element by which may be determined the amount of current required to flow through the solenoid in order that the armature may be attracted thereto. It will likewise restore the break contacts to their normal closed position when current ceases to flow in the solenoid. Thus the phosphor-bronze spring in combination with the resilient contact blade carrying the armature and the armature itself constitute a mechanical couple having a definite moment, and thus provide a mechanical damping arrangement, the natural frequency of oscillation of which lies well outside the duration of any current transients which might otherwise tend to cause the armature to rise prematurely. The device is therefore prevented from operating on momentary current surges such as might arise where the device is used to protect a circuit containing an electric motor, or where the circuit is completed through sliding or rolling contacts.

In operation, the current flowing in the circuit which is being protected by the current limiting device passes through the solenoid, and should such current rise to a value which, as mentioned above, is predetermined by the setting of the phosphorbronze spring, the armature is attracted to the yoke, thus causing the break contacts to open. The spring blades carrying these contacts are so adjusted that the

latter remain closed until the armature has moved an appreciable distance towards the yoke faces. Thus, when finally the contacts do open, the magnetic reluctance of the air gaps between the armature and the end faces of the limbs is considerably reduced. When the break contacts separate, the limiter winding is introduced into the circuit and, being of comparatively high ohmic resistance, considerably reduces the current which is allowed to flow in said circuit. The armature, however, remains in the attracted position since, with the closure of the air gaps, the magnetic reluctance is so reduced that only a relatively small current is now required to keep the armature "held." It is preferable that both the solenoid and the limiter winding are connected so that their individual magnetomotive forces are additive. Clearly, breaking the electric circuit at any point, will ultimately restore the current limiting device to its normal position.

The arrangement described is clearly capable of variation to meet differing requirements in differing circuits. For instance, the limiter winding may take the form of an inductance, the reactance of which will vary considerably according to whether the air gaps are closed by the armature, or are open as is the case when the current limiting device is in the normal operating position. Thus, when used in an alternating current circuit of known frequency, the reactance of the limiter winding when the device is in the normal position with the air gaps open, may be designed to be only a fraction of an ohm, but when in the closed position the reactance will rise to many times this value. Again, the solenoid and limiter winding need not be wound concentrically, but may be disposed one on each of two limbs of a U-shaped yoke, or the limiter winding may even comprise a separate element. Similarly, the lower limb of a U-shaped yoke may be fitted with a copper slug to give a delayed restoring action.

To indicate when the current limiting device has operated, a lamp, bell or other appropriate audible or visual alarm may be connected in parallel with the limiter winding.

The current limiting device proposed by the invention is particularly suitable for use in power packs designed to provide an output which is variable within predetermined limits.

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1 SHEET This drawing is a reproduction of the Original on a reduced scale

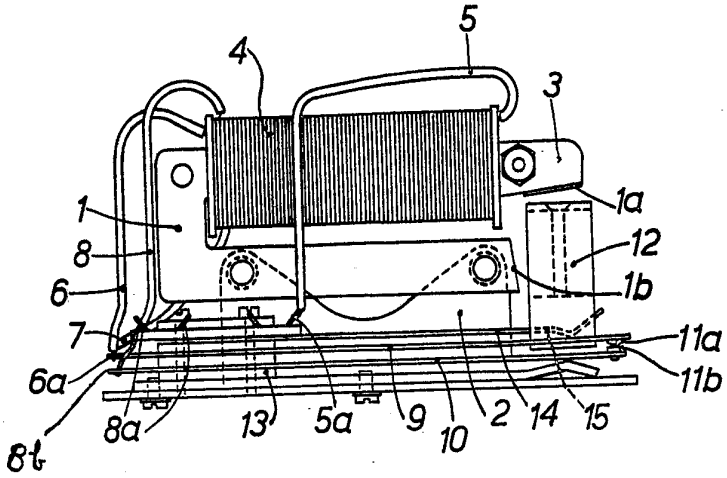

FIG.1.

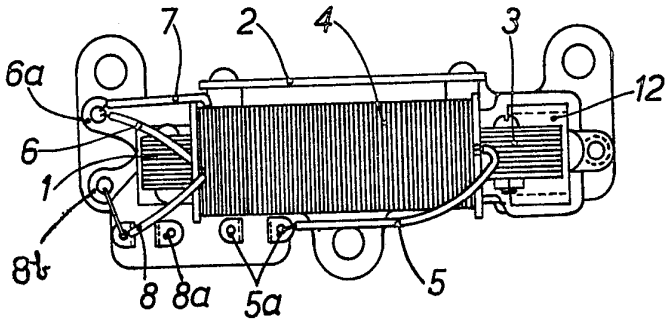

FIG.2.