1214659

PATENT SPECIFICATION (11) 1214659

DRAWINGS ATTACHED

(21) Application No. 9193/68 (22) Filed 26 Feb. 1968
(31) Convention Application No. 16197 (32) Filed 27 Feb. 1967 in
(33) Japan (JA)
(45) Complete Specification published 2 Dec. 1970
(51) International Classification H 01 h 87/00
(52) Index at acceptance
H1N 693 694



(54) A CURRENT LIMITING DEVICE

(71) We, MITSUBISHI DENKI KABUSHIKI KAISHA, a Japanese Company, of No. 12, 2-chome, Marunouchi, Chiyoda-ku, Tokyo, Japan, 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 current limiting devices of the kind having a casing in which is disposed a quantity of current limiting material. This current limiting material is liquid or solid at ordinary temperatures and is vaporised by a large short circuit current so that the current is limited. This type of current limiting device is self-restoring as the material condenses when it cools and is different from a conventional fuse in that the current limiting operation can be carried out repeatedly. However in order to produce such self-restoration type current limiting devices, special current limiting material is required and this material must be at ordinary temperatures, a good electrical conductor i.e. of the same order as general conductive metal while it must be vaporised by the joule heat produced by an electric current which is large. When vapourised the material must show a higher resistance than the short circuit impedance of the circuit and, after the current limiting operation, it must be again liquidized or solidified on cooling or replacement to revert to a good electrical conductor.

The current limiting material is an alkali metal, such as sodium or potassium, or mercury; however, because of the large pressure rise which occurs on vaporisation, the construction of the casing in which the material is disposed must give sufficient strength to safely withstand this pressure.

This kind of current limiting device has the drawback that rate of change of current (di/dt) which occurs during the current limiting operation is great, giving rise to voltage surges.

It is an object of this invention to provide an improved current limiting device of the kind described.

According to this invention there is provided a current limiting device comprising a casing, a conductive vaporizable current limiting material selected from alkali metals and mercury sealed therein and terminals connected to opposite ends of the material for passing a current therethrough, the arrangement being such that when the current exceeds a predetermined value part or all the material is vaporized to increase resistance to current flow thereby to effect current limitation and that the material subsequently condenses to re-establish a comparatively low resistance connection between the terminals, in which device the casing acts as or incorporates a resistance element which is electrically connected in parallel with the material and which has a resistance, during current limitation, such that voltage surges are at least partially suppressed.

Embodiments of this invention will now be described, by way of example only, with reference to the accompanying drawings of which:—

Fig. 1 is a diagram or circuit including a current limiter in accordance with this invention.

Figs. 2 and 3 are side elevations of current limiters in accordance with this invention, and

Fig. 4 is a sectional elevation of another current limiter in accordance with this invention.

In the Figures, the same reference numerals indicate the same or equivalent parts.

Fig. 1 is a diagram of a circuit in which a current limiter and a separate resistance unit are connected in parallel to suppress voltage surges. In detail, an a.c. electric source 1 is connected in series with a current limiter 2 in parallel with a resistance 3, a circuit breaker or isolating switch 4 and a load 5. The provision of the resistance 3 in parallel with the current limiter 2 ensures that the rate of change of current (di/dt) due

[Price 5s. 0d. (25p)]

to the current limiting operation is small, so that voltage surges are prevented.

However not only is the resistance 3 in parallel with the current limiter 2, but is in the form of a casing which contains the current limiting material of the current limiter 2. The casing may be of a resistance material or maybe of a substance impregnated or painted with a special resistance paint; moreover, it is possible to use a substance the surface resistance of which changes at high temperatures.

Fig. 2 and Fig. 3 show two forms of combined current limiter 2 and resistance 3. In these Figures a casing 11 has one bore 12 which is at least near the central axis of the casing 11. The casing 11 is of a resistance material or a substance impregnated or painted with a special resistance paint. Detailed explanations of these materials will be given later. A current limiting material 13 fills in the bore 12; flanges 14 and 15 of the casing 11 seal and support its ends and may be used as connecting terminals to the external circuit. In Fig. 3 a pressure absorber 16 is included to limit the pressure rise due to vaporization of the current limiting material 13.

It is to be noted first that in the embodiment of Fig. 2 because no pressure absorber 16 is provided, the pressure rise due to vaporization of the current limiting material 13 reaches 4600 atm, for mercury and 2000 atm. for potassium for a plasma temperature of 5000°K. The result of this is that the casing 11 having the bore 12 filled with the current limiting material 13 must be constructed of very rigid material to withstand such high pressures. However, in the embodiment of Fig. 3, because the pressure absorber 16 is provided, the pressure rise due to vaporization of the current limiting material 13 is restricted and limited to a range of 100—200 atm., so that the casing 11 need only have a strength capable of withstanding pressures of 100—200 atm. However, whether or not the pressure absorber 16 is provided, as will be obvious, the casing 11 must have a construction capable of withstanding the pressure rise that occurs and which is dependent, inter alia, on the diameter of the bore 12 which is filled with the current limiting material 13.

From the point of view of mechanical strength materials which are usable for the casing 11 are as follows:—

(A) Porcelain Materials
- a. Lucalox (crystalline alumina)
- b. Cojelite ($2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$)
- c. Beryllia (BeO)
- d. Boron nitride (BN)
- e. Zircon ($ZrO_2 \cdot SiO_2$)
- f. Alumina (Al_2O_3)
- g. Steatite ($MgO \cdot SiO_2$)
- h. Quartz, tempered glass (SiO_2) and the like.

(B) Organic Materials
- a. Carbon fibre laminated reinforced plastic.
- b. Glass fibre laminated reinforced plastic.
- c. Metallic wire filament reinforced rubber and plastic.
- d. Polytetrafluoroethylene mixed with filler.
- e. Pyrolitic graphite
- f. Epoxy resin mixed with graphite powder or SiO_2 powder.

The resistance of the casing 11 which carries the current limiting material 13 must be much higher than the resistance of the current limiting material 13 at ordinary temperatures, for instance, approximately the same or higher than the resistance of the current limiting material when vaporized. The casing 11 may be given the required resistance by making it of a material produced by blending suitable components or of a material impregnated or painted with an appropriate resistance substance.

The porcelains listed under "A" are insulating materials, and cojelite, zircon and alumina can be made to possess a suitable resistivity by mixing and melting them with a suitable metal at the time of sintering. "Thermet" is a product manufactured by such a process. A casing 11 made of the poreclain materials listed under "A" other than alumina and the glass fibre laminated reinforced plastic etc. listed under "B" can be made to possess the required resistance by painting resistance painted on its surface. The other organic materials listed under "B" other than glass fibre-laminated reinforced plastic are substances having suitable resistivities and from these substances a substance can be manufactured having a desired resistivity by adding a variable quantity of carbon powder or by incorporating resistance wires such as metallic wire filaments. In particular pyrolitic graphite, which is a crystalline graphite which has been produced by carbonization of high molecular hydrocarbon gas at high temperatures so that its resistivity has a directional character in that in a certain direction its resistivity is considerably higher than that of ordinary graphite and which is also very strong mechanically, is extremely effective when used as the material of the casing 11. It is known that quartz, tempered glass and the like have the characteristic that, at the high temperatures which occur when current limiting takes place, the surface resistance of a portion exposed to such high temperature falls, so that the resistance of the current limiting material 13 may be of the same order as or nearly 10 times as large as the

resistance of the casing 12 during vaporization of the material 13 at the time of current limiting operation.

Further, it is also known that hot pressed moulded products which use mica powder as basic material and glass powder as the bonding material for instance, Micarex, have the characteristic that its surface resistance varies at high temperature. Consequently as shown in the embodiment of Fig. 4, such current limiter having a casing 11 of these materials can also give a satisfactory performance if the casing 11 (indicated at 17) which surrounds the current limiting material 13 is itself surrounded by insulating material 18 having a pressure proof character and a resistance which is substantially infinity.

The current limiters described are of simple and robust construction and have the advantage that voltage surges due to the current limiting operation are suppressed.

WHAT WE CLAIM IS:—

1. A current limiting device comprising a casing, a conductive vaporizable current limiting material selected from alkali metals and mercury sealed therein and terminals connected to opposite ends of the material for passing a current therethrough, the arrangement being such that when the current exceeds a predetermined value part or all the material is vaporized to increase resistance to current flow thereby to effect current limitation and that the material subsequently condenses to re-establish a comparatively low resistance connection between the terminals, in which device the casing acts as or incorporates a resistance element which is electrically connected in parallel with the material and which has a resistance, during current limitation such that voltage surges are at least partially suppressed.

2. A device according to claim 1, wherein the resistance element is provided on the internal surface of the casing.

3. A device according to claim 1, wherein at least a part of the casing is of a resistance material which acts as the resistance element.

4. A device according to claim 1, wherein a resistance material is impregnated into at least a part of the casing so as to provide a resistance element.

5. A device according to claim 2, wherein the resistance element is of a material possessing a comparatively high resistivity at the high temperatures which occur during current limitation, the resistance of the resistance element during current limitation being sufficiently low at least partially to suppress voltage surges.

6. A device according to any preceding claim, wherein said current limiting material is potassium.

7. A current limiting device substantially as hereinbefore described with reference to Fig. 1, Fig. 2 or Fig. 3 of the accompanying drawings.

GEE & CO.,
Chartered Patent Agents,
51—52 Chancery Lane,
London, W.C.2.
and
22 Whitefriargate, Hull.
Agents for the Applicants.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1970.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

resistance of the casing 12 during vaporization of the material 13 at the time of current limiting operation.

Further, it is also known that hot pressed moulded products which use mica powder as basic material and glass powder as the bonding material for instance, Micarex, have the characteristic that its surface resistance varies at high temperature. Consequently as shown in the embodiment of Fig. 4, such current limiter having a casing 11 of these materials can also give a satisfactory performance if the casing 11 (indicated at 17) which surrounds the current limiting material 13 is itself surrounded by insulating material 18 having a pressure proof character and a resistance which is substantially infinity.

The current limiters described are of simple and robust construction and have the advantage that voltage surges due to the current limiting operation are suppressed.

WHAT WE CLAIM IS:—

1. A current limiting device comprising a casing, a conductive vaporizable current limiting material selected from alkali metals and mercury sealed therein and terminals connected to opposite ends of the material for passing a current therethrough, the arrangement being such that when the current exceeds a predetermined value part or all the material is vaporized to increase resistance to current flow thereby to effect current limitation and that the material subsequently condenses to re-establish a comparatively low resistance connection between the terminals, in which device the casing acts as or incorporates a resistance element which is electrically connected in parallel with the material and which has a resistance, during current limitation such that voltage surges are at least partially suppressed.

2. A device according to claim 1, wherein the resistance element is provided on the internal surface of the casing.

3. A device according to claim 1, wherein at least a part of the casing is of a resistance material which acts as the resistance element.

4. A device according to claim 1, wherein a resistance material is impregnated into at least a part of the casing so as to provide a resistance element.

5. A device according to claim 2, wherein the resistance element is of a material possessing a comparatively high resistivity at the high temperatures which occur during current limitation, the resistance of the resistance element during current limitation being sufficiently low at least partially to suppress voltage surges.

6. A device according to any preceding claim, wherein said current limiting material is potassium.

7. A current limiting device substantially as hereinbefore described with reference to Fig. 1, Fig. 2 or Fig. 3 of the accompanying drawings.

GEE & CO.,
Chartered Patent Agents,
51—52 Chancery Lane,
London, W.C.2.
and
22 Whitefriargate, Hull.
Agents for the Applicants.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1970.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

