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(12) # EUROPEAN PATENT APPLICATION

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(54) **Power transformer.**

(57) A power transformer (1) includes a heat sensitive interrupter (6) connected in series with a primary winding (2) and disposed between primary and secondary windings (2,3). The resistances of the primary and secondary windings are chosen so that the primary winding exhibits a temperature rise greater than that of the secondary winding in response to a flow of an overcurrent which exceeds a normal current.

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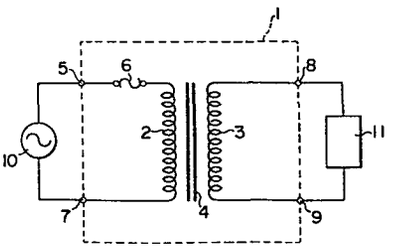

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DESCRIPTION

"POWER TRANSFORMER"

The invention relates to power transformers and, in particular, to power transformers having a heat sensitive interrupter such as a thermal fuse.

Power transformers are known which are provided with a heat sensitive interrupter such as thermal fuse connected in circuit with the primary winding in order to protect the transformer from abnormal heating. In such transformers, the protection is achieved by disconnecting the transformer from an a.c. source through the operation of the interrupter in response to heat produced by the secondary winding upon occurrence of a short-circuit of the secondary winding or its connected load circuit.

However, the known arrangements suffer from the disadvantage that the secondary winding may frequently be burnt out before the interrupter is operated because it takes time for the conduction of heat from the secondary winding to the interrupter to operate the latter. Thus the heat sensitive interrupter in the known arrangements can not always provide a rapid, reliable response to abnormalities occurring on the secondary side.

It is an object of the invention to eliminate or at least to mitigate the above problem of the known arrangements.

In accordance with the present invention, the primary winding is arranged to exhibit a temperature rise which is greater than that of the secondary winding in the event of abnormal heating of the transformer caused by the occurrence of an overcurrent which exceeds a normal operating current. Hence, the heat sensitive interrupter connected in the primary circuit is rapidly blown to interrupt the primary circuit, thus avoiding a burn-out of the transformer.

Where the transformer is provided with a plurality of secondary windings, a rapid blowing of the thermal fuse can be assured by arranging for the primary winding to exhibit a greater heat value than any one of the secondary windings. In this manner, it is assured that the thermal fuse will be rapidly blown in response to an overcurrent flowing in any one of the secondary windings.

The invention is described further hereinafter, by way of example, with reference to the accompanying drawings, in which:-

Fig.1 is a circuit diagram of one embodiment of a power transformer constructed in accordance with the present invention;

Fig.2 is a cross section of the power transformer shown in Fig.1;

Fig.3 is a perspective view of the power transformer of Fig.1; and

Fig.4 is an equivalent circuit diagram of the power transformer shown in Fig.1.

The power transformer of Fig.1 includes primary and secondary windings 2, 3, both disposed on a core 4, a pair of input terminals 5, 7 for connection with an a.c. source 10, a heat sensitive interrupter 6 such as thermal fuse which is connected between the input terminal 5 and the associated end of the primary winding 2, and a pair of output terminals 8,9 connected respectively to the two ends of the secondary winding 3 and across which a load 11 is connected.

When the output voltage of the source 10 is applied across the input terminals 5,7 and thence to the primary winding 2 through the interrupter 6, a voltage is developed across the secondary winding 3 or output terminals 8, 9 by electromagnetic induction and is applied to the load 11.

The resistance values of the primary and secondary windings 2, 3 are chosen such that the primary winding 2

exhibits a greater temperature rise than the secondary winding 3 in response to an over-current which exceeds a normal operating current and which may occur upon short-circuiting the circuit across the output terminals 8, 9 or the load 11.

As shown in Figs. 2 and 3, the core 4 is of an E-I type, and the primary winding 2 is wound directly thereon. The secondary winding 3 is disposed on the primary winding 2, and the heat sensitive interrupter 6 is disposed between the windings 2, 3. As shown in Fig.3, the input and output terminals 5, 7, 8, 9 are disposed on the outside of the secondary winding 3.

Fig.4 illustrates the equivalent circuit of the power transformer 1. As shown, connected in series between the interrupter 6 and the output terminal 8 are the resistance R_1 and the leakage reactance X_1 of the primary winding 2, and the resistance a^2R_2 and the leakage reactance a^2X_2 of the secondary winding 3 as converted into the primary circuit, where "a" represents the turn ratio between the primary and the secondary winding. Connected in shunt across the junction between the reactance X_1 and the resistance a^2R_2 and the input terminal 7 are the resistance R_0 and the reactance X_0 caused by the hysteresis loss and the eddy current loss of the core 4. During normal operation, current I_1 passes through the resistance R_1 of the primary winding 2 and current I_1' through the resistance a^2R_2 of the secondary winding 3. An exciting current I_0 which compensates for the iron loss passes through the parallel circuit of the resistance R_0 and the reactance X_0.

In the event that the secondary circuit is short-circuited, an overcurrent flows through the secondary circuit, and the exciting current I_0 will be negligible as compared therewith. Accordingly, the primary current I_1 will increase in proportion to the secondary current I_1', and will be substantially equal to the latter.

Thereupon, a power loss is developed as the sum of $I_1^2R_1$ and $I_1'^2R_2$ to cause the transformer to be heated. The heat produced causes the interrupter 6 to be blown. In this connection, it will be understood that an arrangement wherein the primary winding exhibits a greater heat value than the secondary winding can be achieved by the following inequality:

$$I_1^2R_1 > I_1'^2a^2R_2 \qquad (1)$$

Incorporating the approximation

$$I_1 \fallingdotseq I_1' \qquad (2)$$

the equation (1) can be rewritten as follows:

$$I_1^2R_1 > I_1^2a^2R_2 \qquad (3)$$

or

$$R_1 > a^2R_2 \qquad (4)$$

Thus the choice of a value for the resistance R_1 of the primary winding 2 which is greater than the converted resistance a^2R_2 of the secondary resistance R_2 permits a greater a^2R_2 of the secondary resistance R_2 permits a greater heat value in the primary to be achieved as compared with the secondary, thus facilitating blowing of the fuse to avoid a burn-out of the secondary winding 3.

It should be understood that the invention is not limited to a core of E-I type or to any particular configuration, but is equally applicable to any one of a variety of core configurations. A conventional fuse or contact opening assembly may be used for the heat sensitive interrupter which has been illustrated as a thermal fuse. Rather than disposing the interrupter between the primary and the secondary winding, it may be located within the primary winding or at any other suitable location.

CLAIMS.

1. A power transformer which includes primary and secondary windings (2,3) and a heat sensitive interrupter (6) connected in series with the primary winding (2) and disposed in or between the windings, characterised in that the resistances (R_1, R_2) of the primary and a secondary winding (2,3) are chosen such that the primary winding (2) exhibits a greater temperature rise than the secondary winding (3) in response to the occurence of an overcurrent which exceeds a normal operating current.

2. A power transformer as claimed in claim 1, in which, representing the resistance of the primary winding (2) and the secondary winding (3) by R_1 and R_2, respectively, and the turns ratio between the primary and the secondary winding (2,3) by a, the resistances (R_1, R_2) are chosen to satisfy the inequality:

$$R_1 > a^2 R_2$$

3. A power transformer as claimed in claim 1 having a plurality of secondary windings, characterised in that the resistances of the primary and secondary windings are chosen such that the primary winding exhibits a greater temperature rise than any one of the secondary windings alone in the event of the occurrence of an overcurrent.

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FIG. 1

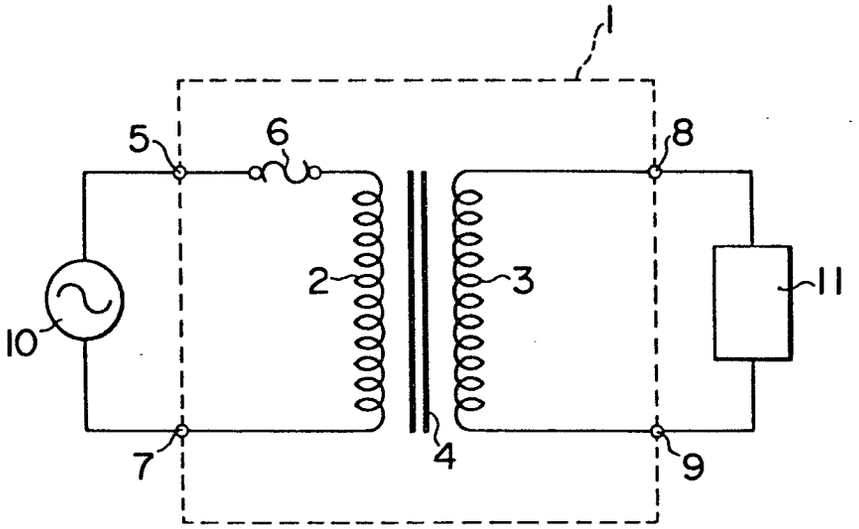

FIG. 2

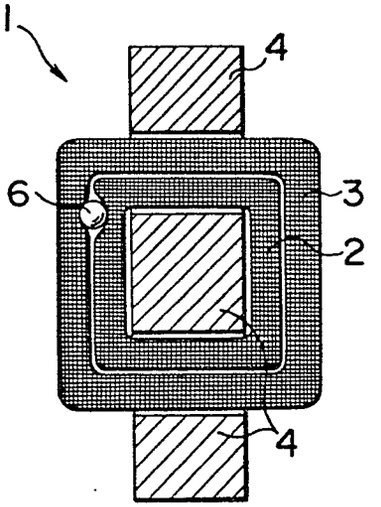

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FIG. 3

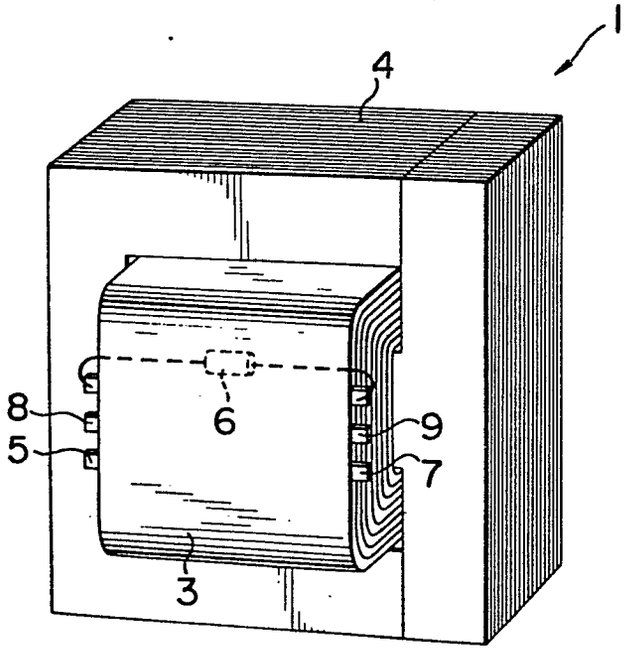
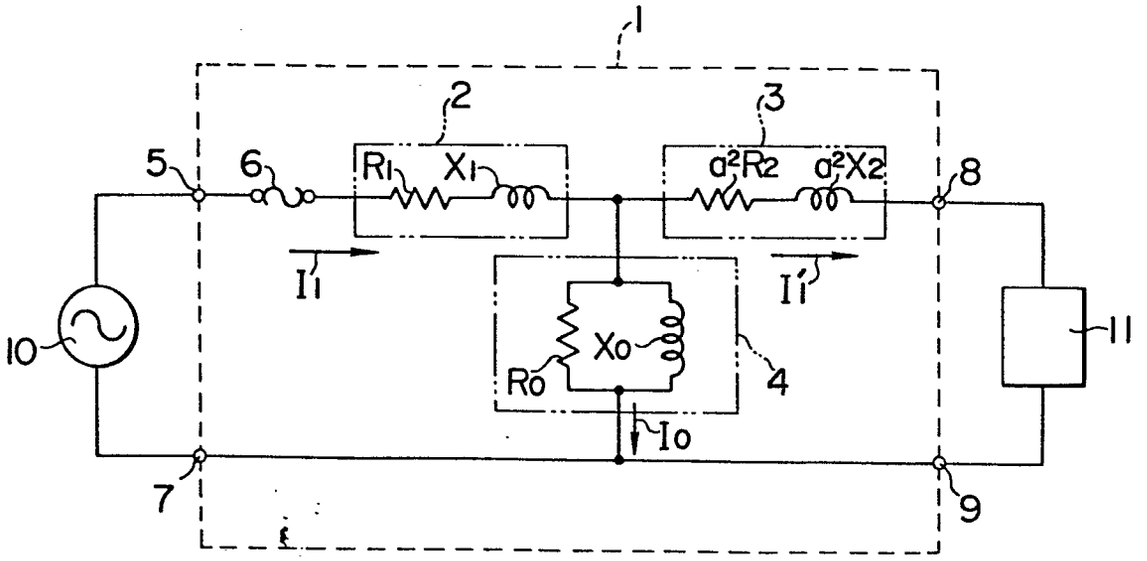


FIG. 4



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EUROPEAN SEARCH REPORT

Application number
EP 80 30 3007

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	US - A - 3 287 599 (ADVANCE TRANSFORMER) * Column 2, lines 1-15 * --	1
	FR - A - 2 066 960 (FRIEDLAND) * Page 2, lines 6-29 * --	1
A	ELECTRONIC ENGINEERING, vol. 49, no. 594, July 1977 Roy HOLE: "Transformer protection using a ptc thermistor", page 25 --	
A	US - A - 3 700 965 (KUNIO TONE)	
A	CH - A - 131 199 (MOSER GLASER)	
A	US - A - 1 972 319 (A. RYPINSKI)	
A	US - A - 3 992 690 (THE GARRETT CORP.) ----	

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

H 01 F 27/40
27/28

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

H 01 F 27/40
27/28
5/00
H 02 H 7/04

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O. non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	27-11-1980	VANHULLE

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