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3,255,383

FUSE CONTAINING MEANS RESPONSIVE TO LARGE FAULT CURRENTS AND
MEANS RESPONSIVE TO SMALL CONTINUOUS OVERLOADS

Filed Jan. 29, 1963

3 Sheets-Sheet 1

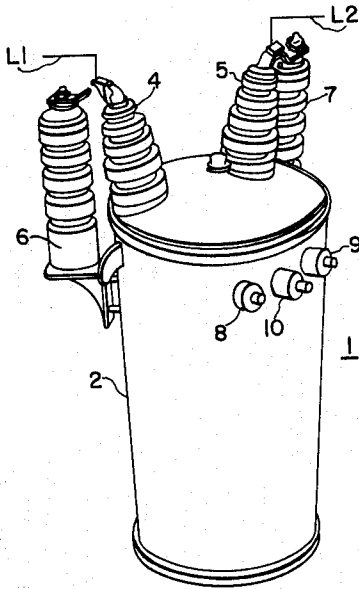


Fig. 1.

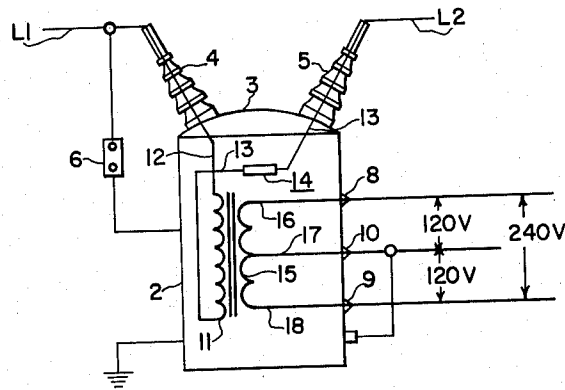


Fig. 2.

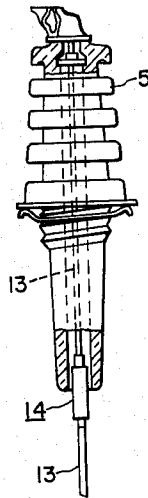


Fig. 3.

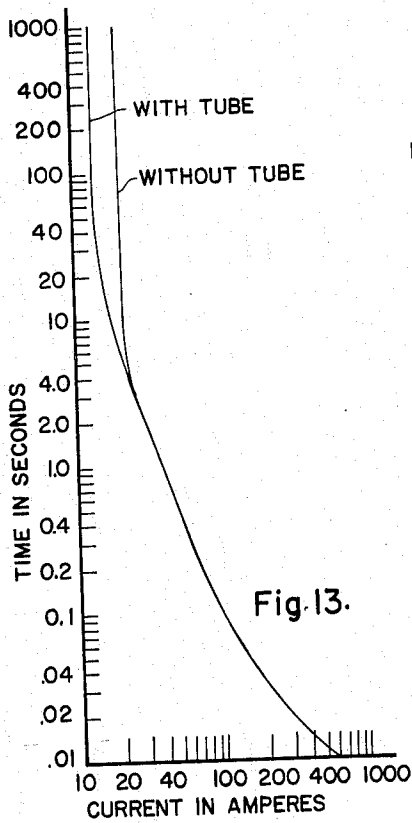


Fig. 13.

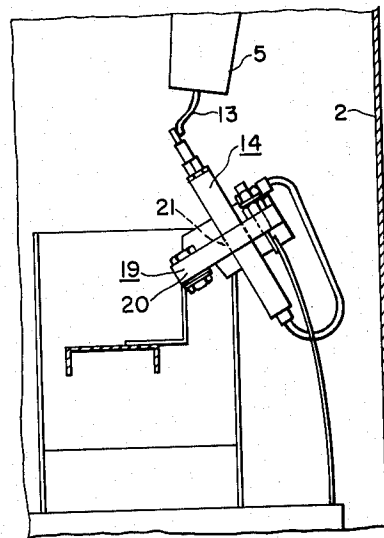


Fig. 4.

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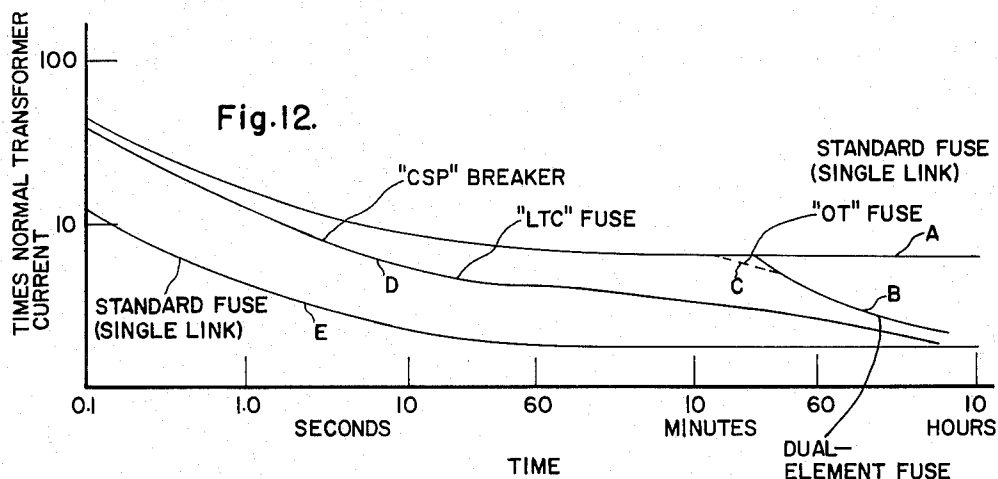
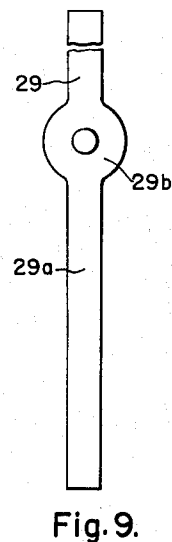
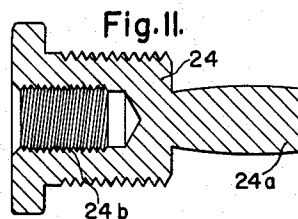
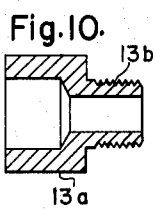
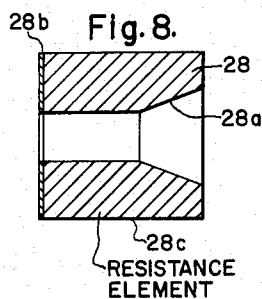
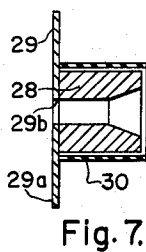
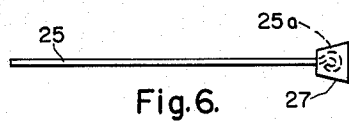
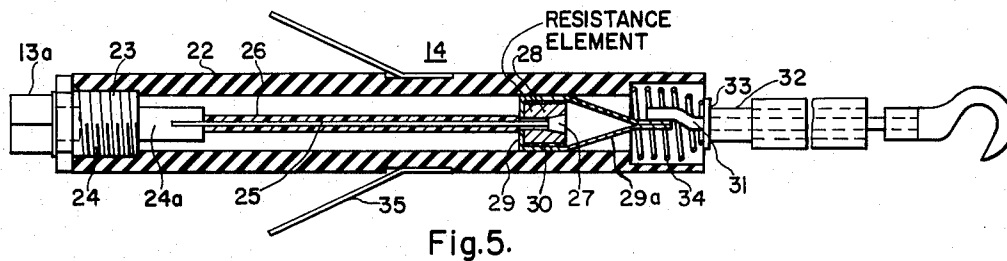
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Filed Jan. 29, 1963

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WITNESSES

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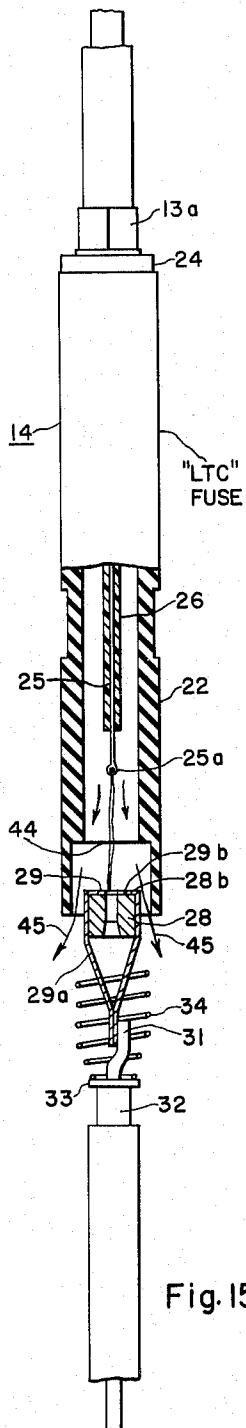


Fig. 15.

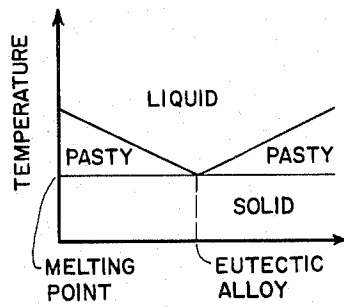


Fig. 14.

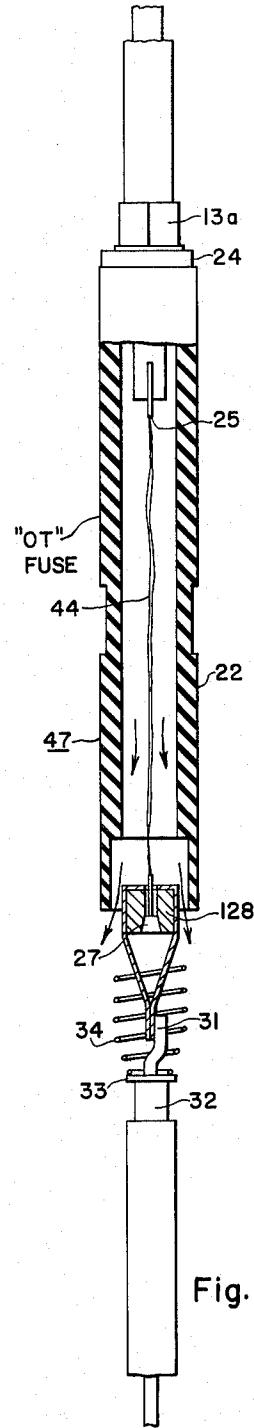


Fig. 16.

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FUSE CONTAINING MEANS RESPONSIVE TO LARGE FAULT CURRENTS AND MEANS RESPONSIVE TO SMALL CONTINUOUS OVERLOADS

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15 Claims. (Cl. 317-15)

This invention relates generally to fuse constructions and, more particularly, to fuse constructions adaptable for providing a wide range of current protection for electrical equipment.

A general object of the present invention is to provide an improved fuse construction, or protective device, for electrical equipment to not only protect against high fault currents, but also to protect against overloads existing for a long period of time.

Still a further object of the present invention is to provide an improved fuse construction particularly suitable for an oil-filled transformer to take the place of transformer constructions of the prior art in which a circuit breaker was provided in series with the low-voltage winding and the load, and a high-voltage fuse was interposed in the high-voltage winding, such as set forth in U.S. Patent 2,066,935, issued January 5, 1937 to John K. Hodnette, and assigned to the assignee of the instant application.

Still a further object of the present invention is the provision of an improved fuse construction which is highly reliable and may be accurately preset to fuse at a predetermined winding temperature condition.

Another object of the invention is to provide an improved fuse construction for an oil-filled transformer which may be accurately preset to fuse at a predetermined oil temperature condition.

One of the problems of properly protecting oil-filled transformers from over-heating is the design of a protector that will accurately measure the winding temperature. This is a difficult problem to solve as the time constant of the transformer may be as long as several hours, and it is difficult to design an inexpensive device with a time constant this long. To some extent, this has been accomplished in prior-art transformers of the completely self-protecting type by immersing a current-carrying bimetal in the transformer oil, such as disclosed in the aforesaid Hodnette patent, so that the bimetal temperature exceeds the oil temperature by the same amount as the winding temperature rise over the oil temperature. The bimetal, of course, controls a circuit breaker to drop the load when the winding temperature exceeds a predetermined level.

The present invention, in part, is particularly concerned with a high-voltage fuse which can replace both the circuit breaker and the high-voltage protective link of a distribution-type transformer of the completely self-protecting type. The novel fuse construction of the present invention is connected in series with the distribution transformer primary winding, so that it provides a means of disconnecting defective transformers from the feeder line. Preferably, the fuse construction is actually located in the oil within the transformer tank.

It is, accordingly, a further object of the present invention to provide an inexpensive and highly-reliable protective device for an oil-filled distribution transformer, which may be readily manufactured, and which will perform all of the functions previously accomplished by the low-voltage circuit breaker and the high-voltage fuse of prior-art transformer constructions.

Although the present invention is illustrated as applied

to the protection of a distribution-type transformer, it is to be clearly understood that certain aspects of the invention are applicable to fuse constructions generally, and the present invention is not solely limited to transformer application.

According to one aspect of the present invention, a protective fuse is provided in which a heat-sensitive alloy is disposed in contiguous relationship with a resistance element, which carries the series current of the fuse and the device to be protected by the fuse and, consequently, evolves a heat proportional to I^2R . Preferably, a biasing spring is utilized to exert tension upon a fuse element which is secured to the heat-responsive alloy so that upon melting of the alloy due to the heat generated, the fuse element will, in effect, break and an expulsive blast action will occur out of the enclosed fuse tube being assisted by the biasing action of the aforesaid spring.

According to another aspect of the present invention, a protective fuse is provided with a heat-sensitive alloy element along with a biasing spring arrangement to break the fuse circuit when excessive transformer oil temperatures occur because of over-loading.

Further objects and advantages will readily become apparent upon reading the following specification taken in conjunction with the drawings, in which:

FIGURE 1 is a side elevational view of a distribution-type oil-filled transformer embodying the present invention;

FIG. 2 is a diagrammatic view illustrating the circuit and winding connections for the distribution transformer of FIG. 1;

FIG. 3 illustrates a high-voltage terminal bushing having supported therein the improved fuse construction of the present invention, and illustrating a possible type of mounting therefor;

FIG. 4 illustrates a modified type of mounting arrangement for the improved fusible device of the present invention, as supported by the transformer core-coil assembly;

FIG. 5 illustrates a longitudinal sectional view taken through the improved fusible device of the present invention, drawn to an enlarged scale, and illustrating the fuse element in its intact unfused condition;

FIG. 6 is a detailed view showing an assembly operation of securing the fusible element to the cast heat-responsive alloy;

FIG. 7 is another detail view showing an assembly operation in connection with the heat-responsive alloy;

FIG. 8 is a detailed view of the resistance element utilized in the present invention;

FIG. 9 is a plan view of the resistor holder prior to the assembly operation of FIG. 7;

FIG. 10 is a vertical sectional view taken through a jack electrode used during the assembly operations;

FIG. 11 is a detailed view of the fuse terminal element;

FIG. 12 is a graph illustrating, in comparative manner, the performance of improved fusible devices of the present invention as compared with a circuit breaker and a dual-element fuse of prior-art construction;

FIG. 13 is a graph illustrating the improved characteristics of the fuse link resulting from an enclosed sleeve construction;

FIG. 14 is a phase diagram of a typical alloy system;

FIG. 15 is a view showing the long-time slight overload release of the fuse of FIG. 5 caused by long time excessive temperature rise of the transformer winding; and,

FIG. 16 illustrates the fusing of a modified type of fuse structure on high fault current interruption.

Referring to the drawings, and more particularly to

FIG. 1 thereof, the reference numeral 1 generally designates an oil-filled distribution transformer comprising a tank 2 containing the core and winding structure (not shown), and having extended into the cover 3 of the tank 2 high-voltage terminal bushings 4, 5. Associated with the high-voltage terminal bushings 4, 5 are lightning arresters 6, 7, which may, for example, be of the valve type, as set forth in United States Patent 2,677,072, issued April 27, 1954 to Eugene J. Deval, and assigned to the assignee of the instant application.

Extending outwardly from the lateral wall of the casing 2 are the low-voltage bushings 8, 9 and the grounding pad 10. As illustrated in the diagrammatic view of FIG. 2, the low-voltage bushings 8, 9 serve to provide suitable low voltages for associated distribution circuits.

With further reference to FIG. 2, it will be observed that the high-voltage winding 11 has high-voltage leads 12, 13 associated therewith, and interposed in the high-voltage lead connection 13 is the fuse construction, or protective device 14, of the present invention. As shown in FIG. 2, the low-voltage winding 15 has secondary leads 16-18 associated therewith and connected to the low-voltage bushings 8-10, as shown.

The improved fusible device, or protector element 14 of the present invention may be, for instance, disposed interiorly of a high-voltage bushing 5, as shown in FIG. 3, or, alternatively, the protector element 14 may be secured in a mounting block 19, as illustrated in FIG. 4 of the drawings. Preferably, the mounting block 19 comprises an insulating support plate 20 having one or more apertures 21 therethrough, within which is fixedly secured the improved fuse construction 14 of the present invention.

Reference is now directed to FIG. 5 of the drawings, which shows, in enlarged fashion, the improved fusible construction 14 of the present invention. As shown, the protector element 14 comprises an outer insulating tube or casing 22 preferably formed of a gas-evolving material, such as fiber, for example, and having the requisite structural strength to provide an expulsive blast action during fuse operation. As shown in FIG. 5, preferably the left-hand end of the fuse tube or casing 22 is internally threaded, as at 23, to threadedly secure into a proper position a fuse terminal element 24 having a relatively flat blade portion 24a, to which is secured, as by brazing, for example, an elongated fusible element 25. A jack electrode 13a secured, as by soldering, to the high-voltage lead 13 may be secured by threads 13b, 24b to the fuse terminal 24.

The fusible element 25 may, for example, be composed of any suitable fusing material, such as that sold under the tradename "Everdur" by the Anaconda Company, which is believed to be a copper-silicon-manganese alloy. Different fusing characteristics for such a fusible element may readily be obtained, as well known by those skilled in the art, by varying the cross-sectional area of the fusible element 25 and, additionally, providing a different alloy.

The fuse wire 25 can be any reasonably good electrical conductor, such as copper, aluminum, silver or an alloy, as mentioned, sold under the tradename "Everdur." One particular fuse rating uses an "Everdur" wire because of the low current rating, 3.5 amps., for example, of this fuse.

The composition of "Everdur" wire is believed to be:

96% copper
1.5% silicon
0.3% manganese

Its electrical conductivity is 7.5% that of copper.

Preferably the fusible element 25 has enclosing the axial length thereof an insulating jacket, or sleeve 26, which performs the desirable function of changing the shape of the fuse load-time curve as shown by FIG. 13. The tube 26 acts as a thermal insulator to retain the

heat generated by the I²R loss of the fuse wire 25. This insulation causes a greater temperature rise at the wire 25 for a given amount of current and, therefore, reduces the "minimum fusing current" as shown in FIG. 13. Also, as the thermal time constant of any device is equal to the thermal capacity divided by the heat dissipation factor, there results an increase of the fuse time constant because of the decrease in heat dissipation. The combination of these two effects reshapes the load-time characteristics of the fuse, as shown in FIG. 13.

The tube 26 used for one rating is .042 I.D. with a .020 wall thickness. It is braided woven glass fiber tubing impregnated with a continuous film of a flexible organic material.

As shown in FIG. 6, the extremity of the fuse element 25 is preferably bent into a closed loop 25a, and has cast thereabout a heat-sensitive casting alloy 27, which may, for example, for one particular application, be a 57% bismuth-43% tin composition having a melting temperature of 138° C. Preferably, the alloy 27 is a eutectic-grade alloy having the characteristics, as well known by those skilled in the art, of passing immediately from the solid phase to the liquid phase, as shown in FIG. 14, thereby providing the desirable characteristic of enabling the fusible element 25 to pull free once the selected melting temperature of the alloy 27 has been reached.

The alloy used to release the fuse element 25 is, preferably, a eutectic alloy, because a eutectic alloy will pass directly from a solid to the liquid phase, whereas non-eutectic alloys pass through a pasty region as they melt, as shown in FIG. 14. In addition, with a non-eutectic alloy, the pull-apart temperature will vary with spring loading, which may be undesirable for certain applications.

As it is generally desirable to use eutectic alloys, the alloy melting point is changed by using different metals to form the alloy. The table below shows some of the possible eutectic alloys and their corresponding melting points.

Eutectic alloy:	Melting point, ° C.
52% bismuth, 32% lead, 16% tin -----	94
55.5% bismuth, 44.5% lead -----	125
57% bismuth, 43% tin -----	138
67.8% tin, 32.2% cadmium -----	177
88% lead, 12% antimony -----	247

Disposed in contiguous relationship, or in any event, in immediate proximity thereto, is a resistance element 28, more clearly illustrated in FIG. 8 of the drawings. As shown, the resistance element 28 is of substantially sleeve-like configuration having a frustoconical enlarged opening 28a, into which is preferably assembled the frustoconicaly-shaped alloy element 27. Additionally, the surface 28b of the resistance element 28 is sprayed with a copper surface coating to make good contact with a resistor holder 29 of conducting material, as more fully illustrated in FIG. 9 of the drawings.

The resistor element 28 is made of an electrographic-grade material supplied by the Stackpole Company of St. Marys, Pennsylvania, under their trade designation G112 and, for a particular example, having a resistivity of .0009 ohm-inch. As well known by those skilled in the art, for increasing or decreasing the resistance value of the resistor element 28, other resistance materials may be selected depending upon the particular application.

As illustrated in FIG. 7, to prevent contact of the legs 29a of the resistor holder 29 from contacting the sides 28c of the resistance element 28, preferably insulating means, assuming the form of a round tube 30, is disposed about the resistance element 28 prior to bending the legs 29a of the resistance holder 29, as more clearly shown in FIG. 5 of the drawings.

The extremities of the legs 29a of the resistance holder 29 are preferably secured, as by brazing, for example, to a flexible lead 31. A crimping sleeve 32 is threaded over the lead 31 and is crimped so as to provide a stop for a

washer 33, serving as a spring seat for a compression biasing spring 34. It is desirable to make the biasing spring 34 of a suitable resilient material, such as stainless steel, for certain applications.

To fixedly secure the fuse tube 22 into the aperture of the mounting block 19, preferably a resilient link clip 35 is provided.

The operation of the improved fusible device 14 will now be described. As mentioned hereinbefore, the fusible device 14 can replace the circuit breaker in the low-voltage winding and the fusible device in the high-voltage winding of prior-art types of distribution transformers, as shown in the aforesaid Hodnette patent. The fusible device 14 of the present invention is connected in series with the distribution transformer primary winding, so that it provides a means for disconnecting defective transformers from the feeder line. Also, the fusible device 14 is actually located in the transformer tank in the oil.

Generally, the fusible element 14 comprises the fuse wire 25, current-heating resistor element 28, an alloy cone 27, all spring biased to an open position. As the current heating resistor 28 is connected in series with the fuse wire 25, its I^2R losses heat the alloy cone temperature above the oil temperature. The melting point of the alloy 27 is selected as the maximum allowable winding temperature. The current path is through fuse element 25, alloy cone 27, resistance block 28 and the resistance holder legs 29a to the terminal lead 31.

When the alloy cone 27 melts, the spring 34 pulls the fuse wire 25 away from the current-heating resistor 28, thereby opening the circuit as shown in FIG. 15. The arc 44, which is established between the surface 29b of the resistor holder 29 and the extremity 25a of the fusible element reacts upon the oil, which is disposed interiorly of the fuse tube 22, and generates considerable pressure. The resulting arc is then extinguished by the expulsion of the oil from the tube as indicated by the arrows 45 in FIG. 15.

On relatively high currents, such as above 500% rating, the fuse wire 25 melts before the alloy cone 27 heats up, and the fuse 14 operates in the manner of a standard expulsion fuse, as shown in FIG. 16.

The resistance of the current-heating resistor element 28 is deliberately selected to achieve the right temperature differential of the cone 27 over oil temperature for all loads.

Curve "D" of FIGURE 12 illustrates that by a proper selection of the fuse wire size and the resistance, a smooth current-time curve can be developed to provide total thermal protection for the distribution transformer, such as provided by the usual CSP secondary circuit breaker as shown in the aforesaid Hodnette patent.

Or, if it is desired to make a fuse with characteristics similar to the dual-element fuse as shown by curve "B" of FIGURE 12, the resistor 28 can be made of a highly-conducting material, such as copper, so that the temperature of the cone 27 corresponds to the oil temperature of the transformer.

Such a modified fuse construction 47 is shown in FIG. 16 of the drawings wherein a copper slug element 128 is substituted for the resistance element 28 of the fuse construction of FIG. 5.

The temperature of the low-resistance element 128 corresponds to the oil temperature of the transformer because of the negligible I^2R loss of the high conductivity element 128. Such a fuse, hereafter called a type "OT" (oil temperature) fuse, would have a fusing characteristic such as shown by curve "C" of FIGURE 12.

The long-time constant fuse (LTC) 14 of the present invention will always limit the coil temperature to about 140° C., for the particular rating specified, for example, or whatever is preselected by design, as the temperature of the fusible element 25 in the fusible device 14 of the present invention is actually equal to the coil temperature, and will limit the coil temperature to the melting point of the fusible section. With the modified fuse construc-

tion 47 of FIG. 16 using the low-resistance thermal sensing element 128, the sensing element 128 is at the oil temperature and controls the long-time fusing as a function of oil temperature.

From the foregoing description, it will be apparent that there are provided improved fusible protector devices particularly suitable for oil-filled transformers, say of the distribution type. It will, however, be apparent to those skilled in the art that certain features of the invention may be applicable to fuse structures generally, regardless of specific transformer application. In other words, for a wide variety of fuse applications, where it is desired to provide a performance curve which is responsive to the temperature of the coil winding such a device would prove to be desirable.

Also, if it is desired to provide protection against excessive oil temperature caused by overloads, by changing the composition of the resistor element 28 to a material of low resistivity such as copper, as by using the low-resistance element 128 of FIG. 16, the load-time fusing characteristic can be shaped to correspond to the curve "C" shown by FIGURE 12. Such a device will provide short-circuit protection for the transformer and system in the high current ranges, and also will provide a measure of overload protection for the transformer.

When using standard fuses with time constants of about 600 seconds as a means of protecting transformers from overloads and short circuits, a compromise either in short-time overload capacity or in long-time thermal protection is necessary. A fuse can be selected with a characteristic such as shown by curve "A" of FIG. 12 so that the overload capacity of the transformer at short times is matched by the fuse characteristic. However, the transformer is not protected against burn-out by slight overloads which last for several hours.

If a fuse is selected with the characteristic as shown by curve "E" of FIG. 12, the transformer is protected from overtemperature for long-time overloads, but as shown by the curve the short-time overload capacity is greatly reduced below that actually built into the transformer. (Difference between Curve "E" and "D" at short-times.)

A standard fuse is always a protection compromise; a dual-element; or "OT" fuse improves the protection characteristic; and a CSP breaker or LTC fuse match best the thermal capacity of the transformer.

Although there have been illustrated and described specific structures, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may readily be made therein by those skilled in the art, without departing from the spirit and scope of the invention.

I claim as my invention:

1. The combination with an oil-filled transformer of winding means, protector means for said winding means immersed at least partially in the oil and comprising a fuse tube open at one end and closed at the other end, a fusible element disposed within said fuse tube and having a heat-sensitive metallic element secured to one end thereof, series resistance means electrically connected in series with the heat-sensitive metallic element and the fusible element for carrying the series current of the protector means and disposed in heat-transmitting relation to said heat-sensitive metallic element, the series resistance means including a cylindrical resistance element having the fusible element passing therethrough and having the heat-sensitive metallic element mounted therein, the heat-sensitive metallic element melting at a predetermined temperature and electrically disconnecting the fusible element from the series resistance means, and biasing means for urging the series resistance means toward the open end of said fuse tube when the electrical circuit through the protector means is broken.

2. In combination, a fuse protector device including a fuse tube, terminal means closing one end of said fuse tube, a fuse link secured to said terminal means at one

end thereof, a block-like heat-sensitive metallic element secured to the other end of said fuse link, cylindrical resistance means electrically connected in series with the fuse link and the heat-sensitive element for carrying the series current through the fuse device disposed at least partially on the fuse-link side of said block-like heat-sensitive metallic element, the heat-sensitive element being normally in abutting relationship to the resistance means whereby a temperature rise of the resistance means as a result of current flowing therein heats the heat-sensitive element, the heat-sensitive element melting at a predetermined temperature and breaking the electrical circuit between the fuse link and the resistance means, and spring means for biasing said resistance means toward the open end of said fuse tube.

3. In combination, a fuse protector device including a fuse tube, terminal means closing one end of said fuse tube, a fuse link secured to said terminal means at one end thereof, a block-like heat-sensitive metallic element secured to the other end of said fuse link, cylindrical resistance means electrically connected in series with the fuse link and the heat-sensitive element for carrying the series current through the fuse device disposed at least partially on the fuse-link side of said block-like heat-sensitive metallic element, the resistance means having the fuse link passing therethrough, the heat-sensitive element being normally in abutting relationship to the resistance means whereby a temperature rise of the resistance means as a result of current flowing therein heats the heat-sensitive element, the heat-sensitive element melting at a predetermined temperature and releasing the fuse link and breaking the electrical circuit between the fuse link and the resistance means, a sleeve of insulating material around the outside of the cylindrical resistance means, spring means for biasing said resistance means toward the open end of said fuse tube, and bifurcated connecting means passing around the insulating sleeve and the cylindrical resistance means in two paths substantially 180 degrees apart and making electrical connection with the resistance means at the end thereof remote from the heat-sensitive element, the bifurcated connecting means electrically connecting said resistance means to the fuse cable of the device.

4. A fuse responsive to large fault currents and to small continuous overloads comprising, in combination, a fuse tube composed of electrically insulating material, first terminal means secured at one end of the fuse tube, second terminal means at the other end of the fuse tube, said other end of the fuse tube being open, spring biasing means mounted in the fuse tube and normally urging the second terminal means away from the fuse tube, a fusible element having one end secured to the first terminal means and having a heat-sensitive element secured to the other end thereof, a resistance element disposed in the fuse tube, the resistance element being generally cylindrical in shape and having a passageway therethrough, the fusible element passing through the passageway, the heat-sensitive element being disposed in the passageway in heat receiving relationship to the resistance element, and electrical circuit means connected to the second terminal means and making electrical contact with the resistance element at a position thereon whereby a current path is provided through at least a substantial portion of the resistance element and thence through the heat-sensitive element and thence through the fusible element, the fusible element being adapted to be burned in two by a large fault current, the resistance element being adapted to have the temperature thereof increased by current flowing therethrough and to raise the temperature of the heat-sensitive element, the heat-sensitive element melting at a predetermined temperature and breaking the electrical circuit between the resistance element and the fusible element.

5. A fuse according to claim 4 in which the heat-sensitive element is composed of a eutectic alloy.

6. A fuse responsive to large fault currents and re-

sponsive to small continuous overloads comprising, in combination, a fuse tube composed of insulating material, a first terminal secured at one end of the fuse tube, a second terminal at the other end of the fuse tube, the other end of the fuse tube being open, spring means normally biasing the second terminal away from the adjacent end of the fuse tube, a fuse element disposed in the fuse tube and having one end thereof connected to the first terminal, an insulating sleeve around at least a portion of the length of the fuse element, a resistance element mounted in the fuse tube adjacent the other end of the fuse element, the resistance element being cylindrical in shape and having a passageway therethrough, the adjacent end of the fuse element passing through the passageway, a heat-sensitive element secured to said last-named end of the fuse element, the heat-sensitive element being disposed within the passageway in the resistance element, and electrical connecting means connecting the resistance element to the second terminal, current flowing from the first terminal through the fuse element through the heat-sensitive element through the resistance element through the electrical connecting means to the second terminal, the fuse element being burned in two by large instantaneous fault currents thereby releasing the resistance element and heat-sensitive element to be partially withdrawn from the fuse tube by said bias spring means.

7. A fuse responsive to large fault currents and responsive to small continuous overloads comprising, in combination, a fuse tube composed of insulating material, a first terminal secured at one end of the fuse tube, the other end of the fuse tube being open, a second terminal at the other end of the fuse tube, spring means normally biasing the second terminal away from the fuse tube, a fuse element in the fuse tube having one end thereof secured to the first terminal and having a heat-sensitive element secured to the other end thereof, a substantially cylindrical resistance element disposed in the fuse tube adjacent the last-named end of the fuse element, the resistance element having a passageway therethrough through which the fuse element passes, the heat-sensitive element being disposed in said passageway, and electrical connecting means connecting the resistance element to the second terminal, the resistance element having the temperature thereof raised in accordance with the value of the current flowing therethrough, heat being transferred from the resistance element to the heat-sensitive element, the heat-sensitive element melting at a predetermined temperature and releasing the end of the fuse element, the resistance element being thereafter drawn away from the fuse element by the tension of said biasing spring means breaking the electrical circuit through the fuse.

8. A fuse according to claim 7 wherein the heat-sensitive element is composed of a eutectic alloy.

9. A fuse according to claim 7 including in addition a sleeve of thermally insulating material surrounding the fuse element over at least a portion of the length thereof and retaining the heat generated by the current flowing through the fuse element thereby reducing the time required for the fuse element to burn through for a given current flowing therein.

10. A fuse responsive to large fault currents and responsive to small continuous overloads comprising in combination, a fuse tube composed of insulating material, a first terminal secured in one end of the fuse tube, a second terminal at the other end of the fuse tube, the other end of the fuse tube being open, spring means biasing the second terminal away from the other end of the fuse tube, a fuse element in the fuse tube having one end thereof connected to the first terminal, a heat-sensitive element secured to the other end of the fuse element, a resistance element disposed in the fuse tube adjacent said other end of the fuse element, the resistance element being generally cylindrical in shape and having a

passageway therethrough, the adjacent end of the fuse element passing through the passageway, the heat-sensitive element being located in the passageway, and electrical connecting means connecting the resistance element to the second terminal, the heat-sensitive element upon melting allowing the end of the fuse element to be withdrawn through the resistance element thereby breaking the electrical circuit through the fuse, the heat-sensitive element melting at a predetermined temperature, current flowing through the resistance element raising the temperature of the resistance element thereby raising the temperature of the heat-sensitive element.

11. A fuse according to claim 10 including in addition a sleeve of thermally insulating material disposed around the fuse element over at least a portion of the length thereof to thereby shorten the burnout time of the fuse element.

12. A fuse according to claim 10 in which the heat-sensitive element is additionally characterized as being composed of a eutectic alloy.

13. A fuse responsive to large fault currents and responsive to small continuous overloads comprising, in combination, a fuse tube composed of insulating material, a first terminal secured at one end of the fuse tube, a second terminal at the other end of the fuse tube, the other end of the fuse tube being open, a fuse element disposed in the fuse tube having one end thereof secured to the first terminal, an apertured resistance block disposed in the fuse tube having a conducting layer on one

end thereof, an apertured U-shaped connecting means with the apertures of the block and connecting means in substantial alignment, the connecting means connecting the block to the second terminal, and spring means biasing the second terminal away from the open end of the fuse tube, the fuse element extending through the aligned apertures and having a low melting temperature heat-sensitive metallic block secured thereto, the metallic block being in contiguous relation with the apertured resistance block.

14. A fuse according to claim 13 in which the heat-sensitive element is additionally characterized as being composed of a eutectic alloy.

15. A fuse according to claim 13 including in addition a sleeve of thermally insulating material extending over at least a portion of the length of the fuse element.

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