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E. V. SUNDT

2,769,877

TIME DELAY FUSE

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Fig. 1.

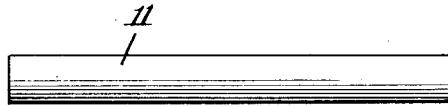


Fig. 2.

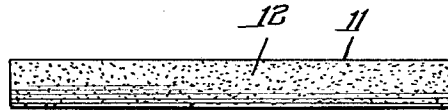


Fig. 3.

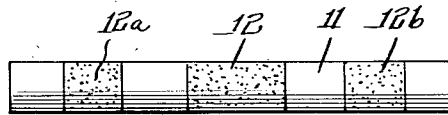


Fig. 4.

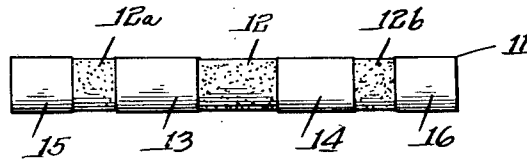


Fig. 5.

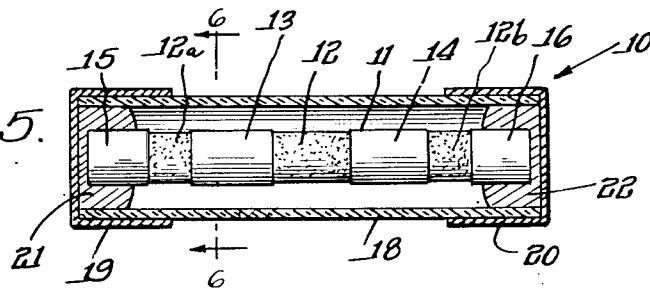
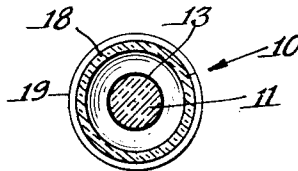


Fig. 6.



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## TIME DELAY FUSE

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10 Claims. (Cl. 200—131)

The principal object of this invention is to provide an improved time delay fuse for protecting electric circuits, which provides for substantially instantaneous action upon the occurrence of shorts or the like in the circuit, which provides a time delayed action upon sustained overloads, which prevents needless fuse blowing on harmless overloads, which utilizes a new and improved principle of operation, which is of new and improved construction, which is rugged fool proof in operation, and which can be simply and inexpensively manufactured while maintaining close tolerances on the ratings thereof.

Briefly, the time delay fuse of this invention includes a fuse element having an elongated supporting member formed of electrical insulating material resistant to high temperatures, a thin film of relatively low melting point fuse metal carried by the supporting member in intimate contact therewith, and a pair of longitudinally spaced apart films of relatively high melting point metal carried by the supporting member with the film of relatively low melting point fuse metal extending therebetween and in series electrical contact therewith. Preferably, this fuse element is located within a tubular cartridge formed of electrical insulating material and provided at its ends with terminal caps, the fuse element being connected in series with the terminal caps for connection into the electric circuit to be protected.

A sustained overload in the electric circuit causes the film of relatively low melting point fuse metal to heat to the melting point thereof for breaking the electric circuit, and the supporting member, which is in intimate contact with the film of low melting point fuse metal, absorbs some of the heat generated in the film and delays the heating thereof to provide the time delay action. The thin film of relatively low melting point fuse metal acts as its own resistance heater and, because of its nature, its resistance for a given rating is low, its heating rate may be simply and accurately calibrated and, at the same time, it is firmly supported by the supporting member so as to be rugged in construction and foolproof in operation.

The fuse element may also be provided with a further pair of thin films of relatively low melting point fuse metal, these films being arranged on opposite sides of the aforementioned film and electrically connected in series therewith. Upon the occurrence of a short in the electric circuit being protected, the fuse will blow at the three points, thereby reducing materially the tendencies to arc. Upon sustained overloads the fuse blows at the center film only and toward this end the outer films may be made somewhat thicker than the inner film.

Preferably, the supporting member is in the form of a ceramic or refractory rod which, in addition to being an electrical insulator and heat absorber, is also resistant to high temperatures and temperature change shocks. The thin films of relatively low melting point fuse metal are in the form of bands on the supporting rod and preferably have a thickness with the approximate range of 5

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millionths to 500 millionths of an inch and a melting point within the approximate range of 150 to 450 degrees centigrade. Any suitable fuse metals within these ranges may be used, as for example, bismuth, cadmium, indium, lead, selenium, tin, and zinc or alloys thereof. In this way, the fuse element does not have to reach such a high temperature, and thus run dangerously hot, before the film melts and opens on an overload, and, also, the fuse operates at a cooler temperature when carrying its rated normal load. On the other hand, the temperature range is sufficiently high so that changes in ambient service temperatures do not include large changes in the blowing point of the fuse. As to the thickness range of the films, the thickness of the films is sufficiently thick to prevent the films from being oxidized away in normal service of the fuse and sufficiently thin to prevent the film from flaking off on repeated heating and cooling of the fuse element.

The thin films of relatively low melting point fuse metal are in intimate contact with and adhere well to the supporting member, and they may be applied thereto in a number of ways, such as by the processes of deposition of evaporated metals, gas plating, burnishing, tumbling or peening, or chemical precipitation, the former providing exceptionally good results. The films of relatively high melting point metal may be applied to the fuse element by spray coating or the like with copper or other higher temperature metal that will easily solder and these films may be considerably thicker than the films of relatively low melting point fuse metal.

Further objects of this invention reside in the details of construction of the time delay fuse and in the co-operative relationships between the component parts thereof.

Other objects and advantages of this invention will become apparent to those skilled in the art upon reference to the accompanying specification, claims and drawing in which:

Fig. 1 is a side elevational view of the supporting member;

Fig. 2 is a side elevational view showing one manner of applying the films of relatively low melting point fuse metals thereto;

Fig. 3 is a view similar to Fig. 2 but showing another manner of applying the relatively low melting point fuse metal films thereto;

Fig. 4 is a view similar to Figs. 2 and 3 but illustrating the films of relatively high melting point metal applied thereto;

Fig. 5 is a sectional view illustrating the completed time delay fuse of this invention;

Fig. 6 is a sectional view taken substantially along the line 6—6 of Fig. 5.

The time delay fuse for protecting an electric circuit is generally designated at 10 in Figs. 5 and 6 and it includes a supporting member 11 illustrated in detail in Fig. 1. The supporting member 11 is formed of electrical insulating material having high temperature resistant characteristics and preferably it is in the form of a cylindrical ceramic or refractory rod. As shown in Fig. 2 a thin film 12 of relatively low melting point fuse metal is applied to and in intimate contact with the cylindrical surface of the supporting rod 11, this film being applied in the manner described above and having a thickness within the approximate range of 5 millionths to 500 millionths of an inch. The melting point of the fuse metal so applied is within the approximate range of 150 to 450 degrees centigrade and the fuse metal, for example, may be bismuth, cadmium, indium, lead, selenium, tin, or zinc or alloys thereof, all of which fall within this temperature range. In Fig. 3, there is illustrated an arrangement wherein three films of relatively

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low melting point fuse metal are applied to the supporting member 11, these films being designated 12a, 12 and 12b and being spaced apart longitudinally along the supporting member 11. Either of the arrangements of Figs. 2 and 3 may be utilized in forming the fuse of this invention. In the arrangement of Fig. 3, however, the films 12a and 12b may be made somewhat thicker than the film 12.

As shown in Fig. 4, films 13 and 14 of relatively high melting point metal are applied to the fuse element at spaced apart points and the film 12 of relatively low melting point fuse metal extends therebetween and is electrically connected in series therewith. Further films 15 and 16 of relatively high melting point metal are also applied to the supporting member 11 and they are arranged at the ends of the supporting member and are in electrical contact with the films 12a and 12b of relatively low melting point fuse metal which in turn are in electrical contact with the films 13 and 14 of relatively high melting point metal. The films 13, 14, 15 and 16 may be applied by spray coating or the like and may be formed of copper or other high temperature metal that will easily solder. The films 12, 12a and 12b regardless of whether they are formed in manners illustrated in Fig. 2 or Fig. 3 form high resistance current paths and the other films 13, 14, 15 and 16 form low resistance current paths, all of the films being electrically connected in series.

The fuse element illustrated in Fig. 4 is preferably contained in a cartridge type of fuse including, as illustrated in Fig. 5, a tubular cartridge 18 formed of electrical insulating material such as glass or the like and terminal caps 19 and 20 carried by the ends of the tubular cartridge 18. The low resistance films 15 and 16 are electrically connected to the terminal caps 19 and 20 by globules of solder 21 and 22, respectively. These solder globules 21 and 22 in addition to forming the electrical connection also operate to support the fuse element centrally within the tubular cartridge 18. The fuse may be connected into an electric circuit to be protected through the terminal caps 19 and 20.

A sustained overload in the electric circuit causes the film 12 of relatively low melting point fuse metal to heat to the melting point thereof whereupon the film separates to break the electric circuit. The supporting member, which has large mass with respect to the film and which is in intimate contact with the film, absorbs some of the heat generated in the film and delays the heating of the film to provide the time delay action. The thin film 12 or relatively low melting point fuse metal acts as its own resistance heater and, because of its nature, its resistance for a given fuse rating is low, and its heating rate may be simply and accurately calibrated by selecting the proper dimensions therefor. Upon the occurrence of a short in the electric circuit resulting in extremely high current flow, the films 12a and 12b of relatively low melting point fuse metal will heat up and melt along with the film 12 so that under this condition the circuit is broken at three points, namely, at the films 12a, 12 and 12b. This multiple breaking of the circuit materially reduces the tendencies of the fuse to arc. Upon sustained overload the fuse blows at the center film 12 only since this film is normally at a higher temperature than the outer films 12a and 12b. However, to assure blowing of the fuse at the center film only the films 12a and 12b may be made somewhat thicker than the film 12 so that their resistance will be less. This can be accomplished by following the method of manufacture of the fuse element as illustrated in Fig. 3.

The fuses of this invention may be constructed to cover a rating range from  $\frac{1}{16}$  amp to about 8 amps and they will carry at least 110% of rating for a minimum of four hours, blow within one hour at 200% of rating, but at the same time will carry 300% of rating for a minimum of six seconds. For example, a fuse constructed in ac-

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cordance with this invention having a one quarter amp rating has a fuse element  $1\frac{1}{4}$  inches long and a diameter of  $\frac{3}{32}$  of an inch. The center film 12 is approximately .000020 inch thick and one half inch long. With the film formed of tin it has a resistance of 6.0 ohms which is considerably less than a resistance of 7.5 ohms for a conventional fuse having the same rating. This fuse produces approximately a 20 second delay at 200% rating in a 250 volt circuit. If the outer films 12a and 12b are not desired they, of course, may be omitted and the films 13 and 14 extended to encompass the films 15 and 16.

While for purposes of illustration one principal form of this invention has been disclosed, other forms thereof may become apparent to those skilled in the art upon reference to this disclosure and, therefore, this invention is to be limited only by the scope of the appended claims.

I claim as my invention:

1. A time delay fuse for protecting an electric circuit comprising, an elongated supporting member formed of electrical insulating material resistant to high temperatures, a first film of relatively low melting point fuse metal carried by the supporting member intermediate the ends thereof and in intimate contact therewith, second and third films of relatively low melting point fuse metal carried by the supporting member in intimate contact therewith and in longitudinally spaced relation from each end of the first film of relatively low melting point fuse metal, first and second longitudinally spaced apart films of relatively high melting point metal carried by the supporting member and extending between and electrically connecting, respectively, the first and second and the first and third films of relatively low melting point fuse metal, third and fourth longitudinally spaced apart films of relatively high melting point metal carried by the supporting member electrically contacting, respectively, the second and third films of relatively low melting point fuse metal, and means including electrical terminals connected to the third and fourth films of relatively high melting point metal for connecting the same into the electric circuit to be protected, a sustained overload in the electric circuit causing the first of relatively low melting point fuse metal to heat to the melting point thereof for breaking the electric circuit with the rate of heating thereof being delayed by the supporting member in intimate contact therewith, and a sudden short in the electric circuit promptly heating the first, second and third films of low melting point fuse metal to their melting points for promptly breaking the electric circuit.

2. A time delay fuse for protecting an electric circuit comprising, an elongated supporting member formed of electrical insulating material resistant to high temperatures, a first film of relatively low melting point fuse metal carried by the supporting member intermediate the ends thereof and in intimate contact therewith, second and third films of relatively low melting point fuse metal carried by the supporting member in intimate contact therewith and in longitudinally spaced relation from each end of the first film of relatively low melting point fuse metal, the second and third films of relatively low melting point fuse metal being thicker than the first film of relatively low melting point fuse metal, first and second longitudinally spaced apart films of relatively high melting point metal carried by the supporting member and extending between and electrically connecting, respectively, the first and second and the first and third films of relatively low melting point fuse metal, third and fourth longitudinally spaced apart films of relatively high melting point metal carried by the supporting member electrically contacting, respectively, the second and third films of relatively low melting point fuse metal, and means including electrical terminals connected to the third and fourth films of relatively high melting point metal for connecting the same into the electric circuit to be protected, a sustained overload in the electric circuit causing the first film of relatively low melting point fuse

metal to heat to the melting point thereof for breaking the electric circuit with the rate of heating thereof being delayed by the supporting member in intimate contact therewith, and a sudden short in the electric circuit promptly heating the first, second and third films of low melting point fuse metal to their melting points for promptly breaking the electric circuit.

3. A time delay fuse for protecting an electric circuit comprising, an elongated cylindrical supporting member formed of electrical insulating material resistant to high temperature, a first film of relatively low melting point fuse metal carried by the supporting member intermediate the ends thereof and in intimate contact therewith, second and third films of relatively low melting point fuse metal carried by the supporting member in intimate contact therewith and in longitudinally spaced relation from each end of the first film of relatively low melting point fuse metal, first and second longitudinally spaced apart films of relatively high melting point metal carried by the supporting member and extending between and electrically connecting, respectively, the first and second and the first and third films of relatively low melting point fuse metal, third and fourth longitudinally spaced apart films of relatively high melting point metal carried by the supporting member electrically contacting, respectively, the second and third films of relatively low melting point fuse metal, all of said films being in the form of bands around said cylindrical supporting member, and means including electrical terminals connected to the third and fourth films of relatively high melting point metal for connecting the same into the electric circuit to be protected, a sustained overload in the electric circuit causing the first film of relatively low melting point fuse metal to heat to the melting point thereof for breaking the electric circuit with the rate of heating thereof being delayed by the supporting member in intimate contact therewith, and a sudden short in the electric circuit promptly heating the first, second and third films of low melting point fuse metal to their melting points for promptly breaking the electric circuit.

4. A time delay fuse for protecting an electric circuit comprising, an elongated cylindrical supporting member formed of electrical insulating material resistant to high temperature, a first film of relatively low melting point fuse metal carried by the supporting member intermediate the ends thereof and in intimate contact therewith, second and third films of relatively low melting point fuse metal carried by the supporting member in intimate contact therewith and in longitudinally spaced relation from each end of the first film of relatively low melting point fuse metal, the second and third films of relatively low melting point fuse metal being thicker than the first film of relatively low melting point fuse metal, first and second longitudinally spaced apart films of relatively high melting point metal carried by the supporting member and extending between and electrically connecting, respectively, the first and second and the first and third films of relatively low melting point fuse metal, third and fourth longitudinally spaced apart films of relatively high melting point metal carried by the supporting member electrically contacting, respectively, the second and third films of relatively low melting point fuse metal, all of said films being in the form of bands around said cylindrical supporting member, and means including electrical terminals connected to the third and fourth films of relatively high melting point metal for connecting the same into the electric circuit to be protected, a sustained overload in the electric circuit causing the first film of relatively low melting point fuse metal to heat to the melting point thereof for breaking the electric circuit with the rate of heating thereof being delayed by the supporting member in intimate contact therewith, and a sudden short in the electric circuit promptly heating the first, second and third films of low melting point

fuse metal to their melting points for promptly breaking the electric circuit.

5. A time delay fuse for protecting an electric circuit comprising, an elongated supporting member formed of electrical insulating material resistant to high temperatures, a film of relatively low melting point fuse metal carried by the supporting member in intimate contact therewith and having a thickness within the approximate range of 5 millionths to 500 millionths of an inch and a melting point within the approximate range of 150 to 450 degrees centigrade, a pair of longitudinally spaced apart films of relatively high melting point metal carried by the supporting member with the film of relatively low melting point fuse metal extending therebetween and in series electrical contact therewith, and means including electrical terminals connected to the pair of films of relatively high melting point metal for connecting the same into the electric circuit to be protected, a sustained overload in the electric circuit causing the film of relatively low melting point fuse metal to heat to the melting point thereof for breaking the electric circuit, the supporting member in intimate contact with the film of relatively low melting point fuse metal delaying the heating rate thereof.

6. A time delay fuse for protecting an electric circuit comprising, an elongated supporting member formed of electrical insulating and high temperature resistant ceramic, a film of relatively low melting point fuse metal carried by the supporting member in intimate contact therewith and having a thickness within the approximate range of 5 millionths to 500 millionths of an inch and a melting point within the approximate range of 150 to 450 degrees centigrade, a pair of longitudinally spaced apart films of relatively high melting point metal carried by the supporting member with the film of relatively low melting point fuse metal extending therebetween and in series electrical contact therewith, and means including electrical terminals connected to the pair of films of relatively high melting point metal for connecting the same into the electric circuit to be protected, a sustained overload in the electric circuit causing the film of relatively low melting point fuse metal to heat to the melting point thereof for breaking the electric circuit, the supporting member in intimate contact with the film of relatively low melting point fuse metal delaying the heating rate thereof.

7. A time delay fuse for protecting an electric circuit comprising, an elongated cylindrical supporting member formed of electrical insulating material resistant to high temperature, a film of relatively low melting point fuse metal carried by the supporting member in intimate contact therewith and having a thickness within the approximate range of 5 millionths to 500 millionths of an inch and a melting point within the approximate range of 150 to 450 degrees centigrade, a pair of longitudinally spaced apart films of relatively high melting point metal carried by the supporting member with the film of relatively low melting point fuse metal extending therebetween and in series electrical contact therewith, all of said films being in the form of bands around said cylindrical supporting member, and means including electrical terminals connected to the pair of films of relatively high melting point metal for connecting the same into the electric circuit to be protected, a sustained overload in the electric circuit causing the film of relatively low melting point fuse metal to heat to the melting point thereof for breaking the electric circuit, the supporting member in intimate contact with the film of relatively low melting point fuse metal delaying the heating rate thereof.

8. A time delay fuse for protecting an electric circuit comprising, an elongated cylindrical supporting member formed of electrical insulating and high temperature resistant ceramic, a film of relatively low melting point fuse metal carried by the supporting member in intimate contact therewith and having a thickness within the approxi-

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mate range of 5 millionths to 500 millionths of an inch and a melting point within the approximate range of 150 to 450 degrees centigrade, a pair of longitudinally spaced apart films of relatively high melting point metal carried by the supporting member with the film of relatively low melting point fuse metal extending therebetween and in series electrical contact therewith, all of said films being in the form of bands around said cylindrical supporting member, and means including electrical terminals connected to the pair of films of relatively high melting point metal for connecting the same into the electric circuit to be protected, a sustained overload in the electric circuit causing the film of relatively low melting point fuse metal to heat to the melting point thereof for breaking the electric circuit, the supporting member in intimate contact with the film of relatively low melting point fuse metal delaying the heating rate thereof.

9. A time delay cartridge fuse for protecting an electric circuit comprising, a fuse element including an elongated supporting member formed of electrical insulating material resistant to high temperatures, a film of relatively low melting point fuse metal carried by the supporting member in intimate contact therewith, and a pair of longitudinally spaced apart films of relatively high melting point metal carried by the supporting member with the film of relatively low melting point fuse metal extending therebetween and in series electrical contact therewith, a tubular cartridge of electrical insulating material, a pair of metallic terminal caps carried by the ends of the cartridge for electrical connection into the circuit to be protected, and solder globules supporting and mounting the fuse element in the cartridge and electrically connecting the films of relatively high melting point metal to the terminal caps, a sustained overload in the electric circuit causing the film of relatively low melting point fuse metal to heat to the melting point thereof for breaking the electric circuit, the supporting member in intimate contact

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with the film of relatively low melting point fuse metal delaying the heating rate thereof.

10. A time delay cartridge fuse for protecting an electric circuit comprising, a fuse element including a supporting member in the form of an elongated electrical insulating and high temperature resistant ceramic rod, a film of relatively low melting point fuse metal carried by the supporting member in intimate contact therewith, and a pair of longitudinally spaced apart films of relatively high melting point metal carried by the supporting member with the film of relatively low melting point fuse metal extending therebetween and in series electrical contact therewith, all of said films being in the form of bands around the supporting member, a tubular cartridge of electrical insulating material, a pair of metallic terminal caps carried by the ends of the cartridge for electrical connection into the circuit to be protected, and solder globules supporting and mounting the fuse element in the cartridge and electrically connecting the films of relatively high melting point metal to the terminal caps, a sustained overload in the electric circuit causing the film of relatively low melting point fuse metal to heat to the melting point thereof for breaking the electric circuit, the supporting member in intimate contact with the film of relatively low melting point fuse metal delaying the heating rate thereof.

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