July 29, 1952 H. H. FAHNOE 2,605,371

FUSE

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Fig.1.

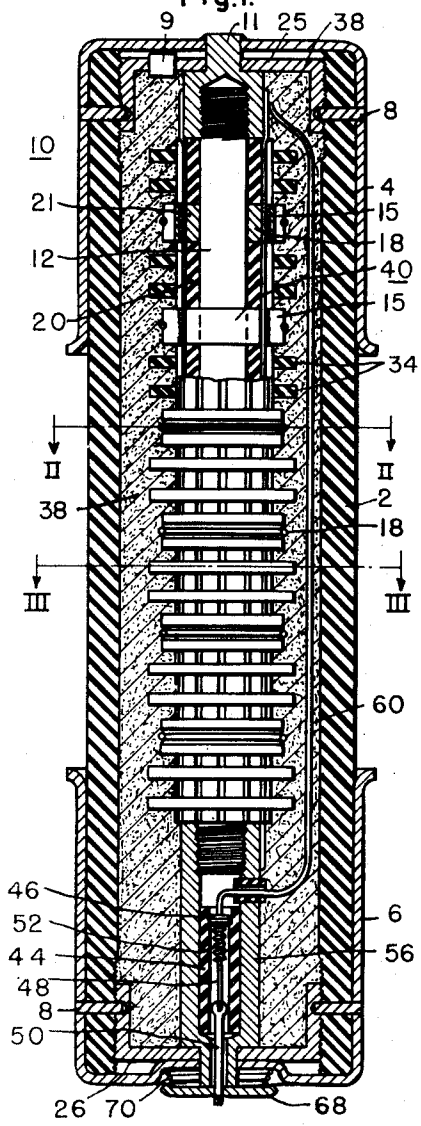


Fig.2.

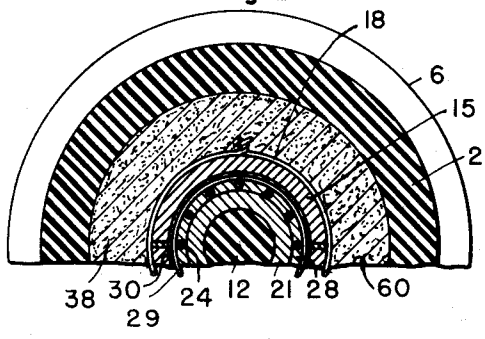


Fig.3.

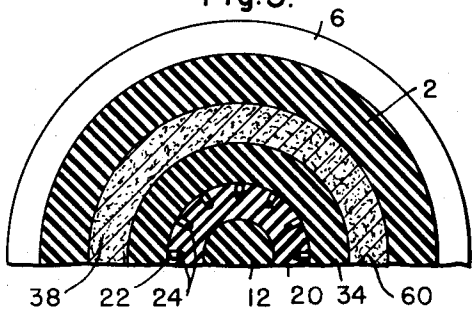
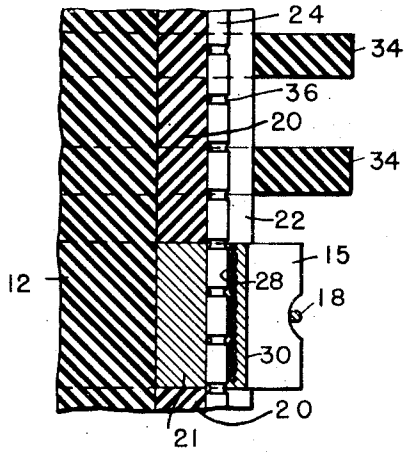


Fig.4.



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2,605,371

FUSE

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Application July 10, 1948, Serial No. 38,031

20 Claims. (Cl. 200—120)

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This invention relates to electrical fuses which are adapted to interrupt an electrical circuit on overloads, and particularly to increasing the ability of such fuses to withstand for short-times moderate overloads, such as may be encountered in starting motors or the like, without materially altering the rated current at which such fuses operate or the time required for their operation on heavier overloads such as those prompted by short-circuits.

This invention is of especial importance in fuses of the current limiting type, such as those disclosed in the copending application of Harold H. Fahnoe, Serial No. 582,867, filed March 15, 1945, and issued as Patent No. 2,496,704, dated February 7, 1950, on the subject of Circuit Interrupters. As explained in the copending application just referred to, most effective current and voltage limitation on high overloads and short-circuits is achieved when the overload is limited before maximum current prevails in the first half cycle of the overload. If limitation is not effected in this manner, the resulting surge on the first half cycle of fault current often is capable of doing considerable damage to the circuit and especially to connected apparatus such as motors, transformers, or the like. It follows from this that the current limiting means importantly becomes effective in a small fraction of a half cycle of such overloads as are to be limited, this amounting in time to a few hundred microseconds.

A variety of the fuses referred to in the copending application gave rise to a problem incident upon the assurance of rapid overload limitation, namely that of preventing interruption of current due to moderate overloads, such as those of short duration which occur in starting an electric motor followed by the resumption of normal relatively low current conditions. By resorting to such measures as adding more parallel fuse wires in the current limiting element of the fuse to compensate for motor inrush starting currents or the like, the peak current limit permitted by the fuse is correspondingly increased thus increasing the interrupting duty of the fuse, and the time-current characteristics on moderate short-circuits or overloads is correspondingly slowed down.

It is, accordingly, an object of this invention to provide a current limiting fuse which is capable of withstanding light overload currents for short periods of time, yet assures an extremely rapid blowing action where relatively large overload currents are encountered.

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Another object of this invention is the provision of a current limiting fuse in which fusion of the fusible portion or portions thereof is reliably and effectively arrested in a relatively low current range by heat absorption, and without substantial impairment of desired rapid limitation of relatively large overloads.

A further object of this invention is the provision of a fuse capable of permitting passage of inrush currents within lower operating limits and of interrupting relatively large overload currents, and which upon being subjected to a sufficient current overload to give the blowing action, enables the rapid achievement of a high arc voltage contributing to the current limiting effect.

A still further object of this invention is to provide a fuse structure including fusible material, and heat absorbing means for cooperating with the fusible material, all supported in a novel and highly useful manner interiorly of a tubular fuse holder.

These and other objects of this invention will become more apparent upon consideration of the following description of a preferred embodiment thereof, when taken in connection with the attached drawing, in which:

Figure 1 is a substantially central longitudinal sectional view of a fuse constructed in accordance with the invention, with certain of the parts shown in elevation;

Fig. 2 is an enlarged, partial, transverse cross-sectional view of the fuse represented in Fig. 1, taken substantially on the line II—II thereof;

Fig. 3 is an enlarged, partial, transverse cross-sectional view of the fuse represented in Fig. 1, this being taken substantially on the line III—III thereof; and

Fig. 4 is an enlarged, partial, longitudinal, sectional view taken through one of the slots or grooves of the fuse supporting member depicted in Fig. 1.

In the particular embodiment of the invention disclosed in the accompanying drawing, a limiting unit 10 is provided for limiting current and voltage. This unit is encased by a tubular fuse holder 2 made of insulating material such as fiber or synthetic resin, and by terminal caps 4 and 6 over the opposite ends of the tube. Terminal caps 4 and 6 are made of an electrically conductive material such, for example, as copper or the like, and are preferably secured in position on the tubular holder, illustratively by the staking pins 8.

The limiter unit 10 includes a supporting rod 12 of suitable insulating material such as fiber or the like, having end terminal plugs 25 and 26, as

for example of brass, each threadedly engaging a corresponding one of the opposite inside wall ends of the tubular fuse holder 2. Staking pins 8 advantageously reach into these end plugs for stability. An electrically conductive rod end cap 11, threadedly receiving one end of the rod 12, has a reduced diameter portion extending through aligned, substantially central openings in the end plug 25 and terminal cap 4. Similarly an electrically conductive rod end cap 56 threadedly receives the other end of the supporting rod 12, and has a reduced diameter portion passing through aligned, substantially central openings in the end plug 26 and terminal cap 6. The reduced diameter portions of the rod end caps 25 and 26, conveniently are secured in electrically conductive relation to the respective terminal caps 4 and 6 as by soldering. A finely divided inert insulating material 38, such as sand, surrounds the current and voltage limiting unit 10 and fills the space to the inside surface of tubular fuse holder 2 and of end plugs 25 and 26. The end plug 25 has a slightly tapered stopper 9 closing off a suitable opening for insertion of the inert material 38. Terminal cap 4 is sufficiently near the stopper to prevent the same from backing out of its related opening. The rod end cap 56 in the present embodiment is greater in length than rod end cap 11, for reasons which appear more fully hereinafter.

The actual current and voltage limiting and arc extinguishing structure embodied in the unit 10 comprises a plurality of tubes 20 disposed on the supporting rod 12. Each of the tubes 20 has spaced grooves 22 running longitudinally along the outside surface thereof for receiving a fusible length or section of wire 24. The grooved tubes are preferably made of an electrically insulating material which is capable of evolving an arc extinguishing gas when in proximity to an electric arc, such for example as fiber or synthetic resin. Also, on the supporting rod 12, and preferably in alternate or spacing relation with the grooved tubes 20, are a plurality of heat wells 40, each including a tube 21, such as copper or other suitable electrically conductive and heat absorptive material. The tubes 20 and 21 as arranged in the present embodiment are easily tightened toward and clamped against each other in substantially coaxial relation on supporting rod 12 by advancing the rod end caps 25 and 56 relative to one another. Grooves 22 are longitudinally aligned throughout the tubes 20 before tightening the end caps, or may be cut in alignment after the tightening operation. The bottoms of grooves 22 conveniently are at about the same level as the outside surfaces of heat well tubes 21.

The fusible wires or elements 24 extend in parallel electrical relation to each other from rod end cap 25 to the rod end cap 56, and each wire has fusible sections individually in the grooves of the tubes 20 which are connected in series with the heat wells 40. For this purpose wires 24 conveniently pass along in the grooves 22 and over the surface of the heat well tubes 21, there being connected in heat conductive and electrically conductive relation to the well tubes as by an embedding layer of silver solder or the like 28. A plurality of washers 34 are slipped onto each of the grooved tubes 20 and are frictionally held in spaced relation to each other along the length of these tubes, for a purpose to be described. Washers 34 may be of any desired electrical insulating material, such, for example, as fiber or the like.

An additional mass of heat absorptive material for the heat wells 40, supplementing the absorptive effect of the tubes 21, conveniently surrounds the solder bed 28 containing the fusible wires 24. This mass, as represented in the accompanying drawing, includes a wrapping of heat conductive wire over or in each of the solder beds 28 for reinforcing and strengthening purposes, and a superimposed segmented collar 15 of thermally absorptive material which may be the same as the material of sleeve 21, is fastened by means of a layer of solder 30, for example of silver, to the wire wrapping. Both the segmented collar 15 and the wrapping wire 30 illustratively are made of copper. The segmented collar conveniently provides a circumferential groove for receiving a binding wire 18 which assists in holding together the several soldered segments both before and after the soldering operation.

The fuse wire 24, being of silver or similar material, has a high temperature coefficient of resistance, and is initially chosen to carry the rated current without undue heating, and yet melt on currents above the rated current. Such a wire is then provided with a plurality of reduced portions 36 (Fig. 4). By this arrangement the fusion time, at least for high values of current is speeded up and substantially corresponds to the fusion time required by a wire having about the same diameter as the reduced diameter portions 36. This speeding up effect has been found to be roughly proportional to the ratio between the area of the large portions of the fuse wire 24 and the reduction portions 36, the ratio being according to cross section. As a practical matter, this ratio may be made as high as possible, being limited of course by mechanical strength considerations. Such a fuse wire retains all of the normal time-current characteristics desired in a fuse for time values in excess of approximately two cycles without appreciable reduction in current carrying ability. Reduction in current carrying ability varies approximately in direct proportion to the length of portions 36, so that it is desirable to make these portions as short as possible. For short times of less than about one-fourth cycle, fuse wire 24 has an exceptionally fast melting time when the overload current is high. When the overload current is relatively low, however, the heat wells 40 absorb enough of the heat to prevent the fuse wires from fusing. This feature gives ample protection against blowing of the fuse wires, as for example when the related electrical circuit is carrying a motor starting or inrush current before normal operating currents are attained. The effect of increased or sustained overloads, such as short circuits is that of limiting the current and voltage by fusion of the wires in an early part of the cycle of fault current. Under the latter conditions the heat wells 40 have substantially no arresting affect on fushion of the wires 24 and the melting time of less than about one-fourth half cycle.

As pointed out in the copending application hereinbefore referred to, the fuse wires 24 retain their current carrying ability where the current is relatively low, and this is not substantially impaired by the introduction of reduced portions 36. Added to this in the present embodiment, is the effect of the heat wells, which extends the short-time current carrying ability of the fuse wire to include appreciably increased overloads, such for example as currents ranging up to about eight times the rated current, all with retention of fast limiting characteristics for higher overloads.

The actual limitation of current is achieved by the high arc voltage produced upon fusion of fuse wires 24, the fusion for example occurring in one of the fusible sections or lengths of the wire represented by the length of the related grooved tube 20. Upon fusion, a high arc voltage is built up substantially instantaneously, thus exerting a limiting or choking effect on the current and preventing rise of the current beyond a predetermined value. The particular structure disclosed provides a high arc voltage per unit of length of the fusible sections of wire 24, which interconnect the wells 40 and lie intermediate the latter in the grooves 22 of tubes 20. This conveniently is achieved by employing a large enough number of reduced portions 36 in the fuse wire so that when these reduced portions melt, a plurality of serially related arcs may be formed and the summation of the arc voltages of these series arcs will be greater than the arc voltage across a single arc. Generally speaking, the arc voltage per unit of length is directly proportional to the number of series arcs or restrictions per unit of length which may be effectively interrupted by fusion. This suggests that maximum arc voltage per unit of length may be attained by providing as many restrictions 36 per unit of length as is physically possible. However, as the number of restrictions 36 per unit of length is increased, a point is eventually reached where a further increase results in a decrease in current carrying ability. It has been found that at least for voltages above 600 volts, at least two restrictions 36 per effective inch of fuse wire 24, or a total of about ten should be provided to obtain an effective rise in arc voltage with a fuse wire which is not of excess length. This corresponds approximately to a spacing of restrictions 36 not to exceed about fifteen times the large diameter of the fuse wire. It is desirable, however, to use the maximum number of restrictions possible without substantially impairing the current carrying ability. The most desirable number of restrictions is dependent upon the size of the fuse wire, and appears to correspond roughly to a spacing of about three and one-half times the largest diameter of the wire. This is an optimum spacing, since spacings as low as about twice the largest diameter of the fuse wire may be employed with good results.

Another reason why the arc voltage is rapidly built up to a value high enough to exert a current limiting effect, has to do with the grooves 22 in which the fuse wires are located. Grooves 22 advantageously are made as narrow as possible, being limited only by the size of the fuse wires, and in practice illustratively are made no more than 0.010 inch larger than the fuse wires. Preferably the grooves are somewhat deeper than the diameter of the fuse wires, so that the wires will closely contact the groove on three sides and thus physically restrict the arc formed upon melting of the fuse wires, thereby raising the arc voltage at the instant the arc is formed.

Since fuse wires 24 are in close proximity to the walls of groove 22, the arc formed upon interruption will cause the evolution of arc-extinguishing gas from the walls of the groove, and this gas will blast laterally through the arc to perform three functions, all of which act to further increase the arc voltage and extinguish the arc. First, the blast of arc-extinguishing gas acts to sweep metal vapor out of the arc stream and out of grooves 22 into the material 38 in which the metal vapor becomes dispersed and

condensed into separated particles insulated from each other, so that a high resistance path is maintained outside the grooves. Secondly, the blast of arc-extinguishing gas also acts to supply un-ionized gas to the arc path to further increase the resistance of the arc path and to extinguish the arc at current zero. A third function of the transverse gas blast is to cause the series arcs to be looped outwardly toward filling material 38, thereby lengthening the arc path and, consequently, increasing the resistance thereof and the voltage drop across it. A function of washers 34 on supporting rod 20 will now be readily understood as preventing escape of the arcs from grooves 22 and, consequently, keeping the arcs in proximity with the gas evolving material and the restricting action of the narrow grooves, and thus preventing the series arcs from re-striking as a single arc outside the grooves.

In view of the above, it becomes clear that efficient current limitation of the first half cycle of the arcing current may be obtained with the structure disclosed, because (1) the fusible wires themselves are capable of melting to establish an arc at least on such high currents which it is desired to limit, in a very short time, that is, in a very small fraction of a half cycle, and (2) as soon as the arc is established it is subjected to all of the factors enumerated above to create an arc voltage high enough to prevent any further rise of fault current.

The arc voltage, and the speed and efficiency of current limitation and interruption appear to be in some measure dependent upon the number and thickness of washers 34. These washers are preferably made thick enough as not to be materially eroded by the action of the arc. It also appears that an increase in the number of washers 34 increases the arc voltage while increasing current limitation and interruption speed. A better understanding of this may be arrived at by considering that fuses are known in the art which comprise one or more silver wires embedded in sand and that these fuses obtain current limitation by the formation of a semi-conductive core about the wire due to the action of the heat of the arc on the sand. However, such fuses must be excessively long in order to obtain sufficient voltage drop to extinguish the arc, and increased length, of course, causes greater voltage surge at interruption. In the fuse constituting this invention the formation of any such semi-conductor is positively prevented by barrier plates 34, and this is one reason why unit 10 may be made relatively short in length. The provision of barrier plates 34 (which themselves are advantageously of a material capable of evolving an arc-extinguishing gas when subjected to the heat of an arc) thus appears to provide spaced deionizing zones along the length of unit 10, which would explain why an increase in the number of barriers would provide an increase in arc voltage, and also explains why a relatively high arc voltage per unit length is obtained with unit 12. Moreover, it is believed that this action of the barrier plates 34 undoubtedly contributes to rapid extinction of the arc.

Though there may be other reasons for the results obtained, tests show that a structure such as unit 10 of and by itself, is capable of limiting high overload currents in the first part of the first half cycle thereof, without producing voltage surges substantially greater than one and one-half times restored circuit voltage, and

is effective to interrupt the circuit at the following first or second current zero.

Further, the unit is thoroughly capable of absorbing heat resulting from relatively low overload currents of short duration, thus preventing interruption of the circuit on such overloads. The number and size of the heat wells 40 are correlated with the length of fuse wires 24 intermediate the wells so that the entire heat input due to momentary light overloads can be conducted to the wells before the centers of the fuse wires attain fusion temperature. Furthermore, a material such as copper is chosen for the heat wells because its specific heat is higher (about twice as high) than the material of which the fuse wires are formed. This means that for a given size of heat well a relatively large amount of heat can be stored therein. This heat lost from the wires to wells 40, as well as some losses to the surrounding media, such as sand 38 and rod 12, thus limits the temperature rise of fuse wires 24 on light overloads of short duration. In addition, since wells 40 electrically and mechanically connect all of the parallel wires, increased uniformity in heating and in division of current flow through the several fuse wires is achieved. Moreover, since wells 40 effectively break up each fuse wire 24 into a plurality of serially arranged short fusible sections located between the wells, longitudinal expansion and contraction of the wires is not a factor in causing fuse wire bending or even breakage occurring in the fuses which employ longer lengths of fuse wire. One reason why peak currents on heavy overloads are not increased with the presen design is that fuse wires 24 intermediate wells 40 are not increased in number, and they act when the fuse blows on such heavy overloads in exactly the same manner as if wells 40 were not present.

To give an indication that fusion of the current limiting wires 24 has occurred in the unit 10, an indicator disc 68 is provided secured to a connecting rod 50 extending through a bore in the outer end of the rod end cap 56, to be normally held adjacent to end terminal cap 6 by a high resistance fusible strain wire 48 and a small tension spring 52. A coil compression spring 70 is provided between indicator disc 68 and cap 6 to bias the disc outwardly away from the end of the fuse. The large end coils 46 of spring 52 are adapted to be supported within fuse tube 2 and more particularly within the bore of rod end cap 56 by a shoulder in a small inner tube 44 of insulating material such as fiber or the like. The inner end of strain wire 48 is connected through spring 52 to the rod end cap 11 by means of a high resistance fusible wire 60. High resistance wires 48 and 60 preferably are of such a high resistance as compared with fuse wire 24 that they normally do not carry any appreciable amount of current. However, as soon as wires 24 are melted, the arc voltage developed in unit 10 forces sufficient current through wires 60 and 48 to fuse these wires at substantially the same time, thus releasing indicator disc 68 and permitting it to be moved by spring 70 outwardly to a clearly visible indicating position. Fusible wires 48 and 60 are of such high resistance relative to wires 24, on the order of several hundred times the resistance of wires 24, that they do not affect the operation of unit 10 in any appreciable way either before or during a circuit interrupting operation.

The fuse construction described herein provides a simplified form of fuse which may be made relatively small in size. It includes both current and voltage limiting means in a single unit, together with arc-extinguishing means. The limiting unit 10 has a definite, continuous current rating and the fusible sections of wires 24 will rapidly fuse on high overload currents which it is desired to limit, but will resist fusion of lower overload currents up to about 800 per cent of rated current and of short duration by aid of the heat wells 40, the latter also being compactly contained in the limiting unit 10.

Having described a preferred embodiment of the invention in accordance with the patent statutes, it is desired that the invention be not limited to this particular structure, inasmuch as it will be obvious to persons skilled in the art that many modifications and changes may be made in this particular structure without departing from the broad spirit and scope of this invention. Accordingly, it is desired that the invention be interpreted as broadly as possible and that it be limited only as required by the prior art.

I claim as my invention:

1. A fuse having a definite, continuous current rating, comprising at least one fusible element having a maximum cross-section area not exceeding that which will fuse on currents in excess of rated current, a relatively large quantity of good heat conducting material located in good heat conducting relation with said fusible element to prevent fusion thereof within a higher range of currents of short duration, and substantially all of said material having a relatively high specific heat.

2. A fuse having a definite, continuous current rating, comprising, serially arranged fusible elements, each of said elements having a maximum cross-section area not exceeding that which will fuse on currents in excess of rated current, a relatively large mass of good heat conducting material located at each pair of adjacent ends of said elements to prevent fusion thereof within a higher range of currents of short duration, and substantially all of said material having a relatively high specific heat.

3. A fuse having a definite, continuous current rating, comprising a plurality of spaced parallel fusible elements each of which comprises serially arranged fusible sections, each of said sections having a maximum cross-section area not exceeding that which will fuse on currents in excess of rated current, and relatively large masses of good electrical conducting material each of which is common to and electrically connects corresponding sections of said elements, respectively.

4. A fuse having a definite, continuous current rating, comprising serially arranged fusible sections, each of said sections having a maximum cross-section area not exceeding that which will fuse on currents in excess of rated current and portions having a reduced cross-section area along the length thereof to substantially decrease melting time thereof on heavy overload; and at least one heat well interposed between said sections in heat conducting relation thereto to prevent fusion thereof within a range of currents of short duration.

5. A fuse having a definite, continuous current rating, comprising, a plurality of parallel fusible elements each of which comprises serially arranged fusible sections, each of said sections having a maximum cross-section area not exceeding that which will fuse on currents in

excess of rated current and portions having a reduced cross-section area along the length thereof to substantially decrease melting time thereof on heavy overload; and heat wells between said sections in heat conducting relation thereto to prevent fusion thereof within a range of currents of short duration, with the heat wells between corresponding sections of said elements comprising single unitary common masses of heat conducting material, respectively.

6. A fuse having a definite, continuous current rating, comprising, a plurality of parallel fusible elements each of which comprises serially arranged fusible sections having a maximum cross-section area not exceeding that which will fuse on currents in excess of rated current, and at least one heat well comprising a sufficiently large mass of good heat conducting material located between adjacent ends of said sections in heat conducting relation thereto to prevent fusion thereof within a range of currents of short duration, with said heat well comprising a single unitary mass of heat conducting material common to all of said elements.

7. A fuse having a definite, continuous current rating, comprising, at least one elongated fusible section having a maximum cross-section area not exceeding that which will fuse on currents in excess of rated current and portions having a reduced cross-section along the length thereof to substantially decrease melting time thereof on high overloads, and a sufficient large quantity of good heat conducting material located in heat conducting relation with said fusible section to prevent fusion thereof within a range of currents of short duration.

8. A fuse having a definite, continuous current rating, comprising, at least one elongated fusible section having a cross-section area not exceeding that which will fuse on currents in excesss of rated current and portions having a reduced cross-section area along the length thereof to substantially decrease melting time thereof on high overloads, a sufficiently large quantity of good heat conducting material located in heat conducting relation with said fusible section to prevent fusion thereof within a range of currents of short duration, and an elongated arc restrictive passage of insulating material receiving said fusible section for increasing the arc voltage along the same under conditions of relatively high overload current.

9. A fuse having a definite, continuous current rating, comprising, serially arranged fusible sections, each of said sections having a cross-section area not exceeding that which will fuse on currents in excess of rated current and portions having a reduced cross-section area along the length thereof to substantially decrease melting time thereof on high overload, heat wells between said sections to prevent fusion thereof within a range of currents of short duration, and insulating material adjacent said fusible sections capable of evolving an arc extinguishing gas for increasing the arc voltage under conditions of relatively high overload current.

10. A fuse having a definite, continuous current rating, comprising, a plurality of parallel fusible elements each of which comprises serially arranged fusible sections, each of said sections having a cross-section area not exceeding that which will fuse on currents in excess of rated current and portions having a reduced cross-section area along the length thereof to sustantially decrease melting time thereof on high overload, heat wells between said sections to prevent fusion thereof within a range of currents of short duration, and elongated arc restrictive passages of insulating material receiving said fusible sections for increasing the arc voltage along the same under conditions of relatively high overload current.

11. A fuse comprising, at least two spaced parallel elongated fusible sections, a single mass of heat conducting material located in heat conducting relation with both of said fusible sections to prevent fusion thereof within a range of currents of short duration.

12. A fuse comprising, at least two spaced parallel elongated fusible sections, a mass of good electrical and heat conducting material electrically and mechanically connecting said fusible sections to prevent fusion thereof within a range of currents of short duration.

13. A fuse comprising, elongated fusible sections, spaced longitudinally grooved elements receiving said fusible sections in the grooves thereof, for increasing the arc voltage along the same under conditions of relatively high overload current, arc escape prevention means longitudinally spaced along said grooved elements and the groove paths thereof, and heat absorptive means between said grooved elements in heat conducting relation with said fusible sections to prevent fusion thereof within a relatively low range of currents of short duration.

14. A fuse comprising, elongated fusible sections, spaced longitudinally grooved elements receiving said fusible sections in the grooves thereof, for increasing the arc voltage along the same under conditions of relatively high overload current, arc escape prevention means longitudinally spaced along said grooved elements and the groove paths thereof, and good electrical and heat conducting means located between said grooved elements and being in electrical and heat conducting relation with said fusible sections to prevent fusion thereof within a relatively low range of currents of short duration.

15. A fuse comprising, a plurality of parallel fusible elements each of which comprises serially arranged fusible sections, spaced substantially tubular heat wells in heat conducting relation with corresponding fusible sections of all of the fusible elements to prevent fusion thereof within a relatively low range of currents of short duration, substantially tubular elements between said heat wells and having longitudinal external grooves for receiving said fusible sections and increasing the arc voltage along the same under conditions of relatively high overload current, arc escape prevention washers longitudinally spaced on said grooved tubular elements and over the groove paths thereof, and a rod extending longitudinally through said heat wells and grooved tubular elements for supporting the same as a unit.

16. A fuse comprising, a plurality of spaced parallel fusible elements, means at corresponding ends of said elements for electrically connecting them in parallel circuit relation, and a plurality of heat wells spaced along the length of said elements, each of said wells comprising a unitary mass of good heat conducting material extending into heat conducting relation with corresponding points of all of said elements.

17. A fuse comprising, a plurality of spaced parallel fusible elements, means at corresponding ends of said elements for electrically connecting them in parallel circuit relation, and a plu-

rality of means of electrical conducting material spaced along the length of said elements, each electrically connecting corresponding points of all of said elements.

18. A fuse comprising, a plurality of spaced parallel fusible elements, means at corresponding ends of said elements for electrically connecting them in parallel circuit relation, and a plurality of heat wells spaced along the length of said elements, each of said wells comprising a unitary mass of good electrical and heat conducting material extending into electrical and heat conducting relation with corresponding points of all of said elements.

19. A fuse comprising, an elongated fusible element, supporting means for said element comprising spaced sections of insulating material and interposed sections of good electrical and heat conducting material arranged longitudinally of said element and mechanically engaging the same.

20. A fuse comprising, a plurality of spaced,

parallel, elongated fusible elements, supporting means for said elements comprising spaced sections of insulating material and interposed sections of good electrical and heat conducting material arranged longitudinally of said elements, each of said sections being in engagement with corresponding longitudinally spaced parts of all of said fusible elements, and said interposed sections of conducting material being mechanically joined to the portions of said fusible elements in engagement therewith.

HAROLD H. FAHNOE.

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