Nov. 22, 1966 T. F. BRANDT 3,287,526

ELECTRIC FUSE ELEMENT HAVING COOLING TABS

Filed Jan. 17, 1966

Fig. 1.

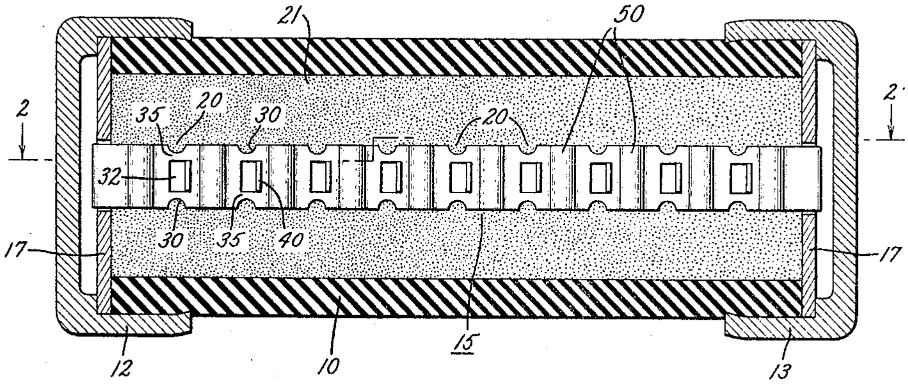


Fig. 2.

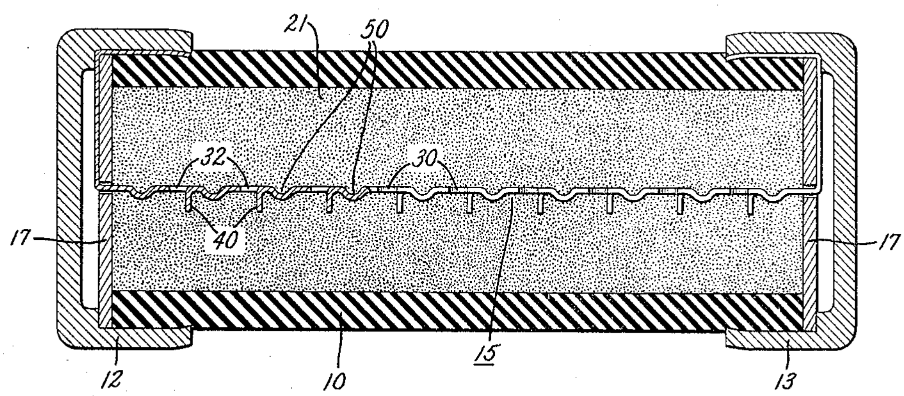
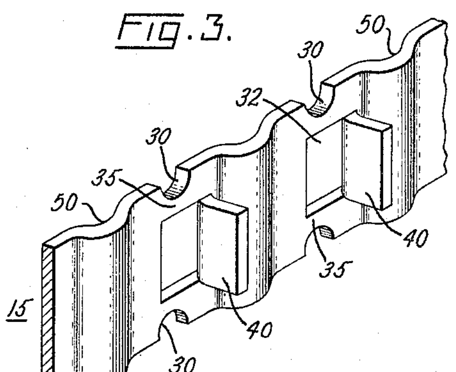


Fig. 3.



INVENTOR:
THOMAS F. BRANDT,

BY William Freedman
ATTORNEY

United States Patent Office
3,287,526
Patented Nov. 22, 1966

1

2

3,287,526
ELECTRIC FUSE ELEMENT HAVING COOLING TABS
Thomas F. Brandt, Swarthmore, Pa., assignor to General Electric Company, a corporation of New York
Filed Jan. 17, 1966, Ser. No. 521,093
4 Claims. (Cl. 200—120)

This invention relates to an electric fuse for protecting a circuit against excessive currents and relates more particularly to a fuse of this type that contains improved means for limiting the temperature rise of portions of the fusible element during short periods of moderate overcurrent.

In the fuse of the present invention, the fusible element is of ribbon-form and comprises a plurality of sections of restricted cross-section located at spaced-apart points along its length. Current flowing through the fusible element produces local hot spots at these regions of reduced cross section, and these hot spots serve to establish the temperature conditions along the element necessary for melting at the desired times. In addition, these regions of reduced cross-section control the rate at which arc voltage builds up when the fuse interrupts a large short circuit current.

In order to obtain the long time delay for moderate overcurrents required in certain protective applications, it is sometimes necessary to provide heat-absorbing masses or other cooling means adjacent the reduced cross-section regions of the fusible element. These cooling means serve during moderate overcurrents to limit the temperature rise of the reduced cross-section regions sufficiently to provide the desired delay in melting.

In prior fuses of this type, the cooling means has either been complicated and expensive to include or has not been as effective as might be desired in providing a time lag of the required duration.

An object of the present invention is to provide, for a fusible element of this type, simple and inexpensive cooling means that can maintain the regions of reduced cross-section exceptionally cool during short periods of moderate overcurrent, yet without interfering with the required rapid interrupting performance during short-circuit conditions.

In carrying out my invention in one form, I provide a ribbon-type fusible element that extends between the usual end caps of the fuse within its insulating casing. This ribbon element has a plurality of regions of reduced cross-section located at spaced-apart locations along its length. Each region of reduced cross-section comprises a pair of notches in the opposed edges of the ribbon and a hole between the notches forming a pair of spaced-apart restricted necks at opposite sides of the hole between the hole and the notches. Integrally attached to the ribbon at an edge of the hole located between the necks is a tab that serves to cool the necks. This tab is formed of the ribbon material that occupied the hole before its formation and is displaced from the plane of the ribbon into a position extending transversely of the ribbon plane. The tab has an area along one of its major surfaces substantially equal to the area of the hole. Because of this very large area, the integrally formed tab is exceptionally effective in cooling the necks, and because of its substantial displacement from the plane of the ribbon, the tab does not interfere with arc-extinguishing action despite its large area.

For a better understanding of the invention, reference may be had to the following description taken in conjunction with accompanying drawings, wherein:

FIG. 1 is a sectional view of an electric fuse embodying one form of my invention.

FIG. 2 is a sectional view along the line 2—2 of FIG. 1.

FIG. 3 is a perspective view of a portion of the fusible element contained in the fuse of FIGS. 1 and 2. The thickness of the fusible element has been exaggerated to facilitate its illustration.

Referring now to FIGS. 1 and 2, the fuse shown therein comprises a tubular casing **10** formed of a suitable insulating material and provided at its opposite ends with electrically conductive terminals **12** and **13**. A ribbon-type fuse element **15**, preferably of silver, is disposed within the casing **10** and electrically interconnects the spaced-apart terminals **12** and **13**. This fusible element **15** is centrally located within the casing **10** by means of suitable washers **17** located at opposite ends of the casing. As shown in FIG. 2, the ends of the fusible element pass through centrally located apertures in the washers **17** and extend over the outer surface of the casing **10** where they are mechanically fastened by crimping cylindrical flanges on the terminals **12** and **13** about the casing **10**.

The fusible element **15** is provided at spaced apart locations along its length with portions **20** of reduced cross-section, which will soon be described in greater detail. Filling the tubular casing **10** between the terminals **12** and **13** is a granular arc-quenching material **21**, preferably quartz sand, in which the fusible element **15** is imbedded.

When the fuse is connected in an electric circuit, current flows between the terminals **12** and **13** through the fusible element **15**. In the event of an electrical overload, the fusible element **15** will melt after a protracted time interval, the duration of which varies inversely with the magnitude of the overcurrent. This melting, which is initiated at one or more of the regions **20** of reduced cross-section, establishes along the length of the fusible element one or more arcs which are quickly extinguished by the reaction between the arc and the surrounding arc-quenching material. This melting and subsequent arc-extinguishing action interrupts the circuit and thus terminates current flow therethrough to provide protection against these over-currents.

In the event of a short circuit, as contrasted to an overload, much higher currents flow through the fusible element **15**. The illustrated fuse is designed to interrupt these higher currents in appreciably less than one-half cycle with a current-limiting action that limits the maximum current permitted to flow to a value appreciably less than the maximum available short circuit current that the system is otherwise capable of supplying. This current-limiting action results from a rapid vaporization of the reduced cross-section regions of the fusible element by the high short circuit current, followed by rapid arc-extinguishing action produced by the reaction of the filler with the resultant arcs.

Each region of reduced cross-section is formed by providing the ribbon element **15** with a pair of aligned notches **30** in its lateral edges and a hole **32** between the notches **30**. The notches **30** are preferably of a substantially semicircular configuration and the hole **32** is preferably of a rectangular configuration. The narrow strip of metal that remains between each notch **30** and the adjacent edge of the hole **32** is referred to as a neck, which is designated **35**. It will be apparent from FIG. 1 that each region of reduced cross-section includes two of these necks **35**, one at each side of the hole **32**.

The minimum cross-section area of these necks must be rather rigidly limited in order to achieve the desired performance under short circuit current conditions. In this respect, the cross-sectional area determines the melting time and influences the amount of energy that the fuse allows through during the period between short circuit-initiation and interruption, i.e., the let-through energy.

When this cross-sectional area is reduced to a low enough value to produce the desired performance on short circuit currents, then it becomes difficult to provide a time lag of the desired duration for moderate overcurrents. In this regard, because of their highly restricted cross-section, the necks **35** have a tendency to melt on moderate overcurrents before expiration of the desired time lag. I am able to overcome this problem by providing at each reduced cross-section region a tab **40** that is integral with the fusible ribbon and extends transversely of the main body of the ribbon. This tab **40** is formed by piercing the ribbon with a suitable tool that is driven perpendicular to the ribbon during the piercing operation. This tool severs the ribbon along three sides of the rectangular hole **32** but not along the fourth side, which is located between the necks **35**. Further movement of the piercing tool along its path perpendicular to the ribbon displaces the resulting tab from the plane of the ribbon, bending it into a plane perpendicular to the plane of the ribbon, as shown in FIG. 2. The notches **30** in the edge of the ribbon are preferably formed simultaneously with the hole **32** and by suitably shaped portions of the same tool.

I have found that for a given energy input into the fusible element **15**, the temperature rise at the necks **35** is directly proportional to the surface area of the fusible element in the region of reduced cross-section. I am able to make available a near maximum surface area because no significant amount of metal is removed from the ribbon **15** by formation of the tab **40**. The metal of the tab **40**, instead of being removed, remains integrally attached to the ribbon and is simply displaced into a position where it extends transverse to the main body of the ribbon.

Although the exact angle that the tab is displaced with respect to the body of the ribbon is not crucial, it is important that the tab be displaced substantially from the plane of the ribbon body, preferably by at least about 45 degrees. If the tab was not displaced by a substantial amount, there would be a very short gap between its free end and the adjacent body of the ribbon. When the necks **35** of such a fuse melted on an overload and an arc voltage began building up, this gap at the free end of the tab would flash over and current would begin flowing through the tab. Portions of the tab would melt and vaporize, thus greatly increasing the amount of silver requiring dispersal before an interruption could be completed, thus unduly prolonging arcing and unduly increasing the let-through energy. I am able to prevent the tab from interfering in this manner with the arc-extinguishing performance of the fuse, even though the tab is of a near maximum size, because of its large displacement with respect to the main body of the fusible element.

Since the tab **40** is integral with the main ribbon body, the joint between the tab and ribbon is an ideal one for effecting rapid heat transfer to the tab. Since the tab is imbedded in the surrounding filler, it can transfer to the filler the heat thus received.

My fuse is highly resistant to mechanical damage for a number of reasons. One is that it has a plurality of necks instead of only a single neck at each reduced cross-section location, and this improves its mechanical stability and its resistance to damage through twisting and other forces. Another reason is that the notches **30** are rounded to reduce stress concentrations, and the necks **35** are very short to reduce the heating that occurs at the notches under normal currents and mild overcurrents. This cooler operation also results in greater mechanical strength.

Perhaps the most severe mechanical stresses are those applied by the thermal conditions resulting from motor-starting duty. Here, current several times rated flows for a short time and heats the fusible element substantially but not to melting. This tends to expand the element with respect to its original mounting, thereby mechanically stressing the element. But in the illustrated fuse, it has been found that the tabs **40** keep the necks **35** so cool during such conditions that such thermally-induced stresses are limited to very low levels.

Further resistance to damage through mechanical stresses is provided by corrugations or bends **50** of substantially semicircular cross section provided between each region of reduced cross-section. These corrugations **50** extend across the ribbon between its laterally-opposed edges. These corrugations increase the surface area that is available for cooling, thereby further helping to keep the necks **35** cool under moderate overcurrent conditions, and also providing a preferred region for expansion and contraction in response to temperature changes. These corrugations **50** also increase the length of fusible element present between the adjacent regions **20** of reduced cross-section. This increased length helps to maintain segregation between the series-related arcs established at the reduced cross-section regions under short circuit current conditions, thus assuring sufficient arc voltage being developed during short circuit interruptions.

By way of specific example and not limitation, in a typical fuse embodying the invention, the thickness of the ribbon-type fusible element is .0145 inch, its width .274 inch; and its length approximately 5 inches. The necks **35** each have a minimum width of .015 inch. The notches **30** have a radius of .031 inch, and their centers are $\frac{5}{16}$ inch apart, measured lengthwise of the ribbon. Each hole **32** has a dimension of $\frac{5}{64}$ inch, measured along the length of the ribbon and .182 inch, measured along the ribbon width.

Although I have shown only the single fusible element being connected between the terminals of the fuse, it is to be understood that for higher current fuses, a plurality of such elements connected in parallel will be used.

While I have shown and described particular embodiments of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention in its broader aspects; and I therefore, intend in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In an electric fuse comprising a hollow casing of insulating material, conductive end members at opposite ends of said casing, an arc-extinguishing filler within said casing, and a conductive fuse element of ribbon form imbedded within said filler and electrically connecting said end members;

(a) said fuse element having a plurality of regions of reduced cross-section located at spaced apart locations along its length,

(b) each reduced cross-section region comprising a pair of notches in the opposite edges of said ribbon and a hole between said notches forming a pair of spaced-apart restricted necks at opposite sides of said hole between the hole and said notches,

(c) and tab means integrally attached to said ribbon at edge regions of said hole located between said necks, said tab means being formed of the ribbon material that occupied said hole prior to formation of the hole,

(d) said tab means being displaced from the plane of said ribbon into a position extending transversely of said plane and having an area along one of its major surfaces substantially equal to the are of said hole.

2. The fuse of claim **1** in which said tab means is a single tab integrally attached to the ribbon at one edge of said hole between said necks.

3. The fuse of claim **1** in which said tab means is a single tab integrally attached to the ribbon at one edge of said hole between said necks, and in which said tab is angularly displaced from the plane of said ribbon by at least substantially 45 degrees.

4. The fuse of claim **1** in which said ribbon contains corrugations formed therein in locations between said regions of reduced cross-section, each of said corrugations

extending transversely of said ribbon between opposite edges thereof.

References Cited by the Examiner

UNITED STATES PATENTS

1,774,252	8/1930	Bussmann	200—135
1,974,119	9/1934	Naher	200—135
3,189,712	6/1965	Kozacka	200—120

References Cited by the Applicant

UNITED STATES PATENTS

2,004,191	6/1935	Bussmann.
2,471,176	5/1949	Von Hoorn.
2,489,501	11/1949	Rensner.
2,988,620	6/1961	Kozacka.

FOREIGN PATENTS

541,116	11/1941	Great Britain.

BERNARD A. GILHEANY, *Primary Examiner.*

H. B. GILSON, *Assistant Examiner.*