V. HOPE.

FUSIBLE CUT-OUT FOR CONTROLLING ELECTRIC CIRCUITS.

APPLICATION FILED JUNE 13, 1912.

1,068,341.

Patented July 22, 1913.

2 SHEETS—SHEET 1.

FIG. 1A.



FIG. 1.

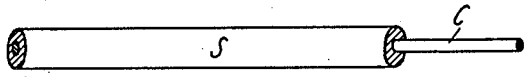


FIG. 2A.



FIG. 2.

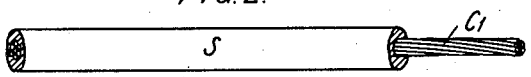


FIG. 3A.



FIG. 3.

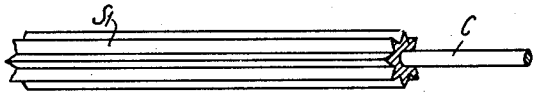


FIG. 4A.

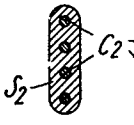


FIG. 4.

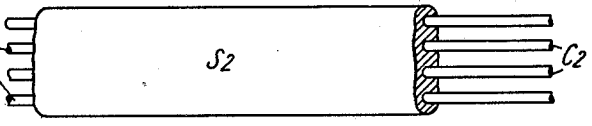


FIG. 5A.



FIG. 5.

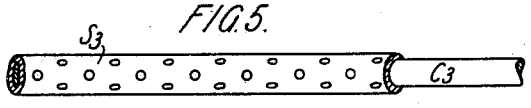


FIG. 6A.



FIG. 6.

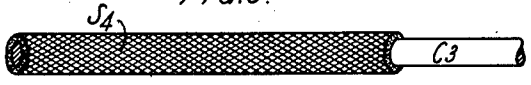
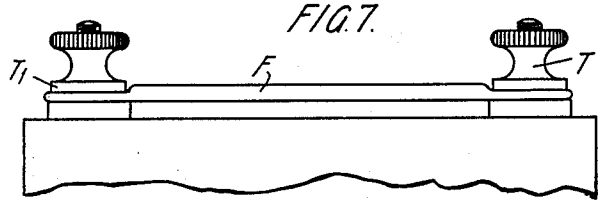


FIG. 7.



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FIG. 10.

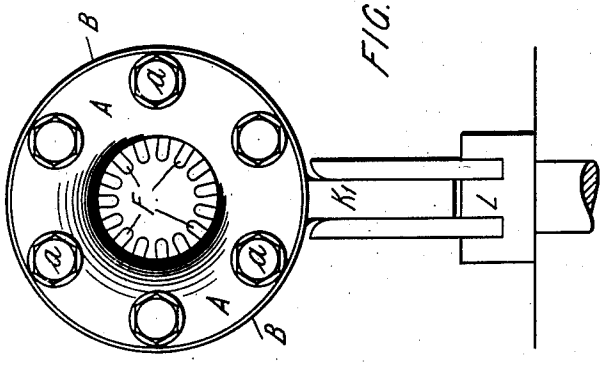
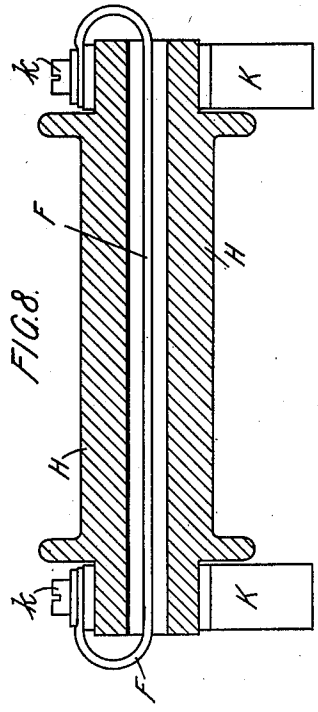


FIG. 8.



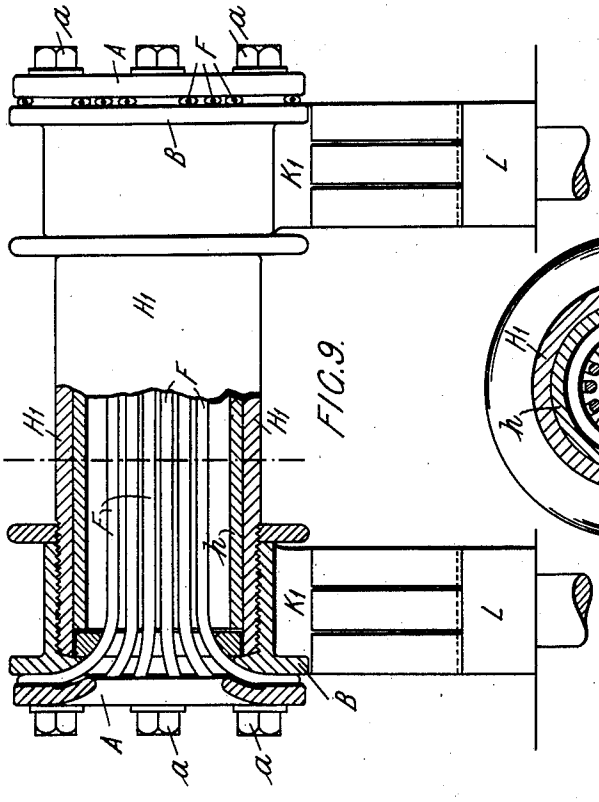
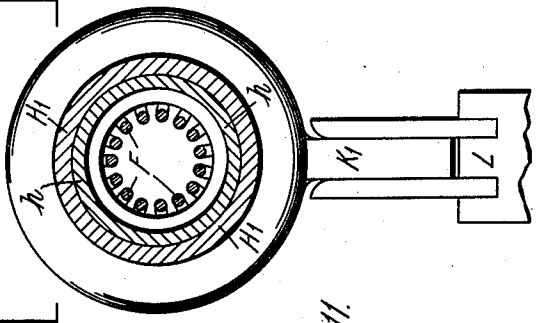


FIG. 9.

FIG. 11.



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FUSIBLE CUT-OUT FOR CONTROLLING ELECTRIC CIRCUITS.

1,068,341. Specification of Letters Patent. Patented July 22, 1913.

Application filed June 13, 1912. Serial No. 703,552.

To all whom it may concern:

Be it known that I, VERNON HOPE, a subject of the King of Great Britain, and residing in Manchester, England, have invented certain new and useful Improvements in Fusible Cut-Outs for Controlling Electric Circuits, of which the following is a specification.

This invention relates to fusible cut-outs for electric circuits, which for the sake of brevity will be termed fuses, and has reference more particularly to fuses made up of two metals, the one having a high electrical conductivity and a relatively high temperature fusing point and the other a relatively low temperature melting point, so arranged that an excess current melts the latter at a comparatively low temperature, whereupon the whole of the excess current is carried by the former, the cross-sectional area of which is such that it is quickly fused by this current.

The objects of the present invention are to so arrange the two metals as to provide a fuse, in which the fusing current shall be very little in excess of the normal current which can be continuously carried by the fuse; in which the total cross-sectional area shall be small in relation to the normal current; in which the resistance and therefore the heat developed while carrying the normal current is small; and in which the fusing shall take place quickly when the current exceeds the maximum.

The two metals used are preferably copper and tin, or a tin-lead alloy, the former having a high conductivity and a relatively high fusing temperature, and the latter a relatively low melting point, but other pairs of metals having these characteristics may be employed.

I prefer to arrange the fuse in the form of a cylindrical wire of tin or tin-lead alloy provided with an inner core of stranded copper wires; the relative cross-sectional areas are determined by the following considerations:—Let A be the normal current, and c and t the portions thereof carried, say by the copper and the tin respectively, so that

$$A = c + t;$$

then, if R be the resistance of the fuse, the heat developed will be $C^2.R.k$, where k is a constant. The radiating surface of the fuse is such that under ordinary working atmospheric temperature this quantity of heat is radiated from the fuse and terminals when the temperature of the fuse is safely below the temperature t at which the tin melts. Assuming that the fusing current is A^1, then the heat represented by $(A^1)^2.R.k.$ is such that the fuse will not radiate it at ordinary atmospheric temperatures until its temperature is higher than that at which the tin melts, and the cross-sectional area of the copper must be such that when it has, on the melting of the tin, to carry the whole current A^1, the heat developed will be sufficient, in relation to the radiating power of the copper, to raise the temperature of the latter quickly to its fusing point. Thus, while the heat developed by the current c in the copper and the current t in the tin, is such as can be effectively dissipated without the temperature of the fuse rising beyond that of the melting point of the tin, the current A^1 carried by the copper alone develops more heat than can be dissipated without raising the temperature beyond that of the fusing point of the copper. It is desirable therefore to have a comparatively high radiating power while the fuse is intact, and a comparatively low radiating power when the tin has melted, and the arrangement of the compound fuse in the form of a tin or the like wire with copper core complies with this requirement, giving a large radiating surface when the current is below the minimum and the tin intact, and a small radiating surface of copper when the excess current melts the tin; the addition of the copper core gives considerable carrying capacity and reduces the resistance; and the stranding of this core gives it the flexibility necessary to prevent the distortion of the outer tin layer due to bending, and so permits of the bi-metallic wire being handled without damage so that it can be vended in rolls or coils in the ordinary way.

It is not necessary to strand the copper core in sizes where a single wire is sufficiently flexible, and as a single wire is a less effective radiator than equivalent strands, there is an advantage in its use.

The invention is illustrated in the accompanying drawings in which—

Figure 1 is an elevation, with a part of the sheathing cut away, and Fig. 1^A a transverse section of a fuse wire with a solid

copper core and a tin or tin-lead alloy sheathing. Figs. 2 and 2A are similar views, showing a fuse wire with a stranded copper core and a tin or tin-lead sheathing. Figs. 3 and 3A are similar views, showing a fuse with a copper core and a tin or tin-alloy sheathing formed with radiating fins. Figs. 4 and 4A are similar views and show a fuse section in which there are several copper cores embedded in a sheathing of tin or tin-alloy. Figs. 5 and 5A are similar views and show a fuse wire with a tin or tin-alloy core and a copper sheathing. Figs. 6 and 6A are similar views showing a fuse wire with a tin or tin-alloy core and a sheathing of fine copper wires woven or twisted thereon. Fig. 7 shows the mode in which the fuse wire is applied to ordinary open type fuse terminals. Fig. 8 shows the fuse wire fitted to an inclosed handle type fuse, the latter being shown in section, and Figs. 9 10 and 11 show multiple fuse wires fitted to an inclosed handle type fuse of comparatively large capacity, Fig. 9 being an elevation partly in section, Fig. 10 being an end elevation, and Fig. 11 an end view in section.

Figs. 1 and 1A show the preferred form; in this case the core C is of copper, and the sheathing S of a tin lead alloy, suitable for application to the core in the manner now well known and adopted in providing a lead sheathing for insulated cables; that is to say, by forcing the alloy under considerable pressure, when heated and in a semi-plastic condition through a suitable nozzle, through the center of which the copper wire is drawn, being coated or sheathed with the alloy as it emerges. The proportions of tin and lead may be varied, but sufficient lead must be added to enable the alloy to flow through the nozzle as described.

In Figs. 2 and 2A the copper core C^1, instead of being solid, is stranded. As stated, in larger sizes of fuses, the stranded core is preferable, as it will bend more readily without distorting the sheathing.

In Figs. 3 and 3A the sheathing S^1, instead of having a plain cylindrical periphery, is so drawn as to form a series of longitudinal fins as shown, which increase the radiating surface.

In Figs. 4 and 4A a number of separated copper cores C^2 are inclosed in the one sheathing S^2 so as to form a tape; obviously the separate cores C^2 may be replaced by a ribbon of copper.

In Figs. 5 and 5A, the core C^3 may be of tin or tin lead alloy, and the sheathing S^3 of copper may be in the form of a tube having thin walls and being preferably perforated; or the tin lead alloy may be coated electrolytically or otherwise with copper, preferably in a granular state, so applied as to leave interstices for the escape of the core when it melts.

Figs. 6 and 6A show a modification equivalent to the last mentioned arrangement, in which the copper sheathing S^4 consists of fine copper wires loosely woven, braided or twisted on to the core.

I find that the last two modifications, while forming effective fuses, and providing very effective low resistance contact with the terminals, do not give as good results as when the metal of low melting point forms the sheathing, since, when the metal of low melting point melts, it does not get away so freely, nor is the radiating surface of the fuse wire so effectively reduced when the metal of low melting point melts.

Fig. 7 shows the bi-metallic fuse wire F used in the ordinary way between the terminals T and T^1 of an open type fuse.

Fig. 8 shows the bi-metallic fuse wire F applied to an inclosed handle type fuse consisting of a hollow handle H carrying terminal contacts K to which the fuse wire is attached by screws *k*.

Figs. 9, 10 and 11 show an arrangement in which a number of bi-metallic fuse wires are fitted to an inclosed handle type fuse. The ends of the fuse wires F are gripped between the flanges A and B which are metallically connected to the contacts K^1, the latter being mounted on a fiber handle H^1 which is lined with fire-proof material *h*. The flanges A and B are drawn together by screws *a*. L are fuse sockets into which the terminal plates K^1 enter.

Pairs of metals possessing the characteristics described, other than copper and tin lead alloy, may obviously be used in the manner described, the high fusing point metal having preferably a comparatively high electrical conductivity, as is the case for example with copper; or in some cases a third metal having characteristics intermediate between the other two may be employed, so that the three metals melt or fuse in succession; and fuse wires of different cross-sectional areas than those shown (which are those I have found to give good results in practice) may be employed.

The low melting point metal must constitute a considerable proportion of the total cross-sectional area, and when applied as a sheathing, its walls must have substantial thickness, otherwise the characteristics of the fuse will practically be that of the high fusing point metal only; the precise proportions of the relative cross-sectional areas will to some extent depend upon the electrical conductivities of the respective metals.

When the fuse carries the current at which it is designed to blow, the metal of low melting point of course melts first, and the metal of high fusing point carries the current for a sufficient length of time to allow the metal of low melting point to fall away, so that when the final rupture of the

fuse takes place, the low melting point metal is not volatilized by the momentary arc formed.

On securing the bi-metallic wire in the fuse terminals, the wire should when it has a copper core, be screwed down so as to flatten the sheathing and practically make contact with the copper core.

When a fuse is on the point of blowing, the tin melts, and the melted tin thus gives the attendant a premonitory warning which may be of use in averting an interruption of the supply by a reduction of the current till it is convenient to replace the fuse; in the case of a series of handle fuses the presence of the melted tin indicates clearly the fuse which has blown.

The compound fuse wire would usually be manufactured in lengths and of sizes to give standard ratings.

Fuses constructed as described will carry as much as 90 per cent. of the full load current without undue heating, and without oxidizing, and such fuses have a definite time element, and for short periods will carry considerably more than the full load current, say six times the full load current; and are thus particularly useful in controlling small alternating current motors where the starting current is excessive.

When used in inclosed replacement or handle fuses, the carrying capacity is somewhat reduced, but such fuses are much more reliable when used in this way than is the case with single metal fuses.

Having now fully described my invention, I declare that what I claim, and desire to secure by Letters Patent is:—

1. A fuse consisting of two metals, the one having a relatively high fusing point and the other having a relatively low fusing point, one of the said two metals forming a sheathing for the other one; substantially as described.

2. A fuse consisting of a copper and a tin-lead alloy, one of the said two metals forming a sheathing for the other one, substantially as described.

3. A fuse consisting of a core of metal having a high fusing point and of a sheathing therefor of metal having a low melting point; substantially as described.

4. A fuse consisting of a core of copper and of a sheathing therefor of tin-lead alloy; substantially as described.

5. A fuse consisting of two metals the one being arranged in the form of multiple wires and the other as a sheathing therefor; substantially as described.

6. A fuse consisting of multiple wires of copper and a tin-lead sheathing therefor; substantially as described.

7. A fuse consisting of two metals having different fusing points the one metal forming a sheathing for the other, the combined cross-sectional area of which two metals is sufficient to carry the rated current without undue heating, the area of the metal of higher fusing point being too small to carry the rated current; substantially as described.

8. A fuse consisting of a plurality of metals one of which has a higher melting point than the others and one of which forms an outer sheathing; substantially as described.

In testimony whereof, I affix my signature in presence of two witnesses.

VERNON HOPE.

Witnesses:
ALICE S. ALLEN,
JOSEPH E. HIRST.