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S. J. SPURGEON ET AL

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ELECTRIC FUSE

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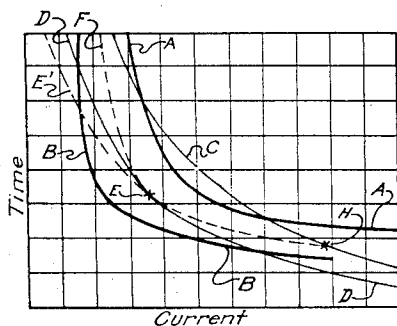


Fig. 1



Fig. 2

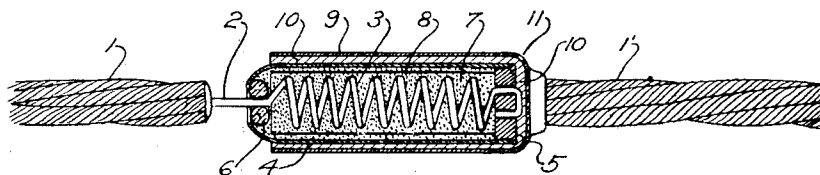


Fig. 3

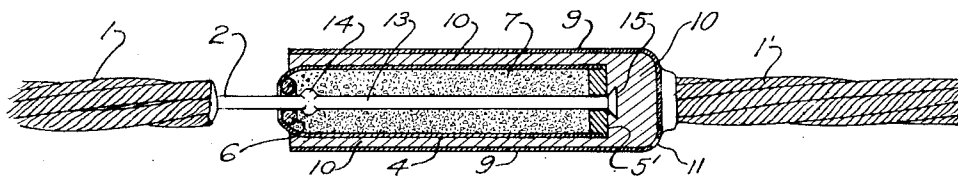


Fig. 4

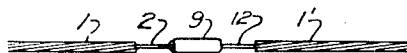


Fig. 5

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ELECTRIC FUSE

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7 Claims. (Cl. 200—113)

The object of our invention is to provide a fusible link which will melt at a relatively low temperature, which has a protected heating element separate from the protecting sleeve, which volatilizes a relatively small amount of metal, and which is of a design that allows a wide variation in proportions with a consequent wide variation in time-current-release characteristics.

It is in many cases desirable that the characteristics of a fuse be similar to those of the relays which operate circuit breakers which are connected to the same transmission line otherwise poorly coordinated operations will occur. The matter is often one where a few seconds make a radical difference in results, and we have found after many tests that our fuses, made as described, give better results than any others with which we are familiar. Some of the advantages are:—the soldered joint is heated from the inside and no radiation losses occur in the transfer of heat from the heating conductor to the soldered joint; there is good conductivity between the joint and the large end-conductors and this carries away considerably more heat than would a small conductor, therefore the heating effect is cumulative over a shorter period; in small amperage sizes the heating effect is much higher than with a straight conductor so that changes in ambient temperatures are relatively less important.

Referring to the drawing, Fig. 1 shows certain time-current-release curves; Fig. 2 shows the general appearance of one of our fuse links; Fig. 3 shows an enlarged cross-section of the fuse-link; Fig. 4 shows an enlarged cross-section of an alternate construction for the fuse link; and Fig. 5 shows a general view of another alternate construction.

A flexible conductor 1 is attached by a solder which consists of 60 percent copper, 20 percent tin, and 20 percent zinc, to a smaller conductor 2 which continues as a coil 3 inside of a metallic sleeve 4, the sleeve and coil being connected together by the metal plug 5. A collar 6 of glass or other suitable insulating material prevents contact between the conductor 2, 3 and the crimped end of the sleeve 4. The space 7 between 3 and 4 is filled with a soft plastic cement which afterwards hardens and becomes a hard electrical-insulating heat-conducting material. A mica sleeve 8 may also be used to provide additional insulation if desired.

A conductor 1' is attached by a solder which consists of 60 percent copper, 20 percent tin, and 20 percent zinc, one end of a sleeve 9 which

is slipped over the sleeve 4, and the two are soldered together by a low-temperature metal which also fills the space 10. This solder preferably consists of equal parts of lead, tin and bismuth and it melts at a much lower temperature than the solder used elsewhere. A small hole 11 prevents the formation of an air-pocket, or a vacuum, between 4 and 9.

In Fig. 4 the conductor is too large to form a coil and it is continued as a straight member 13 which has a flattened place 14 near the insulating ring 6, and an end 15 which is in contact with the metal plug 5. In other respects it is similar to the construction shown in Fig. 3.

Fig. 5 shows a construction which can be used when slightly modified characteristics are desired. This is similar to Fig. 2 except that the conductor 1' has a small section 12 where it attaches to 9.

The operation is that current in passing through the device between 1 and 1' goes from 2 to the plug 5, or the plug 5', without any of the current being carried longitudinally by 4 or 9 which does not also go through the heating element 3, or 13. The relative heating effect of current in 3, or 13, is so great that the heating effect of current flowing through the solder is negligible. The direct path of current flow is from the plug 5 through the solder directly towards the conductor 1' but a small amount of current probably flows backwards from 5, or 5', into 4 and then outwardly through the solder to the sleeve 9 and so to the conductor 1'. The parts are so close together that the observed results are a general heating up of the whole joint until the solder 10 reaches its melting temperature and the external tension on the link then pulls 4 out of the sleeve 9. Therefore, the enlarged joint 4, 9 does not reduce the resistance of the conductor 2, 3 or 2, 13. Many other fuses have been made with joints larger than the adjacent conductor but when such a joint is solid metal the resistance per unit of length is far less than that of the adjacent conductor. On the contrary our coil 3, which is used for fuses of low amperage capacity, has a greater heating capacity per unit of length than that of the conductor 2, and even the construction in Fig. 4 maintains in 13 the same relative heating effect as in 2.

The heat which is released inside of 4, as well as some heat released in the portion of the conductor marked 2, acts to heat 4 and 9 to a temperature that will melt the solder at 10 so that the device pulls apart with the slight strain which is imposed on it in service.

The results we secure can best be analyzed by the curves in Fig. 1. Assuming that A is the curve of the breaker at the main generating station from which the high tension line is supplied, and that B is the curve of the low voltage breaker at one of the substations fed from this line, then the high tension fuse between the transmission line and the transformers at the substation should have a curve lying between A and B. But the curve of a straight fuse of high melting temperature is similar to C; and if the fuse had a low melting temperature, but otherwise were unchanged, its curve would be like D.

We can make a fuse of our design in any desired size. Let us choose a size which will have a time-current-release curve that passes through the point E.

Our fuse has a low melting point and negligible radiation between the part where heat is released and the soldered joint; also compared with a straight wire our fuse has a high rate for conducting heat away from the joint, and until the critical load is reached heat is conducted away from the joint as fast as released. As a result the time-current-release curve of our fuse on light loads diverges from the curve D and may be represented by the dotted line at F. For the higher overloads a new factor affects the curve. There is a slight delay in the conduction of the heat from the internal conductor through the cement to the soldered joint. When the overload becomes heavy enough, the short section of exposed conductor 2 is fused before the soldered joint is melted. Therefore, this portion of the curve finally reaches C at H.

In Fig. 1 no scale is given for either time or amperes, but the comparative relations between the various curves are the same regardless of the scales at which the curves are plotted.

Altering the relative proportions of the different parts of our fuse-link makes possible a considerable modification of the curve. In this way we make fuse-links which are co-ordinated with the time-current-release curves of a wide variety of breakers at main stations or substations.

Another condition sometimes occurs. For small transformers on distribution lines there is usually no oil breaker on the low-voltage circuit, and each transformer is only a very small part of the total load on the line to which it is connected. In such case it is advisable that the fuse should act so that it ruptures only on an over-

load which would burn out the transformer. This curve may be represented by E'.

We secure this result by varying the characteristics of the heating element and the relative proportions of the parts. We thus obtain a fuse which a small current will not open unless it is continued for a long period, and if so continued the fuse will open.

We claim:

1. In a fuse, a large conductor connected to a small conductor, one portion of the small conductor being exposed and one portion being surrounded by a low-melting metal which is removed from the direct path of current flow.

2. In a fuse, a relatively large flexible conductor connected to a relatively small conductor, one portion of the small conductor being exposed and one portion being surrounded by a low-melting metal which is removed from the direct path of current flow.

3. In a fuse, a sleeve, a conductor which is partly exposed and partly within the sleeve, insulating material between the conductor and the sleeve and another conductor soldered to the outside of the said sleeve.

4. In a fuse, an external sleeve connected at one end with a relatively large conductor, said sleeve being vented to the atmosphere at each end, together with an internal sleeve soldered within the external sleeve and a relatively small conductor within the internal sleeve.

5. In a fuse, an external sleeve connected at one end with a relatively large conductor, said sleeve being vented to the atmosphere at each end, together with an internal sleeve soldered within the external sleeve and a relatively small conductor within the internal sleeve, and extending outside of the internal sleeve.

6. In a fuse, two relatively large flexible conductors, a relatively small coiled conductor completing the circuit between the said conductors, a metallic sleeve surrounding the coiled conductor, and insulating material between the coiled conductor and the said sleeve.

7. In a fuse, two relatively large flexible conductors, a relatively small coiled conductor completing the circuit between the said conductors, a metallic sleeve surrounding the coiled conductor, insulating material between the coiled conductor and the said sleeve, and a second sleeve soldered outside of the said first sleeve.

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