

W. ARTHUR.
ELECTRIC CUT-OUT.
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1,208,448.

Patented Dec. 12, 1916.

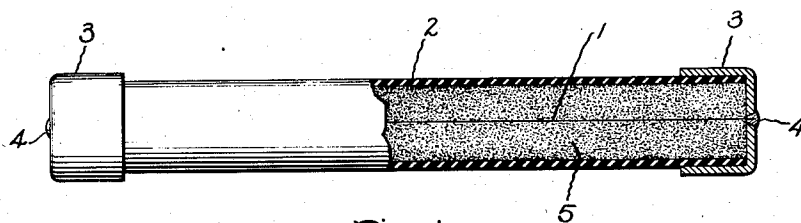


Fig. 1.

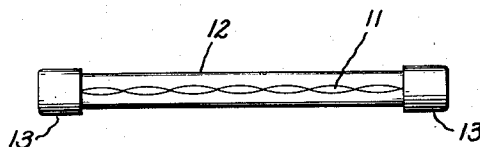


Fig. 2.

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by *Alfred H. Davis*
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UNITED STATES PATENT OFFICE.

WALTER ARTHUR, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTRIC CUT-OUT.

1,208,448.

Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, WALTER ARTHUR, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Electric Cut-Outs, of which the following is a specification.

My invention relates to electric cut-outs in which opening of a circuit under conditions of excessive current flow is brought about by overheating of a fusible member, part, or body in consequence of such flow. Though such cut-outs are very extensively used, it has always been found very difficult, to say the least, to make them sufficiently delicate, accurate, or reliable for conditions of service that were at all exacting, or to be sure that when constructed as nearly alike as possible different ones would be reasonably uniform in their action. It has also been found that even when initially satisfactory such cut-outs were liable to progressive alteration and deterioration which would render them quite unreliable or ineffective after a comparatively short period of service. Such difficulties and defects have been most troublesome in the case of low current overload and short circuit cut-outs of the much-used "fuse" type, in which the fusible member is a conductor (of lead or zinc, for example) forming part of the circuit to be protected,—failure of the fuse to act properly often resulting in the burning out of expensive motors or other valuable apparatus, etc.

I have found that when the fusible member of an electric cut-out is of metallic cadmium all the difficulties above set forth can be overcome, and that various other advantages can be secured. In particular, fuse conductors of cadmium blow promptly when fused, without tending to "hang" in a molten condition; their blowing properties are not substantially changed by any current below the blowing current; and they can be adapted to operate on unprecedentedly small currents with great delicacy and precision. The improvement in these latter particulars arising from my invention is, indeed, very notable; for whereas I have found no difficulty in making a cadmium fuse that would carry a current of 0.4 ampere and blow reliably on 0.55 ampere, the so-called

one ampere fuse, hitherto deemed the smallest practicable, might when new carry anywhere from its rated blowing current of 1½ amperes up to three amperes or over without blowing and after service in which it had several times been subjected to currents approaching its initial blowing current for a couple of seconds at a time might even stand five amperes or more continuously, and some seven amperes momentarily. The superior qualities of cadmium fuse conductors not only increase the protection afforded by a fuse, but also allow "indicator" fuses to be made in smaller sizes than have hitherto been practicable,—down to 1 or 2 amperes, for instance.

The superiority of cadmium to other metals available for the purposes of my invention and its freedom from alteration by currents below the initial blowing current are probably due to a variety of causes; and while I will state the more important ones at present known to me, I do not wish to advance any views as to their relative importance, or as to whether there may not be other causes of equal or greater importance. One important circumstance is the fact that the metal cadmium does not oxidize appreciably at temperatures below its melting point (321.7° C.), and oxidizes but slowly at and just above that temperature, whereas all the other metals that are not disqualified by brittleness, high melting point, etc., do oxidize quite appreciably and rapidly below or at their fusion points. Another important circumstance is the fact that, even when it does form, the oxid of cadmium seems to be weaker than the oxides of the other practicable fuse metals (including those nearest it in resistance to oxidation): At any rate, it certainly fails to hold the molten interior of a fuse conductor as the other oxides will do. In addition, the vaporizing temperature of cadmium (778° C.) is substantially lower than that of any other metal at all suitable for fuses, so that a cadmium fuse will blow very quickly on a heavy short circuit. Incidentally, it may be mentioned that cadmium is not excessively expensive, has a moderate resistance, can be easily squirted, rolled, and otherwise worked when cold, and is quite strong even when in the form of very thin ribbon or foil. Cadmium is, indeed, uniquely

adapted for very thin fuses by reason of its non-oxidizing and uniform blowing properties above referred to.

I have hereinafter illustrated and described several forms of cadmium fuse cut-outs that are simple and rugged in construction and easy and cheap to manufacture. While the structures shown and described are the best for the purposes of my invention at present known to me, and while my invention extends even to various specific features and details of these particular structures, yet the invention is not confined to such details, but can be otherwise carried out and embodied. Moreover, my invention is not in all respects limited to the use of cadmium, since certain novel features hereinafter shown and described are applicable to fuses whose conductors are not of this metal.

In the accompanying drawing, Figure 1 shows a fuse constructed in accordance with my invention, certain parts being in section. Fig. 2 shows a fuse constructed differently from that of Fig. 1, and having its conductor in a different form.

Referring first to Fig. 1, it will be seen that the fuse here shown is of the so-called "inclosed" type, the cadmium fuse conductor 1 being arranged within a cylindrical tube or shell 2 of fiber or other insulating material. The ends of the tubular casing or shell 2 are closed by ordinary caps 3 of brass or other metal which serve as the current terminals of the fuse, and the conductor 1 is directly secured to these caps by being passed through central holes 4 in them and soldered fast. As shown, the conductor 1 is surrounded by a filling of finely divided material 5. Except in the case of the very smallest fuses, I usually prefer to make the fuse conductor 1 in the form of very thin ribbon, since I find that when a ribbon conductor melts the capillary force or surface tension acts to deform it into a more or less cylindrical form, and that if it is thin enough in proportion to its width the very material deformation that it thus suffers causes it to blow very promptly and sharply indeed. Contrary to what might, perhaps, be expected, the presence of a proper filler does not seem to interfere with the capillary effect, but rather tends to break the molten ribbon by its weight and hasten the blowing.

I find that the uniformity and the action of fuses are improved by careful centering of the conductor 1 in the tube 2, by uniform packing of the filler 5, by not using too much filler or packing it too tight (the more or the tighter the filler, the longer the blowing time of the fuse), and by employing a filler that can in practice be made to have uniform heat capacity and to afford the fuse conductor uniform heat insula-

tion,—uniform, that is, both all around the conductor and throughout its length and also in different fuses. Of course it is also important that the filler should not interfere with or counteract the tendency of the conductor to break, and that when the fuse blows it should act to diffuse the liquid or vaporous metal in such a way as to counteract any violent explosive tendency. Superior results can be obtained by using as a filler loose particles of silicic acid in a light, voluminous form, preferably rather finely granulated or even powdered,—the silicic acid that I prefer being hydrated acid such as is commercially known as "Merck's silicic acid, pure, wet process" (made, I believe, by adding hydrochloric or other acid to a solution of sodium silicate or water glass, washing the precipitate, and drying it at a moderate temperature), whose total water content as found by heating at a relatively high temperature until the weight becomes constant is about 14.16%, corresponding to the formula $H_2Si_2O_5$ or $2SiO_2 \cdot H_2O$. As this material contains an amount of very fine particles or dust sufficient to annoy those working in a room where fuses are filled, I usually prefer to prepare it for use by shaking it thoroughly on a sieve of very fine bolting silk, rejecting all that passes the sieve.

For the aid of those wishing to practise my invention, I will now give some detailed data regarding fuses for particular capacities; but this information is to be regarded rather as an aid in the design of fuses according to the needs of particular services than as indicating an exact standard to be followed in particular cases, since exact duplication of results is so dependent on exact duplication of materials and methods that the exercise of some judgment in dealing with the materials at hand may often be necessary.

A fuse to carry 4 amperes and blow almost instantly on 50% overload, suitable for 500 volt circuits or for lower voltages, can be made with ribbon of commercial cadmium 2 mils thick, 65 mils wide, and $4\frac{1}{4}$ inches long. The casing for such a fuse conductor may be a fiber tube about $\frac{5}{8}$ of an inch in external diameter and $\frac{1}{8}$ of an inch thick, a filler of hydrated silicic acid prepared as above described being used and being "packed" merely by a slight shaking or tapping of the tube after it is poured in, and care being taken to have the tube quite full when it is sealed up. For similar voltage conditions and a blowing point of the same percentage overload a 3 ampere fuse can be made of the same length of 2 mil ribbon 56 mils wide, exactly the same casing and filler being employed. For 250 volt circuits and a blowing point of the same percentage overload, a 2 ampere fuse can be made of about

1 $\frac{1}{8}$ inches of 2 mil ribbon 26 mils wide, the fiber tube casing being about $\frac{1}{2}$ inch to $\frac{7}{16}$ of an inch in external diameter and $\frac{1}{16}$ of an inch or more thick, and the filler being un-
 5 prepared hydrated silicic acid to the amount of about 0.78 gram. Again, for circuits of about 250 volts or less, a fuse to carry 0.4 ampere and blow almost instantly on 0.55 ampere can be made with cadmium wire 2.2
 10 mils in diameter and about $1\frac{1}{2}$ inches long, the casing being of the same fiber tubing as that of the 2 ampere fuse just described and the filler being likewise unprepared hydrated silicic acid.

15 Referring, now, to Fig. 2, it will be seen that the fuse conductor 11 shown is merely inclosed in a glass tube 12 with metal caps 13 cemented or otherwise secured on its ends, no filler being employed. In this fuse the
 20 conductor 11 is in the form of thin ribbon; but instead of being flat the ribbon is twisted about its own center line to the extent of about 9 half turns. The twist can conveniently be given the ribbon 11 after one end
 25 of it has been soldered in the hole in the corresponding cap 13, preparatory to soldering the other end fast in the other cap. The twisting insures that in case the ribbon 11 sags far enough to come against the wall of
 30 the tube 12, it will come in contact therewith merely for a short distance along its edge instead of throughout its width, so that the cooling of an excessively sagged fuse ribbon by conduction through the glass will be a
 35 minimum, and its blowing point and time of blowing will be raised as little as possible. There is also reason to believe that the twist somehow reduces the tendency of the ribbon to sag. Obviously, the deformation of the fuse conductor 11 by surface tension when fused is freely permitted in this
 40 type of fuse as well as in the other.

For various well known reasons, fuses of

the type shown in Fig. 2 will ordinarily be made only in small sizes. A $3\frac{1}{2}$ -ampere fuse 45 of this type to blow almost instantly on 50% overload suitable for a 125 volt circuit may be made of 2 mil ribbon 47 mils wide and about $1\frac{1}{4}$ inches long, the glass tube inclosing it being about .203 inch in external di- 50 ameter and $\frac{1}{32}$ of an inch thick. A $2\frac{1}{2}$ ampere fuse for similar conditions and blowing point may be made of the same length of 2 mil ribbon 35 mils wide, and a $1\frac{1}{4}$ ampere fuse of the same length of 2 mil ribbon 18 55 mils wide, the inclosure being like that for the $3\frac{1}{2}$ ampere fuse in both cases.

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

1. A fusible electric cut-out member of 60 metallic cadmium.

2. An electric fuse conductor of metallic cadmium, substantially free from oxidation at any temperature below that of fusion, blowing promptly when fused, and substan- 65 tially unchanged as regards blowing properties by any current below the blowing current.

3. An electric fuse comprising a conductor of metallic cadmium in the form of ribbon 70 so thin as to be materially deformed by surface tension when fused, said conductor being mounted in an environment which freely permits such deformation.

4. An electric fuse comprising a conductor 75 of metallic cadmium in the form of thin twisted ribbon, said conductor being in contact with other material only at its ends, and a tubular casing inclosing said conductor. 80

In witness whereof, I have hereunto set my hand this 25th day of February, 1914.

WALTER ARTHUR.

Witnesses:

ROY WINNE,
HELEN ORFORD.