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J. PARISOT

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ARC LAMP CATHODES

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Fig. 1

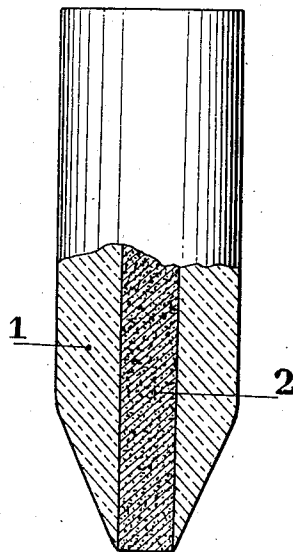
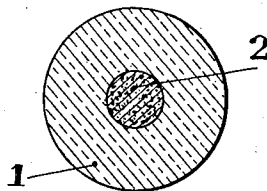


Fig. 2



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UNITED STATES PATENT OFFICE

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ARC LAMP CATHODES

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9 Claims. (Cl. 176—134)

This invention relates to cathodes for the high-intensity arc, particularly for motion-picture projection. It is well-known to those skilled in the art of the projection of light that the high-intensity arc (so-called chiefly because of the abnormally high operating current densities used) has characteristics which sharply distinguish it from all other types of arc, and indeed from all other types of light source. Until the advent of the high-intensity arc there was no other light source available that could even approach the intrinsic brilliancy of the ordinary carbon arc. The high-intensity arc has, however, made available a stable light source that far exceeds the carbon arc in brilliancy.

The production of the high-intensity arc is dependent upon the observance of certain well-known and well-defined conditions of operation and of electrode composition, construction and arrangement. The anode is a cored carbon having a shell of the purest carbon obtainable and a relatively large carbon core (usually one-half the diameter of the shell) which is strongly mineralised (approximately 50-75% by weight of the core) with rare earth fluorides or oxides. Such is the standard type of high-intensity arc anode commonly in use, although certain modified compositions for the core have been more recently developed. The cathode, on the other hand, has a small carbon core which is unmineralised or only slightly mineralised, its shell consisting of the purest carbon obtainable. When mineralised, the cathode core consists of a mixture of carbon and substances the vapours of which are highly conductive for the arc, usually alkali compounds. Most frequently, silicates of potassium or sodium are chosen as the alkali compounds, or mixtures of these silicates with the borates or carbonates. The amount of mineralisation, calculated by weight, is a maximum of 20% of the total weight of the core.

Such an anode and cathode are paired, for operation on direct current, one customary pairing being, for instance, an anode of 8 mm. diameter having a core 4 mm. in diameter, with a cathode of 7 mm. diameter having a core of diameter in the neighbourhood of one-quarter or one-third of the cathode diameter. The high-intensity arc can be produced on alternating current by pairing two anodes as above described intended for direct current operation, but it has been found impossible to establish the high-intensity arc between two of the above described cathodes intended for direct current operation.

It has been found by experience that the paired

anode and cathode give rise, in the arc, to the formation of the rare earth carbides, and these carbides tend to attach themselves to the negative point. It results from this that the electronic emission necessary for starting and maintaining the arc is no longer produced exclusively on the core but takes place both on the carbide deposits and on the core. Since these deposits remain liquid at the working temperature of the arc, the drops formed are displaced in an irregular manner due to capillary action and to new deposits of carbide, so that the arc no longer retains the steadiness necessary for good motion-picture projection. Moreover, as these deposits are non-conductors of electricity when once cooled, the cathode thus contaminated does not permit re-ignition after the arc has been extinguished.

Now, a primary object of my invention is to provide an improved cathode for the high-intensity arc by means of which these inconveniences are avoided at least to a much greater extent than has been the case heretofore. With this object in view, I have found that the degree of mineralisation of the cathode core and the nature of the mineralising material are important factors decisive for suppressing the deposition of carbide entirely or at least to an innocuous level. My experiments have shown that the carbide deposits on the cathode have progressively decreased as the mineralisation of the core is increased, but on the other hand the oxygen-containing alkali salts such as those mentioned above usually employed as mineralising material become dangerous when used in too large a proportion, since the silicates and carbonates are reduced at a slight depth in the core where the temperature is already sufficient to permit such reduction, and the gases which are copiously evolved as a result of this reduction entrain fine particles of core which are injurious to the steadiness of the arc. I have found that this difficulty can be overcome by excluding such salts from the core and employing instead alkali salts which are not liable to reduction, for example the simple or complex halides. Therefore, the essence of my invention, briefly stated, is to mineralise the core of the cathode with a controlled proportion of a simple or complex halogenated alkali compound.

Good results have been obtained with the fluorides, chlorides, fluoborates, fluosilicates of potassium and sodium. The corresponding compounds of the other alkali metals may likewise

be used but their high price does not recommend them except in special cases.

Since, as has already been mentioned, the carbide deposit has been found to progressively decrease (from its greatest amount in the case of a cathode with an unmineralised core) with increasing mineralisation, it will be appreciated that this precludes the fixing of an absolutely critical minimum value for the degree of mineralisation. Therefore, the approximate lowest limit mentioned later is not to be taken as necessarily leading to a complete elimination of the carbide deposit but rather to a limitation of the deposit to an amount which is tolerable in that it is compatible with satisfactory operation.

Whereas with too feeble a degree of mineralisation, the formation of the carbide deposit takes place to a very marked and troublesome extent, too great a degree of mineralisation on the other hand causes troubles of another kind since the mechanical stability of the core then becomes insufficient and there is the risk of the sputtering of incandescent matter, which unfavourably affects the steadiness of the arc.

Taking all these factors into consideration, a suitable proportion of the mineralising material has been found to be 30% or more, and preferably in the neighbourhood of 40%, by weight of the core, the remainder of the core being, of course, carbon. Investigation has shown, however, that it is not the proportion by weight which should be more especially considered, but the atomic proportion of alkali metal to carbon. This will be appreciated upon reflection that the various permissible salts have widely differing molecular weights. It has been found that good results are obtained with core proportions of 1 atom of alkali metal to about 2.5-7.5 atoms of carbon. Thus, for instance, if sodium fluoride (NaF) or potassium fluoride (KF) is employed, the proportion can be calculated as one molecule of the fluoride to about 2.5-7.5 atoms of carbon. In the case of sodium fluoride the optimum proportion has been found to be about 1 molecule of this fluoride to 5 atoms of carbon; this corresponds to a proportion by weight of about 40% sodium fluoride. It follows that if an alkali metal salt with bivalent anion is used, such as potassium fluosilicate (K_2SiF_6), the correct proportion calculated according to the preferred range above mentioned is 1 molecule of the salt to about 5-15 atoms of carbon, since a molecule of the salt contains 2 atoms of alkali metal. Among all the salts which can be used some are less to be recommended than others, either because they are sensitive to moisture or because they are expensive. Nevertheless, the results are good if other halides than those mentioned are used, for example the bromides or iodides of potassium or sodium, or the compounds of lithium, rubidium or caesium.

As has already been explained in the foregoing, it is very difficult to fix a minimum for the proportion of the mineralising material. The range, 1 atom of alkali metal to about 2.5-7.5 atoms of carbon, appears from experiments to be the optimum range and is therefore preferred, but nevertheless further experiments have shown that the lower limit, namely 1 to about 7.5, can be extended still lower with useful results.

In the case of sodium fluoride, for example, it has been found that in mineralising the cathode core with up to 18% by weight of the fluoride, the remainder of the core being carbon, the deposits of carbide only occur to a slightly ob-

jectionable extent. With approximately 25% of the mineralising fluoride these deposits are very slight and innocuous. These determinations have therefore led to the conclusion that the lowest limit is of the order of 20% by weight, corresponding in terms of atomic proportion, to 1 atom of alkali metal to approximately 14 atoms of carbon. This limit depends hardly at all on the nature of the alkali metal compounds selected, especially since a somewhat uncertain limit is involved, as has already been emphasized. It appears therefore that a proportion of the order of 1 atom of alkali metal to about 15 atoms of carbon may be admitted as the practical minimum permissible limit.

Thus, the range of proportions which I contemplate employing by my invention is broadly 1 atom of alkali metal to about 2.5-15 atoms of carbon, the narrower range of 1 atom of alkali metal to about 2.5-7.5 atoms of carbon being the preferred one.

These ranges also apply if, in place of a single alkali metal compound, two or more of these are associated, whether the compounds in question contain ions in common or not. In other words, a plurality of alkali metal compounds of the group in question, viz., non-reducible compounds, may be used together, but in such a way as to always maintain a proportion within the range, 1 atom of alkali metal to about 2.5-15 (and preferably 2.5-7.5) atoms of carbon. The use of mixtures has certain advantages since it is thus possible to deal with any disadvantages of a particular salt by diluting it with one or more others more suitable from the same point of view. For example, sodium chloride is obviously the least expensive material of any in the group, but if it is used in any appreciable quantity it crystallizes into more or less large crystals which always retain small quantities of mother liquor, involving the tendency to decrepitation when the carbon is heated by the arc. By associating for example 1-2 molecules of this chloride with three molecules of sodium fluoride, this disadvantage is avoided and at the same time the cost is kept down.

The salts of potassium are often more advantageous than those of sodium because they do not tend to colour the arc yellow. However, I have found that this colouration is quite negligible if the sodium is used only in the cathode, even with the large quantities which I contemplate employing. Nevertheless, if it be preferred the potassium salts may be used either alone or associated with other alkali metal salts. Potassium fluoride, being deliquescent, is not to be recommended for use by itself but it may be incorporated in small quantities along with other salts such as sodium fluoride and potassium chloride.

The accompanying drawing illustrates diagrammatically an embodiment of cathode according to my invention. In the drawing, Fig. 1 shows a cathode in elevation, partly in section in the neighbourhood of the tip and Fig. 2 shows a cross-section.

The cathode comprises a shell 1 of commercially pure carbon and a core 2 which consists of carbon and mineralising material as described in the foregoing. The core 2 has a diameter of the order of about one-quarter to one-third (say about 0.2-0.35) of the diameter of the shell 1. As an example, the preferred mode of preparing such a cathode, the core of which is mineralised with sodium fluoride will now be described. A tube 1

of commercially pure carbon is first prepared, which will constitute the shell of the cathode. This tube is manufactured in known manner by extrusion from a paste of powdered carbon agglomerated with coal tar, the soft tube formed being baked in a neutral or reducing atmosphere in order to carbonise the tar. The tube 1 is made of suitable external diameter (7 mm. being one size normally used) and length for use, the internal diameter of the tubes being made equal to that of the core which it is to contain, for example 1.5 to 2 mm. in the case of a 7 mm. cathode. Into this tube and under suitable pressure is injected a thick paste containing 40% of sodium fluoride and 60% of powdered carbon, by weight. This paste is agglomerated by means of a small quantity of organic binder such as gum arabic, dextrin, various glucidic materials or suitable mixtures of these different substances. The necessary quantity of water for forming a paste of suitable consistency is added, the amount of water depending especially on the particle size of the powdered carbon. When the tube 1 has been filled with this paste it is heated in an oven to a suitable temperature so as to dry and harden the paste and char the organic binder sufficiently to avoid any evolution of tar or odours when the carbon is in use. Thus the core 2 is formed.

In a modification, the core 2 is preformed from a paste consisting of a mixture of powdered carbon and sodium fluoride in proper proportions agglomerated with a binder of coal tar. This paste is formed into a rod which is hardened by baking in a neutral or reducing atmosphere. Such rod, constituting the core 2, is introduced into the tube constituting the shell 1 and cemented therein, the rod and/or tube having been previously prepared with a binder for this purpose. The rod is made of such diameter as to fit closely into the tube with mild friction. Cementing together of the two parts is effected by means of an organic or mineral binder, the use of an alkali silicate having no inconveniences under these conditions. The binding agent is then dried and hardened in an oven. Of course, when following this procedure the proportion of the mineralising material is calculated on the weight of carbon subsisting after baking.

Cathodes thus prepared may be utilised as such, or more often after having been jacketted with a metal conductor, preferably copper, which enables them to withstand without excessive wear the high current densities usual for the high-intensity arc; 60-75 amps. for a 7 mm. cathode.

I claim:

1. A cathode for a high-intensity arc, comprising a shell composed entirely of carbon enclosing a core consisting essentially of carbon and at least one oxygen free alkali metal compound, the proportion of said compound to car-

bon in said core being 1 atom of alkali metal to about 2.5-15 atoms of carbon.

2. A cathode for a high-intensity arc, comprising a shell composed entirely of carbon enclosing an oxygen free core consisting essentially of carbon and at least one halogenated alkali metal compound, the proportion of said compound to carbon in said core being 1 atom of alkali metal to about 2.5-15 atoms of carbon.

3. A cathode for a high-intensity arc, comprising a shell composed entirely of carbon enclosing a core having a diameter of about 0.2-0.35 that of the shell, said core being free from oxygen and consisting essentially of carbon and at least one halogenated alkali metal compound, the proportion of said compound to carbon in said core being 1 atom of alkali metal to about 2.5-7.5 atoms of carbon.

4. A cathode for a high-intensity arc, comprising a shell composed entirely of carbon enclosing a carbon core containing a mixture of sodium fluoride and sodium chloride, the total proportion of said sodium compounds to carbon in said core being 1 atom of sodium to about 2.5-15 atoms of carbon and the molecular proportion of the sodium fluoride being greater than that of the sodium chloride.

5. A cathode for a high-intensity arc, comprising a shell composed entirely of carbon enclosing a carbon core containing a mixture of sodium fluoride and sodium chloride, the total proportion of said sodium compounds to carbon in said core being 1 atom of sodium to about 2.5-7.5 atoms of carbon and the molecular proportion of the sodium fluoride being greater than that of the sodium chloride.

6. A cathode for a high-intensity arc, comprising a shell composed entirely of carbon enclosing an oxygen free carbon core containing about 20-40% by weight of sodium fluoride.

7. A cathode for a direct current, high intensity arc, comprising a shell composed entirely of carbon, enclosing a core consisting essentially of carbon mixed with oxygen free, halogenated, alkali metal compounds.

8. In a direct current high intensity arc light having a carbon anode mineralized with rare earth compounds, whereby rare earth carbides are formed in the arc, a carbon cathode having a core mineralized with an oxygen free, alkali metal compound.

9. In a direct current high intensity arc light having a carbon anode mineralized with rare earth compounds, whereby rare earth carbides are formed in the arc, a carbon cathode having a core consisting essentially of carbon mixed with oxygen free, halogenated, alkali metal compounds, whereby the deposit of said carbides on said cathode is substantially prevented.

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