Dec. 6, 1949 J. C. READ 2,490,542

MERCURY ARC RECTIFIER

Filed Jan. 9, 1945

FIG. 1.

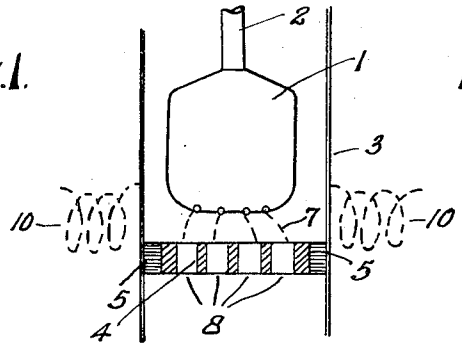


FIG. 2.

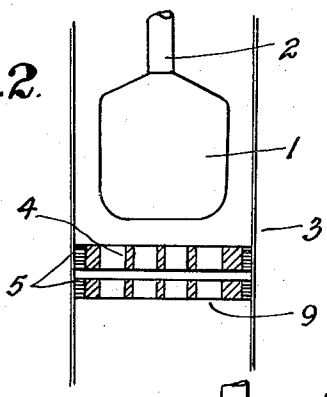


FIG. 3.

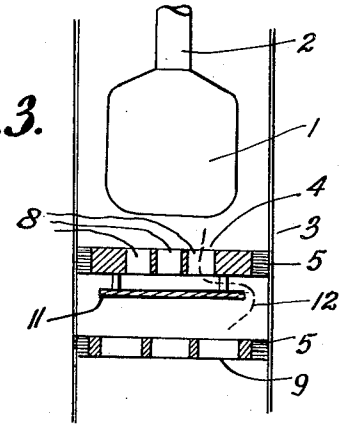


FIG. 4

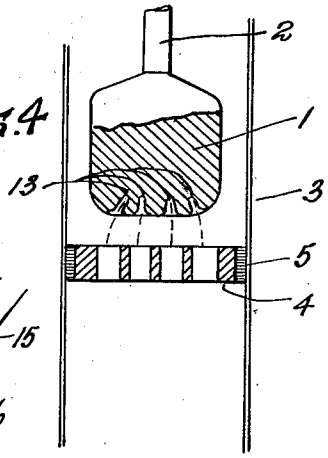


FIG. 5.

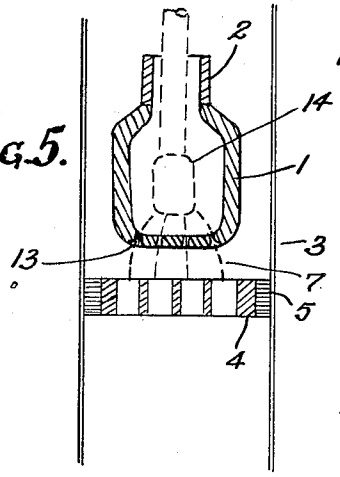
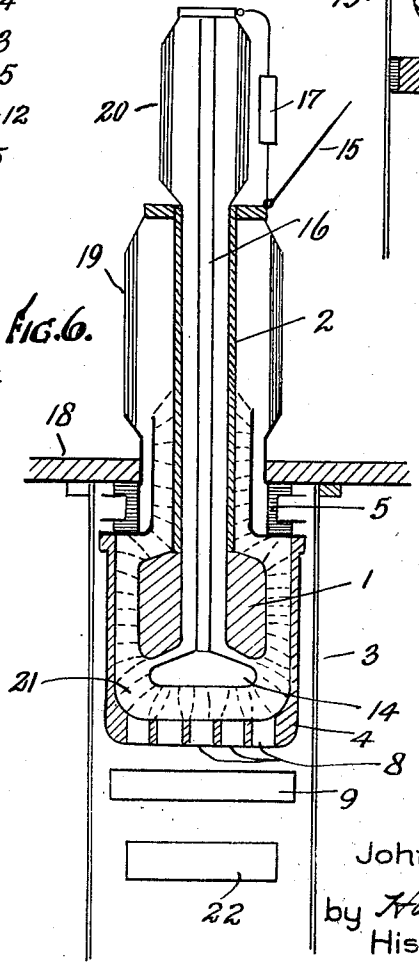


FIG. 6.



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MERCURY ARC RECTIFIER

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2 Claims. (Cl. 250—27.5)

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This invention relates to mercury arc rectifiers and the like, and more particularly to a method of reducing the tendency to backfires, especially at high voltages.

It is generally considered that a contributory cause of such backfires is the bombardment of the anode by positive ions which occurs during the time when the anode is negative. In rectifiers for the higher voltages a considerable part of this positive ion bombardment is produced by positive ions attracted into the anode from beyond the de-ionising baffle or grid. It is the object of the invention to reduce the effectiveness for initiating backfires of the bombardment produced by these positive ions.

According to one form of the invention I reduce the quantity of positive ions that are able to be attracted to the anode from the far side of the grid, by certain arrangements of multiple grids with suitable potentials applied to them. In another form I cause this bombardment to be less continuously concentrated on the same part of the anode surface. In another form I cause this bombardment to fall on parts of the anode surface where the electrostatic field strength is low. In another form I divide the anode into a main part which does not receive the bombardment and an auxiliary part, connected to the main part through a suitable high impedance, so arranged that this bombardment falls on the auxiliary part of the anode.

The invention will be better understood by reference to the accompanying drawings, in which Figures 1 to 6 represent various forms of the invention. In the drawings corresponding parts are designated by the same reference numerals in all cases.

Referring to Fig. 1, 1 represents an anode of a high-voltage mercury arc rectifier or the like, which is supported by a stem 2 which is introduced into the rectifier through an insulating gas-tight seal in any suitable or well known manner. The anode is surrounded by a shield 3 supported in any suitable manner, and contains a de-ionising baffle or grid 4 so arranged that the arc from anode to cathode has to pass through this. The de-ionising baffle or grid may be electrically connected to the shield, or it may be insulated from it, for example, by insulation as diagrammatically represented at 5, and it may, if desired, have a connection brought out from it to enable a control potential to be applied to it.

During the time when the anode is negative a considerable part of the positive ion bombardment which it is subjected to is produced by ions attracted to the anode from the further, i. e.

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lower, side of the baffle or grid. These ions which reach the anode from the further side of the grid are not distributed over the surface of the anode, but their bombardment is concentrated on particular points 6 which are respectively about opposite the centres of the holes 8 in the grid, the ions falling on these spots 6 along paths represented by the dotted lines 7. The intensity of bombardment at the points 6 greatly exceeds that over the remainder of the anode surface.

According to one form of the invention I may reduce the average intensity of bombardment on these spots by rotating the anode or grid on their own axes; and the various holes in the grid may be so located that the tracks of the centres of different holes which are thus traced out on the anode face do not coincide. Alternatively the spots 6 where the local bombardment takes place from each of the grid holes may be caused to rotate or oscillate by applying a tranverse magnetic field, for example as indicated by the coils shown dotted at 10. In either case the bombardment is thus spread over a relatively large area of the anode face.

Another form of the invention is shown in Fig. 2, in which two grids 4 and 9 respectively, are provided one above the other and fairly closely spaced apart. In using this arrangement the control potentials applied to the two grids are maintained such that, at least during the time when the anode is negative with respect to the cathode, the nearer grid 4 is positive with respect to the farther grid 9. The potential difference between grids 4 and 9, the spacing between them, and the size of holes are so chosen that the electrostatic field in the space between 4 and 9 due to this potential difference is able to over-balance the electrostatic field in the space between 4 and 9 produced by the negatively charged anode. That is, any positive ion from below the grid 9 entering one of the holes in 9 will first experience a repelling field due to the potential on 4 and thus the anode is unable to attract to itself positive ions from the space below the lower grid 9. Conveniently this potential between 4 and 9 may be applied by applying to both 4 and 9 identically similar A. C. voltages superimposed on different D. C. bias voltages, in the manner commonly understood. In this way, providing the dimensions and grid potential difference are suitable as described above, the concentrated bombardment of the anode by positive ions from the far side of the grids can be practically eliminated.

Fig. 3 shows another form of the invention, in which again two grids 4 and 9, are employed, with different potentials on them. In this case,

however, during the time when the anode is negative the upper grid 4 is allowed to be negative with respect to the lower grid 9, either by having such a potential applied to it by external means, or by acquiring this potential by virtue of its capacity to the negatively charged anode, the upper grid 4 in this latter case being nearly or completely insulated. In this form of the invention, however, the passages 8 through the upper grid 4 are made of tortuous form so that a particle can only pass through 8 by following a sharply curved path. The actual form of the tortuous passages through 4 is in other respects not relevant to this present invention, but for purposes of example this has been indicated in Fig. 3 by the addition of a plate 11 fixed below and connected to the grid 4 such that a particle in passing through 4 must describe a curved path as indicated by the dotted line 12. With this arrangement a positive ion entering the lower grid 9 from below the latter immediately experiences an accelerating field due to the relative negative potential of the upper grid 4 and consequently on reaching 4 is already travelling at considerable speed. The curvature of the path through 4 is made too sharp for a particle already possessing this velocity to be able to get round the corners without striking some part of the grid 4. Thus again few or none of the positive ions entering from below the lower grid are able to bombard the anode.

It has already been explained in connection with Fig. 1 that the points 6 on the anode face where the intense bombardment occurs are very small and exactly located. According to another form of the invention, shown in Fig. 4 small holes or grooves 13 are provided in the anode face exactly located where these points of intense bombardment occur. The velocity of the ion by the time that it approaches the anode face is so high that it travels almost in a straight line, and consequently the bombarding particles then strike the anode down inside these holes or grooves. The bombarding particles therefore impinge on a point where the electrostatic field strength is much lower than on the outer surface of the anode, and further, the material sputtered out of the anode by the bombardment tends largely to be retained inside the holes or grooves. The positive ion bombardment is in this case less effective in producing backfires.

Alternatively, as shown in Fig. 5, the anode may actually be made hollow with the holes or grooves 13 passing right through to the interior. If the hollow space inside the anode is left empty the ions will then bombard the interior surface of the anode, where the field strength is zero.

In a further form of the invention, however, an additional electrode or auxiliary anode, shown dotted at 14 in Fig. 5 may be provided inside the hollow anode, so placed that if it is at or about the same potential as the main anode 1 the ions passing in through the holes 13 along passages as indicated by the dotted lines 7 will be collected on this auxiliary anode. The actual current flow corresponding to this flow of bombarding ions is very small. I therefore connect the auxiliary anode 14 to the main anode 1 through a very high impedance, which may be either internal or external to the rectifier, this high impedance taking the form of a high resistance or small condenser or the natural self-capacity between 1 and 14, or a combination of these. Due to the very small value of the bombarding ion current this current is able to pass through the high impedance without causing the potential of

14 to depart far from that of 1, but at the same time the presence of the high impedance in series with 14 prevents the establishment of a backfire on 14 as a result of the ion bombardment to which this is subjected.

Further, similar results can be obtained with simpler anode construction than that in Fig. 5. In general, any form of anode may be employed where the anode is similarly divided into a main part which carries the normal power current and an auxiliary part connected to the main part through a high impedance as described, providing that the main and auxiliary parts of the anode, which should preferably be closely adjacent to one another, are so located relative to the holes in the adjacent de-ionising baffle or grid that such bombarding positive ions entering through the latter will fall on the auxiliary part of the anode. For practical purposes this means that all the electrostatic stress lines from the grid holes to the anode will fall on the auxiliary part of the anode.

Many constructions that would comply with these requirements will be obvious to those skilled in the art. An example of such a construction is shown in Fig. 6.

In Fig. 6 the anode is thus divided into an annular main part 1 which carries the normal power current and is connected through its tubular support stem 2 to the connection 15 leading to the main transformer; and an auxiliary part 14 of disc-like form closely adjacent to the main part 1, and connected through its stem 16 and the external high impedance 17 to 1. The main part of the anode is supported and insulated from the vacuum chamber 18 of the rectifier by a lead-in insulator 19 of any of the known forms; and the auxiliary anode is in turn insulated from this by a further lead-in insulator 2. The grid 4 which is mounted on its support insulator 5 partially surrounds the main and auxiliary parts of the anode, and during the time when the anode is negative the electrostatic stress lines consequently take the form approximately sketched by the dotted lines 21. The location of the auxiliary part of the anode 14 with respect to the holes 8 in the grid is such that the stress lines from these holes to the anode all fall on the auxiliary part of the anode, and thus bombarding positive ions entering from outside the grid will impinge on the auxiliary part of the anode.

The anode shield 3 may contain additional grids 9 or baffles 22 if required. The high impedance 17 may take the form of a high resistance or small condenser or combination of these, of values as already described in connection with Fig. 5.

Alternatively the high impedance can take the form of a semi-conducting rod forming part of the length of the auxiliary anode stem 16, i. e. inside the rectifier. In this case the additional lead-in insulator 20 is not required. If the impedance is thus internal it should preferably be well screened from the general ionisation of the arc, as would in fact be the case with a construction on the lines illustrated in Fig. 6.

Arrangements such as shown in Fig. 6 may be used in conjunction with any of the arrangements in Figs. 1 to 5. For example, the auxiliary part 14 of the anode may have holes or grooves provided in its bottom face at the points where the bombarding positive ions strike it, as in Fig. 4.

The characteristic feature of constructions according to the invention, in which the anode is divided into two parts as exemplified in Fig. 6, is thus that the load current is carried on one part

while the other part, which is incapable of sustaining a backfire, receives the positive ion bombardment, by utilising the fact that the bombarding positive ions entering through the grid holes travel in nearly straight lines, whereas the normal flow of load current can follow a relatively curved path and thus can flow from the grid holes to the main part of the anode.

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

1. In discharge apparatus of the type in which the discharge takes place between an anode and a cathode through an ionizable medium, the combination which comprises an anode having a discharge receiving surface, an electrode interposed between said surface and the cathode of the apparatus, said electrode having a plurality of openings positioned transversely of the discharge path for sub-dividing the forward discharge, and means producing an electromagnetic field in the region between said discharge receiving surface and said electrode for causing relative motion between the discharge receiving surface of the anode and the sub-divided forward discharge to spread the discharge over an extended portion of the discharge receiving surface.

2. In discharge apparatus of the type in which the discharge takes place between an anode and a cathode through an ionizable medium, the combination which comprises an anode having a discharge receiving surface, an electrode interposed between said surface and the cathode of the apparatus, said electrode having a plurality of openings positioned transversely of the discharge path for sub-dividing the forward discharge, and means producing relative motion between the discharge receiving surface of the anode and the sub-divided forward discharge to spread the discharge over an extended portion of the discharge receiving surface.

JOHN CARLEY READ.

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