May 24, 1932. E. KERN 1,859,875

MERCURY VAPOR RECTIFIER

Filed May 12, 1927

Fig. 1

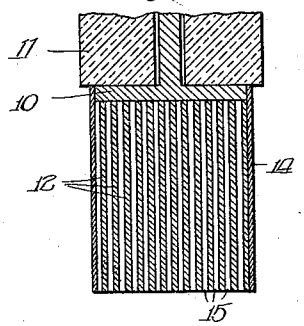


Fig. 2

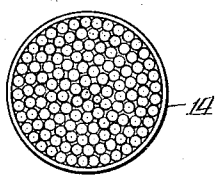


Fig. 3

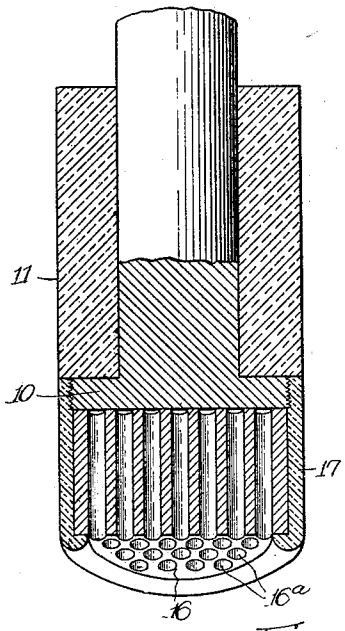


Fig. 4

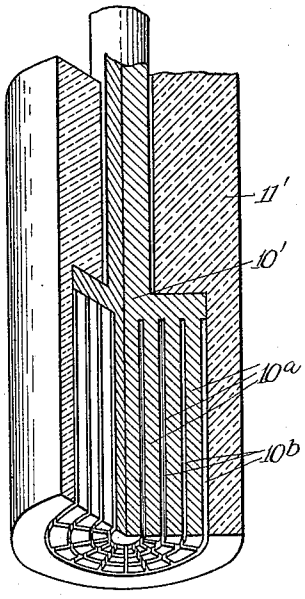


Fig. 5

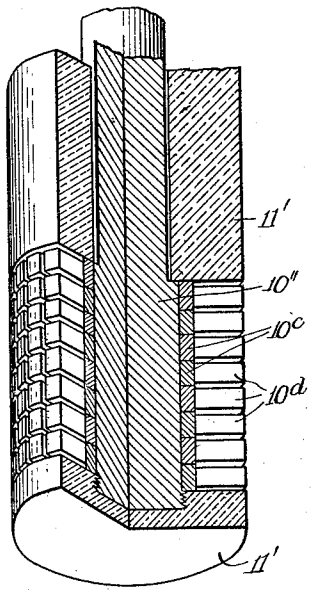


Fig. 6

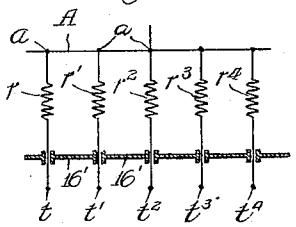
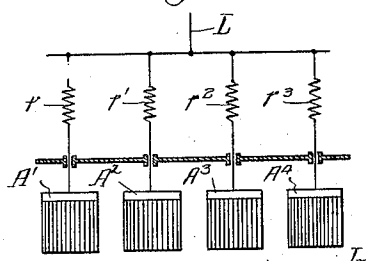


Fig. 7



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UNITED STATES PATENT OFFICE

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MERCURY VAPOR RECTIFIER

Application filed May 12, 1927, Serial No. 190,714, and in Germany May 17, 1926.

This invention relates to mercury vapor rectifiers, and has to do with construction of the electrodes, particularly the anodes or positive electrodes from which the current is discharged in the rectifier.

The general object of the present invention is the provision of an anode construction which will be effective in eliminating or reducing the possibility of back ignition or reversals of current flow through the rectifier, as well as short circuits between anodes.

Another object is the provision of a construction which may be arranged and assembled in the apparatus with facility, which does not involve complications in related portions of the rectifier construction, and which will be reliable in operation.

Other and further objects will be pointed out hereinafter or will appear to one skilled in the art upon an understanding of the invention or its employment in practice.

In the drawings forming a part of this specification, I illustrate a number of arrangements in which the invention may be embodied, but it is to be understood that these are presented for illustrative purpose only and that the invention is not limited to the particular constructions or arrangements shown, and hence that the present disclosure of particular constructions is not to be accorded any interpretation having the effect of limiting the claims short of the true and most comprehensive scope of the invention in the art.

In the drawings,

Fig. 1 is a diagrammatic illustration of an anode construction, the same being in the nature of a sectional elevation;

Fig. 2 is a bottom view of the same;

Fig. 3 is an illustration in the nature of a part longitudinal section of an anode, shown in perspective;

Fig. 4 is a sectionalized perspective view of another form of anode construction;

Fig. 5 is a sectionalized perspective view of a fourth form;

Fig. 6 is a diagram illustrating an anode construction in elemental fashion; and

Fig. 7 is another diagram of similar elemental nature, illustrating a modified construction.

Mercury vapor rectifiers, particularly those for the handling of polyphase currents of high power, are sometimes subject to short circuits between anodes of different phases, which cause disturbances or interruptions in the operation of the apparatus. These short circuits are sometimes caused by the formation of a cathode spot on one of the anodes, the result of which is that current is able to traverse the anode in both directions, thus producing a condition which may establish a short circuit with another anode. In normal operation of such a rectifier, when current flows in the normal direction, from anode to cathode, the whole of the anode surface takes part, to a greater or lesser extent, in the passing of the current from the anode into the exhausted space within the rectifier, whereas, when a condition of back ignition arises, the passing of the current in the reverse direction takes place at only a localized point or area on the anode. At this point, the anode surface ceases to maintain the valve action and receives the reverse current. By virtue of the present invention, the occurrence of such localized changes in the current-transmitting nature of the anode is prevented or rendered less likely, and the capability of the anode for passing current in the reverse direction is reduced to such a point that the proper valve action of the anode is consistently maintained. Thus, the conditions which contribute to short circuits between the anodes are obviated. This result is attained by the provision of a construction whereby the path which may be taken by a reverse current in the anode is such as to offer a resistance effective to prevent, or so limit such current to such extent that the anode cannot assume such a character or condition as to establish a short circuit with another anode.

The nature of the invention may be ascertained from the examples shown in the drawings. In that represented in Fig. 1, the reference character 10 designates the end of the anode which is within the rectifier cylinder, said anode being supported in an insulator

11. The actual surface of the anode exposed within the rectifier is subdivided into segregated areas by provision of elements 12, which may be in the nature of rods composed of material having dielectric or low electrical conductive characteristics, and qualified to resist the heat of the mercury vapor. These elements may be rods of quartz held together in a bundle by a surrounding tube 14 of insulating material, which covers the lateral surfaces of the electrode head 10 and holds the rods in lateral contact with one another and with their inner ends in contact with the surface of the electrode head. By this arrangement, a large number of small channels 15 is provided, opening at their outer ends into the rectifier chamber and debouching at their inner ends on the surface of the anode. As a consequence of this arrangement, the only portions of the anode surfaces which can function to pass current into or from the rectifier chamber are those segregated areas which are exposed between the channels. When the rectifier is operating in the normal way and discharging current into the rectifier chamber, all of these segregated areas function in parallel, and the flow of current through the passages 15 is likewise in parallel. Should a cathode spot occur on one of these segregated areas or elements of the anode surface, however, the only path available for the reverse current would be the particular passage which debouches on the particular segregated area or element of surface so affected. Thus, if the cross sections and the length of these passages are suitably chosen, it is possible, through the resistance offered to an arc by the passages, to limit the current striking back to such value as to prevent the establishment of a reversely flowing arc. A somewhat similar arrangement is illustrated in Fig. 3, whereby the exposed surface of the anode head 10 is subdivided into segregated areas by means of a foraminous shield 16 seated against the head of the anode and having the passages 16^a affording communication between the rectifier chamber and limited surface areas of the anode. This foraminous shield is held in position by a sleeve 17, of heat resisting insulating material, which covers the lateral surface of the anode head.

The nature of the effect obtained is illustrated in elemental fashion in Fig. 6. Here the conductor A is the element representing the electrode head and the points a represent the segregated elements of surface thereon which have communication with the rectifier chamber individually by way of ohmic resistances r, r^1, r^2, r^3, and r^4 the terminals of the conductive paths being indicated at t, t^1, t^2, t^3 and t^4. When the rectifier is operating in the normal way, that is, when the current flows from anode to cathode, these conducting paths all work in parallel. If, however, the terminal t^1 assumes a character such as would make it the objective of a back-fire arc, the reverse-direction current is opposed by the relatively high resistance r^1, which limits its value to a degree such that no injury, or interruption of the operation of the rectifier, results. The elements 16′ represent the high resistances of the passageways interposed across the arc between the conductive paths to the respective segregated elements of the anode surface. By this means a reverse current arc reaching one of the points t, t^1, t^2, etc. is confined to the particular path of which that point is the terminus. As illustrated in Fig. 7, the anode is subdivided into a plurality of segregated elements A^1, A^2, A^3 and A^4 each communicating with the common lead L by way of respective resistances r, r^1, r^2 and r^3, and each of the elements A^1, A^2, A^3 and A^4 is provided with a device such as illustrated in Figs. 1 or 3. As thus analyzed in the diagrams of Figs. 6 and 7, therefore, it is apparent that if all of the anode circuits are resolved into a large number of conductive paths, each containing a sufficiently large ohmic resistance, the forward current which flows under normal working conditions is opposed by a resistance equal to that of one of the parallel paths divided by the number of parallel paths per phase. The reverse current, however, which flows in the event of a back-fire, can pass along only one of the parallel paths at any given instant, and it therefore, is opposed by the whole resistance of the circuit. Or, to state it another way, the effective resistance opposed to the back-ignition current and the normal working current, respectively, are in the proportion of the number of parallel conducting paths per phase.

The foraminous mask or shield, as exemplified in Figs. 1, 2, and 3, contributes a further protective effect in that it guards the surface of the anode head from eddies of mercury vapor and from drops of liquid mercury which are liable to be thrown off occasionally from the cathode. Moreover, by use of a suitable material for the shield, the anode surface may be protected from the ultra-violet rays of the mercury arc.

With the arrangements above described, the resistances in the respective arc-conducting paths of the anode should be so chosen that the back-ignition arc is broken after not more than one phase period. If the resistance in each arc path is dimensioned on this principle, the question as to whether the ohmic voltage drop in the parallel conductive paths will be sufficiently low to enable the rectifier to operate with the required efficiency, depends on the way in which the anode is subdivided. In order to keep the losses, due to these resistances, as low as possible, the anode must be subdivided into a comparatively large number of conductive paths. The stationary back-ignition arc con-

sists of direct current and alternating current components. The controlling factor, therefore, for the breaking up of the back-ignition arc, is the ratio of resistance to reactance in the circuit taken by the arc. In order to insure that the back-ignition arc shall be extinguished, therefore, the proportion of D. C. to A. C. component in the current must be kept below a certain value. To accomplish this, the ratio of resistance to inductance in the back-ignition circuit must not fall below a certain value. Since the general arrangement of the rectifier and its transformer determines the value of the inductance, the same provides the basis for determination of the magnitude of the resistance necessary to limit the back-ignition current to a value at which the arc will be extinguished at the end of a period. Experience has shown that it must be distributed among a relatively large number of parallel paths in order that its effect upon the normal current shall not lead to excessive losses. In other words, it must be so subdivided that the total losses, which with a given resistance per subdivision are reduced as the number of parallel paths is increased, do not reach an inadmissable value. The minimum value for this resistance per subdivision is given by a short-circuit reactance per phase of the transformer at normal frequency measured from the secondary side. By an alternative arrangement, the effect may be attained by subdividing the anode itself into a plurality of parallel sections and incorporating the resistance in the sections themselves. For such a construction, it follows from the considerations above pointed out, that a material of relatively high specific resistance must be used and the anode must be constituted of a large number of parallel subdivisions, each having a resistance not less than the critical value referred to above.

Illustrations of structures in which the resistance may thus be incorporated in the anode are shown in Figs. 4 and 5. In Fig. 4 the anode 10′ has its arcing terminal subdivided into a large number of rod-like sections 10^a with intervening slots 10^b segregating the respective sections from one another throughout their length. The length of these sections, and the material of which they are composed, are so chosen that the resistance of each section is sufficient to limit the current of a back-ignition arc, striking that section at its terminus, to such an extent that the arc cannot maintain itself. The sections are suitably sheathed with insulating material 11′ in such fashion that only their ends are exposed within the rectifier chamber. By this arrangement, the current from a back-ignition arc is confined to the section on which the arc impinges, and the arc is extinguished, due to the resistance of that section, at the end of the phase period.

In the construction shown in Fig. 5, the anode is built up of a spindle portion 10″ and a plurality of rings 10^c fitting thereon and subdivided into radial sections 10^a. These rings and the spindle portion are suitably sheathed with insulating material 11′ so that only the ends of the sections are exposed within the rectifier chamber. As in the former instance, the respective sections are segregated from one another throughout their length. Because of the limitations imposed on the cross sectional size of the anode by consideration of the rectifier design, these sections must be comparatively short. Hence, in order to obtain the requisite resistance in each section, the material of the rings must be one of fairly high specific resistance, such as graphite. With this construction, as with that illustrated in Fig. 4, a back ignition arc impinging one of the sections is confined thereto and extinguished at the end of the phase period through the effect of the resistance offered by the section.

It will be observed that in each of the arrangements above described, the arc feeding current of each anode is discharged through a plurality of parallel paths, each of which offers to a reverse-direction arc a resistance such that it cannot maintain itself. By such arrangement and effects, short circuits between anodes are prevented without material losses in the conversion efficiency of the rectifier.

What I claim is:

1. In a vapor rectifier, an anode having its arcing surface constituting a plurality of separated areas energized in parallel and arranged in series with respective resistances.

2. In a vapor rectifier, an anode having its arcing surface constituting a plurality of separated areas energized in parallel and arranged respectively in series with resistances sufficient to prevent the maintenance of a reverse direction arc to any of said areas.

3. In a vapor rectifier, an anode having its arcing surface arranged to subdivide the arc among a plurality of paths through respective resistances.

4. In a vapor rectifier, an anode having its arcing surface constituting a plurality of areas separated by resistances which are greater than the resistances in the path of the arc current.

5. In a vapor rectifier, an anode having its arcing surface constituting a plurality of areas energized in parallel and separated from one another by resistances which are greater than the resistances in the path of the arc current.

6. In a vapor rectifier, an anode affording a plurality of separated arcing surface portions arranged respectively in series with respective resistances which are in parallel in the path of the arc current.

7. In a vapor rectifier, an anode affording a

plurality of separated arcing surface portions energized in parallel through resistances which respectively are so proportioned with respect to the inductance of the rectifier circuit as to preclude maintenance of a reverse direction arc on any of said surface portions.

8. In a vapor rectifier, an anode affording a plurality of separated arcing surface portions energized in parallel through respective resistances.

9. In a vapor rectifier, an anode having its arcing surface subdivided into a plurality of areas separated by resistances which are greater than that offered to the flow of the normal arc.

10. A polyphase rectifier of the vapor type with the arc surfaces of its respective phase anodes subdivided into separated areas which are arranged respectively in series with separate resistances, said separated areas being energized in parallel, and said resistances being individually of a value such as to prevent the maintenance of a reverse-direction arc on any of said areas.

11. In an electric current rectifier of the arc type, an anode having a restricted arcing surface subdivided into a plurality of arcing areas separated by passageways of higher resistance than the arcing areas.

12. In an electric current rectifier of the arc type, an anode having a restricted arcing surface subdivided into a plurality of arcing areas operating in parallel and separated by passageways of higher resistance than the arcing areas.

13. In an electric current rectifier of the arc type, an anode having a restricted arcing surface, the said arcing surface comprising the ends of anode portions operating in parallel and separated by passageways of higher resistance than the arcing areas.

14. A mercury arc rectifier comprising an evacuated vessel, a cathode, an anode extending into said vessel and provided with a plurality of active and inactive surfaces, and an insulation shield mounted within said vessel to cover said inactive surfaces of said anode.

In testimony whereof I have hereunto subscribed my name this 22 day of April, A. D. 1927, at Zurich, Switzerland.

ERWIN KERN.