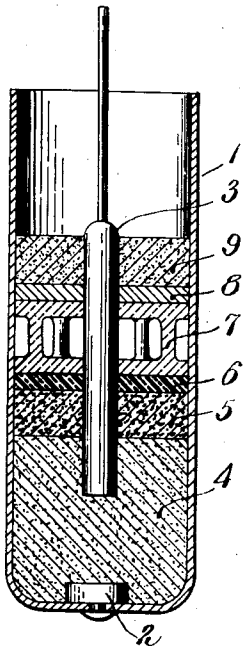
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SOLID RECTIFIER

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SOLID RECTIFIER

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The present invention relates to electrical apparatus and in particular to alternating current rectifiers in which two metals of different character are employed as electrodes, the metals fulfilling alternately the function of cathode and anode. The rectifier described hereinafter is designed to carry current of an order sufficient to energize the filamentary cathodes of the largest radio sets in use and employs a product of oxidation on one or both electrodes to effect a portion of the unilateral conducting characteristic. Heretofore in the art, it has been proposed to derive the product by subjecting the electrodes to a liquid oxidizing agent, usually an acid. However, this form of device presents many disadvantages, one of which is the fact that the liquid is apt to spill and, in the case of concentrated acid, to attack the metallic or other surfaces over which it spreads. Moreover, under continued operation, considerable gas may be formed due to violent electrolysis throughout the entire fluid, necessitating a vent or opening that offers to the liquid ready escape from a container otherwise carefully sealed. The vent, if large, also has the undesirable feature of varying the specific gravity of the oxidizer by promoting evaporation or condensation of moisture in the same manner as a leaky container. Some of these defects are accentuated when the rectifier is under normal load and in a heated condition. Furthermore, in the rectifiers evolved by prior art, the voltage drop, as measured in the direction of current flow, is often of such magnitude as to cause considerable loss of energy by heat with resulting reduced efficiency.

In order to eliminate the disadvantages of a liquid rectifier, some of which have been pointed out, I propose to provide a structure that employs a solid substance for the oxidizing agent. Moreover, by a special form of electrode I am enabled to minimize the loss in voltage referred to and to procure an oxidation product without destructive gas formation, permitting the container to be sealed.

Objects of the invention are, to improve generally on the structure and operation of a rectifier, the efficacy of which depends in part on the phenomenon of oxidation; to dispense with the liquid electrolyte, particularly an acid; to provide an oxidizing agent in solid form; to devise apparatus that will efficiently pass considerable current; to provide a sealed container of rugged construction; and to reduce the cost of manufacture of the unit by simplifying the design and materials. Other objects and features will be apparent as the specification is perused.

Referring to the drawing, numeral 1 designates a container preferably of metal, as iron, that is resistant to various salts; the container may conveniently take the form of tubing closed at one end in any suitable manner. Secured to the bottom of the receptacle is the anode 2, preferably of silver, and in juxtaposed relation thereto, I place cathode 3 shaped as a rod and preferably of a nickel-silicon alloy having a content of silicon approximating 22 per centum. The specific proportion of metals forming this alloy is dictated primarily by manufacturing considerations, and I do not wish to be limited in this respect. It is apparent that other metals, as aluminum and alloys, having various proportions of constituent members, that readily form adherent protective surface films of oxide or other compound, and thus become asymmetrically conductive, are useful in my rectifier. For the oxidizing agent 4, I employ a fusible salt or mixture of salts, preferably neutral in reaction and preferably including the nitrates and salts of ammonium and of silver, the latter substance appearing to facilitate ion travel upon the reapplication of potential to the cold rectifier. Excellent results have been obtained by mixing with either or both of silver and ammonium nitrates certain other substances; in particular, thallium nitrate. It has been found that generally speaking, constituents such as thallium nitrate which reduce the melting temperature of the salt mass also decrease the losses in the device ensuring long life for the rectifier. For the purpose of removing any tendency to short circuit, I may include a small amount of potassium or lithium salt as a nitrate.

When employing a mixture of silver and ammonium nitrates, with or without alkali nitrate, I find that the proportion most suitable for the purpose at hand to be two to four parts of ammonium salt to one of silver salt. In order to facilitate passage of current, I may incorporate in the mixture a quantity of silver in powder form preferably equal to about one-third the weight of the salts. This powdered silver may be considered as an extension of the anode 2 of silver. In fact the anode 2 is really more of a conductor to make good contact with the salt and silver mixture and also furnish a supply of silver. Thus the device will rectify even without button 2.

In the manufacture of my rectifier, approximately two grams of the powdered salt mixture is placed in bottom of the container followed by the cathode which is preferably held in a position defining the central axis of the tube. In case a nickel-silicon alloy is employed for the cathode material, I find it advantageous to heat the member in an oxidizing flame. While the precise nature of the reaction is uncertain, whether the treatment affects the metallic structure throughout or merely the surface, a cathode treated in this manner exhibits a tenacious film when subjected to the salt mixture. The salt may be moistened with a minimum quantity of water, then more powder firmly packed around the cathode by aid of the water and preferably by moderate warming. If the water is omitted, the device is heated in any suitable manner to the fusion point of the salt, at which time connection is made to a source of alternating potential and electrolytic conduction sets in. During this "forming" period, so-called, the device is preferably allowed to rectify considerable current, approximately as much as it can stand without excessive heating which would decompose the ammonium nitrate. After forming, the rectifier works equally well in solid or fused state, hence may be started when cold and dry; moreover, the solid state is considered preferable on account of increased stability and less attack on the electrodes.

While any suitable method of closing the container may be employed, I prefer the structural arrangement shown. This comprises a layer 5 of sand, insulating washer 6 of mica, glass spacer 7, asbestos washer 8 and a poured seal 9, preferably not air-tight, which may be of a fused salt, as potassium nitrate.

The completed rectifier may be connected by usual circuits to the alternating current source from which the direct current is to be derived. Moreover, by obvious change, it is apparent that the structure may be modified to rectify both half waves.

While the operation of my device is rather obscure at present, the indications seem to point to the following theory: When the potential tends to force current from the alloy to the silver, the surface molecules of the alloy are forced into chemical combination with oxygen or other material obtained from the oxidizing agent; this forms an insulating layer and stops the passage of substantial current. On the other half-wave, the opposite potential tends to set this oxygen free, perhaps to combine with silver atoms in close contact with it, forming conducting silver oxide and permitting current to pass freely without electrolysis. This phase may take place only at certain points of the cathode surface, since when a free path for the current becomes available, there is no further tendency to decompose the protecting film. Occasionally, when this reciprocal transfer of oxygen takes place imperfectly at a point, the passage of considerable back current at that point may fuse or vaporize a few nearby molecules of the oxidizing agent, which furnish additional oxygen to reform the protecting film. The current in the conducting direction is carried electrolytically at the very first application of potential, as evidenced by the formation of a little gas. The stoppage of gas evolution indicates the prompt formation of metallically conducting paths, composed at least in part presumably of silver electrolyzed out of the salt mixture and conductively united with the powdered silver and the anode; this of course means also the saving of the energy necessary for the electrolysis. It will be apparent that the subdivided, filamentary, comminuted or other porous character of the totality of conducting paths thus formed allows access of the oxidizing agent to the cathode surface. Whatever may be the correct theory, it is a fact born of experience that a unilateral conductor made in the manner stated is capable of passing current having an order of several amperes without undesirable heating.

I claim:

1. Electrical apparatus comprising two conductors of dissimilar material, at least one of the conductors being metallic and having a thin surface stratum converted into an oxidation compound which permits flow of current from one conductor to the other while obstructing flow of reverse current, and a solid oxidizing agent active during operation to maintain said stratum, the other conductor being of a nonfilm-forming material in porous form to permit access of said agent to said stratum.

2. In combination, a film-forming electrode and a porous nonfilm-forming electrode incorporated in a solid electrolyte.

3. In combination, a plurality of electrodes, one being film-forming and another of a nonfilm-forming material in subdivided form, said electrodes being embedded in a solid oxidizing agent.

4. In a rectifier, a plurality of electrodes,

one of said electrodes being of non film-forming material in porous form, means including a solid electrolyte for deriving a unilaterally conducting characteristic between said electrodes, another of the electrodes being film-forming.

5. Electrical apparatus comprising two conductors of dissimilar material, a thin surface stratum of one electrode being converted into a compound which permits flow of current from one conductor to the other while obstructing flow of reverse current and a solid substance active during operation to maintain said stratum, one of the conductors being non film-forming and in finely divided form to permit access of said substance to said stratum, and another of the said conductors being of film-forming material.

6. A rectifier comprising electrodes separated by a solid salt mixture, one of said electrodes consisting of silver, and another of the said electrodes being formed of film-forming metal.

7. In a rectifier, a plurality of electrodes and means including a silver salt in solid form for deriving a uni-laterally conducting characteristic between said electrodes, one of the said electrodes containing silver and another being formed of film-forming metal.

8. Electrical apparatus comprising two electrodes of different composition, one of which is of a nonfilm-forming material in porous form, and means including a solid electrolyte which penetrates the porous material for covering one of the electrodes with a self-healing surface film giving rise in conjunction with the other materials to a unidirectionally conducting system.

9. Apparatus for rectifying alternating current comprising in combination a film-forming electrode adapted to serve as a cathode, a layer of oxidation product in contact with said cathode and serving to separate the electrode from adjacent portions of the apparatus, a finely divided nonfilm-forming material in proximity to said oxide adapted to serve as an anode, a solid electrolyte in contact with said metallic material adapted to regenerate said layer, and means for passing an alternating current to said electrodes.

10. A rectifier comprising the combination within a casing of a plurality of electrodes within said casing, at least one of which electrodes contains silver and the other electrode is film-forming, and a separating medium comprising a non-acid mixture of solid oxidizing compounds, one of the said compounds containing silver.

11. Electrical apparatus comprising two electrodes, one of which serves as an anode and the other as a cathode, the said anode comprising silver in finely divided form, and the said cathode being of a film-forming material, and a solid oxidizing mixture between and substantially surrounding the said electrodes, the said mixture permitting the flow of current from one electrode to the other, while obstructing flow of reverse current, the said mixture acting through the formation of film upon the said film-forming cathode.

Signed by me at Cambridge, Massachusetts, this 24th day of February, 1927.

EASTMAN A. WEAVER.