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U. LAMM

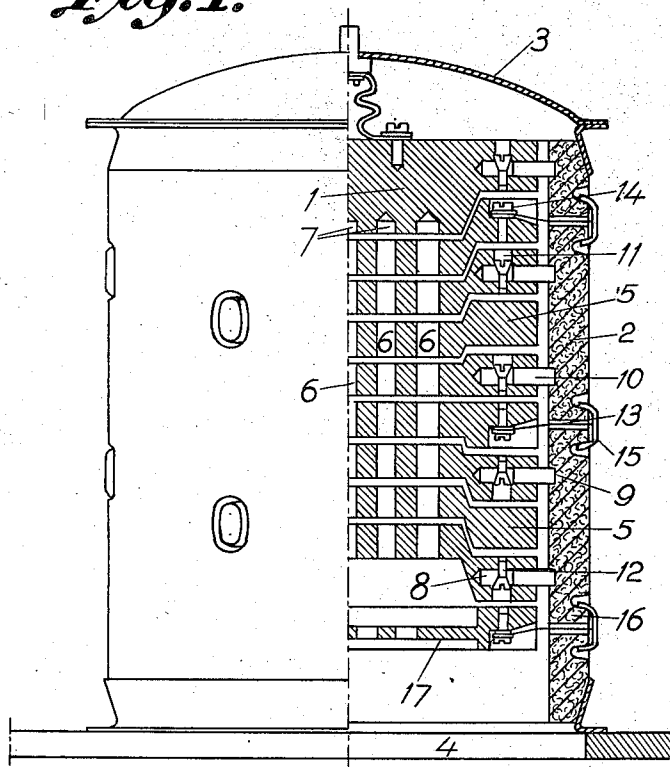
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ANODE TUBE FOR IONIC VALVES FOR HIGH-VOLTAGE
STATIC CURRENT CONVERTERS

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2 Sheets-Sheet 1

Fig. 1.



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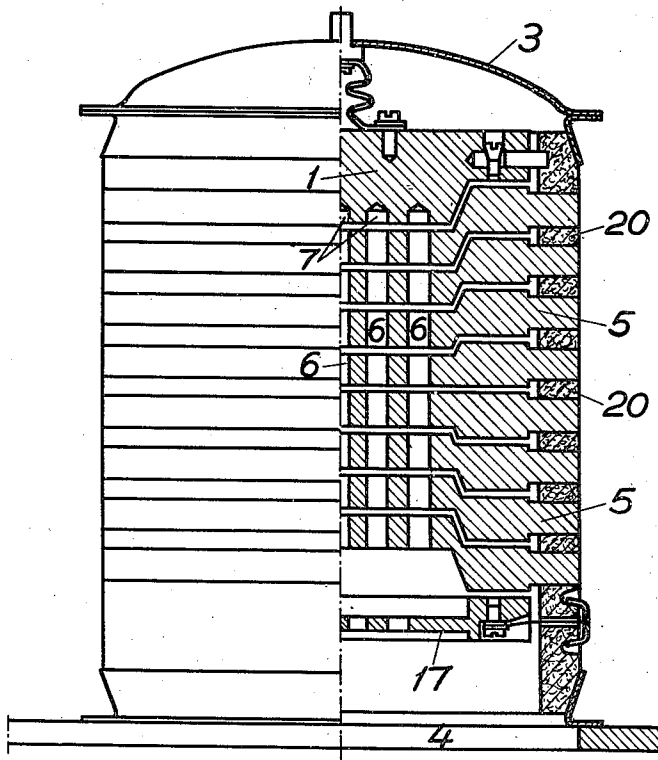
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2 Sheets-Sheet 2

Fig. 2.



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UNITED STATES PATENT OFFICE

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ANODE TUBE FOR IONIC VALVES FOR
HIGH-VOLTAGE STATIC CURRENT
CONVERTERS

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In ionic valves for high voltage rectifiers it is known to mount, adjacent to or across at least a part of the current path near the anodes, one or more conductors or semi-conductors which are submitted, during the blocking intervals or im-
permeable half—or more than half—cycles, to different potentials decreasing from the anode towards the cathode, and which serve to prevent a concentration of the voltage drops which occur during the said intervals in the region next to the anode, said concentration causing a risk of arc-back in the current path. For such purpose, either a large number of grid-like conductors or a coherent conductor of such material and/or construction as to permit a gradual decrease of voltage has been proposed. The form using a large number of discrete conductors of a grid-like type submitted to different potentials has for several reasons been found preferable in practice. In the practical realisation of this design, however, problems arise which are not readily solved. One such problem is to prevent the strong ionisation which occurs in the current path from spreading through the interspaces between the different conductors to the surrounding insulator, in the presence of which it may cause disturbances. Another problem is to keep the current path within suitable temperature limits, so that the temperature becomes neither so low as to permit a condensation of the cathode liquid (mercury) in the anode tube nor so high that cathode spots can be formed on the solid conductors. The risk of the latter alternative is generally the greater one. It has now been found that these two problems can be solved at the same time according to the invention by utilizing conducting bodies limiting the current path or the parallel current paths, of such volume and shape that they will occupy at least half of the volume of the space in the anode tube between the anode and the cathode space. This means first that all distances between bodies of different potential will be so small as to correspond substantially to a maximum of dielectric strength at the vapor density prevailing in the anode tube. Further, the spaces become so narrow that the vapor is deionized in its passage from the current path or paths outwards, so that, due to such deionizing and to the narrowness and consequent coolness, no arc can be maintained in the said spaces. Further it means that the diameter of the tube will be considerably larger than that of the current path, which not only increases the length of passage between the current path and the tube wall, available for deionisation, but also increases the ex-

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ternal heat radiating surface of the conducting bodies by increasing their outer diameter.

The condition that the conducting bodies shall occupy at least half of the volume of the anode tube refers to their outer dimensions but does not exclude the existence of cavities therein which from an electrostatic point of view can be regarded as entirely closed so that no electric fields causing or maintaining ionisation may be found in them. Such cavities may then be regarded as forming parts of the bodies proper.

In order to ensure a satisfactory removal of the heat developed by the losses within wide variations of the dimensions of the ionic valve, a specific rule should be applied to the dimensioning of the conducting bodies. As experience proves that the current density in the current path (this expression being used in the following, although the invention may also involve a plurality of parallel current paths) should be kept at about the same value for different values of total current and voltage, and as the voltage drop per unit length is also substantially the same, the losses per unit length become substantially proportional to the area of the current path. As, on the other hand, the surface of radiation per unit length is only proportional to the diameter, an increase of the total current must be accompanied by an increase of proportion between the outer diameter of the bodies and the maximum diameter of the current path, for instance upon a doubling of the current the proportion between the outer diameter of the bodies and the maximum diameter of the current path should be increased from 2 to about 2.8. In such a case, the rule may be applied that the external diameter of the bodies, expressed in centimeters, should be represented by a number of the same order of magnitude as the total mean area of the current path, expressed in square centimeters.

If the effort to improve the cooling tends to give too large values of the outer diameter, the latter can be somewhat reduced while providing the same total radiating surface by making the axial dimension of the bodies larger at the periphery than adjacent to the current path. In a suitable shaping, this generally gives the result that the parts lying between the periphery and the current path will be defined by conical surfaces of greater height the nearer to the ends of the anode tube the bodies are situated. This shaping is also advantageous with respect to the dielectric strength.

A form of the invention of the last-mentioned kind is illustrated in the accompanying drawing,

Fig. 1 of which shows the part of the current path of an ionic valve adjacent to the anode, with surrounding parts, in a side view with parts in longitudinal section, and Fig. 2 is a corresponding view showing a modification.

1 represents the anode, to which the current is supplied from above. The space adjacent to the anode is in the form here shown surrounded by a porcelain tube 2, which is closed at the top in a vacuum-tight manner by a cover 3, which may be metallic and serve at the same time as an anode conductor. At the bottom, the tube is joined to the cathode space 4, also in a vacuum-tight manner.

Between the anode and the cathode space, a number of conducting bodies 5 are mounted, said bodies being submitted, during the blocking interval of the ionic valve, to different potentials decreasing in value towards the cathode space. These bodies, which, like the anode, are preferably of graphite or iron, have near their centres a number of holes 6, which in the different bodies register with each other so as to form straight passages for the passage of the current. A bore 7 in the anode preferably also registers with each passage. The number of the passages is preferably adapted to the total current, so that each passage conducts a maximum current of a substantially fixed value and in connection therewith preferably has a substantially fixed area. This is desirable to produce the deionisation during the blocking intervals by providing a short path for every ion in the conducting gas path to the nearest neutralizing surface. Under the operating conditions presently in general use, it has been found suitable in order to obtain a stable operation to make the width of the passage about 2 cm. and the normal current in each channel (mean value during one cycle) about 5-10 amp. The distance between the passages should as a rule not be larger than is necessary to provide the required mechanical strength, so that an equalizing of ions between the channels and a uniform current distribution will be facilitated. If the distance between the passages is chosen with these points in mind, a cross-sectional area is obtained, about half of which is formed by the passages and the rest by the walls between them. Outside this area, the conducting bodies according to the present invention extend so far that their outer diameter will be at least twice as large as the maximum diameter of the area containing the passages or current paths. When the bodies as in the form shown are surrounded by a vacuum-tight insulating tube 2, the space between this tube and the bodies is made as small as possible in view of necessary tolerances and at any rate so small (as a maximum 1 cm.) as to be of the same order of magnitude as the free ion path at the prevailing vapor density, so that any ionisation by impact in the interspace between the bodies and the tube wall will be practically excluded and a spark thus practically prevented. The same rule applies to distances between the voltage distributing conducting bodies at least for those nearest to the anode, as a result of which the said bodies fill the major portion of the volume of the space in the anode tube. In this way, still more advantages are obtained. First, the ionisation of the metal vapor will be substantially limited to the conducting passages, while ionisation outside these passages towards the surrounding wall will be small, and the possibility of striking an arc in these outer spaces will be a minimum. This possibility is still further reduced by the small width

of the space adjacent to the outer wall. Further, the external heat radiating surface of the conducting bodies will be large as compared with the volume of the current path, in which the quantity of heat developed at normal current is substantially constant per unit of volume. This proportion can be further increased by making the axial dimension of the conducting bodies 5 greater at the periphery than near the current path, the parts between the periphery and the current path being then defined by conical surfaces of greater height the closer the bodies lie to the ends of the anode tube. Also the anode preferably has a corresponding shape, as shown.

Referring to Fig. 2, it is not necessary that the anode space be externally limited by a coherent insulating tube, although under present day practice this may perhaps seem preferable. If the conducting bodies 5 consist of a vacuum-tight material, for instance of iron or other metal, which can be joined as shown to a vacuum-tight insulating material 20, as porcelain or steatite, in a satisfactorily vacuum-tight manner, the conducting bodies may extend externally to the open air and be joined in a vacuum-tight manner to the separating insulator rings 20 so as to form one continuous tubular wall alternately consisting of insulating and conducting material. An essential advantage of this arrangement is that the holding of the conducting bodies in their proper relative positions and the supply of current for keeping them at the appropriate potentials are easier than in the form shown.

If the anode space is enclosed by a continuous porcelain tube as shown at Fig. 1, the latter cannot conveniently be provided before it is burned with projections which can be directly used for supporting the conducting bodies, because the deformations produced in burning the porcelain will be too great for the precision necessary in the positioning of the conducting bodies with respect to each other, the anode and the tube.

It will as a rule be necessary to operate on the tube internally after burning by grinding or boring. In this way, bores may be produced, in which the conducting bodies can be secured by bayonet catches, but in order to limit the working of the porcelain to a minimum, it is preferred to use the construction shown in the drawing. In this form, radial holes 8 are made from the outside in the conducting bodies, for instance three in each body, uniformly distributed along the periphery, and opposite the places where these holes are intended to be placed notches 9 are ground in the insulating tube 2. For assembling the device, pins 10, preferably of porcelain or other ceramic insulating material, are introduced into the holes 8, and then the conducting bodies are introduced to their positions, and in axial holes 11 therein, screws 12 with conical heads are screwed, which then press the pins 10 into the notches 9, so as to keep the connecting body firmly in place. The bodies are preferably introduced from the nearest end of the tube, by which the assembly is facilitated. By making the pins 10 of insulating material, the advantage is gained that the joint between conductor and insulator will be better screened than if the pins are made of metal.

When each conducting body has been fixed in position in the way just described and before the next one is introduced, the current connection is made. For this purpose, flexible conductors 13 are employed, which are introduced through holes in the insulating wall and are fixed to the conducting bodies by means of screws 14 and joined

at the outer ends of the holes to metal caps 15, which are glazed to projections 16 outside the insulating tube in a vacuum-tight manner. These projections can be shaped before the burning of the porcelain, as no precision is necessary on account of the flexibility of the conductors 13. The glaze for fixing the caps 15 should penetrate as little as possible into the holes traversed by the conductors in order not to make contact with the hot metal vapor, which could then be adulterated by a comparatively volatile constituent of the glaze.

As the currents, which must be supplied to the conductive bodies in order to keep these at suitable potentials, are rather weak and as also the best insulating materials, for instance porcelain, generally have a certain limited conductivity at the operation temperature of the tubular wall, it may in some cases be possible to conduct the current to the conducting bodies through the tubular wall, which for this purpose is then provided with conducting layers, for instance of metal, opposite each other on its outer and inner faces. The inner layers are then connected to the conducting bodies and the outer layers are connected to suitable points of a voltage source.

If special grids 17 for control or for other purposes are placed nearest to the cathode, these grids may also be maintained in place and connected to current sources in the same manner as the conducting bodies 5.

I claim as my invention:

1. An anode tube for ionic valves for high voltage static current converters, said tube having an anode and a cathode space and at least one current path therebetween, and having means therein to distribute the voltage in said path during the non-conducting parts of the cycles, said means comprising a group of conducting bodies mounted in said tube adjacent the current path, the volume of said bodies being equal to at least half of the volume of the space between the anode and the cathode space.

2. An anode tube for ionic valves for high voltage static current converters, said tube having an anode and a cathode space and at least one current path therebetween, and having means therein to distribute the voltage in said path during the non-conducting parts of the cycles, said means comprising a group of conducting bodies mounted in said tube adjacent the current path and having the distance between the outer periphery of the current path and the outer periphery of said bodies exceeding one centimeter, the volume of said bodies, including the volume occupied by the current path through said bodies, being equal to at least 60 per cent of the volume of the space between the anode and the cathode space.

3. An anode tube as claimed in claim 2, in which the diameter of the bodies is at least twice the diameter of a circle circumscribing all the current paths.

4. An anode tube as claimed in claim 2, in which the diameter of the bodies expressed in centimeters is close to the total mean area of current path expressed in square centimeters.

5. An ionic valve for high voltage static current converters comprising, an anode, a cathode space, a tube surrounding said anode and communicating with said cathode space, a number of conducting bodies contained in said tube, conductive connectors for impressing different voltages on said conducting bodies, passages in said bodies adapted to carry discharge current between said anode and said cathode space, said bodies being spaced from

each other at distances which are less than one tenth of the distance between the outermost of said current-carrying passages and the periphery of said tube.

6. An anode tube for ionic valves for high voltage static current converters, said tube having an anode and a cathode space and at least one current path therebetween, and having means therein to distribute the voltage in said path during the non-conducting parts of the cycles, said means comprising a group of conducting bodies mounted in said tube at small distances from each other, and adjacent the current path the peripheral parts of said bodies being thicker than the central parts.

7. An anode tube as claimed in claim 6, the portions of the bodies connecting said peripheral and central parts having frustoconical surfaces.

8. An anode tube as claimed in claim 6, the portions of the bodies connecting said peripheral and central parts having frustoconical surfaces, the said surfaces being shorter on the bodies near the center of the group and increasing in length toward each end of the group.

9. An anode tube of ceramic material for ionic valves for high voltage static current converters, said tube having an anode and a cathode space and at least one current path therebetween, and having means therein to distribute the voltage in said path during the non-conducting cycle portions, said means comprising a group of conducting bodies mounted in said tube adjacent the current path and slightly spaced from the wall of said anode tube, said tube having holes therethrough, conductors connected to said bodies and extending through said holes, and sheet metal pieces closing said holes and glazed to said tube, said sheet metal pieces being connected to said conductors.

10. An anode tube of ceramic material for ionic valves for high voltage static current converters, said tube having an anode and a cathode space and at least one current path therebetween, and having means therein to distribute the voltage in said path during the non-conducting cycle portions, said means comprising a group of conducting bodies mounted in said tube adjacent the current path and slightly spaced from the wall of said anode tube, said tube having holes therethrough, conductors connected to said bodies and extending through said holes, and sheet metal pieces outside said tubes glazed thereto and covering said holes, said sheet metal pieces being connected to said conductors.

11. An anode tube of ceramic material for ionic valves for high voltage static current converters, said tube having an anode and a cathode space and at least one current path therebetween, and having means therein to distribute the voltage in said path during the non-conducting cycle portions, said means comprising a group of conducting bodies mounted in said tube adjacent the current path and slightly spaced from the wall of said anode tube, said tube having holes therethrough, conductors connected to said bodies and extending through said holes, said tube having projections on the outer surface thereof around said holes, and sheet metal caps covering and glazed to said projections, said caps being connected to said conductors.

12. An anode tube for ionic valves for high voltage static current converters, said tube having an anode and a cathode space and at least one current path therebetween, and having means therein to distribute the voltage in said

path during the non-conducting parts of the cycle, said means comprising a group of conducting bodies mounted in said tube adjacent to the current path and having the distance between the outer periphery of the current path and the outer periphery of said bodies exceeding one centimeter, the volume of said bodies, including the volume occupied by the current path through said bodies, being equal to at least 60 per cent of the volume of the space between the anode and the cathode space, and said bodies being spaced from each other and from any other adjacent conducting parts by less than about one centimeter.

13. An anode tube for ionic valves for high voltage static current converters, said tube having an anode and a cathode space and at least one current path therebetween, and having means therein to distribute the voltage in said path during the non-conducting parts of the cycle, said means comprising a group of conducting bodies mounted in said tube adjacent to the current path and having the distance between the outer periphery of the current path and the outer periphery of said bodies exceeding one centimeter, the volume of said bodies, including the volume occupied by the current path through said bodies, being equal to at least 60 per cent of the volume of the space between the anode and the cathode space, and in which said bodies are formed of a vacuum-tight material, vacuum-tight rings of insulating material between the outer part of said bodies, said bodies being glazed to said rings, and said rings together with the outer part of said bodies forming the wall of the tube.

14. An anode tube for ionic valves for high voltage static current converters, said tube having an anode and a cathode space and at least one current path therebetween, and having means therein to distribute the voltage in said path during the non-conducting parts of the cycle, said means comprising a group of conducting bodies mounted in said tube adjacent to the current path and having the distance between the outer periphery of the current path and the outer periphery of said bodies exceeding one centimeter, the volume of said bodies, including the volume occupied by the current path through said bodies, being equal to at least 60 per cent of the volume of the space between the anode and the cathode space, a member of vacuum-tight insulating material around said bodies and spaced slightly therefrom, said member forming the wall of the tube around the space between the anode and the cathode space, said member having notches on its inner surface, and said bodies having pins engaging the said notches to support the bodies in said member.

15. An anode tube for ionic valves for high voltage static current converters, said tube having an anode and a cathode space and at least one current path therebetween, and having means therein to distribute the voltage in said path during the non-conducting parts of the

cycle, said means comprising a group of conducting bodies mounted in said tube adjacent to the current path and having the distance between the outer periphery of the current path and the outer periphery of said bodies exceeding one centimeter, the volume of said bodies, including the volume occupied by the current path through said bodies, being equal to at least 60 per cent of the volume of the space between the anode and the cathode space, a member of vacuum-tight insulating material around said bodies and spaced slightly therefrom, said member forming the wall of the tube around the space between the anode and the cathode space, said member having notches on its inner surface, and said bodies having pins engaging in said notches to support the bodies in said member, and said pins being composed of a ceramic material.

16. An anode tube for ionic valves for high voltage static current converters, said tube having an anode and a cathode space and at least one current path therebetween, and having means therein to distribute the voltage in said path during the non-conducting parts of the cycle, said means comprising a group of conducting bodies mounted in said tube adjacent to the current path and having the distance between the outer periphery of the current path and the outer periphery of said bodies exceeding one centimeter, the volume of said bodies, including the volume occupied by the current path through said bodies, being equal to at least 60 per cent of the volume of the space between the anode and the cathode space, a member of vacuum-tight insulating material around said bodies and spaced slightly therefrom, said member forming the wall of the tube around the space between the anode and the cathode space, said member having holes therethrough, conductors connected to the bodies and extending through said holes, said member having projections on the outer surface thereof around said holes, and metal caps covering and glazed to said projections, said caps being connected to said conductors.

UNO LAMM.

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