E. W. CALDWELL.

VACUUM VALVE TUBE.

APPLICATION FILED MAY 14, 1914.

1,174,676. Patented Mar. 7, 1916.

Fig. 1,

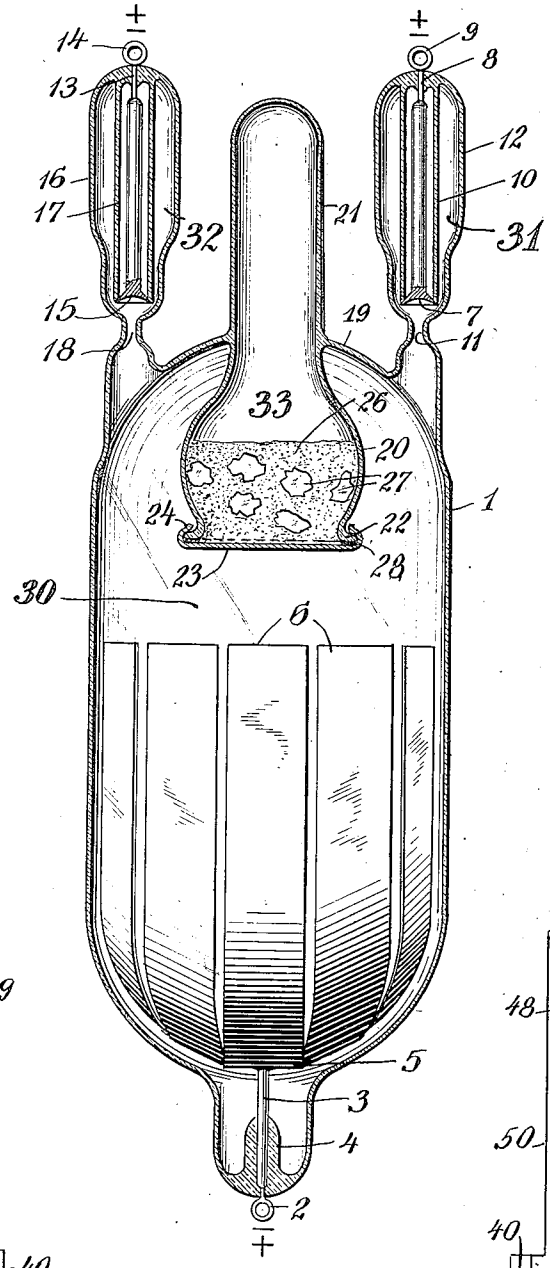


Fig. 2,

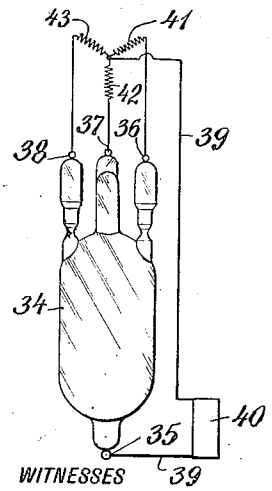
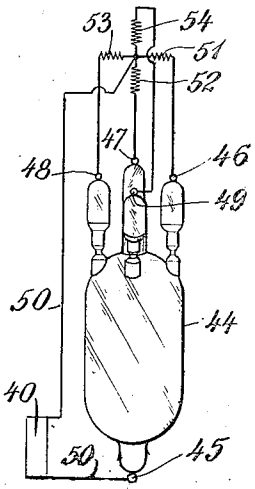


Fig. 3,



WITNESSES

Jessie B. Kay.

Charles Eberhard

Eugene W. Caldwell INVENTOR

BY

Harry L. Duncan ATTORNEY

UNITED STATES PATENT OFFICE.

EUGENE W. CALDWELL, OF NEW YORK, N. Y.

VACUUM VALVE-TUBE.

1,174,676. Specification of Letters Patent. Patented Mar. 7, 1916.

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To all whom it may concern:

Be it known that I, EUGENE W. CALDWELL, a citizen of the United States, and resident of the city, county, and State of New York, have made a certain new and useful Invention Relating to Vacuum Valve-Tubes, of which the following is a specification, taken in connection with the accompanying drawing, which forms part of the same.

This invention relates especially to vacuum valve tubes which are related to those of the general Villard type and are provided with a cathode arranged to coact with coöperating regulating means so as to automatically regulate the vacuum or condition of the tube and promote uniformity of operation along the general lines described in my Patent 1,076,949 of October 28, 1913.

According to the present invention the effectiveness and efficiency of the valve action is promoted by the use of a cathode having a large effective diameter or capacity; and a highly desirable regulating action is secured by arranging the gas generating material or salt in a separate regulating chamber having a suitable regulating diaphragm between it and the cathode chamber of the valve tube. When the tube is in normal operating position the gas generating material in this regulating chamber is more or less in contact with the regulating diaphragm so as to cause the evolution of gas and consequent regulating action whenever the tube gets into the regulating condition which causes heating effects on the regulating diaphragm or other exposed parts of the regulating chamber so that the tube is promptly restored to its normal critical condition in which such regulating action is imminent but no longer actually takes place. The valve tube may also for some purposes be with advantage provided with a plurality of separated anodes so that they may be simultaneously connected to different sources of potential which may be out of phase with each other so as to combine in a single tube the current impulses from these different sources of electricity.

In the accompanying drawing showing in a somewhat diagrammatic way several illustrative embodiments of this invention Figure 1 is a vertical section. Fig. 2 is a diagram showing a somewhat modified form of tube connected in circuit; and Fig. 3 is another diagram showing still another form.

The tube may have a body of any suitable size, shape and material and as indicated in Fig. 1 the substantially cylindrical tube body 1 may have mounted therein adjacent one end a cathode terminal 2 connected to the cathode stem or support 3 which may be firmly supported by being more or less surrounded and supported by a glass reinforcement 4 extending up from the wall of the tube at this point. The cathode 5 is preferably given a large effective diameter or capacity which seems to materially increase the effectiveness and efficiency of the valve action of the tube. The cathode may be conveniently formed of a number of electrically connected strips 6 of aluminum or other suitable material which may be bent up into generally cylindrical or tumbler shaped form so as to be, for example, about two and one-half inches in diameter and three or three and a half inches long when the main cathode chamber 30 in the tube body is about two and three-quarters inches in diameter and about six inches long inside with the approximate contour indicated in Fig. 1.

It is desirable to have a separate regulating chamber to hold the gas generating material or salts, such as sodium formate or the like and for some purposes it is desirable to have this regulating chamber in part within the cathode chamber or subject to the heating or regulating action caused when the tube gets into regulating condition while part of the chamber is preferably so arranged as not to be substantially exposed to such heating or regulating effects. This may be conveniently effected by using a separate glass tube or extension such as 21, fused into the top 19 of the tube body, so that the lower or inner portion 20 of this regulating chamber 33 which may be suitably enlarged as indicated extends sufficiently near the cathode to be exposed to the heating effects caused when the tube gets into regulating condition. Any suitable regulating diaphragm may be arranged between this regulating chamber and the cathode chamber 30 and a suitable thin metallic regulating diaphragm 23 of aluminum, for instance, may be conveniently secured on the outwardly flaring end 22 of the regulating chamber by bending the securing clips or extensions 24 of this diaphragm around the same and securing them in position in any desired way. A suitable somewhat porous washer or packing is preferably used to close the joint around this dia-

phragm and an asbestos washer, such as 28, may be interposed between these parts so as to prevent all substantial leakage of the gas generating material or salt 26 within the chamber while allowing the gas generated under regulating conditions to pass into the cathode chamber. For some purposes it is desirable to break up the aggregations of the gas generating salt which is sometimes caused by the heat developed in the portions adjacent the regulating diaphragm and this may be readily effected by suitable loosening devices, such as lumps or particles of glass or other inert material or metal which may be mixed with the gas generating salt in the regulating chamber so as to break up lumps or aggregations by gently agitating the tube. By arranging the regulating chamber so that part of it such as the outer extension 21, for instance, is outside or removed from the action of the heating or regulating effects caused under regulating or high vacuum or resistance conditions of the valve tube, the initial pumping or exhaustion of the tube may be considerably facilitated by transferring the gas regulating salt to such inoperative or inactive portion of the regulating chamber as by keeping the tube in an inverted position and preventing any substantial portions of the gas generating material from coming in contact with the regulating diaphragm until the tube is fully exhausted. This allows current to be run through the tube during the pumping or exhausting process which facilitates the elimination of the gases therefrom and enables any desirable degree of exhaustion to be readily secured after which the tube may be sealed in the usual way. The finished tube may then be turned into its normal operating position as shown in Fig. 1 and connected in circuit when the initial high vacuum and resistance which may be caused by the exhaustion will at once cause a regulating condition in the tube in which sufficient heating effects are caused on the regulating diaphragm 23 as by the concentration of the cathode stream in the tube because of the well known electrical repulsion of the stream of cathode particles on increase of vacuum and potential, so as to cause the generation of gas from the gas generating material in substantial contact with the regulating diaphragm. This quickly brings the tube into its normal critical condition where the vacuum and resistance conditions are such that no further regulating action takes place, although such effects are immiment and are again brought into play by a relatively slight increase in the vacuum, resistance and so forth. This is shown by the action of the electrical measuring instruments in circuit with the tube which show a gradual decrease in the tube resistance, the normal resistance being quickly attained after which the tube resistance remains practically constant under all normal working conditions.

Any suitable anode electrodes may be arranged in connection with the tube and either a single anode or any desired number of separated multiple anodes may be used for some purposes in a vacuum valve tube of this character. As indicated the anode 7 may be mounted on the stem 8 so as to be electrically connected with its terminal 9 outside the anode extension 12, the anode being mounted within a restricted glass shield, such as 10, and arranged in connection with a coöperating constricted anode passage 11 between the anode chamber 31 and the cathode chamber 30. If desired one or more additional anodes may be arranged in the tube each preferably separated from the other anodes so as to maintain the desired electric insulation under working conditions. The anode 15 may as indicated be mounted on a stem, such as 13, and connected with the terminal 14 outside of the tube or anode extension 16 fused thereon. This anode may be mounted within the usual restricted glass shield 17 and arranged so as to coöperate with the constricted anode passage 18 between the anode chamber 32 and the cathode chamber 30. Such valve tubes have given highly effective and efficient valve or rectifying action with high potential currents up to a few hundred milli-amperes or more, suitable for X-ray work, etc., and the tubes have maintained their high efficiency and run cool when operated in a number of instances continuously for hours at a time. With a vacuum tube of this character having a main cathode chamber about two and three-quarter inches in internal diameter and about six inches in length, the valve action was very pronounced and the direct resistance of the tube was found to be very low so as to give the tube a correspondingly high working efficiency. The potential required to break down the starting resistance in the direction of the normal operation of the tube was in the neighborhood of 1,000 volts, while a potential of about 30,000 to 40,000 volts was required to overcome the starting resistance of the tube in the reverse direction. By using multiple separated anodes in such valve tubes each anode may be connected to a separate source of polyphase high potential electricity so as to allow periodic current impulses to pass through the tube in the desired direction and superimpose through a single tube current impulses from a number of branches of a polyphase circuit. Fig. 2 shows diagrammatically such an arrangement, the tube 34 being provided with the cathode terminal 35 and with the three separated anode terminals 36, 37, 38 which are shown as each connected to one of the branches 41, 42 and 43 of a three-phase high potential circuit, the neutral

point of which may be connected to the working circuit 39 by which the working device 40, such as an X-ray apparatus, for example, is connected to the cathode terminal 35.

Fig. 3 shows diagrammatically a four-phase arrangement in which the tube 44 is provided with the cathode terminal 45 and with the terminals 46, 47, 48 and 49 connected to the separated anodes within the tube which are not shown. A four-phase high potential circuit of any description may have its branches 51, 52, 53 and 54 each connected to one of the anode terminals, while the mid or neutral point of the four-phase circuit may be connected to the working circuit 50 including a similar utilizing device 40.

This invention has been described in connection with a number of illustrative embodiments, forms, proportions, sizes and materials, parts, arrangements and methods of preparation and operation, to the details of which disclosure the invention is not of course to be limited, since

What is claimed as new and what is desired to be secured by Letters Patent is set forth in the appended claims.

1. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided adjacent one end with a cathode formed of a plurality of electrically connected strips of sheet metal arranged in substantially hollow cylindrical form and having large effective diameter and capacity to secure correspondingly high valve efficiency, said vacuum tube having a regulating chamber containing loosening devices and gas generating material retained in said regulating chamber by a metallic regulating diaphragm and an interposed somewhat porous washer arranged between said regulating chamber and said cathode chamber, said regulating diaphragm being arranged in coöperation with said cathode to have heating effects developed therein when said tube is in regulating condition, said regulating chamber having an inoperative extension outside of the tube body and beyond the substantial influence of said regulating effects and into which said gas generating material may be transferred when the tube is inverted, said vacuum tube having a plurality of separated anodes each communicating with the cathode chamber through a constricted anode passage.

2. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided with a cathode formed of a plurality of electrically connected strips of sheet metal arranged in substantially hollow cylindrical form and having large effective diameter and capacity to secure correspondingly high valve efficiency, said vacuum tube having a regulating chamber containing gas generating material retained in said regulating chamber by a regulating diaphragm arranged between said regulating chamber and said cathode chamber, said regulating diaphragm being arranged in coöperation with said cathode to have heating effects developed therein when said tube is in regulating condition, said vacuum tube having a plurality of separated anodes communicating with the cathode chamber through constricted anode passages.

3. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided with a cathode having large effective diameter and capacity to secure correspondingly high valve efficiency, said vacuum tube having a regulating chamber containing gas generating material retained in said regulating chamber by a regulating diaphragm arranged between said regulating chamber and said cathode chamber, said regulating diaphragm being arranged in coöperation with said cathode to have heating effects developed therein when said tube is in regulating condition, said vacuum tube having a plurality of separated anodes communicating with the cathode chamber through constricted anode passages.

4. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided adjacent one end with a cathode having large effective diameter and capacity to secure correspondingly high valve efficiency, said vacuum tube having a regulating chamber containing gas generating material retained in said regulating chamber by a metallic regulating diaphragm arranged between said regulating chamber and said cathode chamber and in coöperation with said cathode to have heating effects developed therein when said tube is in regulating condition, said regulating chamber having an inoperative extension beyond the substantial influence of said regulating effects and into which said gas generating material may be transferred, said vacuum tube having multiple separated anodes each arranged around said regulating chamber in an anode chamber communicating with the cathode chamber through a constricted anode passage.

5. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided adjacent one end with a cathode, said vacuum tube having a regulating chamber containing gas generating material retained in said regulating chamber by a regulating diaphragm arranged between said regulating chamber and said cathode chamber and in coöperation with said cathode to have heating effects developed therein when said tube is in regulating condition, said vacuum tube having multiple separated anodes each arranged

around said regulating chamber in an anode chamber communicating with the cathode chamber through a constricted anode passage.

6. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided adjacent one end with a cathode, said vacuum tube having a regulating chamber containing gas generating material retained in said regulating chamber by a regulating diaphragm arranged between said regulating chamber and said cathode chamber and in coöperation with said cathode to have heating effects developed therein when said tube is in regulating condition, said vacuum tube having multiple separated anodes arranged around said regulating chamber in an anode chamber.

7. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided with a cathode and having a regulating chamber containing loosening devices and gas generating material retained in said regulating chamber by a metallic regulating diaphragm and an interposed porous asbestos washer arranged between said regulating chamber and said cathode chamber, said regulating diaphragm being arranged in coöperation with said cathode to have heating effects developed therein when said tube is in regulating condition, said regulating chamber having an inoperative extension outside of the tube body and beyond the substantial influence of said regulating effects and into which said gas generating material may be transferred when the tube is inverted.

8. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided with a cathode and having a regulating chamber containing loosening devices and gas generating material retained in said regulating chamber by a metallic regulating diaphragm arranged between said regulating chamber and said cathode chamber, said regulating diaphragm being arranged in coöperation with said cathode to have heating effects developed therein when said tube is in regulating condition, said regulating chamber having an inoperative extension outside of the tube body and beyond the substantial influence of said regulating effects and into which said gas generating material may be transferred.

9. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided with a cathode and having a regulating chamber containing loosening devices and gas generating material retained in said regulating chamber by a regulating diaphragm arranged between said regulating chamber and said cathode chamber, said regulating diaphragm being arranged in coöperation with said cathode to have heating effects developed therein when said tube is in regulating condition, said regulating chamber having an inoperative extension beyond the substantial influence of said regulating effects and into which said gas generating material may be transferred.

10. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided with a cathode and having a regulating chamber containing loosening devices and gas generating material retained in said regulating chamber by a regulating diaphragm arranged between said regulating chamber and said cathode chamber, said regulating diaphragm being arranged in coöperation with said cathode to have heating effects developed therein when said tube is in regulating condition.

11. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided with a cathode and having a regulating chamber containing gas generating material retained in said regulating chamber by a metallic regulating diaphragm arranged between said regulating chamber and said cathode chamber, said regulating diaphragm being arranged in coöperation with said cathode to have heating effects developed therein when said tube is in regulating condition, said regulating chamber having an inoperative extension outside of the tube body and beyond the substantial influence of said regulating effects and into which said gas generating material may be transferred.

12. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided with a cathode and having a regulating chamber containing gas generating material retained in said regulating chamber by a regulating diaphragm arranged between said regulating chamber and said cathode chamber, said regulating diaphragm being arranged in coöperation with said cathode to have heating effects developed therein when said tube is in regulating condition, said regulating chamber having an inoperative extension beyond the substantial influence of said regulating effects and into which said gas generating material may be transferred.

13. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided with a cathode and having a regulating chamber containing gas generating material retained in said regulating chamber by a regulating diaphragm arranged between said regulating chamber and said cathode chamber, said regulating diaphragm being arranged in coöperation with said cathode to have heating effects developed therein when said tube is in regulating condition.

14. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided adjacent one end with a

cathode formed of a plurality of electrically connected strips of sheet metal arranged in substantially hollow cylindrical form and having large effective diameter and capacity to secure correspondingly high valve efficiency, said vacuum tube having multiple separated anodes each arranged in an anode chamber communicating with the cathode chamber through a constricted anode passage.

15. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided with a cathode arranged in substantially hollow cylindrical form and having large effective diameter and capacity to secure correspondingly high valve efficiency, said vacuum tube having multiple separated anodes each arranged in an anode chamber communicating with the cathode chamber through a constricted anode passage.

16. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided with a cathode having large effective diameter and capacity to secure correspondingly high valve efficiency, said vacuum tube having a plurality of separated anodes each arranged in an anode chamber communicating with the cathode chamber through a constricted anode passage and gas generating material coöperating with said cathode to be exposed to the heating effects therefrom when said tube is in regulating condition.

17. The self-regulating vacuum valve tube comprising a vacuum tube having a cathode chamber provided with a cathode, said vacuum tube having a plurality of separated anodes each arranged in an anode chamber communicating with the cathode chamber through a constricted anode passage and gas generating material coöperating with said cathode to be exposed to the heating effects therefrom when said tube is in regulating condition.

18. The vacuum valve tube comprising a vacuum tube having a cathode chamber provided adjacent one end with a cathode formed of a plurality of electrically connected strips of sheet metal arranged in substantially hollow cylindrical form and having large effective diameter and capacity to secure correspondingly high valve efficiency, said vacuum tube having an anode arranged in an anode chamber communicating with the cathode chamber through a constricted anode passage.

19. The vacuum valve tube comprising a vacuum tube having a cathode chamber provided with a cathode arranged in substantially hollow cylindrical form and having large effective diameter and capacity to secure correspondingly high valve efficiency, said vacuum tube having an anode arranged in an anode chamber communicating with the cathode chamber through a constricted anode passage.

EUGENE W. CALDWELL.

Witnesses:
HARRY L. DUNCAN,
JESSIE B. KAY.