Aug. 22, 1933. P. L. SPENCER 1,923,335

THERMIONIC VAPOR DISCHARGE DEVICE

Filed Sept. 23, 1931 2 Sheets-Sheet 1

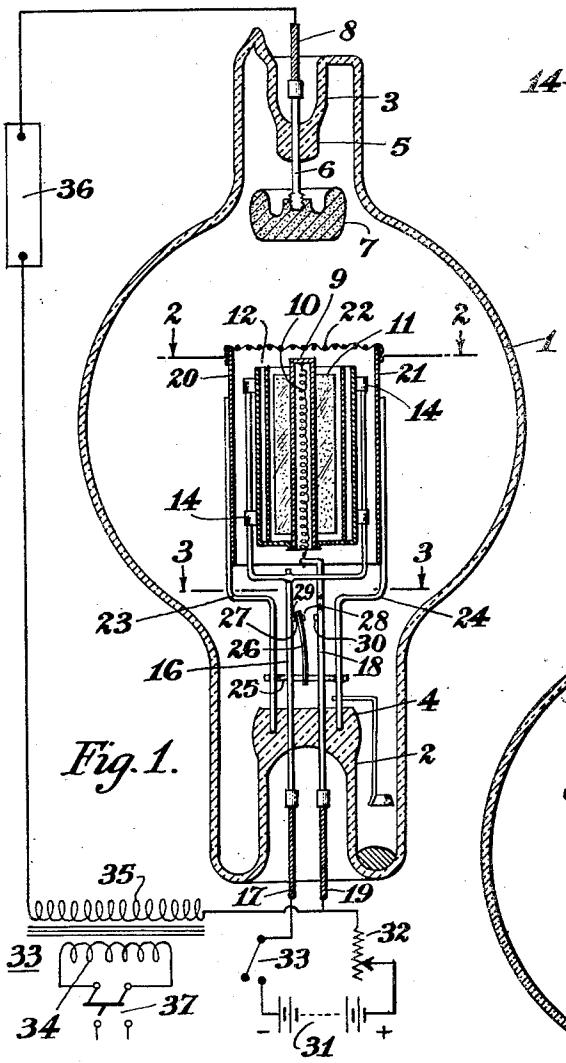


Fig. 1.

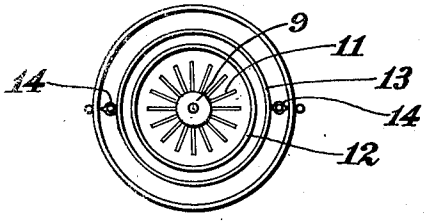


Fig. 2.

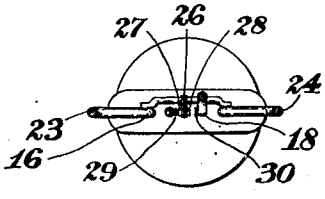


Fig. 3.

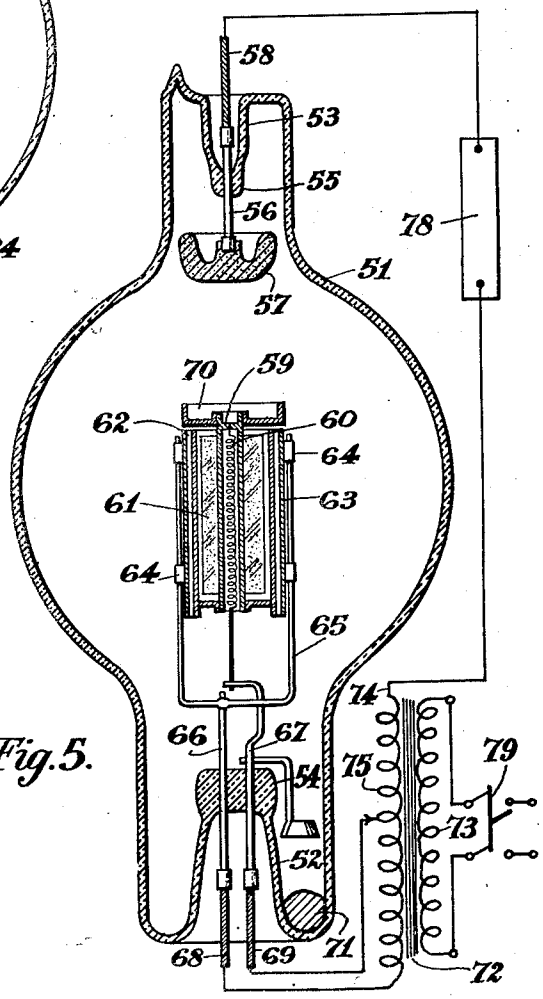


Fig. 5.

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Aug. 22, 1933. P. L. SPENCER 1,923,335

THERMIONIC VAPOR DISCHARGE DEVICE

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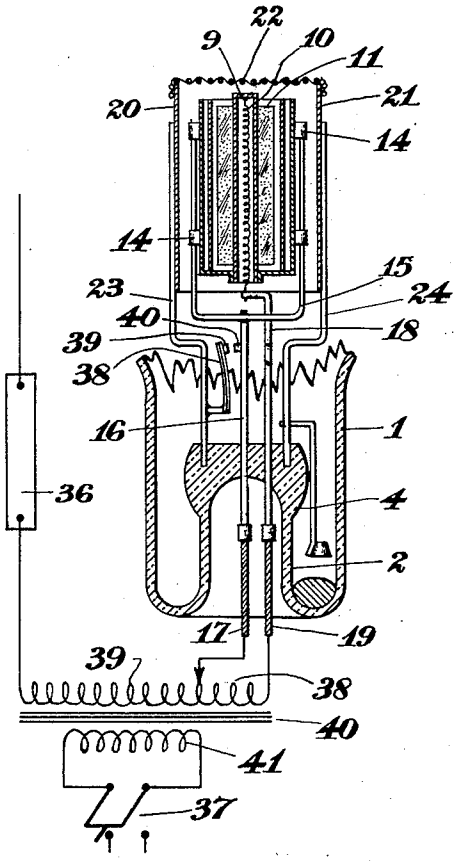


Fig. 4.

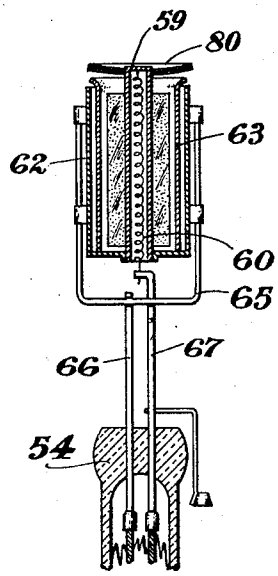


Fig. 6.

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THERMIONIC VAPOR DISCHARGE DEVICE

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Application September 23, 1931
Serial No. 564,580

10 Claims. (Cl. 250—27)

This invention relates to a thermionic vapor discharge device of the type employing a thermionic cathode and an anode. Such a device may be, for example a rectifier.

One of the objects of my invention is to provide means for preventing a discharge from passing between the cathode and anode until the temperature conditions within the device are such that the discharge will not injure the surface of the cathode.

The foregoing and other objects of my invention will be best understood from the following description of exemplifications thereof, reference being had to the accompanying drawings, wherein:

Fig. 1 is a view of one embodiment of my invention;

Fig. 2 is a section taken along line 2—2 of Fig. 1;

Fig. 3 is a section taken along line 3—3 of Fig. 1;

Fig. 4 is a fragmentary showing of a modification of the device as shown in Fig. 1;

Fig. 5 is a view of another embodiment of my invention; and

Fig. 6 is a fragmentary showing of the embodiment of the device, as shown in Fig. 5.

In a device which operates by an ionizing discharge in a vapor between a thermionic cathode and an anode, certain precautions are necessary in starting. It has been found that if a voltage is applied between the cathode and the anode before the cathode is sufficiently and uniformly hot, the discharge which passes has a tendency to localize upon one spot on the cathode, thereby causing a destructive burning of the cathode at that point. This effect, according to my present understanding of the phenomena involved, appears to be due to the following reasons.

Upon initially furnishing heating current to the heating filament of a cathode, the temperature of the electron-emitting surfaces of the cathode will usually not rise uniformly at the same rate. Therefore, one part of said surface will reach a point at which it emits electrons sooner than the other parts of the cathode surface. Thus if a potential exists between the cathode and anode, a discharge will start to pass between that part of the cathode surface and the anode. When the discharge starts, a considerable number of positive ions are created adjacent the point at which the electrons leave the cathode surface. These positive ions are attracted toward the negative cathode and fall on the cathode surface with considerable velocity and momentum. This bombardment by positive ions of that part of the cathode surface referred to is sufficient to raise the temperature of the cathode at that point. Also the passage of the resulting current through the cathode surface itself at this point has a tendency to raise its temperature. Therefore as soon as a discharge tends to start at any particular point on the cathode surface, due to the fact that its temperature is higher than the rest of the cathode, the above conditions arise which tend to raise the temperature of the cathode still further and emphasize the tendency of the discharge to continue at that point. The result is a concentration of the entire discharge through the discharge device at a particular point on the cathode surface. As a result, this point becomes overheated, resulting in the destruction of the coating and a disintegration of the cathode at said point.

I have discovered that if a time interval is allowed to elapse after the heating current is first furnished to the heating filament of a cathode before a voltage is applied between the cathode and the anode, the temperature of the cathode surface will rise to its operating value and the entire electron-emitting surface of the cathode will assume practically the same temperature. Thus the tendency for a discharge to localize upon a particular spot on the cathode is eliminated.

It is also desirable that the vapor pressure of the vapor surrounding the cathode be somewhat higher than it is at ordinary room temperature. At the comparatively low vapor pressure which exists at room temperature, the distances between the individual atoms of the vapor is comparatively great. If a discharge is allowed to start at this low vapor pressure, ionization of the vapor will occur and the positive ions created will be attracted toward the negative cathode. These comparatively heavy positive ions travel freely toward the cathode without much impedance, due to collision with vapor atoms, and consequently fall upon the cathode with considerable momentum. This may be sufficient to destroy the coating with which the cathode is usually provided to increase its electron emissivity. If, however, the temperature of the vapor and consequently its vapor pressure is allowed to rise, the concentration of the atoms in the vapor increases. Therefore, the positive ions created by the discharge passing between the cathode and the anode are impeded in their travel toward the negative cathode by numerous collisions with vapor atoms. Thus these positive ions at the higher vapor pressure do not fall upon the cathode with the excessive momentum which may exist at the lower vapor pressure. If a time interval is provided during which the

cathode may heat up, as set forth above, the temperature of the vapor within the device will be raised by the heat generated in the heating filament. The vapor pressure, therefore, will also rise, and when a discharge is allowed to start, the coating on the cathode will be protected against destruction by positive ion bombardment.

In order to protect devices of the type described against the destructive action, as outlined above, special precautions have been necessary to insure that the circuit between the cathode and the anode is kept open for a certain time interval to allow the temperature conditions within the device to reach safe operating value. In accordance with my invention, I provide an arrangement whereby both the cathode-heating circuit and the cathode-anode circuit can be simultaneously energized, and the difficulties enumerated above are entirely eliminated.

In Fig. 1, which illustrates an embodiment of my invention, I have shown a rectifier consisting of a hermetically sealed envelope 1 having two reentrant stems 2 and 3 carrying presses 4 and 5 at the inner ends of said stems, respectively. Press 5 has sealed therein an anode lead 6 supporting an anode 7 at one end thereof. This anode preferably consists of carbon. The lead 6 extends through the press 5, and is provided with a conductor 8 affording an exterior electrical connection to the anode 7.

The press 4 supports a cathode structure. This cathode structure consists of a hollow cylinder 9, preferably made of nickel, provided with an internal heating filament 10. The cylinder 9 is provided with a series of fins or wings 11 radiating from the exterior surface of said cylinder. The fins 11 as well as the outer surface of the cylinder 9 are preferably coated with some material to increase the electron emissivity thereof. Such a coating may be, for example, strontium or barium oxide. In order to conserve the heat generated by the filament 10, the cylinder 9 together with the fins 11 are surrounded by two concentric nickel heat shields 12 and 13, said heat shields being supported by being welded to the lower end of the cylinder 9, thus forming a unitary structure. The outer shield 13 is provided with a number of supporting lugs 14 to which is welded a U-shaped supporting member 15. This U-shaped supporting member 15 is in turn welded to a cathode-supporting standard 16 sealed in the press 4. The cathode standard 16 extends through the press 4 and is provided with a conductor 17 affording an exterior electrical connection for the cathode. The heating filament 10 is connected at one end to the interior of the hollow cathode 9, and at its other end to a filament standard 18 also sealed in the press 4. This filament standard 18 likewise extends through the press 4, and is provided with a conductor 19, whereby an external electrical connection may be made to said filament 10.

In order to prevent a discharge from passing between the cathode structure described above and the anode until the temperature of the cathode has risen to the desired point, I surround said cathode structure by a shield 20. This shield consists of a metal cylinder 21 placed concentrically around the cathode structure. The upper end of this shield carries a screen mesh 22 interposed between the upper end of the cathode structure and the anode 7. This screen mesh 22 is fastened to the upper end of the cylinder 21 by being welded thereto. The screen 20 is supported on the press 4 by two shield standards 23 and 24, each welded at one end to the cylinder 21 and sealed at its other end in the press 4. A cross-piece 25 is welded to and connects the two shield standards 23 and 24. It will be noted that this cross-piece is maintained out of electrical connection with the two standards 16 and 18. The cross-piece 25 supports, adjacent the cathode 9, a thermostatic element 26 intermediate the two standards 16 and 18. This thermostatic member 26 carries two contacts 27 and 28 on opposite sides of the outer end thereof. The standards 16 and 18 carry two contacts 29 and 30 cooperating with said two contacts 27 and 28 on said thermostatic element. When the thermostatic element 26 is cold, it is in the position in which contact 27 touches contact 29 on the standard 16. As the temperature of the cathode rises, the temperature of the adjacent parts, including the thermostatic element 26, also rises. The constants of the thermostatic element 26 are so chosen that when the temperature of the cathode has risen to the desired point, the contact 27 leaves the contact 29 and the contact 28 moves over against the contact 30 on the standard 18.

The rectifier may be connected in some suitable circuit, such as, for example, that illustrated in Fig. 1. A source of direct heating current, such as a battery 31, is connected between the two conductors 17 and 19. In series with said battery 31 is a controlling resistance 32 and a switch 33. The source of potential 31 is connected with the negative terminal thereof connected to the conductor 17 and the positive terminal thereof connected to the conductor 19. The alternating voltage to be rectified is impressed between the conductors 19 and 8. In series with said latter circuit is a suitable output device 36. A switch 37 may be used to connect the primary winding 34 to an alternating current power line.

The rectifier, as described above, is put in operation by closing the switches 33 and 37. This may be done simultaneously as distinguished from prior arrangements in which a considerable time interval elapsed between the closing of the switch corresponding to my switch 33 and the switch corresponding to my switch 37. Upon closing said switches, the filament 10 is supplied with heating current, and raises the temperature of the cylinder 9 and the fins 11 to a point at which they start to emit electrons. If the shield 20 were not provided in the device, these electrons so emitted during the half cycle in which the anode 7 was positive and the cathode was negative would travel toward the anode under the influence of the voltage impressed between said electrodes and during said passage would ionize the vapor atoms existing in the space between said electrodes. This ionization creates a large number of free electrons and positive ions which enable a large current to pass between the cathode and anode with a comparatively low voltage drop. In order, however, that such a discharge, which is termed a breakdown discharge, can pass between the cathode and the anode, a sufficiently large number of electrons must be free to travel between the cathode and the anode. By connecting the shield in the manner in which I have indicated, I prevent practically all of the electrons emitted from the cathode from passing out into the space in which they may be attracted toward the anode 7. In the arrangement as shown in Fig. 1, this results from the fact that the negative terminal of the battery 31 is directly connected to the shield 20. Thus the shield 20 possesses a negative po-

tential with respect to the electron-emitting surfaces of the cathode. The negative charge which the shield 20 assumes as a result of this negative potential repels the electrons emitted from the cathode, and prevents practically all of them from passing through the screen 22 into the space in which it may be attracted toward the anode 7. As long as the shield 20 is connected to the negative terminal of the battery 31, a breakdown discharge will not occur between the cathode and the anode. However, the heat liberated by the heating current passing through the filament 10 will gradually raise the temperature of the cathode structure. It will be noted that during this period, the temperature of the mercury vapor within the envelope and consequently the vapor pressure thereof will also rise. As the temperature of the cathode increases the thermostatic element will move so that the contact 27 leaves the contact 29. However, the discharge is still prevented from passing between the anode and the cathode. This is due to the fact that the shield 20 is now free within the envelope 1, and is insulated from all of the surrounding conducting members. Thus it retains the negative charge which it previously possessed, and in fact this negative charge might tend to increase due to the fact that some of the electrons coming from the cathode will fall upon said shield. As the temperature continues to rise, the thermostatic element 26 moves until finally the contact 28 touches the contact 30. At this point the shield 20 will lose its negative charge, and due to the fact that it is connected to the positive terminal of the battery 31, it will assume a positive potential with respect to the cathode-emitting surfaces. When this happens, the electrons instead of being repelled by the charge on the screen 20 will now be attracted toward said screen. Practically all of the electrons so attracted will sheet through the openings in the screen 22, and are then free to pass toward the anode 7. Thus on the helf cycle in which the anode 7 is positive, a breakdown discharge will occur and the rectifier will start operating. The operation of the rectifier from this point on continues as in the usual rectifier of the present type. The shield 20 now acts merely as an additional heat shield, and does not interfere with the further operation of said rectifier. The rectified current is utilized in some suitable manner in the output device 36.

The arrangement of the device in Fig. 1 effectively prevents the discharge from starting prematurely, whereby the dangers incident to such a premature starting as described above are effectively eliminated.

Although I have described the filament in Fig. 1 as being fed from a direct current source, it is possible to utilize my arrangement with a source of alternating heating current. In Fig. 4 I have shown one example of such an arrangement. Between the conductors 17 and 19 is connected a winding 38. This winding 38 is a small section of a secondary 39 of a transformer 40. Said transformer possesses a primary winding 41 connected through the switch 37 to a source of alternating potential, as described for Fig. 1. The secondary winding 39 is connected in series with the output device 36 between the anode and cathode in a manner similar to that in which the secondary winding 35 is connected in Fig. 1. Instead of connecting the shield 20 to one terminal of the heating current source in the cold position, as is done in Fig. 1, I leave the shield 20 entirely free during the preliminary heating of the rectifier. I accomplish this by mounting a thermostatic element 38 directly on one of the shield standards, such as, for example, 23. The thermostatic element 38 has but a single contact 39 which touches a contact 40 mounted on one of the cathode standards, such as, for example, 16 in the hot position. When, however, the cathode is cold, the thermostatic element 38 merely moves so that the contacts 39 and 40 are separated, thus leaving the shield 20 electrically disconnected from any of the conducting members within the envelope.

The device as shown in Fig. 4 is started by closing the switch 37 which simultaneously energizes the filament-heating circuit and the cathode-anode circuit. However, as soon as the electrons start coming off of the cathode-emitting surfaces, some of these electrons will fall upon the shield 20 which will thereby acquire a negative charge. This negative charge will practically immediately build up to a point at which all of the electrons are repelled back to the cathode, and the breakdown discharge between the cathode and anode is effectively prevented, as explained for Fig. 1. When the temperature of the cathode in Fig. 4 rises to the desired point, the contact 39 will touch the contact 40. It will be noted that the connections to the windings 38 and 39 are made in such a manner that when the anode 7 is positive, the shield 20 will likewise be positive. When the anode 7 is positive with respect to the cathode, the shield 20 will likewise be positive with respect to the cathode. Thus during the half cycle in which breakdown would tend to occur between the cathode and the anode, the shield 20 is connected in such a direction as to attract the electrons emitted from the cathode, whereby these electrons will pass out into the space in which they may be attracted toward the anode and the breakdown discharge will thus be enable to occur. Therefore, the rectifier will become conducting during the half cycle in which the anode 7 is positive, and will become non-conducting in the alternate half cycle, whereby the rectifier will operate in the usual manner.

In Fig. 5 I have illustrated a further embodiment of my invention in which discharge is prevented from occurring in a cold metallic vapor rectifier by the use of a thermostatic member. The rectifier shown in Fig. 5 consists as does the rectifier shown in Fig. 1 of an evacuated envelope 51 having two reentrant stems 52 and 53 carrying presses 54 and 55 at their outer ends respectively. An anode-supporting press 55 has sealed therein an anode-supporting lead 56 which carries a carbon anode 57 at one end thereof. The lead 56 extends from the press 55, and is provided with an external conductor 58. The press 54 carries a cathode consisting of a hollow nickel cylinder 59 provided with an external heating filament 60. The cylinder 59 is provided with a number of fins 61 similar to the fins 11 in Fig. 1. The fins 61 and the outer surface of the cathode 59, except for the top thereof, are preferably coated with some material to increase the electron emissivity thereof. The cylinder 59 and the fins 61 are surrounded by two concentric nickel heat shields 62 and 63, each supported by and electrically connected to the lower end of the cylinder 59. The outer heat shield 63 carries a number of supporting lugs 64 connected to a U-shaped supporting member 65 which is welded to a cathode-supporting standard 66 sealed in the press 54. One end of the filament

60 is connected to the cylinder 59, and the opposite end of said filament is connected to the filament standard 67 also sealed in the press 54. The standards 66 and 67 extend through the press 54, and are provided with external electrical conductors 68 and 69, respectively. Upon the upper end of the cylinder 59 is mounted a cup-shaped disk 70. The envelope 51 is also evacuated and provided with a quantity of mercury 71 which furnishes mercury vapor for the interior of said envelope. A suitable circuit, such as that illustrated in Fig. 5, may be provided for the rectifier shown therein. A transformer 72 comprises a primary winding 73 and a secondary winding 74. One section 75 of the secondary winding 74 is connected between the conductors 68 and 69, and furnishes heating current to the filament 60. The other section 76 of the secondary winding 74 is connected in series with an output device 78 between the conductors 69 and 58. The primary winding 73 is provided with a suitable switching device 79, whereby it may be connected to a source of alternating current. The rectifier in Fig. 5 is set in operation by closing the switch 79 which simultaneously energizes the filament-heating circuit and the cathode-anode circuit. The dimensions of the parts are so chosen that when the cathode is cold, there is a very slight clearance between the upper edges of the heat shields and the lower surface of the disk 70. Due to this small clearance, the electrons emitted from the electron-emitting surfaces of the cathode have difficulty in passing out through this space. Furthermore the arrangement of the disk 70 and the heat shields 62 and 63 form an electrostatic shield around the electron-emitting surfaces of the cathode. Due to this shield arrangement, the electrostatic lines of the field between the anode and the cathode terminate on the disk 70 and the heat shield 62. Due to the small clearance referred to above, these electrostatic lines have difficulty in entering the space created between the heat shields and the disk 70. Thus there will be very little tendency for the field between the two electrodes to exert any influence upon the electrons emitted from the cathode-emitting surfaces. Although the filament 60 will raise the temperature of the structure surrounding the cathode to some degree, yet the external surfaces of said structure not being coated with any electron-emissive material will give off an insignificant number of electrons. The total number of electrons which can escape from the cathode into a region in which they are affected by the field between the cathode and the anode is insufficient to initiate a breakdown between these electrodes. As the filament 60 continues to give off heat, the temperature of the cylinder 59 will rise much more rapidly than will the temperature of the heat shields 62 and 63. Due to the fact that nickel has a fairly high temperature coefficient of expansion, the cylinder 59 will elongate considerably more than will the heat shields 62 and 63. Therefore, the clearance between these heat shields and the disk 70 will increase as the temperature of the cathode increases. I have found that the parts may be so arranged that this slight increase in clearance between the disk 70 and the heat shield 62 is sufficient to enable the field between the anode and the cathode to penetrate this space, and to enable a sufficient number of electrons to escape through the space so that a breakdown discharge is initiated between the cathode and anode. I have constructed a tube in which the clearance is originally about 1 mm. in cold position and increases to about 1⅓ mm. in hot position. Such a tube has been found to prevent a discharge from passing until the temperature of the cathode has risen to a sufficiently high point to prevent any destructive action thereon by the discharge. However, after such a cathode has reached a sufficiently high temperature, a discharge readily starts between the cathode and the anode.

The low initial vapor pressure may also have some effect in preventing a discharge from starting through the opening between the heat shields and the disk 70. At the low initial vapor pressure of the mercury within the envelope 51, the distance between individual atoms of the vapor and consequently the mean free path is quite large. The fact that the vapor within the envelope 51 has a large mean free path and the clearance between the disk 70 and the heat shields is rather small may have some effect in preventing the initiation of a discharge through this opening. As the heating filament 60 liberates heat within the envelope 51, the temperature of the vapor within said envelope as well as the temperature of the cathode also increases. The vapor pressure, therefore, increases, resulting in a greater concentration of atoms and a shorter mean free path of said vapor. The decrease in the mean free path of the vapor and the increase of the opening between the heat shields and the disk 70 also appear to have some effect in enabling a discharge to start between the hot cathode and the anode.

After the discharge has once started, the operation of the rectifier from this point on is the same as with the ordinary rectifiers of the type described. The arrangement as shown in Fig. 5 also effectively protects the rectifier against the dangers of premature starting of the discharge in this type of rectifier.

Although I have described the cathode and the heat shields in Fig. 5 as being constructed of nickel, it is obvious that other metals could also be utilized. For example, the cathode could be made of one metal having a high coefficient of expansion, while the heat shields 62 and 63 could be made of other metals having lower coefficients of expansion. It should also be noted that the particular dimensions given above are not necessarily limiting dimensions. Inasmuch as different constants will exist in various types of tubes constructed, the design which would most likely be most effective is one in which the original clearance between the disk 70 and the heat shields is slightly less than that at which a discharge will start. Therefore, a very small increase in said clearance will be necessary in order to enable a discharge to start between the two electrodes. Although I have illustrated the filament 60 as being energized by alternating current, yet the arrangement as shown in Fig. 5 is equally applicable to a rectifier in which the heating element for the cathode is heated in any manner whatsoever, such as, for example, by a source of direct current.

While the arrangement in Fig. 5 depends upon the thermostatic properties of the cathode itself, a separate thermostatic element may be used, as shown in Fig. 6, to open and close a discharge path between the cathode and the anode. In Fig. 6 I have illustrated a thermostatic disk 80 mounted on the upper end of the cylinder 59. This thermostatic disk is a bimetallic, disk-shaped member which snaps from one position to another, and reverses its curvature when the

temperature rises above or falls below certain predetermined temperatures. Such a thermostat may be, for example, like that described in the patent to J. A. Spencer, No. 1,448,240, dated March 13, 1923. This thermostatic disk 80 is tightly fitted around the upper end of the cylinder 59, and may be connected thereto as, for example, by welding. The upper end of the heat shield 63 may be provided with a slight flare to cooperate with the edges of the thermostatic disk 80 in the cold position thereof. When the cathode is cold, thermostat 80 is in its cold position and the edges thereof are in contact with the flare on the upper end of the heat shield 63. When the electron-emitting surfaces of the cathode start emitting electrons upon energization of the heating filament 60, these electrons are prevented from passing out into the discharge space due to the fact that the thermostat together with the heat shield 63 encloses the space into which the electrons are given off, and thus there are an insufficient number of electrons in the space between the cathode and the anode to initiate a breakdown discharge. Although the filament 60 will raise the temperature of the structure surrounding the cathode to some degree, yet the external surfaces of the structure surrounding the cathode not being coated with an electron-emissive material will give off an insignificant number of electrons, which number will be insufficient to start a breakdown discharge. When, however, the temperature of the cathode has risen to the desired point, the thermostat 80 is so designed that it will snap to its upper position, as shown in Fig. 6. In this position the parts are so designed that there is a sufficient clearage between the edges of the thermostat 80 and the upper edge of the heat shield 63 to permit the electrons emitted from the cathode-emitting surfaces to pass out into the envelope 51. The presence of these electrons enables a breakdown discharge to occur between the cathode and the anode during the half cycle when the anode 57 becomes positive. The operation of the rectifier from this point on is the same as with ordinary rectifiers of the type described. The protection afforded by each of the embodiments heretofore described is also present in the arrangement as shown in Fig. 6.

The invention is not limited to the particular details of construction, materials and processes described above as many equivalents will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. A thermionic discharge device comprising a sealed envelope containing an ionizable atmosphere, a thermionic cathode, and an anode within said envelope, means for heating said cathode, means for preventing a discharge from occurring between said cathode and anode, and means responsive to the temperature of said cathode for rendering said last-named means inoperative to prevent said discharge from occurring when the temperature of said cathode has risen above a predetermined point.

2. A thermionic discharge device comprising a sealed envelope containing an ionizable atmosphere, a thermionic cathode, and an anode within said envelope, means for supplying heating current to said cathode, means for preventing a discharge from occurring between said cathode and anode, and thermostatic means within said envelope for rendering said last-named means inoperative to prevent said discharge from occurring until a definite time interval has elapsed after the heating current is first supplied to said cathode.

3. A thermionic vapor discharge device comprising a sealed envelope containing a vapor, a thermionic cathode and an anode within said envelope, controlling means interposed between said cathode and anode, means for impressing a negative charge upon said controlling means whereby a discharge between said cathode and anode is prevented, means responsive to the temperature adjacent the cathode for removing said charge when said temperature rises above a predetermined point.

4. A thermionic vapor discharge device comprising a sealed envelope containing a vapor, a thermionic cathode and an anode within said envelope, means interposed between said cathode and anode for substantially shutting off the flow of electrons from the cathode to the anode, and means responsive to the temperature adjacent the cathode for rendering said last-named means inoperative to prevent said flow when the said temperature rises above a predetermined point.

5. A thermionic vapor discharge device comprising a sealed envelope containing a vapor, a thermionic cathode and an anode within said envelope, two conductors from which said cathode is supplied with heating current, a screen interposed between said cathode and anode, said screen being normally electrically insulated from said cathode, and means responsive to the temperature adjacent the cathode for electrically connecting said screen to one of said conductors when said temperature rises above a predetermined point.

6. A thermionic vapor discharge device comprising a sealed envelope containing a vapor, a thermionic cathode and an anode within said envelope, a source of direct current for furnishing heating current to said cathode, a screen interposed between said cathode and anode, said screen being normally arranged to assume a negative potential with respect to said cathode, and means responsive to temperature adjacent the cathode for removing said negative charge by electrically connecting said screen to the positive terminal of said direct current source.

7. A thermionic vapor discharge device comprising a sealed envelope containing a vapor, a thermionic cathode and an anode within said envelope, a source of direct current for furnishing heating current to said cathode, a screen interposed between said cathode and anode, said screen being normally arranged to assume a negative potential with respect to said cathode, and means responsive to temperature adjacent the cathode for removing said negative charge.

8. A thermionic vapor discharge device comprising a sealed envelope containing a vapor, a thermionic cathode and an anode within said envelope, two conductors from which said cathode is supplied with heating current, a source of alternating current impressed between said cathode and anode, one of said conductors being so connected as to be positive with respect to the rest of the cathode when said anode is positive with respect to said cathode, a screen interposed between said cathode and anode, said screen being normally arranged to assume a negative potential with respect to said cathode, and means responsive to the temperature adjacent the cathode for electrically connecting said screen to said

last-named conductor when said temperature rises above a predetermined point.

9. A thermionic discharge device comprising a sealed envelope containing an ionizable atmosphere, a thermionic cathode and an anode within said envelope, said cathode being provided with electron-emitting surfaces, a shield substantially entirely enclosing said electron-emitting surfaces, and means associated with said cathode responsive to the temperature thereof for providing an opening of sufficient size to allow a discharge to pass between said cathode and anode when the temperature of said cathode reaches a certain predetermined point.

10. A thermionic vapor discharge device comprising a sealed envelope containing a vapor, a thermionic cathode and an anode within said envelope, said cathode being provided with electron-emitting surfaces, a shield for normally entirely enclosing said electron-emitting surfaces, whereby passage of electrons between said cathode and anode is prevented, and thermostatic means responsive to the temperature adjacent the cathode arranged to provide an opening in said shield when said temperature rises above a predetermined point whereby a discharge may occur between said cathode and anode.

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