P. H. THOMAS.

SYSTEM OF CONSTANT CURRENT DISTRIBUTION.

APPLICATION FILED MAR. 22, 1913.

1,168,439.

Patented Jan. 18, 1916.

3 SHEETS—SHEET 1.

Fig. 1

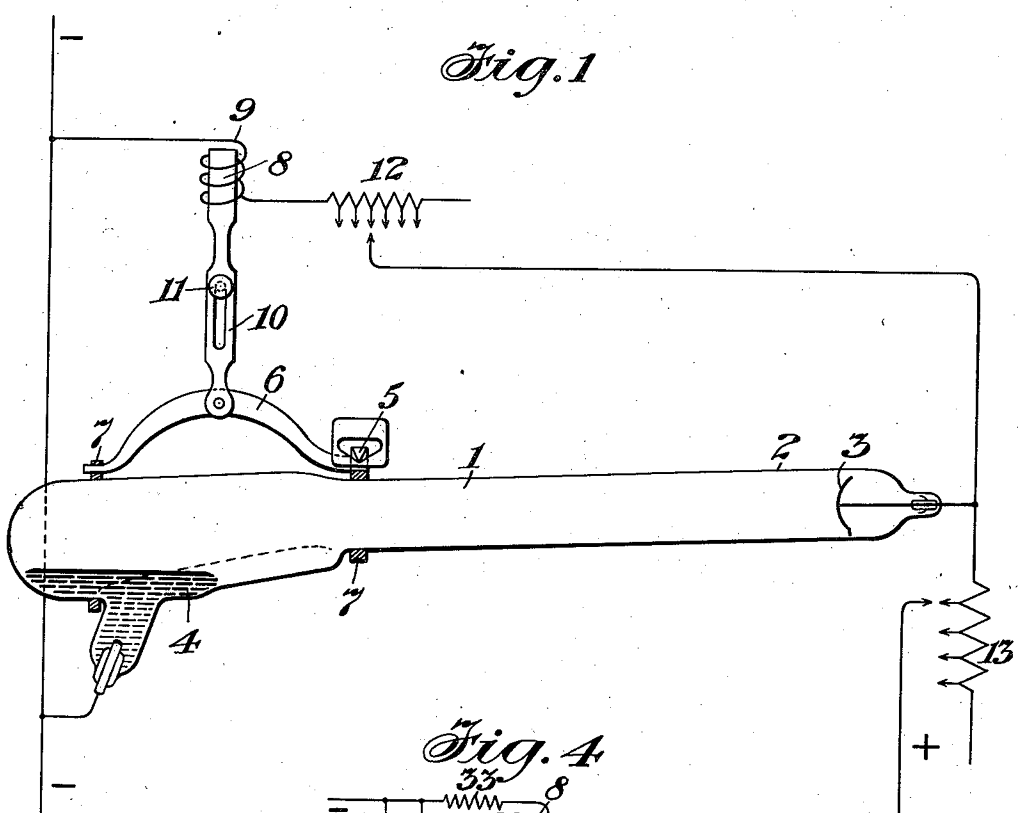


Fig. 4

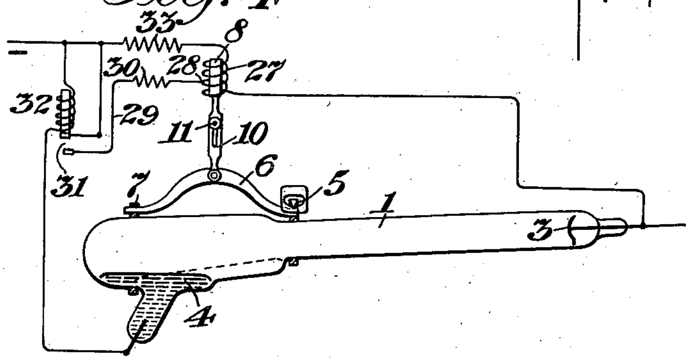
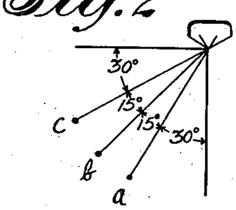


Fig. 2



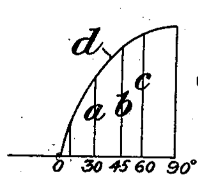


Fig. 3

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3 SHEETS—SHEET 2.

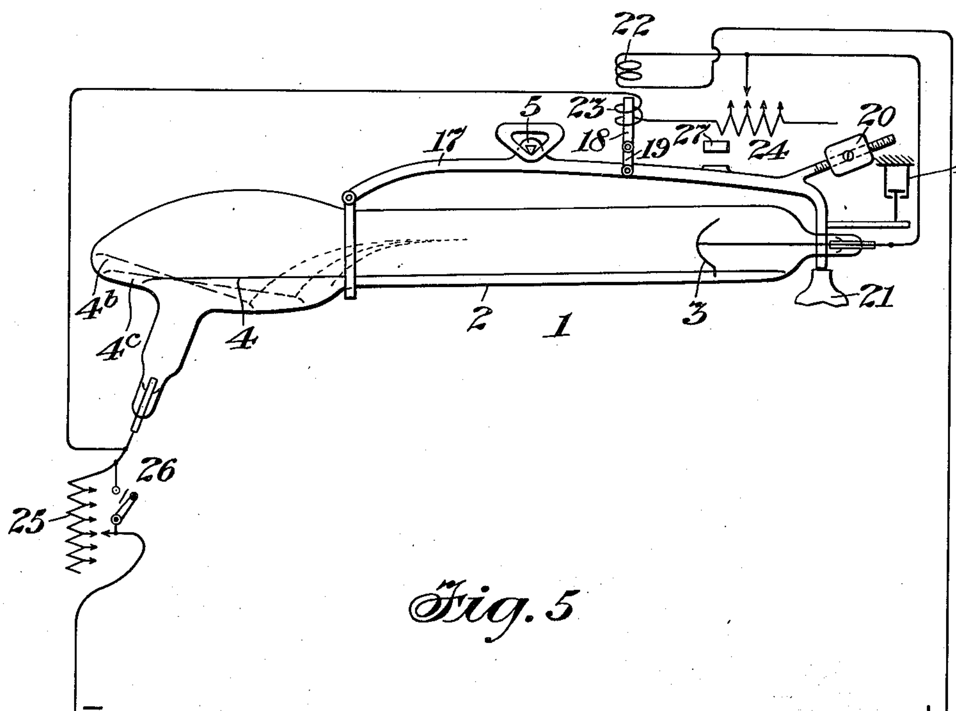

Fig. 5

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3 SHEETS—SHEET 3.

Fig. 6

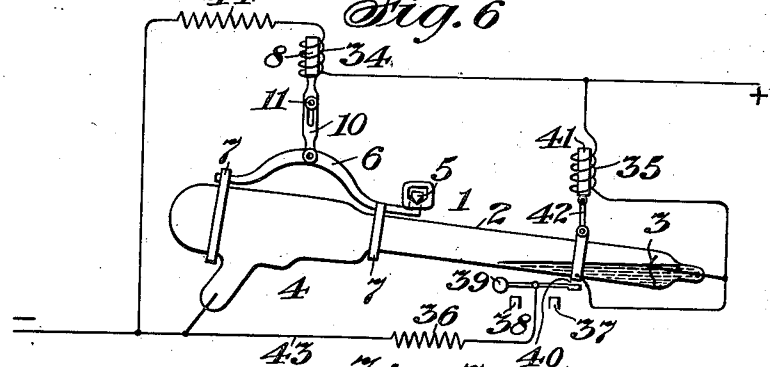


Fig. 7

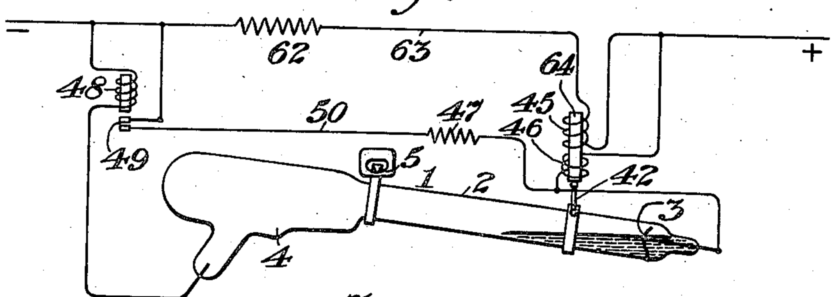


Fig. 8

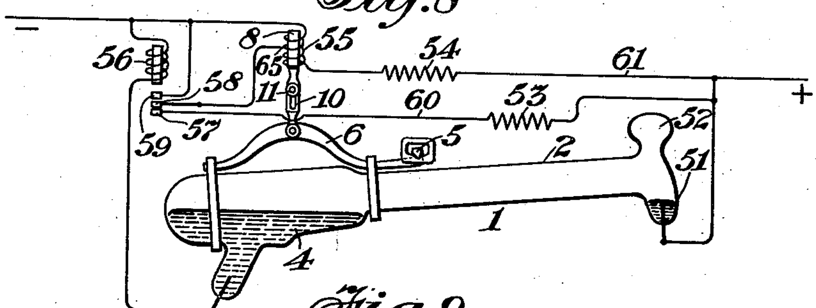
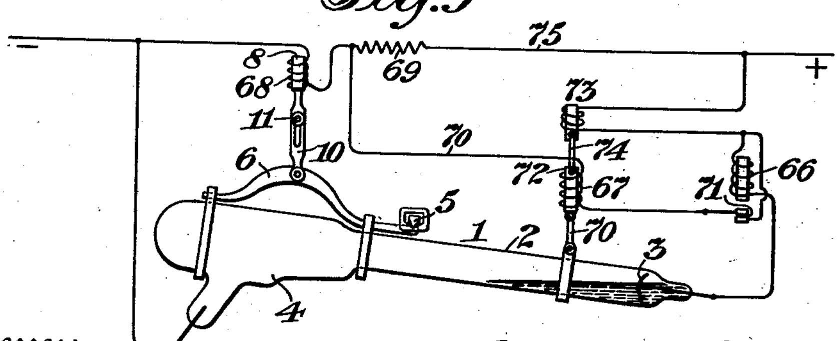


Fig. 9



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SYSTEM OF CONSTANT-CURRENT DISTRIBUTION.

1,168,439. Specification of Letters Patent. **Patented Jan. 18, 1916.**

Application filed March 22, 1913. Serial No. 756,074.

To all whom it may concern:

Be it known that I, Percy H. Thomas, a citizen of the United States, and resident of Upper Montclair, county of Essex, State of New Jersey, have invented certain new and useful Improvements in Systems of Constant-Current Distribution, of which the following is a specification.

My invention relates to the construction of mercury vapor devices for series operation and more particularly for operation on a constant current circuit. However, in some cases my invention is useful in connection with other supply circuits. These mercury vapor devices, comprising exhausted containers with anodes and vaporizable cathodes therein, have a general characteristic in accordance with which the voltage drop on the device tends to increase rapidly with an increase in current throughout a considerable portion of its operating range. In other words in such a device the current flow tends to remain approximately constant, while the voltage drop varies greatly up and down according to the variations in the potential of the supply. This characteristic renders series operation of these devices unstable and unsatisfactory where no means are provided for controlling variations.

My present invention provides for the neutralizing or overcoming or compensating for this characteristic of the mercury vapor apparatus, which tends to disturb series operation. If a number of these mercury vapor lamps are placed in series on a constant current circuit and certain of them become heated more than the others, thus tending to take more voltage, this over heating tendency can be corrected or balanced if means can be found for reducing the heat generated in the device. For since it naturally has a definite heat radiating power, any lessening of the heat generated within it will reduce the temperature at which it operates and thus the pressure of the vapor and the resistance of the device. In my invention I accomplish this result by changing the length of vapor path in accordance with changes in the vapor pressure or the resistance of the lamp, thus automatically interlinking the disturbing cause and the remedial means. If such adjusting system be applied to each of a number of serially operated mercury vapor devices on a constant current circuit which can be made automatically to absorb its own proper share of the voltage available without robbing the others and without itself developing an excessive vapor pressure, the difficulties already pointed out will be overcome. This method is broadly applicable to vapor electric devices and may be carried out in a number of ways.

For instance, I have illustrated in the accompanying drawings Figure 1 carrying such a system with a shunt operating magnet and Fig. 5 a modification with a differential shunt magnet. In Figs. 2 and 3 I show certain illustrative diagrams and in Figs. 4, 6, 7, and 8 certain modified circuits for my system.

In the first figure, wherein I have illustrated the application to a relatively constant potential source, 1 represents a vapor electric device having a hermetically sealed container, 2, with a tungsten anode, 3, and a mercury cathode, 4. This container, which is exhausted to a high degree of purity, contains a tubular portion between electrodes which is approximately horizontal in the operating position, but slants somewhat upward toward the solid anode in the non-operating position and downward to this anode momentarily during the starting period. The device is mounted on knife edges at 5 being held in the yoke, 6, secured to the lamp by straps, 7. The motion of the lamp is controlled by the magnetic core, 8, and its winding, 9, which winding is connected in shunt to the device. The motion of the magnetic core, 8, and the slotted link, 10, connecting the core to the yoke, 6, is limited by a pin, 11, within said slot. I have shown an adjustable resistance, 12, in series with the shunt magnet winding, 9, and an adjustable resistance, 13, in series with the device as a whole, the function of these resistances being regulative and for ballast purposes. Where desired adjustable reactance may be used in place of or in conjunction with the resistances 12 and 13. When the source is connected to the system of Fig. 1, the full line voltage is impressed upon the coil, 8, and resistance, 12, except for such an amount of voltage as is absorbed by the resistance, 13. The latter, however, will be small since the shunt current will ordinarily be selected as a small fraction of the main current for which the resistance, 13, is proportioned. That is a maximum magnetization will be impressed upon the core, 8, which will tilt the container to the full length permitted by the pin, 11. In this position mercury will run from the cathode and make contact with the anode whereupon current will be shunted out of the magnetic winding, 9, and the device will drop back into the non-operating position, the current flow, however, being established between the electrodes. Since when the device is below normal pressure the voltage absorbed will be below normal, the core, 8, will not then be sufficiently magnetized to tilt the device from its lowest position as shown in Fig. 1. As, however, the mercury warms up and the vapor pressure rises, the point is approached at which the pull of the shunt magnet, 9, will be sufficient to raise the yoke, 6, and I prefer to so adjust this apparatus that, with all conditions normal, the coil will raise the core, 8, slightly from its lowest position. If, now, for any reason, the device, 1, becomes overheated and the vapor pressure is excessive, then the voltage upon the shunt circuit will increase and the core, 8, will be drawn somewhat farther upward and the mercury of the cathode, 4, will flow somewhat to the right and shorten the distance between the active portion of the cathode and the anode. This tends to reduce the total heat generated in the device and thus lower the temperature and vapor pressure and correct the tendency to overheat. Since the device, 1, as supported, constitutes a pendulum, there will be found points of equilibrium farther and farther up for increasing currents in the magnetizing coil, 9, up to a certain limit. In other words, there are many points of equilibrium with varying lengths of vapor column in the device, 1, to meet varying conditions of the voltage drop in the tube. In order thus to provide for a plurality of points of equilibrium during the operation of the apparatus corresponding to ordinary variations in operating conditions and at the same time to provide for a positive tilting of sufficient amplitude to produce a free streaming of mercury for the initial starting, I may arrange the various stops and supports in such a way that the center of gravity of the device proper in the non-operating position shall bear the relation to the knife edge support shown by the point *a* in Figs. 2 and 3. In this case the force necessary to operate the tilting is represented by the ordinate *a* of the sign curve *d* in Fig. 3. An increase in the tilting force of a few per cent. will then increase the tilting force to a value, represented here say by the ordinate *b* of Fig. 3, which will correspond to a position shown by the point *b* in Fig. 2. Similarly with a relatively large increase in the operating pressure in the tube we might have a tilting force corresponding to the ordinate *c* of Fig. 3 giving the position shown by the point *c* in Fig. 2. It is clear now that if the tilting force reaches a value during the original starting operation, only a little stronger than that of the ordinate *c* it will be sufficient to carry the tilting operation indefinitely until the stop in the slot, 10, is reached thus securing an ample slant for causing a streaming of mercury to bridge the electrodes. It is not always advantageous, however, to make use of this particular relative location of parts for carrying out my invention.

In Fig. 4 I show a modification of the apparatus of Fig. 1 wherein I provide for a more economical method of permitting a passage for the main current of a constant current system, especially during periods when the lamp tube is not operating. In this figure the various elements designated by the same reference numerals as those used in Fig. 1 are the same as in the earlier figure. The coil, 27, in Fig. 4 serves both the original tilting function relied upon for starting the lamp and also serves to produce the moving of the tube on the knife edge, 5, which is relied upon for regulating the length of the vapor column. The upper portion of this coil, 27, above the point, 28, at which the shunt, 29, is connected to the coil, 27, may be made of fine wire since it is traversed only by a relatively small regulating shunt current and the lower portion of the coil, 27, is made of wire of a size suitable to carry the normal line current. The shunt circuit, 29, contains the resistance, 30, and a cut out, 31, the cut out coil, 32, being connected between the line wire and the lead of the cathode, 4. In series with the coil, 27, which is connected in shunt to the lamp as a whole, I may use the resistance, 33.

The operation of the system of Fig. 4 is as follows: When current is established through the supply circuit, it initially traverses the system by way of the resistance, 33, the lower portion of the coil, 27, the resistance, 30, the cut-out, 31, to the negative main. This current causes the tilting of the lamp through the core 8, and the link, 10, until the mercury streams and connects the cathode, 4, with the anode, 3. The main current is then shunted from the shunt circuit, and traverses the cut-out coil, 32, and the mercury in the device. This allows the container to drop back to the position of rest and at the same time the cut-out coil, 32, opens the cut-out, 31, and the shunt circuit, 29. When the lamp returns to the position of rest, the mercury between the electrodes breaks and operation is started in the usual manner. As the device warms up the voltage on the tube increases and a current is established in the circuit in shunt to the device through the whole winding of the coil, 27, and the resistance, 33. Finally this current becomes sufficiently strong to raise the lamp from its position of rest somewhat with the result that the mercury of the cathode 4 proceeds slightly nearer the anode along the bottom of the container. This may be taken as the condition of normal operation. Should now the device become somewhat overheated, the voltage will rise and the shunt will take more current which will cause a further slight tilting of the device and the still further approach of the mercury of the cathode, 4, toward the anode, 3, tending to reduce the heating in the container to resist the over-heating tendency. As already explained, means should be taken to so shape the core, 8, and to so arrange the relative positions of the center of gravity and the knife edge, 5, to secure the condition that with raising shunt currents, the device will take progressively higher and higher positions of equilibrium.

In Fig. 5, I show the application of the invention in a somewhat different manner. Here, as in Fig. 1, 1 represents the device 2, the container, 3, the anode, 4, the cathode and 5, the knife edge support. 17 represents a yoke supporting the device, 1, 18, a lifting core, 19 a link connecting the core, 18, to the yoke 17, 20 a counterweight, 21 a stop linking the movement of the yoke 17, 22 a series tilting coil, 23 a shunt coil tending to weaken the influence of the coil 22 and 24 a resistance in series with the shunt winding 23. At 25 I have shown a series resistance which may be cut out by closing the switch 26 when desired. In the initial position as shown 4, is in contact with the anode 3. When this device is connected in a constant current circuit, current initially traverses the mercury between the electrodes, excites the winding 22 thus raising the yoke 17 and breaking the mercury connection between the electrodes. Up to this period no current has been flowing in the shunt coil 23 since it has been short circuited by the mercury. As the device warms up, however, the voltage drop on the tube increases and current appears in the shunt coil 23. As long as the voltage drop, however, is below normal the coil, 22, still has power enough to hold the yoke, 15, against the stop, 27, but if the voltage drop tends to become excessive, the coil, 23, so weakens the pull of the coil, 22, as to drop the yoke, 17, and the mercury, 4, which has been in the dotted position shown as 4^b takes an intermediate position such as that shown at 4^c thus reducing the length of the vapor path and lessening the heat generated in the device, which will tend to correct the over heating of the vapor path. Similarly varying positions can be taken by the mercury, 4, corresponding to the various conditions of operation. Should the device drop out, for any reason, the container and yoke 17 will return to the stop 21 and the starting operations will be repeated as already described. The arrangement of the center of gravity with regard to the knife edge support may be adjusted as described in connection with Figs. 2 and 3 if desired.

In Fig. 6 I show a still different embodiment of the invention in which the normal position of rest is with the mercury at the anode end. Two magnet cores, 8 and 41, tend to lift the device on opposite ends of the knife edge support, 5. The core, 41, is attached to the lamp through the link, 42. The core, 8, is magnetized by the coil, 34, which is connected in shunt to the lamp through the resistance, 43. The core, 41, is magnetized by the coil, 35, which is connected in series with the anode lead. In shunt to the device, I use a circuit, 43, containing a resistance, 36, and the cut-out, 40. This cut-out is closed when the lamp tube which carries the upper half of the contact, 40, drops down upon the lower half of the contact, 40. This downward motion of the tube is limited when the cut-out arm reaches the stop, 37. The cut-out, 40, is so devised as not to open the circuit the instant the lamp starts to operate, but at some later period. This action is secured through the use of a counter weight, 39, on the opposite end of the arm of the cut-out, 40. The lower half of the cut-out, 40, will follow the upper half with the rising of the tube until the cut-out arm strikes the stop, 38, when the cut-out will be opened. I use a resistance, 43, in series with the winding, 34, to control the shunt current.

The operation is as follows: When a constant current is established in the main circuit, it traverses the shunt, 43, the resistance, 36, the cut-out, 40, and passes thus through the anode lead out to the line through the coil, 35. This causes a tilting of the device through the core, 41, and the streaming of the mercury to make connection with the cathode, 4. When this connection is made, current will be established through the device in view of the resistance, 36. This establishment of current through the tube will, however, not stop the tilting which will proceed. The cut-out, 40, will ultimately open the circuit, 43, when the cut-out arm reaches the stop, 38. The current will continue to flow and warm up the tube until current is established in shunt containing the resistance, 44, and the coil, 34, and as normal voltage is reached, the core, 8, will raise the cathode, 4, slightly until the mercury approaches nearer to the anode, thus cutting down the heat generated in the device and securing regulation, as already described. It will be understood that during normal operation, the tube is maintained at such angles that the mercury of the cathode ranges from the right hand end of the cathode chamber to a point about the middle of the cathode chamber.

In Fig. 7 I show a modification of Fig. 5. In this lamp I provide a circuit, 50, in shunt to the device, containing the cut-out, 49, and the resistance, 47. I provide also a second shunt, 63, containing a resistance, 62, and a coil, 45. In the lead of the cathode, 4, I insert a cut-out coil, 48, controlling the cut-out, 49. In the lead of the anode, 3, I include the coil, 46, which magnetizes the core, 64, which is also the core of the coil, 45. This core is connected by the link, 42, to the tube. The operation of this device is as follows: When constant current is established in the main circuit, it flows initially through the shunt, 50, to the anode lead, thence through the coil, 46, back to the circuit. This causes the tilting of the device through the link, 42, until current is established by the flow of mercury through the tube itself. The cut-out, 48, then opens the shunt, 50, through the cut-out, 49. As the tube warms up current, its voltage rises and current passes through the shunt, 63, as before, magnetizing the winding, 45, in such a way as to weaken the pull of the coil, 46 and tending to lower the voltage on the tube through the slight raising of the cathode, 4. As before the pull curve of the magnet and the relation of the center of gravity to the knife edge support, 5, must be such as to provide suitable points of equilibrium of the tube corresponding to various magnetizations of the core, 64.

In Fig. 8, I show a modification of the starting circuits. In shunt to the device, 1, I provide two circuits, 60 and 61, the circuit, 60, containing the resistance, 53, and the circuit, 61, containing the resistance, 54. In the shunt, 61, is included the coil, 55, magnetizing the core, 8. The shunt, 60, in the non-operating position is connected through the cut-out points, 57 and 58, with the point, 65, on the winding, 55. I insert in the lead of the cathode, 4, the cut-out coil, 56, controlling the movable cut-out point, 58. The cut-out coil, 59, in operative relation to the point, 58, is connected to the negative main, as shown. In the device 1, I have shown a liquid anode, 51, in place of the solid anode and have provided an auxiliary condensing chamber, 52, for maintaining this anode replenished. Any of the well known means for maintaining distribution of mercury between the anode, 51, and the cathode, 4, may be utilized. The operation of this figure is as follows: When constant current is established in the main circuit, it traverses the shunt, 60, through the upper portion of the coil, 55, the contact points, 57 and 58, and the resistance, 53, to the positive main. This causes a tilting of the device which will be sufficient to produce a streaming of the mercury and the connecting of the electrodes. This establishes current through the tube itself and the cut-out coil, 56, and the movable contact point, 58, is drawn from the contact point, 57, to the contact point, 59, thus cutting off the shunt circuit, 60. The tube then drops back to its original position until the rise of voltage on the warming up of the mercury causes current in the shunt, 61, and a second magnetization of the core, 8, this time by the whole coil, 55, and the usual regulating function, as already described. By making the separation of the cut-out points relatively small, I provide that, should the lamp tend to go out during operation, a high voltage current would immediately be established between the points.

Fig. 9 shows a modification of Fig. 6 wherein 66 is a cut-out coil in series with the anode lead, 70 is a shunt circuit containing the coil, 67, and the coil, 68. I provide also a connection, 75, from the main positive line to the common point between the coils, 67 and 68, and insert therein the resistance, 69. The shunt, 70, contains also the cut-out coil, 66. In the main operating connection to the positive main I insert the coil, 73, whose core is connected with a rigid link, 74, with the core, 72, of the coil, 67. The operation of this figure is as follows: When constant current is established in the system, it initially traverses the coil, 68, the circuit, 70, the coil, 67, the cut-out, 71, to the main positive lead and out through the coil, 73, thus magnetizing the core, 68, and the coil, 67, the latter being proportioned so that its pull will overcome that of the opposing coil, 68. As the device tilts, a circuit is formed between the electrodes and the cut-out coil, 66, operating upon the cut-out, 71, deënergizes the coil, 67. The device, however, does not fall back into the normal rest position where it is shown in Fig. 9 in view of the pull of the coil, 73, through the link, 74, this coil, 73, being sufficient, in the absence of material pull from the coil, 68, to raise the anode end of the device. As the tube warms up, the voltage rises on the shunt circuit, and sufficient current passes through the coil, 68, to produce the regulating action already described.

In any of the figures shown, I contemplate the use of any of the mechanical or magnetic expedients shown in the other figures. For example in Fig. 1 any of the expedients used in connection with any of the other figures. Furthermore I may use a mercury anode in any desired case, or a solid anode, as may be desired. I have not shown specific means for controlling the pull-distance curves of these magnets since the means of controlling such pull curves are well known.

While I have shown forms of containers in some cases suitable for light giving purposes, or for the production of useful radiations, I do not wish to limit my invention to such particular uses of vapor electric device, but may apply the principles thereof to almost any form or embodiment. While I have shown means for automatically tilting these lamps for starting purposes, I may, if I prefer, start them by tilting by hand, or by the use of high potential and a starting band, or by other means. If, for example, the system of Fig. 1 be used on a constant potential circuit and hand tilted, or starting band impulses be utilized for starting purposes, the function of the coil, 9, will be merely to regulate the position of the tube according to the voltage upon the tube and the coil, 8, may be made of smaller dimensions. Similarly with the other figures. In the figures I may use for cut-outs either mechanical cut-outs as shown in Fig. 6, or electrical cut-outs as shown in Fig. 6, or electrical cut-outs as shown in the other figures. For example in Fig. 6 the shunt circuit, 43, may be opened by an electrical cut-out responsive to current through the device itself. The apparatus shown in these figures may be applied to the high pressure mercury vapor lamps with quartz containers to which they are well adapted.

I do not wish to limit my invention to the particular embodiments herein shown, which are merely illustrative, but consider that any similar systems utilizing equivalent means to produce the same result come within its scope. Other materials than mercury may be utilized for the cathode and other materials than tungsten, for example mercury itself, may be used for the anode. I may, of course, supply dash pots or vibration suppressors to prevent undue violence in the operation of the automatic circuits and I may otherwise apply various expedients well known for adjusting and controlling the various elements herein described and shown. For example I may use a dash pot, 100, as shown in Fig. 5.

I claim as my invention:

1. A constant potential device comprising an exhausted container and electrodes therein, one of which is vaporizable, said container being provided with an adjustable cathode position, and pivotal bearings for said container, in combination with means for tilting said device to adjust said cathode position in response to the voltage upon said device.

2. The combination of a constant current circuit, a mercury vapor apparatus comprising an exhausted container and suitable electrodes therein, one being a cathode adjustable in position, a circuit in shunt to said device and means comprising a tilting coil in said shunt circuit whereby the position of said cathode is approached toward said anode on a rise in pressure within the device.

3. A mercury vapor apparatus comprising an exhausted container and electrodes therein, one being of mercury, a pivotal mounting for said container, means for tilting said container whereby movement is secured in said mercury and means for limiting the motion of said container so that the line connecting the center of gravity with the center of the pivotal mounting always lies in the central portion of the angle formed by a vertical and horizontal line through the center of said pivotal mounting.

4. In a system of electrical distribution, the combination of a constant current circuit, a mercury vapor device comprising an exhausted container and electrodes therein, one of which is adjustable on tilting the device and means comprising a coil in series with said apparatus for moving said container, and a coil in shunt thereto opposing said first named coil.

5. A system of electrical distribution comprising a constant current circuit, a mercury vapor apparatus comprising a movable exhausted container and electrodes therein, one of which approaches the other upon the lowering of the anode end of the container from the normal operating position, bearings for said apparatus and tilting means attached to said apparatus on the anode side of said bearing, composed of two opposing coils, one dominating the other and connected in series with the device and the latter connected in shunt thereto, in combination with means for bridging the electrodes in the non-operating condition of the apparatus.

6. In a system of electrical distribution, the combination with a constant current circuit, a mercury vapor device comprising an exhausted container, electrodes therein, one of said electrodes being movable, means for changing the position of said electrode with the tilting of said container, bearings for said container and means comprising two opposing coils for moving said container, of means for energizing one coil from the current through the device and for energizing the other coil from the potential on the device.

7. In a system of electrical distribution, the combination with a constant current circuit, a mercury vapor device comprising an exhausted container, suitable electrodes therein, one of said electrodes being movable, means for changing the position of said electrode with the tilting of said container, bearings for said container and means compris-

ing two opposing coils for moving said container, of means for energizing one coil from the current through the device and for energizing the other coil from the potential on the device and a circuit in shunt to said device, said circuit including a cut-out operative on the starting of the device.

8. In a system of electrical distribution, the combination with a constant current circuit, a mercury vapor device comprising an exhausted container, and suitable electrodes therein, one of said electrodes being movable, means for changing the position of the electrode with the tilting of said container, bearings for said container and means comprising two opposing coils for moving said container, of means for energizing one coil from the current through the device and for energizing the other coil from the potential on the device and a circuit in shunt to said device, said circuit including a cut-out operative on the starting of the device and mechanically operated by the tilting of the device.

9. In a system of electrical distribution, the combination with a constant current circuit, a mercury vapor device comprising an exhausted container, and suitable electrodes therein, one of said electrodes being movable, means for changing the position of said electrode with the tilting of said container, bearings for said container and means comprising two opposing coils for moving said container, of means for energizing one coil from current through the device and for energizing the other coil from the potential on the device and a circuit in shunt to said device, said circuit including a cut-out operative on the starting of the device and electrically operated by current in the device.

10. In a system of electrical distribution, the combination with an electric supply, a vapor device comprising a movable exhausted container and electrodes therein, one of which changes its position with movement of the container, bearings for said device and tilting means therefor comprising two coils one, the dominant coil being in series with said device and the other being opposed to the first named coil and being in shunt to the device, of means for initially passing line current in shunt to said device.

Signed at New York in the county of New York and State of New York this 21st day of March, A. D. 1913.

PERCY H. THOMAS.

Witnesses:
WM. H. CAPEL,
THOS. H. BROWN.