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VAPOR ELECTRIC APPARATUS ADAPTED FOR OPERATION IN SERIES.

APPLICATION FILED JAN. 24, 1913.

1,110,602. Patented Sept. 15, 1914.

Fig. 1.

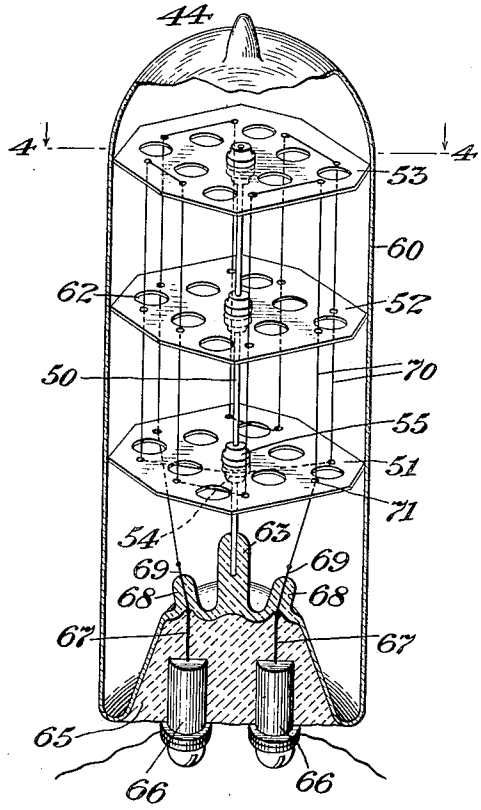
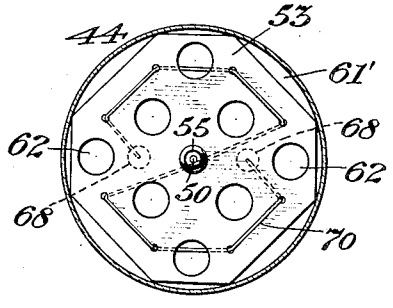


Fig. 2.



WITNESSES

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VAPOR ELECTRIC APPARATUS ADAPTED FOR OPERATION IN SERIES.

1,110,602. Specification of Letters Patent. Patented Sept. 15, 1914.

Original application filed November 22, 1906, Serial No. 344,545. Divided and this application filed January 24, 1913. Serial No. 743,920.

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 Vapor Electric Apparatus Adapted for Operation in Series, of which the following is a specification.

My invention relates to current regulating devices having a rapid change of resistance at a definite critical point. Such a regulating device for example is very well adapted to use as a steadying of ballast resistance for mercury vapor lamps. In such a mercury vapor lamp series ohmic resistance of definite value may be arranged to sustain across its terminals a certain part, say 10%, of the total voltage across the line, and the remainder of the excess voltage above what is required across the terminals of the lamp when in operation, may be taken up by my ballast resistance which has a positive temperature coefficient preferably characterized by a critical region of rapid temperature-resistance variation, in which it normally operates when current flows therethrough at the rate required for normal operation of the apparatus to be protected. Ballasts of iron wire have been thus used to control the comparatively small current necessary for the operation of a Nernst light glower, but such ballasts are not adapted for mercury vapor devices of the Cooper Hewitt type, particularly those which are adapted to be started by short circuiting of the vapor column of the lamp through a low resistance bridge between main electrodes or between a main and an auxiliary electrode. The conditions are essentially different in that the Nernst glower operates with an initially high resistance, decreasing rapidly as it heats up until at the temperatures where it begins to be most efficient as a light giving means, it is very near the critical region, where a comparatively slight momentary excess of current and resulting increase of temperature will damage or destroy the glower. Because of these characteristics, the Nernst ballast must have an extremely small time period of heating in order that the glower may not be damaged or destroyed by excessive overrunning, while the ballast is being heated up to a normal, steady state. The necessary small time period of heating involves several factors. The total mass of the wire and resulting heat capacity is small in order that the rise of temperature in the wire may not lag behind the increase of rate of heat development due to increase of current; and heat capacity of the surroundings is also small, so that the device as a whole quickly attains the critical temperatures. The ballast wire, which is necessarily of considerable length, is therefore disposed in a small space, usually by first bending into an open spiral and then arranging the spiral in closely spaced lengths in a suitable container. Furthermore, the inert gas used to prevent oxidation of the iron at high temperatures, is a gas of the smallest possible specific heat, namely, hydrogen. Such Nernst ballasts have been perfected by experiment and modification, until they are very well adapted for their purpose, but the necessity that they embody a definite value of resistance and that they attain a steady average of temperature in the critical region, under the influence of the current which will flow therethrough against such resistance, precludes any great flexibility of variation to meet materially different requirements and conditions. As illustrating this, suppose it be desired to adapt such a ballast to operate in the critical region to protect or regulate a translating device requiring a normal current flow, say, seven times that of the Nernst glower. If the required reduction of resistance were attained by merely shortening the ballast wire, then, theoretically, the total heat generation would be multiplied by seven and the total heat radiating area divided by seven. The required reduction in resistance must, therefore, be attained in other ways.

The obvious way of getting the decreased resistance and increased current without change of the critical temperature resistance governing effect, is to arrange a desired number of similar Nernst ballasts in parallel. This expedient might be employed in connection with the CooperHewitt vapor devices if they had an operation analogous to that of the Nernst glower, but they had not. For instance, even lamps started without short circuiting, as by po-

tential discharge between electrodes, offer when first started an initially low resistance rising slowly to normal operating resistance, as the lamp heats up. Such expedient is therefore inapplicable to the conditions contemplated herein, for, if enough of the Nernst ballasts are employed so that the current flowing in the normal operation of the lamp will heat them to the required critical temperature, they will not stand the starting overload. On the other hand, if enough of them are used so that they will stand the starting overload, they will not attain the desired critical temperatures under the smaller currents flowing during the normal operation. One method of meeting this difficulty is to arrange in series with the ballast, a conductor having a normal high resistance and a negative temperature-resistance coefficient, such as the carbon filament described in my prior Patent 809,643, granted January 9th, 1906. In such an arrangement the comparatively high resistance of the filament when cold, serves to protect the ballast to a certain extent by interposing its own falling resistance, thus proportionally retarding the rise of current in the ballast during the time required for heating the filament to the lower resistance condition. In attempting any other solution of the problem, there is always the difficulty that a ballast adapted to be heated so as to operate in the critical region on a given normal current flow, will in general be burned out by a given percentage of excess current flow. In my present invention, however, I have taken advantage of the fact that the time required for burn out by a given percentage of overload is not the same in all cases, but varies to a certain extent with the total heat capacity of the ballast, which is determined by the mass of the wire and by the volume, specific heat etc. of the immediate environment, including the geometrical arrangement and space relations of the wire, the size of the container, and the density of the contained gas. I have discovered that this difference in time period of burning out being due to the heat capacity, is greatest in actual lapse of time where the overload is applied to the ballast when cold, and that matters may be so arranged that the extreme overload will come only when the ballast is cold; also that in practice the time period required for destructive overheating may be lengthened to such a value in seconds as will easily permit bridging and breaking of the bridge between the electrodes to start the lamp before the heat capacity of the ballast has been satisfied and destructive temperatures reached.

The required heat capacity tends to make the ballast sluggish as a regulator of normal current flow, but a sluggishness, which would be fatal in a Nernst ballast, is of no disadvantage in a Cooper Hewitt ballast, because a Cooper Hewitt lamp may "overrun" to a considerable extent and for a comparatively long time without damage, whereas in the case of the Nernst glower, the overrunning must be very small and must be limited to fractions of a second in duration.

I have discovered that the actual time values of safe overload for a Cooper Hewitt ballast may be made such as to afford the time practically necessary for the bridge making and breaking operation and for heating up to the normal, steady state, and this without making the ballast too sluggish for its proper regulating function during the normal operation of the lamp and without making it of such proportions as to throw it out of the critical region of temperature resistance change.

In designing the Cooper Hewitt ballast, the favorable factors are at a maximum when all of the ballast is put in a single length of wire and when the arrangement is such that the ballast will be cold at the time of the contemplated overload, but some distribution of the ballast in parallel wires and some initial heating, will only decrease the factor of safety and, if kept within limits, will not completely destroy the desired time period of safe overload.

In designing the Cooper Hewitt ballast, I decrease the total resistance so that the resistance of the ballast, preferably a single length of wire, equals the combined effective resistance of the required number of parallel Nernst ballasts. This is done by selecting an entirely new diameter and a new length, such that the heat radiating rate will be increased proportionally to the increase in the rate of the heat development. Each of the Nernst ballasts being known to have heat radiation and heat development rates suitable for proper operation with a definite fraction of the current desired for the new ballast, say one-seventh, the new ballast must be one-seventh the resistance to carry seven times the current. The heat development rate will be about seven times as great and, other things being equal, the surface area ought to be about seven times as great. Theoretically one-seventh the resistance, requires that the cross section divided by the length be seven times as great, and seven times the radiating area requires that the circumference times the length also be seven times as great. Hence, the new diameter and lengths must be such that in the new ballast $\frac{D}{4L}$ and DL should both be seven times as great as in the Nernst ballast. The dimensions for the new bal-

last may be found by taking successively increasing values of diameter, and the corresponding values of length which will give the desired resistance, until values are reached which will satisfy both conditions.

The dimensions necessary for the changed value of current can be but roughly approximated in this way, for it will be found that other conditions change and that dimensions and also the construction of the ballast will require further modification. By my invention, however, it will usually be unnecessary to do more than alter the length to vary the resistance, the corresponding change in radiation rate being effected by change of the construction and relative arrangement of parts, or of the character or density of the gas within the container.

In construction of Cooper Hewitt ballasts dissipating considerable quantities of heat and consequently having considerable physical size, uniform heating of the wire is desirable and at the same time the disposition of the wire must be such that it will be capable of radiating or otherwise transferring the heat, out of the wire at the required rate, the heat to be developed and transferred per unit time, being relatively very great both for the entire device and for each unit length of the wire. For convenience in manufacture and practical use, the size of the container cannot be increased indefinitely, and that matters should be arranged so that the rate of transfer of heat outside of the container is very rapid. To insure this, I make the distance through which such transfer must be made, comparatively small. For the above reasons, the wires are not coiled so as to bring adjacent turns into proximity and are not disposed in a container of small volume. On the contrary, I prefer to dispose the wire in straight lengths suitably supported at equal distances from the walls of the inclosure and preferably closely adjacent thereto, so that the transfer of heat outside of the container may be as direct as possible. In order that the heating may be uniform, so that all parts of the length of the wire will be heated to the critical regions as far as possible at the same time, care should be taken that all parts of each length of wire be parallel with the surface of the container as well as that the distance be the same for each length. It will be understood that in practice there is a certain fraction of the length of the wire adjacent the supports which it is so difficult to arrange for heating to the critical temperature at the same time with the rest of the wire, that it is hardly worth while in practice to attempt to do so. Such fraction of the length of the wire as cannot well be made uniform in operation with the more effective portions acting in the critical regions, should be so disposed that they will always be underheated rather than overheated, because by this expedient their effect is practically unobjectionable since they merely operate to impair the sharpness of the current governing function, whereas if they tended to reach a higher temperature than the other parts of the wire, the critical region would only be utilized on a small fraction of the ballast and only a very minor governing effect would be obtained, for such overheated parts of the ballast would burn out before the other parts were sufficiently heated.

Uniform heating the wire also requires a low pressure of the surrounding inert gas so that diffusion will be much freer, for with a higher pressure in the container for the large ballast, certain portions of the gas will become hotter than other portions, and on account of the limited diffusion, this will give rise to convection currents caused by movement of bodies of the gas having different densities from adjacent bodies. The bodies of higher temperature, tend to collect in the upper portions of the receptacle and render these portions hotter than others, so that the radiation of heat developed in the wire is less rapid. This causes uneven heating of the wire, and this, from the nature of the operation of iron, particularly in the critical region, tends to be self-exaggerating, a slight elevation of temperature in any one spot tending to produce greater resistance and greater heating effect at such point. In order that the ballast may serve its purpose, it is very desirable that as much as possible of the length of the iron reach the same critical temperatures at the same time. I, therefore, prefer to arrange matters so that the heat will be largely dissipated by radiation and diffusion, so that it will be rapidly and uniformly diffused throughout the whole adjacent region, instead of being carried by convention movements of the gas. The Nernst lamp ballast inclosure of envelop is only $1\frac{1}{4}$ inches long, and diffusion of hydrogen is so good as to keep the whole thing at practically uniform temperature. To get nearly as good diffusion in the Hewitt ballast envelop or inclosure, which for a 3.5 ampere current may be five or six inches long, it is necessary to have a low pressure. In the Hewitt ballast with a pressure of hydrogen near atmospheric, the diffusion in each $1\frac{1}{4}$ inch would be about the same as in the given Nernst ballast, but as the space to be covered is much greater, the diffusion would be very imperfect, and different temperatures in different parts of the container would be unavoidable.

Having thus fully explained the various features of my invention in such manner as will enable any one skilled in the art to

embody the broad principles thereof in the various specific forms and arrangements of apparatus, which may be necessary or desirable for various specific purposes, I will now describe certain illustrative embodiments indicated in the accompanying drawings, it being understood that the invention is as broad as hereinbefore indicated and that my claims are not limited to any feature or element not specifically included therein.

Referring to said drawings: Figures 1 and 2 show a desirable form of ballast for mercury vapor lamps, Fig. 3 showing the ballast support in perspective and the container in vertical section, while Fig. 2 shows the ballast support in plan and the container in horizontal section, on the line 4—4, Fig. 1.

The ballast 44 has been fully disclosed as to all its broader characteristics of construction and purpose. A desirable, specific form, is shown in Figs. 1 and 2. A wire of suitable material, such as iron, and of a length and diameter necessary to pass the desired amount of current at a given voltage, is arranged in a container of suitable size upon supports adapted to maintain the lengths thereof in fixed relation to each other and to the walls of the container. As shown, the support consists of a wire or thrust member 50, of substantial size, carrying disks 51, 52, 53, of nonconducting material, preferably of mica. These disks are spaced apart on the said support and held in fixed relation by collars 54 and 55, engaging the opposite side of each. These collars may be secured in any desired way, as by pinching the smaller ends thereof into secure engagement with said supports 50. The disks are of such size and shape as to extend laterally nearly or quite into contact with the sides of the container 60, so as to be centered and guided thereby. They are formed in such manner as to have ample ventilating passages. For these reasons, they may conveniently be made in the shape of squares with the corners clipped off, thereby affording ample bearing surface, and yet leaving considerable spaces, as at 61, for circulation and diffusion of the gas adjacent to the walls of the container. Diffusion throughout the volume of the container, is arranged for by providing perforations 62 of ample area and of suitable distribution for this purpose, and yet without materially affecting the stiffness and substantial character of the support to be afforded by the disks. The size of all these parts, and the diameter and length of the container 60, as well as the disposition of the wire within the same, are determined in accordance with the rules hereinbefore set forth, which require that the facility of radiation be proportional to the heat generated, the actual sizes of the parts being, of course, no greater than required by such considerations.

The standard 50 is fused into the nipple 63, which secures it firmly from endwise displacement, while the mica disks engaging the surface of the glass, insures against lateral displacement, which might result from vibration or shocks incident to practical use of the device.

The nipple 63 may be formed upon an inwardly extending projection 64, the exterior cavity of which may be filled, as at 65, with nonconducting cement of any suitable composition. Embedded in this, are terminals 66, 66, connected by substantial conductors 67, 67, with leading in wires 68, 68, sealed into nipples 69, 69. The specific construction and arrangement of these parts may be of construction or materials well known in the analogous arts involving such constructions.

The ballast wire 70, is led through registering perforations 71 in the various disks, preferably passing from the leading in wire to the upper disk, thence across to an adjacent perforation and down to a lower disk, thence again to the upper disk, and back to the lower disk, then diametrically across the lower disk to a perforation on the far side, then up and down, as before, and out to the other leading in wire 69.

The arrangement is such that the wires are positively held substantially parallel with each other and parallel with the surface of the glass, closely adjacent to the surface of the glass, and at equal distances from the surface of the glass. It is not necessary that the spacing be exactly as described, provided each length of wire is parallel with the wall of the container, comparatively close thereto, and all of them the same distance therefrom. The lengths are preferably parallel with each other, unless separated by considerable distances, for otherwise their mutual heating effect would serve to cause portions of the length close to each other to run hotter than those more distant. If the parallelism with and the distance from the walls of the container are maintained, the lengths may be located in pairs or groups, provided they be symmetrical or regular, so as to avoid any unequal heating. Thus it will be clear from what has so far been stated that it is in many cases desirable that applicant's ballast conductor be chosen of a large diameter and great length to obtain a given resistance as say, six ohms, rather than of a small diameter and short length to obtain the same resistance. The net result of this expedient is to give a certain overload capacity to this device which is peculiarly important in the case of the present apparatus, since its op-

eration depends upon a critical point and while a momentary overload causes no harm, a momentary rise of temperature may be fatal. For this same reason I have pointed out that it is important that where for structural or for other reasons it is not possible to secure exactly proportionate heat radiating capacity in the different parts of the conductor, all those parts which must be different from the greater part of the conductor or should be given greater heat radiating capacity in proportion to the total radiation rather than less, so that they will run at a lesser temperature rather than at a higher temperature than the main effective body of the conductor. It is clear that a short hot spot on the conductor would have practically no corrective effect, but will, nevertheless, readily burn off and disable the apparatus.

This case is a division of my application Serial Number 344,545, filed November 22nd, 1906.

I claim as my invention:

1. A ballast device comprising a sealed envelop containing a nonoxidizing gas and a ballast therein consisting of substantially straight lengths of wire operated at a critical temperature, serially disposed, said lengths being arranged close to the walls of the container and substantially parallel therewith.

2. A ballast device comprising a sealed envelop containing a nonoxidizing gas and a ballast therein consisting of substantially straigth lengths of wire operated at a critical temperature, serially disposed, said lengths being arranged close to the walls of the container substantially parallel therewith and with each other.

3. A ballast device consisting of a conductor operated at a critical temperature disposed with various portions of its length adjacent other portions of its length, all effectively operating portions thereof being substantially parallel with the wall of the container and with each other.

4. A ballast device consisting of a conductor operated at a critical temperature disposed with various portions of its length adjacent other portions of its length, all effectively operating portions thereof being close to and substantially parallel with the walls of the container.

5. A ballast device comprising a sealed envelop containing a nonoxidizing gas, a ballast support comprising transverse members extending approximately into engagement with the walls of the container at suitable points, a spacing member for said transverse members, and a ballast wire operated at a critical temperature led back and forth upon said transverse members, adjacent the walls of the container and approximately equidistant therefrom.

6. A ballast device comprising a sealed envelop containing a nonoxidizing gas, a ballast support comprising transverse disks having ventilating openings, a spacing member for said transverse members, and a ballast wire threaded upon said transverse members.

7. A ballast device comprising serially arranged lengths of suitable conducting material disposed within a sealed container, the length and diameter of said conductor being such as to give it a relatively large current carrying capacity and the dimensions and arrangement thereof being such as to give the major portion of said conductor a uniform dissipation rate less than that of the remainder, for the purpose described.

8. A ballast device comprising serially arranged lengths of suitable conducting material disposed within a sealed container, the length and diameter of said conductor being such as to give it a relatively large current carrying capacity and the dimensions and arrangement thereof being such as to cause the major portion thereof to normally operate uniformly in the same region of great temperature resistance change when passing current at a desired definite rate.

9. A ballast device comprising serially arranged lengths of suitable conducting material disposed within a sealed container, the length and diameter of said conductor being such as to give it a relatively large current carrying capacity and the dimensions and arrangement thereof being such as to cause the major portion thereof to normally operate uniformly in the same region of great temperature resistance change when passing current at a desired definite rate, and to have a slow time period of temperature resistance change at temperatures lower than normal.

10. A ballast device comprising a sealed envelop containing a nonoxidizing gas and a ballast therein consisting of substantially straight lengths of wire operated at a critical temperature, serially disposed, said lengths being substantially parallel with the walls of the container.

11. A ballast device comprising a sealed envelop containing a nonoxidizing gas and a ballast therein consisting of substantially straight lengths of wire operated at a critical temperature, serially disposed, said lengths being substantially parallel with the walls of the container and with each other.

12. A ballast device comprising a sealed envelop containing a nonoxidizing gas and a ballast therein consisting of substantially straight lengths of wire operated at a critical temperature, serially disposed, said lengths being arranged close to the walls of the container.

13. A ballast consisting of a containing chamber, a ballast conductor operated at a

critical temperature therein, and a relatively rapidly diffusing non-corroding gas or vapor within the container.

14. A ballast consisting of a containing chamber, a ballast conductor operated at a critical temperature therein, and a relatively low pressure non-corroding gas or vapor within the container.

Signed at New York, in the county of New York and State of New York, this 22nd day of January, A. D. 1913.

PERCY H. THOMAS.

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