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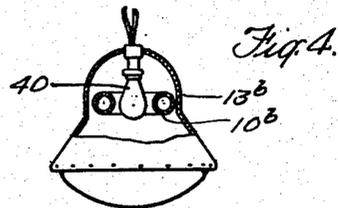
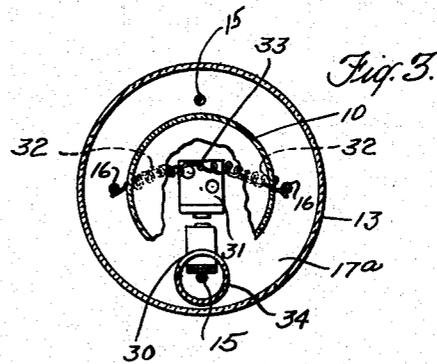
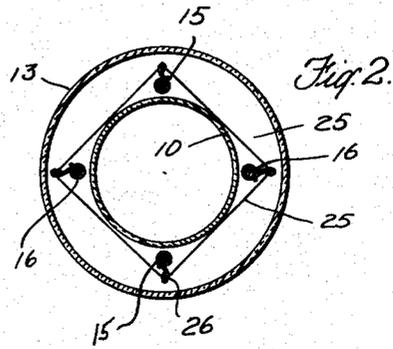
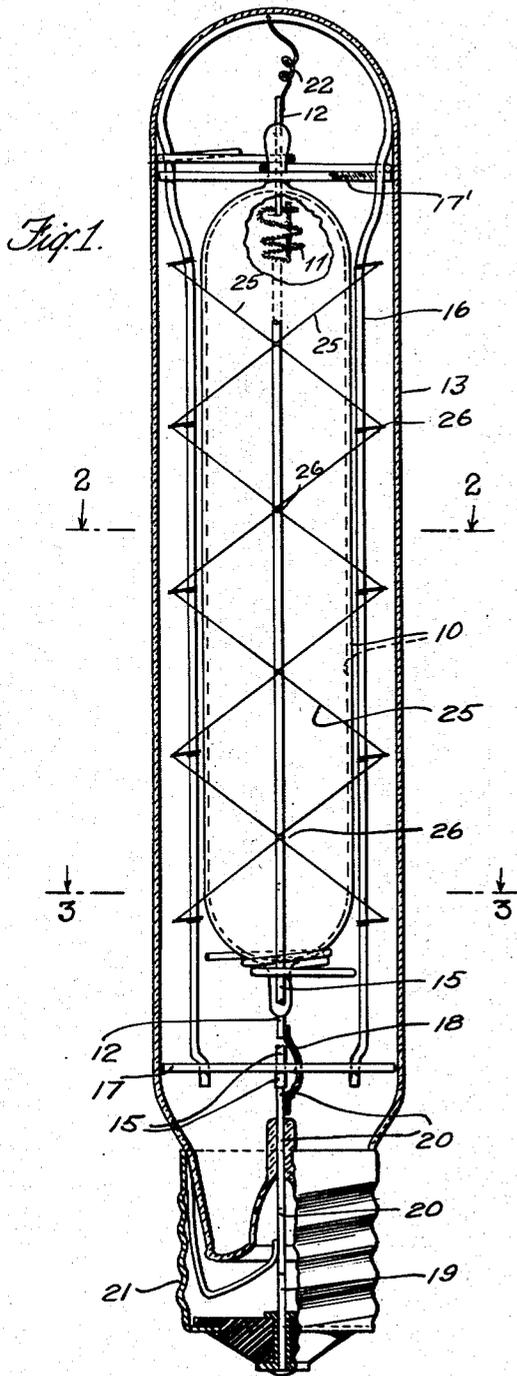
H. J. SPANNER

2,203,550

ELECTRIC LAMP

Filed Oct. 23, 1936

2 Sheets-Sheet 1



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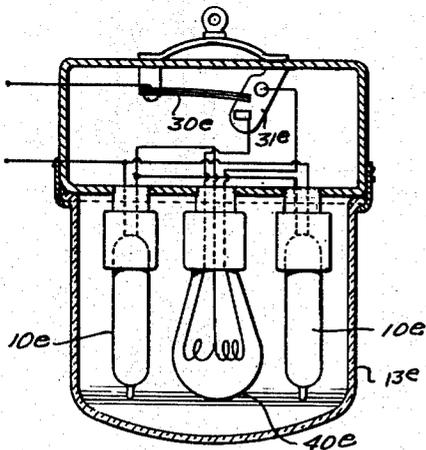
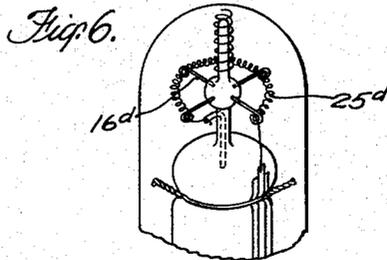
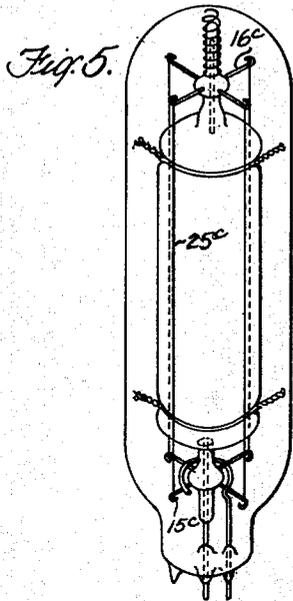
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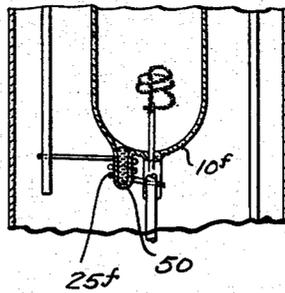
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2 Sheets-Sheet 2



*Fig. 7.*

*Fig. 8.*



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# UNITED STATES PATENT OFFICE

2,203,550

## ELECTRIC LAMP

Hans J. Spanner, Berlin, Germany

Application October 23, 1936, Serial No. 107,190

16 Claims. (Cl. 176—1)

This invention relates to gaseous electrical discharge devices and especially to those in which discharge occurs through a vapor at a pressure sufficiently above the pressure at which the discharge starts so that the voltage of the discharge is substantially increased thereby. More particularly this invention relates to a combination of such electrical discharge device with a radiant series resistance.

10 This application is a continuation in part of my prior applications Serial No. 397,429, filed on October 4, 1929, Serial No. 558,148, filed August 19, 1931, Serial No. 643,502, filed November 19, 1932 now Patent #2,092,363, Serial No. 744,206, filed September 15, 1934, and Serial No. 51,390, filed November 25, 1935.

One of the problems of efficient use of gas discharge devices as sources of illumination is the loss of energy in the ballasting device. This is particularly true in D. C. operation or in other cases where a resistance is used rather than a reactance. It has been suggested to use resistance devices capable of giving useful radiation and thereby to utilize some of the energy dissipated in the ballasting resistance. An important obstacle has stood in the way of the complete success of this suggestion, namely, that the gaseous discharge devices are subject to substantial fluctuation in voltage drop with variations in conditions of operation and normal variations in line voltage, with the result that it is difficult to design a ballasting resistance device which can operate as an efficient source of useful radiation without being subjected at times to serious overloading such as would reduce its useful life.

This difficulty is especially acute in the case of the so-called high pressure vapor lamps in which the pressure and the voltage in the lamp rise substantially after the discharge is started. With such lamps if the ballast resistance is efficiently designed for normal operation it will, under ordinary circumstances, be seriously overloaded during the initial starting period before the pressure has reached its normal operating value.

Accordingly, it is an object of the present invention to provide a combination of a radiant discharge device and a radiant ballasting resistance in which the resistance is protected against over-load and the energy which otherwise would tend to deteriorate the resistance during the over-load condition is utilized for regulating the operation of the discharge device, e. g., by evaporating mercury.

Another object of the invention is to provide a vapor discharge device, and especially a high pressure vapor discharge lamp, in which means is provided for hastening the heating-up period during which the pressure is increased to its normal operating value.

Another object of the invention is to provide a combined gaseous discharge and incandescent light source in which the deficiency of the gaseous discharge spectrum are made up by radiation from the incandescent source.

In the accompanying drawings are shown several preferred embodiments of my invention and certain modifications thereof. These are not intended to be exhaustive or limiting of the invention, but are chosen for purposes of illustration in order that others skilled in the art may fully understand the principles of the invention and their application in practical use, and that they may have no difficulty in applying the invention in numerous other forms according to the requirements of various conditions and special problems.

Fig. 1 is a view partly in longitudinal section of a typical high pressure vapor lamp for general illumination purposes having incandescent filament therein according to my invention.

Fig. 2 is a view in cross section taken on line 2—2 of Fig. 1.

Fig. 3 is a view in cross section showing a lamp similar to that of Fig. 1, but having special means for protecting the filaments against overload.

Fig. 4 is a view partly in side elevation, partly in vertical section of another embodiment of my invention.

Fig. 5 is a view in perspective of still another embodiment of my invention.

Fig. 6 is a fragmentary view similar to the upper portion of Fig. 5 but showing another modification.

Fig. 7 is a view partly in vertical section and partly in side elevation of another embodiment of my invention; and

Fig. 8 is a fragmentary view in axial section of another embodiment of my invention.

Referring first to Fig. 1, I have shown there a lamp for general illumination purposes. An inner envelope 10 serves to enclose the atmosphere in which the electrical discharge takes place between the fixed solid electrodes 11 mounted on the lead-in wires 12.

This inner envelope 10 is supported within an outer jacket 13 by means of a framework 15—16 the construction of which is clearly shown in the drawings and which is advantageously made of

nickel or other resilient material, so as to avoid breakage of the envelope 10 during shipment, etc.

As will be observed from the drawings, the supporting frame is made in two parts 15 and 16 angularly spaced from one another and held in this relation by means of the insulating discs 17.

The lower electrode, i. e., the one nearest the base, 21 is connected to a flexible wire 18, which wire 18 is connected as shown to the center lead-in wire 19 which with the other lead-in wire 20 is sealed through the end of the jacket 13, e. g., by a press seal and eventually is connected to one of the contacts on the base 21, e. g., a standard Edison Mogul base.

The upper part 16 of the mounting frame is connected by the flexible connection 22 to the lead-in wire 12 of the upper electrode and is shaped so that it is engaged between the upper domed end of the jacket 13 and the upper end of the envelope 10.

The connections 18 and 22 are not essential and the lead wires can be welded directly to the frame parts 15 and 19, but I prefer by means of these flexible connections to relieve the seals between the envelope 10 and the lead-in wires 12 of any possible strain which may result from direct welding to the frame.

As will be observed the longitudinal wire members of the frame portions 15 and 16 extend, between the insulating discs 17, along the sides of the envelope 10. In order to give further support and also to provide a capacity along the side of the envelope to assist in starting (as described and claimed in a prior application Serial No. 744,206) these are brought as close as possible to the wall of the envelope 10, preferably without quite touching it, so as to avoid possible electrolysis of the hot glass.

It will be observed that the construction as shown and thus far described connects the center contact of the base 21 to the lower electrode and the shell of the base to the lower portion 15 of the frame, but that direct connection from the base to the upper electrode is made only through the filament wires 25, which are hung in zig-zag arrangement between the longitudinal members of the frame 15 and 16, and are supported thereon by the fine looped wires 26 welded to the frame members, or by welding directly to, or winding around the frame members.

It will be observed that this arrangement of the filament provides numerous parallel paths for passage of the current between the frame portions 15 and 16. The size of the filament wires is designed so that with all of these paths operating in parallel and with the envelope 10 at full operating temperature, these filaments will be at low incandescence, giving a very red radiation.

The envelope 10 is filled with a starting gas such as argon, neon, etc., at low pressure and with a supply of a vaporizable material such as for example, mercury in amount sufficient when vaporized to increase the resistance of the discharge path so that the voltage drop within the envelope 10 between the electrodes 11 is substantially increased after starting of the discharge. The jacket 13 is filled with a suitable gas inert with respect to the filament, e. g., argon, or nitrogen or hydrogen, or mixtures of such gases as more fully described below.

In the operation of this device a voltage is impressed upon the lamp across the terminals of the base and conducted, substantially without decrease, through the filaments 25 and the frame

members 15-16 and connections 18-12 and 22-12 to the electrodes 11, and there serves to break down the gas filling between the electrodes and establish a discharge. This discharge in turn heats the electrodes 11, converting the initial discharge to an arc. At this point the discharge operates with a minimum voltage, and a maximum current; and a maximum loading is, therefore, imposed upon the filaments 25, with a corresponding tendency to overheat these filaments to a brilliant white incandescence. It is an advantage of my combination lamp that at this stage, while the illumination from the discharge is at relatively low intensity, the intensity of the incandescent filaments is substantially increased, and furthermore the color from the filament is substantially white. Without special precaution to protect the filament, however, there would be serious danger of destructive overheating at this stage and consequent burning out of the filaments. It is an advantage of the construction shown, however, that these filaments are in intimate heat-exchange relation to the envelope 10 which, at this stage of operation, is relatively cool. There is, therefore, a rapid transfer of heat by radiation and convection from the filament to the envelope, which has the double advantage of protecting the filament against over-heating and of hastening the evaporation of the vaporizable filling within the envelope 10.

In order to give full effect of this heat transfer, a suitable convection gas is provided within the jacket 13. This may be an inert gas such as has been used heretofore in incandescent lamp bulbs, e. g., argon, nitrogen, etc., or mixtures of such gases, at pressures sufficiently high to avoid any short-circuiting discharge across the filament 25, e. g., about one-half atmosphere, but I have found it particularly advantageous to use a gas having a high heat transfer capacity. Hydrogen gas is particularly suitable for this purpose, probably because at temperatures below those at which destruction of the tungsten filament occurs and above the temperatures of the filament in normal operation, the hydrogen is decomposed from the molecular state to the atomic state with absorption of large amounts of heat from the filament which are carried to and yielded up to cooler surfaces, as for example the surface of the envelope 10. The expansion in volume and decrease in density of the gas due to this dissociation also facilitate the convection circulation of gases over the filament and the envelope. This arrangement, therefore, has the known action of the so-called "iron-hydrogen" resistance, with the additional advantage that its heat is utilized for rapidly bringing the arc lamp to operating temperature. Obviously the overload protection action of the hydrogen atmosphere around the hot resistance wire can be utilized elsewhere than in the concentric jacket for a part or all of the ballast for the arc lamp.

Although an atmosphere of pure hydrogen may be used in the jacket 13, I prefer to use a mixture of hydrogen and an inert gas, for example hydrogen and argon.

In the above I have referred to the use of a convection gas in the jacket at a pressure such that no short-circuiting discharge will occur across the filament. In one embodiment of my invention, however, such a discharge may be taken advantage of to protect the filaments against overloading. Thus if the gaseous filling in the jacket is at a pressure regulated to break down at the voltage at which the maximum tem-

perature of the filament is reached the gas itself will serve as a protection for the filament. In such case the initial operation is exactly as described above, namely the full voltage is imposed through the filament upon the electrodes, a break-down occurs within the envelope and the initial discharge is converted into an arc by heating of the electrodes. At this point, however, the voltage within the envelope has become so low and consequently the voltage imposed on the filament is so high that the heated filament will cause substantial ionization of the gas around it, and a breakdown of the gas will occur along the filaments 25 in parallel with the filament current. This discharge, however, can continue only so long as the discharge in the envelope 10 remains at low voltage and so long as the filament remains hot enough to provide the necessary electron emission. As soon as the voltage consumption in the main discharge increases due to the evaporation of the mercury and the temperature of the filament is consequently decreased the remaining voltage will be insufficient to sustain the external discharge, and consequently the further operation of the lamp at normal operating temperature will continue exactly as in the case described above.

It will be understood by those skilled in the art that where a discharge is to be permitted in parallel to the filament 25 this must never be permitted to become an independent discharge, but must at all times depend upon the heating of the filament so that, upon cooling of the filament whether due to short-circuiting by the discharge itself or to the increased voltage requirement of the main discharge the electrode drop of the short-circuiting discharge will rise above the voltage drop of the filaments when carrying the entire current and thus these auxiliary short-circuiting discharges will be extinguished. In no case can the ballasting effect of the resistances be completely destroyed by the short-circuiting discharges. In Figs. 1, 4, 5, 6 and 7 the unit may be made self-contained for operation from constant potential circuit, whereas with the use of parallel discharges as described as an alternative of Fig. 1, or parallel filaments as in Fig. 3, additional ballast outside the lamp would obviously be used in the operation as described.

The vaporizable filling within the envelope 10 is preferably chosen to give an emission spectrum which is strongest in the violet, blue, green and yellow-green and preferably one which is fairly complete in that range so as to complement the low incandescence of the filament which radiates mostly in the red, orange and orange-yellow; and it is furthermore preferably chosen so as to raise the envelope 10 to a relatively high temperature at which it will help to sustain the incandescence of the filament by reducing the cooling effect of radiation and convection. Both of these effects are produced with greatest advantage by a high pressure mercury filling e. g., of one or more atmospheres of pressure during normal operation.

In Fig. 3, I have shown another device adapted to provide further protection for the filament during the initial heating-up period, while the voltage requirement of the main discharge is low. In this case a bimetallic, thermostatic contact 30 is secured to the disc 17a corresponding to the lower disc 17 of Fig. 1 and is connected to the frame 15 as shown.

A fixed contact strip 31 is secured at 10 to the disc 17a as shown, and is bowed over the end

of the thermostatic strip 30 so as to make contact therewith when the thermostat is cool but leave room for the thermostatic strip 30 to move out of contact when it is heated by the lamp. Filament wires 32 are connected from the frame members 16 to a hook 33 on the strip 31. Thus when the lamp is cold and until it has reached a temperature at which the increased voltage in the main discharge will protect the filament wires 25 the filaments 32 are connected through the strips 30 and 31 and the hook 33 in parallel with the filament 25 and the size of the filament wires 32 is regulated so that during the initial over-load period all of these parallel filaments will be at high incandescence but well below the temperatures at which burning out of the filament would occur.

In order that the thermostat 30 may be primarily responsive to the temperature of the envelope 10 rather than to the temperature created by the filaments 25 and 32 a tube 34 or other suitable baffle member is preferably placed over the thermostat 30 to intercept heat transfer from the filament while permitting direct interchange of heat with the envelope 10. Ordinarily, however, this will not be necessary if the strip 30 is welded at one end to the member 15 close beside the envelope 10 and extended therealong on the opposite side of the envelope from the filament wires 32.

In Fig. 4, I have shown another embodiment of my invention in which the series resistance filament is enclosed within a separate bulb 40 within the jacket 13b. In this case the discharge envelope 10b can be around the incandescent lamp bulb 40 as closely as possible so as to be in heat-exchange relation thereto; but at best this arrangement is less advantageous than that described above because the closed bulb 40 tends to limit the heat exchange between the two. The principal advantage of this arrangement is that standard discharge and incandescent lamps can be combined in a fixture without the necessity of sealing the two together, and therefore if the filament should burn out due to over-load this can be more readily replaced.

In Fig. 5, is shown another alternative similar to that of Fig. 1 but using a simpler and less rugged mounting. In this case the filament wires 25c run longitudinally along the lamp, instead of in zig-zag, between the frame members 15c and 16c.

In Fig. 6, I have shown still another lamp similar to that of Fig. 5, but using a spiral filament 25d supported by the frame 16d at one end of the lamp instead of the parallel longitudinal filament.

Instead of a single vaporizable metal, I may also use a plurality of metals, as for example a mixture of mercury, cadmium and zinc, or a mixture of mercury and other higher boiling point metals. This is particularly advantageous where the incandescent filament is to be operated at a temperature of maximum practicable efficiency, as for example where it is protected during the initial starting period by a short-circuiting discharge or by the parallel or substituted filament as illustrated for example in Figs. 3 and 7. In such case the use of such a mixture of metals is advantageous because it brings the current-voltage characteristic of the discharge lamp closer to that of the filament with the result that variations in voltage applied to the entire device will affect the two parts of the lamp in combination more nearly equally and the life

and efficiency of the incandescent lamp will be less impaired. This is especially advantageous where the lamp is designed to reach equilibrium without total evaporation of the vaporizable metal, e. g., as described in my application, Serial No. 558,148, filed August 19, 1931.

In Fig. 7, I have shown another device similar to that of Fig. 4, but in this case a special lamp 40e having two filaments and three contacts brought through the base is used instead of a standard incandescent lamp. The filaments of the lamp 40e are connected in parallel with each other and in series with the discharge lamps 10e by a circuit controlled by the thermostatic switch 30e and 31e, so that either the heavier filament for starting or the lighter filament for normal operation will be connected in series with the gaseous discharge lamp according to the temperature of the thermostatic switch.

An enclosing jacket 13e in this case is not essential but is highly desirable.

Fig. 8 shows a ballast resistance coil 25f surrounding the pump tip 50 at the lowest part of the lamp. The liquid metal collects in this depression and as soon as the discharge begins is strongly heated by the resistance coil 25f so that it is very quickly evaporated. The resistance 25f may advantageously be only a protecting parallel resistance switched into the circuit only during starting and thus corresponding to the filament 32 of Fig. 3. Or the heater 25f may be in series or parallel with other lighting filaments and the tip 50 may be so remote from the discharge that it controls the pressure of at least the highest boiling point metal in the tube 10f. Thus if an overload condition occurs this heater will evaporate more metal and with under-load will allow metal to condense and thereby keep the loading of the filaments approximately at the best temperature for life and efficiency.

I claim:

1. The combination of a radiant electrical discharge device having a vaporizable filling therein adapted by vaporization to at least double the voltage drop in the discharge device and a radiant ballast resistance therefor, in which the ballast resistance is in heat-exchange relation to the discharge device such that during initial operation the heat generated in the ballast resistance is utilized to hasten the vaporization of the filling in the discharge device and during the initial low voltage operation before vaporization of the filling and in other case of overload, the thermal capacity and heat dissipating capacity of the discharge device will absorb excessive heat developed in the ballast resistance and protect it against destructive over-heating.

2. An electrical discharge device which comprises an envelope, a filling within said envelope including a vaporizable material adapted to provide a gaseous medium for the discharge and by vaporization to increase the voltage of the discharge, electrodes spaced therein, lead-in connections, an incandescent filament connected in series to one of said lead-in connections, adapted to be heated by the current of the discharge and positioned outside but in heat-exchange relation to the envelope a substantially closed jacket enclosing the envelope and filament, and a heat transfer gas in said jacket which includes hydrogen.

3. The combination of a vapor electric discharge device having a vaporizable filling adapted by vaporization to at least double the voltage drop of the discharge device and an incandescent

filament in series therewith in a gas adapted to break down and carry a discharge across the filament at a voltage less than sufficient to cause destructive overheating of the filament, and the filament and its connections are adapted to sustain such discharge only above the voltage applied to the filament in normal operation.

4. The combination of a vapor electric discharge device having a vaporizable filling adapted by vaporization to increase the voltage drop of its discharge, an incandescent filament in series therewith, means in parallel to said filament for carrying at least a part of the discharge current during the warming-up period of the discharge while its voltage consumption is low, and means to discontinue the current through said parallel means after the warming-up.

5. The combination of a vapor electric discharge device having a vaporizable filling adapted by vaporization to increase the voltage drop of the discharge and an incandescent filament in series therewith, and means adapted to protect the filament against excessive heating by increased current during the warming-up period of the discharge while its voltage drop is low in which the means for carrying discharge current during the starting period comprises an auxiliary filament in parallel to the first named filament and a switch therefor responsive to conditions resulting from evaporation of the vaporizable filling adapted to break the circuit of said auxiliary filament and leave the first named filament in series with the lamp.

6. The combination of a vapor electric discharge device having a vaporizable filling adapted by vaporization to increase the voltage drop of the discharge and an incandescent filament in series therewith, and means adapted to protect the filament against excessive heating by increased current during the warming-up period of the discharge while its voltage drop is low in which the means for carrying discharge current during the starting period comprises an auxiliary filament in parallel to the first named filament and a thermostatic switch therefor responsive to temperature resulting from evaporation of the vaporizable filling adapted to break the circuit of said auxiliary filament and leave the first named filament in series with the lamp.

7. The combination of an electrical discharge device of the type which increases its effective voltage drop after starting of the discharge, a ballast resistance therefor, a molecular cooling fluid over said resistance adapted to be decomposed by heat generated by said resistor and with an endothermic reaction and to recombine at lower temperature with liberation of heat of combination and means for holding said fluid over said resistance.

8. The combination of an electrical discharge device of the type which increases its effective voltage drop after starting of the discharge, a ballast resistance therefor, an atmosphere of hydrogen over said resistance and means for holding said hydrogen over said resistance.

9. The combination of a vapor electric discharge lamp having a vaporizable filling adapted by vaporization to increase the voltage drop of the discharge and an incandescent filament lamp in series therewith, and means adapted to increase the resistance in series with the discharge during the warming up period of the discharge while its voltage drop is low whereby to protect said filament against overload, said

increased resistance being less than will fully compensate for the lower voltage of the discharge whereby the current is temporarily increased for heating the discharge lamp and for supplying greater illumination from the filament lamp.

10. The combination of a vapor electric discharge device having a vaporizable filling adapted by vaporization to increase the voltage drop of the discharge and an incandescent filament in series therewith, and means adapted to protect the filament against excessive heating with increased current during the warming up period of the discharge while its voltage drop is low, said protecting means being less than sufficient to fully compensate for the lower voltage of the discharge, whereby the current is temporarily increased for heating the discharge lamp and for supplying greater illumination from the filament lamp while the voltage of the discharge is at its lowest value.

11. A lighting circuit which comprises a source of current, a vapor electric discharge lamp having a vaporizable filling adapted by vaporization to increase the voltage drop of the discharge and an incandescent variable filament lamp in series therewith, and means for switching the filament circuit so that the filament effectively in the circuit during the starting period is adapted to reach incandescence in the circuit with a higher voltage drop than that of the filament in the circuit during normal operation, and the filament in the circuit during normal operation is adapted to maintain incandescence with the voltage drop available to it during said normal operation.

12. The combination of a vapor arc lamp of the type which increases its voltage to a substantially predetermined extent by evaporation of a limited supply of vaporizable material, and a plurality of incandescent filaments connected in parallel with each other and in series with the lamp, each carrying a relatively small part of the total arc current whereby any one may become disabled without seriously impairing the operation of the arc lamp or the other filaments.

13. A lamp comprising in combination a vapor arc lamp of the type which increases its voltage

by evaporation of a vaporizable material therein, an incandescent filament ballast, and means for supporting said incandescent filament, which combination is characterized by having a fixed body in intimate heat exchange relation to the incandescent filament substantially throughout the incandescent length of the filament and having a heat absorbing capacity sufficient to prevent burning out of the filament due to overloading in the first moments after the arc and filament are energized and until the arc voltage has been increased by vaporization of its filling material.

14. A lamp comprising in combination a vapor arc lamp of the type which increases its voltage by evaporation of a vaporizable material therein, an incandescent filament ballast, and means for supporting said incandescent filament, which combination is characterized by having the filament in intimate heat-exchange relation to the envelope of the vapor arc lamp whereby the heat developed by the filament during the starting period is utilized for vaporization of the vaporizable filling in said envelope and thereby the heating up period is reduced and the filament protected against excessive overheating.

15. The combination of a vapor arc lamp of the type which increases its voltage by evaporation of a vaporizable material therein and a series resistance connected thereto having a positive temperature coefficient of resistance, whereby the initial arc current through the lamp is greater due to the lower resistance value of the series resistance than during subsequent operation and means for cooling the resistance during its initial operation, whereby its resistance remains relatively low during the initial heating of the lamp and such heating is thus hastened.

16. The combination as defined in claim 15, in which at least a part of the resistance is in intimate heat-exchange relation with the arc lamp, whereby the heat capacity of the arc lamp delays the heating up of the resistance value, thus permitting a greater initial heating of the arc lamp by overloading the arc as well as by heat-exchange from the series resistance.

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