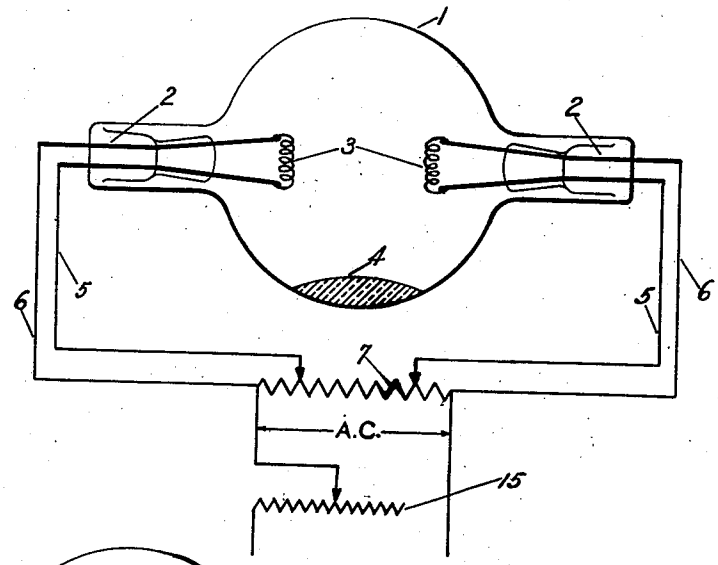
Nov. 3, 1931. A. H. COMPTON 1,830,312

ELECTRIC LAMP

Filed May 8, 1919

FIG 1



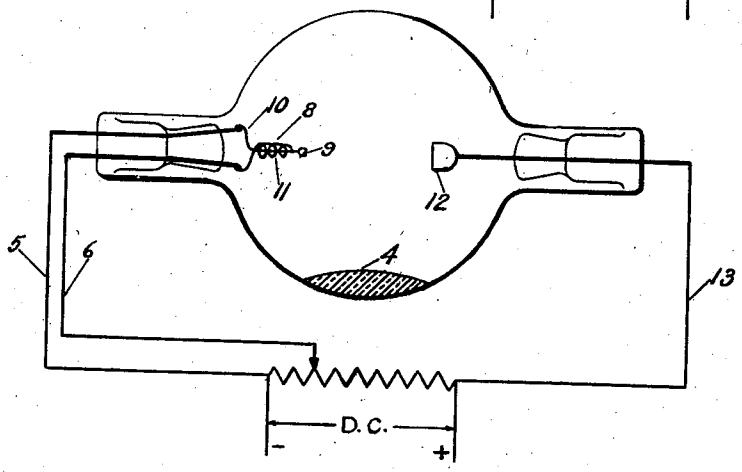


FIG 2

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UNITED STATES PATENT OFFICE

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ELECTRIC LAMP

Application filed May 8, 1919. Serial No. 295,539.

This invention relates to electric lamps, and, more particularly, to those of the vapor type.

A feature of the invention is a method of operating a vapor or gas-filled lamp at the best efficiency, from the standpoint of effective radiation emitted. This includes means for increasing the amount of effective light produced for a given power consumption.

Another feature of the invention is the regulation of the vapor pressure in a vapor lamp by coordinating the operating temperature and voltage in such manner as to effect the greatest emission of that light, which, of the substance vaporized, is the most sensitive to the eye.

Another object of the invention is to provide an organization of certain elements or instrumentalities which may produce a gas or vapor lamp that is self-starting and free from line ballast usually employed in the operation of an arc device.

A special object of the invention is to provide means for securing a highly luminous electric discharge through sodium vapor in such a manner that as large a part as possible of the light emitted shall lie in the characteristic yellow or "D" lines.

Further objects of the invention relates to novel combinations or circuit arrangements and details of construction, tending to increase the general efficiency of a gas or vapor arc device of this particular character, as will hereinafter more fully appear.

As is known, there are three critical potentials which may become manifested in the operation of a metallic vapor lamp. These potentials determine the nature of the collision between atoms and electrons moving with velocities imparted by the operating voltage impressed upon suitable electrodes. They are characteristic of the atom with which the electron collides, differing as regards the atoms of different metallic elements but remaining constant, under varying conditions, as regards the atoms of any one metallic vapor.

It has been shown that, if an atom of a metallic vapor is struck by an electron, at least four different types of collision may occur.

Firstly, if the electron is moving with a velocity less than that attained by falling through a certain potential difference, known as the "resonance potential", it apparently rebounds elastically from the atom, the only energy lost by the electron being the small amount taken up by the rebound of the atom.

Secondly, if the electron is moving with a velocity equal to, or slightly greater than, that corresponding to a fall through the "resonance potential", it may cause the atom to emit radiation the spectrum of which consists of a single line. If it does not cause the atom to produce this "resonance" spectrum, the electron rebounds elastically, as in the first instance. In any case, practically all of the energy which the electron loses in this type of collision appears as light of the wave-length corresponding to this single spectrum line.

Thirdly, if the potential through which the electron falls is further increased, another critical velocity is attained, where, at least for many metallic elements, the atom may emit light of another definite wave-length. When an electron having a speed slightly in excess of this second critical value collides with an atom, the energy which the electron loses by the collision appears as light of either the first or second definite wave-length.

Fourthly, if the potential through which the electron falls is further increased to the so-called ionizing potential, which is over twice that required to produce resonance, a third critical velocity is reached, upon which the atom may be excited to emit its "complete" radiation, which consists of light of a great many wave-lengths. When an electron, moving at such velocities, collides with an atom, the energy, which it loses, is radiated by the atom in light covering a large range of wave-lengths. Additional types of collisions may occur but these four, at least, are known.

In order to obtain as large an amount of light as possible from the electric energy put into a vapor, the conditions should be so adjusted that the electronic collisions will

occur at such speeds that the particular type of radiation is emitted to which the eye is most sensitive. Thus, in the case of sodium vapor, electronic collisions of the second, or resonance, type cause the atom to emit light consisting wholly of the yellow "D" lines, to which the eye is highly sensitive. Collisions of the third type have not as yet been observed, but collisions of the fourth type produce a complete radiation to which the eye is not nearly as sensitive as it is to the yellow light produced by collisions of the second type. For this reason it is advantageous, in the case of a sodium vapor lamp, to have as many of the electronic collisions as possible occur at velocities under that corresponding to the ionizing potential.

This condition can be secured ideally if the cathode of the sodium vapor lamp is heated to incandescence by an auxiliary source of energy so as to give off a stream of thermo-electrons, and if a potential difference of about 3 volts, which is between the resonance and the ionizing potentials, is applied between the anode and the cathode. The radiation emitted in this case by the sodium vapor is practically wholly yellow light but its intensity is too low for practical use. In order to increase the amount of light emitted, it is necessary to increase the number of collisions which produce resonance. This may be done by increasing the voltage applied between the anode and the cathode. The voltage may be raised to a value which is slightly less than the ionizing potential of the vapor, without producing ionization. Another way of increasing the number of collisions and therefore the amount of light is to increase the vapor pressure. I prefer to increase the light by the latter method. If the pressure of the sodium vapor is low and the distance between the anode and cathode small, a large number of "ionizing" collisions will occur between the electrons given off by the cathode and the atoms of the vapor. But, if the vapor pressure is sufficiently increased, the collisions of the electrons with the atoms will be so frequent that a resonance collision, absorbing most of the electron's kinetic energy, will probably occur before the electron can attain sufficient speed to produce ionization. Thus, it is possible to cause practically all the radiation from the sodium vapor to be of the yellow "resonance" type, and, at the same time, to obtain a brilliant light.

At the same time, if the cathode of the lamp is made of material, such as tungsten, which does not emit electrons under the influence of the light emitted by sodium vapor, the electric discharge through the lamp is stable without any line ballast. If the cathode were some other material, such as sodium, which would emit electrons when under the influence of the light emitted from the vapor of sodium, the electric discharge through the lamp would be unstable without line ballast. This phenomenon can possibly be explained as follows: An increase in the voltage between the electrodes would increase the amount of light and this increased amount of light would, in turn, cause more electrons to be emitted from the cathode, which is the well known photo-electric effect. The resulting increased number of electrons emitted would produce more light and the cycle would repeat itself. But with a cathode such as tungsten, which does not emit electrons when exposed to light from sodium vapor such a condition as just described could not exist. Furthermore, since practically all the electronic collisions are of the resonance type, a slight increase in voltage across the lamp merely increases the number of resonance collisions and does not produce ionization, so that the current through the tube is not materially changed.

In the accompanying drawings, Fig. 1 illustrates, diagrammatically, an electric lamp of the gas or vapor type embodying the features above discussed and operable by means of alternating current; and, Fig. 2 illustrates a modification operable by means of direct current.

Referring to Fig. 1 of the drawings, the vapor-arc device shown comprises an exhausted sealed container 1, having pairs of leading-in conductors 2 sealed into the ends thereof and terminating in incandescent electrodes or filaments 3 of refractory material, such as tungsten. Auxiliary-current sources are required for heating the electrodes 3 and they may be independent of each other or be obtained from a common source through the agency of a translating device, such as an auto-transformer, as will be explained later. A vaporizable substance 4 having low vapor pressure, such as sodium, mercury, or the like, is inserted within the container 1, and, when in a vaporized state, becomes luminous by reason of the passage of a current between the electrodes 3. The conductors 2 are connected, by leads 5 and 6, to the taps of an auto-transformer 7, which, in turn, is connected to a suitable source of alternating current. These connections may be made in any approved manner and will vary with the operating efficiency of the starting filaments 3. It will be noted that each of the auxiliary circuits is connected in the main operating circuit, which permits applying the full line voltage between the electrodes.

Upon closing the operating circuit, each of the filaments 3 is rendered incandescent. The heat therefrom produces thermo-electrons and effects the vaporization of the substance 4. Whenever the electrons moving between the electrodes 3 collide, at sufficient speed, with the molecules of the sodium vapor, light is produced. As I have pointed out, in order that the light shall be produced

as efficiently as possible, it is essential that the vapor pressure be kept so high that comparatively few of the electronic collisions can produce ionization of the sodium molecules. If the cathode is used to maintain the desided temperature, this vapor pressure may be obtained by properly adjusting the comparative sizes of the hot filaments 3 and of the container 1. The arc is maintained by the current flowing through the leads 6, and will serve as the principal source of light emanating from the lamp. With a lamp of this construction, it is advisable to apply the current to the auto-transformer 7 through a starting rheostat 15, in order to prevent a destructive arc from forming in the lamp before the vapor pressure of the sodium has become sufficient to prevent any appreciable ionization.

In Fig. 2 I have illustrated a direct-current device provided with a starting electrode or cathode 8, comprising an arcing tip 9 connected to a support 10, the latter being designed to have sufficient resistance to the conduction of heat to enable the arcing tip 9 to operate at incandescence. The support 10 is also connected to the conductor 5. The starting filament 11 is coiled about the cathode support 10 and connected thereto near the tip 9. The opposite end of filament 11 is connected to the conductor 6. The anode 12 may have any convenient shape, having regard for proper heat-dissipating capacity, and may consist of any suitable refractory material.

The operation of the form of lamp just described is as follows: The filament 11 of the cathode 8 is heated to incandescence by the application of suitable current. This will cause the volatilization of the substance 4 and effect the formation of an arc between the cathode and the anode which will persist by reason of a flow of the operating current through the leads 5 and 13.

I have found that, if the vaporizable substance used is sodium, no series resistance is required in the line circuit, as is customarily employed in this type of device, and, further, that the lamp will be self starting. It is also possible to employ various expedients for protecting the glass, of which the container is made, from being attacked by the sodium by using a protective mantle of some suitable gas which will surround the column of sodium vapor and prevent the latter from contacting with the glass. Like results may be obtained by coating the interior surface of the container with some suitable transparent coating which will be unaffected by the sodium vapor.

While I have described and illustrated certain embodiments of my invention, these are illustrative rather than definitive, as it is, of course, possible to vary the structural details and arrangements of the parts without departing from the spirit or scope of the invention as defined in the appended claims.

What is claimed is:

1. The method of converting electrical energy into light which consists in passing an electrical discharge between an incandescent cathode and an anode through sodium vapor and maintaining the pressure of said vapor at a value at which a luminous discharge is produced having a stable electrical characteristic.

2. An electrical device comprising the combination of a sealed envelope, a refractory cathode adapted to operate at incandescence, an anode and a quantity of alkali metal within said envelope, said device having a heat dissipating capacity adapted to maintain the vapor pressure of said alkali metal at a value at which an electrical discharge therethrough has stable electrical characteristics.

3. An electrical discharge device comprising the combination of a tungsten cathode, an anode, means for heating said cathode, an enclosing bulb and a quantity of sodium in said bulb, said lamp being proportioned to maintain the vapor pressure of said sodium below the value at which the volt-ampere characteristic of a discharge therethrough becomes negative.

4. An electrical device comprising the combination of an enclosed envelope, a cathode adapted to operate at incandescence, an anode, and a quantity of sodium in said envelope, said envelope being proportioned to operate at a temperature at which the vapor pressure of said sodium is sufficiently high to enable an electric discharge therethrough to ionize said vapor but below the value at which a discharge through said device has a negative volt-ampere characteristic.

5. The method of increasing the current-carrying capacity of an electron discharge which consists in maintaining in the path of said discharge the vapor of an alkali metal within pressure limits sufficiently high to cause substantial positive ionization by collision but insufficient to permit of an arc-like discharge having a negative volt-ampere characteristic.

6. An electrical discharge device comprising an evacuated envelope, electrodes therein, means for heating one of said electrodes to incandescence independently of a discharge therebetween, an alkali metal contained therein, said device being constructed to maintain the vapor pressure of alkali metal during operation high enough to increase the current carrying capacity of said device, but below the value at which an arc-like discharge of negative volt-ampere characteristic may occur.

7. An electrical discharge device comprising a sealed evacuated envelope, a filamentary cathode consisting of refractory material, terminal conductors therefor whereby

a heating current may be conveyed to said cathode, an anode, and a quantity of alkali metal in said envelope, said device being proportioned, when dissipating heat under ordinary external conditions, to operate at a temperature at which the vapor pressure of said alkali metal is sufficiently high to enable an electric discharge therethrough to ionize said vapor but below the value at which a discharge through said device has a negative volt-ampere characteristic.

8. An electrical discharge device comprising an hermetically sealed envelope, electrodes within said envelope comprising a solid cathode adapted to be heated to give electrons and an anode, an ionizable medium within said envelope, the temperature to which said cathode is heated and the heat dissipating characteristics of said envelope being designed to maintain the medium within the envelope at a pressure whereby a stable electrical discharge between the electrodes occurs upon heating the cathode to electron emitting temperature and applying a potential between the electrodes sufficient to ionize the gaseous medium.

9. An electrical discharge device comprising an hermetically sealed envelope, electrodes within said envelope comprising a solid thermionic electron-emitting cathode and an anode, an ionizable medium within said envelope, the temperature to which said cathode is heated and the heat-dissipating characteristics of said envelope being designed to maintain the medium within the envelope at a pressure whereby upon heating the cathode to electron-emitting temperature and applying a potential between the electrodes substantial ionization occurs but not sufficient to cause the discharge between the electrodes to have a negative volt-ampere characteristic.

In testimony whereof, I have hereunto subscribed my name this 6th day of May, 1919.

ARTHUR H. COMPTON.