June 22, 1937. J. W. MARDEN 2,084,772

SODIUM VAPOR LAMP

Filed April 29, 1933 3 Sheets-Sheet 1

Fig. 1.

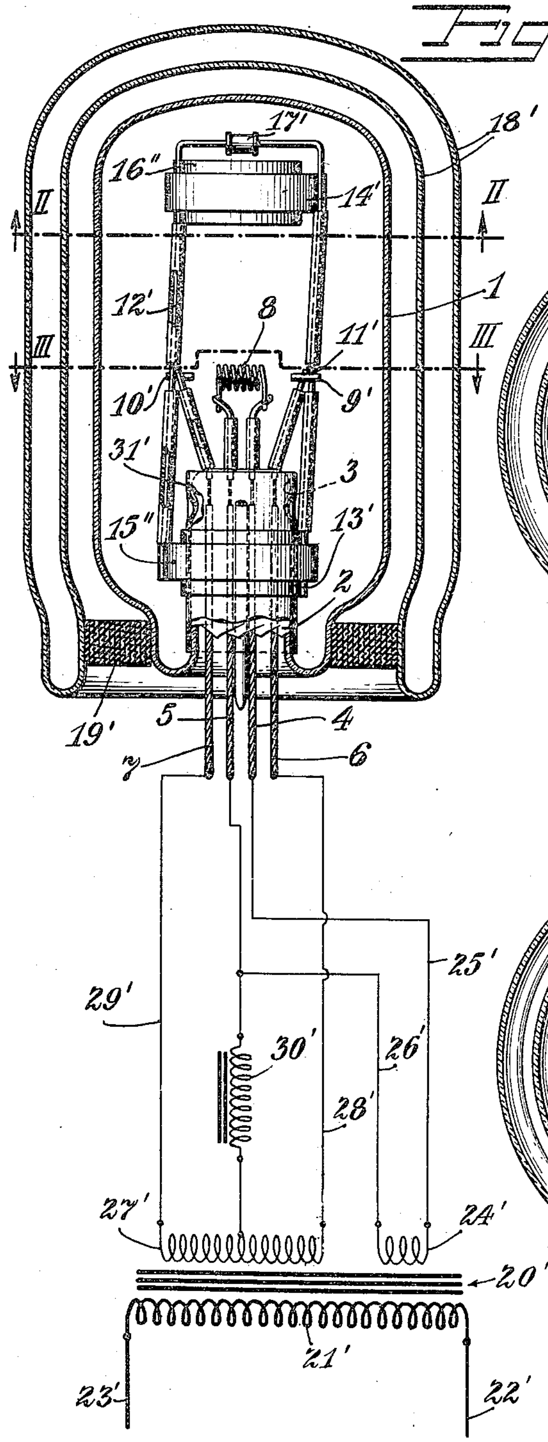


Fig. 2.

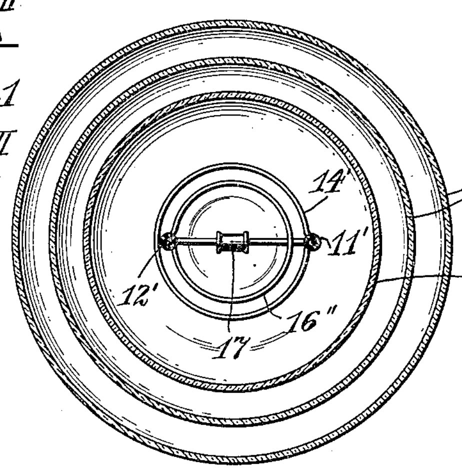
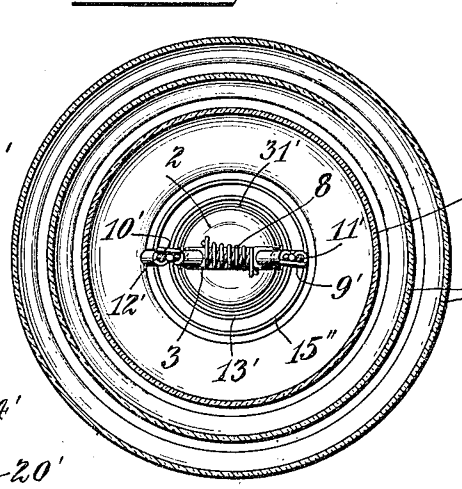


Fig. 3.



INVENTOR
J. W. MARDEN
BY M. F. Reges
ATTORNEY

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Fig. 4.

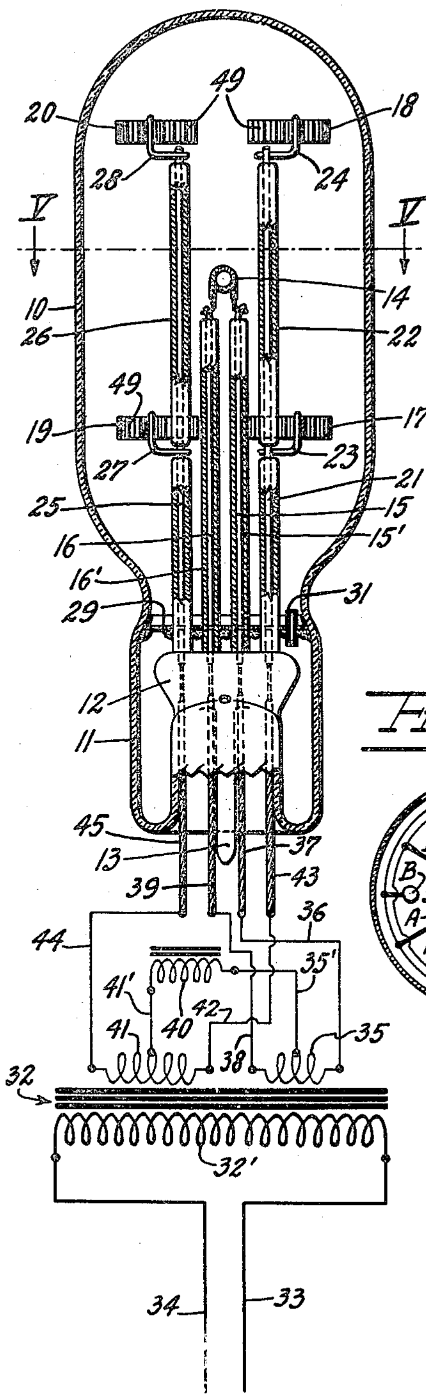


Fig. 5.

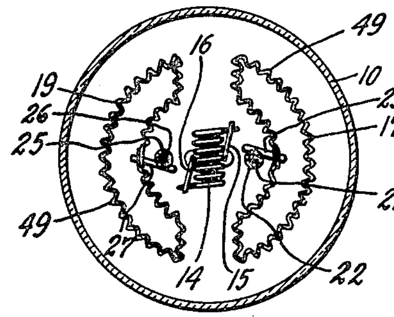


Fig. 6.

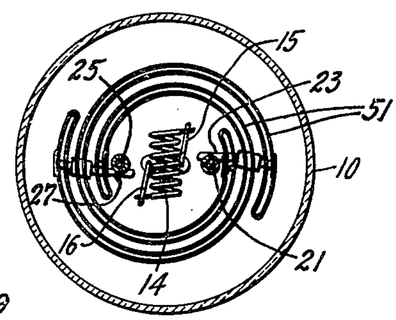


Fig. 13.

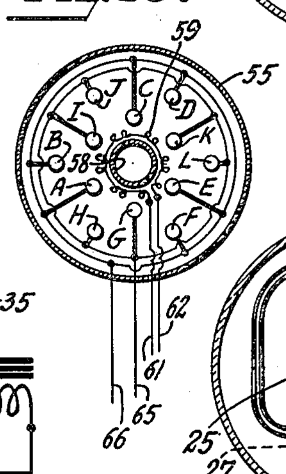
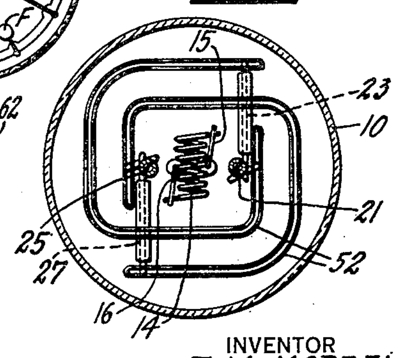


Fig. 7.



INVENTOR
J. W. MARDEN
BY M. F. Rege
ATTORNEY

June 22, 1937.

J. W. MARDEN

2,084,772

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Fig. 8.

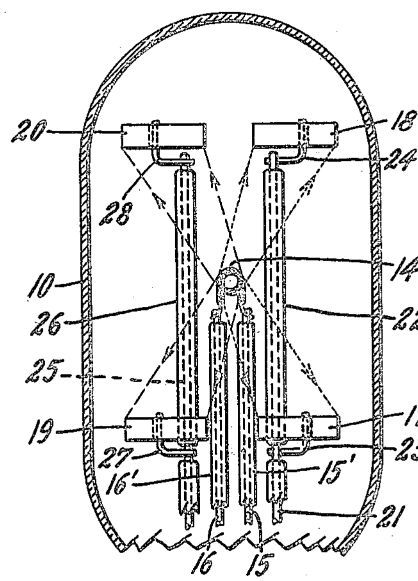


Fig. 9.

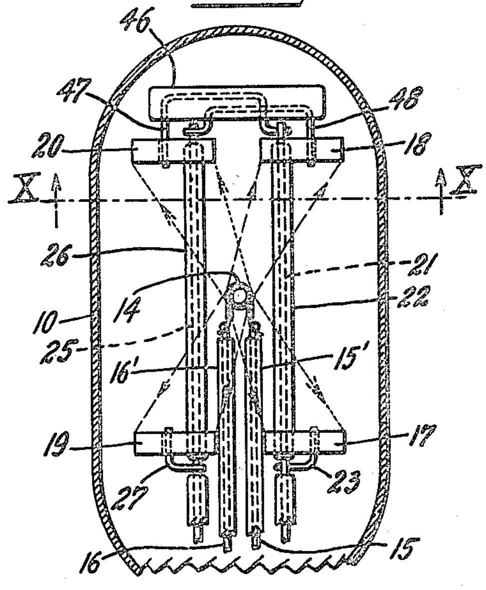


Fig. 12.

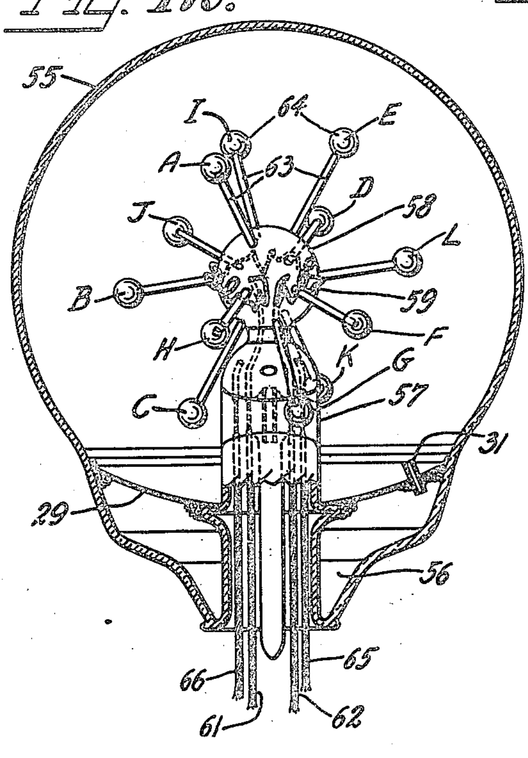


Fig. 10.

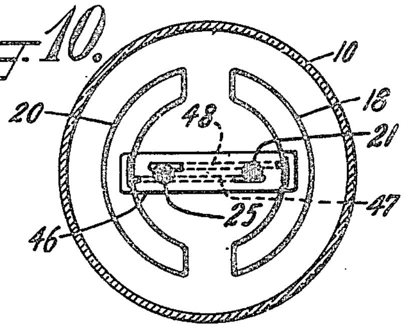
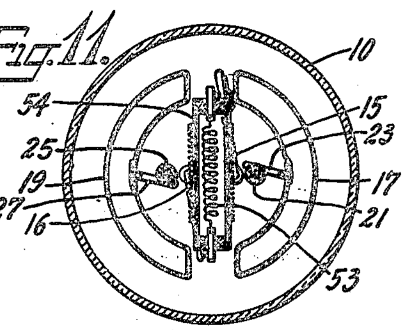


Fig. 11.



INVENTOR
J. W. MARDEN
BY M. F. Regers
ATTORNEY

Patented June 22, 1937 **2,084,772**

UNITED STATES PATENT OFFICE

2,084,772

SODIUM VAPOR LAMP

John W. Marden, East Orange, N. J., assignor, by mesne assignments, to Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application April 29, 1933, Serial No. 668,506

19 Claims. (Cl. 176—122)

This invention relates to luminous electric discharge tubes of the type employing a hot cathode and solid electrodes for use with alternating current and a filling of one or a plurality of vapors of metals solid at room temperatures or a mixture of one or more of such vapors with a gas to initiate a discharge. The gas may preferably be one of the rare gases.

In accordance with the present invention it has been found that good results are obtained with an easily condensable vapor from an alkali metal such as sodium.

Sodium glow lamps have been proposed heretofore and it is known that many such lamps have been made, particularly for use on direct current. It has been found heretofore, however, that when operating such lamps on alternating current the necessary efficiency to make the lamp practical is not attainable inasmuch as a low current density is necessary to make the device practical particularly when it is to be used as an illuminant.

Sodium vapor lamps as heretofore constructed, operating on direct current of about 1.6 amperes per square inch of anode surface give a relatively high output of lumens per watt. When attempting to construct a lamp to be used on alternating current, following the general construction of the direct current lamp it was found that only about one-third of the efficiency was obtained at the same current density the efficiency being taken for glow alone.

It was found that the current density could be controlled and reduced by making a device with two large area anodes and could be further reduced by dividing each of the anodes into two or more. This made it possible to not only divide the current but to dispose the electrodes in portions of the bulb remote from the cathode so as to cause a wide and complete distribution of the glow bringing it near to the surface of the bulb. It was also observed that when operating a sodium vapor lamp best results are obtained with a tubular bulb instead of a long tube since a more uniform temperature distribution is more readily maintained. The coolest part of the bulb should be at relatively high temperature and cool pockets should be avoided to prevent condensation of the sodium.

It has been found desirable from an operating standpoint to provide a lamp, constructed in accordance with the present invention, with a pressure of ½ to 4 millimeters of a suitable gas as for example either neon or argon. The presence of a gas is essential for initial starting. At room temperature sodium has no appreciable vapor pressure and the discharge is, therefore, started in the gas with a consequent heating of the sodium to vaporize the same. It has been found that it takes only about one-half to one-third as much argon as neon to operate a lamp. Good results have been obtained when using 1½ or 2 millimeters pressure of neon. Neon seems desirable since it gives a reddish colored glow which blends with the color of the sodium discharge and, furthermore, tests so far have shown that a more efficient light output is had with neon than with argon.

Curves have been ploted which show the effect of keeping the discharge current in an alternating current lamp constant with different pressures of neon. The output of the lamp decreases with increasing pressure but it decreases just as the wattage consumed by the lamp decreases and, as far as can be determined, it is a temperature effect. It may be desirable to use higher pressure gas on account of the lower voltage obtained. It is pointed out that if a lamp is sealed off the pumps cold, only about one-half of the gas pressure must be put in; that is, one-half of what is expected when the lamp is burning hot.

Curves have also been plotted to show the luminous output of the lamp measured with different wattage inputs. It has been found that a lamp constructed in accordance with the present invention has a maximum efficiency of about 80 watts total input and that the efficiency decreases after the maximum is reached. The total wattage consumed should, therefore, be near the peak value.

The reason for the maximum efficiency at 80 watts and subsequent decrease in efficiency has been shown by curves indicating the increase in luminous efficiency of the sodium discharge with decreasing current density. It has been found that the higher the current density the poorer the luminous efficiency of sodium lamps which may be due to the reabsorption of the light by the sodium vapor. It has been found that if a sodium lamp is placed behind a screen with a hole in it so that a measurement can be made of the light output of the lamp, and another sodium lamp is placed in front of the opening and operated, only the light from the lamp in front of the screen can be read and not the total light given by the two lamps. The lamp in front of the screen absorbs practically all of the light from the one behind.

Much of the light obtained from sodium lamps comes from very near the surface of the bulb and if it were possible to keep the lamp hot enough and draw a current of say one-tenth of an ampere instead of five amperes with a bulb of the diameter shown in the present construction, it might be possible to obtain an efficiency of 200 or more lumens per watt. This condition is approached in the present construction since by reason of the arrangement herein set forth a low current density is made available and the heat so distributed as to be effective in producing an operable device of relatively high efficiency.

The problem, therefore, as hereinbefore mentioned, is to obtain sufficient discharge to heat the lamp hot enough to give enough sodium vapor to support the discharge and at the same time draw no more current than is necessary.

When constructing the present type of lamp to burn on alternating current it has been found that the high peaks in the current are objectionable if they cause the lamp to go out with each half cycle and start again. In order to average five amperes output it would be necessary at the peak currents to draw perhaps two or three times that amount and a curve has been plotted which shows that it would not be possible to have a lamp with high efficiency having a series of such peaks and periods of no discharge. It has been found that when an alternating current lamp is made in a form similar to a full-wave rectifier or in the form which might be called a self-rectifying lamp, and connected with a choke coil, as shown on the wiring diagram of the drawings, for smoothing out the alternating current wave, good efficiencies were obtained.

With sufficient smoothing, considering only the wattage put into the lamp, very little difference in output can be read between the present alternating current lamp and one constructed to operate on direct current at the same wattage. It has been found that the present lamp running at about four amperes will give about ninety-seven percent of the output obtained on direct current if a one-tenth henry choke coil, as shown, is provided in the filament return lead. It has also been found that even without the choke at least ninety percent as good light output is obtained as with direct current with the same wattage lamp.

It is an object of the present invention to provide a sodium vapor lamp operable on alternating current at low current density.

Another object of the invention is to provide a glow lamp of the sodium vapor type operable on alternating current, wherein the current density is controlled by the geometrical proportions of the component operative parts.

Another object of the invention is to provide a glow discharge device wherein a given current density is divided and in which large current surges are avoided in the absence of the occurrence of relatively large amounts of sodium ions or high current densities.

Other objects and advantages of the invention will be more clearly understood from the following description together with the accompanying drawings in which:

Fig. 1 is a side elevational view of a lamp embodying the present invention having two pairs of concentric anodes and a hot cathode, the enclosing envelope being shown in vertical cross section;

Fig. 2 is a view taken on line II—II in Fig. 1;

Fig. 3 is a view taken on line III—III in Fig. 1;

Fig. 4 is a vertical sectional view of a lamp constructed in accordance with the present invention showing an arrangement wherein pairs of spaced electrodes are disposed at opposite ends of an envelope and a centrally disposed hot cathode is used;

Fig. 5 is a view taken on line V—V in Fig. 4;

Fig. 6 is a view similar to Fig. 5 but showing a pair of anodes in the form of concentrically disposed open rings;

Fig. 7 shows a pair of the anodes formed of wires or rods bent to provide a plurality of rectilinear portions on different planes;

Fig. 8 is a fragmentary view similar to the construction shown in Fig. 4, the current flow being indicated in dotted lines;

Fig. 9 is a fragmentary view showing the same arrangement of anodes as shown in Fig. 4 but including cross connections between the anodes to give a flow of current as indicated in dotted lines;

Fig. 10 is a view taken on line X—X in Fig. 9;

Fig. 11 is a view similar to that shown in Fig. 10 but including a cathode of the indirectly heated type;

Fig. 12 shows a modified form of the present invention wherein a plurality of anodes are disposed in the form of a constellation surrounding the cathode to give a widely distributed glow; and

Fig. 13 is a diagrammatical view showing the circuit arrangement for the cathode and anodes illustrated in Fig. 12.

The advantage of a glow lamp as an illuminant has long been recognized since such lamps, and particularly lamps utilizing a metallic vapor such as sodium, give a relatively large amount of evenly diffused light. From a practical standpoint, however, it is obvious that such lamps must be dependable and operate efficiently. Furthermore, it is essential for commercial reasons to make a lamp of the present type operable on alternating current with an efficiency which preferably exceeds present forms of lighting.

The problems attending the production of a sodium glow lamp are many and it has been found that the light absorption by the sodium vapor is very high. It appears that the useful light obtained from a sodium vapor lamp is obtained from the outer surface of the glow and that the light from the other portion of the glow is absorbed.

It has also been found that the distribution of heat is important and the relative dimensions of the device must be considered to obtain the required current density.

Extensive experimentation with lamps of various constructions has shown that the lumens per watt increases rapidly as the current density becomes lower so that it is possible that very high efficiencies may be obtained from the glow alone, although such condition would not be practical for making lamps. It must be kept in mind, however, that although the lower the current density the higher the efficiency in the glow discharge, an operating temperature must be maintained. This is accomplished by the construction, shown and more particularly described hereinafter, which includes a novel formation and arrangement of electrodes, especially the anodes.

When anodes of a molybdenum strip of five mil thickness are used the dimensions may be varied somewhat but when very much smaller there is a tendency of the anodes to run red hot.

As hereinbefore mentioned, it is necessary for the purpose of obtaining the required efficiency when operating on alternating current to use low current densities. When a device of the present character is constructed with two anodes as found in a direct current device the best output was about 30 lumens per watt.

In accordance with the present invention, four anodes are employed with the result that an output of about 50 lumens per watt is obtained.

The present construction includes two pairs of anodes arranged so that the anodes are disposed at each end of a tubular bulb with the cathode substantially central with respect to the bulb.

The arrangement of the anodes is such that current is drawn to one anode at each end of the bulb during each half cycle, so dividing the current as to give low current density during operation.

A device constructed in accordance with the present invention may comprise a bulb 1 of relatively short cylindrical form. This form of bulb has been found to be satisfactory with the arrangement of electrodes in the relative positions shown to obtain the results which follow the teaching of the following description.

As illustrated in Figs. 1 to 3, a preferred embodiment of the invention may comprise a bulb 1 in which a flare tube 2 is sealed to the neck portion in the usual manner. The flare tube may have a press 3 in which lead wires or conductors 4, 5, 6, and 7 are sealed. The lead wires 4 and 5 extend through the press and are connected to opposite ends of heater element in the form of a helical coil 8 the construction of which will be later described.

The lead wires 6 and 7 extend through the press and may be secured to short pieces of rod 9' and 10' which in turn are secured to support rods 11' and 12'. The pieces 9' and 10' are so disposed as to constitute starting tips to initiate the glow discharge. The starting tips 9' and 10' are shown as projecting metallic pieces but, if desirable, they may consist of oppositely disposed exposed surfaces of the support rods. That is, the support rods 11' and 12' may be covered with an insulative sleeve as shown except that a portion on each rod opposite to the cathode may be exposed to serve as a starting electrode.

The support rod 9' has a relatively small electrode 13' of cylindrical form secured to its lower end and a relatively large electrode 14' secured to its upper end. These electrodes which are electrically connected may be considered as a pair or may be termed as double electrode.

The support rod 12' has a relatively large cylindrical electrode 15'' secured to its lower end and a relatively small similar electrode 16'' secured to its upper end. These electrodes being also electrically connected may be considered as another pair or as a double electrode.

For the purpose of strengthening the structure the rods 9' and 10' extend partially across the upper electrodes and are connected by an insulative coupling 17'. The rods 11' and 12' may be insulated by sleeves of alundum or magnesium on portions between the starting tip and the electrodes. In Figs. 1 to 3 the electrodes are of cylindrical form and opposite electrodes of each pair are disposed in concentric relation. Other forms of arrangements of electrodes may, however, be employed, as shown in other figures of the drawings.

Inasmuch as it is necessary to keep the device at relatively high temperatures to maintain the sodium in vapor form, it is desirable to provide the bulb 1 with an enclosing vacuum chamber 18' which may be a double-wall vessel so proportioned as to enclose the bulb. The vessel 18' may be held in position by a suitable collar or packing 19' which may serve to seal the air space between the vacuum chamber 18 and the bulb 1 against the circulation of air. The chamber 18, as shown in Figs. 1 to 3, may be employed with the other constructions shown.

Electrical energy may be supplied to the device by means of a suitable transformer 20'. The primary 21' of the transformer may be connected to conductors 22' and 23' receiving current from a suitable source (not shown). The device may be operated where commercial line voltage of 110 to 115 volts is available. In the present construction the transformer is provided with a secondary winding 24' to provide a source of relatively low voltage current for the heater element 8. One side of the winding 24' is provided with a conductor 25' connected with lead wire 4 of the heater element 8 and the other side is provided with a conductor 26' connected with the lead wire 5 of the heater element. A source of high voltage is furnished by a secondary winding 27', one side of which is connected by conductor 28' with lead wire 6 which leads to the double electrode 13'—14'. The other side of the winding 27' is connected by a conductor 29' to lead wire 7 for the flow of current to the double electrode 15''—16''.

It is desirable for the efficient and effective operation of the device to smooth out the alternating current wave. This may be accomplished by providing a suitably proportioned choke coil 30' or by other means such as an auto or constant-wattage transformer. By smoothing out the alternating current wave the device is made operable in the absence of light flicker and periods in which no discharge or light occurs are avoided.

In the construction of the device shown in Fig. 1, opposite electrodes 13' and 15'' surround the flare tube which makes it possible to provide a bulb without pockets to receive vapor which might be subject to cooling and thus condense the vapor. As shown in other constructions hereinafter described, the bulb is made so that the electrodes are in pairs and spaced apart in which case certain advantages follow by reason of the arrangement of the electrodes but in such constructions it is necessary to provide a pocket to contain the flare tube. The preferred construction shown in Fig. 1 avoids the pocket and makes a more compact device. It has been found, however, that in order to prevent overheating the press 3, it is desirable to cover the press and flare tube 2 with a sleeve or shield 31' of nickel or other protective material to dissipate the heat or distribute and avoid concentration of hot spots which may crack the press or flare tube.

The present device may be constructed with starting tips 9' and 10' as shown in Fig. 1 or without such tips as shown in the remaining figures. The starting tips are preferable, however, for quick operation at low voltage and may be provided in any or all of the forms shown.

In the construction, as illustrated in Fig. 1, the winding 24' serves to heat the filament effecting an initial discharge between the starting tips 9' and 10' by reason of a given amount of neon or other rare gas provided for this purpose. The sodium vapor within the bulb then quickly reaches a temperature ionizable or capable of providing a glow discharge at the operating voltage of the device. When a discharge has been initiated it continues between the electrodes 13' and 14' and the cathode 8 during one-half cycle and electrodes 15'' and 16'', and the cathode 8 during the other half cycle of the alternating current.

The arrangement of the double electrodes 13', 14' and 15'', 16'', makes it possible, as above mentioned, to operate the device at low current density. With a current of say five amperes supplied, the two electrodes will receive the current and thus divide it and owing to the relatively large area of the electrodes the current density will be relatively low. The present arrangement of electrodes provides a large area and since the current density is reduced per unit of area it is possible to attain the desired result in accordance with the present invention.

As shown in Figs. 4 to 8 the structure may be modified to include a bulb 10 having a neck portion 11, a press 12 and an exhaust tube 13. The envelope is provided with a cathode which may comprise a coiled tungsten filament coated with a thermionically active material to provide a copious electron flow. Conductive support members 15 and 16 extend into the bulb and are attached to the terminals of the filament to support the same in a position substantially central within the bulb. These support members are suitably insulated by sleeves 15' and 16' of glass or other suitable material.

The device is provided with pairs of electrodes or anodes 17, 18 and 19, 20. The electrodes or anodes 17 and 18 are mounted on arms 23 and 24 respectively extending from a conductive support member 21 which is insulated along its length by a suitable sleeve 22 of glass or other electrically non-conductive material. These electrodes are disposed in symmetrical spaced relation to the cathode 14. The electrode 17 is disposed in the lower portion of the bulb and the electrode 18 is disposed in the upper portion to afford a uniform distribution of the glow discharge.

The electrodes or anodes 19 and 20 are mounted on arms 27 and 28 respectively, extending from a conductive support member 25. This support member is insulated substantially throughout its length by an insulative sleeve 26 which may be similar to the sleeve 22. These anodes are disposed in symmetrically spaced relation to the cathode 14. In the construction shown, the anodes 18 and 20 are disposed in the upper portion of the bulb in a common plane and the anodes 17 and 19 are disposed in the lower portion of the bulb and in a common plane. This arrangement of the electrodes with respect to the cathode affords a wide and even distribution of the glow discharge and brings it to the surface of the bulb to afford the best light output.

The bulb may be supplied with the vapor of an alkali metal as for example sodium, potassium, caesium, or rubidium. Sodium, however, is preferable and readily vaporizable and, for the purpose of preventing the vapor from reaching the cooler portion of the bulb neck, a baffle or partition 29 is provided. This baffle may have a tubular passage 31 for exhaust purposes.

Electrical energy may be supplied to the device by means of a transformer 32. The primary 32' of the transformer may be connected to conductors 33 and 34 receiving electrical energy from a suitable source of alternating current, not shown. The transformer is generally the same as shown in Fig. 1 and is provided with a secondary winding 35 constituting a source of filament current. One side of this secondary winding is provided with a conductor 36 connected with a lead wire 37 which is a continuation of the conductive filament support member 15. The other side of the winding 35 is provided with a conductor 38 connecting with a filament lead wire 39 which is a continuation of the filament support 16.

One side of a high voltage winding 41 of the secondary is provided with a conductor 42 connected to a lead wire 43 which is a continuation of the support 21 connected with anodes 17 and 18. The other side of the winding 41 is provided with a conductor 44 connected with the lead wire 45 which is a continuation of the support 25 connected with the anodes 19 and 20. The winding 35 operates to heat the filament causing an initial discharge by reason of a quantity of neon or other rare gas provided for this purpose whereupon the sodium vapor becomes ionized and a discharge takes place between electrodes 17 and 18 and the cathode during one-half cycle and between electrodes 19 and 20 and the cathode during the other half cycle. For the purpose of flattening the alternating current wave to produce a pulsating direct current, suitable means may be provided such as choke 40 connected to lead 35' connected to the central top of the secondary winding 35 and lead 41' connected to the center of the secondary winding 41.

The arrangement of the electrodes shown in Figs. 1 and 4 gives satisfactory results but, if desirable, the arrangement may be altered as shown in Fig. 9 wherein a crowfoot insulative member 46 is provided to carry a conductive connector member 47 which electrically connects anode 20 with the conductive support member 21 and an electrical connector member 48 electrically connects anode 18 with conductive support member 25. With this arrangement a flow of current during one-half of the cycle occurs between electrodes 17 and 20 and the cathode 14 and, during the other half cycle, current flows between electrodes 18 and 19 and the cathode 14.

The anode construction, as shown in Figs. 4 and 5, may comprise a corrugated strip 49 in the form of a flattened tube bent to provide arcuate surfaces, the corrugations serving to increase the area and if possible the electrodes shown in Figs. 1 to 3 may be corrugated. If desirable, however, anodes 51, as shown in Fig. 6, may be provided which may be comprised of spirally-formed rods or narrow strips of metal. Fig. 7 shows electrodes or anodes 52, as an example of another practical construction, wherein the anodes may comprise bent rods or wires having straight sides and overlapping each other. The various anode constructions shown serve to give a wide distribution of the discharge.

Fig. 11 shows a modification of the cathode structure wherein a coiled filament or heater element 53 is disposed in a sleeve 54 which latter may be coated with a thermionically active material. The cathode is of the indirectly heated type and may be employed where a greater supply of electron emission is desirable.

Fig. 12 shows a modified form of a device wherein a greater number of anodes are employed to give a wide distribution of glow throughout the device. The same principle of operation is employed in that certain sets of electrodes operate to divide the current to provide a device wherein operation at low current density is obtained. As shown in Fig. 12 a modified form of the device may comprise a substantially spherical bulb 55, a neck portion 56 of which is sealed to a pedestal 57 of glass or other suitable insulative material, extending into the bulb and terminating in a head 58.

A filament 59 may be suitably supported on support wires extending from the head. The filament may be of the helically wound type comprised of tungsten wire, the terminals of which may be connected with leading-in conductors 61 and 62. Extending from the head in substantially radial formation are conductive support members 63 terminating in spherical anodes 64. The several anodes and their supports are similar in construction but their electrical connections are so made that a given number of the anodes serve to pass current on one half of the cycle and another series of anodes serve to pass current on the other half of the cycle.

Fig. 13 shows a diagrammatic arrangement of the electrodes and their circuit and, as will be noted, conductive members 65 and 66 are provided which may be connected to a transformer in a manner similar to that shown in Figs. 1 to 4. In the arrangement shown in Fig. 13, however, during one-half of the cycle electrodes A, B, C, D, E, and F operate and during the other half cycle electrodes G, H, I, J, K and L operate.

It will be evident with the construction just described having a constellation of electrodes disposed in the most effective spaced relation, that a wide and even distribution of glow may be obtained. The areas of the respective electrodes may be proportioned to give the required low current density and to be in the proper ratio with respect to the cross-sectional area of the glow. The modified constructions shown in Figs. 4 to 13 may be provided with vacuum chambers as shown in Fig. 1 to conserve the heat and maintain the bulb at the required temperature.

In constructing a device in accordance with the present invention a bulb may be employed having a diameter of about two and a half inches and a length of four inches measuring from the constricted neck portion to the other end of the bulb. This bulb, as shown, may be generally of cylindrical form and rounded at the end opposite to the neck. The bulb may be of any suitable sodium resistant glass.

A filament giving satisfactory results requiring two volts and eight amperes during operation may be employed. This filament is made by wrapping a six mil nickel wire on a sixteen mil tungsten mandrel. This wrapped tungsten wire is then coiled up into a helix of about six turns having an internal diameter of about one-eighth of an inch. The size of the mandrel and the size of the tungsten wire can be varied to give the desired current and voltage. The ends of the tungsten coil or mandrel serve as the terminals and are connected to the leading-in conductors of the lamp. The nickel winding serves as a support for the thermionic material.

The nickel wire wound on the tungsten coil may be sprayed with a mixture of carbonates in the usual nitro-cellulose amyl acetate binder. It is desirable to have electron emission of the coil as high as possible and good results have been obtained in lamps having the coil coated with barium azide. Various types of indirectly heated cathodes of suitable dimensions have been used.

The internal structure of the lamp may comprise supporting means for the double electrodes shown. These electrodes may be in the form of rings or bands of five mil molybdenum and, as illustrated, may be disposed at each end of the bulb and symmetrically placed so as to be from three-eighths to a half inch from the end of the bulb or the metal partition or disk, depending upon the structure used. The lead or support wires of the internal structure of the lamp may be covered either with sodium resistant glass or with an alundum or magnesium insulator so that the discharge travels to the electrodes and not to the supports.

It is preferable to employ starting tips, as shown in Fig. 1 of the drawings, so that the lamps which are used on alternating current will start at low voltages as for example on transformers giving 45 volts.

In certain of the modifications of the lamps shown in the drawings a metal disk is sealed across the neck of the bulb and this disk should be positioned about three-eighths to a half inch from the lower electrodes. In the construction shown in Fig. 1 in which the bulb does not require the disk and does not have a relatively cool chamber, the lower electrodes may be positioned from three-eighths to a half inch from the neck portion of the bulb.

When a disk or partition is used such partition may be secured by a suitable cement such as sodium silicate and kaolin. Preferably, the disk or partition is sealed in the most constricted portion of the neck of the bulb. The disk may be provided with an aperture or small tubing to provide a communicating passage, as shown, for exhaust purposes.

The lamp should be exhausted by means of a careful and slow exhaust, particularly when the disk is employed with a sodium silicate cement in order that the water vapor may be removed from the sodium silicate during the heating of the device during exhaust.

The lamp should be thoroughly baked after which the filament is heated to a sufficiently high temperature and the carbonates or azides decomposed and the gas pumped off in the usual manner. The anodes are usually heated for degasification by induction heating or by bombardment with a very low pressure of neon gas.

In practice sodium has been introduced into the bulb by two methods, either by electrolysis or by placing the sodium in small glass bottles which are broken after the lamp has been sealed off from the pump.

For the purpose of making the lamp burn at the best voltage it is often necessary to season the lamp at a higher current than five amperes for a short period of time in order to vaporize the sodium and clean up residual gases which may exist as impurities. It has been found that a lamp made in accordance with the above description operates best at 80 watts total wattage input; that is, if 15 watts are used to heat the filament, 65 watts are used in the discharge. The filament current may be 8 amperes at about two volts, with about 4 to 5 amperes in the discharge.

As hereinbefore pointed out, it is important, particularly when using sodium, to maintain the necessary high temperature of the device to keep the sodium at a vapor pressure capable of supporting a glow discharge preferably at a temperature within the range of about 200° to 300° C. as described in Patent 1,531,966 issued March 31, 1925. The present construction provides a device in which the cathode, operable at incandescence, is disposed substantially central with respect to the container or bulb. The anodes are arranged in positions remote from the cathode and in close relation to the wall of the bulb.

The anodes which cooperate with the cathode to produce a glow discharge are, as shown in the form of double or multiple electrodes, i. e. a common conductor is provided to supply electrical energy to an anode consisting of a number of relatively large area bodies. These bodies are disposed so as to spread out within the bulb making possible the most effective and advantageous use of the electrical energy consumed.

By reason of this novel disposition of the anodes, they operate not only to produce a glow discharge but, by reason of their close proximity to the wall of the envelope or bulb, the device is maintained at a temperature sufficiently high to keep the sodium vaporized at which a glow discharge may be produced at low current density. In addition, the arrangement of the anodes, as above pointed out, brings the sodium glow close to the wall of the container so that a high light output is attained in that the outer surface of the glow is of relatively large area.

Lamps have been made in accordance with the above and have been burned both on alternating and direct current in vacuum chambers both in reflectors indoors and as units for outdoor use with satisfactory results.

What is claimed is:

1. An electrical discharge device operable on alternating current comprising a sealed envelope, a thermionically active cathode, a gas at reduced pressure and sodium in said envelope, starting electrodes to produce a discharge to vaporize said sodium and a pair of electrodes, each of said electrodes being divided into a plurality of sections for ionizing said sodium vapor to produce light of relatively high intensity at relatively low current density.

2. An electrical device comprising a sealed envelope, a refractory cathode operable at incandescence, anodes and a quantity of alkali metal within said envelope, each of said electrodes being divided into a plurality of sections cooperating with said cathode to vaporize said metal and produce a glow discharge and being so proportioned and disposed in such spaced relation as to distribute said glow adjacent to the surface of said envelope and give a maximum light output.

3. An electrical device comprising the combination of a sealed container, a thermionically active cathode, a quantity of alkali metal within said container and anodes, each of said anodes being divided into a plurality of sections and arranged to effectively distribute the heat within said device to maintain a glow discharge close to the wall of said container.

4. An electrical device comprising a sealed container, a cathode, a quantity of alkali metal within said container, anodes each disposed on one side of said cathode to cooperate with said cathode to produce a glow discharge, a gas at reduced pressure for initiating said discharge, each of said anodes being divided into a plurality of sections so proportioned and arranged as to cause a widely distributed glow in the vapor of said alkali metal.

5. An electrical device comprising a sealed tubular container, a cathode, a quantity of sodium in said container, anodes each disposed at one side of said cathode to cooperate with said cathode to produce a glow discharge, a gas at reduced pressure within said container for initiating a discharge causing an elevation in the temperature of said device to vaporize said sodium and produce a sodium glow each of said anodes being divided into a plurality of sections so proportioned and arranged as to produce said glow adjacent to the wall of said container.

6. An electrical device operable on alternating current comprising a sealed container, a thermionically active cathode, a quantity of sodium in said container, a plurality of anodes to cooperate with said cathode to produce a glow discharge, a gas at reduced pressure within said container for initiating a discharge causing an elevation in the temperature of said device to vaporize said sodium and produce a sodium glow, each of said anodes being divided into a plurality of sections so proportioned and arranged as to distribute the sodium glow throughout the container and maintain the glow constant at low current density.

7. An electrical discharge device operable on alternating current comprising a sealed tubular envelope, a thermionically active cathode, an alkali metal vapor in said envelope, a pair of anodes, each of said anodes having a portion disposed adjacent to one end of said envelope and another portion disposed at the other end of said envelope, said anodes cooperating with said cathode to cause a glow discharge to be distributed throughout said envelope.

8. A sodium vapor lamp operable on alternating current comprising a sealed bulb, a thermionically active cathode, an ionizable medium in said bulb, a plurality of pairs of electrodes arranged to alternately cooperate with said cathode to produce a glow discharge, electrodes of opposite pairs being disposed in adjacent spaced relation.

9. An electrical device operable on alternating current comprising a sealed envelope containing a gaseous atmosphere, a cathode disposed substantially central within said envelope, a pair of anodes, a portion of an anode of each pair being disposed in opposite ends of said envelope said oppositely disposed portions cooperating with said cathode to produce a glow discharge.

10. An electrical device operable on alternating current comprising a sealed envelope containing a gaseous atmosphere, a cathode, a multiplicity of sets of ring-like anodes, the anodes of each set being electrically connected and disposed remote from said cathode one set of said anodes operating during each half cycle of said alternating current.

11. An electric discharge lamp device comprising a tubular container, electrodes arranged in pairs at opposite ends of the container and sealed therein, a gaseous atmosphere therein comprising sodium vapor and neon, the gaseous electric discharge between said electrodes being an arc discharge, and means for maintaining said container at the operating temperature of said sodium vapor.

12. An electric discharge lamp device comprising a tubular container, an electrode at each end of the container and sealed therein, a thermionically active cathode in said container, a gaseous atmosphere therein comprising sodium vapor and neon, the neon pressure being less than 4 mm. at room temperature, means for heating said cathode to electron emitting temperature to initiate a discharge between said electrodes, the gaseous electric discharge between said electrodes being an arc discharge and a heat retaining envelope surrounding said container and spaced therefrom.

13. An electric discharge lamp device comprising a container, a pair of electrodes sealed therein, a thermionically active cathode cooperating with at least one of said electrodes to initiate a glow discharge between said electrodes, one of the electrodes of said pair being disposed at one end of the container and the other electrode at

the other end of said container, a gaseous atmosphere therein comprising sodium vapor and neon, the neon pressure being less than 4 mm. at room temperature, the gaseous electric discharge between said electrodes being an arc discharge and a heat retaining envelope surrounding said container and spaced therefrom.

14. An electric discharge lamp device comprising a container, an electrode disposed in relatively close relation to each end of said container, each of said electrodes consisting of a plurality of electrically connected sections, a gaseous atmosphere therein comprising sodium vapor and neon, said electrodes having relatively large effective areas capable of distributing heat throughout the device to maintain said gaseous atmosphere at a pressure to support a glow discharge.

15. An electrical discharge device operable on alternating current comprising a sealed envelope, a thermionically active cathode, an ionizable medium in said envelope, means for heating said cathode to electron emitting temperature, a plurality of electrodes cooperating with said cathode to produce a glow discharge, each of said electrodes comprising a plurality of parts disposed in spaced relation in the bulb whereby the glow discharge is distributed throughout the bulb.

16. An electrical discharge device operable on alternating current comprising a sealed envelope, a thermionically active cathode, an ionizable medium in said envelope, means for heating said cathode to electron emitting temperature, electrodes cooperating with said cathode to produce a glow discharge, each of said electrodes comprising a plurality of sections, at least one section of each electrode being disposed at one side of the bulb and at least one section of the other electrode being disposed at the other side of the bulb.

17. An electrical discharge device operable on alternating current comprising a sealed tubular envelope, a thermionically active cathode, sodium vapor in said envelope, a pair of electrodes each of said electrodes being divided into a plurality of sections at least one section of each electrode being disposed at each end of said envelope.

18. An electrical device comprising a sealed tubular bulb, a cathode disposed substantially centrally between the ends of said bulb, a quantity of sodium within said bulb, a plurality of anodes disposed adjacent to each end of said bulb, means for holding said anodes in space relation to the bulb wall, said anodes being so proportioned and arranged as to cause an effective sodium glow discharge in close relation to the surface of said bulb wall.

19. An electrical device operable on alternating current comprising a sealed tubular bulb, a thermionically active cathode disposed substantially mid-way between the ends of said bulb, an alkali metal vapor within said bulb, a plurality of anodes having large effective areas disposed adjacent to each end of said bulb to cause a distribution of heat throughout said device to maintain said vapor at a pressure capable of supporting a glow discharge at high luminous efficiency.

JOHN W. MARDEN.