Feb. 14, 1933. C. E. KENTY 1,897,482

SELF STARTING LOW VOLTAGE GASEOUS ELECTRIC DISCHARGE DEVICE AND METHOD OF OPERATING SAME

Filed May 9, 1932 3 Sheets-Sheet 1

Fig. 1

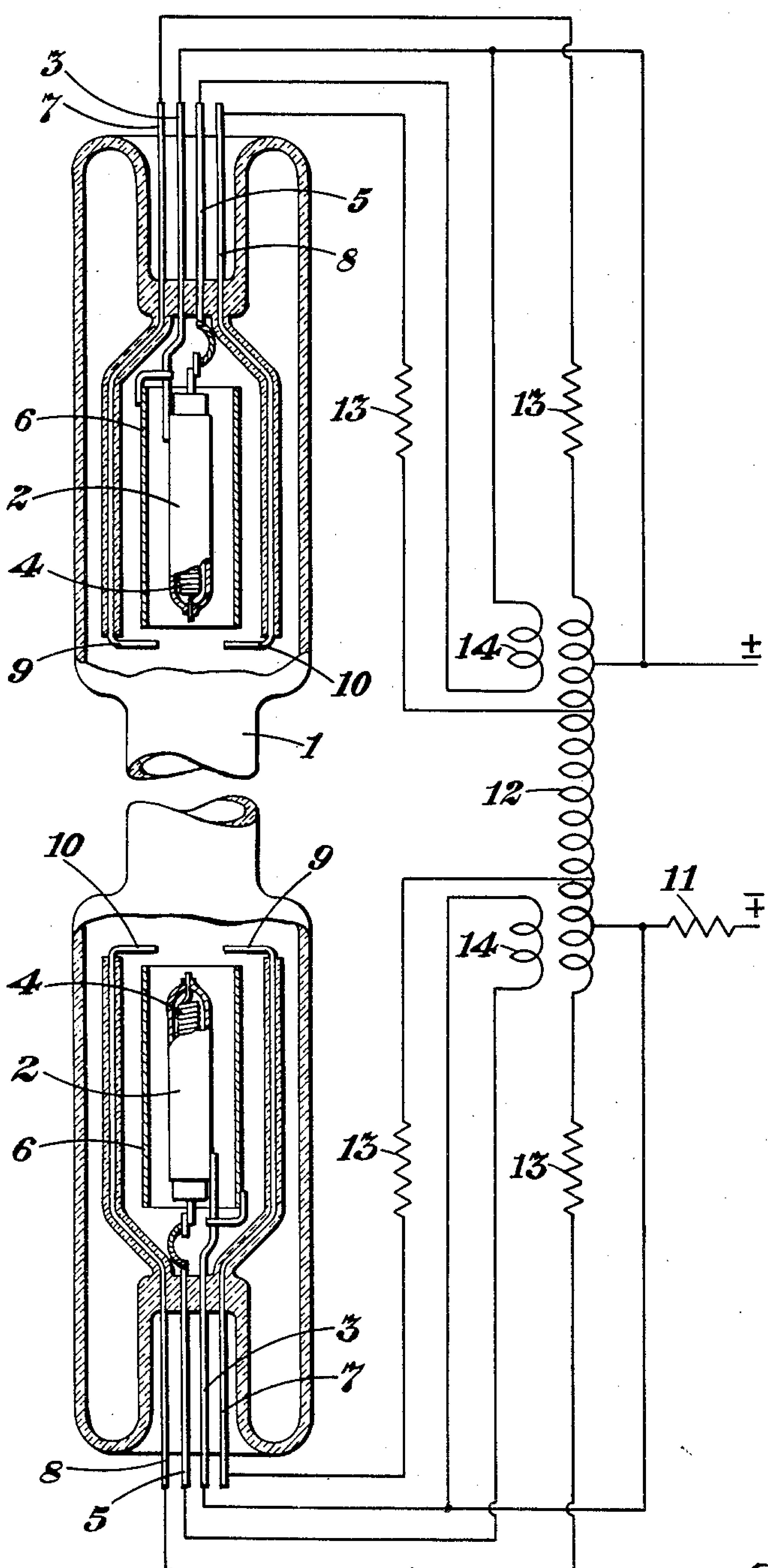
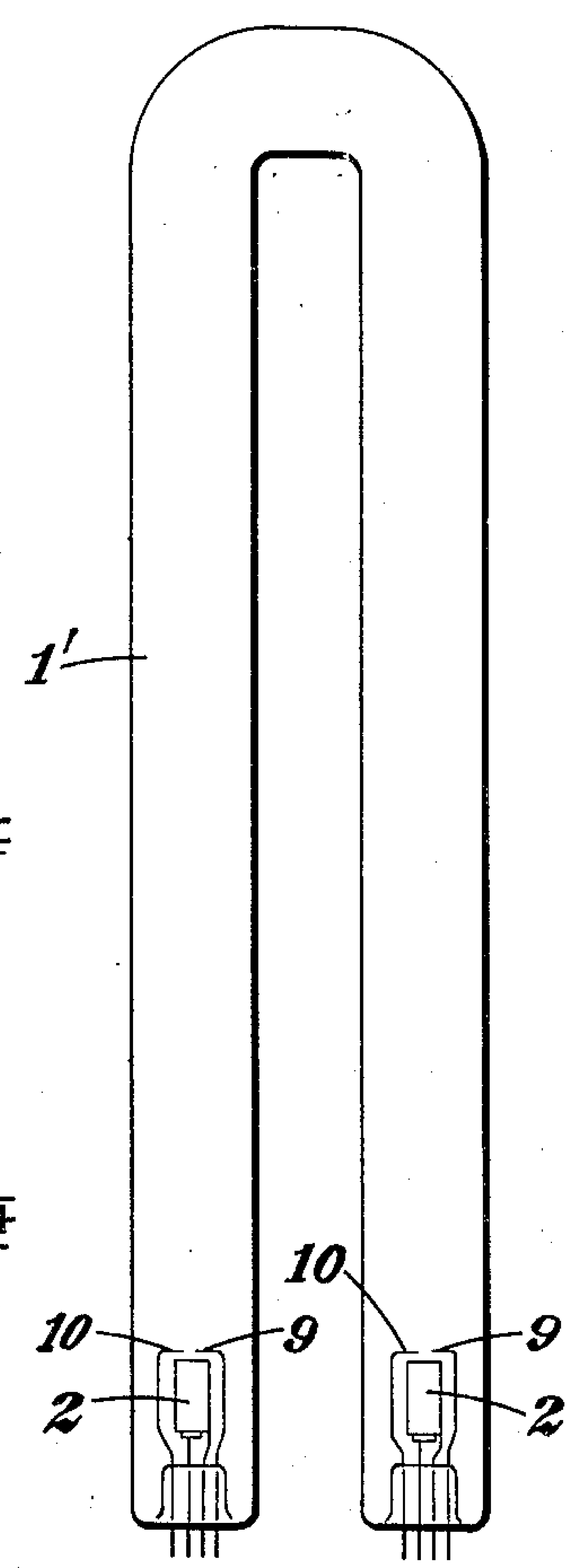


Fig. 2



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Filed May 9, 1932 3 Sheets-Sheet 2

Fig. 3

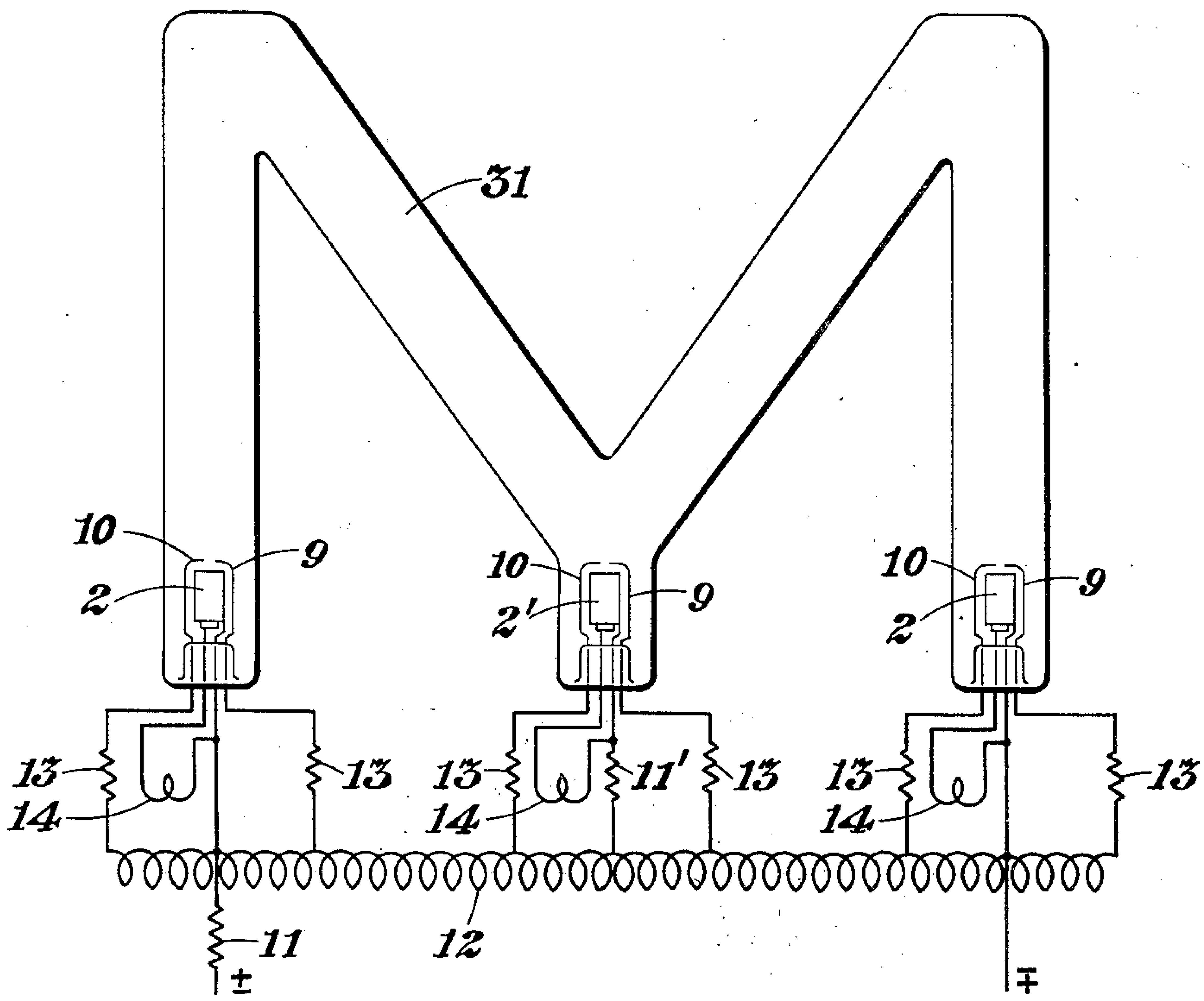

Fig. 4

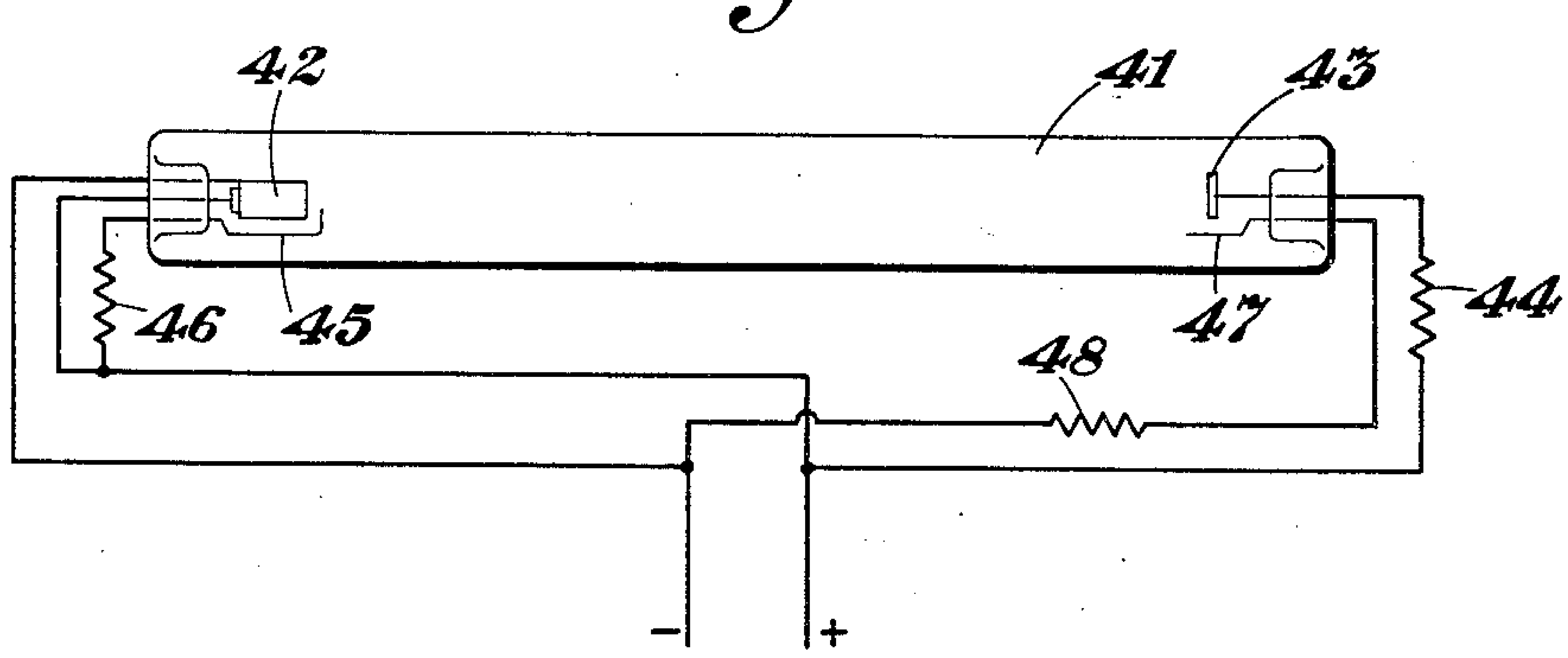

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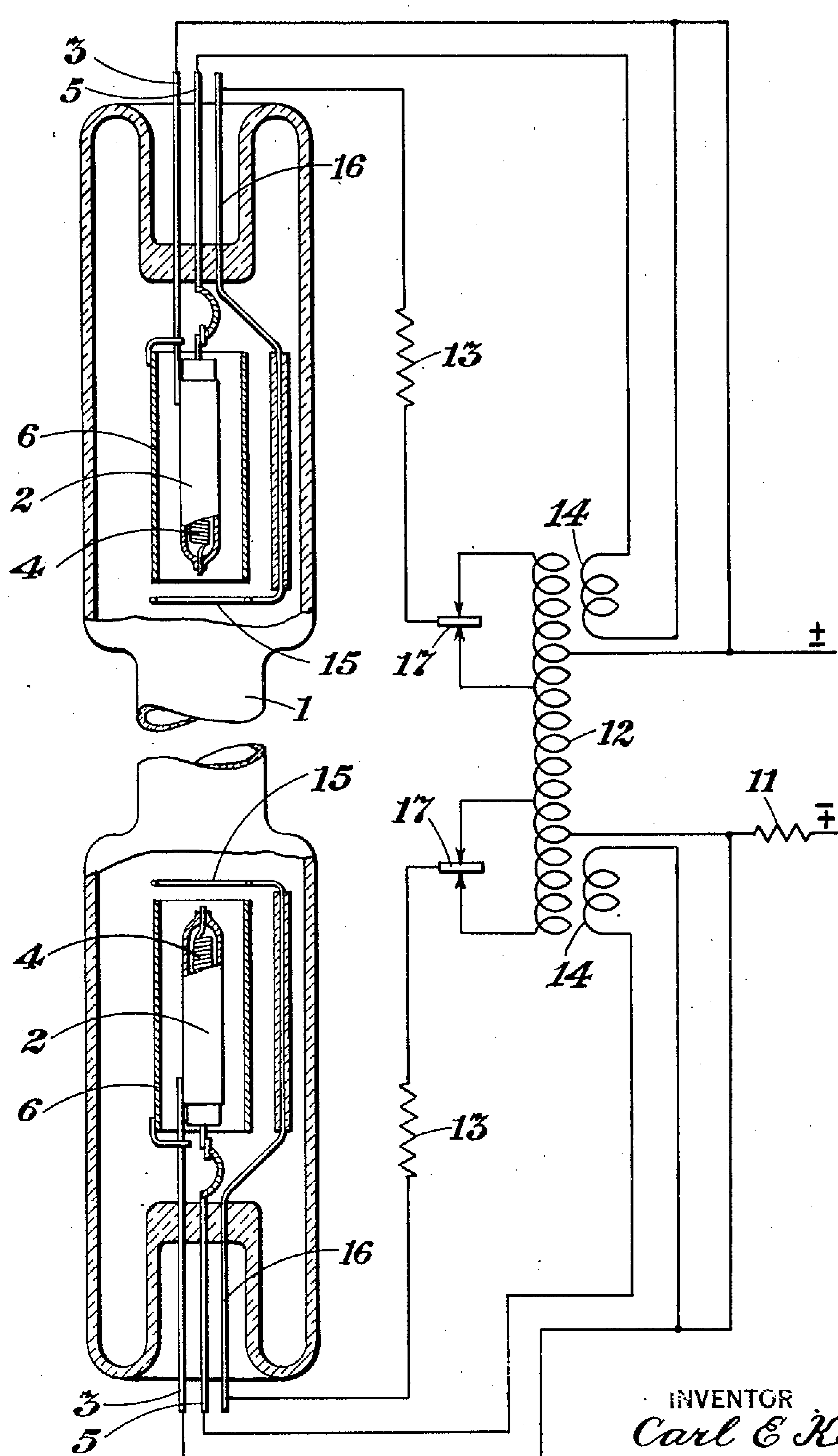
Fig. 5



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Patented Feb. 14, 1933 **1,897,482**

UNITED STATES PATENT OFFICE

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SELF-STARTING LOW VOLTAGE GASEOUS ELECTRIC DISCHARGE DEVICE AND METHOD OF OPERATING SAME

Application filed May 9, 1932. Serial No. 610,230.

The present invention relates to electric gaseous discharge devices generally, and more particularly to discharge devices operating with a long positive column discharge.

A particular object of the invention is to provide an electric gaseous discharge device having a long positive column through which a discharge may be initiated by the application of a potential of less than 110 volts D. C. between the electrodes. A further object of my invention is to provide a novel method of starting and operating an electric gaseous discharge device. Still other objects and advantages of the invention will appear from the following detailed description thereof, or from an inspection of the accompanying drawings.

The invention consists in a new and novel electric gaseous discharge device, and in a novel method of starting and operating gaseous discharge devices, as hereinafter set forth and claimed.

Electric gaseous discharge tubes in their normal unionized state offer a very considerable resistance to the passage of an electric discharge therethrough, it being necessary to ionize the gas or vapor before a normal positive column discharge can take place therethrough at low voltage. To attain this ionization it is obviously necessary to provide means for producing ions at a rate which exceeds the loss thereof through recombination with electrons in space and at the walls of the device. Among the various methods of accomplishing this which have been suggested heretofore, is the one disclosed in the co-pending application of Ted. E. Foulke, Serial No. 541,021, filed May 29, 1931. According to the method there disclosed an auxiliary discharge is produced at the cathode end of a tube within which there is a desired gas containing a trace of another gas whose ionizing potential is of substantially the same value as, or somewhat less than, a metastable potential of the main gas. The radiations from this auxiliary discharge passing down the tube excite atoms of the main gas throughout the length of the tube, and many of these excited atoms gain or lose enough energy as a result of collisions to place them in the metastable state. The excess energy possessed by these metastable atoms is in turn transmitted to atoms of the other gas upon collision therewith, producing ionization of the latter atoms. Thus ionization is produced throughout the length of the tube, permitting the initiation of the desired arc discharge at a relatively low potential. Since the radiations from this auxiliary discharge are gradually absorbed by the gas, however, the intensity thereof falls off toward the anode, with the result that there is a more or less definite limitation on the length of tube which may be started by this method with an economical expenditure of energy in the auxiliary discharge. Furthermore the gas of lower ionizing potential has been found to move away from the anode during operation of the device, so that there is also a scarcity of the needed gas of low ionizing potential at the point where the radiations are weak. This factor adversely affects the restarting of the discharge, such as is necessary, for example, each half cycle with a reversing alternating current discharge, and thus also limits the practical length of a discharge which can be started by this method. I have found that both of these limitations may be overcome by providing an auxiliary discharge simultaneously at both ends of the tube. This not only produces intense radiation at the anode end of the tube, where it is most needed, but also has the effect of shortening the gas column which must be ionized by the radiation by several tube diameters due to the diffusion of positive ions down the tube. This construction furthermore permits the starting of a discharge in bent tubes in which the radiations from the cathode can not reach the anode. On alternating current this construction is also of additional advantage since it increases the effective potential between the main electrodes and eliminates the grid action of the idle auxiliary anode in a manner which will be pointed out hereinafter. I also find it desirable to employ a relatively low voltage in these auxiliary discharges, because the sputtering, with its accompanying gas clean-up, is greatly reduced with low potentials; and because the initiation of the discharge can be more accurately delayed until the cathode has reached a predetermined temperature, preventing destruction of the cathode by the "hot spots" which are invariably produced if the main discharge is prematurely initiated. Since an autotransformer is usually required to produce the desired continuous auxiliary discharge at each end of the tube on alternating current this desired low potential is easily supplied. Thus the life of the device is materially increased as the result of my new invention while at the same time the maximum length of positive column discharge which can be initiated on a given voltage is also materially increased. The efficiency of these novel discharge devices is also extremely high, due to the increased length thereof for a given voltage.

For the purpose of illustrating my invention I have shown several embodiments thereof in the accompanying drawings, in which

Fig. 1 is an elevational view, in part section, of an electric discharge device designed for operation on alternating current with a full-wave, reversing discharge, together with a schematic diagram of the operating circuit therefor,

Fig. 2 is an elevational view of a modification of the device of Fig. 1, showing the application of my novel starting method to a U shaped lamp,

Fig. 3 is an elevational view of a further modification of the device of Fig. 1, together with a schematic diagram of the operating circuit therefor, showing the application of my invention to a lamp having a plurality of bends therein,

Fig. 4 is an elevational view of a direct current lamp embodying my invention, together with a schematic diagram of the operating circuit therefor, and

Fig. 5 is an elevational view of another modification of the device of Fig. 1, together with a schematic diagram of the operating circuit therefor.

In these drawings, with special reference to Fig. 1, there is shown a lamp having a sealed tubular envelope 1 of any suitable material. At each end of said envelope there is a thermionic cathode 2 of a well known type, each cathode being supported by an inlead 3 which is sealed through the adjacent end of said envelope 1. Each of said cathodes is preferably coated in a well known manner with a substance such as barium oxide, strontium oxide, or the like, or a mixture thereof, in order to increase the thermionic emission therefrom. Within each of said cathodes there is a heater 4, one end of each of said heaters being connected to its cathode while the other end thereof is connected to an inlead 5 which is sealed through the adjacent end of the envelope 1. Around each of said cathodes 2 there is preferably placed a tubular shield 6 of nickel or the like, said shields being supported by the cathode inleads 3. These shields perform a three-fold function. They conserve the heat of the cathodes 2; they confine the auxiliary discharge which will be hereinafter described in such a manner as to more efficiently direct the radiations therefrom along the envelope 1; and they increase the effective surface of the cathodes 2 and thus better adapt them to serve as anodes on alternate half cycles. Two additional inleads 7 and 8 are sealed into each end of said envelope 1 and extend past the shields 6 on opposite sides thereof, and then extend inwardly, terminating in the auxiliary anodes 9 and 10, respectively. Each of said inleads is preferably shielded from a discharge to a point near the end thereof, in order to concentrate the discharge therefrom.

Within said envelope 1 there is a gaseous atmosphere such as disclosed in the previously mentioned Foulke application. For example, in a neon lamp I preferably add a trace, of the order of 0.2%, of argon. The neon has a metastable potential of about 16.5 volts, while the ionizing potential of the argon is but 15.7 volts so that atoms of the latter are readily ionized upon collision with metastable atoms of the former. A relatively low pressure, of the order of 1–3 m.m. of mercury, is preferably employed, since this low pressure facilitates the initiation of the desired auxiliary discharge, enhances the production of ionization by the radiation, and increases the luminous efficiency of the discharge.

The cathode inleads 3 of this device are connected to opposite sides of a suitable alternating current line, of say 110 volts potential, through a ballast resistance 11, of the order of 10–15 ohms. An autotransformer 12 of the order of 100 watts capacity is likewise connected to said line through said resistance 11. Said autotransformer has two taps symmetrically arranged on either side of each line connection. Where the aforesaid neon atmosphere is employed these taps are arranged to give about 30 volts plus and minus with respect to each side of the line, although this voltage may be decreased somewhat if it is not essential that the discharge should be initiated early in each half cycle. This voltage moreover varies with the atmosphere employed, being higher, for example, with helium and lower with argon. The taps which are adjacent to one line connection are connected to the inleads 7 and 8 which are at the same end of the device as the cathode 2 to which that side of the line is connected, while the other pair of taps are similarly connected to the other inleads 7 and 8, a resistance 13 of the order of 75 ohms being included in each of said connections. Each of the auxiliary anodes 9 is thus positive with respect to the adjacent cathode 2 whenever the auxiliary anodes 10 are negative with respect thereto, and vice versa. Two low voltage secondaries 14 inductively associated with said autotransformer 12 each have their terminals connected between the cathode inleads 3 and the heater inleads 5 at opposite ends of the device, and serve to energize the heaters 4.

In the use and operation of this device, assuming the aforesaid neon-argon mixture to be employed, upon application of a suitable alternating current potential current immediately flows from each of the secondaries 14 through the associated heater 4, gradually raising the temperature of the cathodes 2. So long as the gas in the device is not ionized the applied potential is entirely insufficient to initiate the discharge between the cathodes 2, and the low potential applied between each of the auxiliary anodes 9 and 10 and the associated cathode 2 is likewise insufficient to initiate a discharge therebetween until the free electron emission from said cathodes has reached such a value that it will support the main discharge without the formation of hot spots. This latter feature, which is readily controlled by the size and spacing of the auxiliary anodes 9 and 10, as well as by the potential applied thereto, is of great importance since it protects the device from the evils attendant upon premature initiation of the main discharge, such as the sputtering of the cathode material, which is invariably accompanied by rapid clean-up of the gas, and by the ultimate destruction of the cathode. As soon as the emission from the cathodes 2 has reached the desired value a discharge takes place on a given half cycle from each of the auxiliary anodes 9 to the adjacent cathode 2, with a resultant ionization of the gas adjacent to said cathodes. Some of the positive ions from these discharges diffuse into each end of the tubular envelope 1, but the concentration of these diffused ions falls off rapidly with distance, as is well known, so that no practical use may be made thereof at a distance greater than a few tube diameters. The radiations produced by these discharges are characteristic of a discharge in pure neon, due to the low argon concentration, and hence are rich in the resonance lines of neon. While the core of these lines is absorbed within a very short distance by the neon, the fringes or edges thereof have been found to penetrate the gas for a considerable distance before they are absorbed. The neon atoms which absorb these radiations are put in an excited state thereby, this excited state being normally of short duration so that these atoms are relatively ineffective as ionizing bodies. An appreciable portion of the excited atoms, however, gain or lose enough energy through collisions to get into a metastable condition, the life of these metastable atoms being relatively long, so that there is plenty of opportunity for these atoms to collide with an argon atom. Upon such a collision the energy of the metastable atom is transferred, causing ionization of the argon atom. Thus ionization is produced throughout the length of the tube by the radiations of the auxiliary discharges, provided the radiations penetrate that far before absorption, and further provided that there is argon which may be ionized throughout the length of the tube. It is due to the latter conditions that my new structure and novel method of operation produce such startling results. By providing an auxiliary discharge at the anode end of the tube as well as at the cathode end, I provide a high intensity of radiation at the point where the radiations would otherwise be inadequate, due to the absorption thereof by the gas nearer the cathode. Thus this construction, for this reason alone, would markedly increase the length of column which can be started at a given voltage. But in addition to this my novel construction overcomes a difficulty due to the differential action of the discharge on the argon, it having been found that in any of these tubes having a mixture of gases the discharge tends to drive the gas of lower ionizing potential away from the anode. In a double ended tube with a reversing discharge, such as here illustrated, this causes a concentration of the gas of lower ionizing potential at the middle of the tube. As a result the region about each of the cathodes 2 of this device is virtually stripped of argon, making it exceedingly difficult to ionize the gas about each of these electrodes by radiations from the opposite end of the tube. With my novel construction the discharge at the acting anode end of the tube supplies ionization directly to this point by diffusion, and furthermore provides a wealth of radiation in the adjacent region where it is most needed, due to the attenuation of the argon.

Thus the use of simultaneous discharges at opposite ends of the tube overcomes a serious limitation in the method heretofore disclosed. There are other advantages gained by this construction however. The discharges from the auxiliary anode 9 at the acting anode end of the tube causes a sheath of positive ions to form about the adjacent inactive auxiliary anode 10, which otherwise has been found to act as a grid obstructing the initiation of the main discharge due to its negative potential with respect to the anode, this factor also facilitating the initiation of the main discharge. Furthermore this auxiliary discharge at the anode end of the device raises the potential of the gas column above that of the main electrode 2 when the latter is serving as an anode, and thus compensates for the voltage loss in the auxiliary discharge at the cathode end of the tube, leaving the full line potential available to initiate the discharge. And due to the relatively low voltage employed in these auxiliary discharges the sputtering of the various parts of the device by these discharges is virtually eliminated, with a great increase in the useful life of the device, due both to the decrease in envelope blackening and to the decrease in gas clean-up by the sputtered deposits. As a result of these various factors I have found it possible to initiate a positive column discharge an inch in diameter and approximately forty inches long on 110 volts, using the aforesaid neon-argon atmosphere, while the same tube without the additional auxiliary discharge at the acting anode end of the tube requires 240 volts to initiate the discharge therethrough. Of course, once the main discharge is initiated through the argon ions it immediately ionizes the neon, after which substantially all the energy is transmitted by the neon. Upon reversal of the alternating current source the auxiliary anodes 10 take up the burden of producing the auxiliary discharges in the same manner as described above, with an immediate reinitiation of the main discharge in the reverse direction through the envelope 1. A r. m. s. current of 250 milliampers is usually sufficient in the auxiliary discharge, this representing but a small percentage of the total energy supplied to the device. Moreover, the luminous efficiency of the device is increased by the use of a simultaneous auxiliary discharge at each end of the device, due to the fact that with the increased arc length which can be started on a given voltage the ratio of arc maintaining voltage to line voltage is increased, less energy thus being dissipated in the ballast resistances.

With this novel construction it is possible to initiate a discharge in a tube having a single bend therein, or even with a plurality of bends therein, such as shown in Fig. 2. The device shown in this figure is identical with that of Fig. 1, except that the tubular portion of the envelope 1 is bent into the form of a **U**. With this construction the radiations from each end of the tube penetrate to the nearest bend in said tube, ionizing the gas content of the straight portions of the tube in the same manner which has been described in connection with the lamp shown in Fig. 1. Some of the metastable atoms and positive ions produced by these radiations diffuse into the bottom of the **U** from each end thereof, and at the same time scattered and reflected resonance radiations from each of the auxiliary discharges also penetrate into this portion of the tube, producing additional ionization therein in the manner previously described, these two effects cooperating to produce the necessary ionization in this portion of the tube. As a result the positive column discharge is readily started in a lamp of this type on an extremely low potential which is but little in excess of that required for a straight tube of the same length. This construction is, therefore, extremely effective, especially where the transverse portion of the tube to be ionized by diffusion and by scattered and reflected resonance radiations is relatively short, as in the lamp illustrated in Fig. 2.

Where lamps having a more complicated shape, or an extremely long section transverse to the end portions thereof are desired I prefer to use the construction shown in Fig. 3. In this figure the long tubular envelope 31 has the form of a letter **M**, for example. At each end of said envelope there is an electrode assembly which is identical with the assembly shown at each end of the device of Fig. 1, while a third electrode assembly, which is identical with the others except that the cathode 2′ thereof need not have as large a current carrying capacity, is placed at the junction of the two middle arms of the **M**. The cathodes 2 at the ends of the envelope 31 are each connected to a suitable alternating current line, a ballast resistance 11 being included in one of said connections, while the cathode 2′ is connected to the mid-point of an autotransformer 12 which is likewise connected to said line through said resistance 11, a resistance 11′ of the order of 50 to 100 ohms being included in the connection between said autotransformer and said cathode. Each of the auxiliary anodes 9 is connected through a resistance 13, of the order of 70 ohms, to a tap on said autotransformer 12 which is approximately thirty volts higher, on a given half cycle, than the associated cathode 2 or 2′, while each of the auxiliary anodes 10 is connected through a similar resistance to a tap approximately 30 volts lower, on the same half cycle, than the associated cathode 2 or 2′. The heaters (not shown) of each of the cathodes 2 and 2′ are each connected to a suitable source of low voltage, such as the low voltage secondaries 14, in a manner identical with that described in connection with Fig. 1. The sealed envelope 31 contains a gaseous atmosphere such as described in connection with the device of Fig. 1.

In the use and operation of the device of Fig. 3 upon energization of the supply line current flows from the secondaries 14 through each of the cathode heaters, raising the temperature of the cathodes 2 and 2′. As soon as the free thermionic emission from the cathodes 2 is adequate to support the main arc discharge without the formation of a hot-spot thereon, the potential applied between either the auxiliary anodes 9 or the auxiliary anodes 10 (depending upon which is positive at that instant) and the cathodes 2 and 2′ causes a discharge of say 250 milliamperes to flow to each of said cathodes 2 and 2′. The radiations from these discharges penetrate every part of the tube through which the main discharge is to be initiated, ionizing the gaseous content in the manner hereinbefore described, with the result that the desired arc discharge is immediately initiated between the cathodes 2. On the next half cycle this procedure is repeated, the other set of auxiliary anodes then functioning to produce the desired auxiliary discharge, whereupon the main arc is reinitiated in the reverse direction. During maintenance of the discharge the cathode 2′ is obviously maintained at substantially space potential by its connections, and hence this electrode tends to draw but little current from the main discharge. This current is furthermore reduced to a very small value by the relatively large resistance 11′ which is connected in series with said cathode 2′. As a result it is obvious that the autotransformer 12 carries but little current, and hence may be of low capacity and relatively small. The capacity and size of this autotransformer may be still further reduced, if desired, by utilizing cathode heaters which may be operated directly on line voltage. Such heaters, which are commonly embedded in alundum or the like to prevent a discharge between different portions thereof, are well known and hence a further description thereof appears unnecessary.

As a result of the novel construction illustrated in Fig. 3 extremely long positive column discharges of any desired configuration may be initiated on 110 volts, or other desired voltage, with a resulting high efficiency in the utilization of the applied energy during operation. Moreover, this novel device has an unusually long useful life, due to the virtual elimination of sputtering from the inactive anodes.

My novel construction also offers many advantages in a discharge device which is operated on direct current, a preferred arrangement therefor being illustrated in Fig. 4. In this figure the sealed tubular envelope 41 of any suitable vitreous material has a thermionic cathode 42 at one end thereof, and an anode 43 at the opposite end thereof. Said cathode is connected directly to the negative side of a suitable direct current line, while said anode is connected to the positive side thereof through the ballast resistance 44. Said cathode contains a heater (not shown) of the high voltage type hereinbefore referred to, one end thereof being connected to said cathode 42, while the other end thereof is connected to the positive side of the line. An auxiliary anode 45 is located adjacent to the cathode 42, and is connected to the positive side of the line through a high resistance 46. An auxiliary cathode 47 which is located near the anode 43 is connected to the negative side of the line through a high resistance 48. This auxiliary cathode is preferably coated with an alkaline or alkaline earth metal, such as barium or strontium, or a compound thereof, in order to ensure breakdown between the anodes 43 and said auxiliary cathode at the applied potential. A thermionic cathode may be substituted therefor, however, in order to facilitate the initiation of the auxiliary discharge, if it is so desired. Within the sealed envelope 41 there is a gaseous atmosphere comprising a mixture of the main gas with a trace, of the order of 0.2% of another gas having an ionizing potential which is somewhat less than a metastable potential of the main gas, such as disclosed by Ted. E. Foulke in his co-pending application, previously identified. For example, for a red light source I prefer to use neon containing about 0.2% argon at a pressure of the order of 3–6 m. m. of mercury, the pressure being made high enough to facilitate the initiation of the auxiliary discharge from the anode 43.

In the use and operation of this device, upon application of a suitable potential, such as 110 volts D. C. a discharge immediately starts from the anode 43 to the auxiliary cathode 47, providing ionization and resonance radiations at the anode end of the envelope 41. These radiations produce additional ionization along said tubular envelope, but not enough to start the main discharge. The auxiliary anode 45 is so spaced from the cathode 42, however, that there is no appreciable discharge therebetween at this time. As the cathode 42 heats up its free electron emission increases, changing the voltage distribution thereabout until finally a discharge occurs thereto from the auxiliary anode 45. This discharge also produces ionization and resonance radiations, the latter indirectly ionizing the argon along the tubular envelope in the manner hereinbefore described. As a result of the ionization thus produced from both ends of the envelope the main arc discharge is initiated and continues so long as potential is applied to the device. During this operation of the main discharge the argon (or other gas of lower ionizing potential) is driven from the anode end of the envelope 41 and concentrated about the cathode 42. As a result if the discharge is stopped for any reason, as in a flashing sign, the reinitiation of the main positive column discharge is very largely dependent upon the auxiliary discharge at the anode 43 for the necessary ionization of the gas in proximity thereto, since due to the absence of argon at that point the radiations from the cathode are ineffectual to produce ionization near said anode. Thus the addition of the auxiliary cathode offers a distinct advantage, especially in a lamp which is to be frequently restarted, and permits a much longer discharge on a given voltage than would otherwise be possible.

While I have illustrated each of my alternating current lamps as having two auxiliary anodes at each end of the device a single auxiliary anode may be utilized, if desired, by a novel arrangement of my invention, as shown in Fig. 5. In this figure the discharge device is identical with that of Fig. 1, except that a single auxiliary anode 15 is substituted for the anodes 9 and 10 at each end of the device. Each anode 15 is in the form of a ring adjacent to the end of a cathode 2, and is supported by an inlead 16 which is sealed through the adjacent end of the envelope 1. Each of the inleads 16 is connected through a resistance 13 to the negative side of a full wave rectifier 17, while the positive leads of each of said rectifiers is connected to the taps on the autotransformer 12 which are on either side of the line connected to the cathode 2 at the same end of the device as the auxiliary anode 15 energized by said rectifiers.

With this novel construction the auxiliary anodes 15 are continuously maintained at a positive potential with respect to the associated cathode 2, thus performing the functions of both the anodes 9 and the anodes 10, the lamp being started and operated in the same manner as that of Fig. 1. An additional advantage is gained, however, due to the absolute elimination of the inactive anode, since not only is any remanent grid action thereby eliminated, but the sputtering of particles from the inactive anode is avoided, with an additional increase in the useful life of the device. Hence this construction is preferred in many cases, despite the slight increase in auxiliary apparatus. In this connection it may be noted that the rectifiers 17 are never traversed by any currents save those of the auxiliary discharge, and hence need to be of only a low current capacity. Dry rectifiers, such as the copper-copper oxide type, are entirely suitable for use in this circuit and are preferred since they require a minimum of attention. This novel construction is, of course, of great advantage in a discharge device containing a pure gas, as well as in those devices containing a mixture of gases, since the elimination of the grid action and of the sputtering is likewise accomplished in that case.

While I have described my invention by reference to certain specific examples thereof, it is to be understood that it is not limited thereto, but that various changes, omissions and substitutions, within the scope of the appended claims, may be made therein withous departing from the spirit thereof.

I claim as my invention:

1. In combination, an electric gaseous discharge device comprising a sealed envelope, a gaseous atmosphere within said envelope, said atmosphere comprising a major component and a minor component, a metastable potential of the major component being greater than the ionizing potential of the minor component, two main electrodes sealed into said envelope, and an auxiliary electrode adjacent to each of said main electrodes, and means to produce a simultaneous discharge between each of said auxiliary electrodes and the main electrode adjacent thereto to ionize the gas column between said main electrodes.

2. An electric gaseous discharge device comprising a sealed envelope, a gaseous atmosphere within said envelope, said atmosphere comprising a major component and a minor component, a metastable potential of the major component being greater than the ionizing potential of the minor component, two main electrodes sealed into said envelope, and two auxiliary electrodes adjacent to each of said main electrodes.

3. In combination, an electric gaseous discharge device comprising a sealed envelope containing a gaseous atmosphere, two main electrodes sealed into said envelope, and an auxiliary anode adjacent to each of said main electrodes, means to connect said main electrodes to a source of alternating current, and means including a full-wave rectifier to continuously effectively connect each of said auxiliary electrodes to a point on said source of higher potential than that applied to the adjacent electrode.

4. In combination, an electric gaseous discharge device comprising a sealed envelope containing a gaseous atmosphere comprising a major component and a minor component, a metastable potential of said major component being greater than the ionizing potential of the minor component, two main electrodes sealed into said envelope, and an auxiliary anode adjacent to each of said main electrodes, means to connect said main electrodes to a source of alternating current, and means including a full-wave rectifier to continuously effectively connect each of said auxiliary electrodes to a point on said source of higher potential than that applied to the adjacent electrode.

5. The method of starting and operating an electric gaseous discharge device having a desired gaseous atmosphere containing a trace of a gas having an ionizing potential which is lower than a metastable potential of said gaseous atmosphere which comprises creating simultaneous localized discharges adjacent to two widely separated main electrodes, utilizing radiations from said discharges to produce ionization throughout the gas column between said main electrodes, and applying the normal operating potential between said main electrodes to initiate the main discharge therebetween through said ionized gas.

6. The method of starting and operating an electric gaseous discharge device having two main electrodes and an auxiliary elec-

trode adjacent to each of said main electrodes on alternating current which comprises applying the normal operating potential between said main electrodes, maintaining each of said auxiliary electrodes sufficiently positive with respect to the adjacent main electrode to produce a full-wave uni-directional discharge therebetween, and availing of said discharge to ionize the gas column between said main electrodes to permit initiation of the main discharge therebetween at the normally applied potential.

Signed at Hoboken in the county of Hudson and State of New Jersey this 6th day of May, A. D. 1932.

CARL ERIC KENTY.