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G. E. INMAN

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ELECTRIC DISCHARGE DEVICE AND METHOD OF STARTING

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Fig. 3.

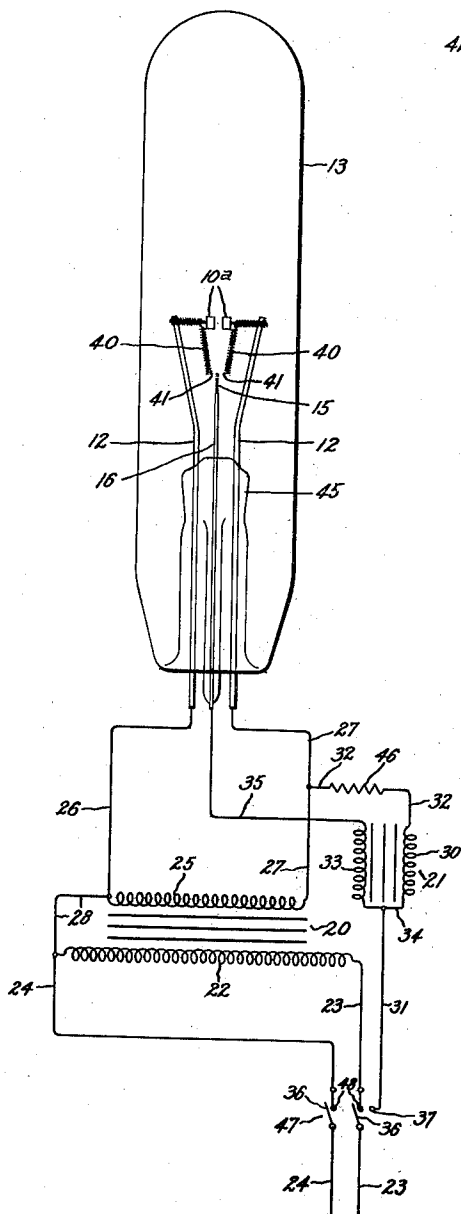


Fig. 2.

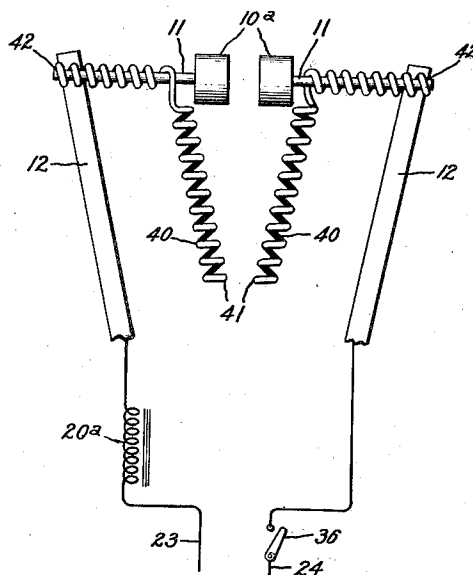
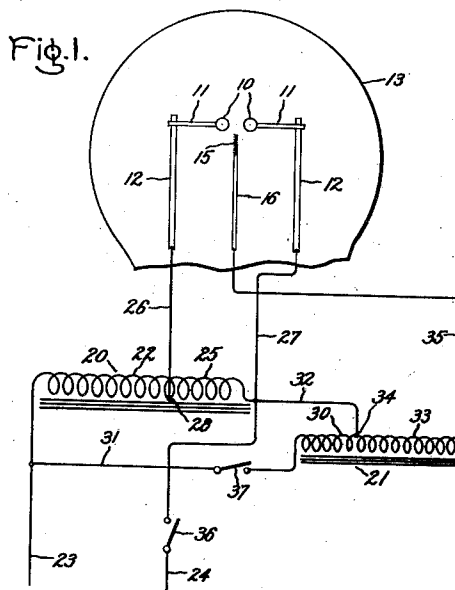


Fig.1.



Inventor:
George E. Inman,
by *Harry E. Dunham*
His Attorney.

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ELECTRIC DISCHARGE DEVICE AND
METHOD OF STARTINGGeorge E. Inman, East Cleveland, Ohio, assignor
to General Electric Company, a corporation of
New York

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My invention relates to electric discharge devices such as arc lamps, and especially to the starting of such devices without any mechanical provisions for drawing an arc. The invention is particularly applicable to enclosed alternating current devices having solid electrodes heated by the arc, and to devices in which relatively heavy currents and correspondingly massive electrodes are employed, although it is not necessarily so limited. It is applicable to metal-vapor arc lamps, as well as to the gas-filled types of lamp here illustrated and described.

In the case of electric discharge devices containing quite appreciable gas pressures (as contrasted with those containing such very low pressures as must be expressed in a few mm.), starting the arc is a matter of some difficulty, unless provisions are made for preheating an electrode to render it electron-emissive, or unless a highly heated tungsten or other filament is provided to supply electrons in the electrode gap. Both of these expedients are either wasteful of energy or otherwise undesirable in many cases. The use of very high starting voltages between the electrodes to initiate the arc has been proposed but this has the disadvantage that a transformer capable of giving the necessary high starting voltage is very inefficient for the relatively moderate or low voltages suitable for regular operation, after the arc has been established. The use of a special starting electrode located in the main electrode gap, so close to one of the main electrodes as to start an auxiliary arc on a moderately increased voltage, has also been proposed, but has not proved wholly satisfactory.

I aim to provide for starting the arc easily, quickly, reliably, and with comparatively simple and inexpensive equipment. For this purpose, I may use a special starting electrode in a novel way or I may provide easy-starting auxiliary electrodes, so associated with more massive main electrodes that an initial auxiliary arc, itself easily started, heats the main electrodes and renders them electron-emissive, thus permitting easy establishment of the main arc,—whereafter the auxiliary electrodes need not remain in action or consume current. Such auxiliary electrodes may be connected to the main electrodes or their current leads, or may be connected to some other source of current affording a potential suitable for initiating an arc in an atmosphere ionized by electrons, and afterward maintaining the arc, such, for example, as about 30 volts on open circuit, before the arc starts, and about 10 volts on closed circuit after the arc starts. Or, again, my starting electrode arrangement may be combined with the auxiliary electrode arrangement. Other features and advantages of the invention will appear from the following description of species thereof, and from the drawing.

In the drawing, Fig. 1 is a diagram of an arc lamp embodying my invention in very simple form, with its current supply arrangements; Fig. 2 is a fragmentary side view of main and auxiliary electrodes for another form of my device, the enclosing bulb being omitted, and different current supply arrangements being shown; and Fig. 3 is a side view of yet another form of my arc lamp, with a diagram of its current supply arrangements.

Fig. 1 shows a lamp or the like comprising electrodes 10, 10 mounted on aligned support wires 11, 11, which also serve as current leads and are in turn attached to current supply conductors or leads 12, 12. These parts are all enclosed in a glass bulb or envelope 13. The lead wires 12, 12 may be sealed through a stem-press (not shown) as usual in incandescent lamps, and as illustrated in Fig. 3 and referred to herein-after. The bulb or envelope 13 preferably contains an atmosphere of easily ionized gas such as argon, at an (absolute) pressure when cold of about 600 mm. of mercury. The electrodes 10, 10 here shown are spheres (of tungsten, for example) considerably more massive than the wires 11, 11. A relatively high gas pressure such as 600 mm. is desirable in the bulb 13 to minimize evaporation of the electrodes 10, 10.

With the electrodes 10, 10 is associated a separate starting electrode 15 (also of tungsten, for example) mounted on the upper end of a current supply conductor or lead 16 which may also be sealed through the stem-press (not shown.) The starting electrode 15 is preferably very slight in cross-section or metal as compared with the main electrodes 10, 10. It is here shown as consisting of a helical coil of a number of turns of fine (tungsten) wire of decidedly finer gauge, even, than the electrode wires 11, 11. Its distance from either electrode 10, 10 is only about half the gap between the latter. Preferably, its active upper end is substantially in the gap between the electrodes 10, 10 but a little below the direct line between them.

When a relatively moderate difference of potential equal to (or reasonably exceeding) the operating voltage is maintained between the main electrodes 10, 10, the basis and phenomena of starting with the starting electrode 15 are essentially as follows:

The gap between starting electrode 15 and either electrode 10, 10 being only half that between the electrodes 10, 10 themselves, it is obviously easier to initiate a discharge to this starting electrode, by a suitable difference of potential created between electrode 15 and one of the electrodes 10, 10, than to initiate a discharge directly between the latter. Furthermore, the conduction of heat away from the minute point of incidence of the slight initial discharge is very

much more rapid in the mass of the electrode 10 than in the slight cross-section of the electrode 15; so that an initial discharge which is powerless to heat electrode 10 appreciably will readily heat the small active end of electrode 15 to a temperature of electron emission, thus multiplying the initial discharge many-fold. By such augmented discharge, electrode 15 is heated still more, and the discharge is thus further augmented, until it begins to heat up the electrode 10 with which it is coacting. This will provide a supply of electrons in the longer gap sufficient to initiate the main discharge, between the electrodes 10, 10, which will then be self-sustaining and grow very quickly to its full value corresponding to the operating voltage maintained between electrodes 10, 10.

With main electrodes 10, 10 arranged and operating as just set forth in connection with Fig. 1, the starting voltage required is high. A transformer capable of giving it cannot operate efficiently for the much lower voltage normally required for the main arc at 10, 10. I have found, however, that with the starting electrode 15 this difficulty can be overcome by special provisions to supply high starting voltage across the gap between electrodes 10 and 15 temporarily, during the starting period, while the much lower operating voltage for the main arc between electrodes 10, 10 is otherwise supplied. Thus if a transformer 20 is used for the main arc, it can be designed entirely with a view to efficiency when giving the low operating voltage, because it will never be required to give a high starting voltage; while if a special or separate transformer 21 is used to give a high voltage for the starting or auxiliary arc to electrode 15, its inefficiency for the much lower operating voltage is unimportant, because it need not continue in operation after the main arc at 10, 10 has started.

One such arrangement is illustrated in Fig. 1, where a (step-down) auto-transformer 20 is shown with its primary 22 connected across the main current supply or primary circuit 23, 24, and with its secondary 25 connected in a circuit 26, 27, across the main gap between electrodes 10, 10. As usual for auto-transformers, the primary 22 and secondary 25 are interconnected at 28, and are there also both connected to the side 26 of the secondary circuit. The other (step-up) auto-transformer 21 is shown with its primary 30 connected in a supply or primary circuit 31, 32 across the primary and secondary leads 23 and 24, so that the circuit 31, 32 includes the primary 22 and secondary 25 of transformer 20. The primary 30 and secondary 33 of transformer 21 are interconnected at 34, where they are also both connected to the lead 32, which is common to the primary and secondary circuits of transformer 21. The secondary 33 is connected in a secondary circuit 32—27 and 35 across the starting gap between electrodes 10 and 15. A switch 36 is shown in one lead (24) of the supply circuit 23, 24, and a switch 37 (preferably of a self-opening push-button type) in one lead (31) of primary circuit 31, 32.

The transformers 20 and 21 may be so designed that if the supply voltage across circuit 23, 24 is the ordinary lighting voltage of 115 volts, for example the open-circuit voltage across secondary circuit 26, 27 and main electrode gap 10, 10 may be 30 volts, and the closed circuit voltage 10 volts. On this basis, the voltage across primary circuit 31, 32 will be 115 volts and that across secondary circuit 27—32, 35 and starting gap 10, 15 may be

about 600 volts,—under the open circuit conditions before either arc starts, that is. Such a potential difference of 600 volts is ample to start an arc in argon of some 600 mm. pressure, under the conditions here involved, between the electrodes 10, 15; and after this has happened, the open-circuit potential difference of 30 volts is ample to bring about an arc between the electrodes 10, 10. All that is required is first to close switch 36, then to close switch 37 and hold it closed until the auxiliary and main arcs are observed to have started, and then to release switch 37 and allow it to open.

Fig. 2 shows relatively massive (tungsten) main electrodes 10a, 10a, with their support wires 11, 11 and current leads 12, 12, intended to be used in a bulb or envelope (not shown) similar to that of Figs. 1 or 3. Instead of a starting electrode like that of Fig. 1, there are auxiliary electrodes 40, 40 associated with the main electrodes 10a, 10a, and in heating proximity to them, but extending thence (laterally and convergently downward) away from them to a relatively remote starting gap formed by their portions that are closest together,—which in the present instance are their very ends 41, 41. For convenience, the auxiliary electrodes 40, 40 are preferably connected to the current supply leads of the main electrodes 10a, 10a, to take current from the same source and be subject to the same difference of potential, although this is not absolutely essential. The auxiliary gap at 41, 41 may about correspond in magnitude to that between starting electrode 15 and its coacting main electrode 10 in Fig. 1. The auxiliary electrodes 40, 40 are made much slighter in cross-section of metal than the main electrodes 10a, 10a so as to be much more easily heated by an initial discharge between them; and as here shown, they consist of helices of a considerable number of turns of (tungsten) wire. From the auxiliary gap 41, 41, the electrode wires 40, 40 extend divergently upward to the support and lead wires 11, 11 behind the heads or masses of the electrodes 10a, 10a, and then coil around the lead wires outward to the leads 12, 12, to which said wires 40, 40 are welded (or otherwise electrically connected) at 42, 42. The wrapping of the electrode wires 40, 40 around the supports 11, 11 relieves the relatively brittle welded portions at 42, 42 of mechanical stress and protects the wires 40, 40 from risk of breakage close to the welds.

When a sufficient difference of potential is created between the main and auxiliary electrodes 10a, 10a and 40, 40, a discharge will start across the auxiliary gap between their ends 41, 41, heating the latter to electron-emissive temperature. The resultant arc will tend to work upward along the auxiliary electrodes 40, 40 toward the main electrodes 10a, 10a, because the rise of the arc cuts out more and more of the electrode-circuit resistance represented by the length of the coiled electrode wires 40, 40, and under the influence of the convection currents which the heat causes in the surrounding gaseous atmosphere in the bulb. As the arc creeps upward, it heats the electrode wires 40, 40 closer and closer to the main electrodes 10a, 10a, until it provides an ionized atmosphere between these electrodes, establishes itself between them, and finally heats these main electrodes to emissive temperature. As soon as this happens,—or, indeed, as soon as the arc starts to creep up the auxiliary electrodes 40, 40,—the voltage between the electrodes 10a, 10a may be very greatly reduced, to a final normal operating value of about 10 volts, for instance.

In Fig. 2, the lamp is shown with its leads 12, 12 and electrodes 10a, 10a connected directly across the supply circuit 23, 24, and with a choke 20a in one lead 23 to limit the voltage and current across the electrode gap after the arc has been initiated. A switch 36 is also shown in one lead 24, as in Fig. 1. With an atmosphere of very pure argon of about 5 mm. pressure in the lamp bulb (not shown), and an auxiliary electrode gap 41, 41 of about $\frac{1}{8}$ to $\frac{1}{4}$ inch, the arc across this gap 41, 41 will start on a supply circuit voltage of about 220 to 250 volts, more or less. If a highly emissive coating (such as barium oxide) is used on the electrodes, the starting voltage is much less. In any case the current required at the higher voltages to obtain the arc across the main electrodes is much less than if the two auxiliary electrodes are not present.

In the lamp shown in Fig. 3, the starting electrode 15 of Fig. 1 is shown combined with the main and auxiliary electrodes 10a, 10a and 40, 40 of Fig. 2. The operation in starting represents a combination of what has been described in connection with Figs. 1 and 2: i. e., an auxiliary or "starting" arc is first started between one of the coiled electrode wires 40 and the much finer coiled wire of the starting electrode 15. The main arc is thus started between the ends 41, 41 of the electrode coils 40, 40 themselves, as in Fig. 1, and then this arc creeps up the auxiliary electrodes 40, 40 and establishes itself between the main electrodes 10a, 10a, as just described in connection with Fig. 2. The stem press 45 through which the current leads 12, 12, and 16 are sealed is here shown. In this lamp, a gas pressure of argon around 600 mm. in the bulb 13 will not interfere with starting of the arc by a voltage of 600 volts between electrodes 15 and 10. The current supply arrangements and connections are equivalent to those shown in Fig. 1. These and other parts and features similar to those shown in Figs. 1 and 2 are marked with the same reference characters, as a means of dispensing with repetitive description. However, in this case the line voltage of 115 volts is applied across the primary 22 of transformer 20 so that with an open circuit voltage of 30 volts across the secondary 25, the voltage across the primary 30 of transformer 21 will be 145 volts, instead of 115 volts as in Fig. 1 where the line voltage is applied across the whole transformer 20. It may be observed that in Fig. 3 a resistance 46 is shown in the primary lead 32, in series with the primary 30 of transformer 21. By absorbing part of the high voltage across the primary circuit 31, 32, the resistance 46 allows of using a smaller transformer 21, with fewer primary turns. Also, a unitary switch device 47 is diagrammatically indicated, which combines the switch 37 of Fig. 1 with duplicate switches 36, 36 that make and break both sides 23 and 24 of the supply circuit. The contacts 48, 48 of switches 36, 36 are resiliently yielding, to permit one of them to be forced over into contact with the stationary contact which is the only special part required for the switch 37. Commercial rotary switch devices suitable for the purpose are also available, in which the first snap-turn closes both switches 36, 36, the second also closes switch 37, the third opens switch 37 again, and the fourth opens both switches 36, 36.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An enclosed electric arc discharge device

comprising a pair of relatively massive coating main electrodes or cathodes; a pair of much slighter auxiliary electrodes or cathodes associated with and in heating proximity to corresponding main electrodes and extending away from them to a relatively remote starting gap, where said auxiliary electrodes are closest together; and a separate starting electrode located at an intermediate point just below the starting gap between said auxiliary electrodes, and very much slighter in cross-section than the latter.

2. The combination of an enclosed electric arc discharge device comprising a pair of coating electrodes or cathodes, and a separate starting electrode at an intermediate point substantially in the gap between said first-mentioned electrodes; means including a step-down transformer for deriving from a circuit of ordinary lighting voltage a lower voltage for operation of an arc between said first-mentioned electrodes; and means including a step-up transformer for temporarily deriving from such a circuit of ordinary lighting voltage a higher voltage for initiating or starting an arc between one of said first-mentioned electrodes and said starting electrode.

3. The combination of an enclosed electric arc discharge device comprising a pair of relatively massive coating main electrodes or cathodes; a pair of much slighter auxiliary electrodes or cathodes associated with and in heating proximity to corresponding main electrodes, and extending away from them to a relatively remote starting gap, where said auxiliary electrodes are closest together; a separate starting electrode at an intermediate point substantially in the starting gap between said auxiliary electrodes; means for maintaining a relatively moderate difference of potential between said main electrodes, and between their associated auxiliary electrodes; and means for temporarily creating a much higher difference of potential between one of said auxiliary electrodes and said starting electrode, and for subsequently doing away with said higher difference of potential, while said moderate difference of potential continues.

4. The method of starting an enclosed electric arc discharge device comprising a pair of relatively massive coating main electrodes or cathodes, a pair of much slighter auxiliary electrodes or cathodes associated with and in heating proximity to corresponding main electrodes and extending away from them to a relatively remote starting gap where said auxiliary electrodes are closest together, and a separate starting electrode at an intermediate point substantially in the starting gap between said auxiliary electrodes, said method consisting in maintaining a relatively moderate difference of potential between said main and auxiliary electrodes, temporarily creating a much higher difference of potential between said starting electrode and one of said auxiliary electrodes until an auxiliary arc thereby started between said starting electrode and auxiliary electrode heats the latter and thus enables an arc to start between the two auxiliary electrodes under the moderate difference of potential between them, and allowing the arc thus started between the auxiliary electrodes to travel along the latter, as it heats them, toward the main electrodes until it also heats the latter and brings about an arc between them under their moderate difference of potential.

GEORGE E. INMAN.