# PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

## Improvements in or relating to Low-Pressure Electric Discharge Lamps

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British Company, and HENRY GRAINGER JENKINS and EDWARD ERNEST MILES, both of Research Laboratories of The General Electric Company Limited, Wembley, Middlesex, both British Subjects, do hereby declare the nature of this invention to be as follows:—

This invention relates to electric discharge lamps of the type having a gas and/or vapour filling at a pressure much less than atmospheric but such that in operation the discharge path, or each discharge path if there is more than one, is occupied mainly by the positive column; the invention is applicable both to hot-cathode and to cold-cathode lamps of this type.

The invention relates more particularly, but not exclusively, to lamps of the type specified comprising luminescent material adapted to be excited to luminescence by the discharge; such lamps are usually known as low-pressure fluorescent lamps and the filling used with them is usually mercury vapour admixed with a few millimetres pressure of a rare gas such as argon.

For obtaining high efficiencies and high lumen output lamps of the type specified are usually arranged to have discharge paths of considerable length, often several feet, and for convenience in mass production the envelopes of the lamps at present generally consist mainly of straight lengths of glass tubing. But long straight discharge lamps have several practical disadvantages; thus they are often inconveniently long for handling purposes and are difficult to deal with in fittings, such as for street lighting, owing to the large size of fitting required. Furthermore since the electrodes are situated at opposite ends of the tube, a long straight tube will require two widely separated external contacts or caps which may need to be very accurately spaced apart to enable the lamp to fit into a housing with pre-set sockets for the supply of electrical power to the lamp.

One method of avoiding the difficulty is to use a number of shorter lamps in place of one long lamp, but this entails the provision of an increased number of sockets in the fitting and multiplication of auxiliary apparatus, which is often inconvenient.

It has therefore been proposed to construct compact lamps in which the discharge path is non-linear and the effective length of the lamp is considerably less than the total length of the discharge path; one method of achieving this is to bend the tubular envelope of the lamp into a curved shape such as a spiral or zig-zag, but such methods do not lend themselves readily to mass production as such tube bending in general requires manipulation by skilled craftsmen or complicated machinery.

Other proposals have also been made for producing compact discharge lamps without requiring the bending of glass tubing; thus it has been proposed to form a tortuous channel for the passage of the discharge by the abutment of two initially separate glass components one or both of which is or are provided with one or more upstanding ridges which separate adjacent parts of the discharge passage; it has also been proposed to form a tortuous discharge channel by pressing in suitable parts of the sides of a flat lozenge-shaped bulb.

The object of this invention is to provide an alternative form of compact low-pressure electric discharge lamp which is well suited to mass production methods.

According to the invention an electric discharge lamp of the type specified comprises an hermetically sealed light-transmissive envelope containing the filling of gas and/or vapour and within which are supported two or more sub-

stantially straight lengths of glass tubing, hereinafter referred to as tubes, each closed at one end, open at the other end, and having an electrode mounted within the tube at the closed end of the tube, the tubes being arranged with their closed ends all near one end of the said envelope and their open ends all near to or directed towards the opposite end of the envelope, and wherein leads to the said electrodes, and possibly also to one or more other electrodes which may be mounted within the envelope near the said opposite end thereof, pass to the exterior of the envelope, the arrangement being such that the lamp is adapted to be operated with a discharge passing along the length of each tube between the electrode at the closed end of the tube and another electrode, which other electrode may itself be one of the electrodes at the closed end of a tube.

Preferably the hermetically sealed envelope is a tubular glass bulb closed at one end by the sealing in of a closure member, for example a pinched foot tube, and the glass tubes are mounted with their closed ends near to the closure member and with the leads to the tube electrodes, i.e. the electrodes mounted within the tubes at the closed ends, passing through the closure member or its seal with the envelope.

The closing of the ends of the glass tubes need not necessarily be completely gas tight and need only be sufficient to prevent short-cutting of the discharges between the closed ends of the tubes. It is found with the arrangement in accordance with the invention that when one tube electrode is adapted to co-operate with another, the discharge still takes the longer **U**-shaped path including the lengths of the tubes instead of taking the much shorter path between the leads to these electrodes, even without completely gas tight sealing of the closed ends of the tubes. This somewhat surprising feature enables the leads to the electrodes to be sealed, for example, through a pinch in a glass foot-tube of conventional type which can readily be sealed to the main part of the envelope of the lamp in accordance with well known techniques, thereby simplifying production.

The inner wall of one or more of the glass tubes may be coated with luminescent material adapted to be excited to luminescence by the discharge, and combinations of colours may be obtained by the use in different tubes of different luminescent materials and/or by the omission of luminescent material from one or more of the tubes. If the filling comprises mercury vapour, preferably each tube is coated with luminescent material.

The said sealed envelope and/or the outer envelope of the lamp if the said sealed envelope is not itself the outer envelope, may if required be rendered translucent for mixing and diffusing the light from the individual glass tubes and/or improving the appearance of the lamp by obscuring the details of the internal structure.

If, as is preferred, each electrode is of the hot-cathode type, each pair of electrodes between which a discharge is required to pass in operation may be associated for starting purposes with a starting switch, which may be of the conventional thermally operated type i.e. glow type or coil-heated type, and may sometimes be included within the said sealed envelope to reduce the number of leads passing to the exterior thereof. In some cases the same starting switch may be associated simultaneously with two or more pairs of electrodes; thus, for example, when two tube electrodes both co-operate with a third electrode, leads from the said two electrodes may be connected together and the connection joined through a single lead to the third electrode; a starting switch placed in the said single lead will then serve to start both discharges.

As already indicated, the electrodes within the envelope may all be tube electrodes so that the lamp is adapted to produce one or more substantially **U**-shaped discharges. When two or more tube electrodes both co-operate with the same third tube electrode, the corresponding **U**-shaped discharges will be in parallel and will have one limb in common; this arrangement has the advantage that the loss of power owing to cathode fall is reduced as compared with the case when each discharge terminates on separate electrodes, since the sum of the separate cathode falls is reduced.

The same advantage is obtained in the case where two or more tube electrodes both co-operate with a further electrode mounted at the end of the envelope near the open end of the tubes so that the lamp is adapted to carry two or more substantially straight discharges in parallel. It may be noted that a further advantage of the arrangement having two or more discharges in parallel, as compared with a lamp having a single straight discharge path of the equivalent length, is that it is adapted to operate at only a fraction of the voltage required for the longer lamp.

In order that a lamp in accordance

with the invention may run stably with each glass tube carrying the required discharge current i.e. so as to avoid concentration of the discharge in one or more tubes to the exclusion of another or others, it may be necessary to associate each electrode with the appropriate stabilising impedance, but the necessary arrangement for any particular case will be obvious to those skilled in the art.

In one embodiment of the invention, described by way of example, the envelope of the lamp consists of a tubular glass bulb about 12 inches long and 3 inches in diameter, which is closed by the sealing into an originally open end of a foot-tube terminated by a pinch; within the envelope is a bundle of four glass tubes each about 9 inches long and 1 inch in diameter; each of the glass tubes is closed at the end near the envelope foot-tube by the sealing into the glass tube of a small foot-tube terminated by a pinch on which is mounted an electrode consisting of a tungsten helix coated with thermionically emissive material; leads to the tungsten helix pass through the corresponding small foot-tubes and thence through a mica baffle disc, which extends over substantially the whole of the cross-section of the envelope, to the envelope foot-tube through the pinch of which the leads pass to terminals carried by a cap fitted over the end of the envelope.

The bundle of glass tubes is held together and supported from the wall of the envelope by thin wire spring rings which abut against the inner wall of the envelope.

Each of the glass tubes has its inner wall coated with a luminescent material excitable by the low-pressure mercury vapour discharge, and the filling within the envelope of the lamp consists of mercury vapour together with a few millimetres pressure of argon.

In operation of this lamp a stabilising choke should be included in the lead to each electrode and the inductances of these chokes should preferably all be the same; the two chokes which co-operate with the same discharge column may conveniently be wound on the same core.

Dated the 20th day of December, 1946.

For the Applicants:
A. F. CORNOCK,
Chartered Patent Agent.

COMPLETE SPECIFICATION

## Improvements in or relating to Low-Pressure Electric Discharge Lamps

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British Company, and HENRY GRAINGER JENKINS and EDWARD ERNEST MILES, both of Research Laboratories of The General Electric Company Limited, Wembley, Middlesex, both British Subjects, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to positive column electric discharge lamps of the hot-cathode type, i.e. to electric discharge lamps having a gas and/or vapour filling at a pressure much less than atmospheric but such that in operation the discharge path, or each discharge path if there is more than one, is occupied mainly by the positive column, and in which each electrode that is adapted to act as cathode in operation, either continuously for D.C. operation, or intermittently for A.C. operation, is an activated cathode of the pre-heated type i.e. is activated with electron emissive material and is adapted to be heated prior to the starting of the discharge.

The invention relates more particularly, but not exclusively, to lamps of the type specified comprising luminescent material adapted to be excited to luminescence by the discharge; such lamps are usually known as low-pressure fluorescent lamps and the filling used with them is usually mercury vapour admixed with a few millimetres pressure of a rare gas such as argon.

For obtaining high efficiencies and high lumen output lamps of the type specified are usually arranged to have discharge paths of considerable length, often several feet, and for convenience in mass production the envelopes of the lamps at present generally consist mainly of straight lengths of glass tubing. But long straight discharge lamps have several practical disadvantages; thus they are often inconveniently long for handling purposes and are difficult to deal with in fittings, such as for street lighting, owing to the large size of fitting required. Furthermore since the electrodes are situated at opposite ends of the tube, a long straight tube will require two widely separated external contacts or caps which may need to be very accurately spaced apart to enable the lamp to fit into a housing with pre-set sockets for the supply of electrical power to the lamp.

One method of avoiding the difficulty is to use a number of shorter lamps in place of one long lamp, but this entails the provision of an increased number of sockets in the fitting and multiplication of auxiliary apparatus, which is often inconvenient.

It has therefore been proposed to construct compact lamps in which the discharge path is non-linear and the longest dimensions of the lamp is considerably less than the total length of the discharge path; one method of achieving this is to bend the tubular envelope of the lamp into a curved ~~space~~ shape such as a spiral or zig-zag, but such methods do not lend themselves readily to mass production as such tube bending in general requires manipulation by skilled craftsmen or complicated machinery.

Other proposals have also been made for producing compact discharge lamps without requiring the bending of glass tubing; thus it has been proposed, for example in British Specification No. 465,135 and U.S. Specification No. 2,255,431, to form a tortuous channel for the passage of the discharge by the abutment of two initially separate glass components one or both of which is or are provided with one or more upstanding ridges which separate adjacent parts of the discharge passage; it has also been proposed, for example in U.S. Specification No. 1,984,215, to form a tortuous discharge channel by pressing-in suitable parts of the sides of a flat lozenge-shaped bulb.

The object of this invention is to provide an alternative form of compact low-pressure electric discharge lamp which is well suited to mass production methods.

According to the invention an electric discharge lamp of the type specified comprises an hermetically sealed light transmissive envelope containing the filling of gas and/or vapour and within which are supported a plurality of substantially straight glass tubes each closed at one end, open at the other end, and having an electrode mounted within the tube at the closed end of the tube, the tubes being arranged with their closed ends all near one end of the said envelope and their open ends all near the opposite end of the envelope, and wherein leads for supplying the said electrodes, and possibly also one or more other electrodes which may be mounted within the envelope near the said opposite end thereof, pass to the exterior of the envelope, the arrangement being such that the lamp is adapted to be operated with a discharge passing along the length of each said glass tube.

Preferably each electrode at the closed end of a said glass tube is an activated cathode of the pre-heated type; then for D.C. operation one or more anodes must be provided near the open ends of the glass tubes; for A.C. operation each such anode may be replaced by another activated cathode of the pre-heated type, but in some cases electrodes at the open ends of the glass tubes may be omitted altogether, so that the electrodes at the closed ends of the glass tubes are the only electrodes within the envelope. For convenience the electrodes at the closed ends of the glass tubes will hereinafter be referred to as the tube-electrodes.

Preferably the hermetically sealed envelope is a tubular glass bulb closed at one end by the sealing-in of a closure member, for example a pinched foot tube, and the glass tubes are mounted with their closed ends near to the closure member and with the leads to the tube-electrodes passing through the closure member or its seal with the envelope.

The closing of the ends of the glass tubes need not necessarily be completely gas tight and need only be closed sufficiently to prevent the discharges from taking the shorter paths between the closed ends of the tubes. It is found with the arrangement in accordance with the invention when one tube-electrode is adapted to co-operate with another, the discharge still takes the longer **U**-shaped path including the lengths of the tubes instead of taking the much shorter path between the leads to these electrodes, even without completely gas tight sealing of the closed ends of the tubes, providing the voltage between the leads is not too great; in practice we have found it desirable with exposed leads for the voltage between the leads to be not greater than 140 volts, but higher voltages might be used if the leads are adequately screened, e.g. sheathed in glass. This somewhat surprising feature enables the leads to the tube electrodes to be sealed through a pinched glass foot-tube or other closure member of conventional type which can readily be sealed to the main part of the envelope of the lamp in accordance with well known techniques, thereby simplifying production.

The inner wall of one or more of the glass tubes may be coated with luminescent material adapted to be excited to luminescence by the discharge, and combinations of colours may be obtained by the use of different tubes of different luminescent materials and/or by the omission of luminescent material from one or more of the tubes. If the filling comprises mercury vapour, preferably each tube is coated with luminescent material.

The said sealed envelope and/or the

outer envelope of the lamp if the said sealed envelope is not itself the outer envelope, may if required be rendered translucent for mixing and diffusing the light from the individual glass tubes and/or improving the appearance of the lamp by obscuring the details of the internal structure.

As already indicated, the electrodes within the envelope may all be tube-electrodes so that the lamp is adapted to produce one or more substantially **U**-shaped discharges. When two tube-electrodes both co-operate with the same third tube-electrode, the corresponding **U**-shaped discharges will be in parallel and will have one limb in common; when the electrodes are all activated cathodes this arrangement has the advantage that the loss of power owing to cathode fall is reduced as compared with the case when each discharge terminates on separate electrodes, since there are four cathode falls in the latter case but effectively only three in the former; this advantage is of course obtained to an even greater extent if there are more than two discharges in parallel in this way.

The same kind of advantage is obtained in the case where two or more tube-cathodes both co-operate with a further activated cathode mounted at the end of the envelope near the open end of the tubes so that the lamp is adapted to carry two or more substantially straight discharges in parallel. It may be noted that a further advantage of the arrangement having two or more discharges in parallel as compared with a lamp having a single straight discharge path of the equivalent length, is that it is adapted to operate at only a fraction of the voltage required for the longer lamp.

In using a lamp in accordance with the invention each pair of electrodes between which a discharge is required to pass in operation may be associated for starting purposes with a starting switch, which may be of the automatically operated type, i.e. glow type or coil-heated type. In some cases the same starting switch may be associated simultaneously with two or more pairs of electrodes; thus, for example, when two tube-cathodes both co-operate with a third electrode, leads from the said two tube-cathodes may be connected together and the connection joined through a single lead to the third electrode; a starting switch placed in the said single lead will then serve to start both discharges.

One or more starting switches of the automatically operated type may if required be included within the sealed envelope, as part of the lamp, to reduce the number of leads passing to the exterior of the envelope.

In order that a lamp in accordance with the invention may run stably with each glass tube carrying the required discharge current, i.e. so as to avoid concentration of the discharge in one or more tubes to the exclusion of another or others, it may be necessary to associate each electrode with the appropriate stabilising impedance, but the necessary arrangement for any particular case will be obvious to those skilled in the art.

The invention will be further described with reference to the accompanying drawings in which:—

Figure 1 shows schematically a circuit arrangement incorporating a lamp in accordance with the invention which has two glass tubes;

Figure 2 shows a circuit arrangement similar to Figure 1 but in which the lamp in accordance with the invention has four glass tubes;

Figure 3 shows a modification of Figure 2 in which the lamp has a fifth cathode with which each of the tube-cathodes co-operates, and in which a single starting switch serves to start all four discharges;

Figure 4 shows in side elevation and by way of example the details of one lamp in accordance with the invention; and

Figure 5 shows the end elevation of the lamp of Figure 4.

Referring now to Figure 1, the lamp in accordance with the invention comprises an elongated outer glass envelope 1 containing a gas or vapour filling at low pressure and within which are arranged two glass tubes 2 and 3 each of which is closed at one end and open at the other; the closed ends of the tubes 2 and 3 are disposed together near one end of the envelope 1 and the open ends are disposed together near the opposite end of the envelope 1. Within the tubes 2 and 3 at the closed ends thereof are mounted activated cathodes 4 and 5, each having a pair of leads which pass through the closed ends of the tubes and the adjacent end of the envelope 1. One end of cathode 5 is connected, via the external leads to one end of the cathode 4 through a starting switch 6, and the other ends of the cathodes are connected, via the external leads, through chokes 7 and 8 to the terminals 9 and 10 respectively of a source of A.C. supply. The chokes 7 and 8 could of course be combined into a single choke in this embodiment and in practice this would usually be done for convenience; two chokes have however been shown in order to facilitate the understanding of the more complicated embodiments of the invention later to be described.

In operation a discharge initiated by the closing of the switch 6, which completes a heating circuit for the pre-heating of the cathodes 4 and 5, followed by the opening of the switch, which produces an inductive kick, takes the path indicated by the dotted line 11.

In the arrangement shown in Figure 2 the arrangement of Figure 1 is effectively " doubled ", a second pair of glass tubes $2^1$ and $3^1$ being included within the envelope $1^1$ in addition to the tubes 2 and 3; the tubes $2^1$ and $3^1$ have activated cathodes $4^1$ and $5^1$ mounted within their closed ends and each cathode has a pair of leads passing to the exterior of the envelope 1 in the same way as the cathodes 4 and 5.

One end of cathode $4^1$ is connected, via the external leads, to one end of the cathode $5^1$ through a starting switch $6^1$ similar to the connection of cathode 4 to cathode 5 through the starting switch 6, and the other ends of the cathodes $4^1$ and $5^1$ are connected through chokes $7^1$ and $8^1$, in parallel with the chokes 7 and 8, to the terminals 9 and 10 of the A.C. supply.

In operation two separate discharges, taking the paths indicated by the dotted lines 11 and $11^1$, are initiated by the closing and opening of the switches 6 and $6^1$.

It will be appreciated that the four tubes 2, $2^1$, 3 and $3^1$ need not be arranged side by side as indicated in Figure 2; it may often be more convenient to group them together in a bundle for the sake of compactness.

Figure 3 shows an arrangement in which there are included within a gas or vapour-filled envelope 12, four glass tubes 13, 14, 15 and 16 whose closed ends are disposed together near one end of the envelope 12 and whose open ends are disposed together near the other end of the envelope. Within the tubes at the closed ends thereof are mounted activated cathodes 17, 18, 19 and 20 each of which has a pair of leads passing to the exterior of the envelope 12. Within the envelope and facing the open ends of the tubes 13, 14, 15 and 16 is mounted a fifth activated cathode 21 which has a pair of leads passing to the exterior of the envelope.

One end of the cathode 21 is connected, via the external leads, to one end of each of the cathodes 17, 18, 19 and 20 through a starting switch 22, and the other end of the cathode 21 is connected to one terminal 9 of an A.C. supply; the other ends of the cathodes 17, 18, 19 and 20 are connected in parallel through chokes 23, 24, 25 and 26 respectively to the other terminal 10 of the supply.

In operation the lamp is ignited by closing the switch 22, which completes a heating circuit for all the cathodes, and then opening the switch, which gives rise to inductive kicks initiating four separate discharges which take the paths indicated by the dotted lines 27, 28, 29 and 30.

It will be appreciated that in any of the arrangements described with reference to Figures 1, 2 and 3 the starting switches may be of the automatically operating type, for example glow switches, and that these switches could if required be included within the sealed envelope of the lamp to reduce the number of leads passing to the exterior thereof.

One lamp in accordance with the invention, similar to that shown in Figure 2, will now be described in more detail, by way of example, with reference to Figures 4 and 5 of the accompanying drawing, in which Figure 5 shows an elevation looking from the top of Figure 4.

The outer envelope of the lamp consists of a tubular glass bulb 31 which is about twelve inches long and three inches in diameter; the envelope is closed by the sealing into its originally open end of a foot-tube terminated by a pinch 32; within the envelope is a bundle of four glass tubes 33, 34, 35 and 36 each about nine inches long and one inch in diameter; each of the glass tubes is closed at the end near the envelope foot-tube by the sealing into the glass tube of a small foot-tube terminated by a pinch on which is mounted a cathode 37, 38, 39 or 40 consisting of a tungsten helix coated with thermionically emissive material similar to the cathode used in the well known 40 watt 4 ft. long by $1\frac{1}{2}$ in. diameter lamp; leads to the tungsten helix pass through the closed ends of the glass tubes and thence through a mica baffle disc 41, supported on stout wires 42, 43 embedded in the pinch 32 and which extends over substantially the whole of the cross-section of the envelope, to the envelope foot-tube through the pinch 32 of which the leads pass to terminals carried by a cap 44 fitted over the end of the envelope.

The bundle of glass tubes is held together and supported from the wall of the envelope by thin wire spring rings 45, 46 which abut against the inner wall of the envelope. The glass tubes are also partly located by the stems 47, 48, 49 and 50 (of which 50 does not appear in the drawing) of the foot-tubes closing the glass tubes, passing through holes in the mica disc 41; the stems 47, 48, 49 and 50 are used for centring purposes during the sealing in of the foot tubes.

Each of the glass tubes has its inner wall coated with luminescent material, the lower boundaries of which are indicated by the lines 51, excitable by the low-pressure mercury vapour discharge,

and the filling within the envelope of the lamp consists of mercury vapour together with a few millimetres pressure of argon.

In operation of this lamp a stabilising choke, to carry the lamp current of approximately 0.3 amp. should be included in the lead to each cathode and the impedances of these chokes should preferably all be the same; we have found that if each choke impedance is about 350 ohms, the lamp will operate satisfactorily on a 240 volt supply in a circuit as shown in Figure 2, the lamp dissipating a total of about 30 watts.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A positive column electric discharge lamp of the hot-cathode type, comprising an hermetically sealed light transmissive envelope containing the filling of gas and/or vapour and within which are supported a plurality of substantially straight glass tubes each closed at one end, open at the other end, and having an electrode mounted within the tube at the closed end of the tube, the tubes being arranged with their closed ends all near one end of the said envelope and with their open ends all near the opposite end of the envelope, and wherein leads for supplying the said electrodes, and possibly also one or more other electrodes mounted within the envelope near the said opposite end thereof, pass to the exterior of the envelope, the arrangement being such that the lamp is adapted to be operated with a discharge passing along the length of each said glass tube.

2. An electric discharge lamp according to Claim 1 wherein each electrode at the closed end of a said glass tube is an activated cathode of the pre-heated type.

3. An electric discharge lamp according to Claim 2 wherein a further activated cathode of the preheated type is mounted within said envelope near the open ends of the said glass tubes.

4. An electric discharge lamp according to Claim 1 or 2 wherein all of the electrodes within the said envelope are activated cathodes of the pre-heated type and each electrode is mounted within a different said glass tube at the closed end of the tube.

5. An electric discharge lamp according to Claim 1, 2, 3 or 4 wherein the inner wall of at least one of the said glass tubes is coated with luminescent material adapted to be excited to luminescence by the discharge within the tube.

6. An electric discharge lamp according to any preceding claim comprising within the said envelope at least one starting switch of the automatically operated type connected in series with at least one activated cathode of the pre-heated type and adapted to complete a heating circuit for the said cathode.

7. An electric discharge lamp according to any preceding claim wherein the said envelope is a tubular glass bulb closed by the sealing of a closure member to the envelope, and wherein the said glass tubes are mounted with their closed ends near to the closure member and with the leads to the electrodes within the tubes at the closed ends thereof passing through the closure member or its seal with the envelope.

8. An electric discharge lamp according to any preceding claim wherein the said envelope is translucent so that in operation the light from the glass tubes is mixed and diffused and the details of the internal structure of the lamp substantially obscured.

9. A combination of a lamp in accordance with any preceding claim with a circut for operating the lamp from a suitable supply, wherein a separate stabilising impedance is connected in series with each electrode of the lamp.

10. A combination of an electric discharge lamp and circuit for operating the lamp, which combination is substantially as shown in and hereinbefore described with reference to Figure 1, or Figure 2, or Figure 3 of the accompanying drawing.

11. A positive column electric discharge lamp of the hot-cathode type which is substantially as shown in and hereinbefore described with reference to Figures 4 and 5 of the accompanying drawing.

Dated the 21st day of November, 1947.

For the Applicants:
A. F. CORNOCK,
Chartered Patent Agent.

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and the filling within the envelope of the lamp consists of mercury vapour together with a few millimetres pressure of argon.

In operation of this lamp a stabilising choke, to carry the lamp current of approximately 0.3 amp. should be included in the lead to each cathode and the impedances of these chokes should preferably all be the same; we have found that if each choke impedance is about 350 ohms, the lamp will operate satisfactorily on a 240 volt supply in a circuit as shown in Figure 2, the lamp dissipating a total of about 30 watts.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A positive column electric discharge lamp of the hot-cathode type, comprising an hermetically sealed light transmissive envelope containing the filling of gas and/or vapour and within which are supported a plurality of substantially straight glass tubes each closed at one end, open at the other end, and having an electrode mounted within the tube at the closed end of the tube, the tubes being arranged with their closed ends all near one end of the said envelope and with their open ends all near the opposite end of the envelope, and wherein leads for supplying the said electrodes, and possibly also one or more other electrodes mounted within the envelope near the said opposite end thereof, pass to the exterior of the envelope, the arrangement being such that the lamp is adapted to be operated with a discharge passing along the length of each said glass tube.

2. An electric discharge lamp according to Claim 1 wherein each electrode at the closed end of a said glass tube is an activated cathode of the pre-heated type.

3. An electric discharge lamp according to Claim 2 wherein a further activated cathode of the preheated type is mounted within said envelope near the open ends of the said glass tubes.

4. An electric discharge lamp according to Claim 1 or 2 wherein all of the electrodes within the said envelope are activated cathodes of the pre-heated type and each electrode is mounted within a different said glass tube at the closed end of the tube.

5. An electric discharge lamp according to Claim 1, 2, 3 or 4 wherein the inner wall of at least one of the said glass tubes is coated with luminescent material adapted to be excited to luminescence by the discharge within the tube.

6. An electric discharge lamp according to any preceding claim comprising within the said envelope at least one starting switch of the automatically operated type connected in series with at least one activated cathode of the pre-heated type and adapted to complete a heating circuit for the said cathode.

7. An electric discharge lamp according to any preceding claim wherein the said envelope is a tubular glass bulb closed by the sealing of a closure member to the envelope, and wherein the said glass tubes are mounted with their closed ends near to the closure member and with the leads to the electrodes within the tubes at the closed ends thereof passing through the closure member or its seal with the envelope.

8. An electric discharge lamp according to any preceding claim wherein the said envelope is translucent so that in operation the light from the glass tubes is mixed and diffused and the details of the internal structure of the lamp substantially obscured.

9. A combination of a lamp in accordance with any preceding claim with a circut for operating the lamp from a suitable supply, wherein a separate stabilising impedance is connected in series with each electrode of the lamp.

10. A combination of an electric discharge lamp and circuit for operating the lamp, which combination is substantially as shown in and hereinbefore described with reference to Figure 1, or Figure 2, or Figure 3 of the accompanying drawing.

11. A positive column electric discharge lamp of the hot-cathode type which is substantially as shown in and hereinbefore described with reference to Figures 4 and 5 of the accompanying drawing.

Dated the 21st day of November, 1947.

For the Applicants:
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