PATENT SPECIFICATION

Application Date: March 27, 1936. No. 9156/36. **472,658**

Complete Specification Left: Feb. 8, 1937.

Complete Specification Accepted: Sept. 27, 1937.

PROVISIONAL SPECIFICATION

Improvements in or relating to Electric Discharge Lamps

We, The General Electric Company Limited, of Magnet House, Kingsway, London, W.C.2, a British company, and Victor Lewis Emanuel and John Wynne [illegible] both of Research Laboratory of The General Electric Company Limited, Wembley, Middlesex, British subjects, do hereby declare the nature of this invention to be as follows:—

This invention relates to electric discharge lamps.

Recently there have been developed discharge lamps in which light is produced by the passage of an electric current through metallic vapour at a pressure of the order of a few millimetres of mercury. These lamps have a high efficiency and a greater light output per unit area than previously known lamps. They are particularly suitable for use in optical projection apparatus, such as are employed in cinematography. Lamps of this type are of great importance in such large projectors as are employed in cinemas, but owing to their high brightness they may be employed in projectors of small size without loss of brightness. In order that they may be properly defined and distinguished from the previously known lamps, the brightness of the discharge path will be referred to as the brightness of the lamp.

The brightness of the discharge column of these lamps may be increased by increasing the vapour pressure, but in order to obtain a high brightness in the column without a high vapour pressure, the diameter of the discharge path must be small. Lamps of this type in which high brightness is obtained by the use of a small discharge path will be termed tubular lamps.

In order to obtain a high-brightness tubular lamp it is necessary that the current density in the discharge column should be high. Experiments have shown that a current density of the order of 1 ampere per sq. cm. is necessary to obtain a brightness of the order of 1,000 candles per sq. cm. and in order to obtain this current density with a discharge path of small diameter it is necessary that the pressure of the metallic vapour should be of the order of a few millimetres of mercury. Experiments have shown that the current density in a discharge path of small diameter is proportional to the square of the vapour pressure. Thus, for example, if a current density of 1 ampere per sq. cm. is obtained with a vapour pressure of 1 millimetre of mercury, a current density of 4 amperes per sq. cm. will be obtained with a vapour pressure of 2 millimetres of mercury.

In high-brightness lamps it is necessary that the emitting area of the cathode should be small, but it is essential in the lamps for use in optical projection that the emitting area should be as large as possible. For this reason it is important that the cathode in high-brightness lamps of the tubular type should be in the form of a column

[Price 1/-]

is more closely defined by the envelope. In all these lamps it is also desirable that the electrodes should not be liable to disintegration by sputtering, evaporation or the like. But this condition is more important in tubular than in spherical lamps; for in spherical lamps it is easier to guide material from the electrodes to parts of the envelope where it does not matter. On the other hand it is desirable in all lamps that these should be electrodes coated with material of high thermionic emissivity, in order that the starting potential should be small.

If the lamp has only one pair of electrodes this last condition is usually found to be inconsistent with the first two conditions; for material of high thermionic emissivity is always relatively volatile and a discharge is always liable to wander over its surface. We have found that the inconsistency can be removed by providing the lamp with more than one pair of main electrodes, locating the electrodes suitably and making some of the electrodes of suitably different character from the others.

According to the invention a high-brightness metal vapour lamp comprises more than two main electrodes of which at least one is adapted to act as a starting electrode, but not as a running electrode, and at least one to act as a running electrode, but not as a starting electrode.

Some of the terms used in this statement must now be explained.

A main electrode means one adapted to carry the main discharge, that is to say, the discharge which produces or maintains the high temperature and vapour pressure characteristic of high-brightness (or high pressure) metal vapour lamps. An auxiliary electrode adapted to carry only a discharge which could not produce that increase but merely initiates a main discharge is not a main electrode. A lamp according to the invention may have auxiliary starting electrodes as well as main electrodes.

An electrode adapted to act as a starting electrode must be provided with a store of material (e.g. alkaline earth oxides) adapted to confer on it a high thermionic emissivity; it may be heated by the discharge or independently of the discharge. An electrode adapted to act as a running electrode must not be provided with such a store; it must be constructed of a plain refractory material of low volatility, preferably tungsten or possibly a refractory carbide, and must have a definite operating area of small dimensions, for example the end of a wire, on which the main discharge terminates, if it terminates on the electrode at all; it must not be heated independently of the discharge so as to emit thermionically. There must also be a relation between any electrode adapted to act as a starting electrode and a corresponding electrode adapted to act as a running electrode. In a tubular lamp, in which the diameter of the envelope is not much greater than the diameter of the discharge column, the electrode adapted to act as a starting electrode must be more remote from the electrode with which it co-operates than the corresponding electrode adapted to act as a running electrode. But in a spherical lamp, in which the electrodes are nearer to each other than to the walls, this is not essential, though it is usually preferable; for some other difference in the location of the electrodes may tend to transfer a discharge terminating on an electrode adapted to act as a starting electrode to the corresponding electrode adapted to act as a running electrode; thus the latter may be above the former, so that the transference is effected by convection current.

The phrase "adapted to act as" in the foregoing sentences is necessary, because the transference of activating material from the said store with which an electrode is provided to the surface of the electrode unprovided with such a store may cause the latter to assume temporarily a high thermionic emissivity and thus to act occasionally as a starting electrode. For this reason, where a lamp according to the invention is started from cold, the discharge may occasionally start from the refractory metal electrode and continue to terminate on it; but it cannot always start from this electrode, because then the supply of activating material would be exhausted. For this reason it is impossible to distinguish the electrodes by their function of acting as starting and running electrodes; they must be distinguished, as aforesaid, by their constitution and location, in virtue of which they are adapted to act as starting or running electrodes. But now that this matter has been explained, the terms starting and running electrodes may be used for brevity without danger of misunderstanding.

When the lamp is adapted to be run on D.C., there need only be one starting electrode and one running electrode corresponding to it; a third electrode, always acting as anode and co-operating with both, may be of any character; usually it will resemble a running rather than a starting electrode. When the lamp is adapted to be run on A.C., there are preferably two starting electrodes and a

running electrode associated with each bar this is not absolutely essential.

In a running lamp the starting electrodes should be as near as possible to the ends of the lamp, in order that there shall be no cool spot behind them; this is necessary in order that the running condition should develop. When the running condition has developed and the discharge terminates on the running electrodes, there will usually be a relatively cool spot behind them, but since efficiency is not of the first importance, this is of little consequence; the watts dissipated can be pushed up till the requisite pressure is developed. The position of the starting electrodes in spherical lamps is less important, for it is sometimes desirable to place them near the wall.

Here it should be observed that the proposal to use separate starting and running electrodes is not wholly new. It is suggested, for reasons that are partly the same as those given here, in Patent Specification No. 302,409 in which no patent was granted in connection with the older high pressure metal vapour lamps. In such lamps one which efficiency is the main advantage the proposal was practical use because the running electrodes were to be near the ends of the tubular envelopes, in order that no cool spots which are fatal to efficiency may develop behind them. It must be insisted that this invention relates solely to lamps in which brightness rather than efficiency is the main consideration.

Two embodiments of the invention will now be described by way of example. In one, the high-brightness lamp is spherical and is generally similar to that described in Patent Specification No. 431,929 with reference to the drawing accompanying it. The electrodes 2, 3 are the starting electrodes, consisting of tungsten "pips" sealing into a glass bead, and comparatively may be heated solely by the discharge. The distance between them is such that greater than prescribed in that specification and may exceed 20 mm. The running electrodes are plain tungsten wires, one carried on the support of each of the electrodes 2, 3, whose ends are turned towards each other and approach each other more nearly than do electrodes 2, 3. The ring may be 6 mm. apart.

When the lamp is started from cold, the discharge starts between the electrodes 2 and 3, and later transfers itself to the ends of the two tungsten wires.

In the other embodiment, the lamp is tubular. The envelope is a quartz tube 30 cm. long and 6 mm. in diameter. The starting electrodes and running electrodes are similar in construction to those described in the first embodiment, but are of smaller size, the nearest points of the starting electrodes are 25 mm. apart, those of the running electrodes 20 mm. apart. The watts dissipated in the tube in full operation are so great that the mercury vapour pressure rises to some 20 atmospheres.

Dated the 27th day of March, 1936.
For The Apex Lamps,
G. S. STURROCK.

COMPLETE SPECIFICATION

Improvements in or relating to Electric Discharge Lamps

We, The General Electric Company Limited, of Magnet House, Kingsway, London, W.C.2, a British company, and Victor Lewis Frewen and John Wattie Ryan, 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 high-pressure mercury-vapour discharge lamps of the type in which the envelope is distant from the discharge, and the discharge column of high brightness. The term "mercury" does not exclude the presence of other materials whose spectra may contribute appreciably to the light emitted. The terms "short gap discharge" and "high brightness" will be defined hereinafter.

In one type of high-pressure mercury-vapour discharge lamp used commercially at the present time, the distance between the electrodes is some 20 or 30 cm., the pressure of the mercury in full operation is some 1 to 2 atmospheres, the watts dissipated in the discharge is some 1 to 2 watts per mm. of the voltage between the electrodes in full operation, the difference between the electrodes is not more than 20 volts or so, and the luminous intensity denoted by W from the watts dissipated in the said distance is not more than 30 watts cm. The maximum brightness at any part of the discharge column viewed in a plane perpendicular to its length thereinafter called the

brightness) does not exceed 200 candles per sq. cm. Such lamps will be termed hereinafter H.P.M.V. lamps.

Recently there have been described, for example in Patent Specifications Nos. 431,923, 431,919, high pressure mercury-vapour lamps whose brightness greatly exceeds that of H.P.M.V. lamps and may attain 18000 candles per sq. cm. The increased brightness is due primarily to the increase of the watts dissipated per c.c. of the discharge column; it is achieved by making the pressure (and V/l, which is closely associated with the pressure) considerably greater than in H.P.M.V. lamps, thereby constricting the discharge column further, and by making W/l no less or greater.

This great brightness makes the lamps described in the said specifications, suitable as sources in optical projection; for their brightness greatly exceeds that of incandescent filament lamps, in which the brightness cannot easily exceed 1500 candles per sq. cm., unless the life is very short.

By varying suitably V/l and W/l, an almost continuous transition can be made between the lamps of very great brightness described in the said specifications and H.P.M.V. lamps. Accordingly if a distinction has to be made between high and low brightness, it must be somewhat arbitrary. In view of the facts just stated, it is natural to draw the line in the neighbourhood of 1500 candles per sq. cm. However the brightness attainable increases with the wattage of the lamp; moreover it will appear that the nature and basis of the invention has nothing to do with brightness per se; the invention is concerned with high brightness only because, given a sufficient W/l, high brightness is associated with large V/l. Accordingly the conditions that a lamp shall be of high-brightness, for the purpose of the invention, are to be taken to be these: (1) V/l must not be less than 50 volt/cm. (which corresponds roughly to a pressure of 10 atmospheres with a current of some 3A), (2) W/l must not be less than 50 watt/cm., (3) the brightness of the lamp must not be less than 1500 candles per sq. cm., unless the wattage of the lamp is less than 200; if it is less than 200, the brightness must exceed 1000 candles per sq. cm.

It is to be understood that lamps according to the invention will not generally approach these limits, except possibly if they are of low wattage (e.g. 100 watts). Thus in a 400 watt lamp according to the invention, probably V/l will be as great as 100 volt/cm., W/l will exceed 200, and the brightness will be of the order of 10000 candles per sq. cm.

The meaning of "distant from the discharge" must now be explained. At the pressures necessary to obtain high brightness, the discharge column is apt to be unstable and to wander about its mean position. Such wandering is particularly undesirable if the lamp is to be a source in optical projection apparatus. But it is unlikely to do so if the lamp is used as lamps according to the invention may be for purposes where only the total light emitted is important; for the wandering is often accompanied by a variation in the total light. This instability can be prevented in two ways described respectively in the said specifications Nos. 431,923, 431,919. In the former, the discharge is enclosed in a narrow tubular envelope, which has to be artificially cooled in order that it shall not melt under the great heat of the discharge. In the latter, the distance between the electrodes is made so small that W/l exceeds, and may greatly exceed, 100 watt/cm.; the envelope may then be spherical and everywhere at a distance from the discharge at least as great as the distance between the electrodes; it then does not need to be artificially cooled.

Lamps according to the invention belong to the second type rather than the first; but, since here again a continuous transition between the extreme types is possible, the term "distant from the discharge" is to be interpreted for the purpose of the invention thus. Let an ellipsoid of revolution about its major axis be drawn with one electrode at each end of the major axis and with its minor axis half the major axis. Then the envelope is to be regarded as distant from the discharge only if no substantial portion of solid matter, forming an envelope or sheath round the discharge, is within the said ellipsoid.

In all the foregoing statements, the electrodes are to be taken to be the surfaces on which the discharge column actually terminates in full operation. Thus (to anticipate what follows) the electrodes mean the running rather than the starting electrodes, and, if the running electrodes are of appreciable size, mean those parts of them on which the discharge actually terminates.

High-brightness mercury vapour lamps at present known blacken very rapidly, owing to the evaporation or sputtering of material from the electrodes. These electrodes, like the electrodes of H.P.M.V. lamps, have always been provided with a store of thermionically active material.

...preferably alkaline earth compounds, in order that the discharge may be started by the application of merely voltages. Hoods, shields and like devices might be used in known manner to direct the blackening produced on parts of the envelope through which the useful light is required to emerge. But these devices are at wholly unsuitable for some of the heating parts also always tube to reach the part of the envelope and such screens as these do not avoid the condensation on the cold spots which is the main cause of the objectionable projection in which we are interested under working conditions. A screen, even were it able to be so placed, would also shield the glowing material from the discharge. The object of the invention is to avoid this blackening in this way.

It is known that electrodes of refractory material, such as tungsten, are not suitable to produce blackening material like electrodes of thermionically active material. But such electrodes cannot be used alone because the voltage required to start the discharge would be too high, even if the usual auxiliary starting electrodes were used.

This dilemma can be avoided by providing two pairs of main electrodes, one furnished with a store of active material and one of refractory material as free as possible from such active material, and arranging these two pairs so that the discharge starts (possibly with the aid of auxiliary electrodes) between the first pair, but at some stage in the "run up" (that is to say, the period in which the lamp is hearing up and the vapour pressure increasing to its final value) transfers itself to the second pair and remains there during the full running of the lamp. This transference can be made to occur, because the voltage drop per cm. in the discharge increases greatly during the run up. At first, when this voltage drop is small, the discharge prefers to terminate on the electrodes of lower work function, even if the path between them is relatively long; but when the voltage drop increases, the discharge prefers to take the shorter path, even if it has to terminate on electrodes of higher work function.

A device of this nature is proposed in Patent Specification No. 392,408 on which no patent was granted in spite of the distinction between the starting and running electrodes and the relation that must exist between them was not very clearly explained. For the term "solid electrode" is apparently used to denote the running electrode and the term "incandescent electrode" to denote the starting electrode. But the starting electrode, even if it is oxide-coated, is always solid; and the running electrode, even if it is of tungsten is incandescent when the discharge terminates on it. But the arrangement therein described is not applicable or at least has not been successfully applied to H.P.M.V. lamps, because in these the starting electrodes have to be so close to the running electrodes, that cool regions would be developed at the ends of the tubes and cold spots are known to be adverse to the efficiency, which is the main virtue of H.P.M.V. lamps. The discovery on which the invention rests is that this consideration does not apply to high pressure mercury vapour lamps of the type specified; and that starting electrodes can be introduced into them without loss of their valuable characteristics. The reason lies partly in the high value of V/l; for this means that the distance of the starting electrodes behind the running electrodes may be small and yet the required transference of the discharge will occur. It also lies partly in the shape of the envelope; for the region behind the electrode is more easily heated by this discharge when the envelope is distant from the discharge.

According to the invention a high pressure mercury vapour lamp of the type specified comprises two running electrodes both consisting of refractory material free from any store of thermionically active material and two main starting electrodes (of which one, but not both, may be a running electrode) of which at least one (not being a running electrode) is provided with a store of thermionically active material, the relation between the said starting and running electrodes being such that the main discharge, if it starts between the starting electrodes, transfers itself automatically to the running electrodes at some stage of the run up. If the lamp is adapted to be operated on D.C., one of the main starting electrodes, being substantially free from active material, may be also a running electrode. If it is adapted to be operated on A.C., it is preferable that each starting electrode should be provided with a store of active material and thus should not be a running electrode; but, in circumstances can be found in which the discharge can begin to run up on one half-cycle only, this may not be absolutely essential.

Some parts of the foregoing statement must now be explained further. The adjective main is prefixed to starting electrodes in order to distinguish them from auxiliary electrodes of known kind, which may be, and preferably are, provided, in order that an auxiliary dis-

charge may strike and initiate the main discharge between the starting electrodes, which "runs up" and increases the vapour pressure. An electrode is not a main starting electrode, if its function is *merely to carry an initiating discharge*, which starts another discharge without any substantial intervening period of "run up".

A main starting electrode may be heated by means other than the discharge; but preferably, as in most H.P.M.V. lamps, it is heated by the discharge only. It may be similar to the *electrodes employed in H.P.M.V. lamps*, for example a tungsten spiral enclosing a rod of alkaline earth compound or coated therewith.

A running electrode must not be heated independently of the discharge so as to emit thermionically, and it must not be provided with any store of alkaline earths or like thermionically active material from which vapour can be generated continuously during operation. For it is known that active material is apt to be transferred from an electrode provided with a store of it to any other surface in the neighbourhood. Accordingly, a running electrode of plain tungsten may *occasionally become coated with sufficient* active material to cause it to act temporarily as a starting electrode. This is undesirable because this material, when evaporated from the very hot running electrode, may be blackening material; accordingly it is to be avoided, if possible. But it is not always possible to prevent entirely such transference of active material. Accordingly, in the statement of the invention, the running electrodes are said to be free from any store of active material (not entirely free from it), and the word "if" (not when) is used to indicate that the discharge may occasionally start with one or each end on a *running electrode*.

The cross-section of the ends of the running electrodes facing each other should be as small as possible in order that the termination of the discharge may be definite. But a lower limit is set to the cross-section of any running electrode by the temperature that it attains in operation, which must not be so high that there is appreciable evaporation or sputtering from it. If the running electrode is ever to act as cathode, the temperature is preferably as high as is consistent with this limitation; it must, of course, be so high that there is a plentiful thermionic emission.

The relation between starting and running electrodes that must subsist in order that the transference may take place cannot be prescribed exactly, and must be determined by trial; it will not usually be found to be critical. Preferably the starting electrodes lie behind the running electrodes. But if the discharge path is horizontal, it may be sufficient merely to place the starting electrodes below the running electrodes, so that the transfer takes place when the discharge is bowed upwards and increased in length by convection currents.

Since the discharge between the starting electrodes will always be apt to produce some blackening, the transfer should take place early in the run up, consistently with the condition that the run up should continue after the transfer has occurred. For this reason, it is generally preferable to place the starting electrodes nearly as far apart as other considerations, and particularly the need to *maintain a high vapour pressure, permit*. For, as usual, the vapour pressure cannot exceed that corresponding to the temperature of the coldest spot of the envelope.

A large distance between starting and running electrodes is also desirable in order to reduce the amount of active matter transferred from the former to the latter. On the other hand it is not necessary, on this ground, that starting and running electrodes should be entirely separate. Thus a tungsten wire enclosing a rod of alkaline earths to form a starting electrode may be prolonged so that its end, preferably gathered into a compact form, forms a running electrode. Proposals have been made to use as electrodes bodies carrying active material on part, but not all, of their surface and such that the active material can readily diffuse from the part carrying the material to the part initially free from it, the efficiency of the electrodes depending on this diffusion. Such proposals are contrary to that of the present invention; diffusion of active material to the running electrodes is highly undesirable. On the other hand, so long as such diffusion does not occur, for example owing to the active material being always cool, there is no limit to the extent to which running and starting electrodes may be mechanically integral.

Three embodiments of the invention will now be described by way of example. In the first, which is shown in Figure 1 of the accompanying drawings, the lamp is generally similar to that described in Patent Specification No. 431,919 with reference to the drawing accompanying it. The electrodes 2, 3 are then the starting electrodes, consisting of tungsten spirals surrounding rods of alkaline earth compound; they may be heated solely by the

discharge. The distance between them is somewhat greater than prescribed in that specification, namely, about 20 mm. The running electrodes 2, 3 are stout plain tungsten electrodes as customarily used in [illegible] whose ends are turned towards each other and approach each other more closely than the electrodes 2, 3. Thus they may be 5 mm. apart.

When the lamp is started from cold, the final discharge starts between the electrodes 2 and 3, and [illegible] to the ends of the two tungsten wires 2, 3.

The second and third embodiments are illustrated in Figures 2, 3 of the accompanying drawings, of which they are elevations, partly in section, of lamps adapted to operate on A.C. and D.C. respectively, with the line joining the electrodes 2, 3 vertical. In each figure, AA' denotes a plane forming the electrodes 2, 3 and BB' denotes a plane perpendicular to the plane AA'.

In each figure, 1 is a quartz envelope having at each end a seal 2 through which passes a lead 3. The lead is in known manner, a thin molybdenum strip in which the surrounding quartz has been collapsed. The envelope contains argon at a pressure of about 10 mm. and a quantity of mercury so adjusted that it is all evaporated when, during running-up, the watts dissipated in the envelope attain about 90% of the final watts. The junction of the seal with the envelope and the adjoining part of the seal is provided with a reflecting coating 4 of platinum paint. 5, 6 are the tungsten running electrodes on the ends of the tungsten wires 9; 7, 8 are the starting electrodes carried on the wires 9 between the running electrodes and the seals. These starting electrodes are tungsten spirals enclosing alkaline earth or coated with alkaline earth. The sealing-off pip at the top is coated with another reflecting layer 1.

The distance between the adjacent faces of the electrodes 5, 6 is 1 mm. It is a 220 volt lamp. The current was adjusted to be about 1.8 A. The watts consumed were 250, so that the watts per cm. were 625. In addition to the intensely bright column between the electrodes, whose brightest part has a brightness of about [illegible] candles per cm.², a lower luminosity extended into the upper part of the conical envelope.

In Figure 2, where the lamp is adapted to be operated on A.C., both running electrodes are similar. In Figure 3, adapted to be operated on D.C., electrode 6, which is to be the cathode, is smaller in order that it may heat up quickly.

High-pressure mercury-vapour discharge lamps of the type specified may have initial luminous efficiencies at least as great as those of H.P.M.V. lamps of the same wattage. Lamps according to the invention, in virtue of the reduction of black patches due to the use of running electrodes of the [illegible] starting electrodes, may maintain their efficiency during life [illegible] H.P.M.V. lamps for the purpose for which H.P.M.V. lamps are used at present.

We are aware of Patent Specification No. [illegible] wherein electrodes are [illegible] have a portion of relatively small cross-section which projects somewhat [illegible] in front of the running electrodes [illegible] These are used only in combination with [illegible] point distant the same visible metal whose function appears to be to raise the temperature of that metal independently of the discharge. The use of such heaters, not forming part of an electrode, is not contemplated in this invention; but the real distinction between what is disclosed in the said specification and what is disclosed here is the absence in the former of any reference to high-brightness. It must be insisted that the basis of the present invention is the discovery of the peculiar suitability of the known device of running and starting to lamps of the type specified.

We are also aware that Patent Specification No. 111,545 claims: -

In a high-pressure metal vapour electric discharge lamp of the type specified that is to say, having activated thermionic electrodes heated solely by the discharge an electrode comprising an activated portion and an unactivated refractory metal portion extending beyond the activated portion in the direction of the discharge, the said activated and refractory portions being so shaped and arranged that the discharge initially terminates on the activated portion for lower currents and on the refractory portion.

We recognise that the embodiment of the invention described with reference to Figure 1 and the embodiments particularly described and claim within the scope of this claim. But these are distinguished from anything described in the said specification by the fact that the lamps are of the pedestal-electrode type specified. It is to be understood that the scope of the present invention is confined wholly to lamps of that type.

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 high-pressure mercury-vapour dis-

discharge. The distance between them is somewhat greater than prescribed in that specification, namely about 20 mm. The running electrodes 2', 3' are stout plain tungsten wires or rods, one carried on the support of each of the electrodes 2, 3, whose ends are turned towards each other and approach each other more nearly than do electrodes 2, 3. Thus they may be 5 mm. apart.

When the lamp is started from cold, the discharge starts between the electrodes 2 and 3, and later transfers itself to the ends of the two tungsten wires 2', 3'.

The second and third embodiments are illustrated in Figures 2, 3 of the accompanying drawings, which show lamps adapted to operate on A.C. and D.C. respectively, with the line joining the electrodes horizontal. In each figure, (a) shows an elevation in a plane joining the electrodes, (b) a section in the plane A.A.

In each figure, 1 is a quartz envelope having at each end a seal 2 through which passes a lead 3. This lead is, in known manner, a thin molybdenum strip in which the surrounding quartz has been collapsed. The envelope contains argon at a pressure of about 10 mm. and a quantity of mercury so adjusted that it is all evaporated when, during running-up, the watts dissipated in the envelope attain about 90% of the final watts. The junction of the seal with the envelope and the adjoining part of the seal is provided with a reflecting coating 4 of platinum paint. 5, 6 are the tungsten running electrodes on the ends of the tungsten wires 9; 7, 8 are the starting electrodes carried on the wires 9 between the running electrodes and the seals. These starting electrodes are tungsten spirals enclosing alkaline earth rods or coated with alkaline earth. The sealing-off pip at the top is coated with another reflecting layer 4.

The distance between the adjacent faces of the electrodes 5, 6 is 4 mm. If on a 230 volt supply, the current was adjusted to be about 4.8 A, the watts consumed were 250, so that the watts per cm. were 625. In addition to the intensely bright column between the electrodes, whose brightest part has a brightness of about 10000 candles per cm.^{2}, a fainter luminosity extended into the upper part of the conical envelope.

In Figure 2, where the lamp is adapted to be operated on A.C., both running electrodes are similar. In Figure 3, adapted to be operated on D.C. electrode 6, which is to be the cathode, is smaller in order that it may heat up quickly.

High-pressure mercury-vapour discharge lamps of the type specified may have initial luminous efficiencies at least as great as those of H.P.M.V. lamps of the same wattage. Lamps according to the invention, in virtue of the reduction in blackening due to the use of running electrodes distinct from starting electrodes, may maintain their efficiency during life as well that they are suitable for the purposes for which H.P.M.V. lamps are used at present.

We are aware of Patent Specification No. 125,597 wherein electrodes are described having activated and refractory portions which appear to act somewhat in the manner of the starting and running electrodes described above. But they are described only in combination with heaters, extending to a point adjacent the vapourisable metal, whose function appears to be to raise the temperature of that metal independently of the discharge. The use of such heaters, not forming part of an electrode, is not contemplated in this invention; but the real distinction between what is disclosed in the said specification and what is disclosed here is the absence in the former of any reference to high-brightness. It must be insisted that the basis of the present invention is the discovery of the peculiar suitability of the known device of running and starting to lamps of the type specified.

We are also aware that Patent Specification No. 444,545 claims:—

In a high-pressure metal vapour electric discharge lamp of the type specified (that is to say, having activated thermionic electrodes heated solely by the discharge) an electrode comprising an activated portion and an unactivated refractory metal portion extending beyond the activated portion in the direction of the discharge, the said activated and refractory portions being so shaped and arranged that the discharge initially terminates on the activated portion but later transfers itself to the refractory portion.

We recognise that the embodiment of the invention described with reference to Figure 1 (and other embodiments not particularly described) may fall within the scope of this claim. But these are distinguished from anything described in the said specification by the fact that the lamp is of the type hereinbefore specified. It is to be understood that the scope of the present invention is confined wholly to lamps of that type.

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 high-pressure mercury-vapour dis-

* C L M S *

charge lamp of the type specified comprising two running electrodes both consisting of refractory material free from any store of thermionically active material, and two main starting electrodes for which one, but not both, may be a running electrode, of which at least one and being a running electrode is provided with a store of thermionically active material, the relation between the said starting and running electrodes being such that the main discharge, if it starts between the starting electrodes, transfers itself automatically to the running electrodes at some stage of the run up.

2. A lamp according to Claim 1 adapted to be operated on alternating current wherein each of the said main starting electrodes is provided with a store of thermionically active material.

3. A lamp according to Claim 1 or 2 provided also with auxiliary electrodes whereby an auxiliary discharge can be struck which initiates the main discharge.

4. A lamp according to Claim 1, 2 or 3 wherein the said refractory material is tungsten.

5. A lamp according to any of Claims 1 to 4 wherein each of the said main starting electrodes lies behind a running electrode.

6. A high-pressure mercury-vapour discharge lamp of the type specified substantially as hereinbefore described with reference to any of the accompanying drawings.

Dated the 8th day of February, 1937.

For the Applicants,

G. S. STURROCK.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1937.

ERRATA

SPECIFICATION No. 472,658.

Page 3, line 16, *for* "spiral" *read* "spirals".

Page 7, line 26, *for* "in" *read* "on".

THE PATENT OFFICE,

[illegible] 1937.

* C L M S *