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R. F. D. NAVARRE DIT MALHERBE

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LAMPS AND THEIR MANUFACTURE
Filed Nov. 26, 1938

Serial No.
242,540
2 Sheets-Sheet 1

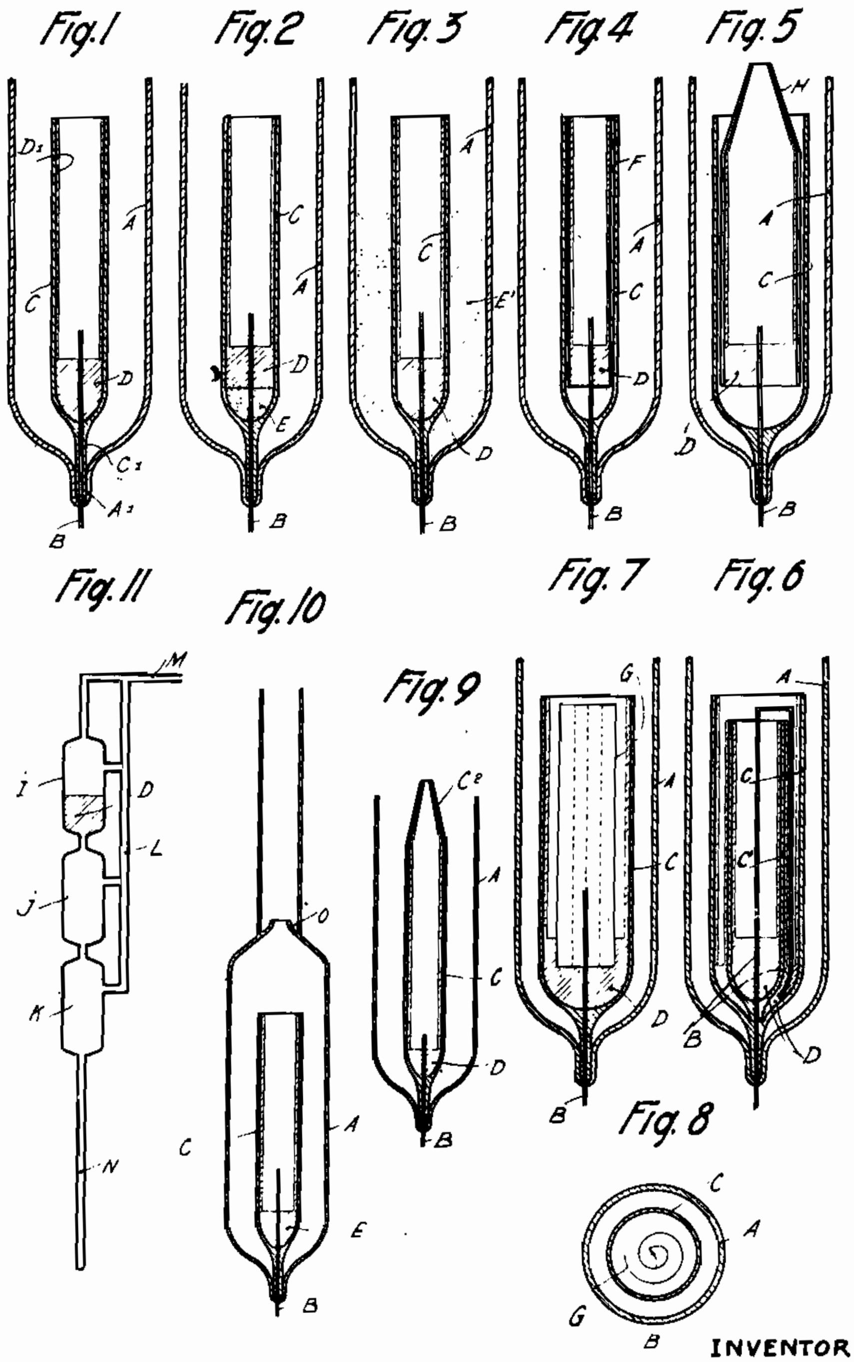

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Fig 12

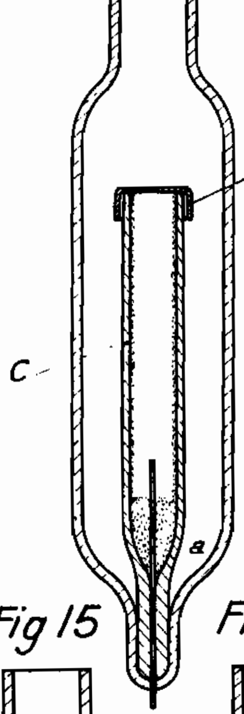


Fig 13

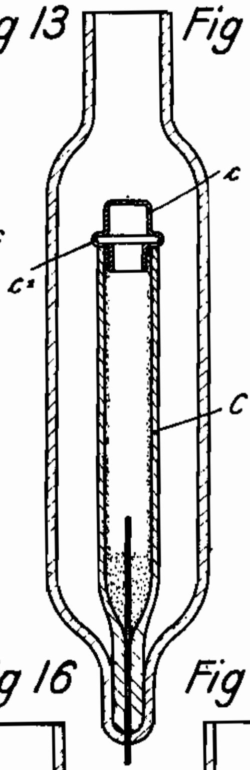


Fig 14

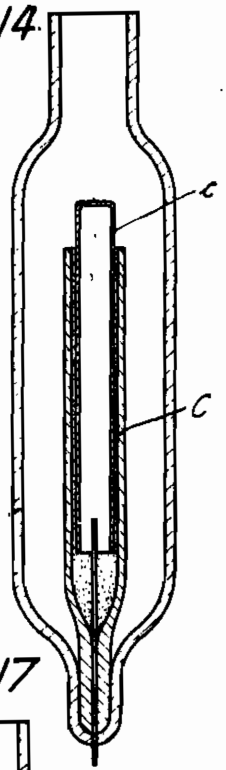


Fig 15

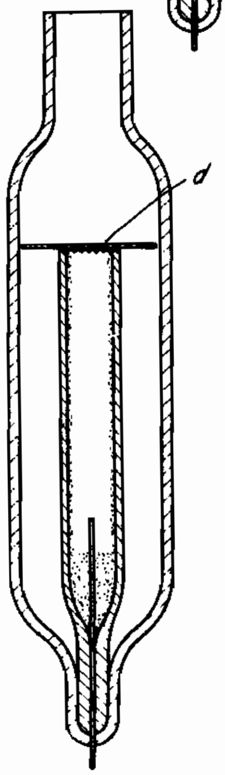


Fig 16

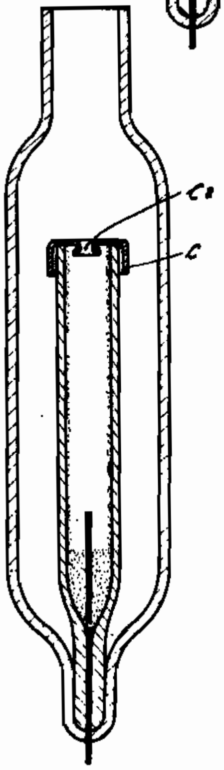
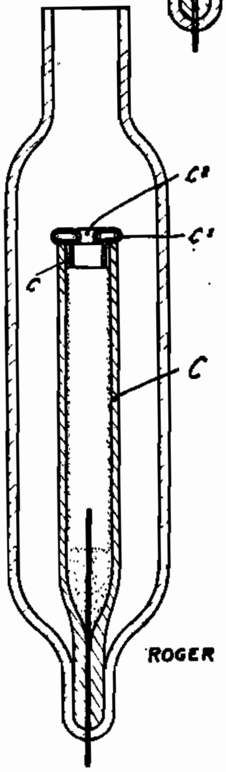


Fig 17



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ALIEN PROPERTY CUSTODIAN

ELECTRIC DISCHARGE TUBES AND LAMPS AND THEIR MANUFACTURE

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Application filed November 26, 1938

Two main methods have been used up to now in the manufacture of electric discharge tubes and lamps and particularly of their electrodes.

One of these methods consists in forming the electrodes of these tubes and lamps of ductile metals such as copper, iron, tungsten, molybdenum, aluminium, etc. The critical temperature of these metals being very high, such electrodes have the disadvantage, whatever may be their form (cylindrical, rectilinear stem, or spirally wound stem, grid, etc.), that they localise the place of electronic recombination and disassociation to the most remote point of the electrode. A relatively important potential drop is the result of this, followed by thermic manifestations which cause the ionoplastism of the metals in the presence of the gases occluded in the envelope of the tube or lamp and by reason of this an increase in the desistance to the passage of the discharges is produced.

Having regard to the weight of metal, these electrodes must be insulated from the internal walls of the envelope by various devices such as collars of beads, porcelain, glass, refractory substances etc. or even by a cup which serves to fix the electrodes.

It has been proved that the temperature of the electrodes varies as a function of the amount of current which is imposed upon them, and attempts have consequently been made to increase the metal surface of these electrodes in order proportionately to decrease their temperature. As however the temperature of an electrode varies also as a function of the fall of potential which it produces, experiments which have commenced with the above conclusions lead to the application of a second method.

This second method consists in forming the electrodes of electric discharge tubes and lamps of a base of alkaline or alkaline-earth metals or metals or alloys having a critical temperature below 800° C. The employment of these metals or alloys was considered as advantageous because, on being brought to a fused state by bombardment or by any other thermic process, they were, at the moment of manufacture, coated on to the inner wall of the envelope enclosing the gaseous atmosphere in such a manner that they adhere perfectly to this wall. It is seen from this that any passage between the envelope and the metal would be prevented, which would prevent electronic recombination being produced on the back of the electrode. With this method it is found that the variation in the temperature of the electrodes was practically nil and that their fall in potential was lowered about 80% with respect to that found with the first method set out above.

It has also been proposed to avoid electronic recombination at the back of the electrodes, in the case in which these latter are formed by means of metals or alloys having a critical temperature above 800° C., either by exact adjustment of them in the glass envelope enclosing the gaseous atmosphere or by completely filling the spaces between the metal employed and the envelope with powder or dust of glass, or of one of the materials mentioned above which have a critical temperature below 800° C.

These arrangements, however, excellent in principle, are difficult to produce if not when employing envelopes of special glass resistant to high temperatures at least with envelopes of ordinary glass. In fact at the moment of fusion of the alkaline, alkaline-earth or other metals, these materials damage the envelope in most cases, thus destroying any previous constructional work.

The present invention relates to improvements in electric discharge tubes and lamps having electrodes with a base of alkaline or alkaline-earth metals or metals or alloys capable of permanent or provoked ionic escape and having a low melting point, with a view to overcoming the disadvantages just mentioned whilst making the maximum use of the advantages present in employing the said metals or alloys as against using ductile metals having a high critical temperature.

In accordance with the invention the alkaline, alkaline-earth or other metal forming the electrode, is put into a cup of glass or isothermic material wihch does not discharge vapours or gases capable of disturbing the gaseous atmosphere at the temperatures at which the tube or lamp operates, the said cup being so disposed as to envelop at its base the conductor leading the current into the envelope which encloses the gaseous atmosphere, and to be itself enveloped at its base by the corresponding end of the envelope in order to insure the sealing of the tube or of the lamp through an intimate alloy. At the same time as it prevents the electronic recombination taking place at the back of the electrodes and thus ensures a decrease in potential drop, this arrangement avoids the risk of accidents during manufacture; accidents caused particularly by the adherence on melting of the alkaline, alkaline-earth or other metals to the envelope, and the device permits with certainty the use of ordinary glass for the formation of the whole tube or lamp and, accordingly of the envelope of the electrodes which terminate them.

The cup enclosing the alkaline, alkaline-earth or other metals will be preferably formed of the same material as the envelope of the electrodes and therefore generally of ordinary glass. However, it is also possible, but without obtaining results of the same characteristic kind, to use, china-ware, refractory earths, glasses of the "pyrex" type, refractory metals and the like. The dimensions (section, thickness, length) of the cup may vary as a function of the result which it is desired to obtain, although it will be convenient to observe in this respect certain general directives which will be disclosed more particularly hereinafter.

The cup may be insulated in various ways on the inside and/or on the outside by means of refractory substances which do not discharge gas or vapours, although this is not absolutely necessary.

According to another improvement forming the subject of the invention, the electrode may be provided with a pointed metal or other hood, fitting into the cup which encloses the alkaline, alkaline-earth or other metal, or this cup may itself have a conical shape, which enables longer lengths of unsectioned tube to be employed, having regard to the increase of power of the discharge which ignition between the points produces.

Other features and advantages of the invention will appear from the description which follows and which refers to the accompanying drawings, in which are shown by way of non-limiting example, various ways of putting the invention into effect.

In the drawings:

Figures 1 to 7 are partial axial sections of electric discharge tubes or lamps provided with different types of electrodes according to the invention;

Figure 8 is a transverse section corresponding with Figure 7;

Figures 9 and 10 are partial axial sections of other modifications;

Figure 11 is a schematic section of an arrangement suitable for fractional distillation in vacuo of alkaline or alkaline-earth metals adapted to form electrodes in accordance with the invention;

Figures 12 to 17 are sections showing different forms of hoods capable of being used for the electrode in a particular application of the invention.

In the example shown in Figure 1, A designates the envelope of the electrode, which is advantageously of ordinary glass, terminating the tube (not shown) which encloses the gaseous atmosphere, and B is the conductor leading current into this envelope. The electrode preferably located vertically, is formed by a glass cup C whose lower end C_1 envelopes the conductor B, this end being itself enveloped by the corresponding end A_1 of the envelope A. In the cup C is placed the metal or alloy D forming the electrode proper and which, after being brought to a fused state, coats the internal surface of the cup as shown at D_1. The conductor B only contacts with the gas inside the cup C and through the intermediary of the metal D.

It has been found that for obtaining the maximum results it is convenient that the cup has an internal section which is approximately equal to the internal section of the body of the tube and preferably somewhat larger than the latter. The thickness of the said cup must be determined while taking into account the various elements which are present in the course of the manufacture, such as: molten metal, an increase of the temperature resulting from the ionic shock caused on the traces of air which are still present for the thermal purification of the internal walls of the tube, and more particularly large differences of dilatation of the materials which are in contact (metal of the conductor, metal of the electrode and the glass which is used). In practice, this thickness may vary between 0.4 mm for small or middle intensities and 0.8 mm for maximum intensities. The length of the cup may be largely calculated, since it defines the electronic surface of the metal which is treated.

In order to protect the cup C, there may be interposed between it and the metal D (Figure 2), a layer of powder, of mica, of glass or any other insulating material which does not discharge vapours or gases at the temperatures at which the tube operates. It is also possible to insulate the cup on the outside, by interposing between it and the wall of the envelope A (Figure 3) a coating E' of mica, glass or similar powder.

One may also insulate the inner walls of the cup C against the destructive action of the metal by a sheet of mica F rolled into cylindrical form (Figure 4), or by a tube of "Pyrex" glass or by any other isothermic material not discharging vapour or gas.

To increase the emission surface of the metal whilst limiting the volume of the envelope, one may increase the number of the cups, as shown in Figure 6 which shows a tube provided with a double cup C—C'. Care must then be taken that the conductor B be in contact with the various surfaces formed by the vaporised metal on the internal and external surfaces of the cups. Instead of employing intermediate cups such as C' (Figures 7 and 8) one may provide a support formed by a sheet G of ductile metal (pure iron, pure copper etc.) which has been carefully degassed, or other isothermic material, rolled into spiral form, being itself supported at its base by the cup C charged with the alkaline, alkaline-earth or other metals. These metals are vaporised during the course of their manufacture simultaneously on the surface of the glass cup C and on the metallic surface of the support G, thus increasing the emission surfaces.

As has been stated above, to improve the power produced by discharge between the points, the electrodes according to the invention may be provided with a conical hood H (Figure 5), open at its end, and fitting into the cup C which encloses the alkaline, alkaline-earth or other metal. This hood may be of glass, insulated or not, or of another substance answering to the conditions above indicated for the cup itself. This arrangement allows tubes of greater length to be employed avoiding the repetition of unsightly sections.

In any case, it is an advantage, before putting the alkaline or alkaline-earth metals into the cup C, to subject them to a fractional distillation in vacuo, in order to free them from traces of oxides and hydrates and from other impurities contained in these metals as normally available in commerce, and which destroy their capability of being used in electric discharge tubes and lamps. For this purpose an apparatus such as that shown in Figure 11 may be used, formed by a series of vessels I, J, K placed one above the other (of which the number, form and material may be varied at will and at need), communicating with each other and individually connected to a pipe-line L connected with a conduit M leading from a vacuum-pump and joined to the end of the upper vessel I. The lower vessel K is extended into a thin glass stick N. The metal D to be treated is introduced into the vessel I which is heated to a temperature suitable to produce fusion of the metal. The melted metal runs successively into the vessels J and K which are heated also in proportion to this flow. When the fused metal fills the stick N, and after cooling, the stick is cut off and its content is an alkaline or alkaline-earth metal perfectly suited to the use in question.

To enable a better use in electric discharge tubes and lamps to be made of the natural ionic qualities of the alkaline or alkaline-earth metals, two or more of these metals may be intimately combined in proportions which conform to the laws of luminescence. For this purpose it is advantageous to produce the alloys in bulk by means of the fractional distillation process above described, introducing the metals to be alloyed in suitable proportions into the evacuated apparatus. The differences between the critical temperatures of the metals to be combined is balanced by working in vacuo, which, in addition to its use in absorbing vapours and impurities to be eliminated, operates as a compensator. It is thus possible to produce below 100° C, alloys, among others, of sodium and potassium in any desired proportions. In this particular case the potassium reinforces, by means of its high ionic power, the anodic and cathodic qualities of sodium. It will of course be understood, that it is possible to obtain in similar conditions any other alloys of alkaline and alkaline-earth metals.

In the production of electric discharge tubes and lamps provided with electrodes formed in accordance with the invention in order to simultaneously clean the gaseous space and the electrodes, it is possible to proceed in the following manner:

The discharge tube, which is provided with electrodes having been made in the above mentioned manner is connected as usually with a vacuum pump having an output which is sufficient for enabling to rapidly lower the internal pressure of the tube to a value which is lower than 0.0000 1 mm of mercury. During the operation of connecting the tube with the pump, the metal of the electrodes, which has already undergone the preliminary treatment under a vacuum as previously described is molten once more under the vacuum of the tube and when the pressure reaches a value which is sufficiently low, it is vaporized by a sudden raise of the temperature on the walls of the cup which contains it and of the envelope which encloses the latter. The electrode is then definitely formed, the vaporization being automatically limited as a function of the volume of the tube itself to the surface of emission which is necessary for the total ionization of the latter.

The thermal processes which may be used for bringing the metal to these different conditions can be of various kinds. The simplest and the most practical one, besides the heating by induction at a high frequency, consists in heating by an ionic bombardment exchanged between the metals of the electrodes energized with alternating current of a high voltage; the intensity and the voltage varying according to the volume of the gases. Whatever may be the process which is used, the use of alkaline or alkaline-earth metal electrodes permits of considerably lowering the temperature which is to be attained with respect to the temperature which is necessary with electrodes on the base of ductile metals such as copper, iron and the like, even if only the temperature corresponding to the dark red is considered for the latter. On the other hand, during these thermal treatments the presence of the cup of glass or other isothermic material which serves as a support for melting the alkaline, alkaline-earth or other metal until the definitive vaporization of the latter, renders impossible any adherence of the metal to the walls of the enclosure owing to the difference between the internal and external temperatures and simultaneously avoids, in the glass of the envelope, the stresses which are due to different coefficients of dilatation between the glass and the metal which forms the electrode, as well as leakages which may result therefrom and which could trouble the gaseous atmosphere. Furthermore, it permits of the electronic re-combination without any destruction of electrodes, since the portion which is carried forth by the movement of the ion is re-constructed on every cycle.

In accordance with the invention, one may use in electric discharge tubes equipped with electrodes having the characteristics set out above, a pre-ionisation by impact. The pre-ionisation can particularly be produced by means of incandescent filaments mounted within the tube and capable of providing ions of thermic origin animating by their movements the electrode ions at rest or insufficiently animated which may have the effect of lowering the discharge potential within the tube. The entraining movement may also be given by means of intermediate electrodes suitably arranged.

The arrangements according to the invention have a particularly advantageous application in the formation of luminescent discharge tubes. It may be mentioned that the spectral flame of alkaline and alkaline-earth metals, apart from its luminous intensity, is in the neighbourhood of the spectra of luminescent gases. It is moreover possible with these metals, by regulating the metallic vaporisation, to admit into the discharge tubes, intensities which can reach up to two amperes even for a reduced surface and volume of metal, and this without any modification of the light spectrum of the discharge nor exaggerated heating of the electrodes and especially without any accident. In comparison with the electrodes of ductile metals such as copper, iron, etc. the variation in temperature is practically nil. Even for high intensities, the temperature of alkaline or alkaline-earth electrodes does not rise above 100° C, so that the dielectric value of the glass remains constant. On the other hand when using electrodes of ductile metal, when the intensity is increased the temperature may rise to 1000° C and the glass then becomes conductive, which, having regard to the difference of pressure between the interior and exterior of the envelope, causes the glass to crack under the effect of the ignition.

On the other hand, in luminescent tubes employing rare gases, the use of electrodes having a base of alkaline and alkaline-earth metals under the conditions provided by the invention, also makes it possible to decrease the fall in potential whilst maintaining the ionic energy produced by the luminous emission, thus confirming the works of Wood and Einstein. The starting and working potentials which are used may be lowered by 40% with respect to the potentials which are necessary with the electrodes of ductile metals, which permits of reducing the secondary voltage of the transformers employed. The starting potential is also reduced from a high potential. Furthermore, the ionisation of the gaseous column being prepared by the quality of the metals, is more rapidly obtained as soon as the metals are excited. In accordance with the works of Weinehalt and Bloch the speed and power particularly of the alkaline-earth ions is 80% greater than of those of amorphous metals used in the existing electrodes. The luminous emission moreover which is obtained is more intense, because of the agreement of the spectra in question (rare gases and alkaline or alkaline-earth), the effects of these spectra supplementing one another. Finally the heat given off due to the resistance of the electrodes being practically nil, a more rational use is being made of the lighting current. In all, it is possible to realise on the consumption of current an economy which may reach 50% of the primary of the transformer.

Likewise as a result of the description given above the main disadvantages of the electrodes which normally contribute in reducing the life of the discharge tubes are overcome. In particular the discharge of gaseous atoms joined with metallic atoms into the atmosphere of the tube is made impossible, since the metal of the electrode has, before being finally located in position, been subjected twice to being melted and to a vaporisation in vacuo. The iono-metallic emanation can no longer give place to any liberation so that the purity of the gases is maintained. During the ionic movement moreover a normal exchange of metallic atoms is produced together with, as illustrated above, a reconstruction of the whole of the electrode. Finally the very low temperature of operation of the tubes avoids discharge from the glass walls, which have been moreover thoroughly cleansed during the bombardment of the electrodes. The life of the tubes is therefore considerably increased, without their resistance undergoing any substantial variation whatever may be the length of their life.

Another important advantage of the invention already mentioned above, is the possibility of using, without risk of accident, ordinary glass for the manufacture of the electric discharge tubes. The normal use of ordinary glass avoids the complications of working with special glasses which will resist high temperatures, and makes it possible to have recourse to glasses tinted chemically or naturally thus increasing in considerable proportions the range of colours obtainable.

On the other hand electrodes having a base of alkaline or alkaline-earth metals improved in accordance with the invention lend themselves perfectly to the formation of blue or other coloured tubes, employing a neon or argon atmosphere or any other rarefied gases or atmospheres in the presence of mercury, using certain proper measures for preventing the formation of amalgams between the mercury and the alkaline or alkaline-earth metals. For this purpose it is possible for example to provide a restriction C_2 (Figure 9) at the end of the cup C enclosing the alkaline or alkaline-earth metals. Another method consists in providing a soldered double joint 0 (Figure 10) on the middle of the lighted part of the tube. Mercury vapours may be applied to the internal walls of the tube; and to enable the traces of mercury to adhere the internal walls of the tube may be roughened by being slightly attacked with fluorhydric acid. These last mentioned arrangements may advantageously be combined with one or other of the arrangements shown in Figures 9 and 10.

It has also been found that when using as electrodes for the discharge tubes certain alkaline-earth metals which are freed from any trace of impurities, it was possible to re-create, more particularly with an argon atmosphere, the spectral line 2536 of the mercury which it is desired to obtain especially for exciting ultra-violet rays.

The invention is also applicable, with the same advantages, to the production of discharge tubes comprising phosphorescent, fluorescent or opaline glass screens. In this application, in order to avoid transparent spots, the electrodes may be hooded by one or more covers of glass or other isothermic material not giving off gases or vapours and to provide a grid to stop the projected ions and to localise them on the metal of the electrode. Various shapes of hoods may be used for this purpose. Figures 12 to 17 of the accompanying drawings show by way of non-limiting example schematic sections of various forms which may be employed.

In Figure 12 the hood is formed by a simple cover *c* covering the cup C which encloses the alkaline or alkaline-earth metal. The section of this cover is preferably 2 or 3 mm. greater than that of the cup; its purpose is to gather the projected ions towards the bottom of the electrode at *a*.

In Figure 13 the hood *c* fits into the cup C and a lip c_1 holds it in position.

In Figure 14 the hood *c* likewise fits into the cup C but it is extended to the bottom thereof and rests on this bottom.

In Figure 15 the hood *c* is replaced by a simple disc *d* for example of mica resting flat on the edge of the cup C, this edge preferably being of irregular section.

Figures 16 and 17 show arrangements similar to those in 12 and 13 but in these figures the hood c is provided at its centre with a hole c^2 having inwardly turned lips, in order that the stream of the ions shall not be too broken at high intensities.

Another advantageous application of the invention consists in using Wood's glass tubes or similar tubes, provided with electrodes having a base of alkaline or alkaline-earth metals made in accordance with the arrangements described above, to excite the fluorescence or phosporescence of any materials having such properties. The electric discharge tubes may thus particularly be employed for outlining, framing or decorating objects having a base of or covered with fluorescent or phosphorescent materials.

The improved electric discharge tubes according to the invention may also be advantageously applied to radio. In this case their employment eliminates radiophonic parasites produced by bad contacts and generally observed in ordinary discharge tubes having ductile metal electrodes. Because of the impossibility of intimately combining the elements which normally form these electrodes (for example tungsten with copper or the alloy known as "copper clead" with iron) these elements are simply connected by being clamped together so that the differences of expansion produced during heat treatment of the electrodes produces retractions and gaps which form parasites by bad contact when the apparatus is operating at a high alternating potential. On the other hand, in tubes provided with electrodes according to the invention, the conductor leading the current to the electrode is in direct contact with the alkaline or alkaline-earth metals, which have been first melted and then vaporised, and this ensures an intimate welding between them and enables all parts of the electrode to be at the same potential. Furthermore the radiophonic troubles produced by electric combination at a distance are eliminated by reason of the adherence of the alkaline or alkaline-earth metals to the walls, avoiding the formation of intermediate electrodes.

Another useful application of the invention lies in the formation of non-filament lamps for lighting purposes using a rare gas atmosphere. The use of ordinary glass for the envelope, ensured by the invention, enables in particular the incorporation into the material of this envelope of fluorescent or phosphorescent colouring materials, which, in combination with mixtures of rare gases and metallic vapours, make it especially possible in a single tube to approximate to daylight as far as the main rays are concerned. One may thus obtain as closely as possible an approximation to the light suitable to the retina of the human eye. By suitably varying the combinations set out above it is possible also to obtain any desired coloured effects, for example for decorative purposes. It has moreover been found with electrodes having an alkaline or alkaline-earth metal base according to the invention that the excited spectra are fog-piercing, so that they may with advantage be employed in lamps for buoys or for signalling purposes. In any case the non-filament lamps having electrodes in accordance with the invention produce an economic light since there is practically no dissipation of energy in heat form.

For a gap of about 5 cm. between the electrodes the starting potential of the lamps with alternating current is about 110 volts, so that these lamps may be used in current distribution networks. This potential may be further lowered if metallic vapours with rare gases are used, but this may produce transparent spots on the walls of the lamps, thus destroying the regularity of the light. These spots can however be avoided by providing points or hoods on the electrodes similar to those described above.

It is to be understood that what has been stated above concerning the possibilities of using ordinary glass does not exclude the possibility of making the tubes and lamps according to the invention of glass of any composition or quality, coloured or not.

Lastly, it is also to be understood that the improvements to electric discharge tubes and lamps forming the subject of the invention are generally applicable both for high frequency purposes and for high potentials. It is also to be noted that the length of the luminous wave would appear to have greater interest in the field of high frequency than in that of high potential. The use of high frequency moreover makes it possible, for low intensities where ionisation by impacts is sufficient, to suppress certain intermediate electrodes required for discharge tubes and lamps operating at high pressure.

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