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APPARATUS FOR DEVELOPING LIGHT

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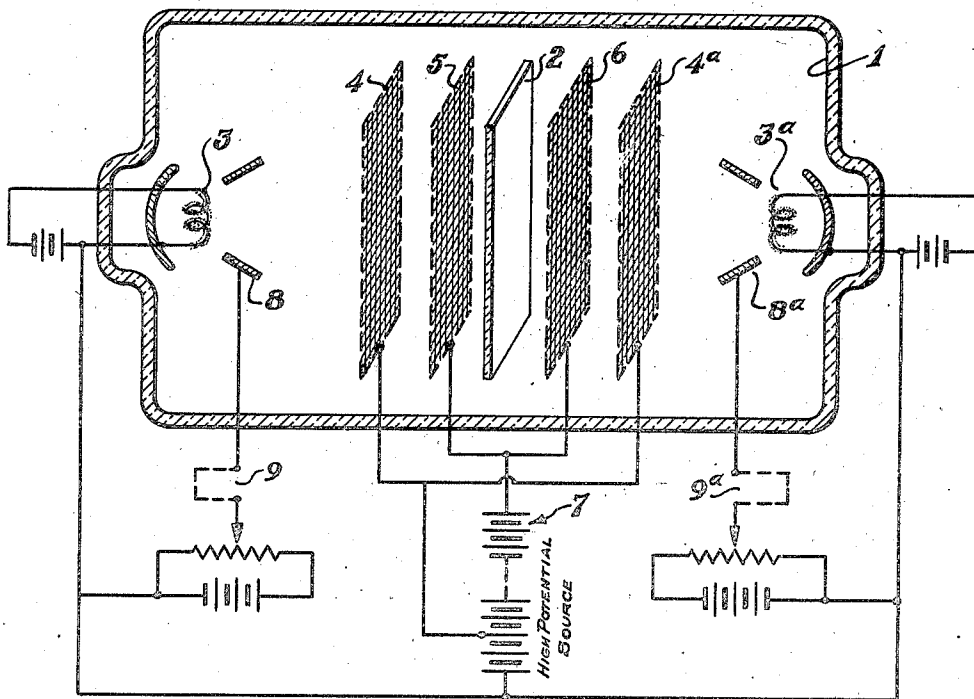


FIG. 1

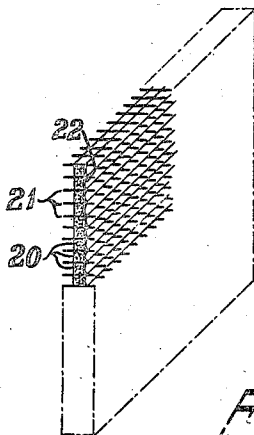


FIG. 2

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APPARATUS FOR DEVELOPING LIGHT

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4 Claims. (Cl. 176—122)

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My invention relates to a highly efficient method and structure for providing light by cathode ray bombardment of materials such as phosphors, incandescent or refractory materials and dielectrics in general and more particularly to cathode ray tubes incorporating targets of luminescent, dielectric or incandescent materials.

In prior cathode ray tubes utilizing luminiferous materials such as luminescent or incandescent targets it has been customary to scan targets to develop light on one side and to view the opposite side by reason of the translucency of the target. Such arrangements are inefficient and, in addition, for general illumination one side of the target is of lower intrinsic brilliance than the scanned side. In addition, such targets have been provided on a foundation of glass or other material and it is difficult to design a tube with the proper target thickness to most effectively utilize the cathode ray energy. Furthermore, it has been found that incandescent targets when of sufficient thickness to utilize the incident cathode ray energy have excessive thermal inertia so that their use in television applications has been impractical.

It is an object of my invention to provide a tube and method for developing light of high intrinsic brilliance. It is another object to provide a more efficient light source of the luminescent or thermal incandescent type. It is a further object to provide a luminous target having substantially the same luminosity on both sides thereof, and it is a still further object to provide a thin target structure excited by high-velocity cathode rays wherein the total energy in the rays may be utilized. In accordance with my invention, I develop a beam or flood of high velocity electrons, accelerate the electrons toward a luminiferous target which is semi-permeable to the electrons so that those electrons which are not absorbed pass therethrough, and I then redirect the electrons to the target, repeating these steps until all of the energy of the electrons is absorbed. These and other objects, features and advantages of my invention will be apparent to those skilled in the art when considered in view of the following description and the accompanying drawing wherein;

Figure 1 is a partial perspective view of a tube made and operated in accordance with my invention, and

Figure 2 is a perspective view of a modified target electrode for use in the tube of Figure 1.

Referring to Figure 1, the tube comprises an evacuated transparent envelope 1 preferably of

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elongated form enclosing a centrally positioned imperforate target 2 which may be of luminescent or incandescent material. Such targets are well known in the art, although as explained hereinafter, the thickness and composition of the target 2 is predetermined in accordance with the excitation electron velocity. In accordance with my invention, I excite the target 2 either to luminescence or thermal incandescence depending upon the material comprising the target from one or both sides, and I so choose the target material and thickness as well as the velocity of the excitation means, such as the electron velocity, that the target 2 is penetrated and I then redirect the electrons passing through the target to the side thereof opposite from the side of original incidence. As indicated the target is imperforate, although a few electrons, such as fewer than 1% per cent of the electrons incident on one side thereof, may pass through the target unhindered. Referring again to the figure, I provide an electron source or cathode 3 at one end of the tube and preferably an electron accelerating anode 4 between the target 2 and the cathode 3 which may be of wire mesh as shown or a conductive coating on the inner envelope surface between the cathode 3 and the target 2. In addition, I provide a second anode 5 to accelerate the electrons liberated by the cathode 3 immediately adjacent the target 2 so that electrons are incident thereon at high velocity. Alternatively only a single anode either of the wire mesh or conductive coating type may be used. On the opposite side of the target 2 from the cathode 3 I provide an auxiliary anode 6 preferably maintained at the same potential as the anode 5, such as by the potential source 7.

While it is not necessary to provide an additional electron source or sources within the envelope 1, the structure may be made entirely symmetrical and improved operation obtained by providing a second cathode 3a and a second first anode 4a in corresponding position to the anode 4 but on the opposite side of the target 2. As referred to above only a single anode is essential, one adjacent each side of the target where dual cathodes are used. Adjacent each of the cathodes 3 and 3a I optionally provide a modulating electrode 8 and 8a respectively so that the electron intensity liberated by the cathode or cathodes may be controlled or modulated such as by impressing a modulating potential across the terminals 9—9a, the dashed line shunt across these terminals indicating operation without modulation.

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In operation electrons liberated by the cathode 3, modulated if desired by the electrode 8, are directed by the first anode 4 and are accelerated to a high velocity by the second anode 5, becoming incident upon the target 2. In this mode of operation the electrons are provided with energy exceeding that which may be absorbed by the target 2 in developing light and many of the electrons pass through the target 2 into the electrostatic field of the auxiliary anode 6. These electrons are then re-accelerated by the auxiliary anode 6, passing therethrough in the direction of the cathode 3a. Since these electrons originated at source 3 which is at the potential of cathode 3a, the remaining velocity following penetration will be absorbed in approaching the cathode 3a, and because of the electrostatic field exerted by the auxiliary anode 6, will again be directed toward the target 2, impinging thereon and penetrating as before, whereupon the action on the electrons is repeated, the second anode 5 acting in a manner similar to the auxiliary anode 6. In a symmetrical structure the same mode of operation is performed, simultaneously utilizing electrons from the cathode 3a whereupon the anodes 4a and 6 are the first and second anodes respectively and the anode 5 may be considered as the auxiliary anode for directing and re-accelerating the electrons from 3a penetrating the target 2.

However, in the event that the second cathode 3a and its associated structure is not used, the fundamental operation of the tube is unaffected because in the absence of the cathode 3a electrons penetrating the target 2 will approach the end of the tube which will acquire a negative potential due to initial incidence of electrons, further electrons being reflected into the field of the auxiliary anode 6 so that they may re-penetrates the target 2.

The spacing between the anodes 5 and 6 with respect to the target is not critical, although for certain applications such as in television receiving tubes, minimum spacing is desired to minimize the spreading of the electron beam. Such spreading may be further obviated by immersing the target or envelope in a magnetic field having lines of force normal to the target surface or parallel with the electron beam direction. Obviously, in television arrangements, means, such as magnetic deflection coils, may be provided for scanning the electron beam from an electron gun or cathode such as the cathode 3 as well known in the art on such tubes. Likewise, the structure of the anodes 5 and 6 may be varied to meet the particular tube application. Thus these anodes may comprise open wire mesh such as four wires per linear inch horizontally and vertically, the wire diameter being about .002". Similarly, the anodes 4 and 4a may be closely spaced with respect to the anodes 5 and 6. For high voltage operation, that is, above 15 kilovolts the anodes as well as the screen are preferably of circular form surrounded by a corona shield. For example, the wires of the mesh may be supported by a rim of circular cross-section, the diameter thereof being determined by the desired operating potentials to minimize corona at high potentials for very close spacing. At high potentials the anodes may be made of progressively increasing diameter away from the target, the marginal portions thereof being bent or flared toward the cathode end or ends of the tube to allow space for the corona shields.

As indicated above, the target may be either of the phosphor, thermal incandescent or dielectric type but the thickness of the target in accord-

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ance with my invention is chosen with respect to the desired operating potential so that the electrons following initial incidence are not absorbed but in large measure pass through the target emerging with diminished velocity. If of luminescent material, the target may be either of the single crystal type as described in my copending application, Serial No. 348,790, filed July 31, 1940, in which event the target is of imperforate phosphor material preferably of a single sheet-like crystal. However, the target may be of finely crystalline phosphor material supported upon an electron-permeable foundation of wire mesh. Thus such a target, while of imperforate form, is nevertheless chosen sufficiently thin as to be permeable to the electrons incident thereon.

Referring to Figure 2, I have shown a target incorporating the functions of the anodes 5 and 6 wherein the luminescent material 20 of predetermined thickness is supported between fibrillar or ciliary projections 21 of metal or other electrically conducting material. The projections may be connected together electrically by a thin substantially transparent metal film 22 which is connected to the positive terminal of the potential source 7. With such a construction the luminescent material is still penetrated by the electrons notwithstanding the imperforate character of the target.

The target, if of the thermal incandescent type, may be of refractory metal foil or of cerium and thorium oxides and may be made by impregnating a sheet of fabric with cerium and thorium nitrates followed by burning to convert the nitrates to the oxides. However, in accordance with my invention, the thickness of the target is designed so that the electrons may penetrate the target one or more times, each penetration being followed by re-direction toward the target.

As an example of operating potentials, the anode 5 or both of the anodes 5 and 6 may be operated at 60 kilovolts, in which event the target 2, if of zinc silicate phosphor, should have an effective compact thickness not greater than 60 microns, preferably being about 5-10 microns thick. The penetration varies inversely with the atomic weight of the elements comprising the target material. Consequently, screens of phosphors such as luminescent tungstates should be thinner than those of phosphors of the sulphide or silicate type. Similarly, the maximum penetration thickness of thermal incandescent and other targets may be easily calculated by the method of my paper in the Journal of the Optical Society of America, volume 27, No. 1, pages 25 to 27. Since the electrons following each penetration of the target are re-accelerated and the action is cumulative by the addition of further electrons from the source 3 or 3a, the operation may be interrupted by removal of potential from the auxiliary anode or anodes or by momentary shorting of the cathode to the anode. If no means are provided for interrupting operation, space charge limitations will occur limiting the operation to equilibrium conditions.

It will be appreciated from the above description that my invention is not limited to the specific apparatus embodiments set forth but that many variations both in structure and materials may be made. Furthermore, my method of developing light is not restricted to the specific apparatus herein set forth, inasmuch as the various steps of my method may be performed by other structural equivalents or by manual means. For example, the beam of electrons may be developed

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photoelectrically or frictionally, the beam may be accelerated by subjecting the beam to an electrostatic field of any controlled extent, a portion of the beam energy may be absorbed to develop light by manually introducing an absorbent, such as a rarified atmosphere, in the beam path followed by re-acceleration and absorption by a second introduction of the absorbent. Consequently, the extent and scope of my invention should not be limited except as specifically set forth in the appended claims.

I claim:

1. Apparatus for developing light comprising a cathode and anode to develop a beam of high velocity electrons, an imperforate luminiferous material target sufficiently thin as to allow a part of the electrons in said beam to pass there-through with diminished velocity and an anode adjacent said target on the side thereof opposite said cathode to re-direct and accelerate the electrons passing through said target back to said side of the target.

2. Apparatus for developing light comprising a cathode to liberate electrons, an anode to accelerate said electrons to high velocity, an imperforate electron permeable luminescent screen directly in the path of said electrons from said

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cathode and an auxiliary anode on the opposite side of said screen to re-direct and accelerate back to said screen the electrons passing there-through.

3. Apparatus for developing light comprising an electron permeable imperforate luminescent screen, a cathode directly exposed to said screen positioned to emit electrons, cooperating anodes one on either side of said screen said anodes being connected together and adapted to be maintained at high positive potential with respect to said cathode, one being adapted to impel electrons through said screen and the other to impel them back thereto.

4. Apparatus for developing light comprising an evacuated envelope, an electron permeable imperforate target of luminescent material, a cathode facing each side of said target and an anode between each of said cathodes and said target to initially accelerate electrons to a sufficient velocity to pass through said luminescent material, each of said anodes adapted to direct to said screen the electrons passed therethrough by the other.

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