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H. MAHL

2,264,541

ELECTRON DISCHARGE DEVICE

Original Filed June 25, 1938

Fig. 1

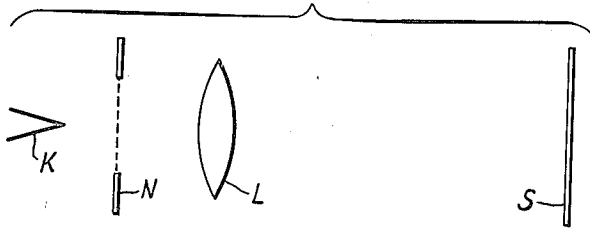


Fig. 2

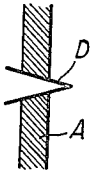


Fig. 3

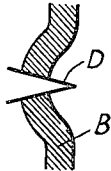


Fig. 4

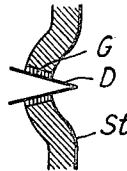


Fig. 5

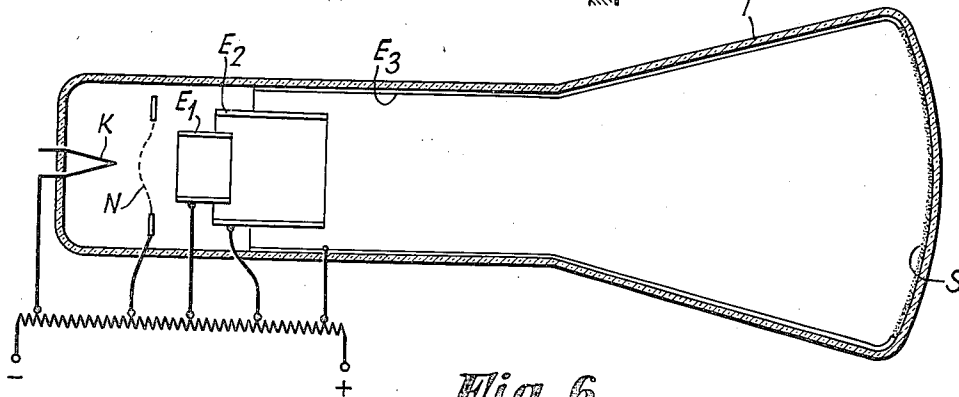
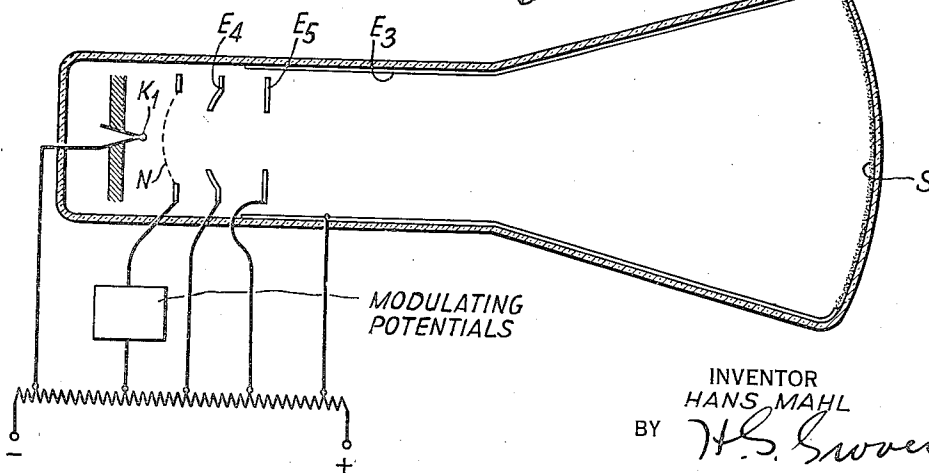


Fig. 6



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ELECTRON DISCHARGE DEVICE

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Original application June 25, 1938, Serial No. 215,749. Divided and this application December 14, 1938, Serial No. 245,564. In Germany June 30, 1937

4 Claims. (Cl. 250—27)

This invention relates to electron discharge devices and more particularly, to the methods and means for improvements in producing and operating such devices of the class known as cathode ray tubes.

This application is a divisional of my copending application Serial No. 215,749, filed June 25, 1938, Patent No. 2,223,040, dated November 26, 1940, and entitled "Electron discharge devices."

It is a well known fact that one of the reasons which make the production of intense spots of minimum size inside a high vacuum as required especially in electron-ray tubes such as cathode ray oscillographs or television tubes so difficult, is the lack of adequate electron density of the incandescent cathode employed therefor. The best high emission cathodes such as oxide cathodes have a maximum specific emission of an order of magnitude of 1 amp. per sq. cm. Any substantial increase beyond this limit may not be expected from cathodes of this kind. To overcome this shortcoming, this invention proposes to use cathodes of the so-called "auto-electric" type wherein emissivity of electrons is brought about by local high electrostatic field intensity. In fact, at such local points, it is feasible to realize current densities of a few thousand amperes per square centimeter.

Such a cathode in which emissivity is predicated upon the presence and action of local electrostatic high field intensities may be used in conjunction with suitable electron-optical means so as to provide spots focused down to an extremely small size or area with very intense currents. In order that a well defined punctiform emission may be obtained it is possible to use for the cathode an extremely slender or fine wire point for which, as known, the maximum field intensity arises at the point of minimum curvature. In the presence of proper electron-optical focusing systems, it is feasible to secure a minute punctiform image of emissive surface even where the enlargement is quite sizable, as for example, 10 times, inasmuch as the emissive spot of the pointed cathode is of an order of magnitude of around 10^{-8} sq. cm. But satisfactory electron optical imaging of an auto-electrically emitting point, especially when an electrostatic lens is used, is attended with difficulties insofar as the potentials required at the various electrodes of the electrical lens for focusing introduce problems of providing the necessary field intensity at the cathode. To obtain auto-electric emission a predetermined high electrostatic field intensity is necessary. However, it would be rather difficult

to make conditions such that the field intensity produced by the lens (which, as a general rule is small) will suffice to occasion any appreciable field emission.

According to this invention, in order to produce the requisite high field intensity, a reticulate (grate or lattice) or grid structure or a foil is interposed between the cathode and the electron-optical focusing or imaging system. The use of such grids or foils has been used in connection with a thermionically or a photoelectrically operated cathode. In these arrangements this scheme is intended either to preclude the arising of an electron space-charge or else to secure a substantially homogeneous accelerating field. However, the arrangement here disclosed is entirely different therefrom since the grid or foil according to this invention is intended to create as high as possible a field intensity in front of the cathode under conditions causing as little reduction of the field as a result of grid transparency as possible.

The foil may be placed upon a reticulate structure, a lattice, grid, grate, or the like. While the grid or foil, as a general rule may be flat or planar, it is further provided to make the grid or foil curved so as to avoid or lessen distortion occasioned by the aberrations of the lens system.

In the drawing, a number of exemplified embodiments of the means here disclosed are shown by the aid of which the invention shall be explained in more detail. At Fig. 1 is schematically an arrangement of elements in accordance with the invention; Figs. 2, 3 and 4 show various embodiments of the cathode structure in accordance with the invention, while Figs. 5 and 6 show diagrammatically two detailed embodiments of the invention. Fig. 1 shows the fundamentals of the arrangement. K denotes the cathode, N is the grate or grid structure or the foil, L is the electronic lens, and S the luminescent screen of a cathode ray tube.

It is vital and essential in this invention that the cathode be positioned properly with respect to the electron lens system in order that the high concentration of field-force lines at the cathode shall not distort the field force lines of the electron optical system. If the cathode itself consists of a pointed or tapered slender wire, the disturbing actions occasioned by this point or peak inside the acceleration field must be eliminated to a large extent if electron-optic focusing is to be made possible. To avoid such interaction of fields, the point may be set into a disk which may be either planar or curved so that the point

protrudes therefrom only to a slight degree, say, .5 millimeter (Fig. 2). Another method of embedding or setting the point is illustrated in Fig. 3 where the point is fitted into a cup-like depression of the disk with the result that the peak no longer projects above the plane of the disk.

In order that the intensity of field emission and thus the point or spot brilliance may be varied with low voltages as well, the cathode may be surrounded by a control electrode, and the latter, as illustrated in Fig. 4 may be of disk shape, the cathode being arranged in a depression thereof while being insulated therefrom. Fig. 4 shows a disposition of this nature. D indicates the auto-electrically emissive wire point (zero potential); St is the control electrode which may be maintained at a potential of (± 0.1 kv.), and G an insulation layer such as a vacuum or a vacuum-stable substance like mica. To enhance the field emission the point or peak is activated by alkali or earth-alkali substances, the latter being applied by vaporization to provide a coat of the desired thickness or depth.

A particular embodiment of the assembly is shown in Fig. 5. K is the cathode having an auto-electrically emissive peak or point, N denotes the reticulate electrode or grid placed about 1-10 mm. from the cathode, kept at a potential of say 5 kv. in reference to the cathode. The electrical lens here consists of several cylindrical electrodes. E₁ is the first imaging or focusing cylinder which may be maintained at a voltage of .3 kv. in reference to the cathode. E₂ is the second focusing cylinder kept at about 1 kv. potential. E₃ is the third focusing cylinder maintained at 3 kv. S again denotes the luminescent screen which may be maintained at the same potential as E₃. Fig. 6 shows a corresponding disposition in which the electrodes E₄ and E₅ are of the diaphragm type. It will be understood that instead of the electrical lenses indicated in the exemplified embodiments Figs. 5 and 6, it would be feasible also to mount magnetic lenses or use both kinds simultaneously.

What I claim is:

1. A cathode-ray tube system comprising an envelope having an end wall, a fluorescent screen mounted on the end wall, an auto-electric electron emissive cathode positioned in register with said screen, means including a surface-of-revolution reticulate electrode for reducing aberration distortions, said electrode being positioned closely adjacent to the cathode and intermediate the cathode and screen, a plurality of focusing

electrodes intermediate reticulate electrode and said screen, and means to maintain said reticulate electrode and said plurality of electrodes at progressively increasing positive potentials with respect to the cathode.

2. A cathode-ray tube system comprising a fluorescent screen, an auto-electric electron emissive cathode, a disk electrode for supporting the cathode, a surface-of-revolution reticulate electrode closely adjacent the cathode, a plurality of electrodes intermediate said reticulate electrode and the screen, means to maintain said reticulate electrode at a positive potential with respect to the cathode, means to maintain each of the plurality of electrodes at a more positive potential with respect to the cathode than said reticulate electrode, and means for varying the potential of said reticulate electrode by modulating potentials.

3. A cathode-ray tube comprising a luminescent screen, a conducting disk electrode having a depressed central portion, an auto-electric electron emissive cathode supported from the center of the depressed portion of said disk electrode, a surface-of-revolution reticulate electrode closely adjacent the cathode, a plurality of electrodes intermediate said reticulate electrode and the screen, means to maintain said reticulate electrode at a positive potential with respect to the cathode, means to maintain each of the plurality of electrodes at a more positive potential with respect to the cathode than said reticulate electrode, and means for varying the potential of said reticulate electrode by modulating potentials, said disk electrode serving to reduce focusing distortion of electrons.

4. A cathode-ray tube comprising a luminescent screen, a conducting disk electrode having an insulated central portion, an auto-electric electron emissive cathode supported from the insulated central portion, a surface-of-revolution reticulate electrode closely adjacent the cathode, a plurality of electrodes intermediate said reticulate electrode and the screen, means to maintain said reticulate electrode at a positive potential with respect to the cathode, means to maintain each of the plurality of electrodes at a more positive potential with respect to the cathode than said reticulate electrode, and means for varying the potential of said reticulate electrode and said disk electrode by modulating potentials.

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