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ELECTROSTATIC WRITING TUBE

Filed March 14, 1960

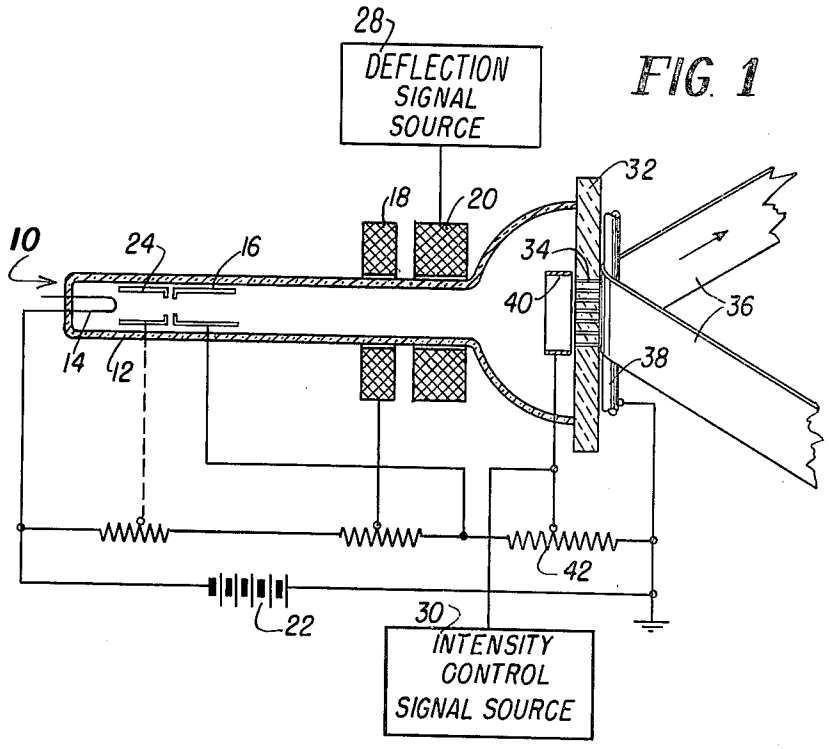

FIG. 1

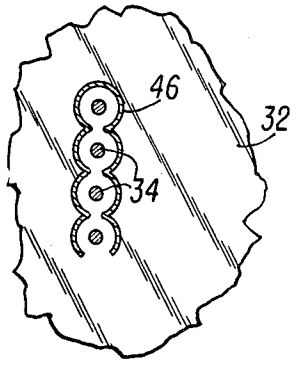

FIG 3

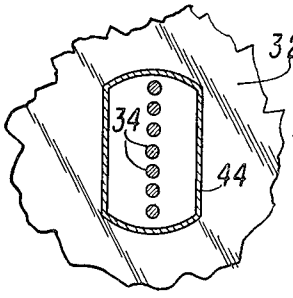

FIG 2

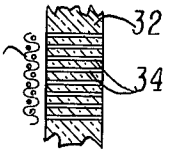

FIG. 4

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ELECTROSTATIC WRITING TUBE

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This invention relates in general to an improved arrangement for electrostatic printing and more particularly relates to an electrostatic printing tube utilizing secondary emission characteristics to control image reproduction.

Electrostatic writing tubes generally comprise a cathode ray tube structure, such as the type disclosed in an application by John S. Tregay, Jr., Serial No. 658,275, filed May 10, 1957, and now abandoned, in which a high voltage electron beam is caused to impinge upon an array of conductors embedded in the non-conductive tube face. The beam is varied in accordance with an object, whose image is to be reproduced and traverses the array at a predetermined scanning rate to repetitively charge the wires of the array accordingly. A properly sensitized dielectric material such as paper, which is simultaneously traversing the wires at the exterior of the tube face, reproduces the image by means of the discharge occurring between the respective wires of the array and a suitable potential provided behind the dielectric.

In the described tube the high voltage beam is modulated by signals representing the object to be reproduced. As this beam is in the neighborhood of —10 kv., load fluctuations on the high voltage power supply creates conditions having considerable effect on those modulations thereby imposing severe design limitations. In addition, problems in image resolution occur due to comparatively unconfined impact area of the beam, the unconfined discharge condition occurring between the wires and the dielectric, and the defocusing effect on the primary beam created by voltage change on the wires.

The present invention takes advantage of the known phenomena of secondary emission for overcoming the described and other disadvantages. This phenomena is characterized by the emission of secondary electrons occurring when a material is bombarded by primary electrons or other particles. The area of emissions is largely confined to the area of impact and the number of secondary electrons emitted depends upon the beam energy level. For a given material, the number of secondary electrons emitted is less than the number of primary electrons bombarding the same, until an energy level of approximately forty to fifty electron volts is reached, commonly known as the first cross-over point. Thereafter the ratio of secondary electrons to primary may exceed 8 to 10, thus providing a high degree of amplification. At much higher energy levels, a second cross-over point takes place after which the number of secondary electrons decreases and becomes less than the number of bombarding particles. This is apparently due to the depth to which the primary beam penetrates at high energy and the release of secondary electrons at such depth prevents their escape.

An electrode, in which secondary emission in excess of the primary beam is occurring, reaches a condition of equilibrium with the surrounding electrodes, when the number of electrons entering it equals the number leaving. In the described printing tube, this will occur when the bombarded electrode becomes slightly positive in relation to an adjacent or collector electrode, and if an external load is attached to the electrode, equilibrium will occur when the external load current plus the primary beam current equals the collector current.

In the present invention the printing tube is therefore

arranged with an interior collector electrode adjacent to the standard wire matrix. By operating the beam below the second cross-over point and by proper selection of material, electrons are made to flow from the surface outside of the printing tube through the respective wires of the matrix to the collector electrode. The magnitude of the image, therefore, will approximately equal the collector potential so that an image signal can be applied to the easily accessible collector electrode, which may be maintained near ground potential, and in addition current amplication can be secured. As the signal is not applied to the electron gun for modulating the primary beam, a steady primary beam is utilized, which minimizes the effect of supply voltage variations and attendant design problems. In this arrangment a comparatively small diameter beam can be used and the area of secondary emission is confined to the impact region of the primary beam. It is, therefore, less scattered than images relying on the modulation of the beam, while the voltage change on individual wires does not exert the described defocusing effect.

Accordingly, it is an object of the present invention to provide an electrostatic printing tube having improved image resolution.

It is another object of the present invention to provide an electrostatic printing tube having an electron beam of constant magnitude.

It is another object of the present invention to provide an electrostatic printing tube in which a low voltage control electrode is modulated by signals to be reproduced as an image.

It is still another object of this invention to provide an electrostatic printing tube in which current amplification is secured.

A feature of this invention is the operation of a primary electron beam in an electrostatic printing tube at a voltage sufficient to produce secondary electrons at more than equality with the primary.

It is another feature of this invention to provide a collector electrode in an electrostatic printing tube.

It is another feature of this invention to modulate a low voltage control electrode with a signal representing an object to be reproduced.

These and other objects and features and advantages of this invention will become apparent on reading the following specification and claim in conjunction with the drawings of which:

FIG. 1 is a cross-sectional view of an electrostatic writing tube including a collector electrode.

FIGS. 2, 3 and 4 are different respective configurations of the collector electrode.

Referring now to FIG. 1 showing a cross section of the electrostatic printing tube incorporating the principles of the present invention, it will be seen that the tube indicated at **10** is similar to a conventional cathode ray tube. It includes an evacuated envelope **12**, which carries a cathode **14**, an anode or accelerating electrode **16**, a focus coil **18** and a deflection coil **20**. The cathode is connected to the negative terminal or high voltage supply **22**. The conventional control grid **24** may be given a suitable bias for the purpose of providing a desired primary beam.

The deflection coil **20** is controlled from a suitable deflection signal source **28**, for controlling the beam produced at the cathode **14**.

In addition the tube includes any well known type of face plate **32** of dielectric material in which the wires **34** are carried or embedded. Adjacent the terminations of the wires, exterior of the tube, a suitable dielectric material **36** is provided for recording the image. It is moved in the direction indicated by the arrow and has

associated on its other side a conductor **38**, at ground potential whereby discharge from the wires through the dielectric is accomplished.

On the inside of the tube **10** and adjacent the interior terminations of the wires **34**, is a collector electrode **40**. Electrode **40** is preferably connected to a point on resistor **42**, between the terminals of source **22**, which maintains it at a negative value with respect to the wire **34**, although by proper selection of resistance values, it may be alternatively maintained at ground potential. Connected between resistor **42** and the collector **40** is an intensity control signal source **30**, which provides signals corresponding to the object reproduced.

In operation, the primary beam is of course directed to the various wires **34**, in accordance with the desired scanning rate, while the image reproducing dielectric **36** passes adjacent these external terminations of the wires. The potential source **22** furnishes a voltage of sufficient magnitude to provide a primary beam, which exceeds the first cross-over point to produce secondary emission in the respective wires **34**. These electrons largely appear at the internal terminations of the wires where the beam strikes, and leaving the external terminations positive. The potential at which collector electrode **40** is maintained, establishes the equilibrium condition of the electron cloud. The collector electrode **40** is also controlled in accordance with the signals applied thereto from source **30**. Thus the signal applied at any instant varies the equilibrium electron cloud surrounding the wire matrix accordingly, so that the voltage differential between the external wire terminations and element **38** is controlled similarly.

This permits the discharge from **38** through the dielectric **36** and the respective wires of the array to proceed in accordance with the image to be reproduced.

In the arrangement it will be noted that the primary beam is operated at a constant unmodulated value and that its diameter is suitably restricted so that the area of emission is considerably limited, while the source **30** is connected at a low voltage terminal. With this arrangement the aforementioned advantages are secured.

In FIGS. 2 and 3 respective end views of different collector embodiments are shown. In FIG. 2 the collector **44** is shown arranged as a conventional cylindrical element around the projected area of the array of wires **34**, while in FIG. 3, the collector **46** is shown as partially enclosing the area adjacent the internal terminations of each wire **34**. In FIG. 4 a screen or mesh collector electrode **48** is shown parallel to and behind the wires **34** for the purpose of controlling the electron cloud. The

choice of these and other arrangements or configurations is of course dictated by the desired control to be exercised by the collector.

In accordance with the above, there has been shown and described herein a novel, useful and simple arrangement for improving the operation of an electrostatic writing tube by utilizing the principle of secondary emission and that the particular embodiments or forms of the invention described herein are not limitations upon other manners of practicing the invention.

I claim:

In an electrostatic printing tube for forming an electrostatic charge on a dielectric medium, said tube comprising an evacuated envelope with a cathode at one end directing an electron beam which repetitively and successively impinges on the internal ends of a series of conductive elements located at the other end of the envelope, said dielectric medium passing adjacent the external ends of said elements outside the envelope, and including an external conductor located outside of said tube in contact with said dielectric medium, the improvement comprising means for operating said beam between the known first and second cross-over points for said elements to produce secondary emissions in excess of the number of electrons in said primary beam, a collector electrode located within said envelope adjacent to and in sapecd-apart relation from the interior ends of the said conductive elements, said collector electrode being continuously maintained at a positive potential relative to said internal ends, and said external conductor being continuously maintained at a negative potential relative to said collector electrode, and a means for applying a signal to said collector electrode, said signal representing the image to be produced and operating to effect an increase in said secondary emissions for modulating said secondary emissions and to control the discharge through said dielectric situated adjacent the said external ends of said elements.

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