Photographic Electrical Copying Device

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13 Claims. (Cl. 95—1.9)

This invention relates generally to devices for recording images and particularly to electronic copying or reproducing devices, including cameras. This application is related to my U. S. Patent No. 2,409,454.

An object is to provide a copying device in which reproductions of a letter, drawing, or light-and-shadow image of any kind are permanently made in or on a sheet of paper or other material by ion bombardment.

Another object is to provide a camera in which pictures are made electronically, without chemical baths or the like.

A further object is to provide an electronic reproducer or copying device in which electron images are passed through a thin metal element to affect a sheet of material adjacent the thin metal element.

Another object is to provide an electronic reproducer in which the image is formed by a scanning sequence.

An additional object is to provide special paper or film sensitive to electronic or ion bombarding.

Other objects will appear in the specification.

In the drawings:

Figure 1 is a part sectional side elevation of an ionic type reproducer including a projector.

Figure 2 is a fragmentary front elevation, in part section, of a leak-proof roller drive for the device of Figure 1.

Figure 3 is a part sectional side elevation of an electronic camera, shown partly broken away.

Figure 4 is a schematic elevation of a lens and electronic system for use in electronic cameras or other reproducers.

Figure 5 is a part sectional side elevation of a scanning-type electronic reproducer employing a rotary drum and reels.

Figure 6 is a sectional side elevation of a perforated mask and associated evacuated element including a photosensitive surface and thin metal anode.

Figure 7 is a top plan view, in part section, of a scanning-type electronic reproducer employing movable parallel arms for holding the object to be copied and the paper to be imprinted or otherwise affected.

Figure 8 is a part sectional elevation of a novel drive for sealed containers, allowing objects within the container to be moved in proportion to movement of a member outside the container.

In Figure 1, glass container 1 has plane transparent wall 2 and the remainder of the container can be covered with opaque material. Cover 3 is pivoted to the container by attached hinge 4 and top rubber gasket 5 is provided so that the cover may be held down by a suitable clamp (not shown) to seal the top edge against leakage of air or other gas. Two uprights 6 are joined by cross pieces 7 and have attached arms 8 serving as bearing supports for small rollers 9 over which ion-sensitive paper or sheet 10 is movable. This paper is rolled from reel 11 to reel 12, the axle of which is supported in slots 13 in uprights 6, as bearings. The ends of the axle of reel 11 may be held in depressions in spring clips 14 attached to uprights 6, so that the clips serve as bearings. The reels can be easily removed by lifting them. Uprights 6 may be set into the container or fastened.

Photomissive cathode 18 of relatively fine mesh is suitably supported in the container and is electrically connected with conductor 16 sealed in a wall of the container and serving to connect the cathode to the negative terminal of battery or other voltage source 17 the positive terminal of which is connected with apertured anode 15 which may be of relatively coarse mesh. Cathode 18 comprises relatively fine mesh wire screening and is coated with photosensitive material like caesium, silver-caesium combinations or the like, or copper oxide. The plane of cathode 18 is substantially parallel with the plane of wall 20 or wall 2.

Anode 15 is made of metal screening and is generally parallel and coextensive with cathode 18 and is suitably supported adjacent to cathode 18. Metal plate 19 may be fastened to wall 20 of the container to serve as an additional negatively charged plate to attract positively charged gas ions, if desired. This element 19 may be of metal screening and may have connected lead 21 sealed in the container.

Pipe 22 is sealed in the lower portion of wall 2 and provides a duct for removal of air from the container by means of connected evacuating pump 23. Valve 24 connected in the pipe line can be closed when desired, to maintain a more or less definite pressure of air or other gas in container 1.

Container 1 is supported on base 26 which supports attached pedestal 25 on which cylindrical lens housing 27 is fastened. Similar smaller housing 28 can be telescoped into housing 27. These housings carry suitable lenses for focusing the image of letter or drawing 29 on cathode 18. Letter 20 is attached or supported on inclined door 30 which is pivoted to housing 27 by hinge 31 and which is normally held in the position...
shown by spring catch 32 extending from frame 33 fastened to housing 27. Reflector 34 having electric lamp bulb 35 is supported on frame 33 and directs light down against letter 29 when the lamp bulb is connected with a suitable source of electricity.

Paper 10 which is rolled on reel 11, is stretched across rollers 5 and is wound on reel 12 by manually turning crank or handle 36 shown in Figure 2. This handle is rotatable in bearing 37 fastened to container 1 and carries strong bar magnet 38. Similar magnet 39 is fastened to the other end of shaft of reel 12. Therefore, as magnet 38 is turned the magnet 39 is rotated with it and reel 12 is revolved to wind paper 10 around it. This construction prevents leakage.

Paper 10 may comprise an elongated sheet of any suitable material which is sensitive to ionic or electronic bombardment. It can be made in a variety of ways including the following:

(a) Impregnate paper with iodide crystals, or iodide and starch so that the iodine liberated or sublimed under bombardment will produce a discoloration.

(b) Provide paper with a colored layer and coat with thin metal, wax or other substance of low melting point. The wax or metal will be melted under ionic or electronic bombardment and will reveal the paper of different color.

(c) Impregnate the paper with crystals of two colorless chemicals which produce a colored substance when combined. Another crystal substance containing water of crystallization can be included if water is necessary to the reaction. Bombardment will then produce a colored compound. The chemicals can be colored but will change color under bombardment. For instance, cupric bromide is brown in solution and produces a yellow precipitate of lead bromide when reacted with lead nitrate. Similarly, limus is blue in the presence of bases and pink with acids, and phenolphthaleine is colorless in presence of acids and red or pink in presence of alkales or the hydroxide ion. Likewise, methyl orange in acid solution is red and is yellow in alkaline solution. Congo red is blue with acids and is red with neutral or alkaline solutions.

Therefore if paper is impregnated with crystals of any of these substances in proper combinations, reactions can be avoided as long as the crystals are kept dry in some cases or separate in others. Each crystal or group of crystals can be coated by a plastic film of paraffin or any suitable substance and so reaction can be avoided until the bombarding electrons or ions puncture the coating or disintegrate the crystal. Then reaction will occur, producing a colored line or area. If water is essential to the reaction various substances containing water of crystallization can be used. Some of these are Glauber's salt, strontium chloride, cupric sulphate, barium chloride, soda, calcium chloride, and the pentahydrate of cupric sulphate. The last named substance has a particularly low vapor tension and therefore will not tend to evaporate as much as Glauber's salt, for instance. These crystals containing water may likewise be coated with paraffin or other protective material. This coating can be applied by blowing the crystals through a paraffin vapor, after chilling the crystals to cause condensation of the vapor. Another method is to spray paraffin on the end of a stick which contacts the crystals either before or after placing them in the paper.

It will be seen that bombardment will puncture the coatings or will liberate the various chemicals to cause combination, in the presence of water if that is included. As an illustration, if the paper 10 is impregnated with blue litmus and one of the previously mentioned sealed chlorides, electronic or ionic bombardment will result in blue litmus turning the litmus red. Images can therefore be recorded. If permanent images are desired the paper can be impregnated with starch and minute coated crystals of iodine and water crystals or water droplets can be distributed throughout the paper. Bombardment will then release iodine which will combine with the starch paper. Many other permanent compounds can be used in similar manner.

(d) The paper can be coated with diazo dye and paraffin globules containing ammonium carbonate or ammonia. Water can be distributed throughout the paper in similar manner as described in my co-pending application, Serial No. 752,584, filed June 5, 1947, now abandoned. When this composite paper is bombarded, ammonia is released and will react with the dye to form a permanent image.

(e) It has been demonstrated that electronic bombardment causes certain carbon-containing substances to form carbon aggregates. It is possible therefore to use a clear plastic sheet or at least a colored sheet and to change its visible character by producing aggregations of carbon as a result of bombardment. Possibilities in this or similar connection are various commercial plastics, sugars, chlorophyll, carotene and the like.

(f) Small particles of ink can be contained in metal or plastic coverings or coatings and can be distributed throughout the body of a paper sheet. Bombardment will then puncture the coatings and will release the ink which will be absorbed by the paper to form a line or other indication of the bombardment pattern.

(g) Some gums are changed in color by X-rays. Materials similarly changeable in color under electron or ionic bombardment can be used.

It is assumed that the photosensitive material of the cathode is chosen so that it will not be damaged by any gases or vapors given off by the paper.

In operation, cover 3 is clamped tight and battery 17 is connected in circuit with its negative pole leading to cathode 18 and its positive pole connected with anode 15 which is assumed to be placed as shown with its sensitive side if any preferably facing cathode 18. Then valve 24 is opened and pump 23 is operated until a suitable degree of vacuum as indicated by an ionization gauge or other means is produced in container 1. Valve 24 may then be closed and the pump stopped. Lamp 35 is then illuminated by closing a suitable switch, so that an image of letter 29, which is previously placed on door 30 before the door is snapped closed, is projected onto photosensitive cathode 18 through relatively coarse mesh screen anode 15. The illuminated parts of cathode 18 will emit electrons which will be accelerated toward anode 15 and will strike and ionize some of the gas particles remaining between the cathode and anode. The positive ions are accelerated through the interstices of cathode 18 and strike ion-sensitive paper 10 and produce a visible mark. Therefore the darkened areas of the cathode will produce few electrons and will result in solution on the crystals. The crystals will produce relatively many, so that an image of letter 29 will be formed in paper 10. The ion bombardment will be in proportion to the degree of...
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Illumination of the cathode so that half tones can be reproduced or copied. If desired, plate 19 can be charged to still lower negative potential with respect to plate 18, and the cathode may be assisted in pulling positive ions against or through the paper.

When lamp bulb 35 is illuminated long enough for the ions to form an image, the lamp is extinguished and handle 36 is turned to bring a fresh section of paper into register with cathode 18. This new section is wound on reel 12 and may be marked with cross lines to show various sections. When sufficient copies are made, lamp 35 is being re-lighted for each copy, valve 24 is opened, cover 3 is unclamped and is raised and reel 12 is lifted out, the shaft ends passing through slots 15, and reel 11 may be lifted out.

The ions, being relatively heavy, exert a powerful bombarding action on the paper. A gas other than air can be admitted, if preferred, but in any case the working pressure in container 1 should be chosen for best results. The pressure should be so chosen that sufficient ions will be formed but the gas density should not be sufficient to cause excessive ion collisions or scattering of the ions by colliding with gas molecules. Some of the ions will strike the cathode which should be of a photo-emissive material sufficiently rugged to prevent serious damage. Various letters or drawings 28 can be placed in position for copying, without breaking the seal.

If it is desired to employ electron bombardment, plate 19 can be a semi-transparent photo-emissive cathode, and element 18 can be the anode. A well known semi-transparent photo-emissive cathode comprises a very thin film of silver deposited on glass or other transparent material and a thin layer of cesium or similar material deposited on the silver. In this case the container will be highly evacuated. As a modification, paper 10 can be placed between element 18 and anode 15 and an image can be projected through wall 26 onto cathode 18, plate 19 being transparent or removed. The connections would be similar to those shown in Figure 4.

In Figure 3, camera 50 has lens system 41, shutter actuator 42, and back 43 hinged at 44 to the other portion of the camera. Spools 45 and 46 are rotatable in suitable bearings as usual and spool 45 is associated with an exterior key for actuating the camera so that wound spool 45 and onto spool 45. This paper may be similar to paper 10 described above.

Rectangular glass box 47 is fastened in the camera and has thin aluminum or other electron-permeable, gas tight metal sheet 48 suitably sealed to it in leak-proof manner to cover the rear opening 49 of the box. The inner front surface of the box is coated with semi-transparent cesium or caesium-on-silver photo-emissive layer 50, and the box is preferably highly evacuated. A suitable inner supporting grid cathode 51 is fastened to the outside air pressure. Layer 50 serves as the cathode and is electrically connected with the negative terminal of battery 51 fastened in the camera. This battery is connected in series with battery 52 through switch 53. The positive terminal of the battery is connected to metal sheet 48 which serves as the anode.

In operation, paper 10 is started on spool 45 and presses against or closely adjacent to metal sheet 48. The camera is then focused upon an object and shutter actuator 42 is pressed, after closing switch 53. The image is focused upon cathode 50 so that electrons are emitted from this cathode in proportion to the degree of illumination thereof. Therefore an electron image, corresponding to the light image of the object focused upon, will be emitted from cathode 59 and will be accelerated through anode 48 at high speed. If the potential difference between the cathode and anode is enough, the electron pattern will pass through the thin metal anode window 43 and will strike paper 10a to form in or on the paper a permanent reproduction of the image. This electron bombardment will continue as long as shutter 42 is held and switch 53 is closed. The switch is opened or the shutter closed when the picture is completed. When it is desired to make another picture or reproduction, the spool 45 is revolved by means of a suitable key until a new fresh section of paper is in alignment with the window.

This construction has the advantage that the cathode is never exposed to outside atmosphere. This same principle can be used for making copies of drawings, letters and the like as well as to photograph scenes or live objects. Back 43 and the camera housing can be of metal to confine the electrons. Batteries 51 and 52 can be removed through the back, after detaching element 41, or through special doors. Back 43 is held in place by a suitable spring clip. It is obvious that the camera can employ the principles described in connection with Figure 1 as disclosed in my U. S. Patent No. 2,409,454.

This camera can be used in airplanes to photograph terrain below as the plane travels. A mask with a slit, as shown in Figure 3, can be placed in front of the lens and the reel 45 can be continuously rotated at speeds proportional to speed of movement of the plane. The reel can be driven by a motor controlled by the plane speed. In this way a reproduction, copy, or picture of the terrain below will be made as the plane flies along. This is particularly useful for military applications. The same principles can be applied to the type of electronic reproducer in which the reels are enclosed in the container.

Figure 4 illustrates means for reducing the area of the metal window. Lens 54 reduces the image so that small glass box 55 with a photosensitive cathode and sealed metal window 56 is used and is connected with battery 57 in similar manner as box 47.

In Figure 5 back board 58 is fastened in vertical position to base 59 and carries fixed stub shafts 60 and 61 on which reels 52 and 53 are rotatable. Suitable cotter pins or other means are provided to prevent the reels from slipping off the shafts. Rollers 54 and 55 are supported on fixed shafts extending from board 53 and they support paper 10b which is rolled on reel 52 and which can be wound onto reel 53 by rotating pulley 66 fastened to this reel coaxially therewith.

Double pulley 67 is attached to the outer end of roller 65 and a belt or pulley 68 is pulled by pulley 66. Another belt connects pulley 67 with pulley 68 fastened to the outer end of sleeve 69 which is rotatable around shaft 70 fixed to board 58. The inner end of the sleeve is fastened coaxially to circular end piece 71 of transparent drum or cylinder 72 so that this is rotated when pulley 68 is revolved. Handle 73 is fastened to sleeve 69 on the outside of pulley 66, and a cotter pin in shaft 70 is provided to prevent the sleeve from slipping off the shaft.

Elongated tubular electric lamp 74 is supported in a suitable socket 75 rising from base 59 and shown broken away. The axis of this lamp is substantially parallel with shaft
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70 and opaque shield 78 supported on board 58 has a narrow elongated slit 77 parallel with lamp 74 and coextensive therewith. Small rectangular glass box 78 (see also Fig. 6) has narrow elongated photo-emissive semi-transparent cathode strip 38 parallel with slit 77 and coextensive therewith. The box is provided with opening 59 over which thin metal sheet 81 is sealed to glass box 78. This metal sheet or strip is narrow and is parallel with cathode surface 79 and is approximately as long as this surface. The anode 82 is electrically connected with the negative terminal of battery 85 through switch 83. The positive terminal of the battery is connected with strip 81. Box 78 extends from board 55 and is supported from this board in any suitable manner. Apertured anode 81a may be included and can be charged positively, if desired. In that case element 84 need not be electrically connected.

In operation, letter or drawing 54 is wrapped around transparent drum 72 and is held in place by adhesive tape or clamps. Handle 73 is turned until one edge of the letter is adjacent slit 77. Then lamp 74 is energized by connecting it in a suitable circuit and switch 83 is closed. Then handle 73 is turned to sweep the letter past slit 77. As the letter passes, the belts rotate roller 95 to feed paper 16b synchronously past metal electron window 81 and to wind the exposed paper on reel 90. The light from lamp 74 is therefore modulated by typing or other markings on the letter so that the cathode strip 78 will emit a line of electrons of proportional modulated density. This line of electrons will be accelerated to pass through thin metal window 81 to strike electron-sensitive paper 19b closely adjacent the window. The moving paper is therefore scanned by a varying line of electrons passing through window 81 to strike it. When drum 72 is rotated until the end of the letter is reached, the electron-produced image is therefore already formed in paper 16b. A succession of copies can be made by continuing to rotate handle 73. Switch 53 can be automatically or manually opened between copies, if desired, as may be a switch controlling current to lamp 74. The exposed paper can be removed from reel 90 when the desired copies are produced. A suitable light-proof housing can be placed around box 78 or the whole mechanism, if preferred.

In Figure 7, bearing block 85 rises from attached base 86 and has two parallel horizontal slots through which integral parallel arms 87 and 88 are slideable. Arm 87 carries glass or other transparent plate 93 to the top edge of which is shown. Similarly, arm 88 carries plate 96 to which electron-sensitive paper 96c is attached. Glass box 78 is as described in connection with Figure 5 except that in this case cathode strip 78 is aligned to be perpendicular to base 85. In either drawing the glass box 78 may be opaque except for a narrow strip in alignment with the cathode strip 78 and slit 77 in opaque shield 78 fastened to base 86. Lamp 74 and slit 77 are likewise perpendicularly positioned. Letter 84 is attached to glass plate 86.

In operation, the lamp is illuminated after placing letter 84, and the cathode and anode of box 78 are connected to a source of potential as shown in Figure 6. The arms 87 and 88 are pushed through block 85 to cause the light beam passing through slit 77 to scan the letter, thus producing a scanning line of electrons to strike paper 96c in manner described in connection with Figure 5.

Figure 8 shows means for mechanically rotating a member through a sealed wall. Equivalent parts are numbered as in Figure 2. Disc 91 is fastened to the end of shaft 92 integral with handle 36 having rotary bearing in bracket 37. The disc has a narrow elongated slit 93 parallel with its face in which the rounded end of arm 95 is fitted. This arm is welded, clamped, or otherwise fastened in an opening in flexible diaphragm 94 sealed in container 1 to close opening 95. Arm 93 is sealed to diaphragm 94 in leak-proof manner. The inner extension 96 of the arm also has a rounded end which is slidably fitted into hemispherical depression in disc 91 fastened coaxially to the shaft of reel 12.

In operation, handle 36 is turned which causes arm 95 to be swept around in circular paths on both sides of the diaphragm which flexes to allow the circular movement even though the arm is rigidly sealed to the diaphragm at the periphery of the opening. Therefore circular movement of a member in a sealed container can be achieved in this manner without danger of leakage. This can be used for many purposes, in connection with electron tubes, electron microscopes, and for other uses. It is not necessary that the movement shown be used as arm 93—96 can be swung through an arc to manipulate members, or an associated rack and pinion can be employed.

Numerous details can be changed and modifications made without departing from the broad principles of the invention. For instance, the paper can be arranged in stacks of sheets so that a plurality of copies will be made simultaneously. Likewise, the sheets may be placed between the cathode and anode or adjacent thereto, one by one, automatically. Other variations are easily possible.

What I claim is:

1. In an image reproducing device, a substantially evacuated container having a light-transmitting portion, an element in said container adapted to receive light from said portion and emitting electrons where struck by said light, said container being of material relatively impervious to passage therethrough of gas ions or molecules and having an opening through which electrons from said electron-emitting element are adapted to pass, and an electron-permeable element sealing said opening against passage of gas molecules and gas ions.

2. In an image reproducing device, a substantially evacuated container having a light-transmitting portion, an element in said container adapted to receive light from said portion and emitting electrons where struck by said light, said container being of material relatively impervious to passage therethrough of gas ions or molecules and having an opening through which electrons from said electron-emitting element are adapted to pass, and an electron-permeable element sealing said opening against passage of gas molecules and gas ions, and means for directing light to said light-transmitting portion.

3. In an image reproducing device, a substantially evacuated container having a light-transmitting portion, an element in said container adapted to receive light from said portion and emitting electrons where struck by said light, said container being of material relatively impervious to passage therethrough of gas ions or molecules and having an opening through which electrons from said electron-emitting element are adapted to pass, and an electron-permeable element sealing said opening against passage of gas molecules and gas ions.
gas ions, means for directing light to said light-transmitting portion, and means for producing an electrical field to accelerate said electrons.

4. The device of claim 1, said electron-emitting element being relatively long and narrow.

5. The device of claim 1, said light-transmitting portion being relatively long and narrow.

6. The device of claim 1, said light-transmitting portion and said electron-emitting element being relatively long and narrow and substantially parallel.

7. The device of claim 2, the effective area of said electron-permeable element being relatively long and narrow.

8. The device of claim 2, said electron-emitting element and said electron-permeable element being relatively long and narrow and substantially parallel.

9. The device of claim 1, said container having a pair of parallel walls, said light-transmitting portion being in one said wall and said opening being in the other said wall.

10. The device of claim 1, and including means for producing a light image of an object to be reproduced.

11. The device of claim 2, said means for directing light including a lens to form a light image of an object to be reproduced.

12. The device of claim 2, and including means for causing relative movement between said electron-permeable element and electron-sensitive material adjacent thereto.

13. The device of claim 3, and including means for causing relative movement between said electron-permeable element and electron-sensitive material adjacent thereto.

ALBERT G. THOMAS.

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