June 16, 1959 W. C. HUEBNER 2,890,923

APPARATUS FOR REPRODUCING ELECTRICAL INFORMATION

Filed March 29, 1956 2 Sheets-Sheet 1

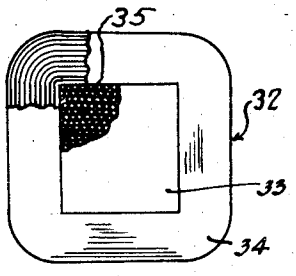


FIG. 2

INVENTOR.
WILLIAM C. HUEBNER
BY Hudson, Boughton, Williams, David & Hoffmann
ATTORNEYS

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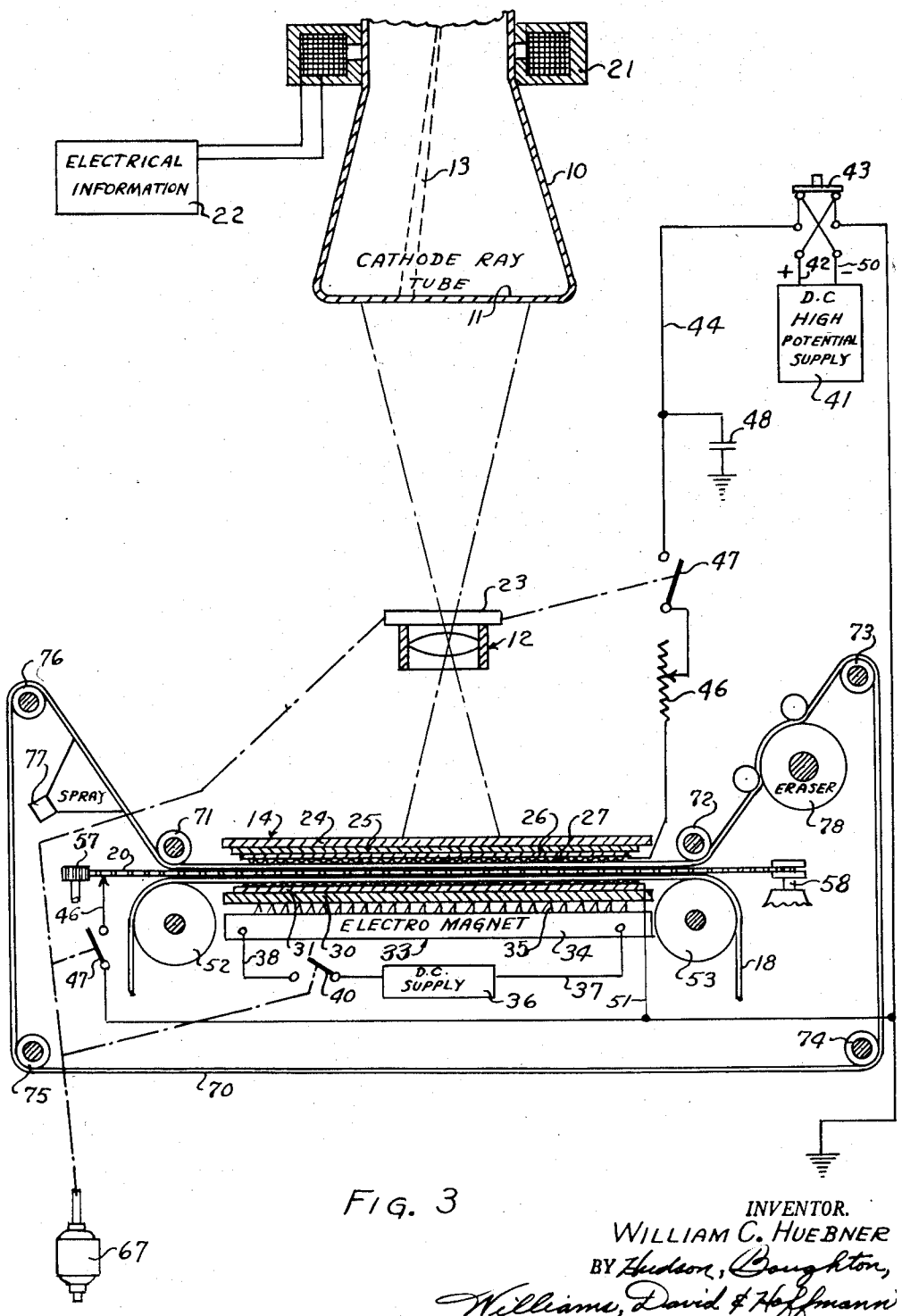


FIG. 3

INVENTOR.
WILLIAM C. HUEBNER
BY Hudson, Boughton, Williams, David & Hoffmann
ATTORNEYS

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2,890,923

APPARATUS FOR REPRODUCING ELECTRICAL INFORMATION

William C. Huebner, Mamaroneck, N.Y., assignor, by mesne assignments, to The Standard Register Company, Dayton, Ohio, a corporation of Ohio

Application March 29, 1956, Serial No. 574,789

8 Claims. (Cl. 346—74)

This invention relates to an apparatus for the direct reproduction of electrical information appearing as image information on a cathode ray tube and more particularly to reproduce the information to a reduced size from the information appearing on the cathode ray tube.

The terms "light image" or "image information" as used throughout the specification and claims are intended to specifically denote the image information derived from cathode ray tubes or television screens and the like produced by electrical information delivered thereto.

The terms "print receiving material" and "untreated print receiving material" are used to define a material which has not been treated to give it special characteristics such as photographic, chemical or mechanical properties to aid in the receiving, developing, fixing or retaining of a reproduced image thereon. The material may be paper, cloth fabrics or other materials which are preferably but not necessarily in sheet or web form.

The term "reproducing material" includes any material capable of receiving an electrical charge or being ionized by any convenient method. The reproducing material may be further characterized as being capable of use in the form of divided and dispersed droplets or globules such as when provided in a cloudlike form.

The term "cloud-like form" is employed with the significance of the definition of "cloud," namely a visible assemblage of solid or liquid particles in the air or in a gas as a cloud of smoke or of dust or of mist or of vapor.

It is therefore an object of the invention to provide an apparatus for immediately and directly reproducing electrical information on print receiving material through the derivation of light image or image information produced by the electrical information on the face of a cathode ray tube and projecting the light image onto a light-sensitive target positioned to influence an electric field and thereby control the flow of reproducing material introduced into the electric field for precipitating same on the print receiving material.

It is another object of the invention to provide an improved apparatus of the above-mentioned character in which the light-sensitive target is photoconductive and preferably is mounted between conductive layers with the outer conductive layer and its exposed surface provided with a plurality of minute projections and the conductive element being similarly provided with such projections.

It is still another object of the present invention to provide an improved apparatus of the kind mentioned for reproducing images to a reduced size utilizing a photoconductive target in an electric field to control the precipitation of reproducing material onto print receiving material, wherein a conductive element spaced from the target includes magnetic means for influencing the electric field.

Further and additional objects and advantages will become apparent hereinafter during the detailed description of the embodiments of the invention which are to follow and which are illustrated in the accompanying drawings, wherein

Fig. 1 is a diagrammatic representation illustrating and embodying a means of carrying out the invention;

Fig. 2 is a top plan view with portions broken away of the magnetic terminal shown in Fig. 1; and

Fig. 3 is a diagrammatic representation of a modified method of carrying out the invention.

Generally, the invention contemplates directly reproducing light images to a reduced size produced by electric information appearing as image formation on a cathode ray tube at high speeds in finished or final form on print receiving material through the utilization of a light-sensitive element as a target. The light-sensitive target is photoconductive and is spaced from a conductive element connected in circuit relationship therewith to a high voltage source to create an electric field therebetween. The light image produced by the electrical information is projected onto the light-sensitive target and is effective to cause a change in the conductivity or resistivity of the target and thereby influence the created electric field in accordance therewith. An image isolator acting as a shutter may be positioned intermediate the light-sensitive target and the conductive element. The reproducing material is introduced into the electric field adjacent the light-sensitive target or when the image isolator is employed intermediate the isolator and the target. The print receiving material is advanced through the electric field adjacent the conductive element in a time relationship with the projection of the light images onto the light sensitive target. The projection of the light images and the creation of the electric field are also controlled in a time relationship with the advancement of the print receiving material. The image isolator is further controlled to expose the spring receiving material momentarily during the existence of the light image and electric field to allow the reproducing material to be precipitated onto the print receiving material during that interval.

Now referring to Fig. 1 the novel reproducing apparatus will be described wherein a cathode ray tube **10** is shown with an image surface or face **11** thereof spaced to provide the image information as a light image to be projected through the lens system **12**. The action of an electron beam **13** excites the phosphor on the face **11** to provide a light image. The light image emerging from the lens system **12** is caused to illuminate the light-sensitive target **14** cooperating with a conductive element **15** spaced therefrom and between which an electric field is created. Reproducing material in cloud-like form derived from a pressure conduit **16** may be passed between the elements **14** and **15** to an outlet or suction conduit **17**. Print receiving material **18** is positioned between the elements **14** and **15** to receive the reproducing material propelled thereto by the electric field. An image isolator **20** is provided intermediate the print receiving material **18** and the path of flow of the reproducing material.

The cathode ray tube **10** is of conventional construction and accordingly the electrode structure in addition to a deflecting coil **21** is not considered necessary to the description of the invention, being well known in the art. Suffice it to say that the electron beam **13** generated in the tube **10** is influenced by the electrical information applied to the deflection coil **21** from an electrical information source **22**, and in this instance is shown as a sine wave to represent the intelligence to be recorded. The electrical information source **22** may be any electrical source including a television signal. The inner surface of the tube face includes a phosphor which is

excited by the electron beam **13** to provide the image information on the outer surface of the tube face **11**.

The lens system **12** is supported intermediate the cathode ray tube **10** and the light-sensitive target **14**. The lens system **12** is arranged to receive the images from the cathode ray tube **10** and to project them onto the adjacent face of the light-sensitive target **14**. The size of the light image projected onto the light-sensitive target **14** is in this instance of a reduced size from the image information on tube face **11** and accordingly an aperture provided for the image isolator **20** is of a corresponding size. A shutter **23** may be provided for the lens system **12** and is opened and closed in timed relationship with the changes in the image information on the tube face **11**, that is, the shutter will be opened when the image information is temporarily stopped.

The light-sensitive element or target **14** comprises a transparent mounting plate, in this instance shown as a glass plate **24**, mounting a light sensitive, photoconductive, material **25** intermediate layers of conductive material **26** and **27**. The conductive material **26** is a layer of silver deposited on the glass plate **24** in intimate contact therewith and having the photoconductive material, in this instance a selenium layer, deposited over the layer of silver. The layer of selenium is prepared with a proper proportion of alloys to render it light-sensitive. A photoconductive material, as is well known, varies in conductivity in response to the presence or absence of light. The change in conductivity takes the form of a change in resistance in elemental or discrete areas in proportion to the light received thereon and can be said to form a pattern of the light. The resistance of the elemental areas decreases in response to light and they revert to their high resistance state upon the removal of the light.

The remaining layer of conductive material **27** is also a silver layer and is deposited in intimate contact with the opposite surface of the light-sensitive layer **25**. This outer conductive layer **27** is provided with a plurality of minute relief buttons or projections **28** spaced over the entire outer surface of the layer. These projections **28** are provided on the conductive layer **27** by depositing a thin layer of a conductive material, in this instance the silver, over a porous cloth such as silk stretched over the layer **27** so as to allow the two layers of silver to adhere to one another through the infinitesimal openings in the cloth. These projections **28** are spaced over the layer **27** in rows and columns in a manner similar to that shown in my copending application Ser. No. 574,787, filed concurrently herewith and which is incorporated herein by reference. The projections **28** are provided to establish the lines of force of the electric field between the light-sensitive target **14** and the receiving element **15** in a substantially straight line.

The conductive layers **26** and **27** along with the light-sensitive layer **25** are preferably arranged with a thickness so as not to reduce the light transmitting power of the mounting plate **24** less than 50%. The layers **25**, **26** and **27** are mounted in intimate contact with one another and also with margins or can be said to be stepped to allow an electrical connection to be made to the desired layer. Specifically, the layer **26** covers a larger area than the light-sensitive layer **25** which layer is in turn larger in area than the conductive layer **27**.

The conductive or receiving element **15** is spaced from the light-sensitive target **14**. The conductive element **15** comprises a flat electrical member **30**, shown in this instance with a deposit of a conductive material **31** fixed to the element **15** and with a plurality of minute projections thereon. The projections for the conductive material **31** are arranged so that they will face the layer **27** of the target **14** and preferably are similarly disposed and arranged as on the layer **27** and in axial alignment therewith. If the print receiving material **18** is transparent or translucent it may be found desirable to place a light-sensitive layer between the conductive layer **30** and the conductive element **15** to further influence the electric field in accordance with the light image.

The conductive element **15** in this instance includes a magnetic attraction terminal **32** spaced on the opposite side of the electrical member **30** from the conductive material **31** provided to better concentrate the lines of force in straight lines created between the target **14** and the element **15**. The use of the magnetic attraction terminal **32** is felt to be necessary when the image information is to be reduced in size so as to give finer and sharper detail of the image. The magnetic attraction terminal **32**, as it is shown in Fig. 2, comprises a needle-point device **33** surrounded by an electromagnet **34**. The electromagnet **34** is of a general toroidal shape with a substantially rectangular window to receive the needle-point device **33**. The needle-point device includes a plurality of needle-like elements **35**, grouped in rows and columns substantially similar to the conductive projections **28**. The elements **35** extend vertically from the electromagnet **34** in contact with the electrical member **30**. The magnet **34** is energized by means of a D.C. supply source **36** connected thereto by the lead wires **37** and **38**, the latter of which is provided with a control switch **40**.

The light-sensitive element **14** and the conductive element **15** are connected in a circuit relationship to a direct current high voltage source identified by the reference character **41**. The positive terminal **42** of the high voltage source **41** is connected through a reversing switch **43** to the lead wire **44**. A lead wire **44** is directly connected to the conductive layer **27** for the light-sensitive element **13** through a lead wire **45** provided with a variable resistor **46** in series circuit relationship therewith. The voltage of the source **41** is arranged to be sufficient to create a high intensity electric field between the light element **14** and the conductive element **15** corresponding to the spacing between them and the characteristics of the light-sensitive layer **25**.

An on-off switch **47** is also provided in series circuit relationship with the lead wire **45** and is arranged intermediate the resistor **46** and the lead wire **44**. A capacitor **48** is also connected to the lead wire **45** intermediate the switch **47** and the lead wire **44** and which capacitor has its opposite terminal connected to ground. A negative terminal **50** for the high voltage source **41** is connected to ground and the electrical circuit through the light-sensitive element **14** and the conductive element **15** is completed by grounding the latter. This grounding connection is shown as a lead wire **51**.

The print receiving material **18** is positioned intermediate the light-sensitive element **14** and the conductive element **15** and, in this instance, is shown adjacent the latter element. The print receiving material **18** is intermittently advanced between the elements **14** and **15** through the provision of feeding devices **52** and **53** spaced on opposite ends of the element **15** as shown. The feeding devices **52** and **53** may be of any convenient construction and may be provided with pinwheels cooperating with marginal perforations in the print receiving material **17**. It should be readily apparent that the intermittent advancement of the print receiving material **17** is accomplished in timed relationship with the delivery of the electrical signals to the cathode ray tube **10**.

The reproducing material for the novel reproducing apparatus is introduced by means of the pressure conduit **16** spaced outwardly of and between the light-sensitive element **14** and the conductive element **15** adjacent the lateral edges thereof.

The reproducing material introduced between the elements **14** and **15** in this instance is in cloud-like form as hereinabove defined. When the reproducing material is introduced in cloud-like form, as in this embodiment, it

may be further characterized as smoke created by combustion of suitable materials such as powdered dyes, plastic powders or any other such material desired due to its color, intensity or ionization characteristics. The pressure conduit **16** is effective to cause the reproducing material to travel in a path between the elements **14** and **15** to the suction conduit **17** spaced on the opposite lateral edges thereof. The reproducing material travels in a path covering the image area of the light-sensitive element so as to come under the influence thereof. The suction conduit **17** is effective to collect or gather the residue of the reproducing material following the projection of the light images on the light element **14**.

It has been found that an improved precipitation of the reproducing material results when it is given a charge to aid its migration or propulsion towards the print receiving material **17**. Accordingly charging electrodes similar to the electrodes **54** and **55** are provided adjacent the outlet passage for the conduit **16**. The electrodes **54** are shown as connected to ground while the electrodes **55** are connected to the high voltage source **41** by means of a lead wire **56** which is connected directly to the lead wire **44** for the voltage source.

The image isolator **20** acts as a shutter to isolate the reproducing material from the print receiving material **18**. Accordingly the image isolator **20** is positioned above the print receiving material **18** and below the path of the reproducing material. The image isolator **20** is mounted in any suitable manner to be continuously moved in timed relationship with the advancement of the print receiving material **18** and the delivery of the electrical signals to the tube **10**. The image isolator **18** is provided with an aperture constructed and arranged thereon to pass the flow of the reproducing material to the print receiving material **18** migrated thereto under the influence of the electric field in a manner as described in my copending patent application Serial No. 574,787, filed concurrently herewith. The image isolator **20** may be provided with a plurality of apertures thereon when the delivery rate of the electrical signals is high. Accordingly it should be readily apparent that the image isolator **20** should be arranged in alignment with the tube **10** and moved in timed relationship with the delivery of the electrical signals thereto.

The image isolator **20** may be rotated by means of a pinion **57** suitably supported adjacent the toothed peripheral edge of the isolator, in this instance shown on the left-hand side thereof. The image isolator **20** is a thin metallic member and is provided with supporting surfaces comprising a plurality of bosses **58** spaced around the peripheral edge thereof.

The image isolator is also arranged to carry a charging wire (not shown) adjacent the leading edge of the aperture thereon. The charging wire extends across the isolator **20** on the surface adjacent the print receiving material **18** so as to contact and charge the latter as it sweeps over it. The charging wire is connected to the ground terminal of the high voltage source **41** through a lead wire **60** which may be provided with a suitable brush for completing the circuit thereto as is well known. The lead wire **60** is also provided with an on-off switch **61** connected in series circuit relationship therewith. The switch **61** is operated in timed relationship with the switches **40** and **47**.

It is thought that improved precipitation of the reproducing material results when in addition to charging the reproducing material, means for ionizing the same is provided. In this instance the reproducing material is ionized by means of short-wave radiant energy transmitted through the path of the reproducing material between the elements **14** and **15**. A transmitting antenna **62** is arranged adjacent the outlet of the pressure conduit **16** and is connected by a suitable transmission line **63** to a short-wave generator **64**. The short-wave generator **64** is arranged to provide radiant energy in the region around 200 megacycles and transmits the energy to a receiving antenna **65** positioned adjacent the inlet for the suction conduit **16**. The receiving antenna **65** is suitably connected in a well known manner to a receiver **66** turned to the frequency of the generator **64**.

With the above described apparatus in mind the steps leading to the final reproductions will become apparent. The reproductions depend upon the timed relationship of the delivery of the electrical signals to the tube **10** with the advancement of the print receiving material **18** which will, in turn, be synchronized or be arranged in a timed relationship with the opening and closing of the switches **40**, **47** and **61** along with the shutter **23**, when the latter is provided. The switches **40**, **47**, **61** and the shutter **23** are driven and controlled by a synchronous motor **67** or the like. The operation of the apparatus is arranged so that while the information for any one image is temporarily stationary on the tube face the print receiving material **18** is at rest and during this interval the image isolator **20** has been moved to a position where the aperture thereof is in alignment with the image focused onto the light-sensitive element **14**. Substantially simultaneously with the alignment of the light image with the aperture the high voltage potential is applied across the elements **14** and **15** and to the charging wire through the closing of the switches **47** and **61**. The combination of the light action and the high voltage stress is effective to cause the reproducing material to be migrated and propelled through the aperture for the image isolator **20** to be deposited on the print receiving material **18** immediately below the aperture. The flow of the reproducing material is defined by the electric field in proportion to the light intensity projected on the light element **14** so as to cause the immediate and direct reproduction of the light image on the print receiving material **18**. Just prior to the change of the image information on the tube face the image isolator **20** is moved to cut off the flow of the reproducing material to the print receiving material **18**. During this interval the print receiving material **18** is advanced to receive the next successive image information appearing on the face of the tube and the image isolator is brought to rest. It should be understood that the reproducing material is continuously passed between the elements **14** and **15** along with the transmission of the short-wave energy thereto.

Now referring to Fig. 3, a modified apparatus for reproducing images will be described. The apparatus shown herein is substantially similar to that previously described except that the reproducing material is introduced in a different and novel manner. In this instance the reproducing material is not introduced in a cloud-like form but is carried between the elements **14** and **15** by an endless belt **70**. The belt **70** is preferably a transparent belt and a transparent plastic commercially identified as Saran Wrap is though to be satisfactory. Saran is a trademark for a thermoplastic resin comprising a copolymer of vinylidene chloride and vinyl chloride. The belt **70** is passed between rollers **71** and **72** spaced on opposite ends of the elements **14** and **15** and above the image isolator **20**. The belt **70** passes from the roller **72** in a clockwise direction around the rollers **73**, **74**, **75** and **76** spaced around the conductive element **15**, the latter roller being spaced upwardly from the roller **71**. The reproducing material is applied to the belt **70** intermediate the rollers **76** and **71** and is put on the ribbon electronographically or by rollers. Any undesired static charge may be removed from the belt **70** in conventional manner when it is found to be necessary. A coating of reproducing material on the belt **70** is in this instance, shown as being applied by a spray **77**. The reproducing material is then carried by the belt **70** through the elements **14** and **15** around the rollers **72** and into contact with an eraser or cleaning brushes **78** which are provided intermediate the roller **72** and the

roller 73 to remove the excess or residue of the reproducing material from the belt so that it may be continuously used.

In this particular embodiment it is thought that the coating of the belt 70 with the reproducing material and passing it through the electric field will cause the reproducing material to be disassociated from the belt and propelled and migrated toward the print receiving material 18 under the influence of the electric field. It is thought that this manner of introducing the reproducing material provides improved reproductions since the background of the image will be more nearly controlled.

Although preferred forms of the invention have been described and illustrated herein it will be understood that the invention may be embodied in other forms coming within the scope and meaning of the appended claims.

Having thus described my invention, I claim:

1. In apparatus for reproducing information directly on print receiving material from a cathode ray tube having a phosphorescent screen comprising a light sensitive target spaced from said screen and including a photoconductive element positioned to receive a light image from said screen and to have substantially instantly a change in the electrical conductivity of discrete areas thereof in response to the configuration of said light image, means for positioning print receiving material spaced from said photoconductive element on the side thereof opposite to said cathode ray tube and defining an air gap therebetween, means for creating an electrostatic field in said air gap between said photoconductive element and said print receiving material, means for arranging the lines of force of said electrostatic field to be intercepted by said photoconductive element whereby said field is influenced in conformity to the configuration of said light image on said element, means for delivering electrical information to the cathode ray tube to produce a light image on the screen thereof, means for projecting the light image from said screen onto the photoconductive element of said light sensitive target at a size substantially reduced from the size appearing on said screen and in a predetermined timed relationship with the positioning of said print receiving material and the creation of said electrostatic field, and means for introducing reproducing material in said air gap to be acted upon by said electrostatic field and migrated thereby in finely divided form toward the print receiving material.

2. In apparatus for reproducing information directly on print receiving material from a cathode ray tube having a phosphorescent screen as defined in claim 1 and wherein said apparatus includes means in said air gap for exposing the light sensitive target to a predetermined area of the print receiving material and in a predetermined timed relationship with the positioning of said print receiving material and the creation of said electrostatic field in said air gap.

3. In apparatus for reproducing information directly on print receiving material from a cathode ray tube having a phosphorescent screen as defined in claim 1 and including means in said air gap effective to ionize said finely divided reproducing material.

4. In apparatus for reproducing information directly on print receiving material from a cathode ray tube having a phosphorescent screen as defined in claim 3 and wherein the means for ionizing the finely divided reproducing material includes means for transmitting short wave electrical radiations onto the air gap traversing the path taken by the reproducing material.

5. In apparatus for reproducing information directly on print receiving material from a cathode ray tube having a phosphorescent screen as defined in claim 3 and including magnetic means effective to cause the lines of force of said electrostatic field to extend across the air gap in substantially straight lines.

6. In apparatus for reproducing images directly onto print receiving material from a cathode ray tube having a phosphorescent screen comprising a light sensitive target having a light transmitting portion mounting a photoconductive layer positioned to receive light images from said screen and to have substantially instantly a change in the electrical resistivity thereof in response to the configuration of said light images, a conductive element spaced from said light sensitive target on the side opposite to said cathode ray tube and defining an air gap therebetween, a source of relatively high voltage effective between said photoconductive layer and said conductive element to provide a high intensity electrostatic field in said air gap, means for positioning print receiving material in said air gap and adjacent said conductive element, means for isolating and exposing predetermined areas of said positioned print receiving material from and to said target in a predetermined time relation with the creation of said electrostatic field, means for delivering electrical information to the cathode ray tube to produce light images on the screen thereof, lens means intermediate said cathode ray tube and said light sensitive target for receiving light images from the screen of said tube and effective to project said images onto the photoconductive layer of said light sensitive target at a size substantially reduced from the size appearing on said screen and in a predetermined time relationship with the positioning of said print receiving material and the creation of said electrostatic field, and means for introducing reproducing material in cloud-like form into said air gap and intermediate the light sensitive target and said isolating means, said reproducing material being acted upon by the lines of force of said electrostatic field and migrated thereby toward the print receiving material to produce thereon in final finished form a reproduction of the light images projected on the screen of said cathode ray tube.

7. In apparatus for reproducing images directly on print receiving material from a cathode ray tube having a phosphorescent screen as defined in claim 6 and wherein magnetic means adjacent the conductive element is arranged to influence the lines of force of said electrostatic field in said air gap.

8. In apparatus for reproducing information directly on print receiving material from a cathode ray tube having a phosphorescent screen comprising a light sensitive target spaced from said screen and including a photoconductive element positioned to receive a light image from said screen and to have substantially instantly a change in the electrical conductivity of discrete areas thereof in response to the configuration of said light image, means for positioning print receiving material spaced from said photoconductive element on the side thereof opposite to said cathode ray tube and defining an air gap therebetween, means for creating an electrostatic field in said air gap between said photoconductive element and said print receiving material, means for arranging the lines of force of said electrostatic field to be intercepted by said photoconductive element whereby said field is influenced in conformity to the configuration of said light image on said element, means for delivering electrical information to the cathode ray tube to produce a light image on the screen thereof, means for projecting the light image from said screen onto the photoconductive element of said light sensitive target at a size substantially reduced from the size appearing on said screen and in a predetermined timed relationship with the positioning of said print receiving material and the creation of said electrostatic field, and means for introducing reproducing material in the form of a coating on a belt into said air gap between said photoconductive element and said print receiving material to be acted upon by said electrostatic field and disassociated thereby from said belt and migrated toward the print receiving

material to deposit and form thereon the finished reproduction of said information.

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