June 16, 1959 W. C. HUEBNER 2,890,922

APPARATUS FOR REPRODUCING ELECTRICAL INFORMATION

Filed March 29, 1956 2 Sheets-Sheet 1

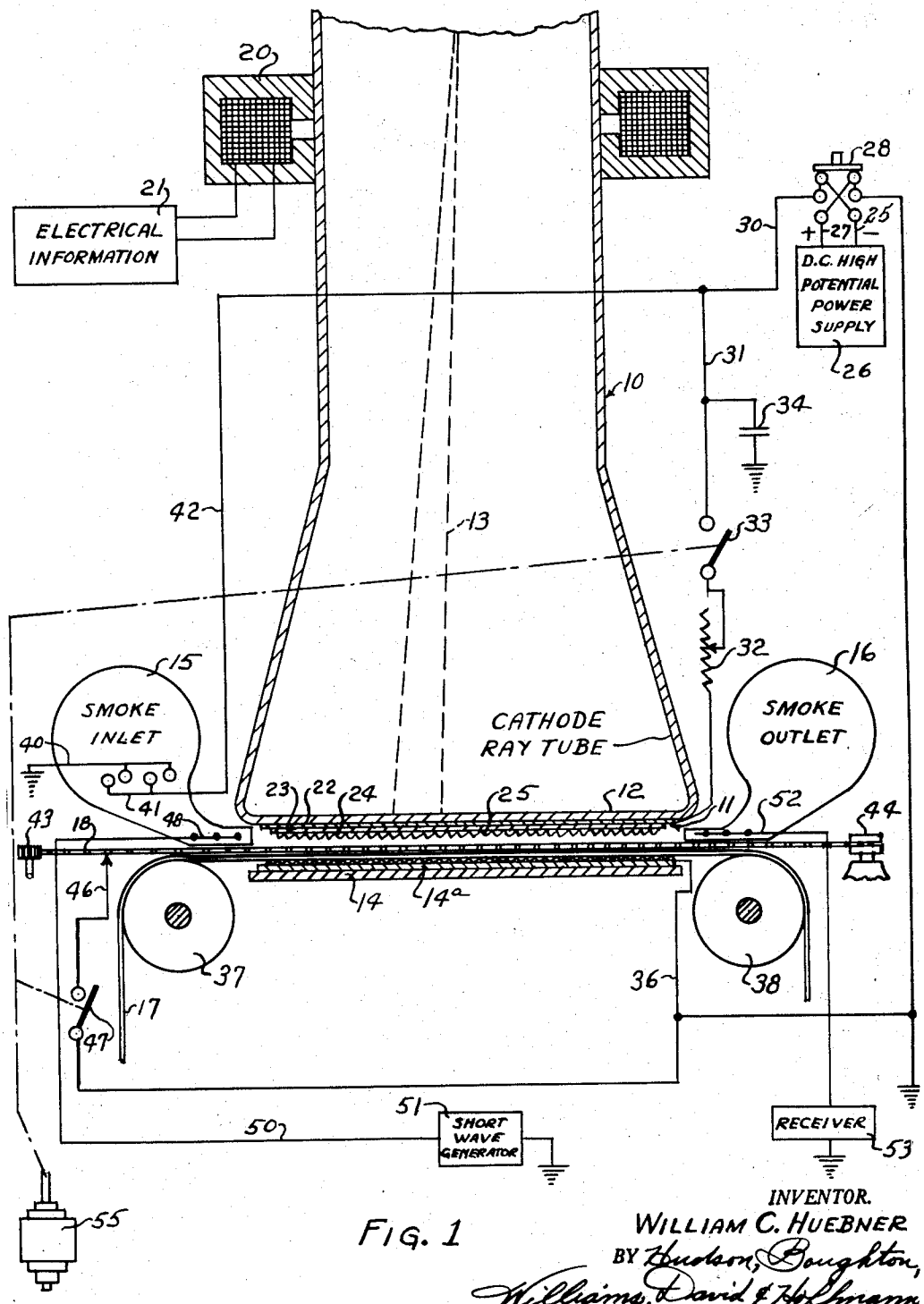


FIG. 1

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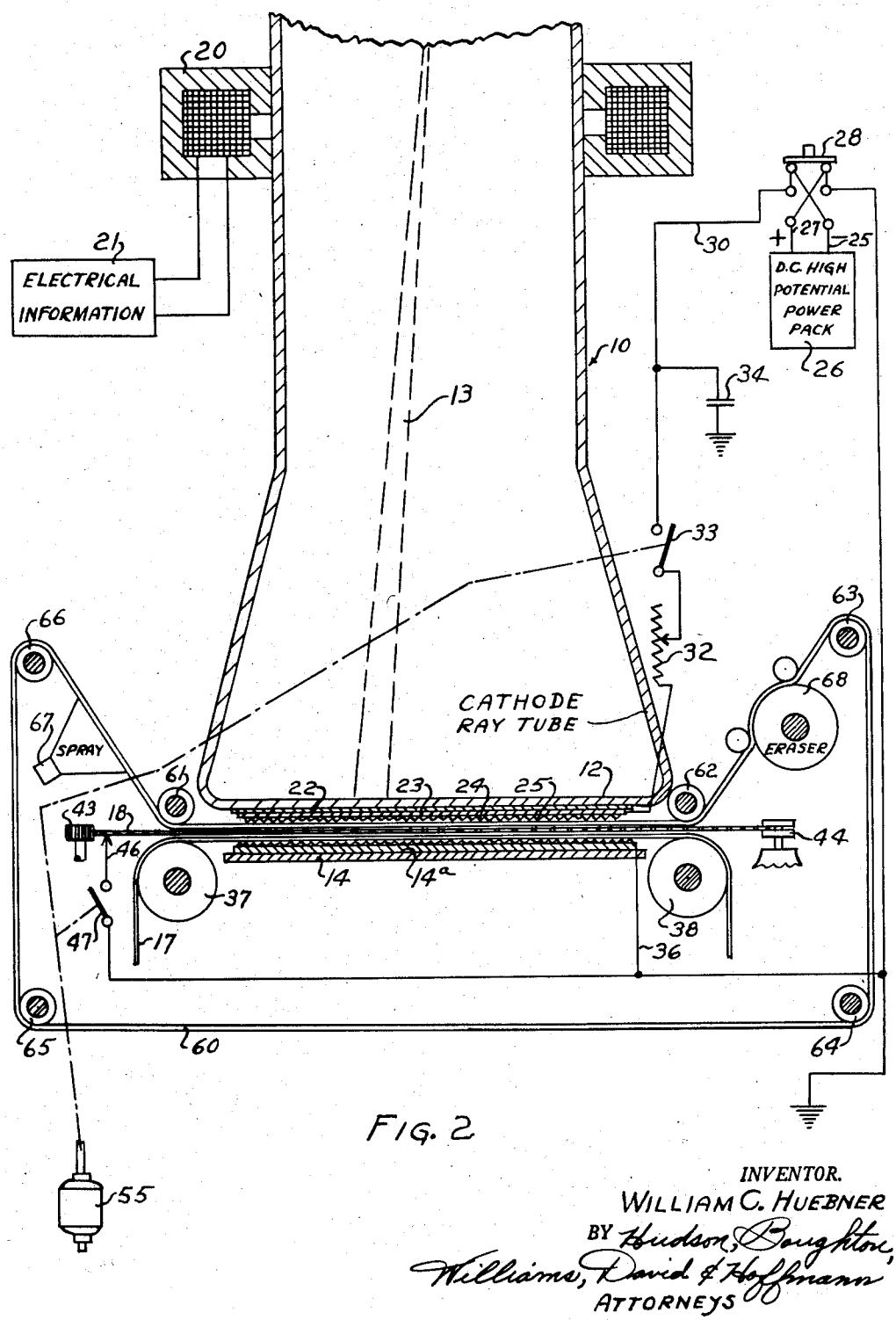


FIG. 2

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2,890,922

APPARATUS FOR REPRODUCING ELECTRICAL INFORMATION

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Application March 29, 1956, Serial No. 574,788

12 Claims. (Cl. 346—74)

This invention relates to apparatus for reproducing images and more particularly to apparatus for the direct reproduction of electrical information providing image information in a cathode-ray tube by the action of a light-sensitive element integral with the face of the cathode-ray tube.

The term "light image" or "image information" as used throughout the specification and claims is referred to as images produced by any type of electrical signal, representative of information, through the excitation of a phosphorous material; such as employed on a cathode-ray tube or television screen.

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 of 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 cloud-like 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 improved apparatus for immediately and directly reproducing electrical information delivered to a cathode-ray tube in final form on print receiving material through the excitation of a light-sensitive target integral with the cathode-ray tube responsive to the light images produced by the information and which target is 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 in the form of the light images.

It is another object of the invention to provide an improved apparatus for reproducing electrical signals as images on print receiving material positioned in an electric field and which field is created between a light-sensitive target integral with the outer face of a cathode-ray tube and a conductive element and which field is influenced by the electrical signals projected through the tube face as light images and onto the target, the electric field under the influence of the target being effective to precipitate reproducing material onto the print receiving material in the form of the light images.

It is a further 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 for reproducing images utilizing a photoconductive target integral with a cathode-ray tube and employed in an electric field to control the precipitation of reproducing material onto print receiving material, wherein the reproducing material is isolated from the print receiving material except for printing purposes.

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 one form of the invention, and

Fig. 2 is a diagrammatic representation of a modified form of the invention.

Generally, the invention contemplates apparatus for directly reproducing electrical signals appearing as image information 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 integral with the outer face of the cathode-ray tube being spaced from a conductive element connected in circuit relationship therewith to a high voltage source to create an electric field therebetween. The electrical signals delivered to the cathode-ray tube excite the tube screen to provide light images causing a conductive change in the light-sensitive target effective to influence the 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 electrical signals onto the face of the tube. The projection of the electrical signals, and thereby the light images, and the creation of the electric field are also controlled in a time relationship with the advancement of the image copy and the print receiving material. The image isolator is further controlled to expose the print receiving material momentarily during the period of excitation provided by the electrical signals and the 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 the cathode-ray tube **10** is shown with a light-sensitive target **11** integral with a face **12** of the tube. An electron beam **13** excites the face **12** providing a light image which changes the conductivity of the light-sensitive target **11**. The cathode-ray tube **10** is arranged with the target **11** spaced from a conductive element **14** for creating an electric field therebetween. Reproducing material in cloud-like form derived from a pressure conduit **15** may be passed between the target **11** and the conductive element **14** to an outlet or suction conduit **16**. Print receiving material **17** is positioned between the target **11** and the conductive element **14** to receive the reproducing material propelled thereto by the electric field. An image isolator **18** is provided intermediate the print receiving material **17** and the path of flow of the reproducing material.

The cathode-ray tube **10** is of conventional construction as to its interior electrode structure including the phosphor provided for the inner surface of the face **12** which is excited by the electron stream **13**. The electrical signal which is to be recorded is applied to a deflec-

tion coil 20 and in this instance the signal is shown as a sine wave derived from a source 21 and represents any intelligence to be recorded. The electrical source 21 may be any electrical source including a television signal. The luminescence provided by the excited portions of the phosphor for the face 12 is projected as a light image through the light-sensitive target 11 mounted on the outer surface of the face 12 of the tube 10.

The light-sensitive element or target 11, in this instance, is shown as comprising a light-sensitive, photoconductive, material 22 intermediate layers of conductive material 23 and 24. The conductive material 23 is a layer of silver deposited on the outer surface of the face 12 in intimate contact therewith and having the photoconductive material 22, 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 24 is also a silver layer and is deposited in intimate contact with the opposite surface of the light-sensitive layer 22. This outer conductive layer 24 is provided with a plurality of minute relief buttons or projections 25 spaced over the entire outer surface of the layer. These projections 25 are provided on the conductive layer 24 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 24 so as to allow the two layers of silver to adhere to one another through the infinitesimal openings in the cloth. These projections 25 are spaced over the layer 24 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 25 are provided to establish the lines of force of the electric field between the light-sensitive target 11 and the conductive element 14 in a substantially straight line.

The conductive layers 23 and 24 along with the light-sensitive layer 22 are preferably arranged with a thickness so as not to reduce the light transmitting power of the tube face 12 less than 50%. The layers 22, 23, and 24 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 23 covers a larger area than the light-sensitive layer 22, which layer is in turn larger in area than the conductive layer 24.

The conductive or receiving element 14 is spaced from the light-sensitive target 11. The conductive element 14 may be a flat electrical member; however, it is shown in this instance with a deposit of a conductive material 14*a* fixed to the element 14 and with a plurality of minute projections thereon. The projections for the conductive material 14*a* are arranged so that they will face the layer 24 of the target 11 and preferably are similarly disposed and arranged as on the layer 24 and in axial alignment therewith. If the print receiving material 17 is transparent or translucent it may be found desirable to place a light-sensitive layer between the conductive layer 14*a* and the conductive element 14 to further influence the electric field in accordance with the light image.

The light-sensitive element 11 and the conductive element 14 are connected in a circuit relationship to a direct current high voltage source identified by the reference character 26. The positive terminal 27 of the high voltage source 26 is connected through a reversing switch 28 to a lead wire 30. The lead wire 30 is directly connected to the conductive layer 23 for the light-sensitive element 11 through a lead wire 31 provided with a variable resistor 32 in series circuit relationship therewith. The voltage of the source 26 is arranged to be sufficient to create a high intensity electric field between the light element 11 and the conductive element 14 corresponding to the spacing between them and the characteristics of the light-sensitive layer 22.

An on-off switch 33 is also provided in series circuit relationship with the lead wire 31 and is arranged intermediate the resistor 32 and the lead wire 30. A capacitor 34 is also connected to the lead wire 31 intermediate the switch 33 and the lead wire 30 and which capacitor has its opposite terminal connected to ground. A negative terminal 35 for the high voltage source 26 is connected to ground and the electrical circuit through the light-sensitive element 11 and the conductive element 14 is completed by grounding the latter. This grounding connection is effected with a lead wire 36.

The print receiving material 17 is positioned intermediate the light-sensitive element 11 and the conductive element 14 and, in this instance, is shown adjacent the latter element. The print receiving material 17 is intermittently advanced between the elements 11 and 14 through the provision of feeding devices 37 and 38 spaced on opposite ends of the element 14, as shown. The feeding devices 37 and 38 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 15 spaced outwardly of and between the light-sensitive element 11 and the conductive element 14 adjacent the lateral edges thereof.

The reproducing material introduced between the elements 11 and 14, 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 15 is effective to cause the reproducing material to travel in a path between the elements 11 and 14 to the exhaust or suction conduit 16 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 exhaust conduit 16 is effective to collect or gather the residue of the reproducing material not required for reproduction purposes.

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 40 and 41 are provided adjacent the outlet passage for the conduit 15. The electrodes 40 are shown as connected to ground while the electrodes 41 are connected to the high voltage source 26 by means of a lead wire 42 which is connected directly to the lead wire 30 for the voltage source.

The image isolator 18 acts as a shutter to isolate the reproducing material from the print receiving material 17. Accordingly, the image isolator 18 is positioned above the print receiving material 17 and below the path of the reproducing material. The image isolator 18 is mounted in any suitable manner to continuously rotate

in timed relationship with the delivery of the electrical signals to the cathode-ray tube **10** and the advancement of the print receiving material **17**. 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 **17** 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 **18** may be provided with a plurality of apertures spaced thereon when the delivery rate of the electrical signals is high. Accordingly it should be readily apparent that the image isolator **18** should be arranged in alignment with the tube **10** and moved in a timed relationship with the delivery of the electrical signals thereto.

The image isolator **18** may be rotated by means of a pinion **43** suitably supported adjacent the toothed peripheral edge of the isolator, in this instance shown on the left-hand side thereof. The image isolator **18** is a thin metallic member and is provided with supporting surfaces similar to the boss **44**, spaced around the peripheral edge thereof.

The image isolator **18** 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 **18** on the surface adjacent the print receiving material **17** 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 **26** through a lead wire **46** which may be provided with a suitable brush for completing the circuit thereto as is well known. The lead wire **46** is also provided with an on-off switch **47** connected in series circuit relationship therewith. The switch **47** is operated in timed relationship with the switch **33**.

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 **11** and **14**. A transmitting antenna **48** is arranged adjacent the outlet of the pressure conduit **15** and is connected by a suitable transmission line **50** to a short-wave generator **51**. The short-wave generator **51** is arranged to provide radiant energy in the region around 200 megacycles and transmits the energy to a receiving antenna **52** positioned adjacent the inlet for the suction conduit **16**. The receiving antenna **52** is suitably connected in a well-known manner to a receiver **53** tuned to the frequency of the generator **51**.

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 illumination of the target **11** with the advancement of the print reproducing material **17** which will, in turn, be synchronized or be arranged in a timed relationship with the opening and closing of the switches **33** and **47**. The switches **33** and **47** are driven and controlled by a synchronous motor **55** 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 **17** is at rest and during this interval the image isolator **18** has been moved to a position where the aperture thereof is in alignment with the image focused onto the light-sensitive element **11**. Substantially simultaneously with the alignment of the light image with the aperture the high voltage potential is applied across the elements **11** and **14** and to the lead wire **46** through the closing of the switches **33** and **47**. 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 image isolator aperture 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 **11** so as to cause the immediate and direct reproduction of the light image on the print receiving material **17**. Just prior to the change of the image information on the tube face the image isolator **18** is moved to cut off the flow of the reproducing material to the print receiving material **17**. During this interval the print receiving material **17** 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 **11** and **14** along with the transmission of the short-wave energy thereto.

Now referring to Fig. 2, a modified apparatus for reproducing images and embodying the invention 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 **11** and **14** by an endless belt **60**. The belt **60** is preferably a transparent belt and a transparent plastic commercially identified as Saran Wrap is thought to be satisfactory. Saran is a trademark for a thermoplastic resin comprising a copolymer of vinylidene chloride and vinyl chloride. The belt **60** is passed between rollers **61** and **62** spaced on opposite ends of the elements **11** and **14** and above the image isolator **18**. The belt **60** passes from the roller **62** in a clockwise direction around the rollers **63**, **64**, **65** and **66** spaced around the conductive element **14**, the latter roller being spaced upwardly from the roller **61**. The reproducing material is applied to the belt **60** intermediate the rollers **61** and **66** and is put on the ribbon electronographically or by rollers. Any undesired static charge may be removed from the belt **60** in conventional manner when it is found to be necessary. A coating of reproducing material on the belt **60** is, in this instance, shown as being applied by a spray **67**. The reproducing material is then carried by the belt **60** through the elements **11** and **14** around the rollers **62** and into contact with an eraser or cleaning brushes **68**, which are provided intermediate the roller **62** and the roller **63**, to remove the excess or residue of the reproducing mateiral from the belt so that it may be continuously used.

In this particular embodiment it is thought that the coating of the belt **60** 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 **17** 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 forming directly and substantially instantaneously on print receiving material and in final finished form reproductions of electrical information comprising a cathode-ray tube provided with a phosphorescent coating on the inner face of its image surface and mounting a light-sensitive target on its outer face and which target includes a photoconductive layer interposed between electrically conductive layers wherein the outer conductive layer is provided with a surface having a plurality of minute spaced projections, an electrically conductive receiving element spaced from the target of said cathode-ray tube and having the surface adjacent said spaced projections provided with a plurality of similar projections and in alignment with the

corresponding projections on said target, a source of relatively high voltage connectable between said target and said receiving element and effective to provide a high intensity electrical field therebetween having the lines of force thereof extending between said aligned conductive projections, means for positioning print receiving material adjacent the projections of said receiving element, means for providing said positioned print material with an electrical charge, means for isolating and exposing predetermined areas of said positioned print receiving material from and to said target in a predetermined timed relation with the creation of the electrical field, means for delivering electrical information to the cathode-ray tube to cause an electron beam to illuminate the coating of said tube and thereby to affect the target thereon during the existence of the electrical field, the illumination of the coating of the cathode-ray tube producing a light image correlating to the electrical information and effective to cause resistive changes in the photoconductive layer, means for passing a ribbon adjacent said target and through the electric field, and means for coating said ribbon with a liquid reproducing material on the surface adjacent said receiving element to be acted on by the electric field and migrated by the same toward the print receiving material to be intercepted thereby and produce thereon in final finished form a reproduction of the electrical information.

2. The combination as defined in claim 1 including means for cleaning the excessive reproducing material from said ribbon after passing through the electric field.

3. The combination as defined in claim 1 wherein said ribbon is a transparent plastic.

4. In apparatus for forming directly and substantially instantaneously on print receiving material and in final finished form reproductions of electrical information comprising a cathode-ray tube provided with a phosphorescent coating on the inner face of its image surface and mounting a light-sensitive target on the outer face of said image surface and which target includes a photoconductive layer between electrically conductive layers, an electrically conductive attraction element spaced from the target of said cathode-ray tube, a source of relatively high voltage connectable between said target and said conductive attraction element and effective to provide a high intensity electrical field therebetween on the energization of said source, means for positioning print receiving material adjacent to said receiving element, means for isolating and exposing predetermined areas of said print receiving material from and to said target in a predetermined timed relation with the creation of the electrical field, means for delivering electrical information to said cathode-ray tube effective to produce image information on the image surface thereof during the existence of the electrical field, the image information being effective to cause resistive changes in the photoconductive layer, and means for introducing reproducing material within the space adjacent the illuminated target to be acted on by the electric field and migrated and propelled thereby in finely divided form toward the print receiving material to the exposed area of the print receiving material and produce thereon in final finished form a reproduction of the electrical information.

5. In apparatus for forming directly and substantially instantaneously on print receiving material and in final finished form reproductions of electrical information as defined in claim 4 and wherein the photoconductive layer is a selenium layer.

6. In apparatus for forming directly and substantially instantaneously on print receiving material and in final finished form reproduction of electrical information as defined in claim 4 including means for ionizing the reproducing material.

7. In apparatus for forming directly and substantially instantaneously on print receiving material and in final finished form reproductions of electrical information as defined in claim 6 wherein the ionizing means comprises means for transmitting short-wave radiant energy adjacent said light-sensitive target.

8. In apparatus for reproducing electrical information as images directly on print receiving material comprising cathode ray tube means provided with a phosphorescent coating on the inner face thereof, exciting means for delivering electrical information to said cathode ray tube means and effective to project a light image onto said coating correlated to the configuration of said information, a light-sensitive target mounted on the outer face of said tube means and including a photoconductive element having substantially instantly a change in the electrical conductivity thereof in response to the presence or absence of a light image on said coating, electrically conductive means in operative relationship to said photoconductive element and coextensive therewith, means for positioning print receiving material spaced from said light-sensitive target, means for creating an electric field between said target and said print receiving material and providing for the electrostatic lines of force thereof to be intercepted by said material and affected by the change in conductivity of said photoconductive element, said exciting means being effective to project a light image upon said coating in a predetermined timed relationship with the positioning of the print receiving material and the creation of said electric field, and means for introducing reproducing material intermediate the positioned print receiving material and said light-sensitive target to be acted upon by the electric field and migrated thereby in finely divided form toward the print receiving material.

9. In apparatus for reproducing electrical information as images directly on print receiving material as defined in claim 8 and wherein said apparatus includes means for isolating and exposing predetermined areas of the print receiving material from and to the light-sensitive target in predetermined timed relationship to the projection of said light image upon said phosphorescent coating.

10. In apparatus for reproducing electrical information as defined in claim 8 including means for transmitting short-wave radiations adjacent said light-sensitive target to ionize said finely divided reproducing material.

11. In apparatus for reproducing electrical information as images directly on print receiving material from image copy comprising cathode ray tube means provided with a phosphorescent coating of the inner face thereof, exciting means for delivering electrical information to said cathode ray tube means and effective to project a light image onto said coating correlated to the configuration of said image copy, a light sensitive target mounted on the outer face of said tube means and including a photoconductive element and electrically conductive means in operative relationship therewith, said photoconductive element having substantially instantly a change in the electrical conductivity thereof in response to the presence or absence of a light image on said coating, an electrically conductive element spaced from said light sensitive target, means for positioning print receiving material spaced from said light sensitive target and between the latter and said conductive element, means for creating an electric field between said target and said conductive element and providing for the electrostatic lines of force thereof to be intercepted by said material and affected by the change in conductivity of said photoconductive element, said exciting means being effective to project a light image upon said coating in a predetermined timed relationship with the positioning of the print receiving

material and the creation of said electric field, and means for introducing reproducing material in cloud-like form intermediate the positioned print receiving material and said light sensitive target to be acted upon by the electric field and migrated thereby toward said print receiving material.

12. In apparatus for reproducing electrical information as images directly on print receiving material comprising cathode ray tube means provided with a phosphorescent coating on the inner face thereof, exciting means for delivering electrical information to said tube means and effective to project a light image onto said coating correlated to the configuration of said information, a light sensitive target mounted on the outer face of said tube means and including a photoconductive element sandwiched between electrically conductive means, said photoconductive element having substantially instantly a change in the electrical conductivity thereof in response to the presence or absence of a light image on said coating, said conductive means having an outer surface provided with a plurality of minute conductive projections, an electrically conductive element spaced from said light sensitive target with its surface adjacent said conductive projections thereof provided with a plurality of substantially similar projections in axial alignment therewith, means for positioning print receiving material spaced from said light sensitive target and between the latter and said conductive element, means for creating an electric field between said target and said conductive element and providing for the electrostatic lines of forces thereof to extend between said aligned projections and be intercepted by said material and affected by the change in conductivity of said photoconductive element, said exciting means being effective to project a light image upon said coating in a predetermined timed relationship with the positioning of said print receiving material and the creation of said electric field, and means for introducing reproducing material in cloud-like form intermediate the positioned print receiving material and said light sensitive target to be acted upon by said electric field and migrated thereby toward said print receiving material.

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