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ELECTROSTATIC PRINTER UTILIZING AN ARRAY OF
MUTUALLY INSULATED PIN ELECTRODES

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2 Sheets-Sheet 1

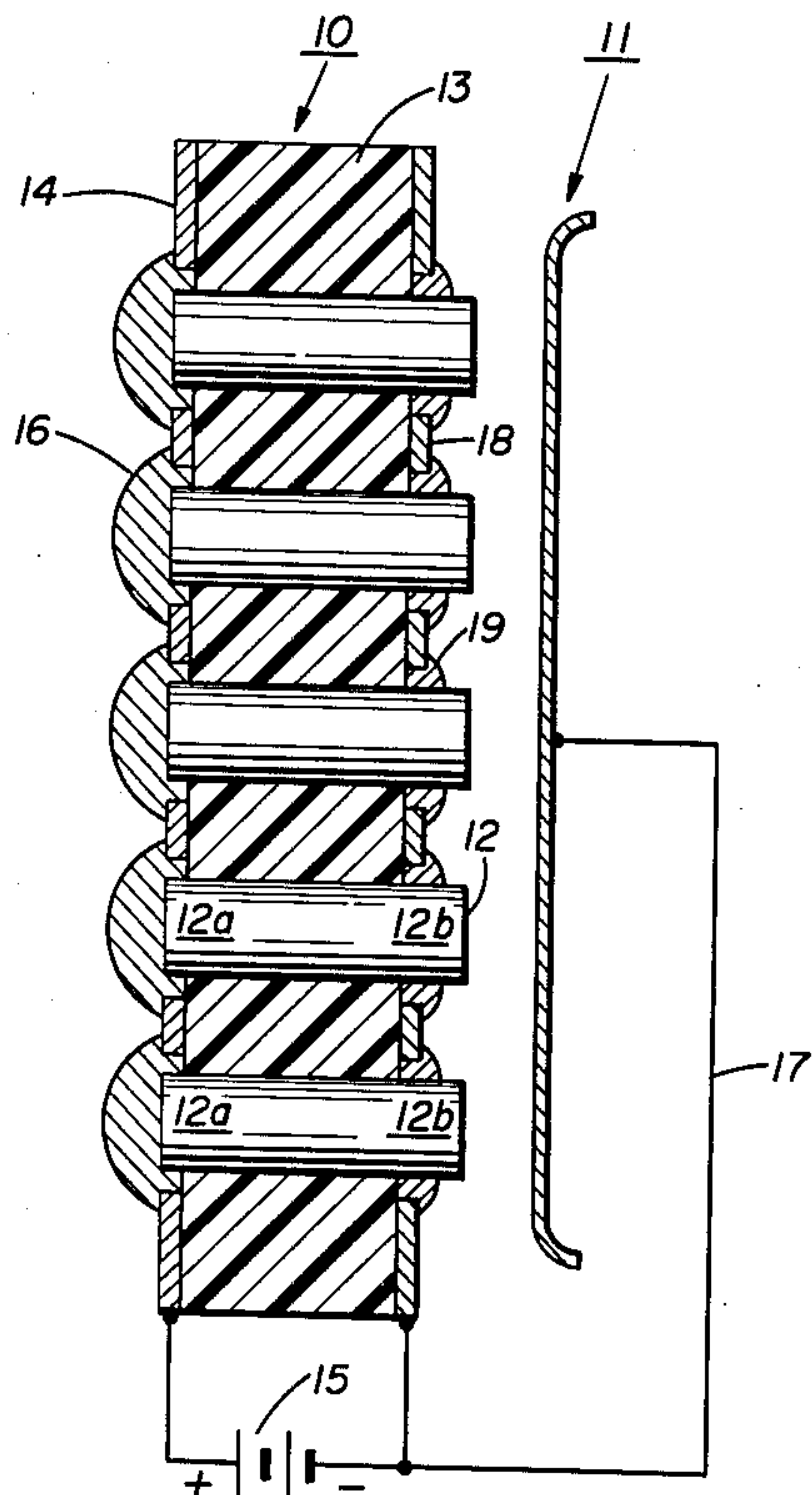


Fig. 1

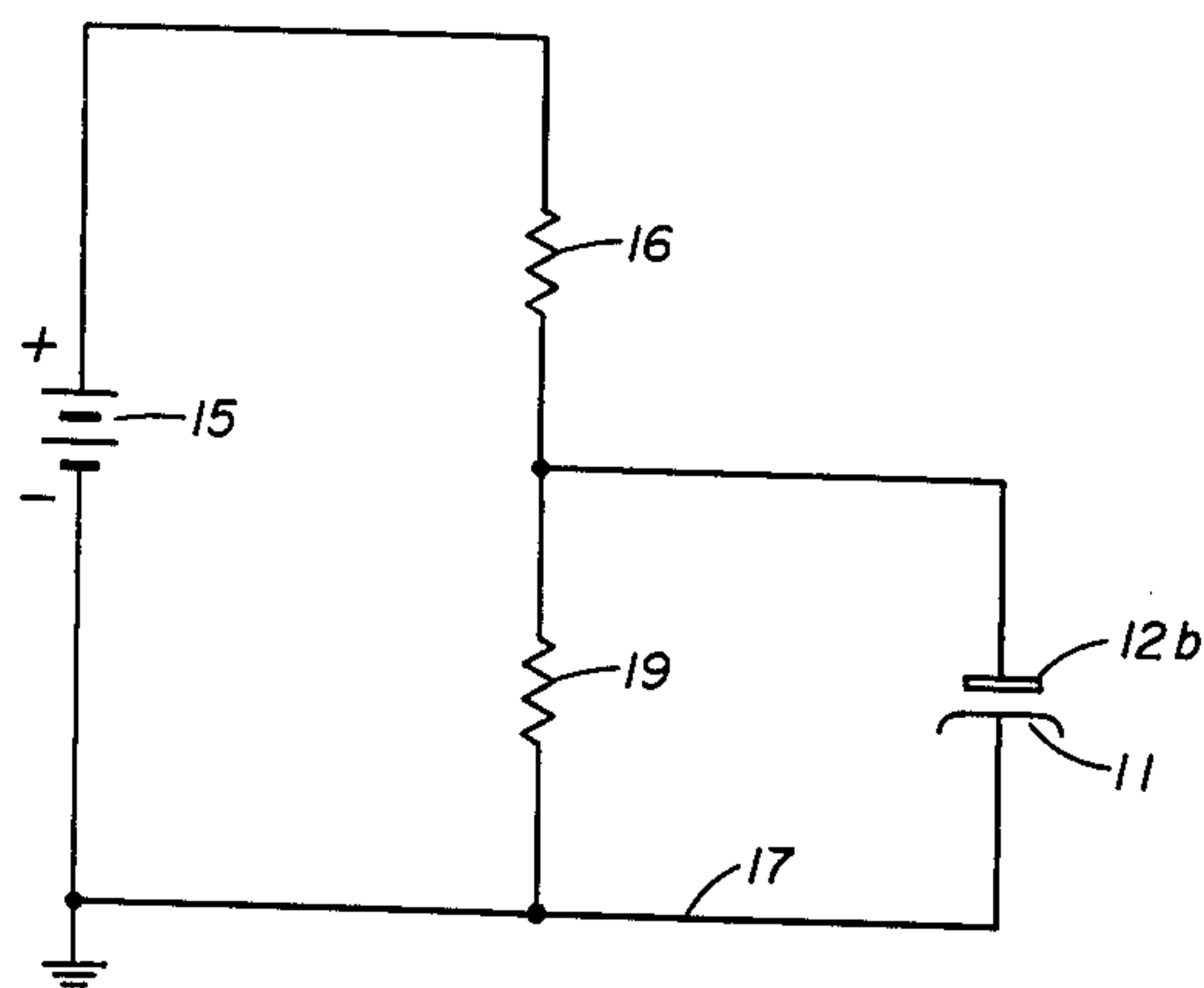


Fig. 3

INVENTORS.
SHERMAN H. BOYD
OMER F. HAMANN
BY

Daniel D. Sharp
ATTORNEY

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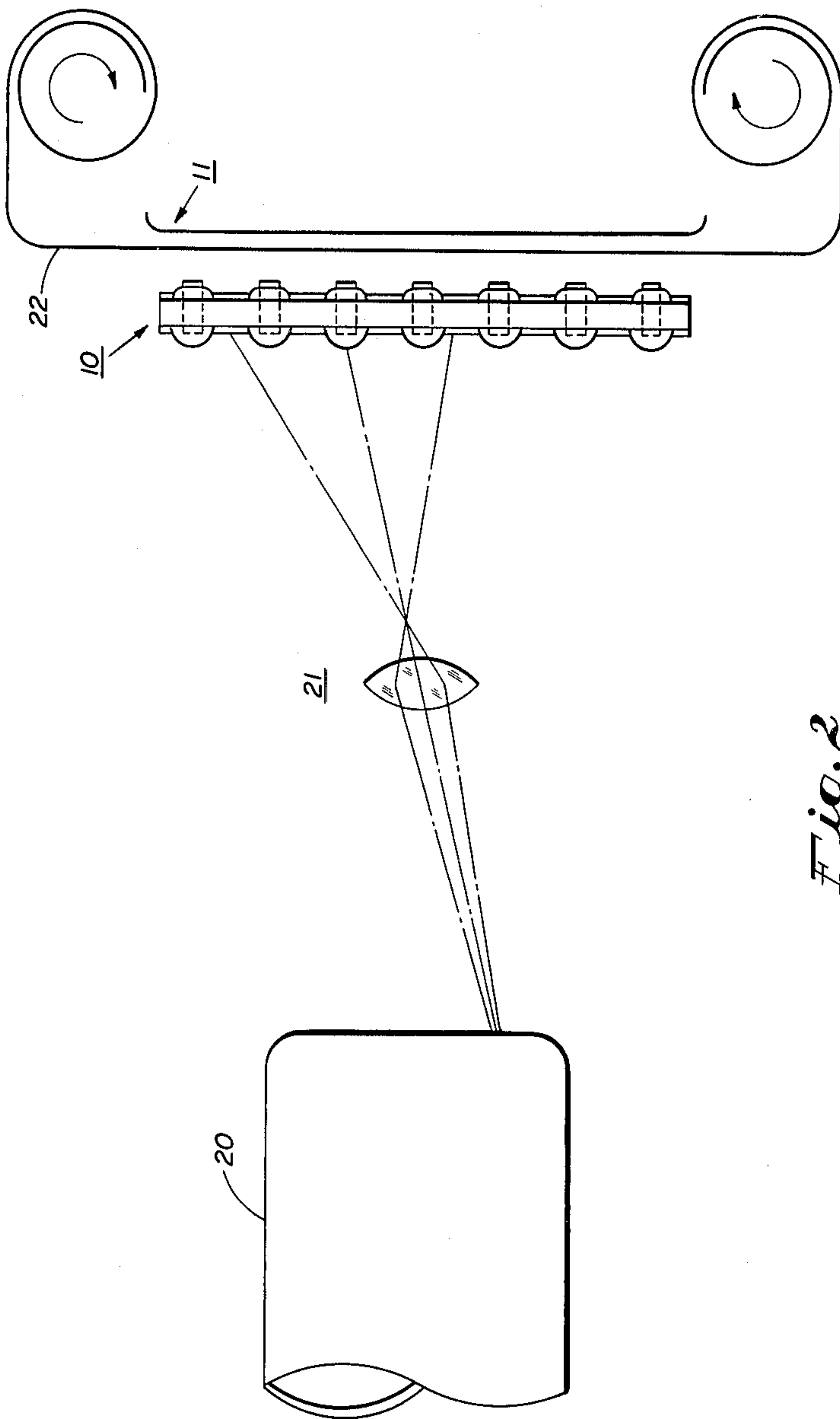


Fig. 2

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ELECTROSTATIC PRINTER UTILIZING AN ARRAY OF MUTUALLY INSULATED PIN ELECTRODES

Sherman H. Boyd, San Diego, and Omer F. Hamann, La Jolla, Calif., assignors, by mesne assignments, to Stromberg-Carlson Corporation, Rochester, N.Y., a corporation of Delaware

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6 Claims. (Cl. 346-74)

This invention relates to electrostatic printers and, more particularly, to improvements in printers which utilize a plurality of mutually insulated pin electrodes in conjunction with a spaced conductive plate.

Prior art electrostatic pin electrode printers are characterized by an array of mutually insulated pin electrodes located in proximity to a conductive plate which is spaced from the array so as to provide a gap which can accommodate a recording medium. Various techniques are utilized in the prior art to selectively apply a charging potential between selected ones of the pin electrodes and the conductive plate. Since the pin electrodes are substantially parallel to each other and insulated from one another by an insulating material, the pin-to-pin capacity between adjacent pins is quite high. In addition, the terminal end of each pin electrode forms, in conjunction with the space conductive plate and the interposed dielectric recording medium, an additional pin-to-plate capacity. Upon selection of a particular pin electrode, the pin-to-plate capacity of the selected pin, as well as the pin-to-pin capacity, charge up until the potential is reached between the terminal end of the selected pin and the conductive backing plate at which a silent discharge takes place. This discharge results in placing an electrostatic charge upon the recording medium which is interposed between the array of pin electrodes and the conducting plate.

Various problems have arisen and various systems have been designed to overcome the detrimental effect that the pin-to-pin and pin-to-electrode capacities have upon the maximum speed at which the system is capable of operating. Originally such systems had no provisions for discharging these capacities other than through the discharge itself that performed the recording operation. Various improvements in these systems have taken place in order to establish independent paths for discharging the pin-to-pin and pin-to-plate capacities of these systems independent of the discharge path that performs the recording operation.

Establishment of the separate discharge paths also facilitated putting a D.C. bias upon the pin electrodes so as to minimize the energy necessary to cause the discharge by biasing the pin electrodes just below their operating point. Thus, a power gain could be effective in such systems.

The various prior art systems designed to provide a D.C. bias for the pin electrodes as well as to provide separate discharge paths for the pin-to-pin capacity were expensive to construct and, in addition, difficulties were being encountered in further reducing the RC time constant of the pin-to-pin capacities so as to increase the maximum recording speed at which an accurate reproduction of the input information would take place.

The limiting factor as far as faithful reproduction of input information is concerned has to do with the ability of the pin-to-pin and pin-to-plate capacities to discharge rapidly so as to individually be able to follow the voltage applied between the pin electrode and the common backer electrode. These independent discharge paths are necessary since it has been found that under proper conditions the space charge cloud formed between the pin electrode and the recording medium tends to extinguish the dis-

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charge before the potential of the pin electrode with respect to the backer electrode has gone below the point at which it would sustain a discharge to the surface of a recording medium having a substantially uncharged surface. Thus, even though there were no independent discharge paths for the pin-to-pin or pin-to-plate capacities, the discharge would cease upon the space charge cloud extinguishing the discharge. Thus, as long as the recording medium remains stationary, no further discharge will take place to the charged area of the record medium in proximity to the selected pin electrode. However, as soon as this charged area is removed from the influence of the pin electrode and the backer plate, an additional discharge from the pin electrode to the backer plate could take place even though the particular pin electrode had not been selected for application of the charging potential between it and the backer electrode. Thus, if this pin-to-pin or pin-to-plate capacity is not discharged rapidly with respect to the speed of advancement of the recording medium, an erroneous discharge can take place until the potential of the previously selected pin electrode is below the point at which a discharge may be initiated to the backer electrode through the recording medium.

It is, therefore, an object of our invention to provide an improved electrostatic printer of the type which utilizes an array of mutually insulated pin electrodes.

It is another object of our invention to provide an improved pin electrode electrostatic printer which facilitates an increase in the speed of an electrostatic recording operation.

It is a further object of our invention to provide an electrostatic printer in which the pin electrodes are D.C. biased just below their operating point so as to accomplish a power gain during the recording operation.

These and other objects of our invention are accomplished by providing individual high resistance discharge paths between each pin electrode and the conductive plate. Since each of these discharge paths are directly in shunt with the recording gap their resistance should be large enough to allow the pin electrode to charge up to its discharge potential in order not to interfere with the recording operation. Once the minimum value of the resistance of the discharge path is established, we have minimized the R.C. time constant of the discharge path for not only the pin-to-plate capacity but, in addition, we have also minimized the RC discharge time of the pin-to-pin capacity. In this way, the potential of the pin electrodes with respect to the conductive plate will more closely follow the input signal applied in the form of varying potentials to the pin electrodes thus facilitating accuracy of reproduction of the input information. This is especially desirable in continuous tone recording.

Other objects, features, and advantages of the present invention will be found throughout the following more detailed description of the invention, particularly when considered with the accompanying drawings in which:

FIG. 1 is a cross-sectional view of an electrostatic printer head in accordance with this invention;

FIG. 2 is a schematic representation of a recording system utilizing the electrostatic printer head of our invention; and

FIG. 3 is a simplified schematic diagram of the equivalent circuit of an elemental pin electrode in cooperation with the conductive plate.

Referring now to FIG. 1 of the drawings, there may be seen a cross-sectional view of the electrostatic printer head in accordance with this invention. The printing head is comprised of an array 10 of mutually insulated pin electrodes and a cooperating conductive plate electrode 11. Array 10 is comprised of a plurality of pin electrodes 12 which are supported in spaced parallel alignment by in-

insulator 13 so that their input ends 12a and their terminal ends 12b are exposed at the two sides of insulator 13.

Conductive coating 14 which is provided on the input side of insulator 13 is connected to one side of voltage source 15. The mosaic of photoconductors 16 provides means for selectively connecting input ends 12a of the pin electrodes to voltage source 15 in response to the irradiation of the input side of array 10 by light information.

Conductor 17 provides means for completing the path for charging the capacity created between terminating ends 12b of the pin electrodes, or writing points, and conductive plate 11. Conductive film 18 in cooperation with high resistance material 19, which links writing points 12b and conductor 18, provide means for establishing individual high resistance discharge paths from the writing points to conductive plate 11 via conductor 17.

Referring now to FIG. 2, in accordance with the preferred embodiment of our invention, the source of light information comprises cathode ray tube 20, the light from which is directed to array 10 by means of optical system 21. Of course, it will be recognized that other sources of light information and other types of optical systems can be utilized with the electrostatic printer head of our invention and that the selected source of light information and the selected optical system illustrated in FIG. 2 are exemplary only.

Under initial conditions when pin array 10 is not being irradiated by light information from source 20, the leakage resistance across high resistance material 19 (see FIG. 3) is such that the corresponding writing point 12b, which forms one plate of the capacitor, is at a voltage below that required to initiate a discharge to conductive plate 11. Supply voltage 15 is above that required for such a discharge. In the preferred embodiment of our invention, the leakage resistance, that is the value of resistance 19, is between 10^6 and 10^{15} ohms. When the resistance of leakage path 19 is in this range and assuming that supply voltage 15 is above that required for discharge, the leakage current through photoconductor 16 and resistor 19 is small enough to prevent writing point 12b from building up to a discharge potential as long as photoconductor 16 remains in the dark. The dark resistance of photoconductor 16 is 10^6 to 10^{12} ohms. Upon being triggered by light, the resistance across photoconductor 16 drops to 10^3 to 10^7 ohms, thereby allowing the corresponding writing point 12b to reach a potential sufficient to support a discharge across the gap. Assuming that a dielectric paper 22 is present within the gap, this discharge is intercepted by dielectric recording medium 22, which is of suitable resistivity to store an electrostatic latent image thereon. This electrostatic latent image may at that time, or later, be rendered visible by developing and fixing the image by standard techniques.

Thus, in accordance with one feature of our invention, the speed of the recording operation is improved over prior art systems thus facilitating a faster movement of the recording medium past the array of pins without a loss of resolution during the recording operation.

In accordance with our invention, the technique that is utilized to selectively energize pin electrodes in accordance with the information to be recorded is accomplished by utilizing photoconductive switching techniques rather than utilizing the beam of a cathode ray tube to energize pins embedded in the face of the tube. Electronic switching has also been utilized in the prior art to selectively energize pin electrodes in accordance with information to be recorded. The use of photoconductive switching as distinguished from beam switching in a cathode ray tube, or electronic switching, lends itself to a character-at-a-time, a line-at-a-time, or a page-at-a-time printing since the elements have built-in, short term storage capabilities due to the utilization of photoconductive material. A photoconductive material has short term storage capabilities since a photoconductor will remain in its low resist-

ance (illuminated) for a finite time after the illumination of the photoconductor has ceased.

For character-at-a-time printing, the individual elements, or pin electrodes, are allowed to build up to the discharge voltage by means of the circuit shown in FIG. 3. However, for line-at-a-time type of operation, an auxiliary voltage pulse is applied to the conductive plate after the line of information has been directed onto the photoconductive surface of pin array 10 and the individual elements have been allowed to charge up to a potential just below the discharge value. Thus, whenever the entire line of information has been stored in the pin array, the printing operation of the entire line can then take place by applying the auxiliary voltage pulse to conductive plate 11 to thereby generate discharges from all of the pin electrodes that have been enabled by the light information.

The same type of operation also occurs for the page-at-a-time operation except that the voltage pulse comes after the page of information has been registered.

The utilization of a photoconductor as a light operated switch and, in addition, as contributing an element of short term storage capabilities, has a marked advantage as to the manner in which the input information is applied to the printer. Due to the storage capabilities of the photoconductor, the input information can be random rather than sequential in a line-at-a-time or page-at-a-time type printer. Thus, the inherent short term storage capabilities attributable to these of photoconductive switching lends greater flexibility to the pin electrode printer of our invention than was previously obtainable with prior art electron beam or electronic switching type of pin electrode printers.

It is therefore apparent from the above detailed description that an economical, high-speed recording device is provided for recording information upon a recording medium. It will be understood, however, that various omissions, substitutions, and changes in the form and details of the illustrated device and in their operation may be readily made by those skilled in the art within the scope of the invention. For example, the top photoconductor need not be in the form of islands but can be continuous as the transverse currents would be very small and would have no substantial effect upon the previously described recording operation. Such construction would facilitate the production of the printer head of the system of our invention. We do not, therefore, desire our invention to be limited to the specific arrangement shown and described, and we intend in the appended claims to cover all modifications within the spirit and scope of our invention.

What we claim is:

1. An electrostatic printer comprising an array of mutually insulated conductive electrodes having writing points which are exposed on one side of said array, a conductive plate adjacent to and spaced from said exposed writing points, means for selectively elevating the potential of selected ones of said electrodes until a space discharge occurs between the writing points of the selected electrodes and said conductive plate, and means for individually establishing a resistive discharge path in parallel with said space discharge path between each electrode of said array and said conductive plate, the resistance of each resistive discharge path being high enough in value to allow the potential of the corresponding electrode to reach its space discharge potential when selected by said potential elevating means, yet at the same time providing minimum discharge time for the capacities between the corresponding electrode and said conductive plate and between the corresponding electrode and adjacent electrodes.

2. The combination of claim 1 in which said selective potential elevating means comprises means for exposing the other side of said array to light information, a source of potential having one side connected to said conductive

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plate, said electrodes being exposed on said other side of said array and means located on said other side of said array for selectively connecting the other side of said source to selected ones of said exposed electrodes in accordance with said light information.

3. The combination of claim 2 in which each resistive discharge path means comprises high resistance means connected between each of said exposed writing points and said conductive plate for providing an individual resistive discharge path for the capacity between each electrode and said conductive plate, and between each electrode of other adjacent electrodes.

4. The combination of claim 3 in which said selective connecting means comprises a first conductive layer disposed on the surface of said array on said other side, said first conductive layer overlying and being in contact with only the insulated area of said array, a plurality of photoconductive elements for interconnecting each electrode and said first conductive layer, and means for connecting said first conductive layer to said other side of said source of potential.

5. The combination of claim 4 in which said high resistance means comprises a second conductive layer disposed on the surface of said array on said one side, said second conductive layer overlying and being in contact with only the insulated area of said array, a plurality of high resistance elements for individually connecting each electrode to the adjacent portion of said second conductive layer, and means for connecting said second conductive layer to said one side of said source of potential.

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6. An electrostatic printer comprising an array of mutually insulated low resistance conductive pin electrodes terminating in writing points which are exposed on one side of said array, a conductive plate adjacent said exposed writing points to provide gaps between each of said writing points and said conductive plate, means for selectively elevating the potential of selected ones of said pin electrodes until a discharge occurs from their writing points to said conductive plate, and means for individually establishing resistive discharge paths directly in shunt with each of said gaps, the resistance of each of said discharge paths being just high enough in value to allow the potential of the corresponding writing point to reach its discharge potential when selected by said potential elevating means to thereby provide minimum discharge time for the capacity of the gap between the corresponding writing point and said conductive plate.

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IRVING L. SRAGOW, *Primary Examiner*.