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ELECTROSTATIC PRINT HEAD AND PRINTING STATION

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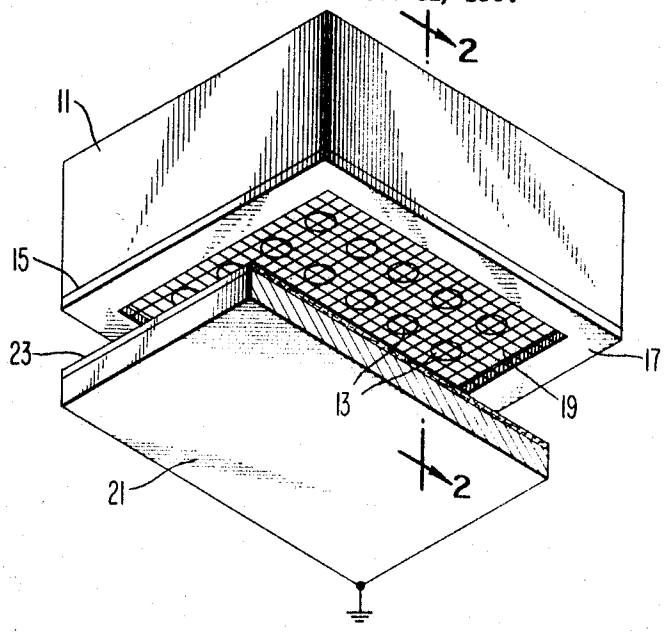


Fig. 1

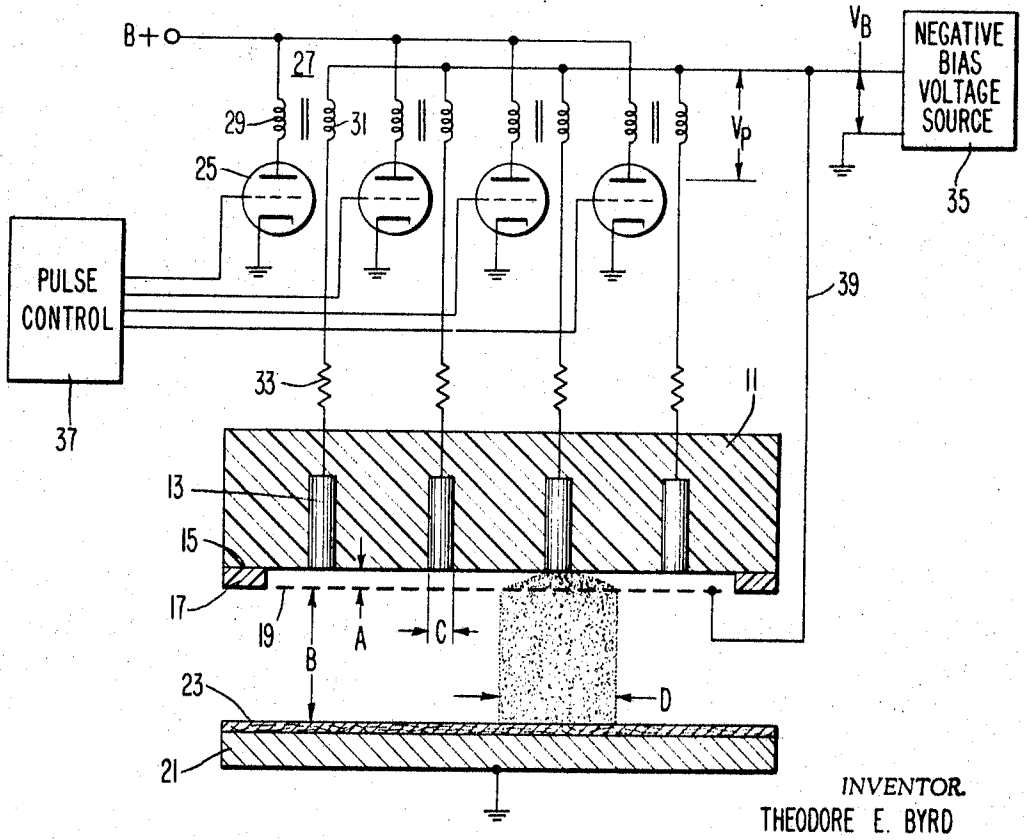


Fig. 2

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ELECTROSTATIC PRINT HEAD AND PRINTING STATION

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ABSTRACT OF THE DISCLOSURE

An electrostatic printing station for controlling the size of latent image charged spots deposited on a charged retentive medium. The printing station is comprised of a print head having a plurality of ionization initiating pin electrodes terminating in a planar face and having an electrically biased flat grid positioned parallel to and closely spaced from said planar pin face, an electrically biased planar back electrode positioned parallel to said grid and spaced away from it to define a gap through which said charge retentive medium is passed and a means to energize a selected pin electrode or selected pin electrodes simultaneously as desired. The size of the charged spot is a function of the spreading of the ionized particles in the area between the grid and the planar pin face.

This invention relates to an apparatus for depositing charged areas upon a record medium and, more particularly, to an electrostatic print station incorporating a print head for depositing relatively large charged spots upon a charge-retentive medium.

Deposition of charged spots has been accomplished by prior art apparatus of the type having a pin electrode facing a planar back electrode or anvil. A record medium is placed upon the back electrode and a high-intensity electric field is established between the pin electrode and the back electrode sufficient to introduce, through field emission, charged particles into the gap existing between the two electrodes. Ions generated by the emission cumulate, and are propagated toward the back electrode by the electric field between the electrodes, causing a charged area to be established upon the record medium. Further details of the electrostatic process and of the means for practicing it are disclosed in U.S. Patent No. 2,955,894, issued Oct. 11, 1960, to Herman Epstein for Page Printing Apparatus and in U.S. Patent No. 2,919,171, issued Dec. 29, 1959, to Herman Epstein and Robert J. Phelps for Page Printing Apparatus, both of which patents are assigned to the assignee of the present invention. The disclosures of these patents are incorporated in the description of this invention.

When a pin electrode is used in combination with the planar electrode, the configuration of the ion stream between the electrodes is conical, with the base of the cone facing the planar electrode in the case where negative voltage is applied to the pin. As a result of this spreading effect, the size of the charged area created upon the record medium will be a function of the distance between the record medium and the pin electrode; to increase the charged area, the record medium-to-pin electrode space must be increased. An increased gap between electrodes, in turn, necessitates a larger operating voltage.

The size of the charged spot is a function of the electric field intensity in the gap between the electrodes at the time of the commencement of ionization. Because of the random variation of the voltage at which breakdown occurs across the relatively large gap needed to create large spots, the size of the charged area has not heretofore been entirely predictable.

Accordingly, it is an object of this invention to provide an electrostatic printing station for creating upon a record medium large, charged spots of predictable magnitude.

It is another object of this invention to provide an improved print head for producing on a record medium charged spots whose size is substantially independent of print head to printing medium distance.

It is a further object of this invention to provide a printing station wherein the voltage gradient across the record medium is substantially reduced.

These and other objects are achieved by a printing station comprising a print head of the type having a plurality of pin electrodes terminating in a print face. A flat metallic grid, preferably a fine mesh screen, is positioned parallel to and closely spaced from the print face. A planar back electrode or anvil is positioned parallel to the grid and far enough from it to admit a record medium. The grid is negatively biased with respect to the anvil to establish a nondivergent unidirectional field between grid and anvil.

A pulse negative with respect to the grid is applied to selected ones of the pin electrodes. A spark discharge is created between an energized pin and the screen, creating a cloud of positive and negative ions. Negative ions are propelled from within the pin-to-screen gap, through the screen-to-anvil gap, until they impinge upon a defined area of the record medium. Ions spread during their travel from the pin to the screen, but spread little in the screen-to-anvil gap.

While some of the objects and a brief description of the invention have been given above, the invention and its objects will be best understood by referring to the following detailed description and to the accompanying drawings wherein:

FIG. 1 is an isometric view, partly broken way, of a preferred embodiment of a print station incorporating the improved print head.

FIG. 2 combines a cross section of FIG. 1 taken along the lines 2—2 with a showing, in addition, of a schematic representation of a circuit which may be used to operate the print station.

Referring to FIG. 1, there is shown a print head **11** of insulating material having embedded therein an array of pin electrodes **13**. While, for purposes of facilitating drafting, an illustrative 4 x 5 matrix of pins has been shown, it will be understood that the matrix may comprise any number of pins in the array desirable for printing indicia and a 5 x 7 pin array has been used successfully in configurations for printing alphabetic and numerical characters. The pin electrodes **13** terminate in a substantially planar print face **15**. Closely spaced by insulator **17** and forming part of the print head **11** is a screen or grid electrode **19** which is parallel to and coextensive with the print face of the print head. A planar back electrode **21** is located in a spaced-apart, substantially parallel relationship with the grid electrode **19**. Record medium **23** is located between grid electrode **19** and back electrode **21**, and in substantial contact with the latter. The combination of print head **11** and back electrode **21** constitutes a print station.

FIG. 2 illustrates the arrangement in more detail. A switching tube **25** and a transformer **27**, having a primary winding **29** and a secondary winding **31**, are provided for each pin electrode **13** to initiate a discharge between it and the grid electrode **19**. Each pin electrode **13** is connected through a current-limiting resistor **33** to a terminal of the secondary winding **31** of its associated transformer **27**. The other terminal of each of the secondary windings **31** is connected to negative bias voltage source **35**. Each primary winding **29** is connected between a source of positive bias and the plate of a switching tube **25**. Each

switching tube **25** is controlled through its grid by an individual output of pulse control unit **37**. The output V_B of negative bias voltage source **35** is also connected through line **39** to the screen electrode **19**.

In operation, the switching tubes **25** are normally nonconducting. Consequently, the pins **13** and the screen electrode **19** are maintained at voltage V_B, a negative voltage when large spots are desired. The back electrode **21** may be maintained at ground potential. To energize a given pin electrode, its associated switching tube **25** is rendered conductive, causing a large negative voltage pulse to be transmitted to that pin through the coupling action of its associated transformer **27**.

Because of this negative pulse, a large potential difference is established between screen electrode **19** and the energized pin electrode **13**, causing a spark discharge to occur therebetween. This spark discharge generates both positive and negative ions between the energized pin and the screen electrode.

Spreading of ions occurs in their travel from the pin to the screen. This spreading provides an area of charges at the screen exceeding that at the face of the pulsed pin, and is believed to be due to the divergence of the field between the pin, relatively a point source, and the screen, and to the travel of ions along such diverging field lines.

The screen electrode **19** and the back electrode **21** are both of a planar configuration, situated substantially parallel to each other. Accordingly, since the back electrode is at ground potential while the screen electrode is at some negative V_B, a unidirectional, nondivergent field exists between these two electrodes. Under the urging of this field, negative ions are propelled from the screen through the screen-to-anvil gap, onto the record medium **23** to deposit thereon a charged area of negative polarity. The size of the charged area will approximately equal the area occupied by the cloud of ions in the vicinity of the screen.

Because there is substantially no spreading of ionized particles during their transit from the screen towards the back electrode or anvil, the size D of the charged area upon the record medium is substantially independent of the magnitude of the screen-to-anvil gap. The size of the charged area is determined by the extent of spreading of ionized particles in the area between the screen and the energized pin which is determined primarily by the magnitude of the pin-to-screen gap.

While not to be construed as limiting the invention to these values, the following values of parameters are those used in a model which was built to incorporate the features shown in FIG. 2:

Pin-to-screen gap A ____	2 mils.
Screen-to-paper gap B__	60 mils.
Pin diameter C _____	20 mils.
Screen size _____	250 lines per inch; 3.35 mil hole width; .65 mil wire width.
Screen bias voltage V_B ___	−1,500 volts with respect to ground.
Pin pulse voltage V_P ___	−1,600 volts with respect to ground.
Pin pulse width _____	100×10^{-6} sec.
Series pin resistor **33**____	10,000 ohms.
Spot size D _____	95 mils.

It will be noted that a spot size D approximately five times that of pin diameter C has been achieved with a pin-to-screen gap A of only 2 mils. The use of a 2-mil gap permits operation with a relatively low pin pulse voltage V_P, which would be impossible if ion spreading were to be accomplished by increasing the pin-to-paper distance B of prior art print heads. Satisfactory operation at relatively low pin pulses voltages can be maintained for space gaps of less than 10 mils.

Experiments with the above model indicate that screen-to-paper gap B may be increased up to ¼ inch without significant effect upon spot size D.

The print station has been described as operating with screen and pins biasted negatively with respect to the back electrode, and with a pin pulse voltage which is negative with respect to the pin and screen bias. This mode of operation is preferred because it makes the pins rather than the screen the cathode, thus providing essentially point sources of electrons.

However, other combinations of operating voltages may be used. The screen and pins may be biased positively with respect to the back electrode, in which event positively charged ions will be attracted onto the recording medium. The pins may be either positively or negatively pulsed with respect to their bias potential, be that potential positive or negative with respect to the back electrode.

Other parameters may be varied, depending upon the size of charged area desired. Screen sizes ranging between 80 lines per inch to 500 lines per inch have been used with a corresponding variation in charged spot size ranging between 95 mils and 110 mils. Satisfactory results are available from screen sizes ranging substantially between 50 lines per inch to 1,000 lines per inch. The screens employed in the above model were all electro-formed nickel mesh manufactured by the Buckbee Mears Company, St. Paul 1, Minn. Molybdenum screens could also be used.

Pulse width may also be varied to alter spot size. Thus, with an 80-lines-per-inch screen, increasing the pulse length from 100 microseconds to 200 microseconds resulted in a corresponding increase in charged spot size from 120 mils to 130 mils. Spot size may also be varied by modifying the size of pin ends in the print face. A print head may have different sized pins, larger pin ends being provided for generation of larger spots.

Having described several embodiments of a printing station utilizing an improved print head operable at reduced voltages for creating upon a record medium large charged spots whose size is predictable, and substantially independent of the print head-to-record medium distance in accordance with the invention, it is believed obvious that many modifications and variations of the present invention are possible in the light of the above teachings.

What is claimed is:

1. An electrostatic printing station for establishing an electrically charged area on the surface of a record medium, comprising:

a pair of substantially planar electrodes located to define a space for receiving said record medium substantially in contact with one of said electrodes, said other electrode being perforate,

at least one pin shaped initiating electrode closely spaced from said perforate electrode, located outside said space and substantially normal to said perforate electrode,

means to establish a substantially non-divergent field between said pair of electrodes of insufficient magnitude to create a discharge, and

means to create a short duration electric field between said initiating electrode and said perforate electrode of sufficient magnitude to create a disruptive discharge between said latter electrodes.

2. An electrostatic printing station for depositing charged spots upon a record medium, comprising:

a set of pin electrodes terminating in a substantially planar print face,

a back electrode positioned to support said record medium in spaced apart, substantially parallel relationship with said print face,

a grid electrode substantially coextensive with closely spaced from, and substantially parallel to said print face, located between said print face and said record medium,

a pulse generator for creating a disruptive discharge between said pin electrodes and said grid for generation of clouds of ions, said discharge accomplished by momentarily driving said pin electrodes negative with respect to said grid electrode, and

means to create an electrical field between said grid electrode and said back electrode for propagation of some of said ions onto said record medium.

3. The printing station of claim 2 wherein said means to create an electrical field is a biasing source poled to maintain said grid electrode positive relative to said back electrode.

4. An electrostatic printing station for depositing charged spots upon a record medium, comprising:

a set of pin electrodes terminating in a substantially planar print face,

a back electrode positioned to support said record medium in spaced apart, substantially parallel relationship with said print face,

a grid electrode substantially coextensive with, closely spaced from, and susbstantially parallel to said print face, located between said print face and said record medium,

means to create a disruptive discharge between said pin electrodes and said grid for generation of clouds of ions, and

a biasing source poled to maintain said grid electrode positive relative to said back electrode, thereby creating an electric field.

5. In an electrostatic printing apparatus for establishing electrically charged areas of controllable size in a communicative arrangement on a charge retentive medium, said printing apparatus having a plurality of ionization initiating pin electrodes terminating in a print face, said pin electrodes being energizable by a means capable of selecting one or more of said pin electrodes, said printing apparatus having a back electrode being maintained at a reference potential and spaced apart from and parallel to said print face and serving as a support for the charge retentive medium, the improvement of gaining large more intensely charged areas while maintaining the charge retentive medium at a relatively great distance from said print face without the need to maintain an operating voltage dependent upon the distance between said print face and said back electrode, the improvement comprising:

an electrically conductive grid between said print face and said charge retentive medium spaced parallel to and less than 10 mils from said print face and electrically biased to a potential insufficient to charge said retentive medium, but upon energization of one or more of said pin electrodes ions are introduced into an electric field existing between the grid and the charge retentive medium rendering the field sufficient to form electrically charged areas on the medium.

6. In an electrostatic printing apparatus for establishing electrically charged areas of controllable size in a communicative arrangement on a charge retentive medium, said printing apparatus having a plurality of ionization initiating pin electrodes terminating in a print face, said pin electrodes being energizable by a means capable of selecting one or more of said pin electrodes, said printing apparatus having a back electrode being maintained at a reference potential and spaced apart from and parallel to said print face and serving as a support for the charge retentive medium, the improvement of gaining large more intensely charged areas while maintaining the charge retentive medium at a relative great distance from said print face without the need to maintain an operating voltage dependent upon the distance between said print face and said electrode, the improvement comprising:

a mesh screen of electrically conductive material having a density of substantially 50 to 1,000 lines per inch, said screen being between said print face and said charge retentive medium and spaced parallel to and less than 10 mils from said print face and electrically biased to a potential insufficient to charge said retentive medium, but upon enerigization of one or more of said pin electrodes ions are introduced into an electrical field existing between the screen and the charge retentive medium rendering the field sufficient to form electrically charged areas on the medium.

7. An electrostatic printing device comprising:

a plurality of ionization initiating pin electrodes whose operating ends terminate in a common plane forming a print face,

a planar back electrode extending substantially parallel but spaced from said print face to form a gap into which a charge retentive medium is introduced,

means to energize a selected one or more of said pin electrodes, and

means to establish individual, substantially non-divergent ion fields, each in line with, but substantially larger than the cross-sectional area of the operating end of each such energized pin electrode, each said field extending in non-divergent form for the major portion of the distance between the print face and the back electrode.

8. An electrostatic printing device comprising:

a plurality of ionization initiating pin electrodes whose operating ends terminate in a common plane forming a print face,

a planar back electrode extending substantially parallel but spaced from said print face to form a gap into which a charge retentive medium is introduced,

means to energize a selected one or more of said pin electrodes, and

a mesh screen of electrically conductive material having a density of substantially 50 to 1,000 lines per inch, said screen being between said print face and said charge retentive medium, and spaced parallel to and less than 10 mils from said print face and electrically biased to a potential insufficient to charge said retentive medium, but upon energization of one or more of said pin electrodes ions are introduced into an electric field existing between the screen and the charge retentive medium rendering the field sufficient to form electrically charged areas on the medium.

9. An electrostatic printing device comprising:

a plurality of ionization initiating pin electrodes whose operating ends terminate in a common plane forming a print face,

a planar back electrode extending substantially parallel but spaced from said print face to form a gap into which a charge retentive medium is introduced,

a mesh screen of electrically conductive material having an area substantially coextensive with said print face, said screen having a mesh density of substantially 50 to 1,000 openings per inch, and

means mounting said screen upon the print face in electrical insulating relation to the pin electrodes and in substantially parallel coextensive relation to the print face and within 10 mils thereof.

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U.S. Cl. X.R.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,460,156 Dated August 5, 1969

Inventor(s) Theodore E. Byrd

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 2 "biasted" should read --biased--. Column 4, line 31 "different" should read --differently--. Column 5, line 66 before "electrode" insert --back--. Column 5, line 74 "enerigization" should read --energization--.

SIGNED AND
SEALED
APR 28 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents