United States Patent [19]

Cavanaugh et al.

[11] **3,742,516**

[45] **June 26, 1973**

[54] **ELECTRO-IONIC PRINTING APPARATUS**

[75] Inventors: **Lawrence R. Cavanaugh**, Chenango Bridge; **Robert E. McCurry**, Vestal, both of N.Y.

[73] Assignee: **International Business Machines Corporation**, Armonk, N.Y.

[22] Filed: **Mar. 16, 1972**

[21] Appl. No.: **235,186**

[52] U.S. Cl. ..... **346/74 R**, 346/74 ES, 250/49.5 ZC, 96/1

[51] **Int. Cl.** **G11b 9/08**

[58] **Field of Search** ..... 346/74 ES, 74 EB, 346/75; 250/41.9, 49.5 ZC; 96/1

[56] **References Cited**

UNITED STATES PATENTS

3,266,046	8/1966	Boyd	346/74 ES
3,449,753	6/1969	Starr	346/74 ES
3,495,269	2/1970	Mutschler	346/74 ES
3,594,162	7/1971	Simm	250/49.5 ZC
3,611,414	10/1971	Frank	346/74 ES

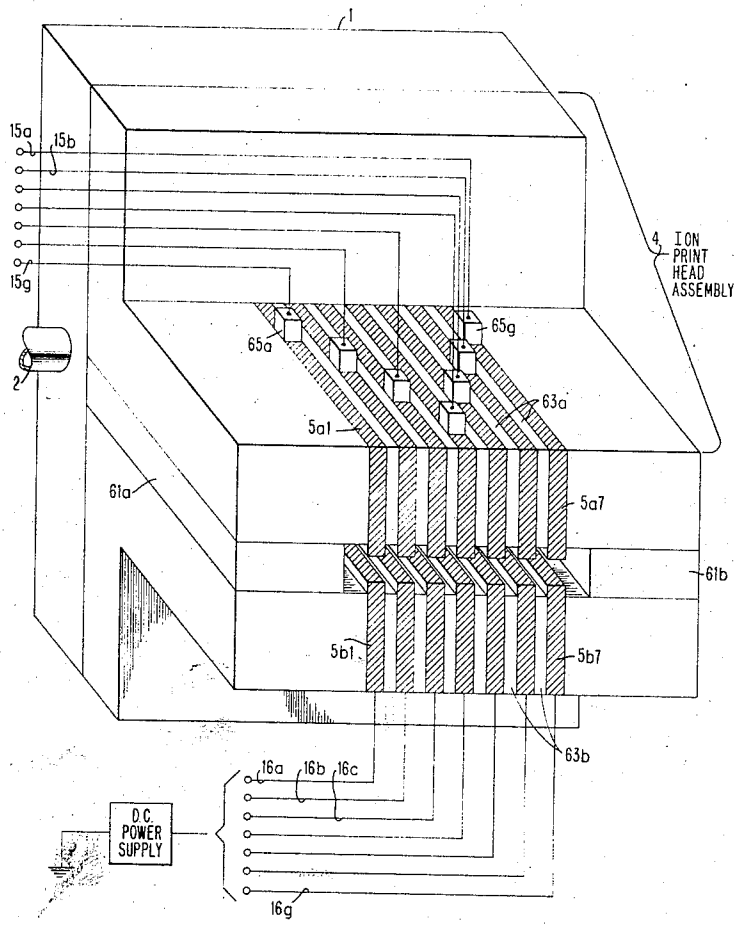
Primary Examiner—Terrell W. Fears

Attorney—Paul M. Brannen et al.

[57] **ABSTRACT**

An improved printing head for forming electrostatic images on a dielectric surface by controlling the relative ion concentration in a gas stream moving through a slot and directed upon said dielectric surface. Application of an electric field across selected pairs of an array of spaced electrodes in the slot enables the stream to vary in ion concentration so as to cause the formation of a desired linear charge configuration on the dielectric. Selective application of low voltage electric fields to selected arrays of the electrodes causes formation of desired image charge configurations on the dielectric surface.

5 Claims, 6 Drawing Figures



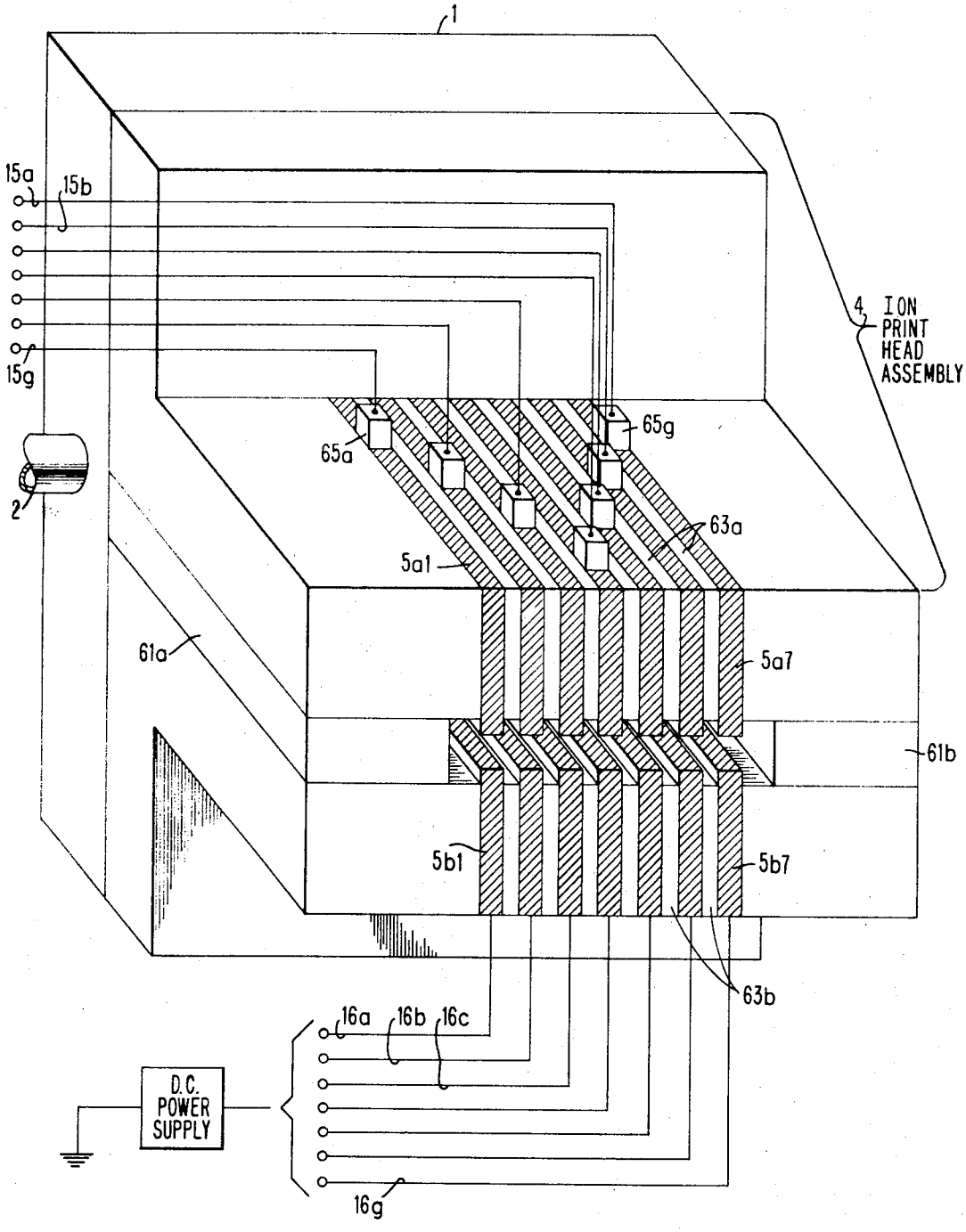

1
15a
15b
15g
4 ION PRINT HEAD ASSEMBLY
65a
65g
2
63a
5a1
61a
5a7
61b
5b1
5b7
63b
16a
16b
16c
D.C. POWER SUPPLY
16g

FIG. 1

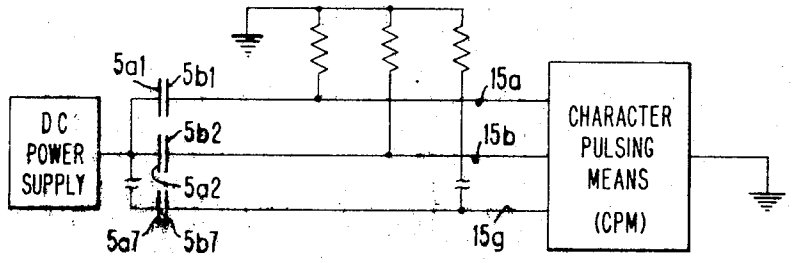


FIG. 2

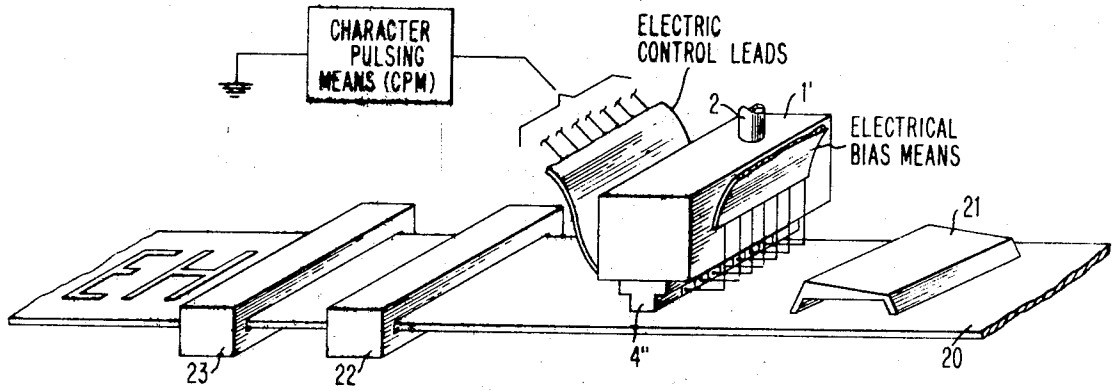


FIG. 3

FIG. 4a

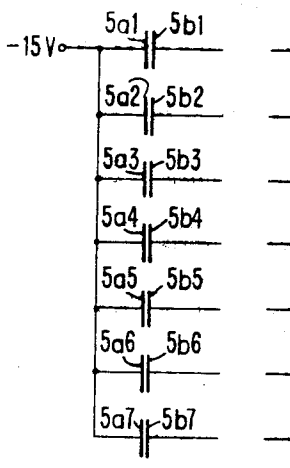


FIG. 4b

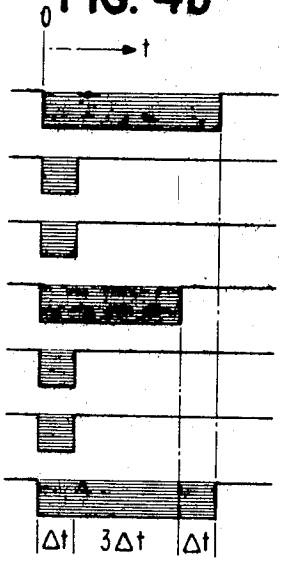
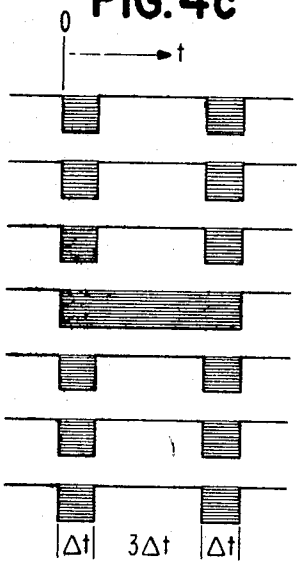


FIG. 4c



ELECTRO-IONIC PRINTING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention.

The invention relates broadly to the control of the ion concentration in a gas stream, and more particularly to the formation of an image on a dielectric surface by directing thereon a controlled concentration of ions borne by the gas stream.

2. Description of the Prior Art

The present invention is an improvement upon the printing head shown and described in U. S. Pat. Application Ser. No. 153,718, filed June 16, 1971, by R. E. McCurry, and assigned to a common assignee.

The most pertinent prior art is found in U. S. Pat No. 3,594,162 issued to W. Simm et al. in which latent image formation is produced as a result of corona discharge through a gap provided with control electrodes. This reference neither shows nor suggests the use of pressurized ionized gas, nor does it have the advantage of the present invention in utilizing low voltages for control purposes.

SUMMARY OF THE INVENTION

The present invention provides an ionic printing head which utilizes a plurality of pairs of electrodes located on opposite sides of a common slot through which an ionized gas stream is moved, energized by relatively low voltages to cause image formation upon a dielectric surface.

Accordingly, it is the principal object of the invention to provide an improved apparatus for controlling ion concentration in a moving gas stream.

Another object is to provide a relatively simple and inexpensive apparatus for forming latent images on a dielectric surface.

Yet another object is to provide a relatively simple and inexpensive means for forming latent images on an image receiving surface by controlling ion concentration in a moving gas stream directed on said surface.

Still another object is to provide electrostatic images of a high quality and resolution on a dielectric surface.

Another object of the invention is to provide an ion printer head capable of writing "block" style characters rather than "dot" or "matrix" style characters.

Another object is to provide an improved ionic print head which is easier and more economical to manufacture.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular descripton of a preferred embodiment of the invention, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an improved ion head assembly;

FIG. 2 is a schematic illustration showing 3 channels of the head assembly of FIG. 1 interconnected between a DC power supply and a character pulsing means;

FIG. 3 is a schematic arrangement of a printer utilizing the head assembly of FIG. 1; and

FIGS. 4*a*, 4*b*, and 4*c* show schematically the 7 control channels of a serial print head as shown in FIG. 1 and the pulse patterns for forming images of the alphabetic characters E and H, respectively.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 of the drawings, there is shown an ion generating chamber 1, similar to the one shown and described in a copending application, Ser. No. 69,647, filed Sept. 4, 1970, titled "Method and Apparatus for Generating Electrostatic Images". A gas, for example, air under pressure, is admitted into the ion chamber by way of an inlet 2 and the ions are generated in the manner described in said copending application. The gas exiting from chamber 1 is laden with a very high concentration of ions. Chamber 1 communicates with a slot in the print head assembly 4. This slot is divided, electrically, into a plurality of ion channels. Each channel comprises a pair of electrical conducting electrodes, such as 5*a*1 and 5*b*1, separated from adjacent electrodes by insulating spacers such as 63*a* and 63*b*. The head assembly 4 is held together and attached to the ion chamber by any suitable means not shown. The head assembly 4 provides a plurality of longitudinal ion flow channels which are physically common but are electrically insulated from each other to provide a plurality of individual ion streams, each of high ion concentration. The cross-section of each channel may be any suitable configuration, for example, square, rectangular, or any other desired cross-section. Attached to the top and bottom electrodes are electrical lines 15*a*–15*g*, 16*a*–16*g*. Lines 16*a*–16*g* are connected in common to a DC power supply, while the lines 15*a*–15*g* are individually controlled by differentially timed pulses issued by a character pulsing means.

As the gas streams pass through their respective electrical channels, ion concentration decreases as a result of recombination and neutralization at the channel walls. The ion loss through a conductive wall may be substantially increased by superimposing an electrical field across opposng channel walls, for example, the top and bottom electrodes. Application of a sufficiently large electrical field will remove substantially 100 percent of the ion concentration in the gas stream of the particular channel. Conversely, the reduction of this electrical field reduces the extent of recombination and neutralization; thus by reducing the electrical field to substantially zero, the maximum concentration of ions may be transmitted through the channels. The concentration of ions and, hence, the electrical charge transmitted through each individual channel is controlled by an appropriate electrical field applied transversely to the direction of stream flow. The electrical field is induced by application of an electrical potential through the lines 15*a*–15*g* connected to the opposing electrodes of the channels shown in the drawing of FIG. 1. the "write" state of a channel is attained when a low or zero transverse electrical field is applied, and the "off" state is attained with the application of a greater biasing electrical field to remove more ions from the gas stream. In the case of a printing application, the variation of the electrical potentials to produce character printing is controlled by the character pulsing means.

The application of desired electrical fields to a write head is schematically illustrated in FIG. 2. In this schematic arrangement, the write head is partially shown schematically with three capacitors, representing three of the seven channels shown in FIG. 1. The plates 5*a*1, 5'*b*1, of the capacitors, correspond to the top and bottom electrodes repectively. Each capacitor is seen con-

nected between the character pulsing means by way of lines 15*a*–15*g* and the DC power supply, the latter being adjusted to a desired potential V, for example, 15 volts, to obtain the desired ion output. The character pulsing means supplies pulses of appropriate polarity and magnitude substantially equal to the potential V of the power supply. During the interval of time that a "write" operation is desired, the field across the capacitors (the channel) is reduced to enable the ion concentration to attain its maximum concentration and be directed against an image receiving surface for the formation of a desired image configuration.

An application of this type or ionic control is seen in FIG. 3 which shows schematically a printer arrangement for forming a latent electrostatic image upon a dielectric medium 20 moving from right to left underneath a precharging unit 21 that precharges the medium 20 with a desired potnetial with polarity opposite the ion polarity. The precharged dielectric medium moves underneath a write head 4'' similar to that described above. The write head communicates with ion generator 1'. By controlling the individual channels of the write head with suitable voltage pulses, a latent electrostatic image of alphabetical characters is formed upon the precharged dielectric surface of medium 20. The medium 20 with its latent image passes through a developer 22 and thereafter through a fixer 23, both of which are well known in the art. After passing through the fixer, the developed and fixed latent image provides a visible permanent image comprised of two alphabetic characters E and H. The character pulse means as mentioned herein above, may provide any desired combination of electrical pulses to the individual channels of the write head image on provide any desired configured latent image on the dielectric surface of medium 20.

Ion transmission is turned on by applying a pulse of the polarity and amplitude as the bias voltage to the electrode on the other side of the slot in the region where one wants the transmission to occur. Hence, if one wants to write a straight line parallel to the long direction of the slot, all 7 electrodes are pulsed simultaneously, thus permitting ion transmission through the entire slot cross section for a short time. To write a line perpendicular to it, one applies a long pulse to one electrode, and as the "paper" moves by, a line is written — the length of the line depending on paper speed and the length of the writing pulse. The two lines above will be perpendicular if the long direction of the slot is accurately at 90° to the direction of relative motion. If this condition is not met, "sloping" characters will be written. The formation of alphabetical characters by means of printer arrangement of FIG. 3 may be described with reference to FIGS. 4*a*, 4*b*, and 4*c*.

The schematic arrangement of FIG. 4*a* shows a line arrangement of 7 capacitors representing the 7 channels of the write head. The left sides, 5*a*1–5*a*7 of the capacitors, are connected to −15 volt DC supply whereas the right sides, 5*b*1–5*b*7 of the capacitors, are connected to the character pulsing means, not shown, that selectively pulses the right sides of these capacitors to cause formation of the desired latent image on the dielectric medium 20. From an inspection of FIG. 4*b* it may be appreciated that in the formation of the image of the character E, the vertical segment of the character E is formed during the interval ΔT during which there is no electrical field present across the channels of the write head; and during this interval ΔT, the character pulsing means supplies −15v pulse potential to the appropriate electrodes of all channels. From a further inspection of FIG. 4*b*, it is seen that the upper and lower horizontal lines, as well as the central horizontal line, of the character E are formed during the application OF −15v potentials to the electrodes 5*a*1, 5*b*1, 5*a*4, 5*b*4, and 5*a*7, 5*b*2 &, as respectively shown in FIG. 4*a* for approximately five time intervals. At the end of the first time interval ΔT, the character pulsing means applies zero voltage to electrodes represented by 5*b*2, 5*b*3, 5*b*5, and 5*b*6. These electrodes are maintained at zero potential for the duration of the character formation. The −15v potential on electrode 5*b*4 is maintained on for four time intervals. It is understood that the latent image is being formed on the dielectric medium as the latter moves from right to left under the respective channels of the write head.

From an inspection of FIG. 4*c*, it can be appreciated that the pattern of pulses applied to the respective channels is consistent for the formation of the alphabetical character H. The factor which permits block type of characters to be formed is that when adjacent electrodes are at the same electrical potential and near the same potential as the opposite electrodes, ions will be transmitted through the channel between the electrodes and also through the region of the gap between electrodes, provided the geometry is chosen judiciously.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

I claim:

1. An electro-ionic printing apparatus comprising, in combination,
   - a source of gas-carried ions comprising a pressurized gas source and means for generating a high concentration of ions therein,
   - an elongate rectangular slot connected to said source, said slot having a substantial depth in the direction of ion flow therethrough,
   - a plurality of electrodes associated with said slot, said electrodes being arranged in pairs on opposite sides of said slot and spaced at intervals along said slot, said electrodes extending for substantially the depth of said slot,
   - and means for selectively energizing one or more pairs of opposing electrodes with a voltage substantially less than the breakdown voltage of said pressurized gas.

2. An electro-ionic printing apparatus as claimed in claim 1, in which said electrodes comprise a plurality of electrically conductive plates separated by plates of insulation, and having interior edges opposing the opposite electrode edge in said slot.

3. An electro-ionic printing apparatus as claimed in claim 1, in which said slot is formed by a first and a second set of electrodes extending the depth of the slot, the respective electrodes in said sets being located opposite each other within said slot, and electrical insulating spacing plates separating said electrodes.

4. An electro-ionic printing apparatus as claimed in claim 3, in which all of the electrodes on one side of said slot are commonly connected to a bias voltage supply.

5. An electro-ionic printing apparatus as claimed in claim 3 in which the electrodes located on one side of said slot are selectively energized to affect the ion flow from said slot.

* * * * *