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ELECTROGRAPHIC PRINTING HEAD

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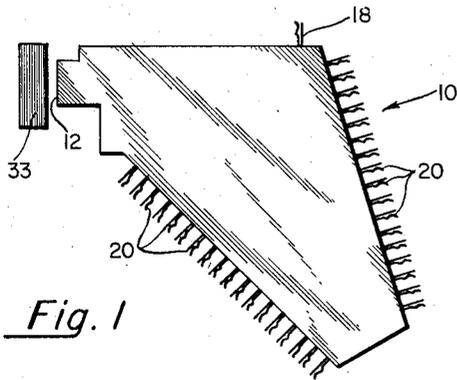


Fig. 1

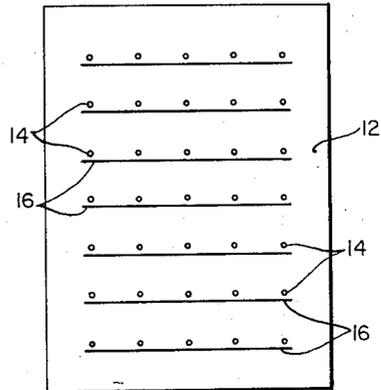


Fig. 2

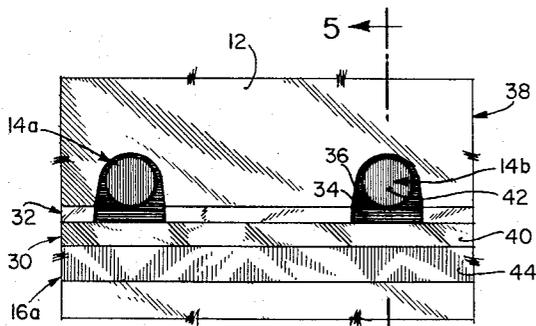


Fig. 4

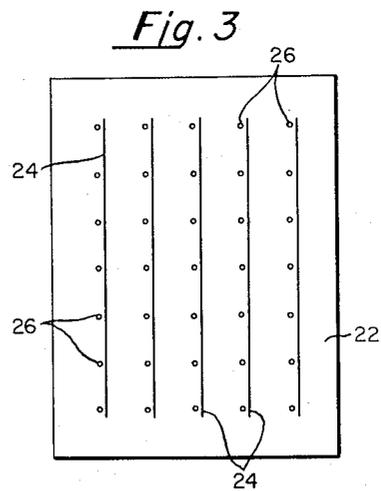


Fig. 3

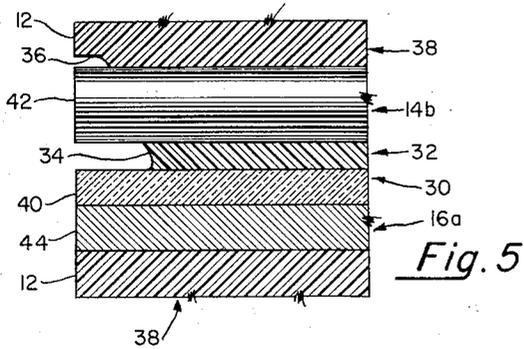


Fig. 5

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ELECTROGRAPHIC PRINTING HEAD

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Application May 9, 1958, Serial No. 734,196

10 Claims. (Cl. 250—49.5)

This invention relates to electrographic print heads and more particularly to improvements in electrographic recording matrix print heads.

Alphanumeric characters can be formed by a plurality of dots as well as by lines. A print head which is capable of producing thirty-five dots of suitable size arranged in any array of five rows of dots in one direction and seven rows of dots at right angles to the five rows, and with the dots in the array equally spaced from each other, can produce legible alphanumeric characters or symbols. Print heads capable of forming symbols in this manner are identified as matrix print heads. A matrix print head capable of producing 35 dots, arranged in 5 vertical rows and 7 horizontal rows, is sometimes identified as being a 5 x 7 matrix head. Obviously the number of dots capable of being printed by a single row of a matrix print head may vary widely depending on the degree of legibility desired. Also the number of vertical and horizontal rows in a matrix can be varied with the minimum being constituted by a head capable of printing only a single row of dots at a single instant of time.

It has been discovered that improved and more reliable electrographic printing can be produced by using an auxiliary, or initiating electrode to introduce electrically charged particles into the gap between a print head and its associated back electrode. The means for introducing the charged particles into the gap is a disruptive electrical discharge, or an initiating arc, between an initiating electrode and a print, or selection electrode, which are both located in the print head. In print heads designed to use an initiating arc to start the printing step, the amplitude of the voltages needed to produce electrographic printing is lowered; and there is no need to provide a specialized atmosphere in the gap as is more fully set forth in U.S. patent application Serial No. 729,847, filed April 21, 1958, entitled "Electrographic Recording Process and Apparatus," by Robert E. Benn and Richard S. Sakurai, which application is assigned to the assignee of this application. It has also been discovered that in an electrographic recorder having a plurality of such print heads that the initiating and print-selection electrodes provide means for controlling the position where printing will occur as is set forth in copending application Serial No. 734,253, filed May 9, 1958, entitled "Electrographic Recording Apparatus," by Robert E. Benn, Richard S. Howell and Richard S. Sakurai, which application is assigned to the assignee of this application.

In print heads having initiating and print-selection electrodes, the printing step is initiated by causing an initiating arc to occur between the ends of an initiating electrode and a print-selection electrode to introduce electrically charged particles, or ions, into the space between the print head and the back electrode at the printing station. The initiating arcs are of very short duration, but nevertheless energy, principally in the form of heat, is liberated. This heat adversely affects the insulating material previously used in making the print heads and in positioning the initiating and selection electrodes

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in the heads. When the material is an organic compound such as an epoxy resin, the heat causes the removal of the epoxy, probably by evaporation between the electrodes. As the resistance material between electrodes is removed, initiating arcs may occur other than between the ends of initiating and selection electrodes. When the initiating arcs substantially do not occur between the ends of the initiating and selection electrodes, the initiation of the printing step does not occur because charged particles are not introduced into the space between the print face and the back electrode. Also, if a conductive residue is formed as the resistive material is removed, the residue, in time, will provide a low resistance path between the electrodes; the initiating arcs do not occur; and, as a result, no printing occurs.

When insulating materials such as glass, or mica, which are substantially not removed, eroded, or evaporated by the arcs, are used, between initiating electrodes and selection electrodes, it is found that after a print head has been used for a few hours that such insulating materials become coated with a conductive film, particularly where the arcs travel over them. This film will, in time, produce a low resistance path which prevents the occurrence of the desired disruptive discharges.

It is therefore an object of this invention to provide an improved electrographic recording print head.

It is another object of this invention to provide an improved electrographic recording print head which is relatively easy to construct and which has a substantially long trouble-free operating life.

It is a further object of this invention to provide an electrographic recording matrix print head constructed so that initiating arcs will reliably be produced between the ends of the initiating electrodes and the selection electrodes over a long period of time.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same become better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a side elevation of a portion of an electrographic recording printing station;

Fig. 2 is an enlarged view of the printing face of the matrix print head illustrated in Fig. 1 with the details of construction not illustrated;

Fig. 3 is a view similar to Fig. 2 of a modification of the print face;

Fig. 4 is a greatly enlarged view showing details of construction of the print head; and

Fig. 5 is a broken away section taken on lines 5—5 of Fig. 4.

Print head 10, illustrated in Fig. 1, is a matrix print head formed of preferably an epoxy resin. Head 10 is suitable for use in a page printer such as is described in patent application Serial No. 734,253, filed May 9, 1958, entitled "Electrographic Recording Apparatus," by Robert E. Benn, Richard S. Howell and Richard S. Sakurai. The print face 12 of head 10 is substantially in the form of a plane surface. The disposition of the initiating or pin electrodes 14 at print face 12 is more clearly illustrated in Fig. 2. The thirty-five initiating electrodes 14 can be considered as being arranged in horizontal and vertical rows with 7 electrodes in each vertical row, or column, and 5 electrodes in each horizontal row. At face 12, the electrodes 14, forming the array, or matrix, are substantially equidistantly spaced from each other. Seven selection, or bar, electrodes 16 are associated, by being spaced a relatively short distance from each horizontal row of initiating electrodes 14. The seven bar electrodes 16 are connected in parallel to terminal 18, illustrated in Fig. 1, by a conductor which is not illustrated. Print head 10 has thirty-five terminals 20; one for and

connected to each initiating electrode 14. Each terminal 20 is connected to but one electrode 14 by insulated conductors which are not illustrated. Each circuit comprised of a pin electrode 14 and a terminal 20 is electrically insulated from the others.

In Fig. 3 the print face 22 of a modified print head is illustrated in which five bar electrodes 24 are associated with the five vertical rows, or columns, of initiating electrodes 26 instead of horizontal rows as illustrated in Fig. 2. The distance between initiating electrodes 26 at face 22 is substantially equal.

Fig. 4 is a greatly enlarged view of two pin, or point, electrodes 14a, 14b, of print head 10, for example, and their associated bar electrode 16a after the head has been in use for a few hours. Point electrodes 14 and bar electrode 16 may be made of a good electrical conductor such as copper, stainless steel, tungsten, or platinum. Bar electrode 16a is insulated from pin electrodes 14a, 14b, by two thin laminae 30, 32 of electrically insulating material. Lamina 30 is preferably made from a material which is not eroded, removed, or evaporated by the occurrence of millions of electrical initiating arcs between electrodes 14b and 16a and between electrode 14a and 16a when the print head is in use in an electrographic recording device over a relatively long period of time. Such a material is glass, or mica. Lamina 32 is preferably made from a material having the characteristic that the portion relatively close to the arcs is relatively easily removed, eroded, or evaporated by the arcs, and that as it is removed it does not leave an electrically conductive residue. A material having these characteristics is polyethylene terephthalate, which is sold by E. I. du Pont de Nemours & Co. under the trade name "Mylar." In a preferred example, bar electrode 16a is approximately 2 mils (.002 inch) in thickness; lamina 30 is between 1.3 and 1.5 mils (.0013 and .0015 inch) in thickness; and lamina 32 is approximately 1 mil (.001 inch) in thickness. The pin, or point electrodes 14a, 14b are substantially 3 mils (.003 inch) in diameter, and are spaced from bar electrode 16a by laminae 30, 32 or a distance of about 2.5 mils. The distance between the center of pin electrodes 14a, 14b, is substantially 16 mils (.016 inch). It should be understood that before use, the end surfaces of the pin electrodes 14, bar 16, lamina 30, and lamina 32 are substantially coplanar with print face 12.

When an electrically charged area is to be established on a recording medium, which is not illustrated, in the space between print face 12 and back electrode 33, the process of establishing the charged area, or printing, is started by an initiating arc, a disruptive electrical discharge between bar 16a and pin electrode 14a, if the charged area is to be printed on the recording substantially between electrode 14a and back electrode 33. When a charged area is to be printed on the recording medium substantially between pin electrode 14b and back electrode 33, then the printing step is started by an initiating arc between electrodes 14b, and 16a. When the insulation between pin electrodes 14 and bar electrodes 16 was provided by the same material with which the rest of the print head was formed, it was discovered that the arcing between electrodes would cause the insulating material between a pin electrode 14 and bar electrode 16 and around electrode 14 to be removed for a considerable depth. This permitted the arc between a pin electrode 14 and its associated bar electrode 16 to occur well within the head rather than between the ends of the electrode and substantially in the plane of print face 12. When this happens, the arc does not initiate the printing step as explained above.

When materials which were substantially not subjected to being removed to any substantial depth by the initiating arcs were used to provide insulation between the initiating electrodes 14 and selection electrodes 16, it was found that such materials, after the print head has

been in use for a few hours, became covered with a conductive film which would short the two electrodes and prevent the initiating discharge from occurring between them which, in turn, causes a failure of electrographic print head to print properly since the initiating arcs were not produced. Materials which are removed as a consequence of the initiating arcs, and which leave or form a conductive residue, can cause the print head to malfunction by shorting the initiating electrode to the selection electrode, and/or by permitting the initiating arc to occur within the print head rather than substantially at the print face.

The particular combination of insulating materials illustrated in Figs. 4 and 5 has solved the problem of assuring that the initiating arcs occur between the ends of the initiating electrodes and the selection or print electrodes and substantially in the plane of the print face of the print head, and such construction also prevents the development of a low resistance conductive path to be established between these electrodes.

In Fig. 5, the effect produced by large numbers of initiating arcs on the insulating layers 30, 32, is more clearly illustrated. Presumably the heat produced by the initiating arcs between electrodes 14b, 16a, removes the outer portion of layer 32, that part near the printing face 12, and forms gap 34 between lamina 30 and electrode 14b. The heat of pin 14b also causes a portion 36 of the resin 38 from which head 10 is principally formed, to also be removed. The depth of gap 34, or the distance that it extends into head 10 varies rather widely, but approximates the distances between the initiating electrode 14b and selection electrode 16a. Since the material of lamina 32 does not form, or leave behind, a conductive residue as it is removed, no low resistance electrical conductor path exists between the end surface 40 of lamina 30 and electrode 14b.

The outer surface 40 of layer 30 is not removed as a consequence of the initiating arcs and, therefore, its outer surface 40 remains substantially coplanar with the end surface 42 of pin 14b, the end surface 44 of bar 16a and print face 12 of the printing head 10. If a conductive deposit or film is formed on the surface 40 of lamina 30, which deposit is apparently only produced when an electric arc is in close proximity to such a surface, there still remains gap 34 between pin electrode 14b and bar 16a across which an initiating arc will occur to initiate the printing step and such arc will occur substantially in the plane of print face 12.

From the foregoing, it is believed to be clear that the use of insulation comprised of resistive materials having certain desired characteristics to insulate the initiating electrodes from the selection electrodes, produces a matrix print head which will operate reliably over an extended period of time.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced other than as specifically described and illustrated.

What is claimed is:

1. In an electrographic recording printing head having a print face, an initiating electrode terminating substantially flush with said print face, and a print electrode terminating substantially flush with said print face; the improvements comprising a thin lamina of a first material and a second thin lamina of a second material separating said electrodes, said first lamina being formed of an electrically insulating material which is substantially not removed by electrical arcs of short duration, and said second lamina being formed of an electrically insulating material which is removable by said arcs.

2. An electrographic recording print head comprising: a plurality of pin electrodes, a bar electrode, means for insulating the pin electrodes from the bar electrodes, said

means comprising a first layer of electrically resistive material which substantially is not eroded by electric arcs between said pin electrodes and said bar electrode, and a second layer of resistive material which is eroded by said arcs.

3. In an electrographic recording matrix print head having a print face, a plurality of substantially point electrodes terminating at said face, the positions of the intersections of said electrodes and said face forming an array, print electrode means, a portion of said print electrode means terminating at said face; the improvements comprising a thin layer of a material which is substantially not removed as a consequence of electric arcs of short duration occurring near it; and a thin layer of a material which is removed as a consequence of electric arcs of short duration occurring near it and which material, when removed, substantially does not leave an electrically conductive residue, one surface of said material which is not removed being terminated substantially flush with said print face.

4. In an electrographic recording matrix print head having a print face, a plurality of initiating electrodes, substantially terminating at said face, the portion of said initiating electrodes at said face forming an array, and selection electrode means, terminating substantially at said face in spaced relation with said initiating electrodes; the improvements comprising a thin layer of a first material and a thin layer of a second material between said initiating electrodes, and the selection electrode means closest to each of said initiating electrodes, said first material being substantially not eroded by electric arcs of short duration between said initiating electrodes and the selection electrode means and the second material being eroded by the electric arcs of short duration between said initiating electrodes and the selection electrode means, the second material, as it is being eroded, substantially not leaving an electrically conductive residue, one surface of said first material being terminated substantially flush with said print face.

5. In an electrographic print head having a print face; the improvements comprising a plurality of pin electrodes terminating substantially at said print face, the portion of said pin electrodes at said print face forming an array, bar electrode means substantially terminating at said face; means mounting the bar electrode means with respect to each pin electrode so that the minimum distance between each pin electrode and said bar electrode means is substantially uniform; a thin layer of glass and a thin layer of polyethylene terephthalate initially comprising the insulation between each pin electrode and said bar electrode means.

6. In an electrographic print head having a substantially planar print face; the improvements comprising a plurality of initiating electrodes substantially terminating at said print face, the portion of said initiating electrodes at said print face being arranged in first rows having a first direction and in second rows having a second direction substantially at right angles to said first direction; a selection electrode associated with each row of pin electrodes of one of said direction; means for mounting each selection electrode so that it is closely and substantially uniformly spaced from the row of pin electrodes with which it is associated at said print face; a thin layer of glass and a thin layer of polyethylene terephthalate between each selection electrode and the initiating electrodes associated with each selection electrode, the glass layer being in contact with the bar electrode, and the surface of said glass layer being substantially coplanar with said print face of said head, said initiating electrodes, said bar electrodes, said glass layer and said layer of poly-

ethylene terephthalate being held in position by a potting compound.

7. In a print head having a plane bottom surface; the improvements comprising a plurality of pin electrodes terminating at said bottom surface and forming a matrix with the distance between said pin electrodes being substantially equal; said pin electrodes being arranged in rows and columns; a bar electrode associated with the pin electrodes forming each column of said matrix; means for mounting said bar electrode so that it is closely and uniformly spaced from the pin electrode with which it is associated; the improvement comprising a thin layer of glass and a thin layer of polyethylene terephthalate between the bar electrodes and the associated pin electrodes with the glass layer in contact with the bar electrode, the surface of said glass layer being substantially coplanar with said bottom surface of said head and said pin electrodes, said bar electrode, said glass insulation and said polyethylene terephthalate insulation being held in position by a potting compound.

8. In an electrographic printing head having a print face, the improvement comprising at least a pair of electrodes, means mounting the electrodes with respect to each other so that the minimum distance thereof adjacent to the print face is substantially uniform, an insulative means interposed between the two electrodes and constituted by laminae having different properties, one lamina lying against one of said electrodes and having its extremity substantially flush with the end thereof and having the property of being non-erodable in the presence of an electric arc established between two electrodes, and the other lamina lying against the other electrode and having its extremity terminating short of the end of the electrode so as to provide an air gap thereat and having the property of retaining high surface resistivity in the presence of an electric arc established between the two electrodes.

9. In an electrographic printing head having a print face, the improvement comprising a plurality of electrodes terminating substantially at said print face and divided into at least two classes of electrodes such that each electrode of a first class is disposed adjacent to and paired with an individual one of the electrodes of a second class, first electrical insulating means occupying part of the space between each such paired electrodes and extending to substantially the terminal end of one of each pair of such electrodes, second electrical insulating means occupying the remainder of the space between each such paired electrodes and terminating short of the terminal end of the other of each such pair of such electrodes to provide an air gap for part of the distance between the terminal ends of the two classes of electrodes.

10. In an electrographic printing head having a print face, the improvement comprising a plurality of electrodes terminating substantially at said print face and divided into at least two classes of electrodes, means mounting each electrode of a first class adjacent to an electrode of a second class for the production of an electric discharge therebetween, an electrical insulating barrier located between each adjacent pair of electrodes of said first and second classes extending substantially to the terminal end of one of the electrodes but terminating short of the terminal end of the other electrode to provide an air gap for part of the distance between the terminal ends of the two classes of electrodes.

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