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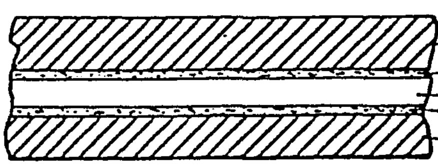
(54) **Dielectric-electrode laminate.**

(57) A dielectric electrode laminate comprises a mica sheet (171), and a metallic sheet electrode (175) bonded to a face of the mica sheet (171) by a layer of pressure-sensitive adhesive (173). The mica sheet (171) may have an electrode bonded to each side, each electrode (174, 175) being cutaway in a bar-like pattern. A method of fabricating a dielectric electrode laminate is also described, comprising coating the mica sheet (171) with a layer of pressure-sensitive adhesive, bonding a metallic sheet to the mica sheet (171) and selectively removing portions of the electrode sheet to create an electrode pattern.



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DIELECTRIC-ELECTRODE LAMINATE.

The invention relates to dielectric electrode laminates, particularly those used in electrophotography and electrostatic printing. The laminates of the invention may be used to produce an ion generator, such as is used in electrophotographic and electrostatic printing apparatus.

The present application is divided out of European Application 81902352.4, which itself derives from a PCT Application published as WO-A-82/00723.

Electrostatic printers and photocopiers share a number of common features as a rule, although they carry out different processes. Electrostatic printers and photocopiers which are capable of producing an image on plain paper may generally be contrasted in terms of the method and apparatus used to create a latent electrostatic image on an intermediate member. Copiers generally do so by uniformly charging a photoconductor electrostatically in the dark, and optically exposing the charged photoconductor to an image corresponding to the image to be reproduced. Electrostatic printers use non-optical means to create a latent electrostatic image on a dielectric surface, in response to a signal indicative of an image to be created. In theory, after creation of the electrostatic latent image, the same apparatus could be used to carry out the common steps of toning the image, transferring it to plain paper, and preparing the member bearing the electrostatic latent image for a subsequent cycle, usually by erasure of a residual latent electrostatic image. It would, in fact, be desirable to standardize the apparatus to perform these functions.

One commonly employed principle for generating ions is the corona discharge from a small diameter wire or a point source. Illustrative U.S. Patent Nos. are P. Lee 3,358,289; Lee F. Frank 3,611,414; A.E. Jvirblis 3,623,123; P.J. McGill 3,715,762; H. Bresnik 3,765,027; and R.A. Fotland 3.961,564. Corona discharges are used almost exclusively in electrostatic copiers to charge photoconductors prior to exposure, as well as for discharging. These applications require large area blanket charging/discharging, as opposed to formation of discrete electrostatic images. Unfortunately, standard corona discharges provide limited currents. The maximum discharge current density heretofore obtained has been on the order of 10 microamperes per square centimeter. This can impose a severe printing speed limitation. In addition, coronas can create significant maintenance problems. Corona wires are small and fragile and easily broken. Because of their high operating potentials they collect dirt and dust and must be frequently cleaned or replaced.

Corona discharge devices which enjoy

certain advantages over standard corona apparatus are disclosed in Sarid et al., U.S. Patent No. 4,057,723; Wheeler et al. 4,068,284; and Sarid 4,110,614. These patents disclose various corona charging devices characterised by a conductive wire coated with a relatively thick dielectric material, in contact with or closely spaced from a further conductive member. A supply of positive and negative ions is generated in the air space surrounding the coated wire, and ions of a particular polarity are extracted by a direct current potential applied between the further conductive member and a counterelectrode. Such devices overcome many of the above-mentioned disadvantages of prior art corona charging and discharging devices but are unsuitable for electrostatic imaging. This limitation is inherent in the feature of large area charging, which does not permit formation of discrete, well-defined electrostatic images. This prior art corona device requires relatively high extraction potentials due to greater separation from the dielectric receptor.

The laminates described may be used to fabricate ion generators which are durable and resistant to delamination due to moisture, and erosion due to ozone, nitric acid and other environmental substances. Such a laminate is physically stable over a wide range of temperatures, and can carry high peak voltage RF signals over a long service life.

According to a first aspect of the present invention, a method of fabricating a dielectric electrode laminate comprises the steps of:

(a) applying a layer of pressure sensitive adhesive to a sheet of mica,

(b) bonding a face of a metallic sheet to a face of said mica sheet with pressure sensitive adhesive, and

(c) selectively removing portions of said electrode sheet to create an electrode pattern.

According to a second aspect of the invention a dielectric electrode laminate comprises a mica sheet; a metallic sheet electrode bonded to a face of said mica sheet, the bond between the electrode and the mica sheet being formed by a layer of pressure-sensitive adhesive.

Preferably the metallic sheet has a thickness in between 6 and 60 micrometres and the pressure sensitive adhesive has a thickness of 0.45 micrometres. The mica sheet preferably has a thickness of 2 to 75 micrometres.

The invention may be carried into practice in various ways, and a dielectric-electrode laminate will now be described, by way of example, in the specific context of its use in an ion generator such as may be found in electrostatic printing or photocopying apparatus. Reference will be made to the following drawings, in which:

Figure 1 is a sectional view of ion generating apparatus in accordance with the preferred embodiment;

Figure 2 is a sectional view of the ion generating apparatus of Figure 1, further showing ion extraction apparatus and an ion receptor member;

Figure 3 is a plan view of dot matrix printing apparatus of the type illustrated in Figure 2;

Figure 4 is a schematic sectional view of a mica foil laminate in accordance with the invention;

Figure 5 is a partial perspective view of an electrostatic imaging device in accordance with an alternative embodiment of the invention;

Figure 6 is a schematic sectional view of the apparatus of Figure 5, further including ion extraction apparatus and an ion receptor member;

Figure 7 is a cutaway perspective view of an alternative version of the imaging apparatus of Figure 5;

Figure 8 is a cutaway perspective view of a further alternative version of the electrostatic imaging apparatus of Figure 5;

Figure 9 is a plan view of matrix imaging apparatus of the type shown in Figure 5;

Figure 10 is a sectional schematic view of a three electrode embodiment of the imaging device of Figure 7;

Figure 11 is a perspective view of an electrostatic imaging device in accordance with yet another embodiment of the invention; and

Figure 12 is a plan view of a serial printer incorporating an electrostatic imaging device of the type illustrated in Figure 6.

Figure 1 depicts an ion generator 100, which produces an air gap breakdown between a dielectric 101 and respective conducting electrodes 102-1 and 102-2 using a source 103 of time-varying potential, illustratively a periodically alternating potential. When electric fringing fields E_A and E_B in the air gap 104-a and 104-b exceed the breakdown field of air, an electric discharge occurs which results in the charging of the dielectric 101 in regions 101-a and 101-b adjacent the electrode edges. Upon reversal of the alternating potential of the source 103, there is a charge reversal in the breakdown regions 101-a and 101-b. The generator 100 of Figure 10 therefore produces an air gap breakdown twice per cycle of applied alternating potential from the source 103 and thus generates an alternating polarity supply of ions.

The extraction of ions produced by the generator 100 of Figure 1 is illustrated by the generator-extractor 110 of Figure 2. The generator 110A includes a dielectric 111 between conducting electrodes 112-1 and 112-2. In order to prevent air gap breakdown near electrode 112-1, the electrode 112-1 is encapsulated or surrounded by an insulating material 113. Alternating potential is applied between the conducting electrodes 112-1 and 112-2 by a source 114_A. The second electrode 112-2 has a hole 112-h where the desired air gap breakdown occurs relative to a region 111-4 of the dielectric 111 to provide a source of ions.

The ions formed in the gap 112-h may be extracted by a direct current potential applied from a source 114-B to provide an external electric field between the electrode 112-2 and a grounded auxiliary electrode 112-3. An illustrative insulating surface to be charged by the ion source in Figure 2 is an electrographic paper 115 consisting of a conducting base 115-p coated with a thin dielectric layer 115-d.

When a switch 116 is switched to position X and is grounded as shown, the electrode 112-2 is also at ground potential and no external field is present in the region between the ion generator 110A and the dielectric paper 115. However, when the switch 116 is switched to position Y, the potential of the source 114B is applied to the electrode 112-2. This provides an electric field between the ion reservoir and the backing of dielectric paper 115. The ions extracted from the air gap breakdown region then charge the surface of the dielectric layer 115-d.

A number of materials may be used for the dielectric layer 111. Possible choices include aluminum oxide, glass enamels, ceramics, plastics films, and mica. Aluminum oxide, glass enamels and ceramics present difficulties in fabricating a sufficiently thin layer (i.e. around 0.025 mm) to avoid undue demands on the driving potential source 114A. Plastics films, including polyimides such as that known by the Trade Mark Kapton, and Nylon, tend to degrade as a result of exposure to chemical byproducts of the air gap breakdown process in aperture 112-h (notably ozone and nitric acid). Mica avoids these drawbacks, and is therefore the preferred material for dielectric 111. Especially preferred is Muscovite mica, $H_2KAl_3(SiO_4)_3$.

The generator and ion extractor 110 of Figure 2 is readily employed, for example, in the formation of characters on dielectric paper in high speed electrographic printing. Devices embodying this principle may be used for charging and discharging a photoconductor as in the apparatus of section II; suitable embodiments are disclosed in U.S. Patent No. 4,155,093. To employ ion extraction in the formation of dot matrix characters on dielectric paper, the matrix ion generator 130 of Figure 3 may be employed. The generator 130 makes use of a dielectric sheet 131 with a set of apertured air gap breakdown electrodes 132-1 to 132-4 on one side and a set of selector bars 133-1 to 133-4 on the other side, with a separate selector 133 being provided for each different aperture 135 in each different finger electrode 132.

When an alternating potential is applied between any selector bar 133 and ground, ions are generated in apertures at the intersections of that selector bar and the finger electrodes. Ions can only be extracted from an aperture when both its selector bar is energized with a high voltage alternating potential and its finger electrode is energized with a direct current potential applied between the finger electrode and the counterelectrode of the dielectric surface to be charged. Matrix location 135_{23}, for example, is printed by simultaneously applying a high frequency potential between selector bar 133-3 and ground and a direct current potential between finger electrode 132-2 and a dielectric receptor member's counterelectrode. Unselected fingers as well as the dielectric member's counterelectrode are maintained at ground potential.

By multiplexing a dot matrix array in this manner, the number of required voltage drivers is significantly reduced. If for example, it is desired to print a dot matrix array across an area 200 mm wide at a dot matrix resolution of 80 dots per cm, 1600 separate drivers would be required if multiplexing were not employed. By utilizing the array of Figure 3 with, for example, alternating frequency driven fingers, only 80 finger electrodes would be required and the total number of drivers is reduced from 1600 to 100.

In order to prevent air gap breakdown from electrodes 132 to the dielectric member 131 in regions not associated with apertures 135, it is desirable to coat the edges of electrodes 132 with an insulating material. Unnecessary air gap breakdown around electrodes 132 may be eliminated by potting these electrodes.

In constructing and operating a matrix ion generator of this construction, it is desirable that the ion currents generated at various matrix crossover points be maintained at a substantially uniform level. Thickness variations in the dielectric layer 131 will result in commensurate variations in the ion current output, in that a lower ion current will be produced at an aperture 135 at which the dielectric 131 is thicker. It is a particuarly advantageous property of mica that it has a natural tendency to cleave along planes of extremely uniform thickness, making it especially suitable for the matrix ion generator illustrated in Figure 3. In this regard, the uniformity of thickness of layer 131 is much more important than the actual value of that thickness.

Ion generators of the type illustrated in Figures 2 and 3 may be fabricated using a layer of mica laminated to thin sheets of metallic foil, by etching the foil to create an array of electrodes on each side of the mica. Electrodes 102-1 and 102-2 (Fig. 11) are formed by laminating a thin sheet of conductive foil to each face of the mica sheet 101. With reference to the sectional view of Figure 13, a mica sheet 171 of uniform thickness is bonded to two layers of foil 174 and 175. The bonding is achieved using thin layers of pressure sensitive adhesive 172 and 173.

The preferred dielectric material is Muscovite mica, $H_2KAl_3(SiO_4)_3$. It is desirable to have a sheet of uniform thickness in the range from about 2μm- 75μm, most preferably 10μm- 15μm. The thinner mica sheets are generally harder to handle and more expensive, while the thicker mica requires higher RF voltages between electrodes

102-1 and 102-2 (see Figure 2). The mica should be free of cracks, fractures, and similar defects.

The foil layers 174 and 175 advantageously comprise a metal which may be easily etched in a pattern of electrodes 132, 133. Illustrative materials include nickel, copper, tantalum, and titanium; the preferred material, however, is stainless steel. A foil having a thickness from about 6μm-50μm is desirable, with the preferred thickness being around 25μm.

A wide variety of pressure sensitive adhesives are suitable for layers 172 and 173. A number of characteristics should be considered in choosing an appropriate pressure sensitive adhesive. The adhesive should be thermoplastic, and be resistant to moisture and chemicals. It should be able to withstand the high temperatures resulting from high voltage alternating potentials, on the order of kilovolts. The adhesive should be suitable for bonding of metal to mica. Illustrative adhesive formulations which satisfy the above criteria include solutions of organopolysiloxane resins, as well as pressure sensitive adhesives.

The mica is coated with a pressure sensitive adhesive formulation using any well known technique which permits precise control over the coating thickness. The adhesive layers desirably have a thickness in the range 0.5μm- 5μm, most preferably in the range 0.6μm- 2.5μm. The thickness may be determined after lamination by subtracting the known thickness of the mica and foil sheets from the total thickness of the laminate. The adhesive may be applied manually, as by brush coating, spraying, and dipping. The preferred method of coating is that of dipping the mica into a bath of pressure sensitive adhesive, followed by withdrawal of the mica at a calibrated speed. Generally, a faster speed of withdrawal results in a thicker pressure sensitive adhesive coating on each side of the mica sheet 171..

In the preferred embodiment of the invention, the pressure sensitive adhesive is applied to the mica in solution. The resin may be diluted to a desired viscosity using a variety of solvents, well known to those skilled in the art. In general, higher viscosity formulations will result in a thicker layer of pressure sensitive adhesive for a given method of application. Advantageously, the pressure sensitive adhesive formulation has a viscosity in the range from $10^{-2} - 10^{-1}$ Pas (10 cps. - 100 cps.) The mixture advantageously is filtered prior to coating onto the mica sheet 171.

The coating of mica sheet 171 preferably involves dipping the sheet into the pressure sensitive adhesive bath to completely cover both sides; it is not necessary, however, to coat the edges of the mica sheet in the preferred embodiment, which calls for a separate protective medium for the edges of the lamination. In lieu of or in addition to a protective coating around the edges of the mica sheet 171, a protective layer of tape may be applied to the edges of the mica-foil lamination. The tape provides protection against migration of moisture between layers of the mica. Alternatively, the tape may be removed after processing of the mica, during which it provides a protective layer, as further discussed herein. Preferably, the tape is coated on one face with pressure sensitive adhesive which may be the same type as used to bond the mica-foil layers.

In the case of certain pressure sensitive adhesives, the adhesive coating is cured in order to cross-link the formulation and thereby enhance its adhesive character. This may be done using any suitable technique for the given adhesive formulation, such as heat or radiation curing.

The foil sheets 174 and 175 are cut to desired dimensions, and cleaned prior to application to the mica sheet 171. Each sheet is placed in registration with one face of the mica sheet, and then bonded to the mica by applying pressure evenly over the foil layers.

After lamination of the foil layers 174 and 175 to mica sheet 171, the foil is selectively removed to create a desired pattern, as for example the pattern of electrodes 132 and 133 shown in Figure 3. In the preferred embodiment, the desired pattern is created by a photoetching process. This involves coating the foil with a photoresistant material; covering the coated foil with a photomask to create the desired patterns; exposing the masked laminate to ultraviolet radiation; and etching the irradiated foil in order to remove those portions which have been rendered soluble during the preceding steps. The preferred versions of this process uses a positive photoresist, which is characterized in that those areas which are exposed to ultraviolet radiation will be rendered soluble and later dissolved.

In the case of solvent based photoresist, there is a tendency of the solvent to leach out the pressure sensitive adhesive around the edges of the lamination. In addition, the photoresist will not coat well due to edge effects, creating a danger of etch-through. For these reasons, it is advisable to tape the edges to provide a protective layer during these processing steps; the tape may be removed after etching. Alternatively, one may employ a dry film photoresist, which will adequately protect the edges of the lamination if applied in a thickness of around 35μm.

In accordance with a particular embodiment, a heat sink may be appended to the mica-foil laminate. The heat sink is applied to the lamination face containing selector bars 133 in order to absorb heat resulting from high voltage alternating potentials. A variety of materials are suitable as well known in the art; in the case of electrically conductive materials, an insulating layer must be included to isolate the heat sink from selector bars 133.

In the examples which follow, all proportions given are by weight unless otherwise noted.

EXAMPLE V-1

220 parts	Methylphenyl polysiloxane resin solution
1 part	2,4 Dichlorobenzoyl peroxide
1 part	Dibutyl phthalate

A pressure-sensitive adhesive composition as set forth in the above table for formulated, then diluted to 0.09 Pas (90 cps.) with butyle acetate. The resulting liquid was filtered under a pressure of approximately 206.8428 kPa (30 PSI), and poured into a graduate.

The following steps were carried out in a dust-free environment. A sheet of mica having a thickness in the range 20-25 μm was cleaned using lint-free tissues and methyl ethyl ketone (MEK). After drying, the mica sheet was suspended from a dipping fixture and lowered into the pressure-sensitive adhesive formulation until all but two millimeters was submersed. The mica was then withdrawn from the adhesive bath at a speed of 2 cm/minute, providing a layer of adhesive approximately 3 μm in thickness. The coated mica was stored in a dust-free jar and placed in a 150°C. oven for five minutes in order to cure the pressure-sensitive adhesive.

Two sheets of stainless steel 25 μm thick were cut to the desired dimensions and cleaned using MEK and lint-free tissues. One of the sheets was placed in a registration fixture, followed by the coated mica and the second foil sheet. Bonding was effected by application of light finger pressure from the middle out to the edges, followed by moderate pressure using a rubber roller. Any adhesive remaining on exposed mica surfaces was removed using MEK and lint-free tissues. The edges of the lamination were then covered with a .6 mm wide Kapton Tape coated with the above pressure sensitive adhesive formulation.

The foil layers were respectively etched in the patterns of electrodes 132 and 133 (Figure 22) using a positive photoresist.

EXAMPLE V-2

An ion generator was fabricated in accordance with Example V-1, modified as follows: The pressure sensitive adhesive was formulated from an acrylic copolymer of vinyl acetate. The adhesive was diluted to 0.05 Pas (50 cps.) using butyl acetate.

EXAMPLE V-3

An ion generator was fabricated in accordance with Example V-I, and placed in a mounting fixture with the selector bars 23 upward. A capacitor glass mounting block of dimensions compatible with the mica was prepared for mounting by application of a layer of silicon adhesive resin in accordance with the table of Example V-1, followed by smoothing of the adhesive using a metering blade. The mounting block was clamped in registration with the laminate, and any excess adhesive at the edges was removed using cotton swabs. The completed structure was set aside for 24 hours to allow the adhesive to set.

Figure 5 shows in perspective a basic embodiment of an electrostatic imaging device which may be utilized, for example, in the printing apparatus of Figure 4. Print device 180 includes a series of parallel conductive strips 184, 186, 188, etc. laminated to an insulating support 181. One or more dielectric coated wires 193 are transversely oriented to the conductive strip electrodes. The wire electrodes are mounted in contact with or at a minute distance above (i.e. less than 50.8 μm $\doteq$ 2 mils) the strip electrodes. Wire electrode 193 consists of a conductive wire 197 (which may consist of any suitable metal) encased in a thick dielectric material 195. In the preferred embodiment, the dielectric 195 comprises a fused glass layer, which is fabricated in order to minimize voids. Other dielectric materials may be used in the place of glass, such as sintered ceramic coatings. Organic insulating materials are generally unsuitable for this application, as most such materials tend to degrade with time due to oxidizing products formed in atmospheric electrical discharges. Although a dielectric-coated cylindrical wire is illustrated in the preferred embodiment, the electrode 193 is more generally defined as an elongate conductor of indeterminate cross-section, with a dielectric sheath.

Crossover points 185, 187, 189, etc. are found at the intersection of coated wire electrodes 193 and the respective strip electrodes 184, 186, 188, etc. An electrical discharge is formed at a given crossover point as a result of a high voltage varying potential supplied by a generator 192 between wire 197 and the corresponding strip electrode. Crossover regions 185, 187, 189, etc. are preferably positioned between 127 and 508 μm (5 and 20 mils.) from dielectric receptor 200 (see Figure 6).

The currents obtainable from an ion generator of the type illustrated in Figure 5 may be readily determined by mounting a current sensing probe at a small distance above one of the crossover locations 185, 187, 189, etc. Current measurements were taken using an illustrative AC excitation potential of 2000 volts peak to peak at a frequency of 1 MHz., pulse width of 25 microseconds, and repetition period of 500 microseconds. A DC extraction potential of 200 volts was applied between the strip electrode and a current sensing probe spaced 203.2 μm (8 mils) above the dielectric coated wire 193. Currents in the range from about .03 to .08 microamperes were measured at AC excitation potentials above the air gap breakdown value, which for this geometry was approximately 1400 volts peak to peak. At excitation voltages above the breakdown value, the extraction current varied linearly with excitation voltage. The extraction current varied linearly with extraction voltage, as well. For probe-wire spacings in the range of 101.6 m to 508μm (4-20 mils), the extraction current was inversely proportional to the gap width. Under 101.6μm (4 mils), the current rose more rapidly. With the above excitation parameters, the imaging device was found to produce latent electrostatic dot images in periods as short as 10 microseconds.

In the sectional view of Figure 6, ions are extracted from an ion generator of the type shown in Figure 5 to form an electrostatic latent image on dielectric receptor 200. A high voltage alternating potential 192 between elongate conductor 197 and transverse electrode 184 results in the generation of a pool of positive and negative ions as shown at 194. These ions are extracted to form an electrostatic image on dielectric surface 200 by means of a DC extraction voltage 198 between transverse electrode 184 and the backing electrode 205 of dielectric receptor 200. Because of the geometry of the ion pool 194, the extracted ions tend to form an electrostatic image on surface 200 in the shape of a dot.

A further imaging device embodiment is illustrated in Figure 7 showing a print head 210 similar to that illustrated in Figure 5, but modified as follows. The dielectric coated wire 213 is not located above the strip electrodes, but instead is embedded in a channel 219 in insulating support 211. The geometry of this arrangement may be varied in the separation (if any) of dielectric coated wire 213 from the side walls 212a and 212b of channel 219; and in the protrusion (if any) of wire electrode 213 from channel 219.

Figure 8 is a perspective view of ion generator 220 of the same type as that illustrated in Figure 7 with the modification that the strip electrodes 224, 226, and 228 are replaced by an array of wires. In this embodiment wires having small diameters are most effective and best results are obtained with wires having a diameter between 25.4μm and 101.6μm (1 and 4 mils).

The air breakdown in any of the above embodiments occurs in a region contingúous to the junction of the dielectric sheath and transverse conductor (see Fig. 6). It is therefore easier to extract ions from the print heads of Figs. 5 and 8 than from that of Fig. 5 in that this region is more accessible in the former embodiments. The ion pool may extend as far as 101.6μm (4 mils) from the area of contact, and therefore may completely surround the dielectric sheath where the latter has a low diameter.

In the preferred embodiment, the transverse conductors contact the dielectric sheath. As the separation of these members has a critical effect on ion current output, they are placed in contact in order to maintain consistent outputs among various crossover points. This also has the benefit of minimizing driving voltage requirements. It is feasible, however to separate these structures by as much as 25.4μm to 50.8μm (1-2 mil).

It is useful to characterize all of the above embodiments in terms of a "control electrode" and a "driver electrode". The electrode excited with the varying potential is termed the driver electrode, while the electrode supplied with an ion extraction potential is termed the control electrode. The energizing potential is generically described herein as "varying," referring to a time-varying potential which provides air breakdown in opposite directions, and hence ions of both polarities. This is advantageously a periodically varying potential with a frequency in the range 60 Hz. - 4 MHz. In any of the illustrated, preferred embodiments, the coated conductor or wire constitutes the driver electrode, and the transverse conductor comprises the control electrode. Alternatively, the coated conductor could be employed as the control electrode.

Figures 5, 7, and 8 illustrate various embodiments involving linear arrays of crossover points or print locations. Any of these may be extended to a multiplexible two-dimensional matrix by adding additional dielectric-coated conductors. With reference to the plan view of Figure 9, a two-dimensional matrix print head is shown utilizing the basic structure shown in Figure 5, with a multiplicity of dielectric-coated conductors. A matrix print head 230 is shown having a parallel array of dielectric-coated wires 231A, 231B, 231C etc. mounted above a crossing array of finger electrodes 232A, 232B, 232C, etc. A pool of ions is formed at a given crossover location $233_{x,y}$ when a varying excitation potential is applied between coated wire 231X and finger electrode 232Y. Ions are extracted from this crossover location to form an electrostatic dot image by means of an extraction potential between finger electrode 232Y and a further electrode (see Figure 6).

In any of the two-dimensional matrix print heads, there is a danger of accidentally erasing all or part of a previously formed electrostatic dot image. This occurs in the ion generator illustrated in Figure 9 when a crossover location 233 is placed over a previously deposited dot image, and a high voltage varying potential is supplied to the corresponding coated wire electrode 231. If in such a case no extraction voltage pulse is supplied between the correspondng finger electrode 232 and ground, the previously established dot image will be totally or partially erased. In any of the embodiments of Figures 5-8 , this phenomenon may be avoided by the inclusion of an additional, apertured "screen" electrode, located between the control electrode and the dielectric receptor surface 200. The screen electrode acts to electrically isolate the potential on the dielectric receptor 200, and may be additionally employed to provide an electrostatic lensing action.

Figure 10 shows in section an ion generator 240 of the above-described type. The structure of Figure 7 is supplemented with a screen electrode 255, which is isolated from control electrode 244 by a dielectric spacer 252. The dielectric spacer 252 defines an air space 253 which is substantially larger than the crossover region 245 of electrodes 242 and 244. This is necessary to avoid wall charging effects. The screen electrode 255 contains an aperture 257 which is at least partially positioned under the crossover region 245.

The ion generator 240 may be utilized for electrographic matrix printing onto a dielectric receptor 258, backed by a grounded auxiliary electrode 259. When the switch is closed at position Y, there is simultaneously an alternating potential across dielectric sheath 242, a negative potential V_c on control electrode 244, and a negative potential V_s on screen electrode 255. Negative ions at crossover region 245 are subjected to an accelerating field which causes them to form an electrostatic latent image on dielectric surface 258. The presence of negative potential V_s on screen electrode 255, which is chosen so that V_s is smaller than V_c in absolute value, does not prevent the formation of the image, which will have a negative potential V_1 (smaller than V_c in absolute value).

When the switch is at X, and a previously created electrostatic image of negative potential V_1 partially under aperture 257, a partial erasure of the image would occur in the absence of screen electrode 255. Screen potential V_s, however, is chosen so that V_s is greater than V_1 in absolute value, and the presence of electrode 255 therefore prevents the passage of positive ions from aperture 257 to dielectric surface 258.

Screen electrode 255 provides unexpected control over image size, by varying the size of screen apertures 257. Using a configuration such as that shown in Figure 10, a larger screen potential has been found to produce a smaller dot diameter. This technique may be used for the formation of fine or bold images. It has also been found that proper choices of V_s and V_c will allow an increase in the distance between ion generator 240 and dielectric surface 258 while retaining a constant dot image diameter. This is done by increasing the absolute value of V_s while keeping constant the potential difference between V_s and V_c.

Image shape may be controlled by using a given screen electrode overlay. Screen apertures 257 may, for example, assume the shape of fully formed characters which are no larger than the corresponding crossover regions 245. This technique would advantageously utilize larger crossover regions 245. The lensing action provided by the apertured screen electrode generally results in improved image definition, at the cost of decreased ion current output.

Figure 11 illustrates yet another electrostatic imaging device 260 for use in a high speed serial printer.

An insulating drum 261 is caused to rotate at a high rate of speed, illustratively around 1200 rpm. To this drum is bonded a dielectric-coated conductor 262 in the form of a helix. The drum is disposed over an array of parallel control wires which are held rigid under spring tension. The dielectric-coated wire is maintained in gentle contact with or closely spaced from the control wire array. By rotating the drum, the helical wire provides a serial scanning mechanism. As the helix scans across the wires with a high frequency high voltage excitation applied to dielectric-coated wire 262, printing is effected by applying an extraction voltage pulse to one of the control electrode wires 263.

Figure 12 illustrates an alternative scheme for providing a relative motion between the print device of the invention and a dielectric receptor surface. A charging head 270 in accordance with Figure 9 is slidably mounted on guide bars 275. Any suitable means may be provided for reciprocating print head 270, such as a cable drive actuated by a stepping motor. This system may be employed to form an electrostatic image on dielectric paper, a dielectric transfer member, etc.

The invention is further illustrated with reference to the following specific embodiments.

EXAMPLE VI-1

An imaging device of the type illustrated in Figure 5 was fabricated as follows. The insulating support 181 comprised a G-10 epoxy fiberglass circuit board. Control electrodes 184, 186, 188, etc. were formed by photoetching a 25.4 μm (1 mil) stainless steel foil which had been laminated to insulating substrate 181, providing a parallel array of 101.6 μm (4 mil) wide strips at a separation of 254 μm (10 mils). The driver electrode 193 consisted of a 127 μm (5 mil) tungsten wire coated with a 3.81 μm (1.5 mil) layer of fused glass to form a structure having a total diameter 203.2 μm (8 mils).

AC excitation 192 was provided by a gated Hartley oscillator operating at a resonant frequency of 1 MHz. The applied voltage was in the range of 2000 volts peak-to-peak with a pulse width of 3 microseconds, and a repetition period of 500 microseconds. A 200 volts DC extraction potential 198 was applied between selected control electrodes and an electrode supporting a dielectric charge receptor sheet. The ion generating array was positioned 0.254 mm (0.01 inches) from the dielectric-coated sheet.

This apparatus was employed to form dot matrix characters in latent electrostatic form on dielectric sheet 200. After conventional electrostatic toning and fusing, a permanent high quality image was obtained.

EXAMPLE VI-2

An ion projection print device of the type illustrated in Figure 7 was fabricated as follows. A channel 219 of 127 μm (5

EXAMPLE VI-2

mils) depth and 254μm (10 mils) width was milled in a 3.175 mm (0.125 inch) thick G-10 epoxy fiberglass circuit board. A driver electrode 213 identical to that of Example VI-1 was laid in the channel. Photoetched stainless steel foil electrodes 214, 216, 218, etc. were laminated to circuit board 211, contacting dielectric 215. The device exhibited equivalent performance to the imaging device of Example VI-1 when excited at the same potential.

EXAMPLE VI-3

The electrostatic print device of Example VI-2 was modified to provide imaging apparatus of the type shown in Figure 8. The control electrodes comprised a series of 76.2μm (3 mil) diameter tungsten wires cemented to support 221. This device achieved approximately double the ion current output as compared with the devices of Examples VI-1 and VI-2.

In all three examples, the glass coated wire was not firmly bonded in place, but was allowed to move freely along its axis. This provided a freedom of motion to allow for thermal expansion when operating at high driving potentials.

CLAIMS

1. A method of fabricating a dielectric-electrode laminate comprising the steps of:

(a) applying a layer of pressure sensitive adhesive (172, 173) to a sheet of mica (171),

(b) bonding a face of a metallic sheet to a face of said mica sheet with pressure sensitive adhesive, and

(c) selectively removing portions of said electrode sheet to create an electrode pattern.

2. A method as claimed in Claim 1 in which step (a) comprises immersing said mica sheet in a bath of pressure sensitive adhesive and withdrawing the mica sheet from the adhesive bath at a controlled speed to form a pressure sensitive adhesive layer of desired thickness.

3. A method as claimed in Claim 1 or Claim 2 in which step (b) comprises bonding a metallic sheet (174, 175) to each face of the mica sheet.

4. A method as claimed in Claim 3 in which step (c) comprises selectively removing portions of each metallic sheet to create first and second electrode patterns on opposite faces of the mica sheet.

5. A method as claimed in any one of the preceding claims in which step (c) comprises the steps of: applying a layer of photoresist to said metallic sheet, placing a photomask patterned in accordance with said electrode pattern, and exposing the resulting structure to ultraviolet radiation.

6. A method as claimed in any one of the preceding claims in which step (a) comprises coating the entire mica sheet (including the edges) with a layer of pressure sensitive adhesive; and applying a protective tape to the edges of said mica.

7. A method as claimed in any one of the preceding claims in which the pressure sensitive adhesive has a viscosity in the range of 10^{-2} to 10^{-1} Pas (10 centipoise - 100 centipoise).

8. A method as claimed in any one of the preceding claims further including bonding a heat sink to the laminate subsequent to step (c).

9. A dielectric-electrode laminate comprising: a mica sheet (171); a metallic sheet electrode bonded to a face of said mica sheet, the bond between the electrode and the mica sheet being formed by a layer of pressure-sensitive adhesive (172, 173).

10. A laminate as claimed in Claim 9 in which a first electrode (133), bonded to one face of the mica sheet (131), comprises a series of longitudinally-extending bars, and a second electrode (132), bonded to the other face of the mica sheet, comprises a series of fingers transversely aligned to the bars.

11. A method or apparatus as claimed in any one of the preceding claims in which the metallic sheet comprises a foil of stainless steel, copper, nickel, titanium or tantalum.

12. A method or apparatus as claimed in any one of the preceding claims in which the pressure sensitive adhesive comprises an organopolysiloxane resin, an acrylic-based pressure sensitive adhesive, or an acrylic copolymer of the polymeric vinyl ester family.

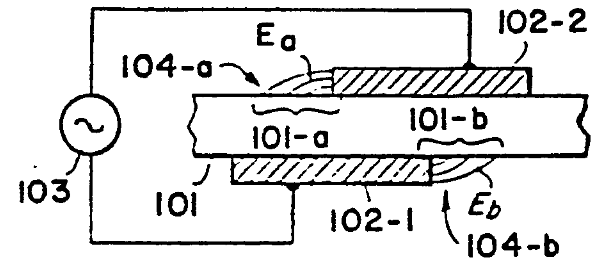


FIG. 1

100

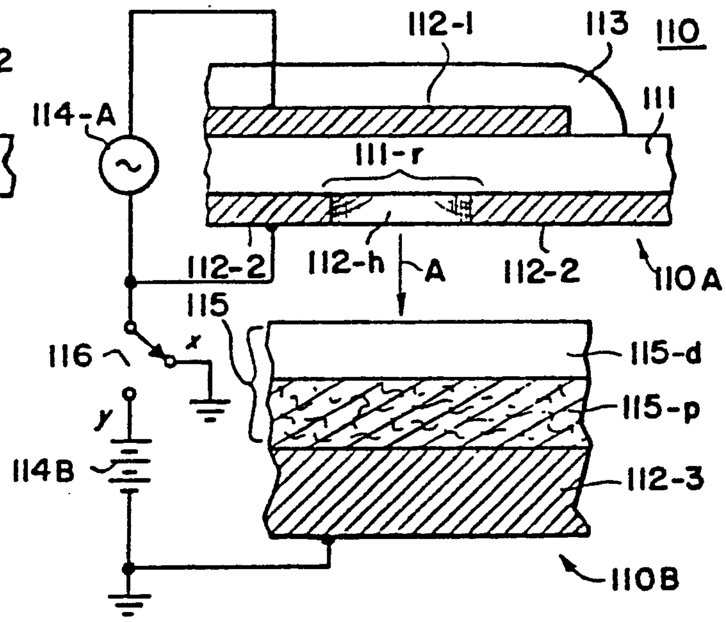


FIG. 2

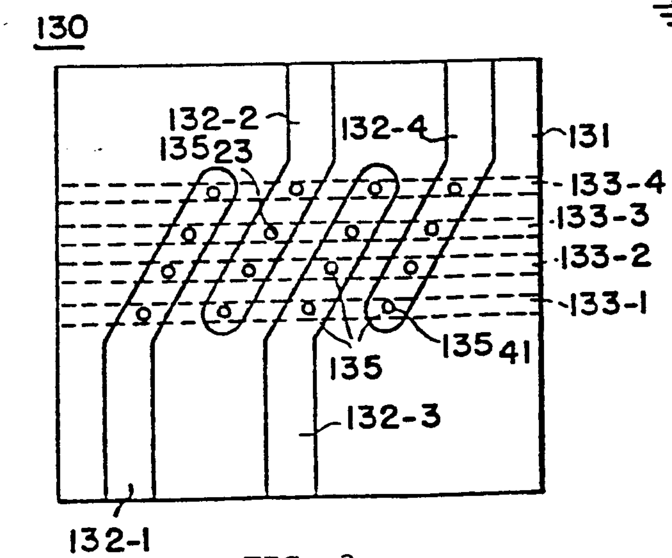


FIG. 3

FIG. 4

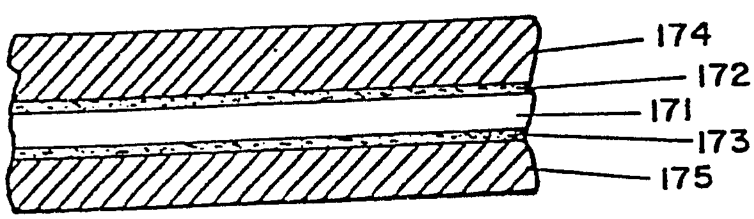
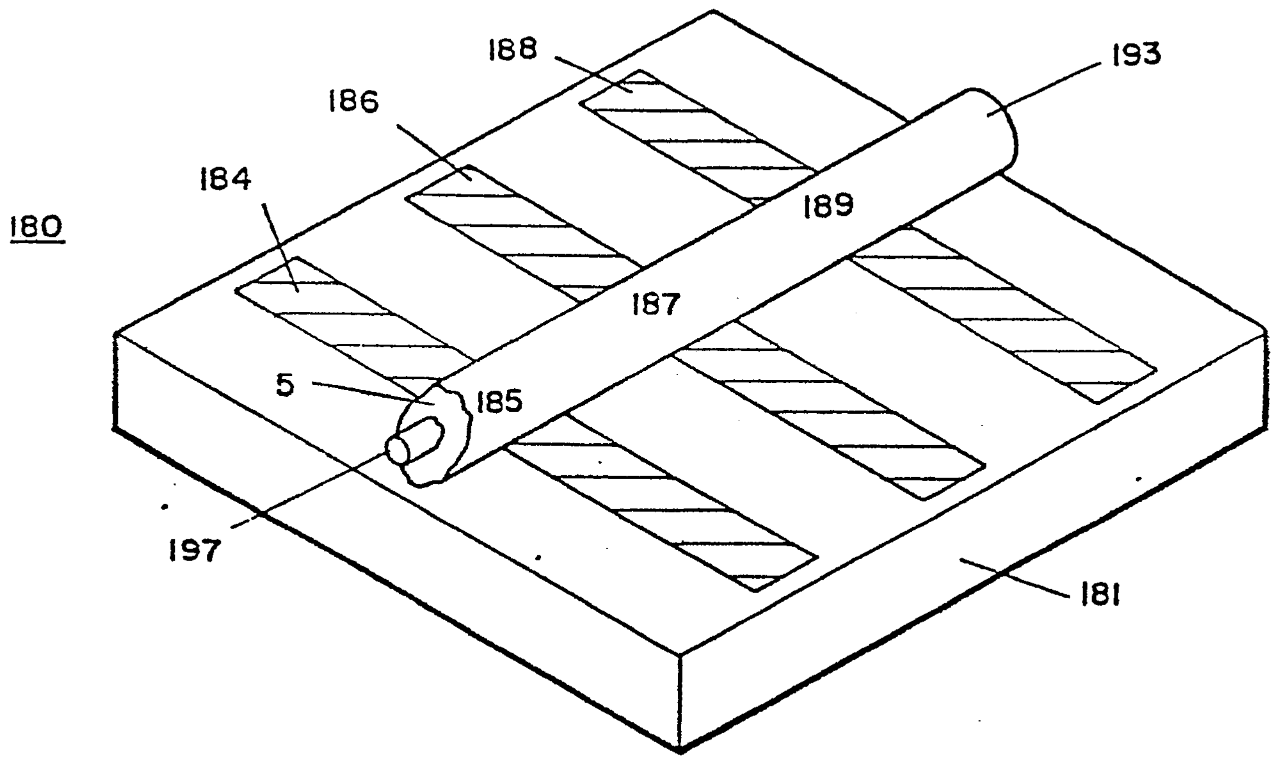


FIG. 5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193
186
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180
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5
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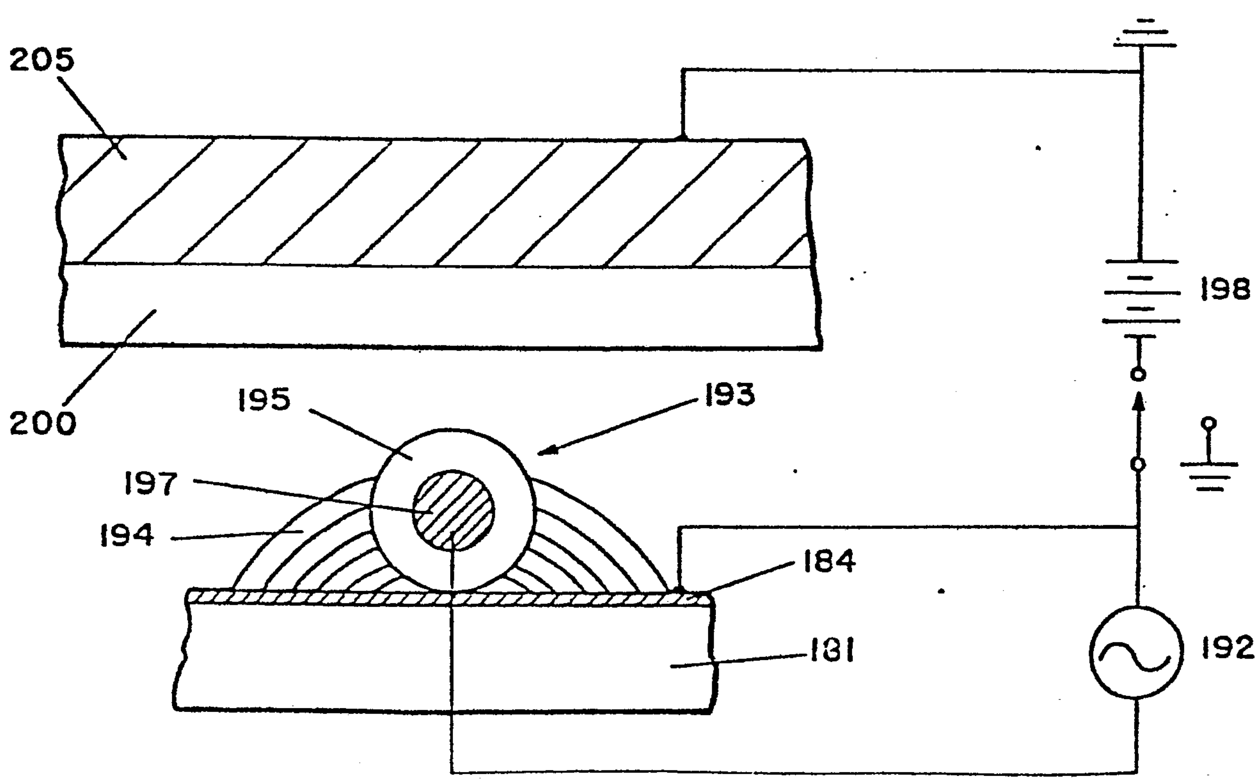
197
181

FIG. 6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198
200
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193
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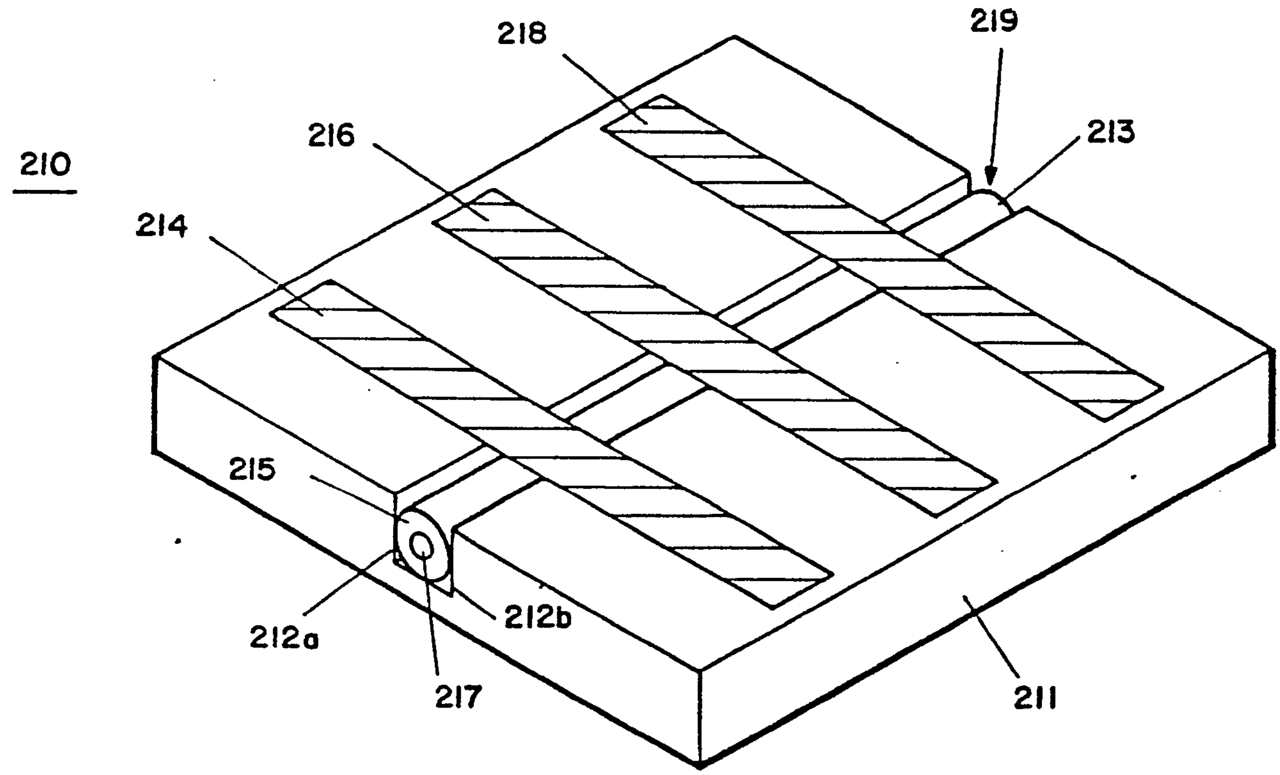
184
181
192

FIG. 7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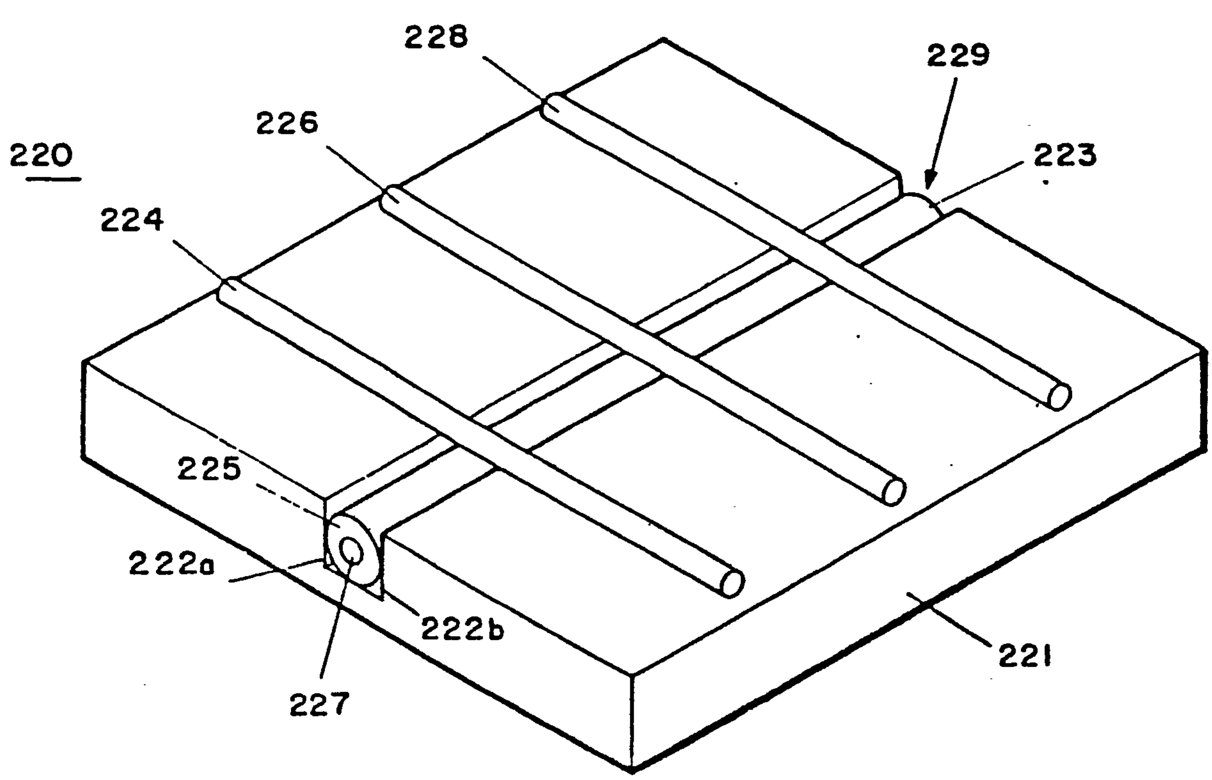
218
219
216
213
214
215
212a
212b
217
211

FIG. 8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228
229
226
223
224
225
222a
222b
227
221

FIG. 9

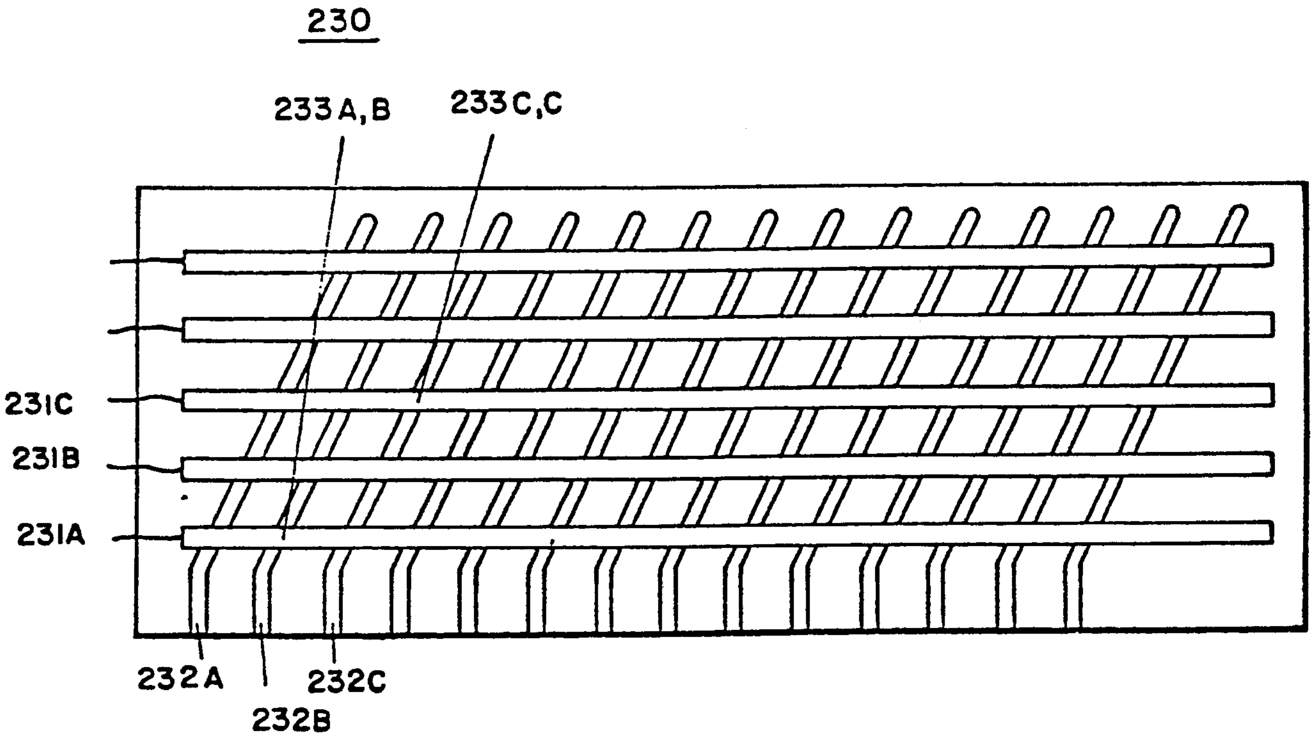

230
233A,B
233C,C
231C
231B
231A
232A
232C
232B

FIG. 10

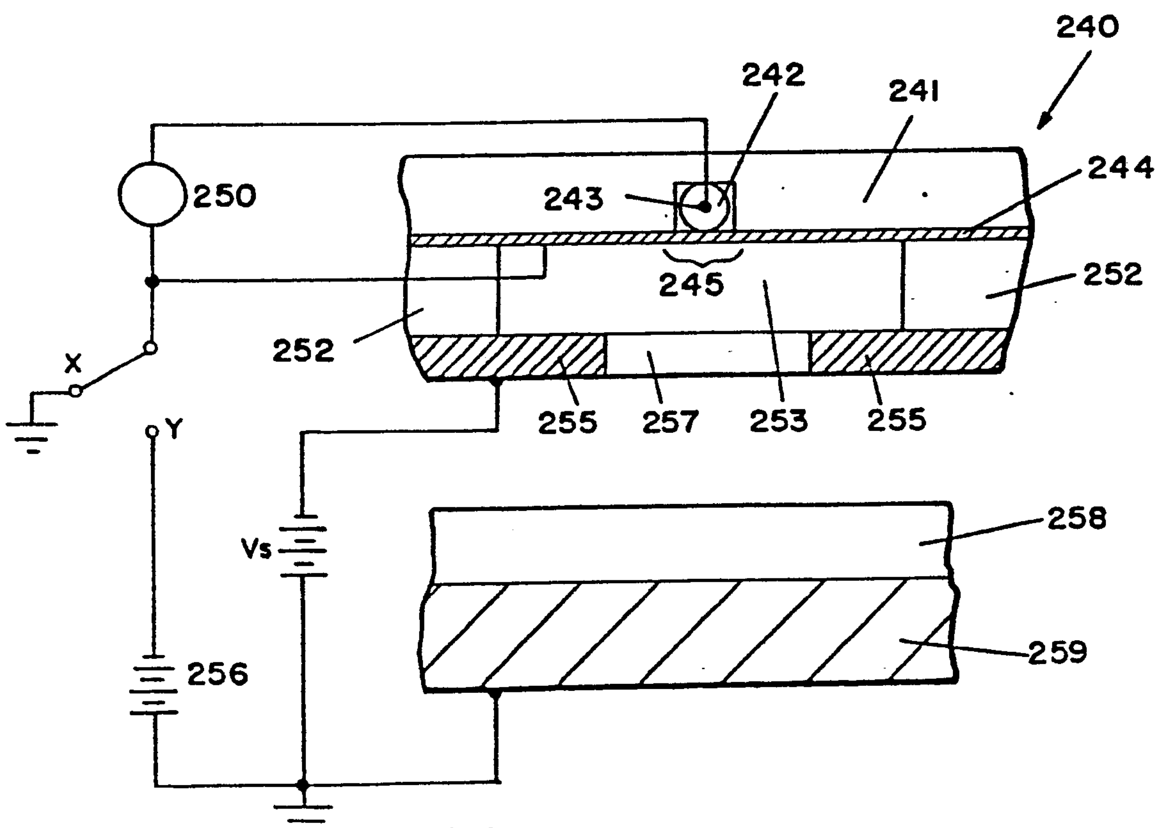

240
242
241
244
243
250
245
252
252
X
Y
255
257
253
255
Vs
258
259
256

FIG. 11

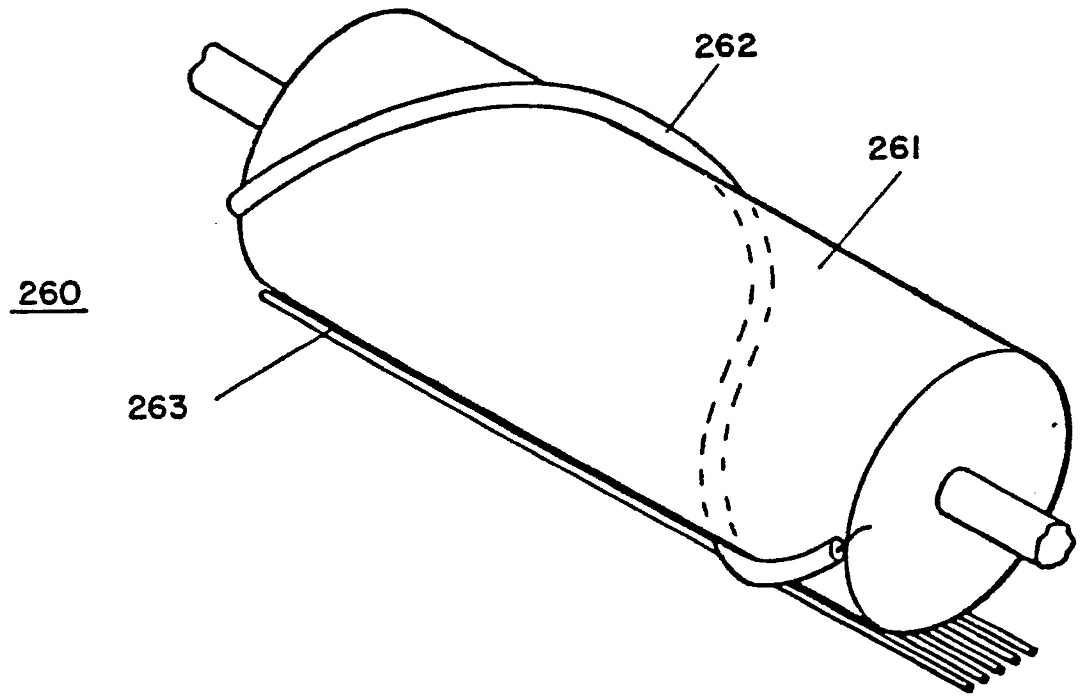
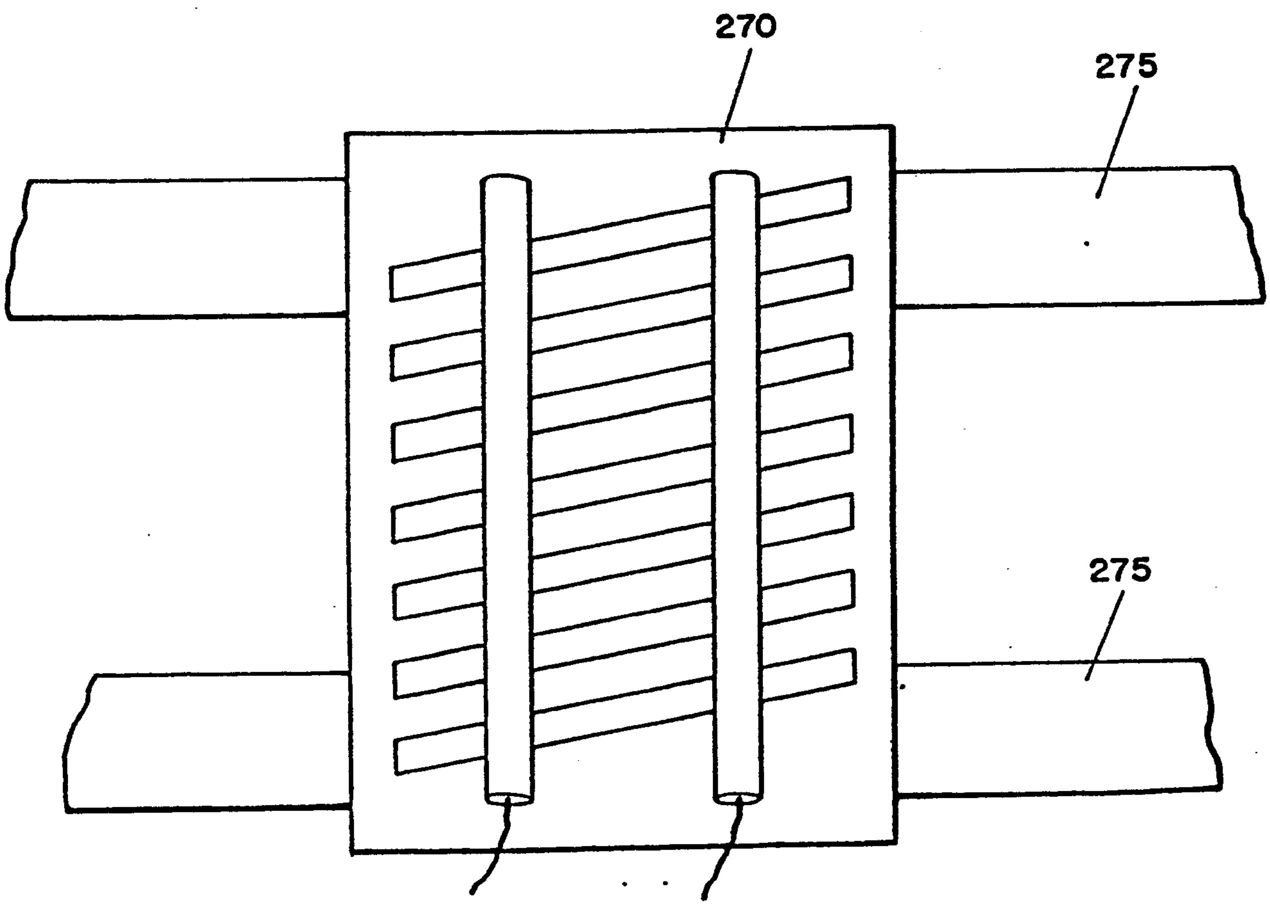


FIG. 12



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EUROPEAN SEARCH REPORT

0166494

Application number

EP 85 20 1056

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	GB-A-2 007 157 (DENNISON MANUFACTURING CO. LTD.) * Page 10, lines 9-16; page 12, lines 16-27; page 14, lines 10-15; figures 10,13,20,21 *	1,3-5, 9,11	H 01 T 23/00
Y	FR-A-2 228 245 (ALLCO) * Page 2, line 27 - page 3, line 24 *	1,3-5, 9,11	
A	US-A-4 088 891 (R.L. SMITH et al.) * Column 6, lines 32-62 *	1,3-5, 9,11	
A	US-A-3 718 936 (P.J. RICE, Jr.) * Column 2, lines 7-30; column 3, lines 1-20; column 4, lines 6-25; figure 2 *	1,3-5, 9-11	**TECHNICAL FIELDS SEARCHED (Int. Cl.4)** H 01 T; G 03 G; B 41 J
D,A	US-A-4 155 093 (R.A. FOTLAND et al.) * Column 7, lines 20-35; figures 1-5 *	1,3-5, 9,11	
A	FR-A-2 441 492 (DYNAMICS RESEARCH CORP.) * Figures 3,4,7 *	1,9,10	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11-10-1985	CIGOJ P.M.

CATEGORY OF CITED DOCUMENTS

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