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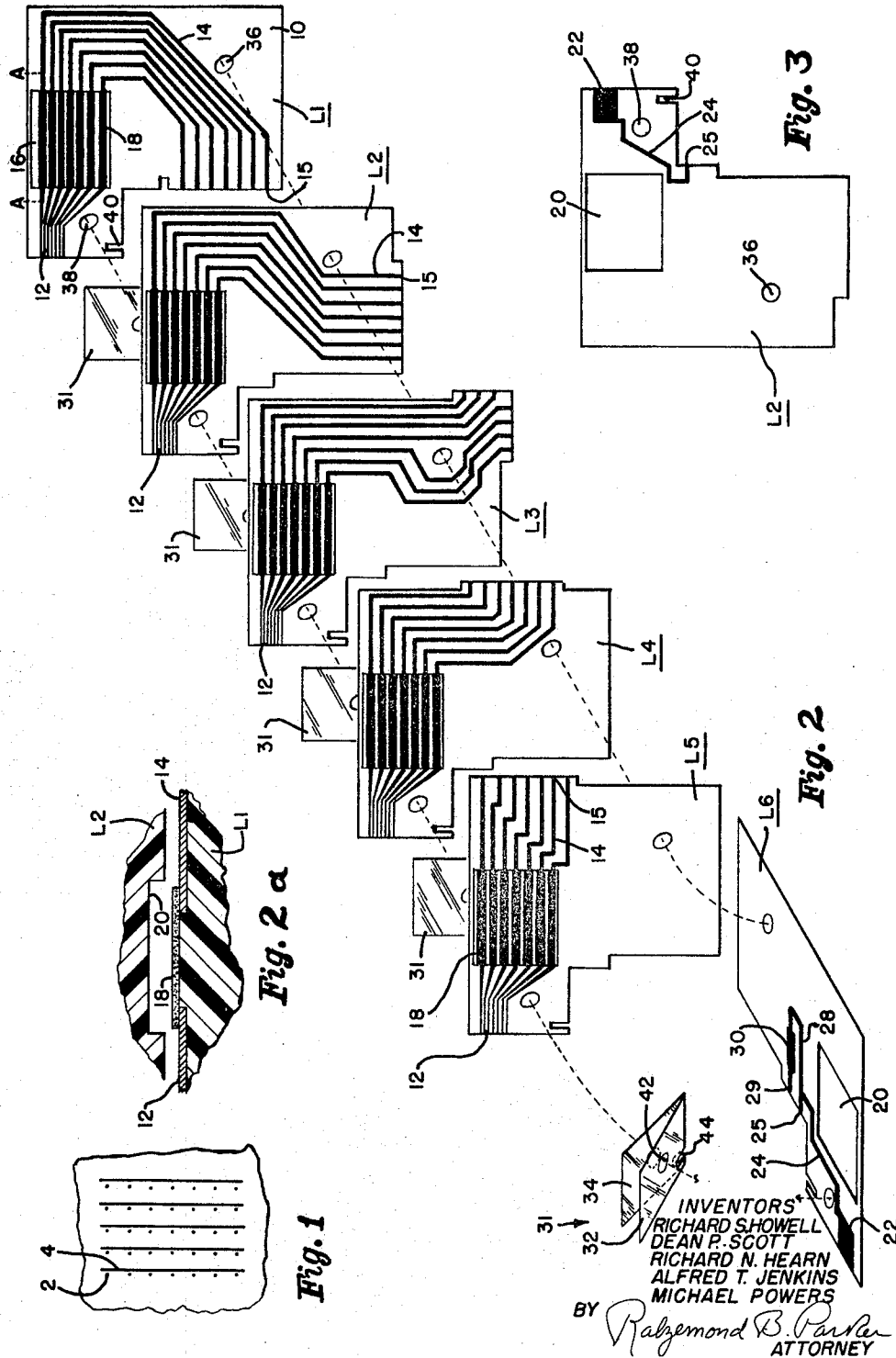
R. S. HOWELL ET AL

3,267,485

ELECTRODE PRINTING ASSEMBLY

Original Filed Dec. 2, 1959

2 Sheets-Sheet 1



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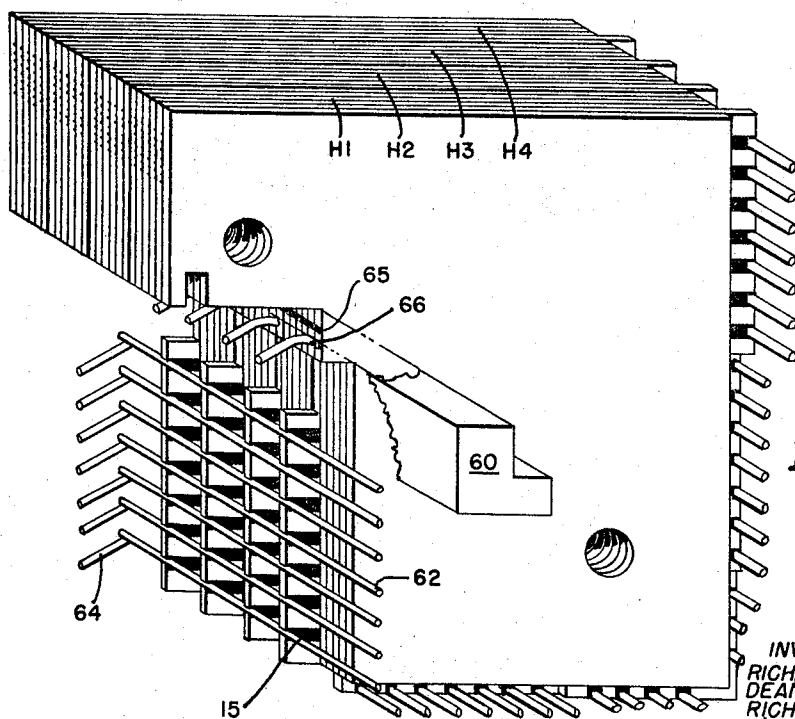
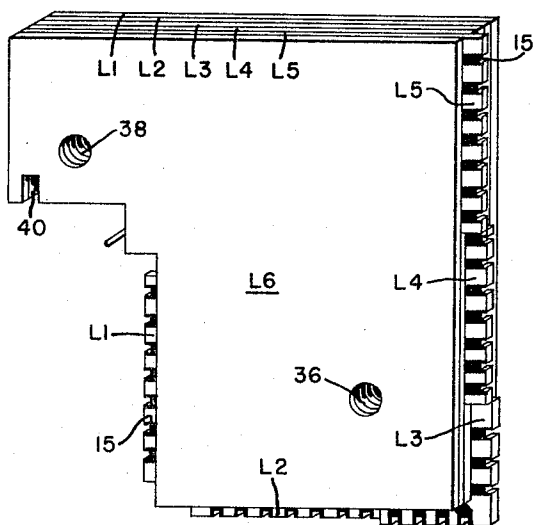
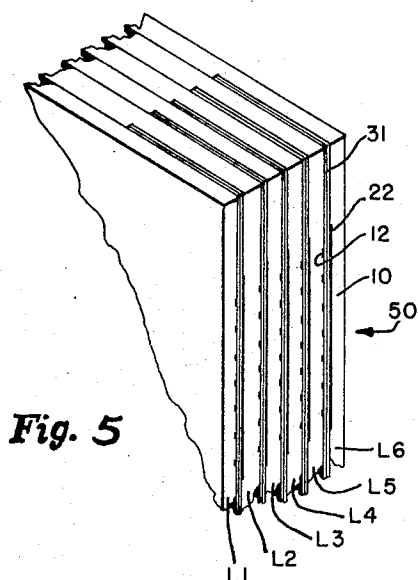
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3,267,485

ELECTRODE PRINTING ASSEMBLY

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Original application Dec. 2, 1959, Ser. No. 856,868. Divided and this application Jan. 21, 1965, Ser. No. 433,830

22 Claims. (Cl. 346—139)

This application is a division of copending application entitled "Electrode Assemblies and Methods of Making Same," Serial No. 856,868, filed December 2, 1959, now Patent No. 3,235,942.

The present invention relates to the art of electrode assemblies and particularly to such assemblies which are comprised of an array or matrix of electrodes selectively energizable for recording information on a record medium.

The invention is herein described with respect to recording or printing head structures, which include a printing face having an electrode arrangement of the general type disclosed in U.S. patent application Serial No. 734,196, filed May 28, 1958, now Patent No. 2,918,580, for use in electrostatic recording or printing apparatus. The printing face of that head comprises a matrix of 35 pin electrodes arranged in vertical and horizontal rows, their being seven electrodes in each vertical row (or column) and five electrodes in each horizontal row. Co-operating with each row of pin electrodes is an auxiliary elongated electrode, or bar electrode. Thus, there may be seven such auxiliary bar electrodes, one cooperating with and closely spaced to each horizontal row of pin electrodes; or there may be five auxiliary electrodes, one for each vertical column of pin electrodes. For purposes of the present description, the latter arrangement using five bar electrodes is herein illustrated.

The printing head is used for applying electrostatic latent images on a record medium in accordance with the energization of the pin electrodes. The auxiliary bar electrodes are connected together in each head and are used to initiate the recording from the pin electrodes. They are sometimes referred to as selection electrodes since they are particularly useful for selecting the head to print. A more complete description of the operation of this type of printing head is found in the above-referenced U.S. Patent No. 2,918,580.

An object of the present invention is to provide an improved printing head assembly requiring critical spatial relationships, such as electrode recording heads and like devices.

A further object of the present invention is to provide an improved recording head structure, which head is characterized by a much longer useful life than the heretofore known head designs.

A further object of the invention is to provide a recording head structure of a design susceptible for production on a high volume, relatively low-cost basis.

A still further object of the present invention is to provide an improved printing head assembly comprising a plurality of substrate members compactly assembled into a stack and bearing electrically conductive and electrically resistive elements on the plane surfaces thereof such that upon energization of such elements an intelligible recording may be made.

These and other objects, which will be readily apparent as the description proceeds, are attainable by the present invention which is described below, illustratively, and not in a limiting sense, in connection with the production of printing heads having printing faces of the type described in U.S. Patent No. 2,918,580.

Briefly, the invention is characterized by forming a plurality of pin electrodes on a substrate or base of suitable insulating material, and then laminating a plurality of such bases to provide an assembly or matrix of pin electrodes. As disclosed, each of the lamina includes not only a plurality of the pin electrodes, but also the leads and terminals for connecting each electrode in the electrical circuit. Of particular importance to the printing head structure disclosed is the inclusion within the head of internal resistors, one for each of the pin electrodes and disposed very closely to its respective pin electrode. The inclusion of these internal resistors has been found to improve the operation of the head and particularly to prolong its useful life. The method of making the head as herein disclosed particularly lends itself to including the internal resistors during the production of the head, since each lamina formed with a plurality of pin electrodes may also be formed, with very little additional effort, with an internal resistor for each pin electrode and proximately located to its respective pin electrode. The present invention also provides for the inclusion of the auxiliary or bar electrode for each row or column of pin electrodes. This auxiliary electrode is formed or applied to the surface of each lamina opposite to the pin electrodes, and cooperates with the pin electrodes of the next adjacent lamina in the assembled head.

The invention will be better understood by reference to the following described embodiment thereof directed to a printing head and method of making same illustrated in the accompanying drawings, in which:

FIG. 1 illustrates the electrode arrangement in the print face of a print head produced by the described embodiment, this electrode arrangement being of the general type disclosed in the above-referred-to Patent No. 2,918,580;

FIG. 2 is a spread-apart view of the several laminae used in making a printing head in accordance with the present invention;

FIG. 2a is an enlarged fragmentary section along the lines A—A of FIG. 2 (lamina L1) and also illustrating a portion of the surface of the succeeding lamina, this figure more clearly showing how the resistors are formed internally of the head;

FIG. 3 is a front elevational view of a typical lamina used in making a printing head, but illustrating the surface of the lamina opposite to that shown in FIG. 2;

FIG. 4 is a view illustrating a complete assembly of laminae making up a printing head;

FIG. 5 is an enlarged fragmentary perspective view of the printing head of FIG. 4 illustrating the electrode arrangement; and

FIG. 6 illustrates a stack of printing heads and the manner in which the electrodes are connected for use in electrostatic recording or printing apparatus.

Referring first to FIG. 1 which illustrates the electrode arrangement in the face of a print head produced by the method to be described, it is seen that the print face comprises 35 pin electrodes 2 arranged in a matrix of seven electrodes in each vertical row, or column, and five electrodes in each horizontal row. The pin electrodes are substantially equidistantly spaced from each other. Five auxiliary or bar electrodes 4 are provided in the printing head, each one being closely spaced to a column of pin electrodes 2.

In accordance with the disclosed embodiment of the present invention, this electrode arrangement, in substance, is produced by first producing a plurality of laminae L1—L6, and subsequently bonding them together to form a complete printing head. Each lamina is preferably formed by a printed circuit technique so as to be more readily susceptible for production on a high volume, relatively low-cost basis.

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FIG. 2 illustrates one surface of all the laminae L1-L6 which go into the production of a complete printing head. Each lamina is produced by forming on one surface of an insulating base 10 a plurality of mutually-spaced first conductors 12 (forming the pin electrodes 2 of FIG. 1) and a plurality of mutually-spaced second conductors serving as electrical leads 14, one for each of the electrodes. In the finished head, leads 14 extend from the edge of the insulating base where they form terminals 15, but terminate short of their respective electrodes 12 so as to be physically disconnected therefrom in a common area 16 as close to the electrodes 12 as possible. These gaps are bridged by a plurality of spaced resistors 18, one between each of the electrical leads 14 and its respective electrode 12.

Electrodes 12 and their electrical leads 14 are preferably formed by any well-known printed circuit technique. For example, beginning with a metal-clad insulating base, an etch-resistant coating is applied to the metal surface in accordance with the pattern of electrodes and leads to be formed. An etchant is then applied to remove the portions of the metal not covered by the etch-resistant coating. Subsequently, the etch-resistant coating is removed, thereby leaving the electrodes 12 and the leads 14 formed on the surface of the insulating base 10 as illustrated in FIG. 2. The patterns formed by this etching technique would differ somewhat with respect to the electrical leads 14 between the various laminae, as shown in FIG. 2, for reasons to be later described.

As examples of materials that may be used, the insulating base 10 may be of an epoxy resin impregnated glass cloth, and the metal cladding may be of copper, stainless steel, or other material suitable for forming the electrodes and leads. Because of the fineness of detail that is required with respect to electrodes 12 and the spacings therebetween, it is preferred to use a photo-resist material for the masking coating, which is exposed and developed to form the etch-resistant coating in accordance with well-known techniques.

The electrodes 12 and their respective leads 14 are preferably formed flush with the surface of the insulating base. To accomplish this the initial metal cladding on the surface of the insulating base is pressed into the base to be flush therewith before the actual etching process is started.

FIG. 2 illustrates the electrodes 12 as formed so as to extend right to the edge of the insulating base 10. It will be understood, however, that these electrodes may be formed to terminate short of the edge of the base since that edge is subsequently trimmed to provide a flat surface in which the electrodes 12 terminate in a common plane. Similarly, leads 14 may be formed to terminate short of the insulating base edges, as these edges could also be trimmed at the same time. This will be further described below.

FIG. 2 illustrates laminae L1-L5, particularly the formation of their electrodes 12 and their electrical leads 14, and end lamina L6 which is not formed with these electrodes. Electrodes 12 are of the same formation in all the laminae L1-L5 since the latter are subsequently assembled with the electrodes in alignment to form the matrix of pin electrodes. The formation of the electrical leads 14, however, differs somewhat in all the laminae L1-L5, the principal difference being that they terminate (terminals 15) at different peripheral edges of the insulating base. Thus, terminals 15 in lamina L1 occupy the edge of the base further along the peripheral edge of the base just under electrodes 12. The terminals 15 in lamina L2 occupy the edge of the base further along the periphery, and so on with laminae L3, L4, and L5. When all the laminae L1-L5 are assembled, it is seen that the terminals 15 for each of the electrical leads 14 will occupy different peripheral edges of the laminated assembly, and that the terminals as a group will extend for

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most of the periphery. This is more clearly seen in FIGS. 4 and 6.

As shown in FIGS. 2, 4 and 6, that edge of each insulating base 10 which carries the terminals 15 for the electrode leads is extended somewhat past the corresponding edges of the other laminae which do not carry the terminals for their leads. This is so the terminal-carrying portion of the insulating base 10 will project from the laminated assembly, as illustrated in FIG. 6, to facilitate the making of electrical connections to these terminals. However, for uniformity in the production of the blank insulating base 10, it may be desired to make the peripheral edges of all the laminae exactly the same, i.e. with no projecting edges. As is also illustrated, particularly in FIGS. 4 and 6 (but not in FIG. 2), the terminal-carrying edge of each lamina may be notched to facilitate the electrical connections (see FIG. 6) to these terminals.

As mentioned earlier, electrodes 12 are physically disconnected from their respective leads 14 by the gap in area 16. In this gap a plurality of resistors 18 are applied to connect each electrode 12 to its respective lead 14. Preferably, the resistors 18 are applied as deposits of a suitable resistor composition in accordance with any well-known technique, such as through a stencil.

FIG. 2a illustrates a section through area 16 (of e.g. L1, FIG. 2) occupied by the ends of electrodes 12 and their leads 14, which ends are bridged by resistors 18. FIG. 2a also illustrates the opposite surface of the succeeding lamina (L2 in this case) at this area. As shown in FIG. 2a, electrodes 12 and leads 14 are flush with the upper surface of the insulating base 10, as described above, and the resistors 18 are applied to overlap the ends of their respective electrodes. Resistors 18 are applied so as to project somewhat from the flush surface. To avoid any interferences when the laminae are assembled, the opposite surface of each lamina is recessed at 20 in the area 16 occupied by the resistors so as to accommodate the projecting resistors of each succeeding lamina. This is also shown in FIG. 3. The recessing may be accomplished during the same step the metal cladding is made flush with the insulating base, i.e. before any etching has occurred.

Also seen in FIG. 3 is the formation of the auxiliary electrode 22, corresponding to electrode 4 in FIG. 1. This electrode is formed on each lamina except that of L1. L1 is the end lamina and therefore does not require an auxiliary electrode to cooperate with the pin electrodes 12 of a succeeding lamina.

FIG. 3 illustrates the surface (of laminae L2-L5) opposite to that shown in FIG. 2. The peripheral configuration is actually that of L2 with respect to the edge of the insulating base occupied by the terminals 15 for the leads 14. This surface includes the recessed area 20 and the auxiliary electrode 22, as discussed above, and also includes an electrical lead 24 extending from auxiliary electrode 22 to a peripheral edge of the insulating base terminating in terminal 25. Electrode 22 and lead 24 are preferably formed also by a printed circuit technique. However, since the tolerance requirements here are not as stringent as with electrodes 12, the auxiliary electrodes 22 may be preformed and inserted between the laminae when the latter are assembled. In that case, the surface of the lamina should also be recessed to accommodate the auxiliary electrode 22 so that the latter electrode will not project nor interfere with the compact assembling of all the laminae. Auxiliary electrode 22 is substantially coextensive with the space occupied by the pin electrodes 12.

As mentioned, FIG. 3 illustrates the opposing surface of the insulating base only with respect to laminae L1-L5. The opposing surface of end lamina L1 would not be recessed at 20, nor would it carry the auxiliary electrode 22 or its lead 24. The other end lamina L6 would carry these elements but would not be formed with electrodes 12, resistors 18 and leads 14. Lamina L6 alone is further

provided with another lead 28 connected to lead 24, another terminal 29, and a resistor 30 connecting lead 28 to terminal 29. When all the laminae are assembled, as will be described more fully below, terminals 25 for the auxiliary electrodes in all the laminae (L2-L6) are aligned and a common connection is made. Terminal 29, formed only on end lamina L6, provides the means for connecting all the auxiliary electrodes 22 of one laminated assembly to the external circuit. The auxiliary electrodes are connected to the external circuit through a resistor 30, which resistor, as well as the other elements of lamina L6, are formed in the same manner as discussed above with respect to the other laminae.

Before laminae L1-L6 are assembled, a thin film or layer 31 of insulating material is applied over each of the auxiliary electrodes 22 to insulate the same from their cooperating pin electrodes 12 of the succeeding lamina. This film of insulating material is preferably a laminate of two materials: one 32 is preferably of glass or mica, which is not easily eroded by the electrical arcing between electrodes; and the other 34 is preferably of polyethylene terephthalate (obtainable under the trademark "Mylar"), which is more easily eroded by the electrical arcing. The functions of these materials in the printing head are more fully discussed in U.S. Patent No. 2,918,580.

In assembling laminae L1-L6 and the insulating materials 32 and 34, the latter are inserted over auxiliary electrodes 22 with the glass or mica 32 in contact with the latter electrodes and the "Mylar" layer 34 in contact with the pin electrodes 12. If the auxiliary electrode 22 is not formed on its insulating base, but is rather preformed and applied thereto just prior to laminating the assembly, as suggested above, insulating layers 32 and 34 could be pre-laminated with the auxiliary electrodes, and all three layers inserted into the assembly as a package. The laminae are assembled with all the pin electrodes aligned to form a rectangular matrix with the auxiliary electrodes 22 spaced between each column of pin electrodes 12 and separated therefrom on one side by insulating film 31 (consisting of layers 32 and 34), and on the other side by the thickness of the insulating base 10. (See FIG. 5.) Films 32 and 34 are relatively thin when compared to the thickness of the insulating base, and therefore each auxiliary electrode will be much more closely spaced to the pin electrodes 12 of a succeeding lamina than to the pin electrodes formed on the opposite surface of the same lamina.

In one embodiment, the thickness of each lamina L1-L6 is 14 mils (.014 inch); the thickness of the metal cladding from which electrodes 12 and leads 14 are formed, and therefore the thickness of these elements, is 2 mils; that of auxiliary electrodes 22 is also 2 mils; that of insulating layer 32 is 1 mil; and that of insulating layer 34 is also 1 mil. Pin electrodes 12 are thus spaced from each other in one direction by the thickness of the insulating base 10 (i.e. 14 mils) and are therefore applied to their respective laminae with the same spacing in the other direction. The depth of recess 20 for accommodating the resistors is about 3 mils. Resistors 18 are each about 5 megohms, and resistor 30 is about 10 kilohms.

In assembling laminae L1-L6, each is coated with an epoxy resin and the assembly is bonded together under heat and pressure to cure the resin, in accordance with well-known laminating techniques. For aligning the laminae during their assembly, each is formed with aligning apertures 36 and 38 and an aligning notch 40. Films 32 and 34 are also correspondingly apertured and notched at 42 and 44, respectively.

After the laminae are bonded together, the periphery of the assembly is trimmed with a cutting tool, and particularly the edge 50 (FIG. 5) of the assembly is trimmed to form a flat printing surface in which all the electrodes 12 and 22 are exposed in a common plane. As indicated previously, electrodes 12, and this is also true with respect to auxiliary electrodes 22, may be initially formed so they

do not extend to the edge of their respective laminae. In fact, this is preferable, for manufacturing reasons, when the electrodes are applied by an etching technique since it is very difficult to maintain the required tolerances when etching the electrodes right to the edge of the insulating base. In any event, trimming the printing face of the assembly, whether the electrodes originally extended to that edge or not, assures that all the electrodes will be exposed in a common plane in the head.

It will be recalled that the auxiliary electrodes 22 in each lamina are connected together in each head. This is accomplished by assembling the laminae L1-L6 with terminals 25 of each lamina in alignment, and then making a common connection to these terminals. This connection may be made by notching the aligned terminals 25, and then filling same with a conductive compound (see 65, FIG. 6) such as solder. The auxiliary electrodes 22 in each head are connected to the external circuitry through the terminal 29 (and resistor 30) formed on end lamina L6 alone.

FIG. 4 illustrates a laminated assembly forming a printing head, and FIG. 5 illustrates the printing face of the head.

In use, the heads may be inserted individually into the recording apparatus, or they may be pre-assembled in the form of a stick of heads and the stick inserted in the apparatus. FIG. 6 illustrates an assembly of four printing heads H1-H4 forming a stick for mounting on a support, such as bar 60, in the recording apparatus. In assembling the stick, a plurality of individual heads H1-H4, each produced as described above, is aligned and bonded together by, e.g. an epoxy resin, under heat and pressure. As described above, each of the heads carries the terminals 15 for the electrodes 12 along a peripheral edge with each terminal occupying a different surface of the periphery. In using the heads in the recording apparatus, corresponding ones of the pin electrodes 12 are connected together in all the heads. Accordingly, in assembling a stick of heads, a common connection is made to the corresponding terminals in each of the heads. For this purpose the stick of heads is assembled with the corresponding terminals in all the heads in alignment. Each group of aligned terminals is then connected together by a wire 62. There being 35 pin electrodes in each head, there would be 35 wires 62 for each stick. Each of the wires 62 carries a lead 64 for connection to the external circuitry, there likewise being 35 of these leads 64.

FIG. 6 also illustrates at 65 the common connection, such as a notched surface filled with solder, made to all the auxiliary electrodes 22 of a single head. The lead connecting the auxiliary electrodes of each head to the external circuitry is designated 66, it being understood that there would be one such lead 66 for each head in the stick. Thus in the stick of four heads illustrated in FIG. 6, there would be four separate leads 66, one for the auxiliary electrodes of each head.

After the plurality of heads H1-H4 are assembled in the form of a stick, the assembly may then be encapsulated in a suitable plastic or varnish material covering the whole assembly but leaving leads 64 and 66 exposed for the external connections. The printing faces 50 of the printing heads could be further trimmed, if necessary, and then cleaned and polished to remove any contaminants.

It has been found that electrostatic printing heads produced in accordance with the present invention exhibit a longer useful life and are capable of recording at higher rates of speed than the heretofore known electrostatic recording heads. These two characteristics are believed attributable to the relatively small local self-capacitance of these heads, particularly because of the inclusion of the internal resistors 18 closely adjacent to the printing electrodes 12. This small capacitance decreases the amount of energy released at the printing face during recording, and therefore decreases the heat generated and the resulting erosion of the electrodes. The small capacitance also

decreases the time constant during electrostatic recording, which is one of the significant limiting factors in the potential speed of an electrostatic printer using this type of head.

In addition, the invention is eminently suited for making printing heads and like assemblies which require very closely and critically spaced elements. In the type of head disclosed, for example, pin electrodes 12 are spaced 0.002 inch (2 mils) from their respective auxiliary electrodes 22, the spacing between the pin electrodes themselves being 0.014 inch. The whole area of the printing face occupied by the 35 pin electrodes and the five auxiliary electrodes, including the various layers of insulating material therebetween, is thus quite small, dimensionally comparable to the printing face of a standard character printing element in a conventional typewriter.

A plurality of the heads, in individual form or assembled in sticks, may be used in page printing apparatus wherein they are arranged to form a line of printing heads. The information to be recorded is applied in the form of voltage pulses to selected pin electrodes 12 in all the heads, the specific head to print being selected by pulsing auxiliary electrode 22 of the selected head. For further information as to the operation of this type of head, reference may be had to the above-identified Patent No. 2,918,580, as well as to patent applications 729,847 of Robert E. Benn and Richard S. Sakurai, filed April 21, 1958, now Patent No. 3,195,142, and patent application of Robert E. Benn, Richard S. Howell and Richard S. Sakurai, filed May 9, 1958, Serial No. 734,253, now Patent No. 3,068,479, all of which are assigned to the same assignee as the present case.

The embodiments of the invention shown in the drawings and described herein are obviously susceptible to considerable modification in form and detail within the spirit of the invention. It is also to be appreciated that certain of the disclosed features could be used in other applications than that disclosed and without other features than that disclosed. The embodiments, therefore, are to be regarded as illustrative only and not as limiting the scope of the invention as defined in the following claims.

We claim:

1. An electrode assembly comprising an insulating layer formed on one surface thereof with a plurality of mutually-spaced electrodes, an electrical lead for each of the electrodes but terminating short of its respective electrodes so as to be physically disconnected therefrom, and a resistor for each electrode and connecting same with its respective electrical lead; said insulating layer carrying on its opposite surface an auxiliary electrode in registration with said mutually-spaced electrodes but separated therefrom by the thickness of said insulating layer; all the electrodes terminating in a common plane on one surface of the assembly to form a plurality of pin electrodes with an auxiliary electrode spaced therefrom.

2. An electrode assembly comprising a lamination of a plurality of insulating layers; each of said layers being formed on one surface thereof with a plurality of mutually-spaced electrodes, an electrical lead for each of the electrodes but terminating short of its respective electrodes so as to be physically disconnected therefrom, and a resistor for each electrode and connecting same with its respective electrical lead; each of said insulating layers carrying on its opposite surface an auxiliary electrode in registration with said mutually-spaced electrodes but separated therefrom by the thickness of said insulating layer, and an insulating film over said auxiliary electrode; said insulating film being relatively thin compared to the thickness of said insulating layer; all the electrodes in the laminated assembly being in alignment throughout the plural layers with the auxiliary electrodes of one layer spaced from said mutually-spaced electrodes of a succeeding layer by said insulating film; all the electrodes terminating in a common plane on one surface of the laminated

assembly to form a matrix of pin electrodes with auxiliary electrodes spaced therebetween.

3. A electrode assembly as defined in claim 2 wherein each of said insulating layers is formed with an individual terminal for each of the mutually-spaced electrodes and for the auxiliary electrode thereof, the terminals of the mutually-spaced electrodes occupying different peripheral positions in each insulating layer, the terminal of the auxiliary electrodes occupying corresponding peripheral positions in each insulating layer so that they are aligned when the layers are laminated; and means providing a common electrical connection to the aligned terminals for the auxiliary electrodes of all the insulating layers.

4. An assembly of printing heads comprising a bonded stack of electrode assemblies each as defined in claim 3, the terminals of corresponding ones of the mutually-spaced electrodes in each electrode assembly being aligned, and means making a common electrical connection to each of said aligned terminals.

5. An electrode assembly comprising a lamination of a plurality of relatively thin insulating layers of substantially like thicknesses each formed with a plurality of closely spaced substantially parallel electrical conductors on one surface thereof, the conductors of all the insulating layers being in alignment within the laminated assembly and terminating along an edge portion thereof, said laminated assembly having said edge portion thereof formed with a flat face so that the conductors terminate at the face as a matrix of exposed coplanar pin electrodes.

6. An electrode assembly comprising a lamination of a plurality of relatively thin insulating layers of substantially like thicknesses; each layer having formed on one surface thereof a plurality of closely spaced substantially mutually-parallel electrical conductors each containing a resistor, the conductors formed on the insulating layers having a common end thereof extending in alignment in the laminated assembly and terminating along a flat faced portion thereof, the terminal ends of said conductors being exposed in said flat face to form a matrix of pin electrodes, and the opposite ends of the conductors formed on each layer extending to different edge portions of the assembly for electrical connection to individual sources of electrical energy.

7. An electrode assembly for an electrostatic printing head comprising an insulating layer having formed on one surface thereof a plurality of closely spaced parallel extending electrodes each having an electrical lead containing a resistor, said insulating layer having formed on its opposite surface an auxiliary electrode registering with said closely spaced electrodes but separated therefrom by the thickness of the layer, all of the electrodes terminating in a common plane along one edge of the layer to form a row of pin electrodes spaced from an auxiliary electrode by the thickness of the insulating layer.

8. An electrostatic printing head comprising a laminated assembly of electrical insulating layers of like thickness, each of said layers having formed on one surface thereof a group of electrodes and an electrical lead for each such electrode containing a resistor therein, each group of said electrodes terminating along a corresponding edge portion of its respective layer and being exposed thereat, each of said insulating layers having formed on its opposite surface an auxiliary electrode which is in registration with said group of electrodes but separated therefrom by the thickness of the layer, and an insulating film over each said auxiliary electrode, said insulating film being relatively thin compared to the thickness of said insulating layers, all the corresponding electrodes being in registration throughout the laminated assembly and all the terminal ends of the electrodes lying in a common plane on one face of the laminated assembly to form a matrix of rows of electrode groups having the auxiliary electrodes interleaved therebetween.

9. An electrostatic printing head assembly comprising, in combination, a laminated assembly of electrical

insulating layers of substantially the same thickness, a plurality of closely spaced parallel extending first conductors carried on one surface of each insulating layer and terminating proximate to an edge portion thereof, a second conductor carried on the opposite surface of each insulating layer and extending along said edge portion in registration with the terminal ends of said first conductors and being substantially coextensive with the span of space occupied by the first conductors, a thin insulating medium of substantially less thickness than the thickness of each insulating layer extending over said second conductor, said layers being assembled in side-by-side compact homologous relation to one another with said edge portions in alignment, said edge portions of said insulating layers being trimmed to form a flat face in which the terminal portions of said first conductors form a matrix array of pin electrodes exposed on the face and in which the second conductors form auxiliary electrodes interposed between the rows of pin electrodes of the matrix, the difference in the thickness between the insulating layers and mediums acting to space the auxiliary electrodes on each layer substantially nearer to the row of pin electrodes carried by the next adjacent layer than to the row of pin electrodes carried by the same layer.

10. An electrostatic printing head assembly comprising, in combination, a plurality of substrates composed of electrical insulating material and having the same thickness, each said substrate having one or more first electrical conductors on one surface thereof terminating at a corresponding edge portion of each substrate, and each said substrate having a second conductor on the opposite surface of the said substrate and terminating at said edge portion thereof, said substrates being compactly assembled in homologous relation to one another with said edge portions thereof in alignment, and an electrical insulating medium of substantially less thickness than the thickness of the substrates interposed between the confronting faces of said edge portions of the substrates thereby to dispose the terminal portions of the first conductors on each substrate in substantially closer but insulated proximity to the terminal portion of the second conductor on the next adjacent substrate than to the second conductor on the substrate with which it is associated.

11. An electrostatic printing head assembly comprising, in combination, a plurality of substrates composed of electrical insulating material and of like thickness, each said substrate having a set of closely spaced parallel extending first electrical conductors on one surface thereof terminating at an edge portion of the substrate, and each said substrate having a second electrical conductor on the opposite surface thereof adjacent to the said edge portion thereof in substantially coextensive relation to the span of the space occupied by the terminal portions of the set of first conductors, an electrical insulating film of substantially less thickness than the thickness of the substrates being interposed between the confronting faces of said edge portions of the substrates, said substrates being compactly assembled in side-by-side homologous relation to one another with their respective edge portions in alignment and with the insulating mediums interleaved between said edge portions, whereby the relative difference in the thickness of the substrates and the films serves to dispose the second conductor of each substrate substantially closer to the set of first conductors of the next adjacent substrate than the first and second conductors of the same substrate are to one another.

12. A printing head for marking record material including a substrate member of high electrical resistivity material having at least one plane surface, a plurality of electrically resistive elements adhered to said plane surface, each said resistive element being elongated in one dimension to assume the form of a strip and all such strips being arranged in close parallel but insulated proximity to one another on the plane surface, and a plurality of electrical conductors carried by the substrate member and

each individually associated with and connected to one of said resistive elements.

13. A printing head for printing a character at a time on record material comprising a substrate member of high electrical resistivity material having at least one plane surface, a plurality of electrically resistive strip-like elements positioned upon said plane surface and being constituted by deposits of electrical resistive material adhering to said plane surface, said resistive elements being substantially coextensive in length and arranged in close parallel but insulated proximity to one another, and a plurality of electrical conductors carried by the substrate member, said resistive elements each being connected to an individual one of the conductors to receive current flow therefrom.

14. A printing head for printing a character at a time on record material comprising a stacked array of a plurality of relatively thin substrates of high electrical resistivity material, each of which substrates has two plane surfaces and at least one edge surface extending between the said plane surfaces, a plurality of electrical conductors formed on one of said plane surfaces of each substrate and terminating in close but insulated proximity to one another along said one edge surface of the substrate, and an electrical conductor formed on the other plane surface of each substrate and terminating at said one edge surface of the substrate in registration with all of the terminal ends of the plurality of conductors on the other plane surface, said substrates being stacked in such a manner that the terminal ends of the conductors along said edge surfaces of the substrates form a matrix array whereby upon energizing selected ones of the plurality of conductors a character to be printed thereby may be outlined as a series of dots.

15. A printing head for printing a character at a time on record material comprising a stacked array of a plurality of substrates of high electrical resistivity material, each of which substrates has two plane surfaces and at least one edge surface extending between the said plane surfaces, a set of electrical conductors adhering to one of said plane surfaces of each substrate and extending to said one edge surface of the substrate in close but insulated proximity to one another, a single electrical conductor adhering to the other plane surface of each substrate and extending to said one edge surface of the substrate in registration with all of the terminal ends of the set of conductors on the other plane surface, and a dielectric film interposed between adjacent ones of said substrates and electrically insulating the conductors on the confronting surfaces of the substrates from one another, each single conductor being operatively associated with an adjacent set of conductors and serving as a common return path for the particular ones of the set which are selected for energization during a printing operation, said substrates being stacked in homologous relation to one another such that the conductors exposed along said edge surfaces of the substrates form a matrix array whereby upon energizing selected ones of the set of conductors a character to be printed thereby may be outlined as a series of dots.

16. An electrode assembly comprising a stacked array of a plurality of relatively thin substrates of high electrical resistivity material, each of which substrates has two plane surfaces and at least one edge surface extending between the said plane surfaces, a set of electrical conductors adhering to one of said plane surfaces of each substrate and extending to said one edge surface of the substrate, said set of electrical conductors extending in close but insulated proximity to one another as they approach said one edge surface of its respective substrate, a single electrical conductor adhering to the other plane surface of each said substrate and extending to said one edge surface of the substrate and shaped therealong so as to register with the set of conductors on the other plane surface, and dielectric means interposed between adjacent ones of said substrates and electrically insulating the con-

ductors on the confronting surfaces of the substrates from one another, said substrates being stacked in homologous relation to one another such that the conductors exposed along said edge surfaces of the substrates form a matrix array.

17. An electrode assembly comprising a relatively thin substrate of high electrical resistivity material having two plane surfaces and at least one edge surface extending between the said plane surfaces, a series of electrical conductors adhering to one of said plane surfaces of the substrate and extending to said one edge surface of the substrate in close but insulated proximity to one another, and a single electrical conductor adhering to the other plane surface of the substrate and extending to said one edge surface thereof, said single electrical conductor being shaped along said edge surface so as to register with the series of electrical conductors on the other plane surface of the substrate.

18. An electrode assembly comprising a stacked array of a plurality of relatively thin substrates of high electrical resistivity material, each substrate having two plane surfaces and several edge surfaces extending between the said plane surfaces, a set of electrical conductors adhering to one of said plane surfaces of each substrate, each set of electrical conductors extending to one of said edge surfaces of its respective substrate and terminating thereat in close but insulated proximity to one another, a single electrical conductor adhering to the other plane surface of each substrate, the single conductor of each substrate extending to said one edge surface thereof and shaped therealong so as to register with the terminal ends of the set of conductors on the other plane surface, and a dielectric film interposed between adjacent ones of said substrates and electrically insulating the conductors on the confronting surfaces of the substrates from one another, said substrates being stacked in homologous relation to one another such that the conductors exposed along said edge surfaces of the substrates form a matrix array.

19. A printed circuit assembly comprising a stacked array of a plurality of relatively thin substrates of similar configuration and composed of high electrical resistivity material, each substrate having two plane surfaces and several edge portions extending between the said plane surfaces, a set of electrical conductors adhering to one of said plane surfaces of each substrate, one end of the conductors of each set of conductors extending to a corresponding one of said edge portions of the substrates and terminating thereat in close but insulated proximity to one another, the opposite end of the conductors of each set of conductors extending to a different edge portion of the substrates and terminating thereat, a single electrical conductor adhering to the other plane surface of each substrate, the single conductor of each substrate extending to said corresponding one of said edge portions thereof and shaped therealong so as to register with the first mentioned ends of the set of conductors adhering to the other plane surface of its respective substrate, and dielectric means interposed between adjacent ones of said substrates and electrically insulating the conductors on the confronting surfaces of the substrates from one another, said substrates being stacked in homologous relation to one another so that their corresponding edge portions are in registration with one another and the ends of the conductors are in relatively exposed conditions along several of the edge portions.

20. A printed circuit assembly comprising a stacked array of a plurality of relatively thin substrates of similar configuration and composed of high electrical resistivity material, said substrates each having two plane surfaces and several edge portions extending between the said plane surfaces and being stacked in homologous rela-

tion to one another so that their corresponding edge portions are in registration, a set of electrical conductors adhering to one of said plane surfaces of each substrate, the sets of conductors carried by said substrates having one end of the conductors extending to a registered edge portion of the substrates and terminating thereat in close but insulated proximity to one another and having the opposite ends of the conductors of each set of conductors extending to a different non-registering edge portion of the substrates and terminating thereat in non-registering relation with one another, a single electrical conductor adhering to the other plane surface of each substrate, the single conductors having one end thereof terminating in registration with one another and with the first mentioned ends of the sets of conductors and having their opposite ends terminating at another registering edge portion of the substrates, dielectric means interposed between adjacent ones of said substrates and electrically insulating the conductors on the confronting surfaces of the substrates one from another, separate circuit leads extending to the non-registering ends of the sets of conductors and electrically connected thereto, and a single common lead extending to the registering edge portion of the substrates at which said opposite ends of the single conductors terminate and electrically connected thereto.

21. An electrode assembly comprising a lamination of a plurality of electrically insulating layers each having formed thereon a plurality of electrical conductors on one surface thereof, the conductors of all of the insulating layers having common end sections thereof extending in alignment and terminating in closely spaced but insulated relation at a common edge portion of the laminated assembly, said common edge portion of the assembly forming a flat face and said common end sections of the conductors terminating in said flat face as an exposed matrix of coplanar pin electrodes, and the opposite end sections of the electrodes of each insulating layer extending to and terminating at a different edge portion of the laminated assembly.

22. An electrode assembly comprising a lamination of a plurality of electrical insulating layers; each layer being formed on a homologous surface thereof with a set of electrical conductors each having a resistor therein; one edge portion of said laminated assembly being formed with a flat face extending substantially perpendicularly to the planes of the layers, a common end of the conductors on each layer extending to said flat face and being exposed thereat to form in conjunction with the common ends of the conductors of the other layers a matrix of coplanar pin electrodes, the opposite ends of the conductors on each layer extending to an edge portion of the laminated assembly different from the edge portions to which the like opposite ends of the conductors on each of the remaining layers extend, and a separate electrical lead connected to each of said opposite ends of the conductors for energizing the same from an external source of electrical energy.

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