Feb. 22, 1966 R. S. HOWELL ETAL 3,235,942

ELECTRODE ASSEMBLIES AND METHODS OF MAKING SAME

Filed Dec. 2, 1959 2 Sheets-Sheet 1

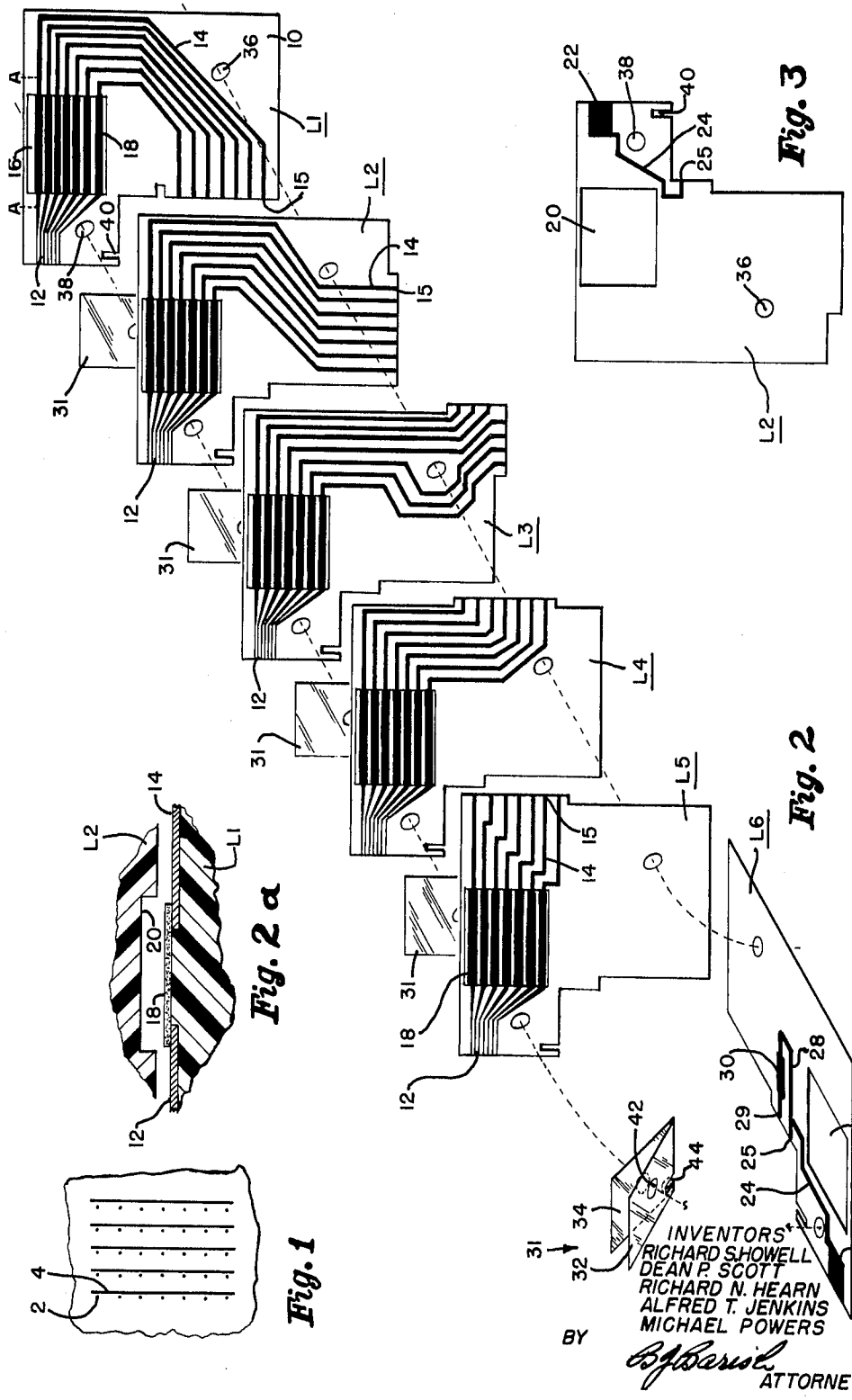


Fig. 1

Fig. 2a

Fig. 2

Fig. 3

INVENTORS
RICHARD S. HOWELL
DEAN P. SCOTT
RICHARD N. HEARN
ALFRED T. JENKINS
MICHAEL POWERS

BY

ATTORNEY

Feb. 22, 1966 R. S. HOWELL ETAL 3,235,942

ELECTRODE ASSEMBLIES AND METHODS OF MAKING SAME

Filed Dec. 2, 1959 2 Sheets-Sheet 2

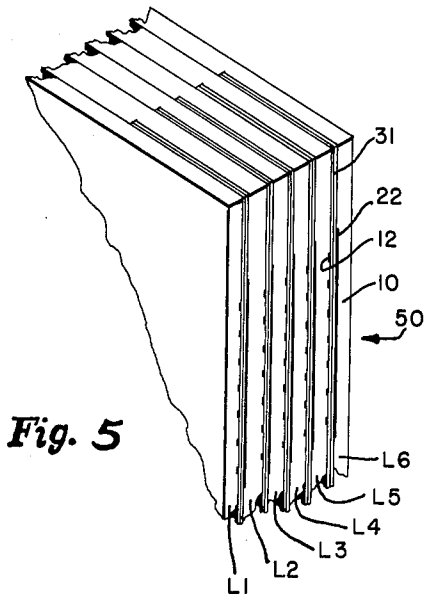


Fig. 5

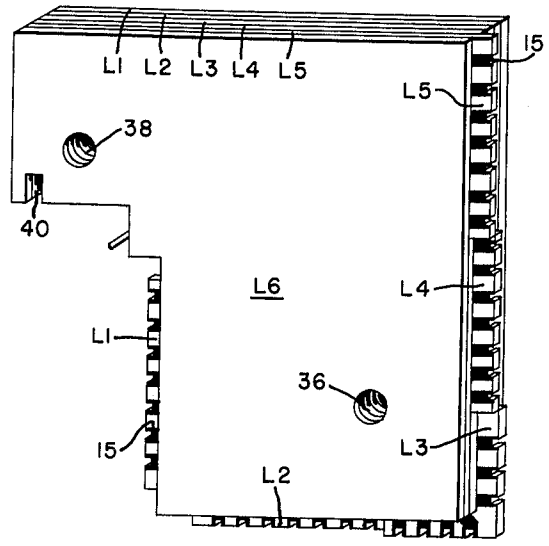


Fig. 4

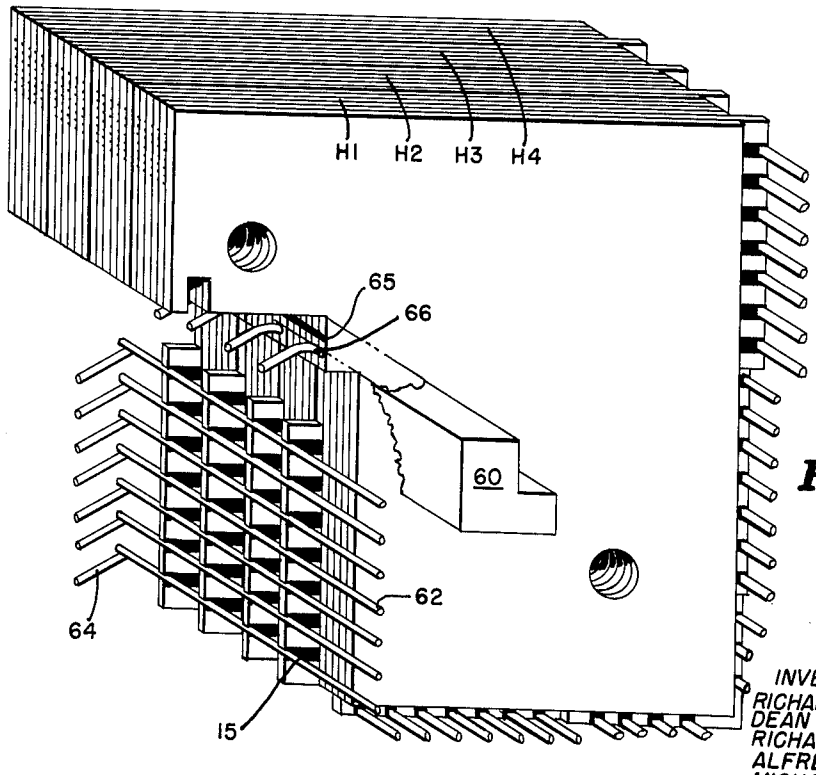


Fig. 6

INVENTORS
RICHARD S. HOWELL
DEAN P. SCOTT
RICHARD N. HEARN
ALFRED T. JENKINS
MICHAEL POWERS

BY

ATTORNEY

United States Patent Office 3,235,942
Patented Feb. 22, 1966

3,235,942
ELECTRODE ASSEMBLIES AND METHODS OF MAKING SAME

Richard S. Howell, King of Prussia, Pa., and Dean P. Scott, Detroit, Richard N. Hearn and Alfred T. Jenkins, Mount Clemens, and Michael Powers, Oak Park, Mich., assignors to Burroughs Corporation, Detroit, Mich., a corporation of Michigan

Filed Dec. 2, 1959, Ser. No. 856,868
3 Claims. (Cl. 29—155.5)

The present invention relates to the art of electrode assemblies and methods of making same, 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, and their methods of making, 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, there being seven electrodes in each vertical row (or column) and five electrodes in each horizontal row. Cooperating 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 application Serial No. 734,196, now Patent No. 2,918,580.

An object of the present invention is to provide improved methods of making assemblies requiring critical spatial relationships, such as electrode recording heads and like devices.

A further object of the present invention is to provide an improved method of making a recording head structure, and to provide an improved head produced by the method, 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 improved methods of making assemblies or stacks of recording heads of the foregoing types, and to provide the improved assemblies produced thereby.

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 application Ser. No. 734,196, now 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 application Serial No. 734,196;

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.

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 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 techniques, such as through a stencil.

FIG. 2*a* 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. 2*a* also illustrates the opposite surface of the succeeding lamina (**L2** in this case) at this area. As shown in FIG. 2*a*, 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 third conductor serving as 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 span of 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 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. Serial No. 734,196, now 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 one 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 edges 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 in size 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 application Serial No. 734,196, now 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 Serial No. 734,253 of Robert E. Benn, Richard S. Howell and Richard S. Sakurai, filed May 9, 1958, 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. The method of making an electrostatic printing head which comprises: applying one or more first electrical conductors to a one surface of each of a plurality of substrates of electrical insulating material and of like thicknesses and terminating the conductors at a corresponding edge portion of each substrate; applying a second electrical conductor to the opposite surface of each said substrate and terminating the same at said edge portion thereof, arranging the substrates in homologous relation to one another and with said edge portions in mutual alignment to form a printing face having the terminal portions of the conductors exposed thereat; interposing electrical insulating mediums of substantially less thickness than the thickness of the substrates between the confronting faces of said edge portions of the substrates; and bonding the substrates together into a compact assembly with the insulating mediums interleaved between the confronting faces of said edge portions, thereby to dispose the exposed terminal portions of the one or more 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 the first conductors on each substrate are to the second conductor on the same substrate.

2. The method of making an electrostatic printing head which comprises: applying a corresponding set of closely spaced parallelly extending first electrical conductors to one surface of each of a plurality of substrates of electrical insulating material and of like thickness and extending one end of the conductors proximate to an edge portion of the substrate to which it is applied; applying a second electrical conductor to the opposite surface of each said substrate adjacent to each said edge portion thereof in substantially coextensive relation to the span of the space occupied by the terminal portions of said first conductors; arranging said plurality of substrates in homologous relation to one another with their respective said edge portions in alignment; interposing thin electrically insulating mediums of substantially less thickness than the thickness of the substrates between the confronting faces of said edge portions of the substrates; bonding the substrates together in side-by-side parallel relationship to form a compact assembly with the insulating mediums interleaved between the said edge portions thereof, and trimming said mutually-aligned edge portions of the bonded substrate assembly in a direction perpendicular to the planes of the assembled substrates to form a flat face in which cross sectional portions of said first and said second conductors are exposed as a matrix array of printing electrodes, the relative difference in the thickness of the substrates and the insulating mediums acting to dispose the second conductors of each substrate substantially closer to the first conductors of the next adjacent substrate than the first and second conductors of the same substrate are to one another.

3. The method of making an electrostatic printing head as defined in claim **2**, wherein each set of first electrical conductors have the opposite ends thereof from said matrix array terminating at an edge portion of its respective substrate different from the corresponding terminal ends of the conductors of the remaining substrates whereby convenient connection may be made by external wiring to these terminal ends in the head assembly, and applying the second conductor to each insulating substrate such that the end thereof opposite to said matrix array terminates at a corresponding edge portion of all of the substrates for connection to a common external electrical conductor aligned with and connected to the exposed ends of the second conductors.

References Cited by the Examiner

UNITED STATES PATENTS

2,502,291	3/1950	Taylor	29—155.5
2,634,310	4/1953	Eisler	29—155.5
2,666,254	1/1954	Eisler	29—155.5
2,756,280	7/1956	Rettinger	29—155.5
2,774,014	12/1956	Henry	29—155.5
2,877,388	3/1959	Reid et al.	29—155.5
2,902,628	9/1959	Leno	29—155.5
2,916,620	12/1959	Kritchever	250—49.5
2,918,580	12/1959	Howell	250—49.5
2,958,120	11/1960	Taylor	29—155.5
2,965,952	12/1960	Gillett et al.	29—155.5
2,981,868	4/1961	Severson	29—155.5
3,029,495	4/1962	Doctor	29—155.5
3,090,706	5/1963	Cado	29—155.5
3,109,226	11/1963	Harmon et al.	29—155.5

WHITMORE A. WILTZ, *Primary Examiner.*

ARTHUR GAUSS, JOHN F. CAMPBELL, *Examiners.*