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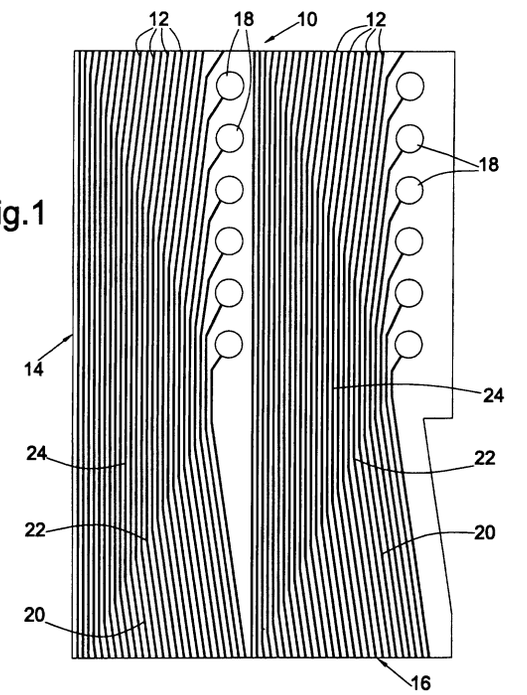
Remarks:
A request for correction of the description has been filed pursuant to Rule 88 EPC. A decision on the request will be taken during the proceedings before the Examining Division (Guidelines for Examination in the EPO, A-V, 3.).

## (54) High density electrical interconnect for a continuous ink jet printhead

(57) Recognizing the need for longer ink jet arrays with higher print densities and the concurrent need for minimal overall size of the printhead, the present invention proposes a system and method for establishing a high-density electrical interconnection between high-voltage driver chips and charging electrodes controlled by the driver chips. A charge plate has a charging electrode density on its face, and an associated mating circuit. Alignment features are then provided on the charge plate and/or the mating circuit. The alignment features of the charge plate and the mating circuit are mechanically engaged to ensure alignment of mating contact pads. And an interconnect is provided for the aligned mating contact pads.

Fig.1

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## Description

### Technical Field

**[0001]** The present invention relates to continuous ink-jet printers and, more particularly, to a compact, high density electrical interconnect system for a continuous ink jet printhead.

### Background Art

**[0002]** In continuous ink jet printing, electrically conductive ink is transferred under pressure to a manifold. The orifices are arranged along this manifold in a linear array(s). The electrically conductive ink discharges from orifices in filaments. These filaments become streams of ink droplets. At the point the droplet stream breaks free from the filament, selected droplets are charged. In order for the droplets of ink to be properly charged, the break off of the drop must be in front of the charging electrode. These charged droplets are deflected away from their normal trajectory. They are caught or attracted to a conductive surface and recirculated. The uncharged droplets proceed in a path to the print medium.

**[0003]** The current method of drop charging and deflection in state-of-the-art printheads relies on what is known as planar charging technology. This method involves a series of electrically grounded ink-jets forming droplets at a controlled distance from the orifice plate. A parallel array of charging electrodes is aligned to the ink jets. Each of these charging electrodes must be individually connected to a separate output lead from the high voltage charge driver chips, which control the charging electrodes. Different methods for providing a compact electrical interconnect between high voltage driver chips and the associated charging electrodes have been employed in certain state-of-the-art printheads, such as those manufactured by Scitex Digital Printing, Inc., in Dayton, Ohio. In each case the density at which the interconnection can be made determines the physical size of the printhead. As the width and print density (dpi) of the printheads increase, the number of interconnects also increases proportionally. Since there is always a need for printheads with a small "footprint" (i.e., small outer dimensions), the interconnect density has been kept as small as possible.

**[0004]** In several prior art printers, charging electrodes which had a pitch of 240 electrodes per inch were fanned out to 100 leads per inch for connection with a flex circuit. In the flex circuit, the lead spacings were further increased to allow connections to be made to commercially available connectors. Even at the fanned out spacing of 100 connections per inch at the flex cable, it has been difficult to make the interconnects reliably. Further reductions in the interconnect density will be difficult to achieve as the technologies required, such as soldering, anisotropic adhesives, flex circuits, and printed circuit board fabrication, have already been pushed to their limits.

**[0005]** For a charge plate such as is shown in U.S. Patent No. 4,560,991, the charge plate width would need to be 2.4 times wider than the ink jet array width to provide the necessary interconnects. For a long array printhead this excess width is not feasible. U.S. Patent No. 5,475,409 illustrates a more compact interconnect. Connections are made between the charge plate and several flex cables. The contacts for each flex cable are in a linear array, with the array oriented perpendicular to the jet array. This configuration adds to the required depth of the charge plate but greatly reduces the width requirement. However, it is still necessary for the leads to be shifted over to provide the room for each linear array of contacts. For this prior art, the required shift is about 0.125 inches for every 64 connection linear array. Therefore, for an approximately 4" array at 240 jets per inch, the configuration required a charge plate width of about 5.5". This is a charge plate width over 35% wider than the jet array. For longer arrays, this configuration becomes unacceptable. For printheads with more jets per inch, the problem becomes worse.

**[0006]** In another prior art configuration, the leads from the charging electrodes were fanned out to wire bond connections directly to the charge driver dies. This allowed for a reduced printhead size by eliminating much of the need to fan out the interconnects. This technique, however, has proven to be costly. With the charge driver electronics attached directly onto the charge plate, both the charge plate and the driver electronics must be scrapped if one of the component fails. With longer arrays having a large number of charge driver electronics, the scrap costs can be excessive.

**[0007]** With the need for longer ink jet arrays with higher print densities and the concurrent need for minimal overall size of the printhead, it is seen that there is a need for an improved charge plate configuration. A preferred charge plate design would allow interconnects to be made reliably, and preferably using a system which allows the components to be salvaged, in the event of a failure.

### Summary of the Invention

**[0008]** The problems associated with prior art interconnect systems are overcome by the design according to the present invention, wherein a lead fan out configuration is proposed, having regions with a higher trace density than the charging electrode density on the charge plate face and terminating in a two dimensional array of contact pads per connector at spacings which are common in the electronics industry. By having a more common electrical interconnect pitch and alignment features in the charge plate and mating flex cable, the two components are self aligning. A clamping means which attaches to the charge plate maintains the alignment of the components and provides the pressure needed to insure electrical contact.

**[0009]** In accordance with one aspect of the present invention, a system and method for establishing a high-density electrical interconnection between high-voltage driver chips and charging electrodes controlled by the driver chips. A charge plate having charging electrodes on its face, connected to an array of contact pads. Alignment features are then provided on the charge plate and/or the mating circuit. The alignment features of the charge plate and the mating circuit are mechanically engaged to ensure alignment of mating contact pads. And an interconnect is provided for the aligned mating contact pads.

**[0010]** The present invention establishes a high-density electrical interconnection between the high-voltage driver chips and the charging electrodes controlled by the driver chips, for a continuous ink jet printhead.

**[0011]** Other objects and advantages of the invention will be apparent from the following description and the appended claims.

Brief Description of the Drawings

**[0012]**

Fig. 1 illustrates a magnified view of a portion of a charge plate fan out pattern, in accordance with the present invention; and

Fig. 2 illustrates an alignment configuration for the interconnect system of Fig. 1, in accordance with the present invention.

Detailed Description of the Invention

**[0013]** As discussed above, charge plates made per the processes defined in patents 4,560,991 or 5,512,117 require the lead structure to be formed by an electroforming process. This electroforming process produces an excessive number of failures when the line widths or the spaces are less than about 2 mils each. The failures are either opens in a conductive lead or lead to lead shorts.

**[0014]** Advances in charge plate circuitry fabrication, such as is disclosed and claimed in co-pending, commonly assigned patent application Serial No. _____ (Attorney Docket No. SDP207PA), totally incorporated herein by reference, facilitate the use of finer lines and spaces than before. The recent advances allow line widths and spaces to be reduced to about 1 mil. Even with an increase in jet array density to 300 jets per inch (a pitch of 3.3 mil), this new process allows the lead density to be higher than the charging electrode density. By going to a higher density of leads, it is possible to free up space for a row of connection pads without requiring extra width.

**[0015]** Referring now to the drawings, Fig. 1 illustrates a magnified view of a portion of the charge plate fan out pattern 10, particularly showing how leads 12 are fanned out to two rows 14 and 16 of contacts with associated connector pads 18. Diagonal traces 20 shown at the bottom of Fig. 1 are at the density of the charging electrodes. Bend 22 in the pattern 10, forming vertical section 24, reduces the line width and spacings. This reduction in the width of a group of leads provides enough space for the contact pads 18 and a clearance area around each pad. As such, in accordance with the configuration of the present invention, the width required for the fan out of a group of leads going to a single row of contacts is equal to the width of the leads at the charging electrode face.

**[0016]** As there is no extra width required for a line of contacts pads when configured according to the present invention, a large number of rows of contacts can therefore be used. Furthermore, since the space required to fan the leads out to the rows of contacts is so compact, the subject invention allows the spacing of contacts to be increased without requiring excessive depth (front to back distance) of the charge plate.

**[0017]** At a spacing of contacts of 25 mil, which is common in the electronics industry, it is now no longer necessary to optically align the contact pads of the charge plate and the mating flex cable. Rather, alignment features of the present invention can be fabricated into each component to insure alignment.

**[0018]** One preferred embodiment utilizes small alignment holes in the charge plate and the flex cable. A clamping bar (not shown) contains two alignment pins. These pins engage alignment holes of both the charge plate and the flex cable to maintain the registration of the two components. One set of alignment features can be used to align a multitude of the rows of contacts. A preferred embodiment, by way of example only, uses one set of alignment features to register 20 rows of contacts, each row having 27 contacts.

**[0019]** Referring now to Fig. 2, alignment holes 32 for the charge plate are machined into ceramic charge plate base 28, prior to laminating the electroformed charge plate coupon to the base. In addition to these alignment holes 32 in the charge plate, there are through holes 30 machined into the ceramic for receiving clamping screws. There are additional alignment features 26 in the coupon and the base to ensure the proper alignment of the charge plate lead pattern with the machined alignment holes 30 in the charge plate base. As in the flex circuit, the charge electrode leads are defined via photolithography, therefore insuring accurate location of the leads in relation to the alignment holes of the electroformed coupon.

**[0020]** With the contact pads of the charge plate and the mating circuit aligned by means of alignment features on both parts, electrical connections can be made using a variety of processes. These include processes such as soldering or using conductive epoxy, where a solder paste or epoxy is applied to the charge plate using a stencil or screen printing process. Anisotropic conductive film adhesives can also be employed. Of course, each of the preceding processes are somewhat perma-

nent in nature, not allowing the charge plate and the flex cable to be separated without causing damage to one or both components.

**[0021]** In addition to these processes, there are various processes which utilize pressure to hold the components together to make the electrical contacts. These processes are more desirable in the art, as such processes do not damage either the charge plate or the mating circuit, allowing the system to be more effectively refurbished and reused. These pressure related processes include the use of raised contacts and/or anisotropic conductive elastomers.

**[0022]** By raising the contact pads for the interconnect above the plane of the substrate, clamping forces can be concentrated at the contacts, helping to ensure electrical contact. The raised contacts for the interconnect pad region can either be located on the flex cable or the charge plate. A process for forming bumps on the charge plate interconnect pads is described in commonly assigned, co-pending patent application Serial No. _____ (Attorney Docket No. SDP206PA), totally incorporated herein by reference. Raised contacts on the flex cable and methods for making the same are well known in the art. Some of these processes, however, require large clamping forces, as many as 100 gram-force per contact, which is undesirable, as being capable of causing mechanical stress and deformation of the catcher component. Other configurations of raised bumps require much lower contact forces, in the range of 25-40 gram-force per contact. These produce minimal deformation of the catcher component. Therefore, care must be taken in the choice and design of pressure-based interconnects to keep the contact forces to a minimum, as excessive contact forces can cause the catcher and charge plate to deform.

**[0023]** To provide and distribute the necessary pressure to raised contact pads, a metal plate is compressed against a formed elastomeric pad which is in contact with the flex circuit containing the raised interconnect pads. The elastomeric pad contains discrete protrusions which concentrates the pressure at the interconnect pad locations on the flex circuit. This plate and elastomeric pad can be combined into what is known as an elastomeric clamping mechanism. The clamping mechanism is compressed against the flex circuit by means of screws. On the charge plate connection, these screws pass through the through holes 30 in the charge plate and are screwed into the catcher underneath the charge plate. In this connection, the catcher is acting as a mechanical stiffener to ensure the contact area remains planar and that all the contacts receive an equivalent amount of pressure. The charge driver board connection involves the screws passing through clearance holes in the printed circuit board and screwing into an external plate known as a stiffener on the opposite side.

**[0024]** Alternatively, the pressure connection may utilize anisotropic conductive elastomers to provide the electrical connection. The elastomer is placed between the charge plate and the mating circuit (flex circuit). Conductive fillers in the material provide electrical contact between the charge plate and the mating circuit while maintaining isolation between adjacent electrodes of the charge plate. As the anisotropic conductive elastomers are compliant, the clamping mechanism does not require an elastomeric pad to distribute the clamping force.

**[0025]** While the description herein has described a single set of connections having a compression pad, it will be understood that a multitude of connectors can be used, each with a two dimensional array of contacts, alignment means to register the contacts and means to maintain electrical connection, all without departing from the invention. A preferred embodiment of the present invention, however, uses five connectors, each with 540 electrical contacts.

**[0026]** The invention has been described in detail with particular reference to certain preferred embodiments thereof, but it will be understood that modifications and variations can be effected within the spirit and scope of the invention.

## Claims

1. A method for establishing a high-density electrical interconnection between high-voltage driver chips and charging electrodes controlled by the driver chips, for a continuous ink jet printhead, comprising the steps of:

   providing a charge plate, the charge plate having charging electrodes terminating at contact pads;
   providing at least one mating circuit for establishing connection to at least one high voltage driver, the mating circuit terminating in contact pads;
   providing alignment features on the charge plate and an associated mating circuit;
   mechanically engaging the alignment features of the charge plate and the associated mating circuit to ensure alignment of mating contact pads;
   providing an interconnect for the aligned mating contact pads.

2. A method as claimed in claim 1 further comprising the step of arranging a lead fan out configuration having regions of trace density higher than the charging electrode density.

3. A method for establishing a high-density electrical interconnection between high-voltage driver chips and charging electrodes controlled by the driver chips, for a continuous ink jet printhead, comprising the steps of:

providing a charge driver circuit board having circuits connected to at least one high voltage driver chip, the circuits terminating in contact pads

providing at least one mating circuit for establishing connection to at least a portion of the charging electrodes, the at least one mating circuit terminating in contact pads;

providing alignment features on the charge driver circuit board and an associated mating circuit;

mechanically engaging the alignment features of the charge plate and the associated mating circuit to ensure alignment of mating contact pads;

providing an interconnect for the aligned mating contact pads.

**4.** A method as claimed in claim 3 wherein the step of providing at least one mating circuit for establishing connection comprises the step of using pressure based connectors.

**5.** A method as claimed in claim 4 wherein the step of using pressure based connectors comprises the step of applying raised bumps on the charge plate or on the associated mating circuit.

**6.** A method as claimed in claim 4 wherein the step of using pressure based connectors comprises the step of sandwiching anisotropically conductive elastomeric material between the charge plate and the associated mating circuit.

**7.** A method as claimed in claim 4 wherein the step of using pressure based connectors comprises the step of using re-useable pressure based connectors.

**8.** A method as claimed in claim 3 wherein the step of providing at least one mating circuit comprises the step of applying raised contacts.

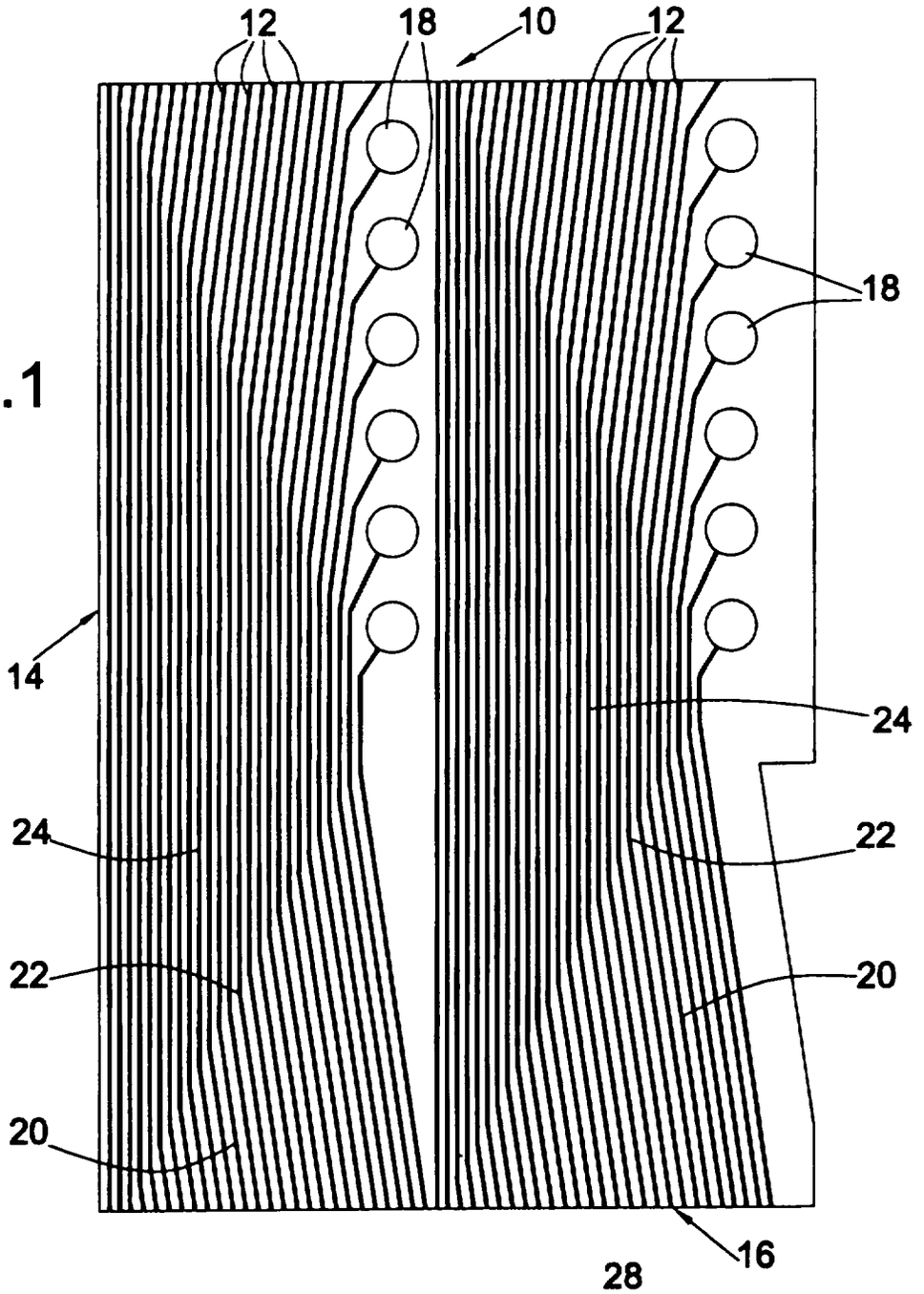
**9.** An improved charge plate for use in an ink jet printer having a high density of charging electrodes along charge face of charge plate the improvement comprising:

means to minimize a footprint required to fan out for connection to high voltage drive electronics; and

means for arranging the lead fan out configuration having regions of trace density higher than the charging electrode density.

**10.** An improved charge plate as claimed in claim 9 wherein the lead fan out configuration terminates in a two-dimensional array of contact pads per connector.

Fig.1



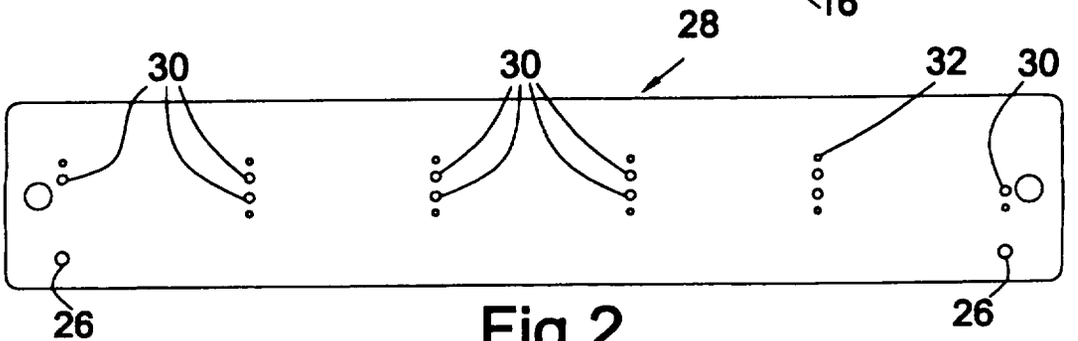




Fig.2