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(71) Applicant: **Scitex Digital Printing, Inc.**
Dayton, Ohio 45420-4099 (US)

(72) Inventors:
- **Morris, Brian G.**
Dayton, Ohio 45419 (US)
- **Sexton, Richard W.**
Huber Heights, Ohio 45424 (US)
- **McWilliams, Kenneth R.**
Miamisburg, Ohio 45342 (US)

(74) Representative: **Freed, Arthur Woolf et al**
Reginald W. Barker & Co.,
Cliffords Inn
Fetter Lane
London EC4A 1BY (GB)

(54) Multi-tabbed orifice plates

(57) An orifice plate for an ink jet printing system has improved fabrication. The orifice plates (10) are formed as part of a larger panel (12). They are mechanically attached to the larger panel and electrically connected to it by means a large number of uniformly space narrow bridge members (18). These bridge members each converge to a narrow point at the edge of the orifice plate to cause the bridge to detach from the edge of the orifice plate when the orifice plate is to be removed from the larger panel at the time of orifice plate bonding.

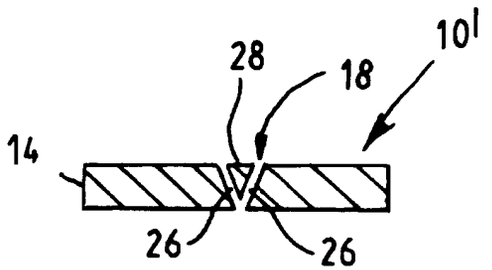

Fig. 3

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Description

Technical Field

[0001] The present invention relates to continuous ink jet printing and, more particularly, to multi-tabbed orifice plates used in ink droplet generation in an ink jet printer.

Background Art

[0002] In the fabrication of orifice plates by an electroforming process such as in patent 4,972,204, orifice plates are formed as part of a larger panel. The perimeter of the orifice plate is defined by the same photolith and electroforming process use to make the orifices. Along the perimeter several contact tabs are formed to attach the orifice plate to the panel once the mandrel is removed. These tabs allow the orifice plate to be safely handled as part of the panel for cleaning, inspection and storage. The tabs are about 30 mil wide and are spaced every 1-2" around the perimeter of the orifice plate.

[0003] When orifice plates are electroformed on a metallized glass substrate such as is described in commonly assigned U.S. patent application Serial No. 08/331,060, these tabs around the perimeter of the orifice plate have an additional function. The tabs serve to provide electrical contact to the metallized area upon which the orifice plate is electroformed. Without such an electrical connection, no plating would occur inside the defined border of the orifice plate.

[0004] While these tabs are useful for handling and electroforming purposes, they are not ideal. The orifice plate must be removed from the larger panel when the orifice plate is bonded to the drop generator. The breaking or cutting of these tabs can produce a distortion in the orifice plate which can lead to bond failures or to jet directionality problems. Reducing the size of the tabs to reduce the distortions caused by cutting can lead to plates prematurely breaking loose from the frame. The tab which has been bent during the cutting or breaking process has, at times, interfered with the orifice plate bonding process, leading to a bond failure. In some cases, it has also bridged the gap to the charge plate and resulted in shorting out charge plate leads.

[0005] On metallized glass mandrels, the resistivity of the metallized layer and the need for the electroforming current to flow through these few tabs produces non-uniform electroforming of the orifice plate. This results in non-uniform hole size down the array of jets.

[0006] What is needed, therefore, is a means to hold the orifice plate as part of the larger panel for handling purposes, while reducing the distortion produced when the plate is removed from the panel. Furthermore, these means when used with metallized glass mandrels should produce more uniform electroforming of the orifice plate.

Summary of the Invention

[0007] In accordance with the present invention, orifice plates are formed as part of a larger panel, for handling purposes, but with uniformly spaced narrow bridge member connection means to reduce distortion produced when the plate is removed from the panel.

[0008] In accordance with one aspect of the present invention, the orifice plate can be securely held as part of the larger panel. Multiple micro-bridge elements or tabs are preferably spaced at even increments, approximately 0.050" apart. These closely spaced fragile bridging members provide the necessary support for the orifice plate to facilitate handling of the orifice plate after it is removed from the mandrel. While these bridge members provide the necessary support for normal handling, they can also be broken or cut with ease at the time of bonding to the drop generator. Furthermore, the closely spaced bridge elements are effective electrical bridges to the orifice plate. Their close spacing, which is about 1/5 the width of an orifice plate, produces the required uniform plating of the orifice plate.

[0009] Other objects and advantages of the invention will be apparent from the following description and the appended claims.

Brief Description of the Drawing

[0010]

Figs. 1 is a prior art views of an orifice plate made as part of a larger panel;
Fig. 2 is a close up view of a single micro-bridging member according to the prior art.
Fig. 3 is a close up view of a single micro-bridging member connecting the orifice plate with the larger panel according to the present invention; and
Fig. 4 is a view of a section of the perimeter around an orifice plate illustrating the spacing of multiple micro-bridge members or tabs.

Detailed Description of the Invention

[0011] In accordance with the present invention, orifice plates are formed as part of a larger panel. They are mechanically attached to the larger panel and electrically connected to it by means a large number of uniformly space narrow bridge members. These bridge members each converge to a narrow point at the edge of the orifice plate to cause the bridge to detach from the edge of the orifice plate when the orifice plate is to be removed from the larger panel at the time of orifice plate bonding.

[0012] Referring now to the drawings, Figs. 1 and 2 show how orifice plates 10 (with six orifice plates on the single panel) have been made as part of a larger panel 12, in accordance with prior art teachings. The perimeter 14 of the orifice plate 10 is defined by the same photolith and electroforming process used to make the orifices.

Along the perimeter, several contact tabs 16 are formed to hold each orifice plate to the panel, once the mandrel is removed. These tabs act as bridging members, connecting the orifice plate to the large panel. The width of each tab is approximately 0.03", while its length, the distance from the orifice plate to the frame is about 0.01". Each of these bridging members is therefore relatively wide, having a width to length ratio greater than one. While these tabs 16 allow the orifice plate to be handled, several associated problems cause distortion in the orifice plate 10, which can lead to bond failures or to jet directionality problems.

[0013] Referring now to Figs. 3 and 4, the problems associated with the prior art method for fabricating and handling orifice plates 10 can be eliminated with the present invention. In accordance with the present invention, a large number of easily snapped micro-bridge members 18 are used between the orifice plate 10' and the larger panel. In particular, Fig. 3 shows an enlarged view of one such micro-bridging member 18, within the perimeter 14 of the orifice plate. The region above the border 14 corresponds to a portion of the larger panel 12, while the region below the border 14 would be a portion of the orifice plate 10. As shown, the micro-bridging member 18 is comprised of two narrow beams 26. These beams should be relatively narrow, that is the width to length ratio should be much less than one. In a preferred embodiment, each of these beams is approximately 0.0015" wide, while the length of each beam is about 0.01". If the beam is too wide, the perforation will be harder to snap, which can cause plate deformation. The region of high stress produced by a bending will extend into the plate an amount which increases with the width of the bridge. Conversely, if the beam is too narrow, the perforation may snap too easily. These beams 26 converge with a 45 degree included angle 28, resulting in a triangular configuration. This shape can be used to contribute to planar stiffness of the panel when removed from the mandrel and during subsequent handling. This is particularly advantageous since the 0.0015" wide lines may be fragile, due to the small size. The triangular shape further contributes to the stiffness just as triangulation contributes to stiffness in trusses.

[0014] By using a large number of these fragile bridge members 18, the orifice plate can be securely held as part of the larger panel. As shown in Fig. 4, the tabs are preferably spaced at even increments, approximately 0.050" apart. These closely spaced fragile bridging members provide the necessary support for the orifice plate to facilitate handling of the orifice plate after it is removed from the mandrel. While these bridge members provide the necessary support for normal handling, they can also be broken or cut with ease at the time of bonding to the drop generator. Due to the fragile nature of the individual bridge members, there is minimal puckering of the thin orifice plate when the bridge elements are cut or broken. With the apex of the triangle at the edge of the orifice plate, thereby giving only one junction at that edge, and the lines being divergent in a direction away from that edge of the orifice plate to the waste side of the border to give two points of junction, cutting or bending stresses are concentrated at the edge of the orifice plate. As a result, the bridge will preferentially break at the edge of the orifice plate. This eliminates problems that could be produced by the presence of the residual bridge member on the orifice plate such as touching or shorting of the charge plate.

[0015] These closely spaced bridge elements are also effective electrical bridges to the orifice plate. Their close spacing, which is about 1/5 the width of an orifice plate, produces the required uniform plating of the orifice plate.

[0016] While the preferred configuration of the micro-bridges comprises two narrow beams which converge and join at a common apex on the orifice plate, other variations are also possible. For example, the converging narrow beams could be spaced apart so that they no longer join at a common apex. Such micro-bridges would still be effective in mechanically and electrically linking the orifice plate to the larger frame. These micro-bridges are not as desirable as the one described earlier, since the failure of these beams to join at a common apex on the orifice plate will no longer concentrate the stresses at the edge of the orifice plate. As a result, the edge of the orifice plate may include some residual bridge members.

[0017] 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 fabricating an orifice plate comprising the steps of:

   mechanically attaching the orifice plate to a larger panel;
   providing a plurality of spaced apart bridge members; and
   electrically connecting the orifice plate to the plurality of spaced apart narrow bridge members.

2. A method as claimed in claim 1 wherein the step of mechanically attaching the orifice plate to a larger panel comprises the step of using bridging members.

3. A method as claimed in claim 2 further comprising the step of converging to an apex each of the plurality of bridge members.

4. A method of fabricating an orifice plate as part of a

larger panel, comprising the steps of:

providing a plurality of micro-bridge members;
spacing the plurality of micro-bridge members with a spacing width to ensure uniform current distribution.

5. A method as claimed in claim 4 wherein the step of providing a plurality of micro-bridge members further comprises the step of providing a plurality of micro-bridge members, each having a width approximately equal to a thickness of the orifice plate.

6. A method as claimed in claim 4 wherein the spacing of the plurality of micro-bridge members is significantly less than a width of the orifice plate.

7. An orifice plate fabricated as part of a larger panel, comprising:

a plurality of micro-bridge members;
means for spacing the plurality of micro-bridge members with a spacing width to ensure uniform current distribution.

8. An orifice plate as claimed in claim 7 wherein each of the plurality of micro-bridge members has a spacing width approximately equal to a thickness of the orifice plate.

9. An orifice plate as claimed in claim 8 wherein the micro-bridge member width is approximately equal to 0.0015 inches.

10. An orifice plate as claimed in claim 7 wherein the spacing of the plurality of micro-bridge members is significantly less than a width of the orifice plate.

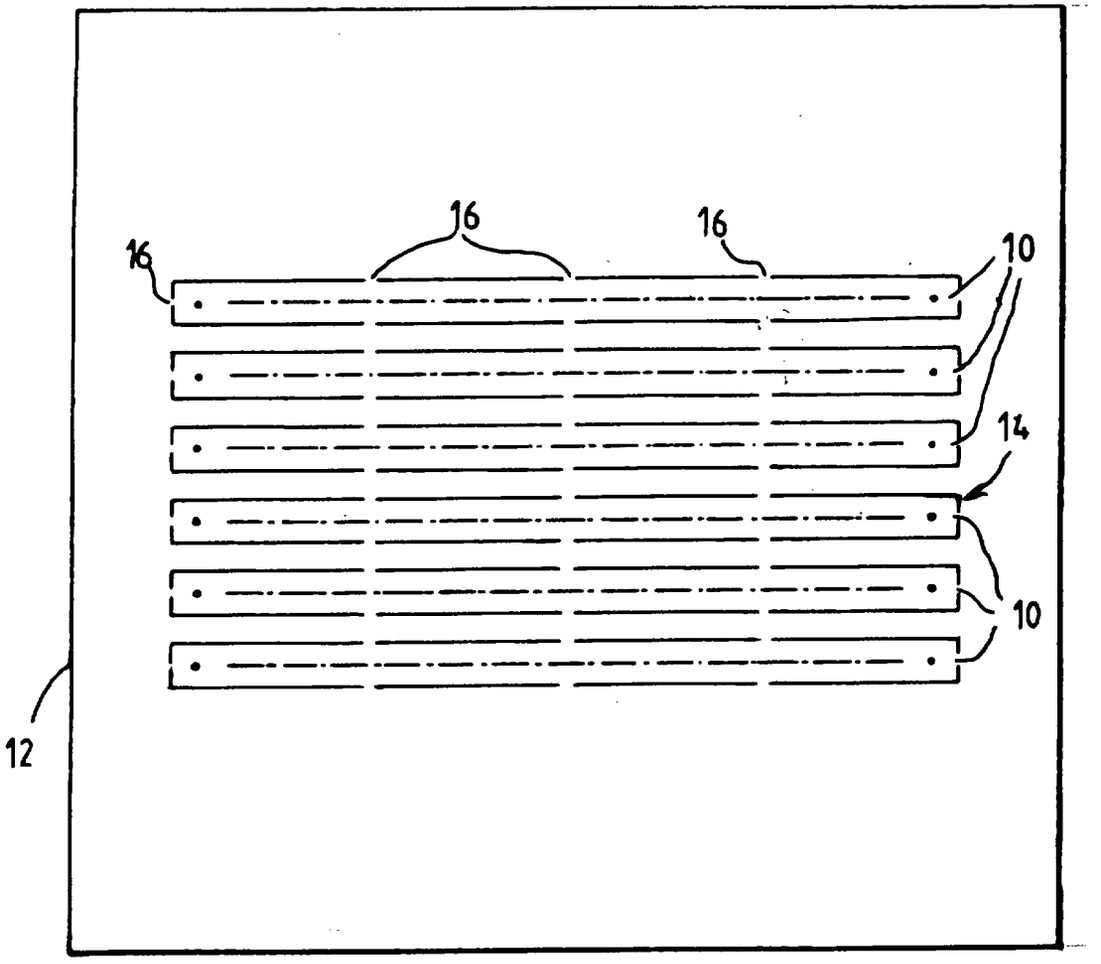

Fig. 1

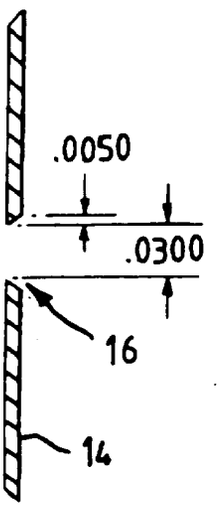

Fig. 2

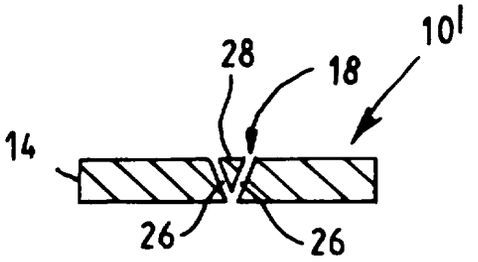

Fig. 3

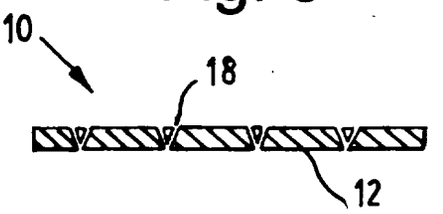

Fig. 4