(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 784 105 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
16.07.1997 Bulletin 1997/29

(51) Int Cl.[6]: **C25D 1/10**, B41J 2/16

(21) Application number: **96309171.5**

(22) Date of filing: **16.12.1996**

(84) Designated Contracting States:
DE FR GB

(30) Priority: **22.12.1995 US 577251**

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(54) Direct plating of an orifice plate onto a holder

(57) An orifice plate is fabricated for use in an ink jet printer. Initially, a mandrel is provided, and a holder is aligned to the mandrel. The mandrel and the holder are maintained in intimate contact and at equal electrical potential. The mandrel and the holder are placed at cathodic polarity. A plating material is then applied to the combined mandrel and holder to cause the mandrel and holder to form a single orifice plate directly bonded to the holder. The mandrel is then removed from the orifice plate.

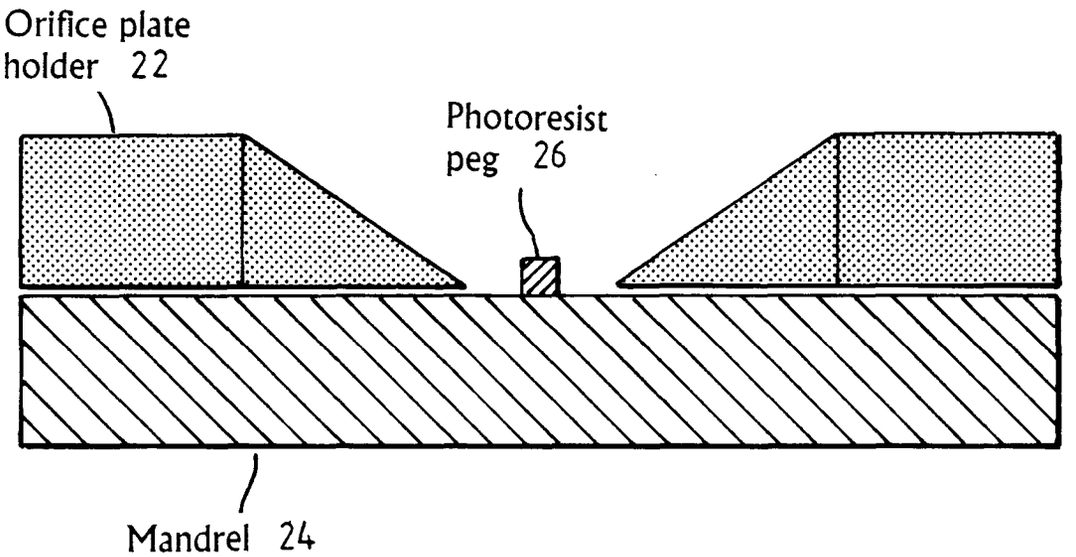

FIG. 2

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Description

Technical Field

The present invention relates to continuous ink jet printers and, more particularly, to improved construction for the orifice plate.

Background Art

Ink jet printing systems are known in which a print head defines one or more rows of orifices which receive an electrically conductive recording fluid, such as for instance a water base ink, from a pressurized fluid supply manifold and eject the fluid in rows of parallel streams. Printers using such print heads accomplish graphic reproduction by selectively charging and deflecting the drops in each of the streams and depositing at least some of the drops on a print receiving medium, while others of the drops strike a drop catcher device.

In one type of ink jet printer, the print head includes a manifold, defining a fluid receiving reservoir, to which is bonded a relatively thin orifice plate, defining the rows of orifices. The orifice plate is made of electroplated nickel or beryllium-copper electroplated with nickel. The orifice plate is somewhat flexible.

Currently in the art, an orifice plate is bonded to a holder, such as a droplet generator body, by first electroplating the orifice plate on a mandrel and then removing the orifice plate from the mandrel. The orifice plate is then typically bonded onto the orifice plate holder by using an epoxy. Of course, it is also possible, by using the right kind of mandrel, to epoxy bond the orifice plate to a holder or droplet generator while the orifice plate is still on the mandrel.

Unfortunately, several problems exist with prior art orifice plate fabrication techniques. One, debris is introduced from the technique of applying the epoxy fillet. Second, the epoxy bond diminishes efficiency of acoustic energy transfer. The epoxy thickness variation and the variation in the distance the epoxy is from the orifices along the array will cause variations in the amount of acoustic energy transferred to the filaments and hence variations in the breakoff length of the filaments along the array. Also, handling of the delicate orifice foil of the current art introduces out-of-flatness in the plane of the orifice plate and a non-straightness of the orifices along the orifice array.

It is seen then that there exists a need for an improved orifice plate fabrication which overcomes the problems associated with the prior art.

Summary of the Invention

This need is met by the direct orifice plate plating method according to the present invention, wherein the orifice plate is bonded directly from the mandrel onto the holder, by means of plating.

In accordance with one aspect of the present invention, a method of bonding an orifice plate onto a holder for an ink jet printer uses direct plating. Initially, the holder is aligned to the mandrel and the two parts are kept in very close proximity, preferably in intimate contact, and at the same electrical potential. The holder and the mandrel are then placed at cathodic polarity. The plating material on the two parts will then grow together, forming a single orifice plate directly bonded to the holder. The mandrel can then be removed by peeling, if the adhesion of the plated material is less on the mandrel than the holder, or by etching the mandrel away.

Accordingly, it is an object of the present invention to provide an orifice plate wherein the plate is bonded directly from the mandrel onto a holder or droplet generator. This provides the advantage of eliminating the use of epoxy on the flexible orifice plate. Acoustic energy will be transferred more uniformly through a stiffer orifice plate holder/epoxy/fluid manifold structure than the orifice plate/epoxy/fluid manifold structure. The epoxy can be eliminated if the orifice plate is directly plated to the fluid manifold. It is a further object of the present invention to provide such an orifice plate wherein the bonding is accomplished by means of plating. This provides the advantage of allowing for the orifice plate to be a mechanically stiffer structure. Being a mechanically stiffer structure will greatly reduce the out-of-flatness in the plane of the array and the nonstraightness of the orifices along the array. Also the mechanically stiffer structure will transfer acoustic energy more uniformly along the array which will improve the uniformity of the breakoff lengths of the filaments along the array.

Other objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

Brief Description of the Drawings

Fig. 1 is a prior art cross sectional view of an orifice plate bonded to a fluid manifold;

Fig. 2 is a cross sectional view of an orifice plate holder in close proximity to a mandrel, in accordance with the present invention;

Fig. 3 is a cross sectional view of the orifice plate holder and mandrel of Fig. 2 electroplated with nickel, in accordance with the present invention;

Fig. 4 is a cross sectional view of an integrated orifice plate holder and orifice plate, in accordance with the present invention; and

Fig. 5 is a cross sectional view of an orifice plate directly plated onto a fluid manifold, in accordance with the present invention.

Detailed Description of the Preferred Embodiments

Currently in the art, the orifice plate is made by electroplating metal onto a mandrel. A mandrel can be defined as a form which when electroplated gives a metal

part with the desired features. The features are formed by having areas on the mandrel which do not electroplate. This is accomplished by having areas on the mandrel which are made os a dielectric material. The dielectric material can be material put on top of a conductive material such as photoresist. Another method of mandrel construction is to coat a dielectric material with a conductive surface. The dielectric areas are then obtained by etching through the conductive surface down to the dielectric, such as are described in U.S. Patent No. 4,773,971; and copending, commonly assigned patent application Serial No. 08/331,060, filed October 28, 1994, both totally incorporated herein by reference. Either style of mandrel can be used to directly plate orifice plates onto a holder, in accordance with the present invention. The type of mandrel with a dielectric on a conductive surface shall be used to demonstrate the method of directly plating an orifice plate onto a holder. The mandrel is then placed into a metal electroplating bath, e.g. nickel or nickel alloy. Metal is then electroplated onto the mandrel where only areas devoid of the dielectric material accept the electroplated nickel. The orifice plate can then be removed from the mandrel. This process is described in U.S. Pat. No. 4,184,925, totally incorporated herein by reference.

Referring now to Fig. 1, orifice plate 10 is bonded to manifold 12, with suitable bonding means such as epoxy 14, at the periphery of the orifice plate. This bridges and closes the manifold opening leading to fluid reservoir 16. As a consequence, orifices in the orifice plate 10 are in direct fluid communication with the reservoir 16. As fluid is applied under pressure to the fluid receiving reservoir, it flows through fluid channel 18, to orifices of the orifice plate 10, and emerges from each orifice as a fluid filament. The fluid filament then breaks at its tip into a succession of fluid drops. The length of the filament can be controlled by the amount of stimulation amplitude applied to the filament from piezoelectric crystals 20 attached to the fluid manifold 12. It is desirable to have all the filament lengths along the array to be the same. This is called synchronous breakoff.

In accordance with one aspect of the present invention, a method of bonding an orifice plate onto a holder for an ink jet printer uses direct plating. Referring now to Fig. 2, initially an orifice plate holder 22 is aligned to a mandrel 24 and the two parts are kept in very close proximity, preferably in intimate contact, and at the same electrical potential. The holder and the mandrel are then placed at cathodic polarity. The orifice is formed as the electroplated metal grows on the conductive portion of the mandrel and around a photoresist peg 26. If necessary, metal can be deposited thick enough to go over part of the top of the peg.

Continuing with Fig. 2 and referring to Fig. 3, plating material, such as electroplated nickel 28, is applied to the combined holder and mandrel. The holder 22 and the mandrel 24 will then grow together, forming a single orifice plate directly bonded to the holder. The mandrel can then be removed by peeling, if the adhesion of the plated material is less on the mandrel than the holder, or by etching the mandrel away, as is illustrated in Fig. 4.

Referring now to Fig. 5, there is illustrated a cross sectional view of an orifice plate 30 manufactured in accordance with the present invention, directly plated onto fluid manifold 12. In comparing Fig. 5 of the present invention with Fig. 1 of the prior art, the differences between the present invention and the prior art are quite clear. Specifically, the epoxy 14 layer of the prior art has been eliminated with the present invention. In Fig. 5, an anode may be axially located at location 32, down the interior of the fluid manifold cavity. An electrolyte is pumped through the fluid manifold cavity during the plating process to assure that the concentration of metal ions being plated is uniform throughout the length of the fluid manifold cavity. If the concentration of metal ions is not uniform, then the orifice plate will not be uniform in thickness along the array, resulting in a variation in the diameter of the orifices along the array.

Industrial Applicability and Advantages

The present invention is useful in the field of ink jet printing, and has the advantage of eliminating the use of epoxy on the flexible orifice plate. Acoustic energy will be transferred more uniformly through a stiffer orifice plate holder/epoxy/fluid manifold structure than the orifice plate/epoxy/fluid manifold structure. It is a further advantage of the present invention that it allows for the orifice plate to be a mechanically stiffer structure. Being a mechanically stiffer structure will greatly reduce the out-of-flatness in the plane of the array and the non-straightness of the orifices along the array. Also the mechanically stiffer structure will transfer acoustic energy more uniformly along the array which will improve the uniformity of the breakoff lengths of the filaments along the array.

Having described the invention in detail and by reference to the preferred embodiment thereof, it will be apparent that other modifications and variations are possible without departing from the scope of the invention defined in the appended claims.

Claims

1. A method of fabricating an orifice plate for an ink jet printer comprising the steps of:

   providing a mandrel;
   aligning a holder to the mandrel;
   placing the mandrel and the holder at cathodic polarity;
   applying a plating material to the mandrel and the holder to cause the mandrel and the holder to form a single orifice plate directly bonded to the holder.

2. A method of fabricating an orifice plate as claimed in claim 1 further comprising the step of maintaining the mandrel and the holder in intimate contact.

3. A method of fabricating an orifice plate as claimed in claim 1 further comprising the step of maintaining the mandrel and the holder at equal electrical potential.

4. A method of fabricating an orifice plate as claimed in claim 1 further comprising the step of removing the mandrel from the orifice plate.

5. A method of fabricating an orifice plate as claimed in claim 4 wherein the step of removing the mandrel from the orifice plate comprises the step of peeling the mandrel from the orifice plate.

6. A method of fabricating an orifice plate as claimed in claim 4 wherein the step of removing the mandrel from the orifice plate comprises the step of etching the mandrel off the orifice plate.

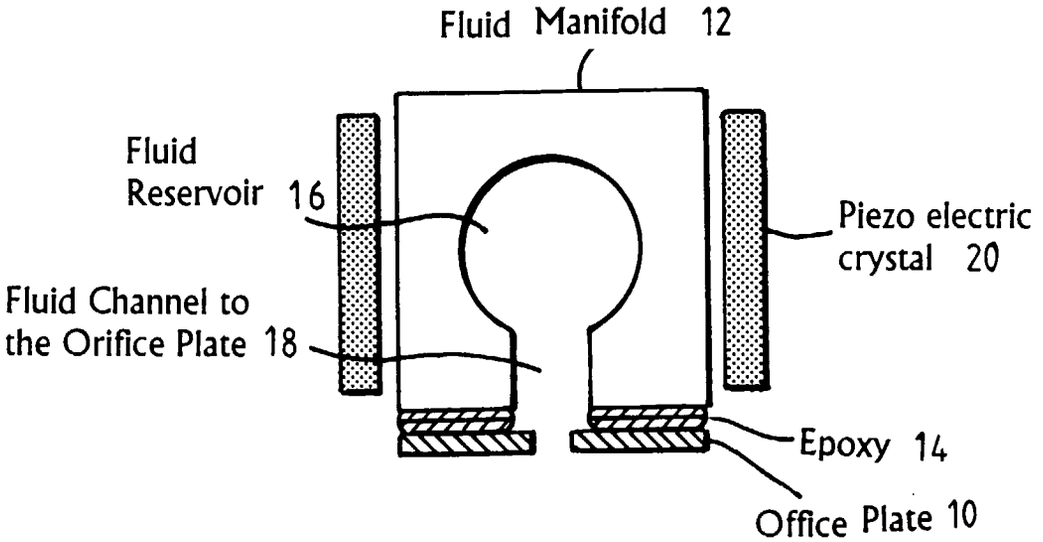
Fluid Manifold 12
Fluid
Reservoir 16
Piezo electric
crystal 20
Fluid Channel to
the Orifice Plate 18
Epoxy 14
Office Plate 10

FIG. 1

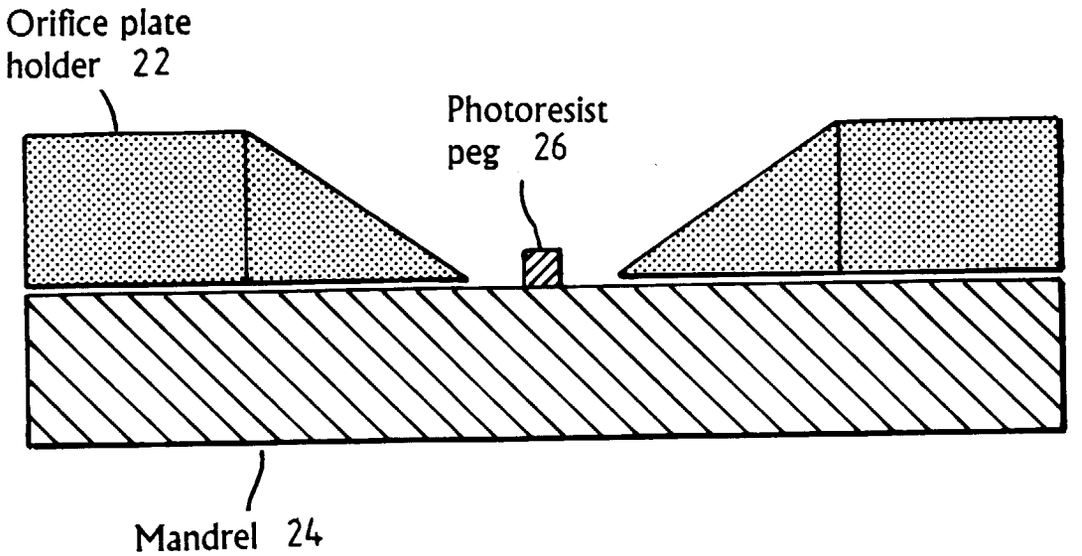
Orifice plate
holder 22
Photoresist
peg 26
Mandrel 24

FIG. 2

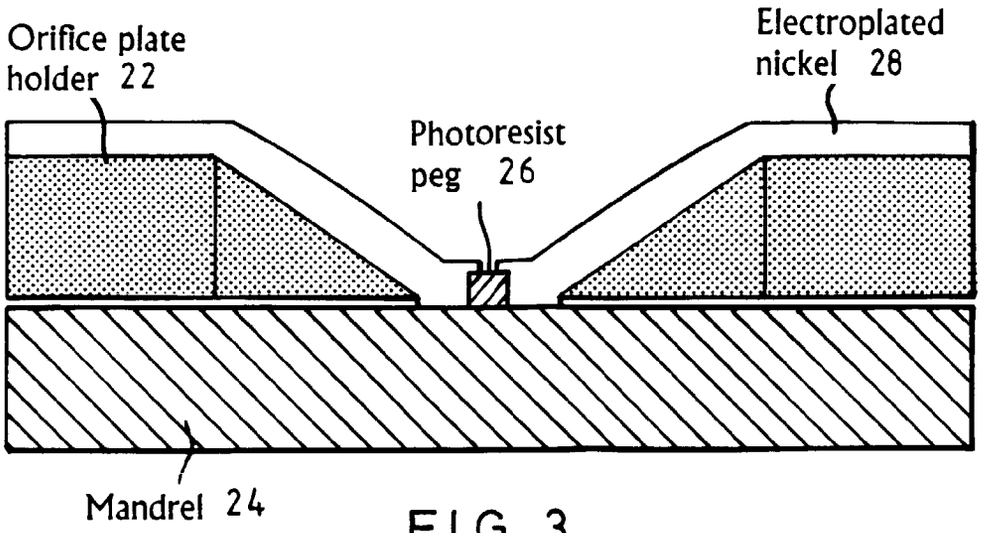

FIG. 3

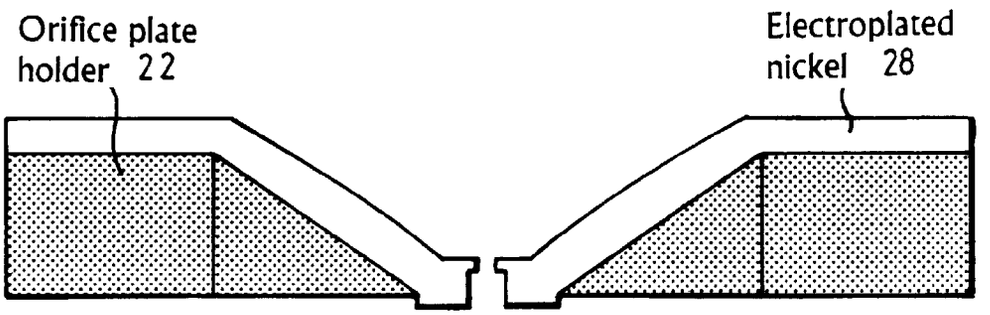

FIG. 4

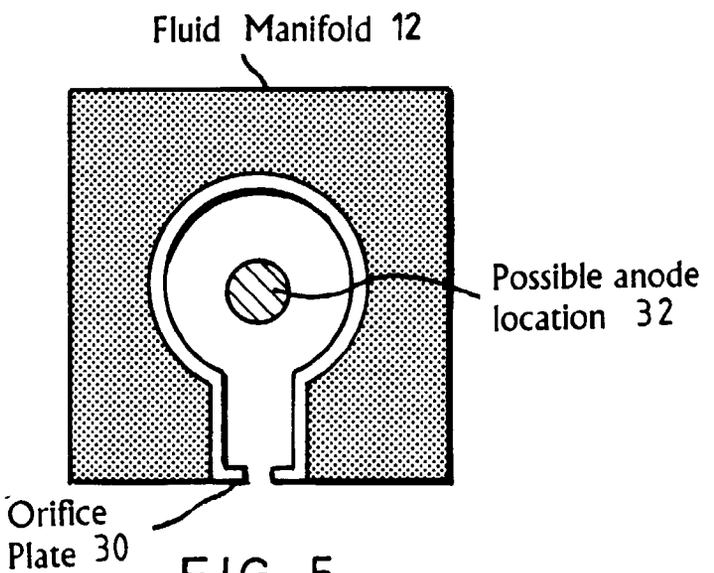

FIG. 5