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(54) **Low airflow catcher for continuous ink jet printers**

Tintenauffangvorrichtung mit geringem Luftstrom für kontinuierlich arbeitenden Tintenstrahldrucker

Intercepteur à écoulement d'air réduit pour imprimantes à jet d'encre continu

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Description

Technical Field

[0001] The present invention relates to drop-catcher devices for continuous ink jet printing apparatus and, more particularly, to improved catcher device constructions for controlling the flow of caught ink.

Background Art

[0002] In general, continuous ink jet printing apparatus have a printhead manifold to which ink is supplied under pressure so as to issue in streams from a printhead orifice plate that is in liquid communication with the cavity. Periodic perturbations are imposed on the liquid streams, such as vibrations by an electromechanical transducer, to cause the streams to break-up into uniformly sized and shaped droplets.

[0003] A charge plate, comprising an array of addressable electrodes, is located proximate the streams break-off points to induce an electrical charge, selectively, on adjacent droplets, in accord with print information signals. Charged droplets are deflected from their nominal trajectory. For example, in a common, binary, printing mode, charged or non-print droplets are deflected into a catcher device and non-charged droplets proceed to the print medium.

[0004] A variety of catcher devices have been developed as constructions to intercept and recirculate the non-print droplets from such printheads. The catcher devices must take several potential problems into account. First, the catcher device must intercept the non-print ink droplets in a way that avoids splattering them onto the print medium, or scattering into an ink mist, which can also cause defects on the print media. Second, the catcher devices must effectively remove the caught ink away from the droplet interception zone so that a build-up of ink on the catching surface does not block the flight path of printing drops.

[0005] To accomplish these purposes, one current catcher for existing printheads requires nearly 3 scfh of air flow to guarantee that ink does not drip from the printhead when operated at various heights and angles. The two-phase flow regime is that of slug flow in which frothy slugs of ink travel at a much higher rate than the average liquid velocity. As a result, the ink is agitated by the airflow as it travels 3,66-7,32 m (12 to 24 feet) back to the fluid system and, as a result, is subject to evaporation and atomization. Such airflow can cause or contribute to several problems.

[0006] One, the present catcher design requires a screen to regulate the high air flow into the catcher. Placement and contour of the screen is critical to proper printhead function. Second, high evaporation rates require a replenishment system with a specifically designed fluid to replace evaporated ink components. Third, high and variable (machine-to-machine, environment-to-environment, etc.) evaporation rates affect ink concentration control using the drop counting method. Additionally, aeration of the ink may be related to mist generation in the fluid system, requiring a replaceable filter media to protect vacuum system components from ingested mist. For some inks aeration of the ink results in a little-understood aging process in which critical runnability properties of the ink degrade. Furthermore, for some inks, aeration of the ink results in foam generation, which adversely affects the function of the fluid system and/or printhead. Also, high catcher airflow may ingest paper fibers and debris which may interface with print drops, thus causing print defects. Finally, high catcher airflow, especially together with a misshapen screen, may deflect print drops, thus causing print defects.

[0007] One approach to improve catcher construction is to provide a catcher having a screen disposed in the catcher throat for wicking ink into the catcher throat. However, a catcher assembly with a screen in the catcher throat is difficult to fabricate. The regulation of ink flow and airflow into the catcher throat is sensitive to the position and shape of the screen.

[0008] Low catcher airflow is desirable in view of the problems listed above. The difficulty with low air flow to this point has been that the ink is not contained in the printhead if it is operated at low airflow, especially when operated at certain orientations relative to gravity.

[0009] It is seen then that there is a need for a low airflow catcher device which overcomes the problems associated with the prior art.

[0010] US-A-3836914 discloses a drop catcher apparatus for a continuous ink jet printer which generates a row of parallel selectively charged drop streams from a fluid system. The drop catcher apparatus comprises a catcher vacuum port for establishing reduced air flow and returning the selectively charged drops of ink from the printhead to the fluid system. The drop catcher apparatus further comprises a catcher face for receiving selectively charged drops of ink, a catcher radius associated with the catcher face for directing the flow of respectively charged drops of ink from the catcher face and a catcher throat associated with the catcher radius for accepting a flow of selectively charged drops of ink from the catcher radius. Attention is also drawn to EP-A-0561205, US-A-4268664 and US-A-4829664.

[0011] Accordingly, it is an object of the present invention to provide for continuous ink jet printing, a droplet catcher apparatus containing a vacuum port which minimizes airflow required to return ink without dripping or dribbling. It is a further object of the present invention to provide such a catcher device which contains a vacuum port for the return of unprinted ink to the fluid system for reuse with minimum agitation. The droplet catcher apparatus is desirably simple in structure.

SUMMARY OF THE INVENTION

[0012] According to the present invention, there is

provided a drop catcher apparatus for a continuous ink jet printer which generates a row of parallel selectively charged drop streams from a fluid system, the drop catcher apparatus comprising a catcher vacuum port for establishing reduced airflow and returning the selectively charged drops of ink from the printhead to the fluid system and comprising:

a catcher face for receiving selectively charged drops of ink;

a catcher radius associated with the catcher face for directing the flow of selectively charged drops of ink from the catcher face; and

a catcher throat associated with the catcher radius for accepting a flow of selectively charged drops of ink from the catcher radius, characterised in that the catcher throat has short, narrow gap with a sudden enlargement downstream of the gap followed by a gap of constant width downstream of the sudden enlargement and in that the catcher throat further comprises two converging-diverging channels formed by an elliptical island and elliptical sidewalls.

[0013] The catcher design of the present invention eliminates the need for a screen to regulate the mixing of air and ink in the catcher throat. In addition, the new catcher design allows the printhead to operate at low airflows while also operating at all orientations. Thus, the benefits of low catcher airflow are realized without affecting the versatility of the printer.

[0014] An embodiment of the invention will now be described with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1A is a schematic side view of an ink jet printhead useful with a catcher according to the present invention;

Fig. 1B is a cross sectional view of a catcher vacuum port in accordance with the present invention; and

Fig. 2 illustrates the underside of the catcher, revealing major geometric features of a vacuum port design, embodying the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] Referring to the drawings, a schematic side view of an ink jet printhead of the type employed with the present invention is shown in Fig.1A, and a cross sectional view of the catcher vacuum port is shown in Fig. 1B. The printhead, generally designated 10, includes a resonator assembly 12 having an ink manifold and orifice plate (not shown) for generating filaments of ink 14. The resonator stimulates the filaments to break off into droplets in the region of charging electrodes 16 on a catcher assembly generally designated 18. Drops of ink are selectively charged by the charging electrodes and deflected onto a catcher face 20 and into a catcher throat 22. Uncharged drops proceed undeflected to a print medium (not shown). Collected ink is withdrawn through a catcher tube 24 and is recirculated.

[0017] The purpose of the present invention is to provide a catcher vacuum port which is simple in structure, which returns unprinted ink to the fluid system with minimum agitation, and which requires minimum air ingestion to control ink removal at any printhead orientation. Fig. 2 illustrates a general view of the underside of the catcher of assembly 18, revealing the major geometric features of vacuum port 26. The vacuum port 26 comprises catcher face 20, radius 28, and catcher throat 22. The face 20 and radius 28 have the same geometry and function as existing vacuum ports, known in the art. The catcher face 20 receives selectively charged drops of ink and the catcher radius 28 directs the flow of selectively charged drops of ink from the catcher face into the catcher throat. The unprinted drops from the array of ink jets impact on the face 20 of the catcher, creating a film of ink attached to the face. Due to momentum from the impacting drops, the ink film flows toward the radius 28. In accordance with the Coanda effect, i.e., the tendency for flows to attach to walls or to one another, the wall attachment occurring under a variety of conditions, the film remains attached to the catcher even as it flows around the radius and along the surface toward the throat opening. The catcher throat 22 accepts the flow of selectively charged drops of ink from the catcher face. The catcher is covered by a simple plate (not shown) which forms one wall of the vacuum port.

[0018] As illustrated in Fig. 1B, the throat 22 comprises a short, narrow gap 34 with a sudden enlargement 36, downstream of the gap, both of which extend across the width of the port 26 of Fig. 2. An elliptical island 30 divides the flow into two paths and, along with elliptical sidewalls 32, creates two converging-diverging channels or passages 33. Narrow gap 34, sudden enlargement 36, and passages 33 establish the desired flow regime in the catcher and the catcher return line.

[0019] To avoid agitation of the ink, the catcher must operate in a different flow regime than slug flow. As the airflow is decreased while the liquid flow is maintained, the flow enters into another regime, commonly known as bubble flow. In this regime of two-phase flow, the airflow is in the form of individual separate bubbles which are entrained in the liquid phase and travel at the velocity of the liquid. Thus, bubble flow provides significantly reduced airflow and much less agitation than slug flow. The catcher vacuum port is designed to establish this bubble flow regime in the catcher return line, and at the

same time allow the printhead to operate at any orientation without dribbling ink. The narrow gap 34 followed by a sudden enlargement 36 and the two converging-diverging channels 33 allow this operation.

[0020] In a preferred embodiment of the present invention, the throat 22 comprises a 0,254 mm (0,010") gap 34 which is 0,762 mm (0.030") in length in the flow direction. The 0,254 mm (0.010") gap is followed by a sudden enlargement 36 to 0,762 mm (0.030"). As the ink film enters the throat 22, capillarity effects cause the ink film to fill the gap and restrict the entry of air. At the center of each branch of flow around the island 30, bubbles individually form downstream of the gap at the 0,762 mm (0.030") enlargement. These bubbles remain individual as they enter the catcher return tube 24 and establish stable bubble flow through the tube to the fluid system. The air flow entering the catcher throat for this mode of operation is 0.2 to 0.7 scfh, in comparison to 3 scfh for existing printheads.

[0021] The island and sidewall geometry control the entry of air at various orientations. At the most difficult orientation, when the printhead is on its side with the flow paths one above the other, an upper flow path will ingest more air than a lower flow path and a lower path will more easily dribble. The converging geometry provides a low pressure region in the center of each channel and limits the imbalance of air ingestion between the two paths. The bubble formation point shifts toward the outer wall in the upper path, but still maintains bubble flow. The illustrated catcher design allows the printhead to operate at low airflows while also operating at all orientations. Thus, the benefits of low catcher airflow are realized without affecting the versatility of the printer.

Industrial Applicability and Advantages

Advantages

[0022] The illustrated embodiment of the present invention is useful in the field of ink jet printing, and has the advantage of providing a droplet catcher apparatus which minimizes airflow required to return ink without dripping or dribbling. It is a further advantage of this embodiment that the catcher device contains a vacuum port which returns unprinted ink to the fluid system with minimum agitation. It is yet another advantage of this embodiment that the vacuum catcher port requires minimum air ingestion to control ink removal at any printhead orientation.

Claims

1. A drop catcher apparatus for a continuous ink jet printer which generates a row of parallel selectively charged drop streams from a fluid system, the drop catcher apparatus comprising a catcher vacuum port for establishing reduced airflow and returning the selectively charged drops of ink from the printhead to the fluid system and comprising:

   a catcher face (20) for receiving selectively charged drops of ink;
   a catcher radius (28) associated with the catcher face (20) for directing the flow of selectively charged drops of ink from the catcher face; and
   a catcher throat (22) associated with the catcher radius for accepting a flow of selectively charged drops of ink from the catcher radius (28), wherein the catcher throat (22) has short, narrow gap (34) with a sudden enlargement (36) downstream of the gap followed by a gap of constant width downstream of the sudden enlargement and the catcher throat (22) further comprises two converging-diverging channels (33) formed by an elliptical island (30) and elliptical sidewalls (32).

2. A drop catcher apparatus as claimed in claim 1, **characterised in that** the short, narrow gap (34) of the catcher throat (22) comprises a gap of approximately 0,254 mm (0.010 inch).

3. A drop catcher apparatus as claimed in claim 1 or claim 2, **characterised in that** the short, narrow gap (34) of the catcher throat (22) comprises a gap approximately 0,762 mm (0.030 inch) in length.

4. A drop catcher apparatus as claimed in any of claims 1 to 3, **characterised in that** the sudden enlargement of the catcher throat (22) downstream of the gap (34) comprises a sudden enlargement of approximately 0,762 mm (0.030 inch).

5. A drop catcher apparatus as claimed in claim 4, **characterised in that** a balance of ingested airflow between the two converging-diverging channels (33) is maintained by converging-diverging geometry of the channels (33).

6. A drop catcher apparatus as claimed in claim 1 further comprising capillarity effects as the flow of selectively charged drops of ink enters the catcher throat (22), causing ink film to fill the gap (34) and restrict entry of air.

7. A drop catcher apparatus as claimed in claim 1, **characterised in that** bubbles individually form downstream of the gap (34) at the enlargement (36).

Patentansprüche

1. Tintenauffangvorrichtung für kontinuierliche Tintenstrahldrucker, die eine Reihe paralleler, selektiv auf-

geladener Tropfenstrahlen aus einem Fluidsystem erzeugen, wobei die Tintenauffangvorrichtung eine Vakuumauffangöffnung aufweist, um einen verringerten Luftstrom zu erzeugen und um die selektiv aufgeladenen Tintentropfen aus dem Druckkopf in das Fluidsystem zurückzuführen, enthaltend:

eine Auffangoberfläche (20) zum Auffangen selektiv aufgeladener Tintentropfen;
einen Auffangradius (28) in Verbindung mit der Auffangoberfläche (20), um den Fluss selektiv aufgeladener Tintentropfen von der Tintenauffangoberfläche wegzuführen, und
eine mit dem Auffangradius verbundene Auffangkehle (22) zur Aufnahme eines Flusses selektiv aufgeladener Tintentropfen vom Auffangradius (28), wobei die Auffangkehle (22) einen kurzen, engen Durchlass (34) mit plötzlicher Erweiterung (36) stromabwärts des Durchlasses hat, auf die ein Durchlass von konstanter Breite stromabwärts der plötzlichen Erweiterung folgt, und wobei die Auffangkehle (22) außerdem zwei zusammen- und auseinanderlaufende Kanäle (33) hat, die von einer elliptischen Insel (30) und elliptischen Seitenwänden (32) gebildet sind.

2. Tintenauffangvorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** der kurze, enge Durchlass (34) der Auffangkehle (22) ein Durchlass von etwa 0,254 mm (0,010 Inch) ist.

3. Tintenauffangvorrichtung nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** der kurze, enge Durchlass (34) der Auffangkehle (22) ein Durchlass von etwa 0,762 mm (0,030 Inch) Länge ist.

4. Tintenauffangvorrichtung nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** die plötzliche Erweiterung der Auffangkehle (22) stromabwärts des Durchlasses (34) eine plötzliche Erweiterung von etwa 0,762 mm (0,030 Inch) ist.

5. Tintenauffangvorrichtung nach Anspruch 4, **dadurch gekennzeichnet, dass** das Gleichgewicht des aufgenommenen Luftstroms zwischen den beiden zusammen- und auseinanderlaufenden Kanälen (33) durch die zusammen- und auseinanderlaufende Geometrie der Kanäle (33) aufrechterhalten wird.

6. Tintenauffangvorrichtung nach Anspruch 1, weiterhin enthaltend Kapillareffekte, wenn der Fluss selektiv aufgeladener Tintentropfen in die Auffangkehle (22) eintritt, so dass der Tintenfilm den Durchlass (34) füllt und den Lufteintritt einschränkt.

7. Tintenauffangvorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** sich stromabwärts des Durchlasses (34) in der Erweiterung (36) einzelne Blasen bilden.

Revendications

1. Dispositif de captation de goutte pour une imprimante à jet d'encre en continu générant une rangée de courants parallèles de gouttes chargées, de façon sélective, à partir d'un système de fluide, dispositif de captation de goutte comprenant un orifice d'arrêt sous vide pour établir un écoulement d'air réduit et pour renvoyer les gouttes d'encre chargées, de façon sélective, à partir de la tête d'impression vers le système de fluide, et comprenant :

- une face de captation (20) pour recevoir les gouttes d'encre chargées de façon sélective ;
- un arrondi de captation (28) associé à la face de captation (20) pour diriger l'écoulement de gouttes d'encre chargées, de façon sélective, à partir de la face du captation ; et
- une gorge de captation (22) associée à l'arrondi de captation pour accepter un écoulement de gouttes d'encre chargées, de façon sélective, à partir de l'arrondi de captation (28), dans lequel la gorge de captation (22) possède un petit intervalle étroit (34) avec un élargissement brusque (36) en aval de l'intervalle suivi d'un intervalle de largeur constante en aval de l'élargissement brusque et la gorge de captation (22) comprend, de plus, deux canaux convergent/divergent (33) formés par un îlot elliptique (30) et des parois latérales elliptiques (32).

2. Dispositif de captation de goutte selon la revendication 1, **caractérisé en ce que** le court intervalle étroit (34) de la gorge de captation (22) comprend un intervalle d'environ 0,254 mm (0,010 pouce).

3. Dispositif de captation de goutte selon la revendication 1 ou 2, **caractérisé en ce que** le court intervalle étroit (34) de la gorge de captation (22) comprend un intervalle d'environ 0,762 mm (0,030 pouce) de longueur.

4. Dispositif de captation de goutte selon l'un quelconque des revendications 1 à 3, **caractérisé en ce que** l'élargissement brusque de la gorge de captation (22) en aval de l'intervalle (34) comprend un élargissement brusque d'environ 0,762 mm (0,030 pouce).

5. Dispositif de captation de goutte selon la revendication 4, **caractérisé en ce qu'**un équilibre de débit d'air

d'admission entre les deux canaux convergent/divergent (33) est maintenu par la géométrie de convergence/divergence des canaux (33).

6. Dispositif de captation de goutte selon la revendication 1, comprenant, de plus, des effets de capillarité tandis que l'écoulement de gouttes d'encre chargées de façon sélective pénètrent dans la gorge de captation (22), provoquant un remplissage de l'intervalle (34) par un film d'encre et une restriction de l'entrée d'air.

7. Dispositif de captation de goutte selon la revendication 1, **caractérisé en ce que** des bulles se forment, de façon individuelle, en aval de l'intervalle (34) sur l'élargissement (36).

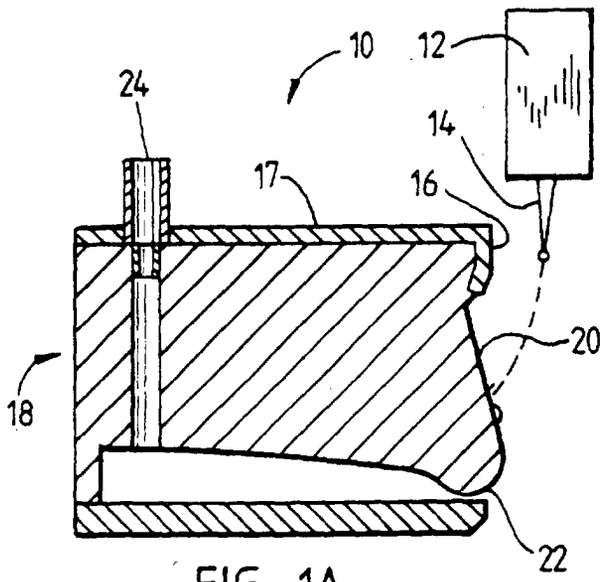

FIG . 1A

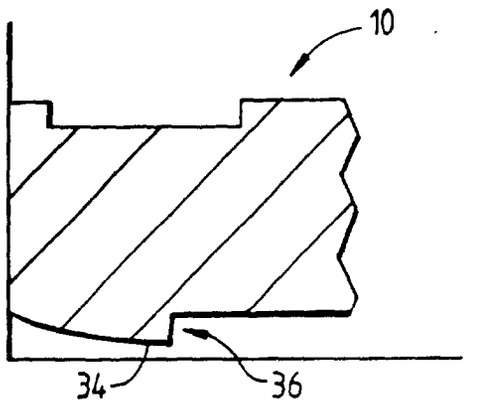

FIG . 1B

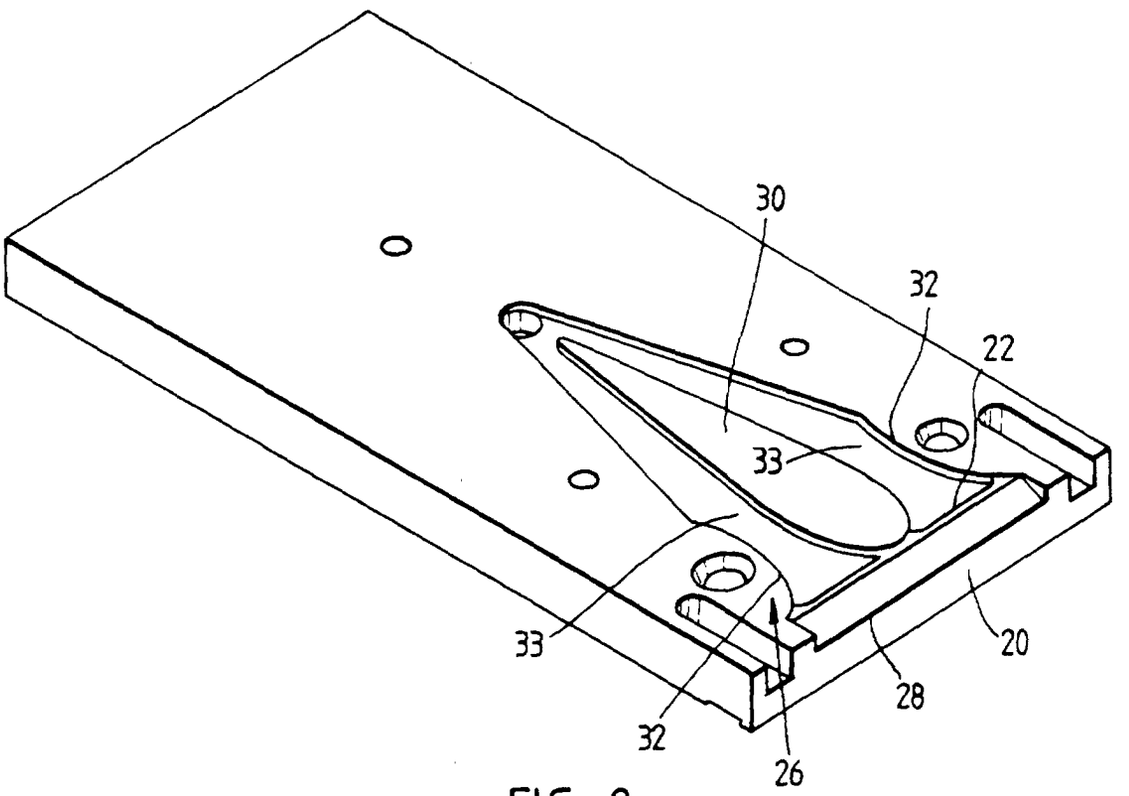

FIG . 2