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Low airflow catcher for continuous ink jet printers

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(56) Related Art
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ABSTRACT

An improved catcher device (18) is provided for use with a continuous ink jet printer of the kind for generating a row of parallel selectively charged drop streams catches charged ink drops. The improved catcher device (18) includes a catcher face (20) for receiving selectively charged drops of ink. A catcher radius (28) associated with the catcher face (20) directs the flow of selectively charged drops of ink from the catcher face (20) into a catcher throat (22). The catcher throat (22) is associated with the catcher radius (28) and accepts a flow of selectively charged drops of ink from the catcher radius (28). The catcher throat (22) has a short, narrow gap (34) with a sudden enlargement (36) downstream of the gap and two converging-diverging channels (33) formed by an elliptical island (30) and elliptical sidewalls (32). Finally, a catcher vacuum port (26), comprising the catcher face (20), the catcher radius (28), and the catcher throat (22), establishes reduced airflow and returns the selectively charged drops of ink from the printhead (10) to the fluid system.

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COMPLETE SPECIFICATION

FOR A STANDARD PATENT

ORIGINAL

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Invention Title: "LOW AIRFLOW CATCHER FOR CONTINUOUS INK JET PRINTERS"

The following statement is a full description of this invention, including the best method of performing it known to us:-

(File: 19659.00)

LOW AIRFLOW CATCHER FOR CONTINUOUS INK JET PRINTERS

Technical Field

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

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.

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.

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.

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 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.

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 interfere 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.

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.

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.

It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

Summary of the Invention

The present invention therefore provides a drop catcher apparatus for use in a continuous ink jet printer for generating a row of parallel selectively charged drop streams from a fluid system, said drop catcher apparatus comprising:

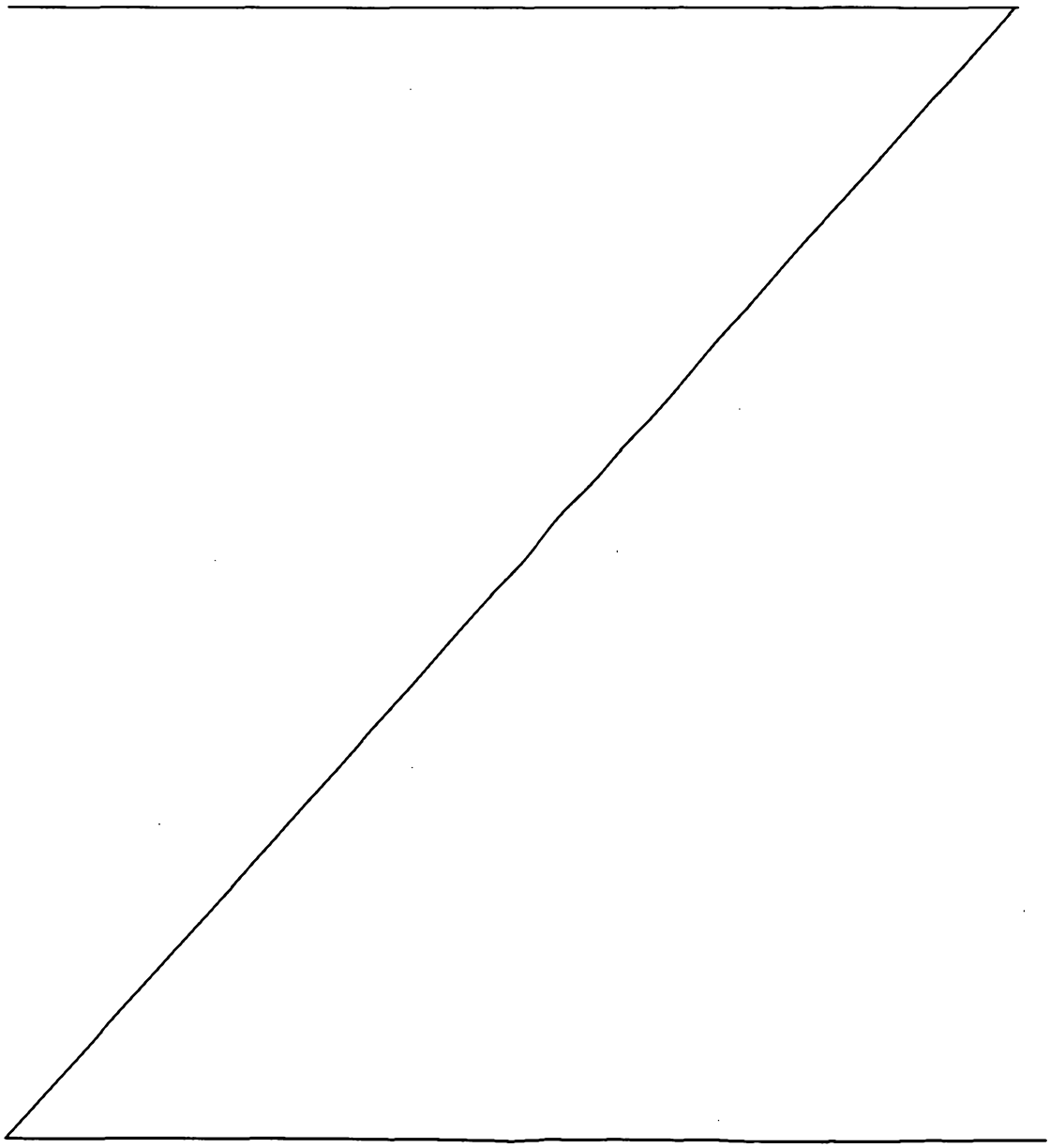
a catcher face for receiving selectively charged drops of ink;

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.

Unless the context clearly requires otherwise, throughout the description and the claims, the words 'comprise', 'comprising', and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".

In this manner, a catcher vacuum port is provided 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. 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

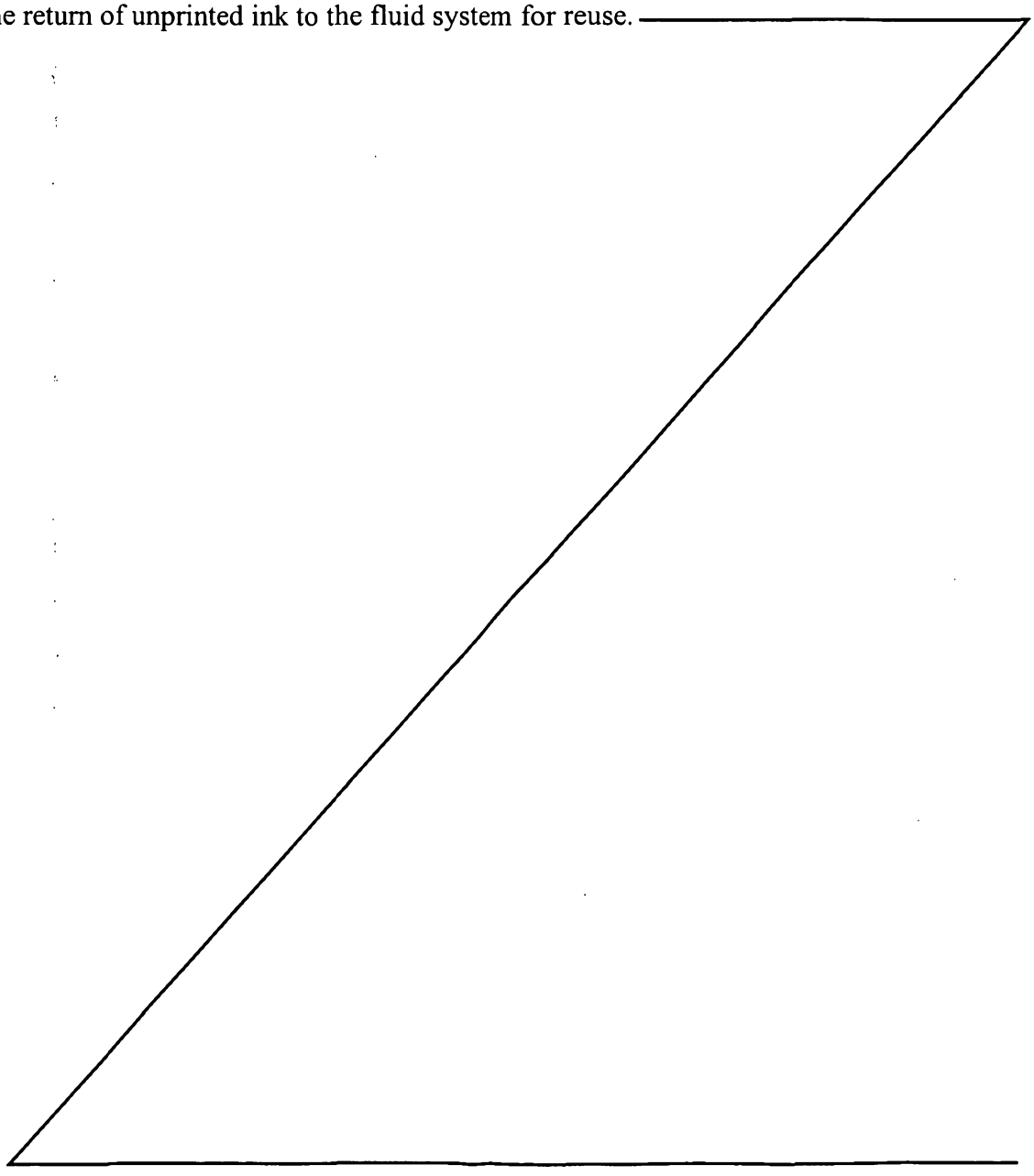


printhead to operate at low airflows while also operating at all orientations. Thus, the benefits of low catcher airflow are realized without affecting the versatility of the printer.

Preferably, the catcher throat has two converging-diverging channels formed by an elliptical island and elliptical sidewalls.

Preferably, a catcher vacuum port establishes reduced airflow and returns the selectively charged drops of ink from the printhead to the fluid system.

In this manner, there is provided, for continuous ink jet printing, a droplet catcher apparatus containing a vacuum port which minimizes airflow required to return ink without dripping or dribbling. The catcher device preferably contains a vacuum port for the return of unprinted ink to the fluid system for reuse.



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

Brief Description of the Drawings

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

One significant purpose of the present invention is to provide a low airflow catcher apparatus which minimizes air flow required to return ink without dripping.

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.

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, according to the present invention. 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.

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.

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.

In a preferred embodiment of the present invention, the throat 22 comprises a 0.010" gap 34 which is 0.030" in length in the flow direction. The 0.010" gap is followed by a sudden enlargement 36 to 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

0.030" 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.

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 catcher design according to the present invention 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

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 the present invention 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 the present invention that the vacuum catcher port requires minimum air ingestion to control ink removal at any printhead orientation.

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.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A drop catcher apparatus for use in a continuous ink jet printer for generating a row of parallel selectively charged drop streams from a fluid system, said drop catcher apparatus 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.

2. A drop catcher apparatus as claimed in claim 1 further comprising a catcher vacuum port or establishing reduced airflow and returning the selectively charged drops of ink from the printhead to the fluid system.

3. A drop catcher apparatus as claimed in claim 2 wherein the catcher vacuum port comprises the catcher face, the catcher radius, and the catcher throat.

4. A drop catcher apparatus as claimed in claim 1 wherein the short, narrow gap of the catcher throat comprises a gap of approximately 0.010 inch.

5. A drop catcher apparatus as claimed in claim 1 wherein the short, narrow gap of the catcher throat comprises a gap approximately 0.030 inch in length.

6. A drop catcher apparatus as claimed in claim 1 wherein the sudden enlargement of the catcher throat downstream of the gap comprises a sudden enlargement of approximately 0.030 inch.

7. A drop catcher apparatus as claimed in claim 6 wherein a balance of ingested airflow between the two converging-diverging channels is maintained by converging-diverging geometry of the channels.

8. 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, causing ink film to fill the gap and restrict entry of air.

9. A drop catcher apparatus as claimed in claim 1 wherein bubbles individually form downstream of the gap at the enlargement.

10. A drop catcher apparatus substantially as herein described with reference to the embodiment shown in the accompanying drawings.

DATED this 12th day of January 2001
SCITEX DIGITAL PRINTING, INC.

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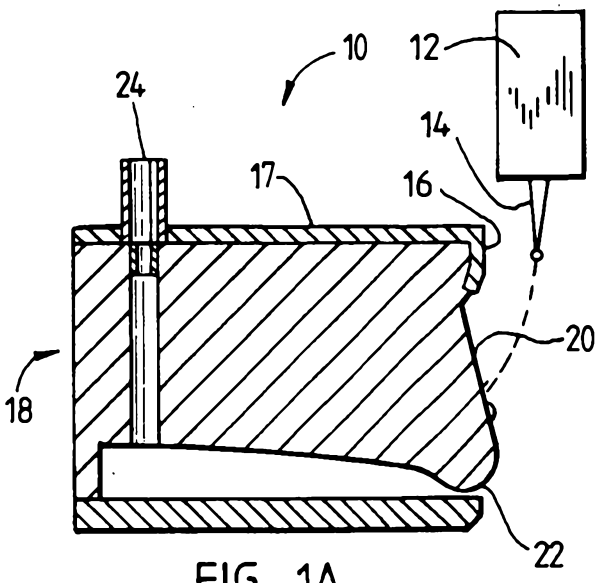

FIG . 1A

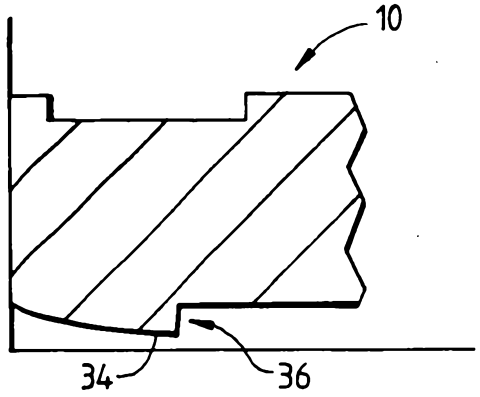

FIG . 1B

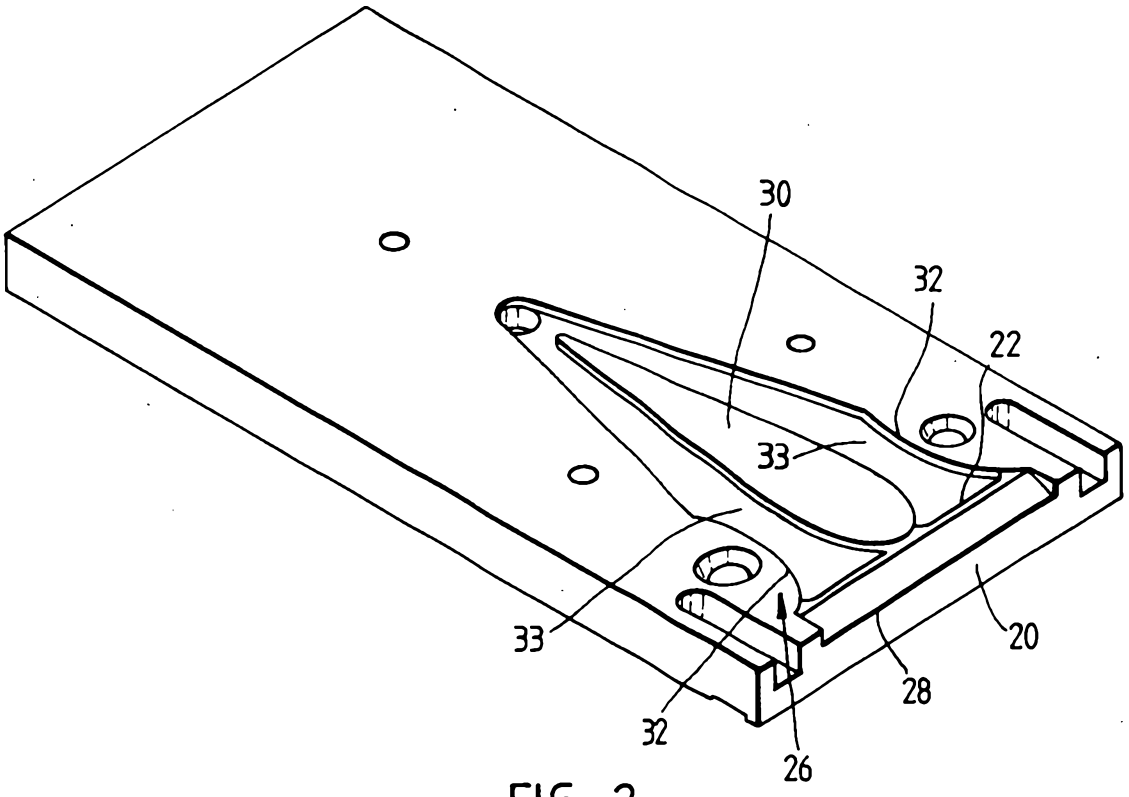

FIG . 2