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(71) Applicant (for all designated States except US): **EASTMAN KODAK COMPANY** [US/US]; 343 State Street, Rochester, New York 14650-2201 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **XU, Jinquan** [CN/US]; 343 State Street, Rochester, New York 14650 (US). **YOKAJTY, Joseph Edward** [US/US]; 343 State Street, Rochester, New York 14650 (US). **GRIFFIN, Todd R.** [US/US]; 343 State Street, Rochester, New York 14650 (US).

(74) Common Representative: **EASTMAN KODAK COMPANY**; 343 State Street, Rochester, New York 14650-2201 (US).

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(54) Title: **PRINthead HAVING IMPROVED GAS FLOW DEFLECTION SYSTEM**

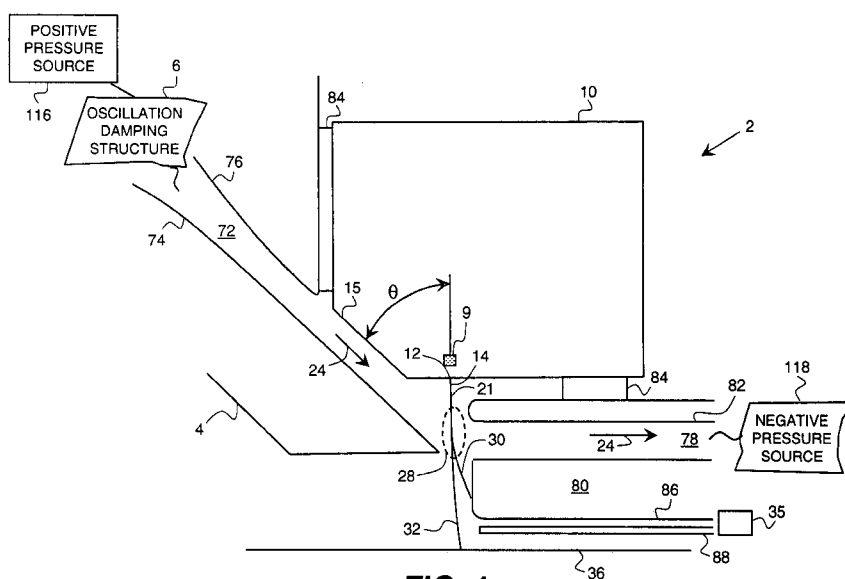


FIG. 1

(57) Abstract: A printhead includes a drop generator configured to selectively form a large volume drop and a small volume drop from liquid emitted through a nozzle associated with the drop generator, the large volume drop and the small volume drop traveling along an initial drop trajectory, and a gas flow deflection system including a gas flow that interacts with the large volume drop and the small volume drop in a drop deflection zone such that at least the small volume drop is deflected from the initial drop trajectory, the gas flow being provided by a gas flow source connected in fluid communication with a gas flow duct, the gas flow deflection system including a gas flow pressure oscillation dampening structure located between the gas flow source and the drop deflection zone.

PRINthead HAVING IMPROVED GAS FLOW DEFLECTION SYSTEM**FIELD OF THE INVENTION**

This invention relates generally to the management of gas flow
5 and, in particular to the management of gas flow in to continuous printing systems
in which a liquid stream breaks into droplets, at least some of which are deflected
by a gas flow.

BACKGROUND OF THE INVENTION

In printing systems, for example, inkjet printing systems, it is
10 critical to provide systems having predictable and accurate printed drop placement
in order to reduce image defects and maintain print quality standards. Conditions
which may lead to reduced printed drop placement accuracy resulting in increased
image defects and reduced print quality should to be minimized.

SUMMARY OF THE INVENTION

15 The present invention helps to provide predictable and accurate
printed drop placement by reducing gas flow velocity fluctuations in printing
systems that use a gas flow to create print drops and non-print drops.

According to one aspect of the present invention, a printhead
includes a drop generator and a gas flow deflection system. The drop generator is
20 configured to selectively form a large volume drop and a small volume drop from
liquid emitted through a nozzle associated with the drop generator. The large
volume drop and the small volume drop travel along an initial drop trajectory.
The gas flow deflection system includes a gas flow that interacts with the large
volume drop and the small volume drop in a drop deflection zone such that at least
25 the small volume drop is deflected from the initial drop trajectory. The gas flow is
provided by a gas flow source connected in fluid communication with a gas flow
duct. The gas flow deflection system includes a gas flow pressure oscillation
dampening structure located between the gas flow source and the drop deflection
zone.

30 According to another aspect of the present invention, a printhead
includes a drop generator, a gas flow deflection system, and a plenum structure.

The drop generator is configured to selectively form a large volume drop and a small volume drop from liquid emitted through a nozzle associated with the drop generator. The large volume drop and the small volume drop travel along an initial drop trajectory. The gas flow deflection system provides a first gas flow
5 through a gas flow duct. The first gas flow interacts with the large volume drop and the small volume drop in a drop deflection zone such that at least the small volume drop is deflected from the initial drop trajectory. The first gas flow has a first speed. A plenum structure includes an outlet located between the drop
10 deflection zone. The second gas flow has a second speed. The first speed of the first gas flow is substantially equivalent to the second speed of the second gas flow.

BRIEF DESCRIPTION OF THE DRAWINGS

In the detailed description of the example embodiments of the
15 invention presented below, reference is made to the accompanying drawings, in which:

Figure 1 is a schematic side view of a printing system with a fluid flow device including an example embodiment of the present invention;

Figure 2(A) shows experimentally measured results without
20 incorporating the present invention into the printing system;

Figure 2(B) shows experimentally measured incorporating the present invention into the printing system;

Figure 3 is a schematic side view of a printing system with a fluid flow device incorporating an example embodiment of the present invention;

25 Figures 4(A) and 4(B) are schematic side views of printing systems that use a gas flow with velocity fluctuations to create print drops and non-print drops;

Figure 5 is a schematic side view of a printing system including another embodiment of the present invention;

Figure 6 is a schematic side view of a printing system including another embodiment of the present invention; and

Figure 7 is a schematic side view of a printing system including another embodiment of the present invention.

5 **DETAILED DESCRIPTION OF THE INVENTION**

The present description will be directed in particular to elements forming part of, or cooperating more directly with, apparatus in accordance with the present invention. It is to be understood that elements not specifically shown or described can take various forms well known to those skilled in the art.

10 The example embodiments of the present invention are illustrated schematically and not to scale for the sake of clarity. One of ordinary skill in the art will be able to readily determine the specific size and interconnections of the elements of the example embodiments of the present invention. In the following description, identical reference numerals have been used, where possible, to
15 designate identical elements.

Although the term printing system is used herein, it is recognized that printing systems are being used today to eject other types of liquids and not just ink. For example, the ejection of various fluids such as medicines, inks, pigments, dyes, and other materials is possible today using printing systems. As
20 such, the term printing system is not intended to be limited to just systems that eject ink. Accordingly, the media includes not only print media, but also other structures, for example, circuit board material, stereo-lithographic substrates, medical delivery devices, etc.

Figure 1 shows a printing apparatus incorporating an example
25 embodiment of the present invention. The printing apparatus comprises a printhead 2 and a gas flow deflection system 4. The printhead 2 has drop generator 10 with at least one nozzle 12 from which ink is emitted under pressure to form filaments of liquid 14. Stimulation device 9, for example, an electric
30 heater, associated with the drop generator 10 is capable of perturbing the filament of liquid 14 to induce portions of the filament to break off from the main filament

to form drops stream 21. Drops are selectively created in the form of large volume drops and small volume drops that fly down toward the receiving media 36.

Printheads like printhead 2 are known and have been described in, for example, US Patent No. 6,457,807 B1, issued to Hawkins et al., on October 1, 2002; US Patent No. 6,491,362 B1, issued to Jeanmaire, on December 10, 2002; 5 US Patent No. 6,505,921 B2, issued to Chwalek et al., on January 14, 2003; US Patent No. 6,554,410 B2, issued to Jeanmaire et al., on April 29, 2003; US Patent No. 6,575,566 B1, issued to Jeanmaire et al., on June 10, 2003; US Patent No. 6,588,888 B2, issued to Jeanmaire et al., on July 8, 2003; US Patent No. 10 6,793,328 B2, issued to Jeanmaire, on September 21, 2004; US Patent No. 6,827,429 B2, issued to Jeanmaire et al., on December 7, 2004; and US Patent No. 6,851,796 B2, issued to Jeanmaire et al., on February 8, 2005, the disclosures of which are incorporated by reference herein.

A gas flow deflection system 4 including a gas flow 24 in gas flow 15 duct 72 interacts with the large volume drops and the small volume drops in the drop deflection zone 28 such that at least the small drop volume drops are deflected from the initial drop trajectory and fly along the small drop trajectory 30. The large volume drops are also deflected from the initial drop trajectory and fly along the large drop trajectory 32. As shown in Figure 1, the small volume 20 drop trajectory is intercepted by the front face of the catcher 80, while the large volume drops are not deflected as much as the small volume drops, missing the catcher 80 and continuing on to the receiving media 36 to form a dot. The margin between the small volume drops and the large volume drops has to big enough so that the catcher 80 can intercept the small volume drops and let the large volume 25 drops pass by.

Another air duct 78 is located on a second side of the drop streams. It is formed between the catcher 80 and upper wall 82, and exhausts air from the deflection zone 28. Optional seals 84 provide air seals between the drop generator and the upper wall 76 and the upper wall 82. Second duct 78 can be connected to

a negative pressure source 118 that is used to help remove air from second duct 78. Typically the positive pressure source 116 can be a gas pump or a gas fan.

The small drop trajectory is intercepted by the front face of the catcher 80. The ink then flows down the catcher face and into the ink return duct 5 86, formed between the catcher 80 and the plate 88, and is returned to the fluid system 35. The large drops are not deflected as much as the small drops, missing the catcher 80 and continuing on to the receiving media 36 to form a dot. A print image can be formed by multiple such dots on the print media.

For a general printing purpose, both the small drop volume drops 10 and the large drop volume drops are tiny, usually ranged from sub-picoliter to hundreds of picoliter. It is obvious that trajectories of such drops are very sensitive to the gas flow in the deflection zone. Gas flow stability, uniformity and speed have to be maintained to place a drop onto a prescribed spot on the receiving media 36, or to achieve the required margin between the small volume drops and 15 large volume drops. Also, the speed of gas flow needs to be optimized to avoid severe turbulence being generated in the drop deflection zone 28.

It has been found, even in printheads having turbulence suppressing features in the gas flow ducts, such as those disclosed in U.S. Application Serial No. 12/265,146 filed November 5, 2008, entitled 20 "DEFLECTION DEVICE INCLUDING EXPANSION AND CONTRACTION REGIONS" by Todd R. Griffin et al., that the printed images can show fluctuations in optical density. These fluctuations show up as somewhat periodic light and dark bands in the direction of relative motion between the printhead and the receiving media 36. Analysis of the images has showed that the fluctuations 25 in optical density are produced by fluctuations in the drop placement parallel to the relative motion of the printhead and the receiving media. These optical density fluctuations have been called chatter marks or chatter defect.

It has been determined that these chatter defects are related to fluctuations in gas flow velocity. Figure 2(A) shows a gas flow velocity profile 30 302 measured from the exit of a positive pressure source using a hotwire anemometer. The gas flow velocity profile 302 has a mean velocity 304, and a

velocity fluctuation 306. A Fourier Transform analysis shows multiple frequencies in the velocity profile 302, ranged from hundreds of Hertz to tens of thousands Hertz. For an acceptable gas flow for the printing device, the amplitudes ratio of the velocity fluctuation 306 over the mean velocity 304 is preferred to be no more than 10%. Most of the gas flow provided by the gas flow source, however, can not meet this requirement.

The gas flow 24 is provided by a gas flow source 116 connected in fluid communication with the gas flow duct 72. Typically, the gas flow source is a positive pressure source, such as a gas fan, a gas blower or a gas pump. These gas flow sources typically produce a positive pressure with some ripple or periodic oscillation in the pressure. Such oscillations can be caused, for the example of a gas fan, by the motion of each of the fan blades past parts of the fan support structure. The resulting periodic pressure oscillations produce periodic fluctuations in gas flow velocity in the gas flow duct. Gas flow velocity fluctuations from the gas flow source 116 have been experimentally detected and characterized.

To solve the gas flow velocity fluctuation issue, a gas flow pressure oscillation damping structure 6 is incorporated. Referring again to Figure 1, the gas flow deflection system 4 includes the gas flow pressure oscillation damping structure 6 located between the gas flow source 116 and the drop deflection zone 28 to damp pressure oscillation in the gas flow before the gas flow reaches the drop deflection zone 28. The gas flow pressure oscillation damping structure 6 comprises a porous media positioned in the gas flow duct 72 such that at least a portion of the gas flows through the porous media.

Figure 2(B) shows a gas flow velocity profile 302 measured after the gas flow passes through a gas flow pressure oscillation damping structure 6 using the hotwire anemometer. Comparison between Figure 2(A) and Figure 2(B) clearly illustrates that velocity fluctuations can be significantly damped after passing through the gas flow pressure oscillation damping structure 6. Again, according to Bernoulli's principle, with the velocity fluctuations being damped, gas flow pressure oscillation is damped accordingly.

To achieve an optimal performance, the size of pores in the porous material should be smaller than the wavelength of the pressure oscillation. For example, for a gas flow $v = 5\text{m/s}$ in the gas duct, fan periodic compressing frequency $f = 4000\text{Hz}$, the wavelength of the pressure oscillation, λ , can be approximated by, $\lambda = v/f$, which gives $\lambda = 0.00125$ meter. That means the size of the pores in the porous media should smaller than 0.00125 meter in this case. Preferably, the size of the pores should be significantly smaller than the wavelength of the pressure oscillation. Viscous damping of the gas as it moves into and out of the pores in response to the pressure fluctuations causes the pressure fluctuations to be attenuated. An example of such porous media is an open cell foam or a fiber mat, such as cotton. Preferably the porous material is a flexible, extensional damping material with viscoelastic properties so that vibrations of the pore walls themselves are damped. For improved performance, the porous media should be secured in the gas flow duct so that the gas flow won't induce vibrations of the porous media. In one embodiment, epoxy can be applied to the interface of porous media and the gas flow duct to secure the media to the walls of the gas flow duct. An example of commercially available device that can be readily used as the gas flow pressure oscillation damping structure 6 is an air purifier & flow equalizer, for example, flow equalizers manufactured by Koby® Incorporated.

Attention should also be paid is resonance frequencies. Resonance frequencies of the gas flow pressure oscillation damping structure and the gas flow deflection system should be different from the pressure oscillation frequency of the gas flow to avoid potential acoustic/vibration resonance.

It has been found that as the gas flows through the gas flow duct, interactions of the gas flow with the gas flow duct can amplify gas flow velocity fluctuations. Referring to Figure 1, the gas flow duct 72, having a lower wall 74 and an upper wall 76, is located on one side of the drop streams 21. The drop generator 10 has a beveled surface 15. The gas flow duct 72 and the beveled surface 15 of the drop generator 10 direct the gas supplied from a positive pressure source 116, passing the gas flow pressure oscillation structure 6, toward

the drop deflection zone 28. A downward angle θ is formed between the beveled surface 15 of the drop generator 10 and the initial drop trajectory such that the gas flow is directed at a non-perpendicular non-parallel angle relative to the initial drop trajectory. Typically, the downward angle θ of approximately a 45° is preferred. Printing systems like this have been previously discussed, for example, in US Patent Application Serial No. 11/744,998 filed May 7, 2007, entitled "PRINTER HAVING IMPROVED GAS FLOW DROP DEFLECTION" by Randolph C. Brost et al., the disclosure of which is incorporated by reference herein.

For manufacture, operation, and maintenance considerations, the drop generator 10 and the gas flow deflection system 4 are manufactured into two separated pieces. Due to engineering tolerance, there is a small gap between the printhead 2 and the gas flow deflection system 4 when the two pieces are assembled. Typically, the gap is only hundreds of micrometers in width. The gap can be sealed with a seal 84, or left open as it is as shown in Figure 3.

Referring to Figure 3, the inner surface of the upper wall 76 is aligned with the beveled surface 15 of the drop generator 10. As one specific example of alignment in this case, the inner surface of the upper wall 76 is parallel and co-planer with the beveled face 15 of the drop generator 10.

If the inner surface of the upper wall 76 is not well aligned with the beveled surface 15 of the drop generator 10, it is possible for the beveled face 15 of the drop generator 10 to be recessed by an offset 401 from the plane of the upper wall 76 as schematically shown in Figure 4A.. Usually, the offset 401 is very small, less than hundreds of micrometers, and not easily detected. Small as it is, however, the offset 401 is believed to induce fluid dynamic instability. Such instability can occur when a velocity shear is present within a continuous fluid or when there is sufficient velocity difference across the interface between two fluids. This causes the flow of fluid at the interface between the higher and lower fluids to become unstable so that the velocity of the fluid in the region of the velocity shear fluctuates. In the print device as shown in Figure 4(A), a gas flow

velocity shear can be present and induce instability because, gas flow from the gas duct 72 is relatively fast, while the gas flow in the offset 401 region is relatively slow.

For example, in the print device shown in Figure 4(A), the gas flow velocity in the gas duct near the beveled surface 15 of the drop generator is, typically, above 10m/s, while the gas flow velocity in the offset 401 is, typically, less than 1m/s. This velocity shear can generate the instability, if the gas flow from the gas flow source is not perfectly stable in time.. As a matter of fact, perfectly stable gas flow is virtually impossible to be generated by a positive pressure sources such a fan, a gas blower or a gas pump. If the gas flow velocity has any periodic fluctuations, the instability can amplify the velocity fluctuations as the gas flow travels toward the drop deflection zone 28. The velocity fluctuated gas flow interacts with the drops in the deflection zone 28 causing the drop trajectories to fluctuate to produce the observed periodic light and dark bands in the image on the receiving media.

The amount of gas flow velocity fluctuation amplification is a function of (i) velocity difference between the fast gas flow in the gas duct and the slow gas flow in the offset region 401, (ii) the width of the offset region 401, (iii) the distance the oscillated gas flow travels, and (iv) the velocity fluctuation amplitude from the gas flow coming from the gas flow source etc. In general, the bigger the velocity difference, the wider the gap, and the longer the travel distance, the larger the oscillation amplitudes.

Referring back to Figure 3, one example embodiment that reduces or even eliminates instability is shown. The inner surface of the upper wall 76 is aligned with the beveled surface 15 of the drop generator 10, that is, the inner surface of the upper wall 76 is parallel and co-planer with the beveled face 15 of the drop generator 10.

To understand the importance of alignment between the inner surface of the upper wall 76 and the beveled surface 15 of the drop generator 10, as another case scenario, Figure 4(B) schematically shows the drop generator 10 is extruded such that the beveled surface 15 is below the plane of the inner surface

of the upper wall 76. In this case, the instability isn't produced but rather the gas flow in the gas duct 72 directly interacts with the surface 402 of the drop generator 10, causes unstable gas flow.

The term "alignment" means the proper positioning the parts in relation to each other. As one specific example of alignment in Figure 1 and Figure 3, the inner surface of the upper wall 76 is parallel and co-planer with the beveled face 15 of the drop generator 10. However, due to various designs of the drop generator and the gas ducts, "alignment" in this context should be understood as smooth transient of gas flow from the gas duct 72 to the drop deflection zone 28.

Referring to Figure 5, mathematically, "alignment" in this context means:

(1) $v_{52} = v_{54}$, The gas flow velocity v_{52} near the tip 52 of the gas duct is substantially equivalent to the gas flow velocity v_{54} near the tip 54 of the drop generator 10; and

(2) $\frac{dv_{52}}{dx_i} = \frac{dv_{54}}{dx_i}$, The first derivative of the gas flow velocity near the tip 52 $\frac{dv_{52}}{dx_i}$ of the gas duct is substantially equivalent to the first derivative of the gas flow velocity near the tip 54 $\frac{dv_{54}}{dx_i}$ of the drop generator 10. Where x_i ($i = 1, 2$ and 3) are three orientations of a Cartesian coordinate system.

In such a context, it is not necessarily for the beveled face 15 of the drop generator 10 to be a plane surface, though a plane surface is preferred for manufacturing considerations.

Figure 6 schematically shows a side-view of a print apparatus including another example embodiment of the present invention. As shown in Figure 3, a drop generator 10 is configured to selectively form large volume drops and small volume drop from liquid emitted through nozzles 12 associated with the drop generator. The large volume drops and the small volume drops travel along an initial trajectory of drop stream 21. A first gas flow 124 having a first speed

flowing along the gas duct 72 directs toward the trajectory of the drop stream 21. A portion of this gas flow passes through the drop deflection zone 28 and exits through the gas flow duct 78.

5 A plenum structure 100 including an outlet located between the drop generator 10 and the gas flow duct that directs a second gas flow 126 towards the initial trajectory of drop stream 21. The second gas flow has a second speed. The first speed of the first gas flow 124 adjacent to the outlet 127 of the plenum structure 100 is substantially equivalent to the second speed of the second gas flow 126 at the outlet 127 of the plenum structure 100. The second gas flow 10 126 is substantially parallel to the first gas flow 124 in the drop deflection zone 28. With the first speed of the first gas flow 124 substantially equivalent to the second speed of the second gas flow 126, and the first gas flow 124 substantially parallel to the second gas flow 126, there would be minimum velocity shear present within the gas flow close to the outlet 127 of the plenum structure 100 15 because there is no significant velocity difference across the interface between two fluids. As both the first gas flow 124 and the second gas flow 126 are parallel, and there is minimum velocity difference between the two gas flow near the outlet 127 of the plenum structure 100, instability is suppressed.

The first gas flow 124 is provided by a first positive pressure 20 source 216 connected in fluid communication to the gas flow duct 72. Typically, the first positive pressure source 216 is a gas fan, a gas blower or a gas pump etc. The gas flow deflection system includes a gas flow pressure oscillation damping structure 218, such as the one described above located between the first gas flow source 216 and the drop deflection zone 28. The gas flow pressure oscillation 25 damping structure 218 comprises a porous media positioned in the gas flow duct 72 such that at least a portion of the gas flows through the porous media.

The second gas flow 126 is provided by a second positive pressure source 226 connected in communication with the plenum structure 100. Typically, the second positive pressure source 216 is a gas fan, a gas blower or a gas pump 30 etc. A gas flow pressure oscillation dampening structure 228, such as the one described above is located between the gas flow source and the outlet 127 of the

plenum structure 100. The gas flow pressure oscillation damping structure 218 comprises a porous media positioned in the gas flow duct 106 such that at least a portion of the gas flows through the porous media.

As stated above, the instability can be suppressed when the first
5 speed of the first air flow 124 is substantially the same as the second speed of the second air flow at the outlet 127 of the plenum structure. In terms of suppressing the instability, the first and second gas flow speeds are substantially the same if the second speed differs from the first speed by less than 40% of the first speed.

Referring to Figure 6, usually the plenum structure 100 has to be
10 very thin so that the plenum structure 100 can be accommodated between the drop generator 10 and the gas duct 72. The plenum structure 100 needs to be rigid to minimize vibrations that can be caused by the gas flow 124 and gas flow 126. It is preferred that the surfaces of the plenum structure 100 are polished. An air plenum 102 is formed between the drop generator 10 and the plenum structure 100 and
15 upper wall 82. The air plenum 102 can be open as it is shown, or be sealed with a seal, for example, seal 84 shown in Figure 1. Figure 7 schematically shows a side-view of another example embodiment of the present invention. In this embodiment, the gas flow duct 106 is sealed with a seal 220.

Also in the description above, the term “gas” is intended to include
20 gases such as air, vapor, carbon dioxide, and any suitable gaseous fluid. Additionally, the gases that are provided to the deflection zone can be filtered or cleaned prior to delivery to the deflection zone to help maintain a clean printhead environment. The drops are typically drops of liquid inks, but can include other liquid mixtures desirable for selective application to a receiver. Typically,
25 receivers include a print media when the drops are ink. However, when the drops are other types of liquid, the receiver can be other structures, for example, circuit board material, stereo-lithographic substrates, medical delivery devices, etc.

PARTS LIST

	2 printhead
	4 gas flow deflection system
5	6 gas flow pressure oscillation damping structure
	9 stimulation device
	10 drop generator
	12 at least one nozzle
	14 liquid
10	15 beveled surface
	21 drops stream
	24 gas flow
	28 drop deflection zone
	30 small drop trajectory
15	32 large drop trajectory
	35 fluid system
	36 receiving media
	52 tip
	54 tip
20	72 gas flow duct
	74 lower wall
	76 upper wall
	78 another air duct
	80 catcher
25	82 upper wall
	84 optional seals
	86 ink return duct
	88 plate
	100 plenum structure
30	102 air plenum
	106 gas flow duct

	116 positive pressure source
	118 negative pressure source
	124 first gas flow
	126 second gas flow
5	127 outlet
	216 first positive pressure source
	218 gas flow pressure oscillation damping structure
	220 seal
	226 second positive pressure source
10	228 gas flow pressure oscillation dampening structure
	302 gas flow velocity profile
	304 mean velocity
	306 velocity fluctuation
	401 offset
15	402 surface

CLAIMS:

1. A printhead comprising:
a drop generator configured to selectively form a large volume
5 drop and a small volume drop from liquid emitted through a nozzle associated
with the drop generator, the large volume drop and the small volume drop
traveling along an initial drop trajectory; and
a gas flow deflection system including a gas flow that interacts
with the large volume drop and the small volume drop in a drop deflection zone
10 such that at least the small volume drop is deflected from the initial drop
trajectory, the gas flow being provided by a gas flow source connected in fluid
communication with a gas flow duct, the gas flow deflection system including a
gas flow pressure oscillation dampening structure located between the gas flow
source and the drop deflection zone.
15
2. The printhead of claim 1, wherein the gas flow source is a
positive pressure source.
3. The printhead of claim 1, wherein the gas flow pressure
20 oscillation dampening structure comprises a porous media positioned in the gas
flow duct such that at least a portion of the gas flows through the porous media.
4. The printhead of claim 1, wherein the gas flow is directed at
a non-perpendicular non-parallel angle relative to the initial drop trajectory.
25
5. The printhead of claim 4, the gas flow duct comprising an
upper wall, the upper wall including an inner surface, the drop generator including
a beveled face, wherein the inner surface of the upper wall is aligned with the
beveled face of the drop generator.
30

6. The printhead of claim 5, wherein the inner surface of the upper wall is parallel and co-planer with the beveled face of the drop generator.

7. A printhead comprising:
5 a drop generator configured to selectively form a large volume drop and a small volume drop from liquid emitted through a nozzle associated with the drop generator, the large volume drop and the small volume drop traveling along an initial drop trajectory;
a gas flow deflection system that provides a first gas flow through a
10 gas flow duct, the first gas flow interacting with the large volume drop and the small volume drop in a drop deflection zone such that at least the small volume drop is deflected from the initial drop trajectory, the first gas flow having a first speed; and
a plenum structure including an outlet located between the drop
15 generator and the gas flow duct that directs a second gas flow toward the drop deflection zone, the second gas flow having a second speed, the first speed of the first gas flow being substantially equivalent to the second speed of the second gas flow.

20 8. The printhead of claim 7, wherein the second gas flow is substantially parallel to the first gas flow in the drop deflection zone.

9. The printhead of claim 7, the first gas flow being provided
by a first positive pressure source connected in fluid communication to the gas
25 flow duct, wherein the gas flow deflection system includes a gas flow pressure oscillation dampening structure located between the first gas flow source and the drop deflection zone.

10. The printhead of claim 9, the second gas flow being
30 provided by a second positive pressure source connected in fluid communication

with the plenum structure, wherein a gas flow pressure oscillation dampening structure is located between the gas flow source and the outlet of the plenum structure.

5 11. The printhead of claim 7, the second gas flow being provided by a positive pressure source connected in fluid communication with the plenum structure, wherein a gas flow pressure oscillation dampening structure is located between the gas flow source and the outlet of the plenum structure.

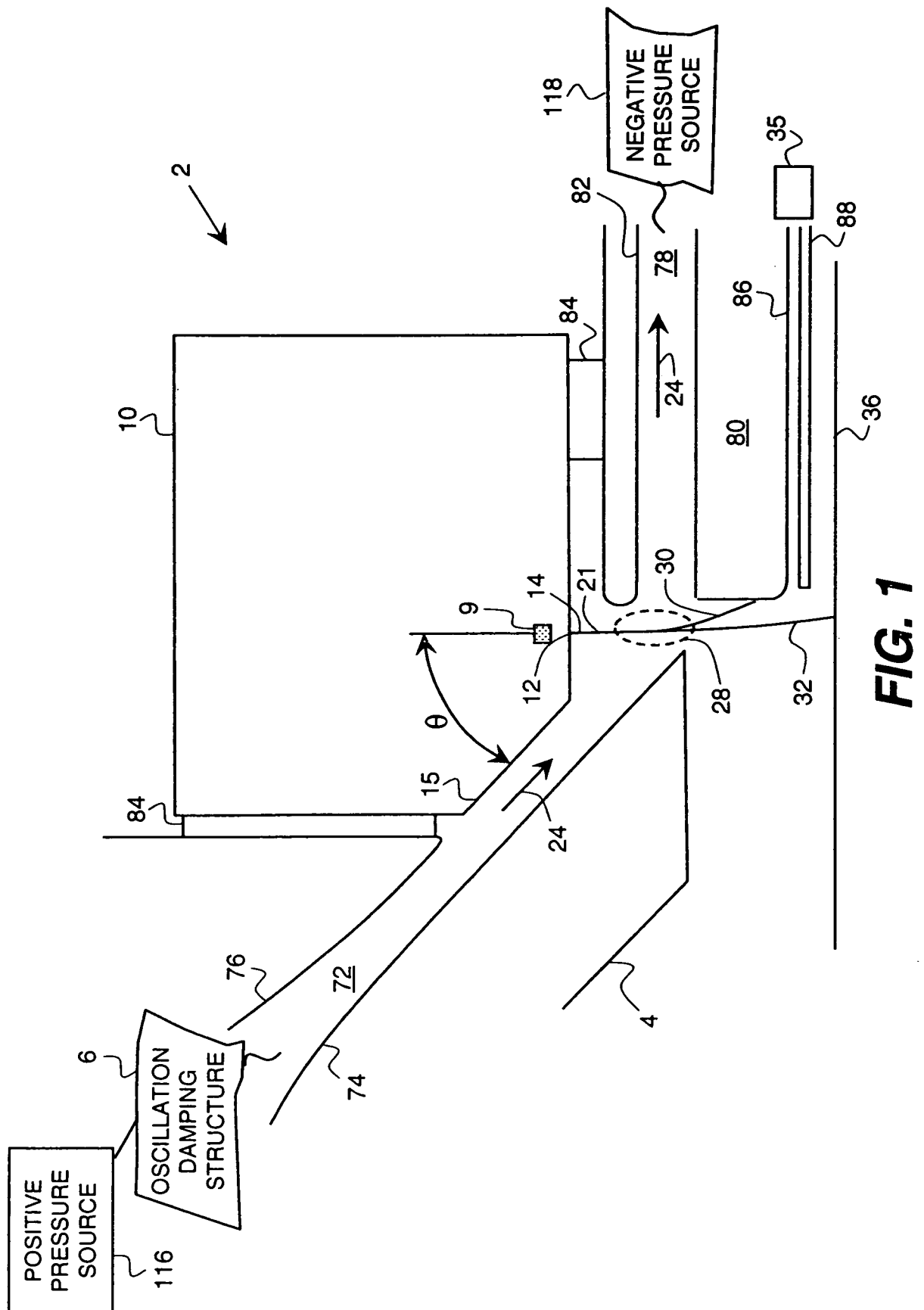
10 12. The printhead of claim 7, the first gas flow being provided by a first positive pressure source connected in fluid communication to the gas flow duct.

 13. The printhead of claim 12, the second gas flow being
15 provided by a second positive pressure source connected in fluid communication with the plenum structure.

 14. The printhead of claim 7, wherein the gas flow pressure
oscillation dampening structure comprises a porous media positioned in the gas
20 flow duct such that at least a portion of the gas flows through the porous media.

 15. The printhead of claim 7, wherein the gas flow is directed at a non-perpendicular non-parallel angle relative to the initial drop trajectory.

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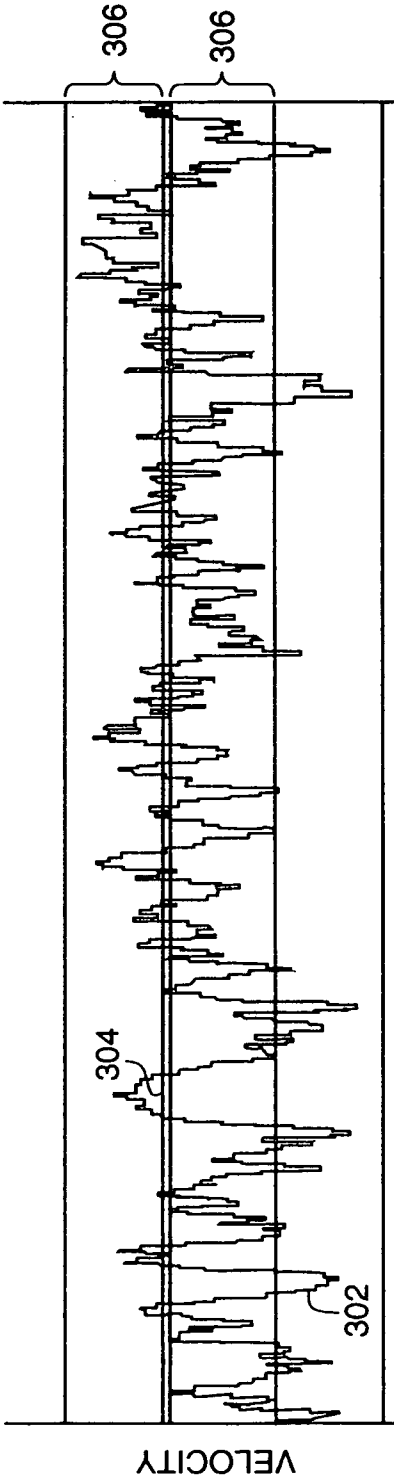


FIG. 2A

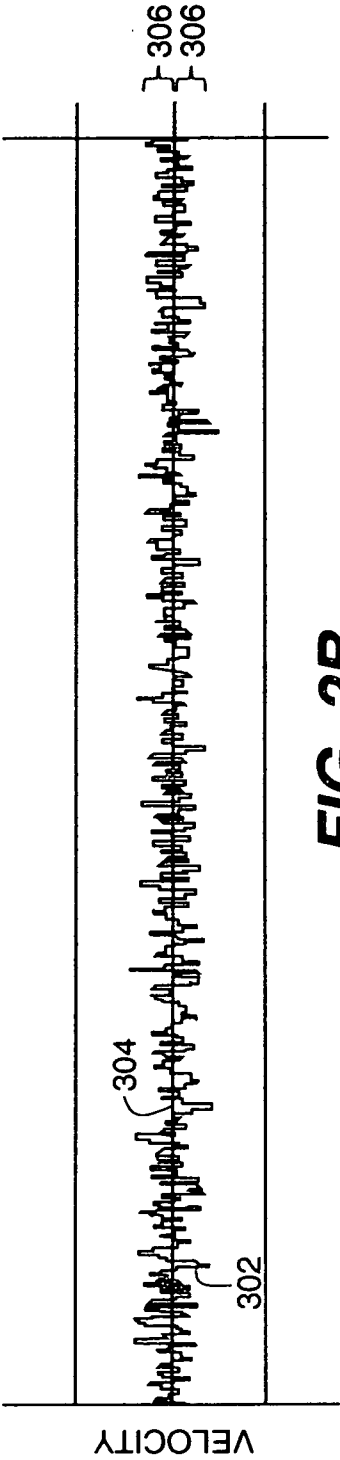


FIG. 2B

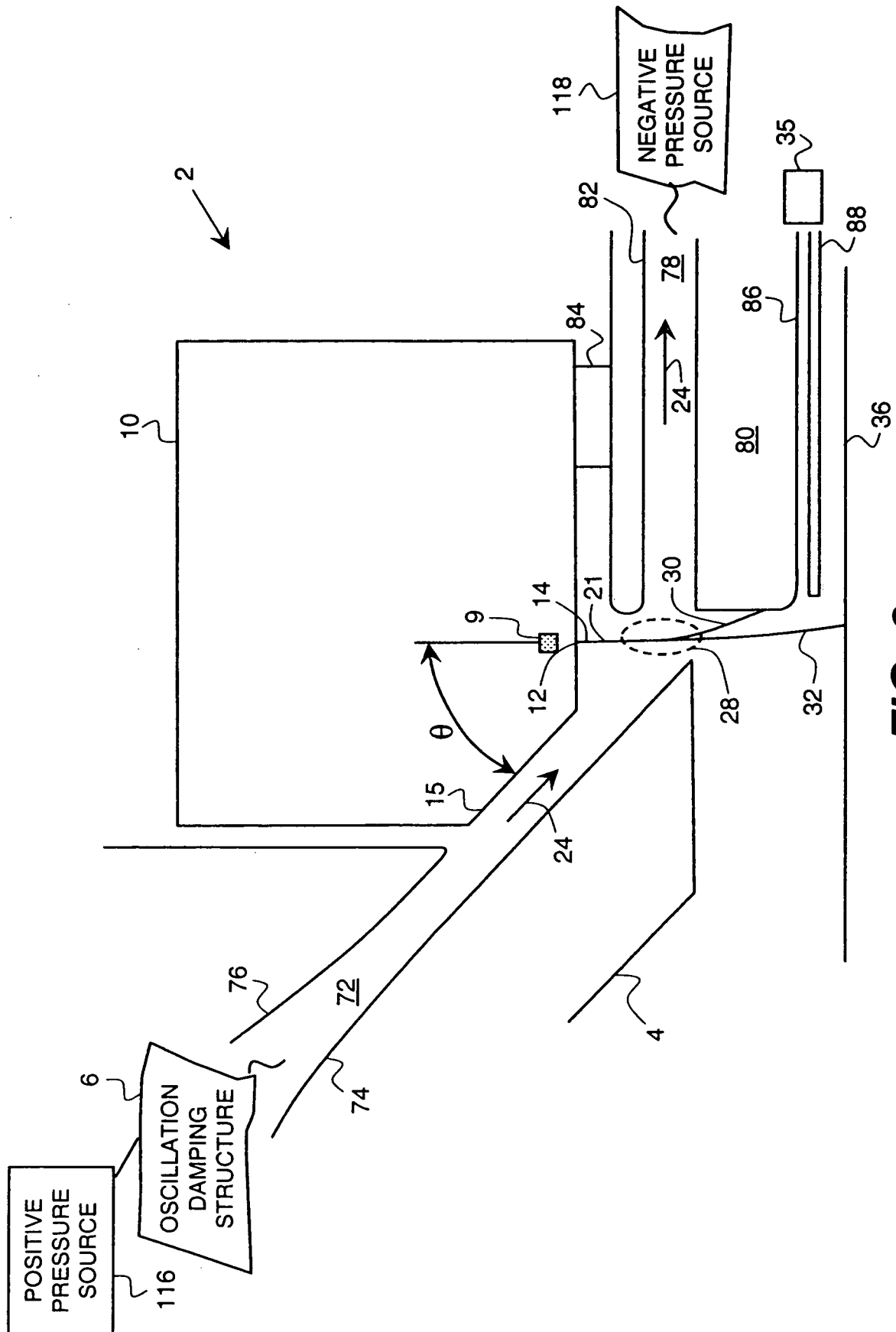


FIG. 3

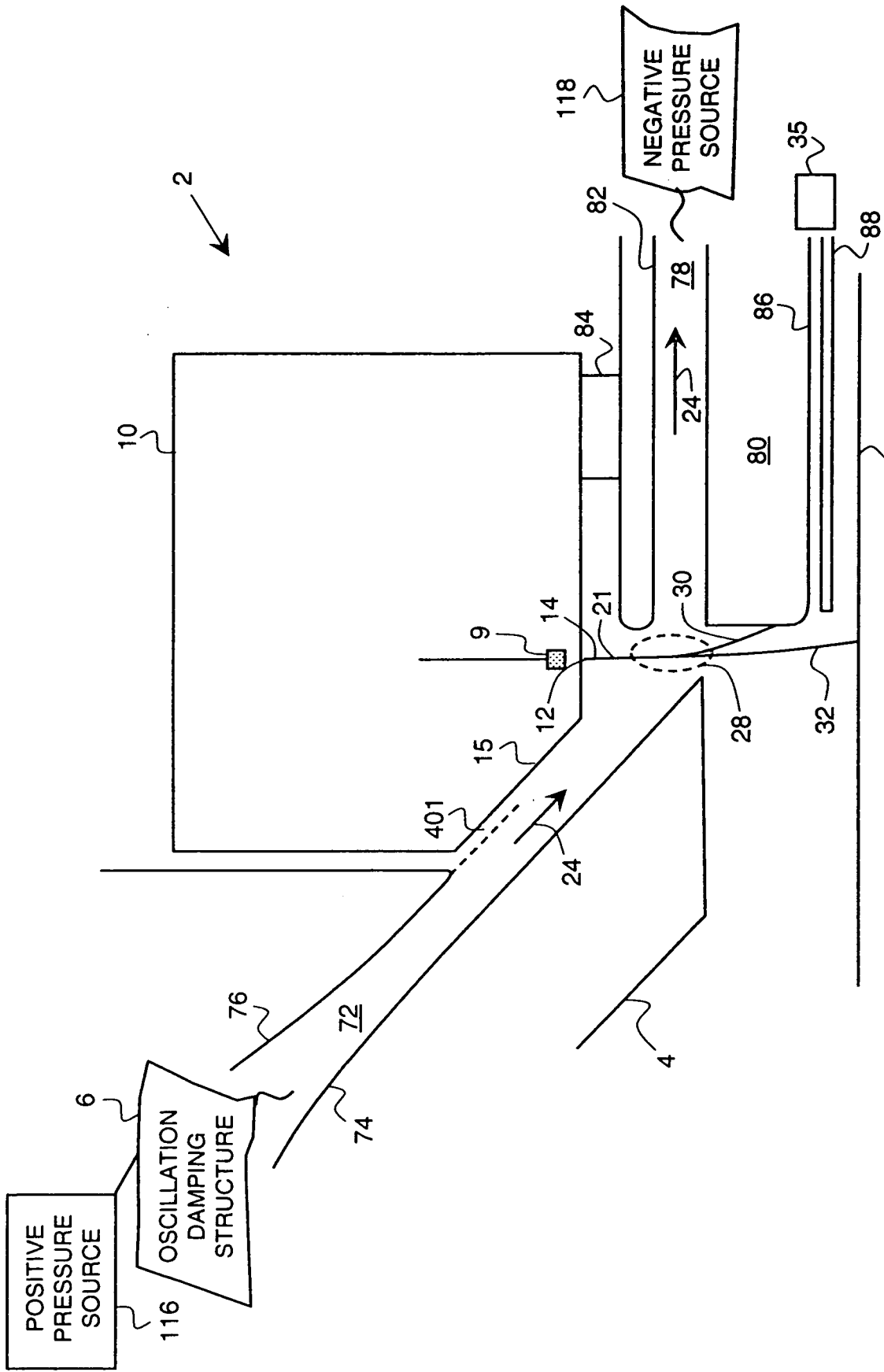


FIG. 4A

5/8

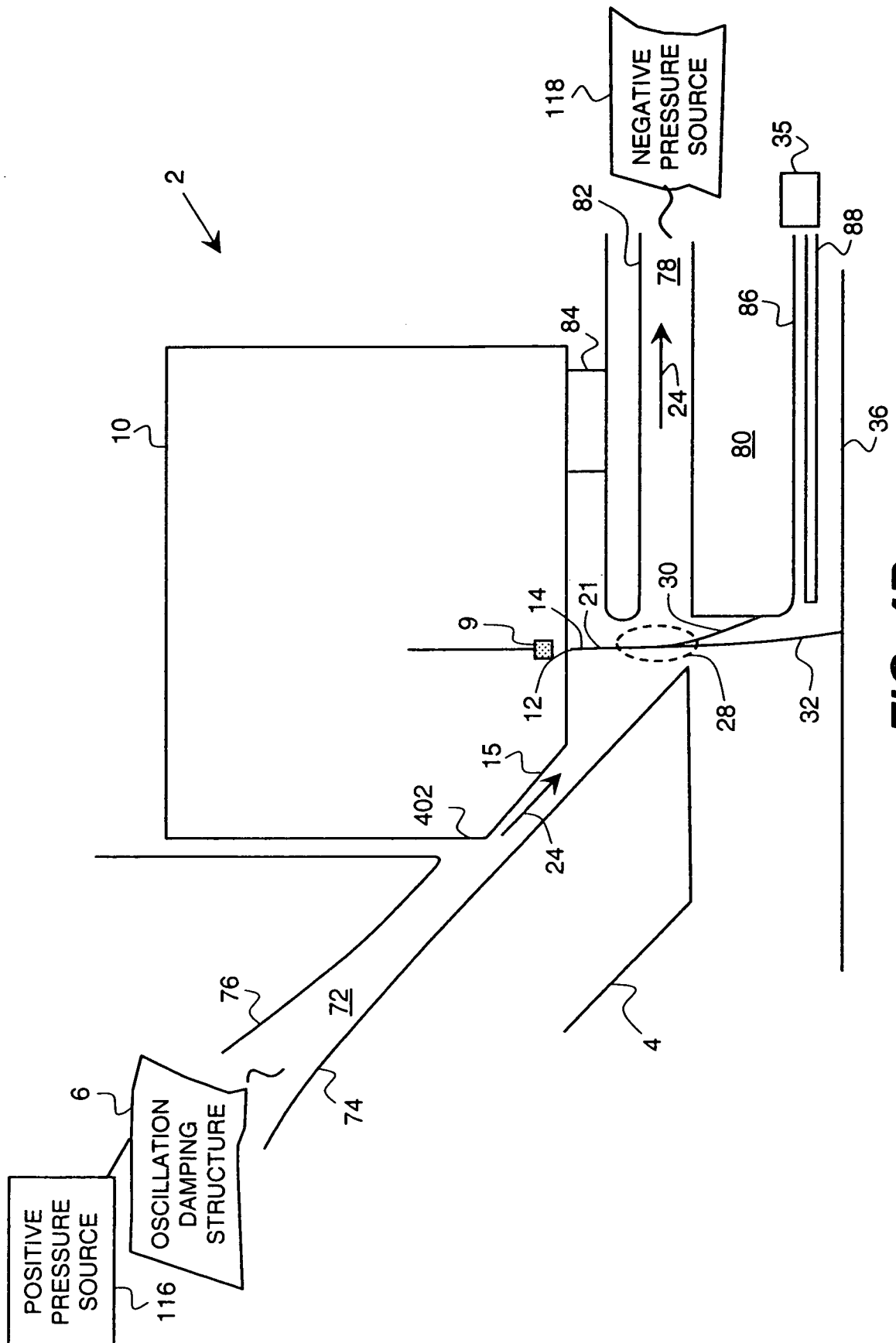


FIG. 4B

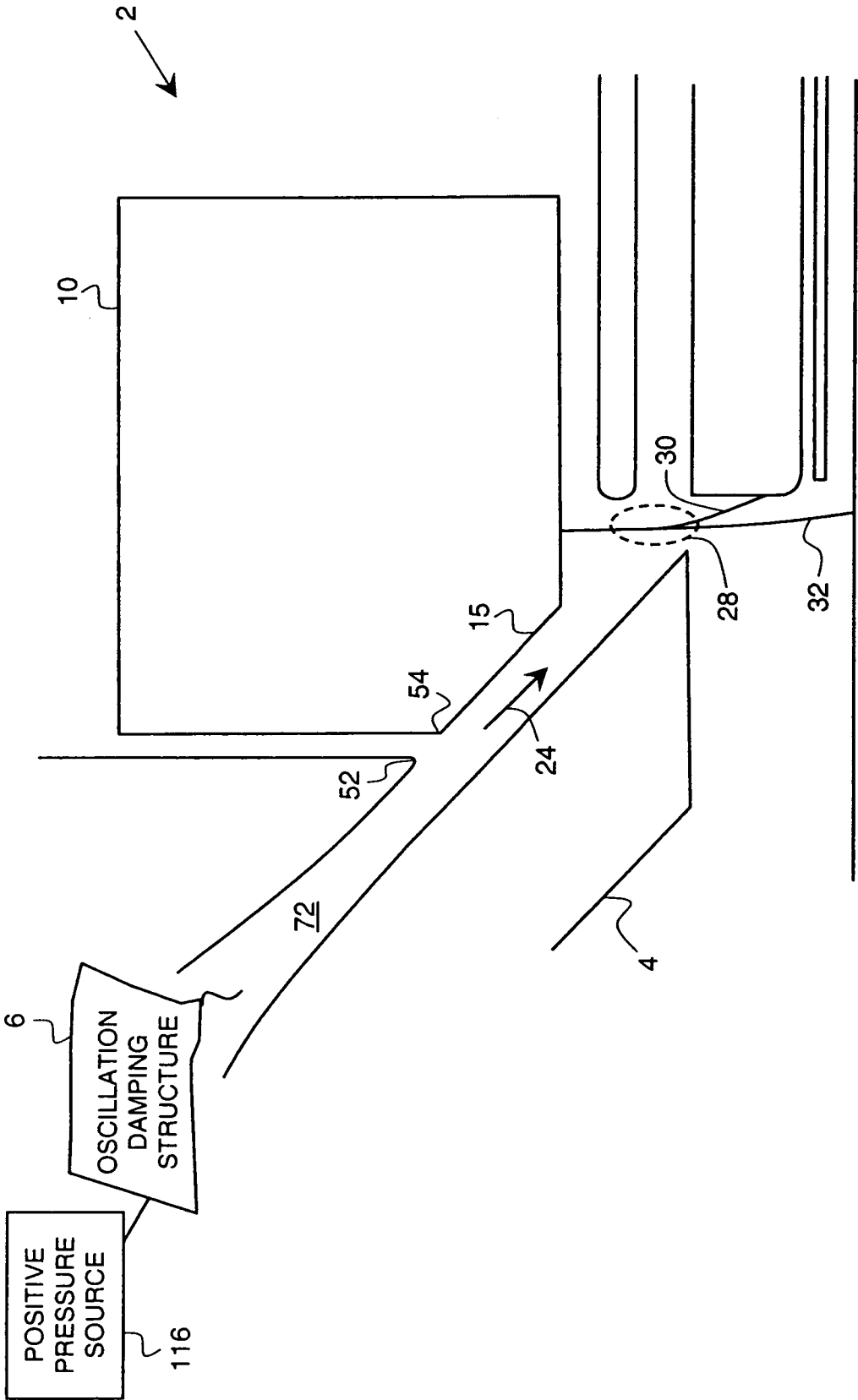
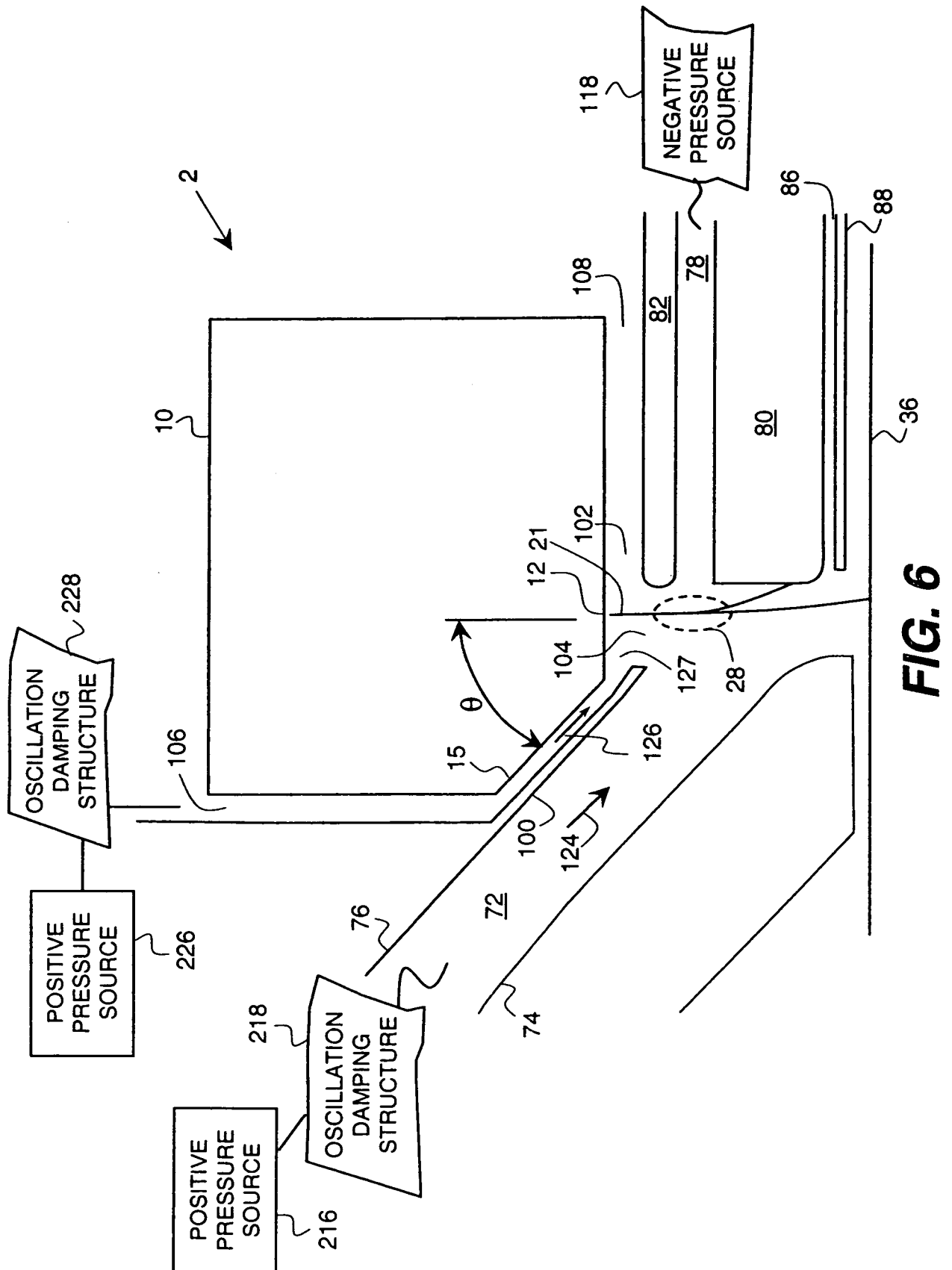
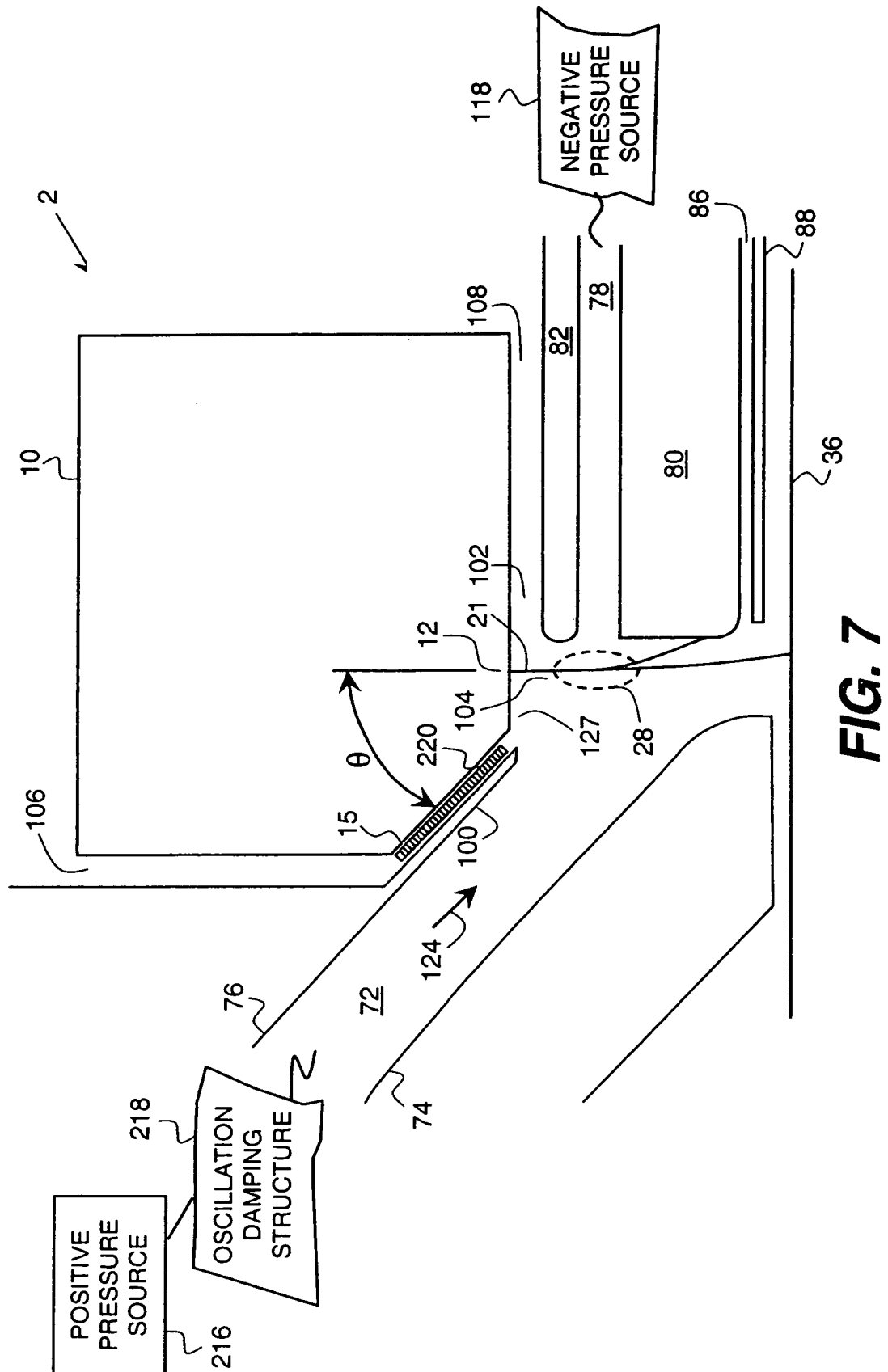


FIG. 5





INTERNATIONAL SEARCH REPORT

International application No
PCT/US2009/005831

A. CLASSIFICATION OF SUBJECT MATTER
INV. B41J2/09

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B41J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2004/095441 A1 (JEANMAIRE DAVID L [US]) 20 May 2004 (2004-05-20) paragraphs [0045], [0 49], [0 50]; figures 4-6	1-6
Y	US 6 491 362 B1 (JEANMAIRE DAVID L [US]) 10 December 2002 (2002-12-10) paragraph [0055]; figure 7	1-4
A		5-6
Y	EP 1 308 278 A1 (EASTMAN KODAK CO [US]) 7 May 2003 (2003-05-07) paragraphs [0032], [0 40]; figures 3, 5	5-6
A	EP 1 228 873 B1 (EASTMAN KODAK CO [US]) 19 October 2005 (2005-10-19) abstract figure 7	1-2
	----- -/-	

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

14 January 2010

Date of mailing of the international search report

25/03/2010

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Adam, Emmanuel

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2009/005831

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 219 429 A2 (EASTMAN KODAK CO [US]) 3 July 2002 (2002-07-03) paragraph [0040]; figure 3 -----	1,5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2009/005831

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-6

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6

A printhead comprising a drop generator and a gas flow deflection system, the gas flow deflection system including a gas flow pressure oscillation dampening structure located between the gas flow source and the drop deflection zone.

2. claims: 7-15

A printhead comprising a drop generator, a gas flow deflection system and a plenum structure including an outlet located between the drop generator and the gas flow duct that directs a second gas flow toward the drop deflection zone, the second gas flow having a second speed, the first speed of the first gas flow being substantially equivalent to the second speed of the second gas flow.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2009/005831

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