

METHOD OF REMOVING PARTICULATES FROM A PRINthead USING A LIQUID FOAM

5 Field of the Invention

This invention relates to inkjet printhead maintenance. It has been developed primarily for facilitating maintenance operations, such as cleaning particulates from an ink ejection face of the printhead.

10 Cross References to Related Applications

Various methods, systems and apparatus relating to the present invention are disclosed in the following US Patents/ Patent Applications filed by the applicant or assignee of the present invention:

09/517539	6566858	6331946	6246970	6442525	09/517384	09/505951
6374354	09/517608	09/505147	6757832	6334190	6745331	09/517541
10/203559	10/203560	10/203564	10/636263	10/636283	10/866608	10/902889
10/902833	10/940653	10/942858	10/727181	10/727162	10/727163	10/727245
10/727204	10/727233	10/727280	10/727157	10/727178	10/727210	10/727257
10/727238	10/727251	10/727159	10/727180	10/727179	10/727192	10/727274
10/727164	10/727161	10/727198	10/727158	10/754536	10/754938	10/727227
10/727160	10/934720	11/212702	11/272491	11/474278	10/296522	6795215
10/296535	09/575109	10/296525	09/575110	09/607985	6398332	6394573
6622923	6747760	10/189459	10/884881	10/943941	10/949294	11/039866
11/123011	11/123010	11/144769	11/148237	11/248435	11/248426	11/478599
10/922846	10/922845	10/854521	10/854522	10/854488	10/854487	10/854503
10/854504	10/854509	10/854510	10/854496	10/854497	10/854495	10/854498
10/854511	10/854512	10/854525	10/854526	10/854516	10/854508	10/854507
10/854515	10/854506	10/854505	10/854493	10/854494	10/854489	10/854490
10/854492	10/854491	10/854528	10/854523	10/854527	10/854524	10/854520
10/854514	10/854519	10/854513	10/854499	10/854501	10/854500	10/854502
10/854518	10/854517	10/934628	11/212823	10/728804	10/728952	10/728806
10/728834	10/728790	10/728884	10/728970	10/728784	10/728783	10/728925
10/728842	10/728803	10/728780	10/728779	10/773189	10/773204	10/773198
10/773199	10/773190	10/773201	10/773191	10/773183	10/773195	10/773196
10/773186	10/773200	10/773185	10/773192	10/773197	10/773203	10/773187
10/773202	10/773188	10/773194	10/773193	10/773184	11/008118	11/060751
11/060805	11/188017	11/298773	11/298774	11/329157	6623101	6406129

6505916	6457809	6550895	6457812	10/296434	6428133	6746105
10/407212	10/407207	10/683064	10/683041	6750901	6476863	6788336
11/097308	11/097309	11/097335	11/097299	11/097310	11/097213	11/210687
11/097212	11/212637	MTD001US	MTD002US	11/246687	11/246718	11/246685
11/246686	11/246703	11/246691	11/246711	11/246690	11/246712	11/246717
11/246709	11/246700	11/246701	11/246702	11/246668	11/246697	11/246698
11/246699	11/246675	11/246674	11/246667	11/246684	11/246672	11/246673
11/246683	11/246682	10/760272	10/760273	10/760187	10/760182	10/760188
10/760218	10/760217	10/760216	10/760233	10/760246	10/760212	10/760243
10/760201	10/760185	10/760253	10/760255	10/760209	10/760208	10/760194
10/760238	7077505	10/760235	7077504	10/760189	10/760262	10/760232
10/760231	10/760200	10/760190	10/760191	10/760227	10/760207	10/760181
11/446227	11/454904	11/472345	11/474273	MPA38US	11/474279	MPA40US
MPA41US	11/003786	11/003616	11/003418	11/003334	11/003600	11/003404
11/003419	11/003700	11/003601	11/003618	11/003615	11/003337	11/003698
11/003420	6984017	11/003699	11/071473	11/003463	11/003701	11/003683
11/003614	11/003702	11/003684	11/003619	11/003617	11/293800	11/293802
11/293801	11/293808	11/293809	CAG006US	CAG007US	CAG008US	CAG009US
CAG010US	CAG011US	11/246676	11/246677	11/246678	11/246679	11/246680
11/246681	11/246714	11/246713	11/246689	11/246671	11/246670	11/246669
11/246704	11/246710	11/246688	11/246716	11/246715	11/246707	11/246706
11/246705	11/246708	11/246693	11/246692	11/246696	11/246695	11/246694
FNE010US	FNE011US	FNE012US	FNE013US	FNE015US	FNE016US	FNE017US
FNE018US	FNE019US	FNE020US	FNE021US	FNE022US	FNE023US	FNE024US
FNE025US	FNE026US	KIP001US	KPE001US	KPE002US	KPE003US	KPE004US
11/293832	11/293838	11/293825	11/293841	11/293799	11/293796	11/293797
11/293798	11/293804	11/293840	11/293803	11/293833	11/293834	11/293835
11/293836	11/293837	11/293792	11/293794	11/293839	11/293826	11/293829
11/293830	11/293827	11/293828	11/293795	11/293823	11/293824	11/293831
11/293815	11/293819	11/293818	11/293817	11/293816	RMC001US	10/760254
10/760210	10/760202	10/760197	10/760198	10/760249	10/760263	10/760196
10/760247	10/760223	10/760264	10/760244	10/760245	10/760222	10/760248
10/760236	10/760192	10/760203	10/760204	10/760205	10/760206	10/760267
10/760270	10/760259	10/760271	10/760275	10/760274	10/760268	10/760184
10/760195	10/760186	10/760261	10/760258	11/442178	11/474272	11/474315
11/014764	11/014763	11/014748	11/014747	11/014761	11/014760	11/014757
11/014714	11/014713	11/014762	11/014724	11/014723	11/014756	11/014736
11/014759	11/014758	11/014725	11/014739	11/014738	11/014737	11/014726
11/014745	11/014712	11/014715	11/014751	11/014735	11/014734	11/014719
11/014750	11/014749	11/014746	11/014769	11/014729	11/014743	11/014733

11/014754	11/014755	11/014765	11/014766	11/014740	11/014720	11/014753
11/014752	11/014744	11/014741	11/014768	11/014767	11/014718	11/014717
11/014716	11/014732	11/014742	11/097268	11/097185	11/097184	11/293820
11/293813	11/293822	11/293812	11/293821	11/293814	11/293793	11/293842
11/293811	11/293807	11/293806	11/293805	11/293810	11/124158	11/124196
11/124199	11/124162	11/124202	11/124197	11/124154	11/124198	11/124153
11/124151	11/124160	11/124192	11/124175	11/124163	11/124149	11/124152
11/124173	11/124155	11/124157	11/124174	11/124194	11/124164	11/124200
11/124195	11/124166	11/124150	11/124172	11/124165	11/124186	11/124185
11/124184	11/124182	11/124201	11/124171	11/124181	11/124161	11/124156
11/124191	11/124159	11/124175	11/124188	11/124170	11/124187	11/124189
11/124190	11/124180	11/124193	11/124183	11/124178	11/124177	11/124148
11/124168	11/124167	11/124179	11/124169	11/187976	11/188011	11/188014
MCD062US	11/228540	11/228500	11/228501	11/228530	11/228490	11/228531
11/228504	11/228533	11/228502	11/228507	11/228482	11/228505	11/228497
11/228487	11/228529	11/228484	11/228489	11/228518	11/228536	11/228496
11/228488	11/228506	11/228516	11/228526	11/228539	11/228538	11/228524
11/228523	11/228519	11/228528	11/228527	11/228525	11/228520	11/228498
11/228511	11/228522	11/228515	11/228537	11/228534	11/228491	11/228499
11/228509	11/228492	11/228493	11/228510	11/228508	11/228512	11/228514
11/228494	11/228495	11/228486	11/228481	11/228477	11/228485	11/228483
11/228521	11/228517	11/228532	11/228513	11/228503	11/228480	11/228535
11/228478	11/228479	6238115	6386535	6398344	6612240	6752549
6805049	6971313	6899480	6860664	6925935	6966636	7024995
10/636245	6926455	7056038	6869172	7021843	6988845	6964533
6981809	11/060804	11/065146	11/155544	11/203241	11/206805	11/281421
11/281422	PFA001US		SBF001US	SBF002US	SBF003US	09/575197
7079712	09/575123	6825945	09/575165	6813039	6987506	7038797
6980318	6816274	09/575139	09/575186	6681045	6728000	09/575145
09/575192	09/575181	7068382	7062651	6789194	6789191	6644642
6502614	6622999	6669385	6549935	6987573	6727996	6591884
6439706	6760119	09/575198	6290349	6428155	6785016	6870966
6822639	6737591	7055739	09/575129	6830196	6832717	6957768
09/575162	09/575172	09/575170	09/575171	09/575161		

The disclosures of these applications and patents are incorporated herein by reference.

Background of the Invention

Inkjet printers are commonplace in homes and offices. However, all commercially available inkjet printers suffer from slow print speeds, because the printhead must scan across a stationary sheet of paper. After each sweep of the printhead, the paper advances incrementally until a complete printed page is produced.

5 It is a goal of inkjet printing to provide a stationary pagewidth printhead, whereby a sheet of paper is fed continuously past the printhead, thereby increasing print speeds greatly. The present Applicant has developed many different types of pagewidth inkjet printheads using MEMS technology, some of which are described in the patents and patent applications included in the cross reference list above.

10

The contents of these patents and patent applications are incorporated herein by cross-reference in their entirety.

Notwithstanding the technical challenges of producing a pagewidth inkjet printhead, a crucial aspect of any inkjet printing is maintaining the printhead in an operational printing condition throughout its lifetime. A number of factors may cause an inkjet printhead to become non-operational and it is important for any inkjet printer to include a strategy for preventing printhead failure and/or restoring the printhead to an operational printing condition in the event of failure. Printhead failure may be caused by, for example, printhead face flooding, dried-up nozzles (due to evaporation of water from the nozzles – a phenomenon known in the art as decap), or particulates fouling nozzles.

20

Particulates, in the form of paper dust, are a particular problem in high-speed pagewidth printing. This is because the paper is typically fed at high speed over a paper guide and past the printhead. Frictional contact of the paper with the paper guide generates large quantities of paper dust compared to traditional scanning inkjet printheads, where paper is fed much more slowly. Hence, pagewidth printheads tend to accumulate paper dust on their ink ejection face during printing. This accumulation of paper dust is highly undesirable.

25

In the worst case scenario, paper dust blocks nozzles on the printhead, preventing those nozzles from ejecting ink. More usually, paper dust overlies nozzles and partially covers nozzle apertures. Nozzle apertures that are partially obscured or blocked produce misdirected ink droplets during printing – the ink droplets are deflected from their intended trajectory by particulates on the ink ejection face. Misdirects are highly undesirable and may result in acceptably low print quality.

30

One measure that has been used for maintaining printheads in an operational condition is sealing the printhead, which prevents the ingress of particulates and also prevents evaporation of ink from nozzles. Commercial inkjet printers are typically supplied with a sealing tape across the printhead, which the user removes when the printer is installed for use. The sealing tape protects the primed printhead from particulates and prevents the nozzles from drying up during transit. Sealing tape also controls flooding of ink over the printhead face.

Aside from one-time use sealing tape on newly purchased printers, sealing has also been used as a strategy for maintaining printheads in an operational condition in between print jobs. In some commercial printers, a gasket-type sealing ring and cap engages around a perimeter of the printhead when the printer is idle. A vacuum may be connected to the sealing cap and used to suck ink from the nozzles, unblocking any nozzles that have dried up. However, whilst sealing/vacuum caps may prevent the ingress of particulates from the atmosphere, such measures do not *remove* particulates already built up on the printhead.

In order to remove flooded ink from a printhead after vacuum flushing, prior art maintenance stations typically employ a rubber squeegee, which is wiped across the printhead. Particulates are removed from the printhead by flotation into the flooded ink and the squeegee removes the flooded ink having particulates dispersed therein.

However, rubber squeegees have several shortcomings when used with MEMS pagewidth printheads. A typical MEMS printhead has a nozzle plate comprised of a hard, durable material such as silicon nitride, silicon oxide, aluminium nitride *etc.* Moreover, the nozzle plate is typically relatively abrasive due to etched features on its surface. On the one hand, it is important to protect the nozzle plate, comprising sensitive nozzle structures, from damaging exposure to the shear forces exerted by a rubber squeegee. On the other hand, it is equally important that a rubber squeegee should not be damaged by contact with the printhead and reduce its cleaning efficacy.

In our earlier US Patent Application Numbers 11/246707 (Docket No. FNE001US), 11/246706 (Docket No. FNE002US), 11/246705 (Docket No. FNE003US), 11/246708 (Docket No. FNE004US) all filed October 11, 2005 and 11/482,958 (Docket No. FNE010US), 11/482955 (Docket No. FNE011US) and 11/482962 (Docket No. FNE012US), all filed July 10, 2006, the contents of which are herein incorporated by reference, we described a method for removing particulates from a printhead. This involves flooding the printhead face with ink and transferring the flooded ink onto a transfer surface moving past the face, but not in contact with the face.

It would be desirable to provide an ink jet printhead maintenance station and method that consume minimal quantities of ink during maintenance cycles and provides effective removal of particulates from the printhead face without any damaging contact therewith.

5

Summary of the Invention

In a first aspect the present invention provides a method of removing particulates from an ink ejection face of a printhead, said method comprising the steps of:

10 (i) providing a liquid foam on said face, thereby dispersing said particulates in said foam; and

(ii) transferring said foam, including said particulates, onto a transfer surface moving past said face.

15 Optionally, said transfer surface does not contact said face.

Optionally, said foam collapses to a liquid droplet as it is transferred onto said transfer surface.

20 Optionally, said liquid foam is an ink foam.

Optionally, ink in said ink foam is provided by ink contained in said printhead.

25 Optionally, said ink foam is provided by passing a gas through ink supply channels in said printhead, thereby expelling the ink foam from nozzles in said ink ejection face.

Optionally, air is forced under pressure through said ink channels.

Optionally, said transfer surface contacts said foam when moving past said face.

30

Optionally, said transfer surface is less than 1 mm from said face when moving past said face.

5

Optionally, said transfer surface is moved past said face by rotating said roller.

In a further aspect the present invention provides a method further comprising the step of:

(iii) removing foam or ink from said transfer surface using an ink removal system.

Optionally, said transfer surface is an outer surface of a first transfer roller and said ink removal system comprises a cleaning pad in contact with said first transfer roller.

Optionally, said second transfer roller has a wetting surface for receiving ink from said transfer surface.

Optionally, a cleaning pad is in contact with said second transfer roller.

- (a) a printhead having an ink ejection face;
- (b) a foaming system for providing a liquid foam on said face; and
- (c) a foam transport assembly comprising:
 - a transfer surface for receiving the foam from said face; and

a transport mechanism for feeding said transfer surface through a transfer zone and away from said printhead, wherein said transfer zone is adjacent to and spaced apart from said face.

5 Optionally, said liquid foam is an ink foam.

In a further aspect there is provided a maintenance system further comprising a valve configurable in first and second positions, wherein in a first position said printhead is in fluid communication with an ink supply system and in a second position said printhead is
10 in fluid communication with said foaming system.

Optionally, said foaming system supplies a gas to ink supply channels in said printhead, thereby expelling an ink foam from nozzles in said ink ejection face.

15 Optionally, said foaming system comprises a pump for supplying air to said ink supply channels.

Optionally, said foaming system comprises an accumulator vessel pressurizable by said
20 pump.

Optionally, said foaming system is configured such that said pump and said accumulator vessel cooperate to supply pressurized air to said ink supply channels.

Optionally, said foaming system comprises a foam dispenser having a nozzle for
25 dispensing a liquid foam onto said face.

Optionally, said transfer surface is a surface of a film.

Optionally, said transfer surface is an outer surface of a first transfer roller.
30 Optionally, said transfer surface is fed through said transfer zone by rotating said roller.

Optionally, said roller is substantially coextensive with said printhead.

Optionally, said transfer zone is spaced less than 1 mm from said face.

Optionally, said ink transport assembly is moveable between a first position in which said transfer surface is positioned in said transfer zone and a second position in which said transfer surface is positioned remotely from said printhead.

In a further aspect there is provided a maintenance system further comprising:

(d) an ink removal system for removing ink from said transfer surface.

Optionally, said transfer surface is an outer surface of a first transfer roller and said ink removal system comprises a cleaning pad in contact with said first transfer roller.

Optionally, said transfer surface is an outer surface of a first transfer roller and said ink removal system comprises a second transfer roller engaged with said first transfer roller.

Optionally, said second transfer roller has a wetting surface for receiving ink from said transfer surface.

Optionally, a cleaning pad is in contact with said second transfer roller.

In a further aspect there is provided a maintenance system further comprising a control system for coordinating the transport mechanism with said foaming system.

Optionally, said control system is configured to activate said transport mechanism at the same time as said foaming system is activated to provide a liquid foam on said face.

In a third aspect the present invention provides a printhead assembly comprising:

- (a) a printhead having an ink ejection face;
- (b) an ink supply system for supplying ink to said printhead; and
- (c) a foaming system for providing a liquid foam on said face.

Optionally, said assembly is configurable such that ink supply channels in said printhead are in fluid communication either with said ink supply system or said foaming system.

Optionally, in a printing configuration, said printhead is in fluid communication with said ink supply system, and in a maintenance configuration, said printhead is in fluid communication with said foaming system.

- 5 In a further aspect there is provided a printhead assembly further comprising a valve configurable in first and second positions, wherein in a first position said printhead is in fluid communication with said ink supply system and in a second position said printhead is in fluid communication with said foaming system.

- 10 Optionally, said foaming system supplies a gas to ink supply channels in said printhead, thereby expelling an ink foam from nozzles in said ink ejection face.

Optionally, said foaming system comprises a pump for supplying air to said ink supply channels.

15

Optionally, said foaming system comprises an accumulator vessel pressurizable by said pump.

- 20 Optionally, said foaming system is configured such that said pump and said accumulator vessel cooperate to supply pressurized air to said ink supply channels.

Optionally, said ink supply system comprises a priming/de-priming system for de-priming said nozzles prior to foaming and/or re-priming said nozzles with ink after foaming.

- 25 Optionally, said foaming system comprises a foam dispenser having a nozzle for dispensing a liquid foam onto said face.

Optionally, said ink supply system comprises one or more ink reservoirs.

- 30 In a further aspect there is provided a printhead assembly further comprising:
(d) a foam removal system for removing the liquid foam from said face.

Optionally, the foam removal system comprises a transfer surface onto which said foam collapses.

Optionally, said transfer surface does not contact said face.

As used herein, the term “ink” refers to any liquid fed from an ink reservoir to the
5 printhead and ejectable from nozzles in the printhead. The ink may be a traditional cyan,
magenta, yellow or black ink. Alternatively, the ink may be an infrared ink. Alternatively,
the ‘ink’ may be a cleaning liquid (*e.g.* water, dyeless ink base, surfactant solution, glycol
solution *etc.*) which is not used for printing, but instead used specifically for cleaning the
ink ejection face of the printhead (see Applicant’s earlier applications 11/482,976 (Docket
10 No. FNE025US) and 11/482,973 (Docket No. FNE026US) both filed July 10, 2006, the
contents of which are incorporated herein by reference).

The present application, in its preferred form, advantageously allows particulates to
be removed from a printhead, whilst avoiding contact of the printhead with an external
15 cleaning device. Hence, unlike prior art squeegee-cleaning methods, the cleaning action of
the present invention does not impart any shear forces across the printhead and minimizes
damage sensitive nozzle structures. Moreover, the transfer surface in the present invention,
which does not come into contact with the printhead, is not damaged by the printhead and
can therefore be used repeatedly whilst maintaining optimal cleaning action.

20 A further advantage of the present invention is that it consumes relatively little ink
compared to prior art suction devices and systems requiring printhead face flooding. In
particular, the present invention requires a fraction of the ink used by maintenance systems
requiring flooding the printhead face with ink (see, for example, 11/246707 (Docket No.
FNE001US), 11/246706 (Docket No. FNE002US), 11/246705 (Docket No. FNE003US),
25 11/246708 (Docket No. FNE004US) all filed October 11, 2005 and 11/482,958 (Docket
No. FNE010US), 11/482955 (Docket No. FNE011US) and 11/482962 (Docket No.
FNE012US) all filed July 10, 2006).

A further advantage of the present invention is that a foam has been found to be
more efficacious than flooded ink in removing particulates from a printhead face. An
30 explanation of this improved efficacy is provided in more detail below.

Brief Description of the Drawings

Specific forms of the present invention will be now be described in detail, with
reference to the following drawings, in which:-

Figure 1 is a schematic view of a printhead maintenance system according to the present invention;

Figure 2 is a schematic view of the printhead maintenance system shown in Figure 1 with an ink foam provided across the printhead;

5 Figure 3 is a schematic view of the printhead maintenance system shown in Figure 2 with the transfer surface positioned in the transfer zone;

Figure 4A is a magnified view of particulates trapped on a printhead face and covered with flooded ink;

Figure 4B shows one of the particulates in Figure 4A floating in the flooded ink;

10 Figure 5A is a magnified view of particulates trapped on a printhead face and covered with an ink foam;

Figure 5B is a magnified view of particulates entrained in the ink foam shown in Figure 5A;

Figure 6 is an enlarged view of the transfer zone in Figure 3;

15 Figure 7 is a schematic view of the printhead maintenance station shown in Figure 1 with ink being transported on a transfer surface;

Figure 8 is a section through line A-A of the printhead maintenance station shown in Figure 10;

20 Figure 9 a section through line B-B of the printhead maintenance station shown in Figure 10;

Figure 10 is a front view of a printhead maintenance station;

Figure 11 is an exploded perspective view of the printhead maintenance station shown in Figure 10; and

25 Figure 12 is a schematic view of an alternative foaming system.

Detailed Description of Specific Embodiments

Printhead Maintenance System with Ink Foaming System

30 Referring to Figure 1, there is shown a printhead maintenance system 1 for maintaining a printhead 2 in an operable condition. During printing, paper dust and other particulates may build up on the ink ejection face 3 of the printhead 2, leading to misdirected ink droplets from partially obscured nozzles or even blocked nozzles. Paper dust is a particular problem in high-speed printing where paper is fed over a paper guide at high speed, generating relatively high abrasive forces compared to low-speed printing. The

printhead maintenance system 1 is configured to maintain the printhead in an optimal operating condition by removing particulates from the ink ejection face 3 and/or unblocking nozzles which may be blocked with particulates.

The printhead maintenance system 1 comprises a plurality of ink reservoirs 4a, 4b, 4c and 4d, each supplying ink to the printhead 2 via respective ink conduits 5a, 5b, 5c and 5d. The printhead 2 is attached to an ink manifold 6, which directs ink supplied by the ink conduits 5a, 5b, 5c and 5d into a backside of the printhead. A plurality of solenoid valves 7a, 7b, 7c and 7d are positioned in respective ink conduits 5a, 5b, 5c, 5d and are controlled by a printhead maintenance control system.

Each valve 7 may be configured for either normal printing or printhead maintenance. In a first printing configuration, as shown in Figure 1, each valve 7a, 7b, 7c and 7d provides fluid communication between the printhead 2 and the ink reservoirs 4a, 4b, 4c and 4d. In a second maintenance configuration, as shown in Figure 2, each valve 7a, 7b, 7c and 7d provides fluid communication between the printhead 2 and a foaming system 10.

The foaming system 10 comprises a pump 11 having an air inlet 13 and an outlet connected to an accumulator vessel 12. With a stop-valve 14 closed, the pump 11 charges the accumulator vessel 12 to a predetermined pressure. When an ink foam on the printhead face 3 is required, the valves 7a, 7b, 7c and 7d are connected to the foaming system 10.

The stop-valve 14 is then opened to force pressurized air from the accumulator vessel 12 into the printhead 2 via an air conduit 15. The pressurized air foams any ink in the printhead 2 and the resultant ink foam 30 is expelled through nozzles in the printhead onto the ink ejection face 3. Figure 2 shows the printhead 2 having an ink foam 30 across its ink ejection face 3.

As shown in Figure 2, the ink foam 30 is generated without a transfer roller 20 in a maintenance position. However, the ink foam 30 preferably generated with the transfer roller 20 in its maintenance position, whilst initiating rotation of the roller at about the same time as the foam is generated, as shown in Figure 3. This prevents the ink foam 30 from spreading excessively over other printer components, such as a wire-bond encapsulant 8 which covers wire-bonds connecting the printhead 2 to power and logic provided by a print controller (not shown).

Foaming may be performed on a fully primed or a de-primed printhead 2. If the printhead 2 is de-primed, there is generally still sufficient residual ink (*ca.* 0.1 mL) in ink channels in the ink manifold 6 and/or printhead 2 to generate an ink foam 30 across the ink

ejection face 3. Obviously, if the printhead 2 is fully primed, then more ink will be consumed by foaming. Accordingly, foaming a de-primed printhead 2 has the advantage of consuming less ink. In our earlier US Patent Application Numbers 11/482,982 (Docket No. SBF001US), 11/482,983 (Docket No. SBF002US), 11/482,984 (Docket No. SBF003US and simultaneously co-filed US Application SBF004US (temporarily identified by its docket number), which are all incorporated herein by reference, describe methods of priming and de-priming a printhead for storage or maintenance operations. SBF004US describes a printer fluidics system, which incorporates an ink supply system suitable for priming/de-priming a printhead and foaming system for providing a foam across the printhead face. It will be understood that the maintenance system of the present invention may include the system described in SBF004US.

Not only does the ink foam 30 consume less ink than merely flooding the ink ejection face 3, it also provides for more efficacious removal of particulates 32. Whereas flooded ink relies primarily on flotation of particulates 32 into the ink, the ink foam 30 provides a multidirectional attractive force onto each particulate, which encourages the particulates to become entrained in the foam, as opposed to remaining on the printhead face 3.

Figures 4 and 5 compare flooded ink 31 and ink foam 30 as a means for removing particulates 32 from an ink ejection face 3 having a nozzle 33. In Figure 4A, there is shown one particulate 32a resting on the ink ejection face 3 and another particulate 32b trapped partially inside a nozzle 33. As shown in Figure 4B, the flooded ink 31 provides sufficient flotation force on particulate 32a to lift it away from the face 3 and the particulate 32a becomes dispersed in the flooded ink 31. However, the relatively weak flotation force is insufficient to lift the other particulate 32b out of the nozzle 33 and it remains trapped, meaning that the nozzle 33 is blocked and inoperative.

Figure 5A, on the other hand, shows the same two particulates 32a and 32b surrounded by the ink foam 30. The foam 30 comprises randomly-packed Voronoi polyhedra. Ink is contained in Plateau borders 35 between adjacent polyhedra, with voids 36 in the foam 30 being filled with air. Each Plateau border 35, where it meets a particulate 32, exerts an attractive force on that particulate. Given the random nature of the foam 30, each particulate receives a multidirectional lifting force as indicated by the arrows in Figure 4A. The result is that each particulate 32 receives a stronger force lifting it away from the ink ejection face 3. As shown in Figure 4B, this stronger multidirectional force is

sufficient to not only lift the particulate 32a away from the face 3, but also dislodge the particulate 32b, which is more firmly trapped in the nozzle 100.

The particulates 32a and 32b become entrained or dispersed into the foam 30 and occupy positions defined by Plateau border vertices.

5 In addition, and depending on the pressure in the accumulator vessel 12, the blast of air through the printhead nozzles (*e.g.* 33) during foaming will also have the effect of dislodging particulates 32 which may be trapped in or on the nozzles themselves.

 Having entrained the particulates 32 into the foam 30, as shown in Figures 5B and 6, the foam is then transferred onto a transfer surface 24 and transported away from the printhead 2. Generally, the ink foam 30 collapses to an ink droplet upon contact with the
10 transfer surface 24. The surface characteristics and movement of the transfer surface 24 ensure that the ink foam 30 collapses onto the transfer surface and not back onto the printhead face 3. As mentioned earlier, foam generation and foam transfer preferably occur simultaneously so as to avoid excessive spreading of the foam 30.

15 Referring now to Figure 6, there is shown a first transfer roller 20 comprising a stainless steel core roller 21 having an outer transfer film 22. A resiliently deformable intermediate layer 23 is sandwiched between the transfer film 22 and the core roller 21. The first transfer roller 20 is coextensive with the printhead 2, which is a pagewidth inkjet printhead. Hence, the metal roller 21 provides rigidity in the first transfer roller 20 along its
20 entire length.

 An outer surface of the transfer film 22 defines the transfer surface 24, which receives the ink foam 30 during printhead maintenance operations. The intermediate layer 23 provides resilient support for the transfer film 22, thereby allowing resilient engagement between the transfer surface 24 and an ink removal system (not shown in Figure 6).

25 The first transfer roller 20 is moveable between a printing configuration (as shown in Figure 1) in which the roller is distal from the printhead 2, and a printhead maintenance configuration (as shown in Figure 6) in which the transfer surface 24 is positioned in a transfer zone. When positioned in the transfer zone, the transfer surface 24 is adjacent to but not in contact with the ink ejection face 3 of the printhead 2. The transfer surface 24
30 may or may not be in contact with the wire-bond encapsulant 8 bonded along an edge portion of the printhead 2 when it is positioned in the transfer zone.

 The first transfer roller 20 is rotatable about its longitudinal axis so as to allow the transfer surface 24 to be fed through the transfer zone and away from the printhead 2. Rotation of the first transfer roller 20 is provided by means of a transport mechanism (not

shown in Figure 1), operatively connected to the core roller 21. The transport mechanism typically comprises a simple motor operatively connected to the core roller 21 via a gear mechanism.

5 A method of maintaining or removing particulates the ink ejection face 3 of the printhead 2 will now be described with reference to Figures 1, 3, 6 and 7. Initially, as shown in Figure 1, the first transfer roller 20 is in an idle or printing position, with the transfer surface 24 distal from the printhead 2. During idle periods or during printing, the valve 14 is closed and the accumulator vessel 12 is charged with air by the pump 11. Hence, the accumulator vessel 12 is charged with pressurized air in readiness for
10 maintenance operations.

When printhead maintenance is required, the first transfer roller 20 is moved into its printhead maintenance position, in which the transfer surface 24 is positioned in a transfer zone adjacent the ink ejection face 3, as shown in Figures 3 and 6. Typically, a minimum distance between the transfer zone and the ink ejection face 3 is less than about 2
15 mm, or less than about 1 mm, or less than about 0.5 mm.

Next, the valves 7a, 7b, 7c and 7d are configured so that ink channels in the printhead 2 communicate with the foaming system 10 (as shown in Figure 3) rather than than the ink reservoirs 4a, 4b, 4c and 4d. An ink foam 30 is then generated by opening the stop-valve 14 and at the same time the transfer roller 20 is rotated.

20 As shown more clearly in Figure 6, the ink foam 30 has particulates 32 of paper dust entrained therein, which have lifted from the ink ejection face 3. The ink foam 30, including its entrained particulates 32, is transferred onto the transfer surface 24 by rotation of the first transfer roller 20, thereby feeding the transfer surface through the transfer zone and away from the printhead 2. The transfer film 22 may be a plastics film comprised of
25 polyethers, polyolefins (*e.g.* polyethylene, polypropylene), polycarbonates, polyesters or polyacrylates. Typically, the transfer film is comprised of a wetting or hydrophilic material to maximize transfer of ink onto the transfer surface 24. Accordingly, the transfer film 22 may be comprised of a hydrophilic polymer or, alternatively, the transfer surface 24 may be coated with a hydrophilic coating (*e.g.* silica particle coating) to impart wetting
30 properties. A polyoxymethylene transfer film 22 is particularly preferred due to its relatively wetting surface characteristics.

As shown in Figures 3 and 6, the first transfer roller 20 is rotated anticlockwise so that the transfer surface 24 transports ink away from the side of the printhead 2 not having the encapsulant 8 bonded thereto. This arrangement maximizes the efficacy of ink transfer.

Referring now to Figure 7, there is shown the printhead maintenance system 1 after completion of a printhead maintenance operation. The ink foam 30 has collapsed onto the transfer surface 24 as a droplet of ink 40 containing entrained particulates. The ink ejection face 3 is left clean and free of any particulates.

- 5 The ink 40 collected on the transfer surface 24 is removed by an ink removal system, which is not shown in Figures 1 to 7, but which will now be described in detail with reference to Figures 8 to 11.

Referring initially to Figure 8, a maintenance station 50 comprises a first transfer roller 20, as described above, engaged with a stainless steel second transfer roller 51. An
10 absorbent cleaning pad 52 is in contact with the second transfer roller. The second transfer roller 51 and cleaning pad 52 together form the ink removal system. Ink is received from the first transfer roller 20 and deposited onto the cleaning pad 52 via the highly wetting surface of the second transfer roller 51.

It is, of course, possible for the second transfer roller 51 to be absent in the ink
15 removal system, and for the cleaning pad 52 to be in direct contact with the first transfer roller 20. Such an arrangement is clearly contemplated within the scope of the present invention. However, the use of a metal second transfer roller 51 has several advantages. Firstly, metals have highly wetting surfaces (with contact angles approaching 0°), ensuring complete transfer of ink from the first transfer roller 20 onto the second transfer roller 51.
20 Secondly, the metal second transfer roller 51, unlike a directly contacted cleaning pad, does not generate high frictional forces on the transfer surface 24. The metal second transfer roller 51 can slip relatively easily past the cleaning pad 52, which reduces the torque requirements of a motor (not shown) driving the rollers and preserves the lifetime of the transfer surface 24. Thirdly, the rigidity of the second transfer roller 51 provides
25 support for the first transfer roller 20 and minimizes any bowing. This is especially important for pagewidth printheads and their corresponding pagewidth maintenance stations.

As shown more clearly in Figure 11, the first transfer roller 20, second transfer roller 51 and cleaning pad 52 are all mounted on a moveable chassis 53. The chassis 53 is
30 moveable perpendicularly with respect to the ink ejection face 3, such that the transfer surface 24 can be moved into and out of the transfer zone. The chassis 53, together with all its associated components, is contained in a housing 54. The chassis 53 is slidably moveable relative to the housing 54.

The chassis 53 further comprises engagement formations in the form of lugs 55 and 56, positioned at respective ends of the chassis. These lugs 55 and 56 are provided to slidably move the chassis 53 upwards and downwards relative to the printhead 2 by means of an engagement mechanism (not shown). Typically the engagement mechanism will

5 comprise a pair of arms engaged with the lugs 55 and 56, and arranged so that rotational movement of the arms imparts a sliding movement of the chassis 53 via a camming engagement with the lugs.

Referring now to Figure 9, it can be seen that rotation of the first and second transfer rollers 20 and 51 is via a suitable gear arrangement. A main drive gear 57,

10 operatively mounted at one end of the second transfer roller 51, drives a subsidiary drive gear 58, operatively mounted at one end of the first transfer roller 20, via intermeshing idler gears 59 and 60. A flipper gear wheel (not shown), driven by a drive motor (not shown) can intermesh with the main drive gear 58 through a slot 61 in the housing 54 (see Figures 10 and 11). Hence, the gear arrangement comprising the main drive gear 57,

15 subsidiary drive gear 58 and idler gears 59 and 60 forms part of a transport mechanism, which rotates the first and second transfer rollers 20 and 51 synchronously, thereby feeding the transfer surface 24 through the transfer zone.

Alternative Foaming System

20 As an alternative to the ink foaming system 10, which generates the ink foam 30 by passing air through residual ink in the printhead 2, a liquid foam may be generated by a separate foam dispenser, which does not use ink supplied to the printhead to generate the foam.

Figure 12 shows a liquid foam dispenser 70 positioned adjacent the printhead 2.

25 The foam dispenser 70 has a nozzle 71, which generates a liquid foam 72 by injection of pressurized gas into the nozzle. A liquid reservoir 73 feeds a liquid for foaming into the foam dispenser 70. The reservoir 73 may contain a cleaning liquid, such as water, surfactant solution, dyeless ink base, glycol solution *etc.* A source of pressurized gas 74 supplies the pressurized gas to the nozzle 71 for foam generation.

30 The liquid foam 72 provided on the ink ejection face of the printhead 2 may be removed by a transfer surface, such as the transfer surface 24 described above, moving past the face.

It will, of course, be appreciated that the present invention has been described purely by way of example and that modifications of detail may be made within the scope of the invention, which is defined by the accompanying claims.

CLAIMS

1. A method of removing particulates from an ink ejection face of a printhead, said method comprising the steps of:
 - (i) passing a gas through ink supply channels in said printhead so as to expel an ink foam from nozzles in said ink ejection face, thereby dispersing said particulates in said foam; and
 - (ii) transferring said foam, including said particulates, onto a transfer surface moving past said face.
2. The method of claim 1, wherein said transfer surface does not contact said face.
3. The method of claim 1, wherein said foam collapses to a liquid droplet as it is transferred onto said transfer surface.
4. The method of claim 1, wherein air is forced under pressure through said ink channels.
5. The method of claim 1, wherein said transfer surface contacts said foam when moving past said face.
6. The method of claim 1, wherein said transfer surface is less than 1 mm from said face when moving past said face.
7. The method of claim 1, wherein said transfer surface is moved past said face immediately as said foam is provided on said face.
8. The method of claim 1, wherein said transfer surface is a surface of a film.

9. The method of claim 1, wherein said transfer surface is an outer surface of a first transfer roller.
10. The method of claim 9, wherein said transfer surface is moved past said face by rotating said roller.
11. The method of claim 10, wherein said roller is substantially coextensive with said printhead.
12. The method of claim 1, further comprising the step of:
 - (iii) removing foam or ink from said transfer surface using an ink removal system.
13. The method of claim 12, wherein said transfer surface is an outer surface of a first transfer roller and said ink removal system comprises a cleaning pad in contact with said first transfer roller.
14. The method of claim 13, wherein said transfer surface is an outer surface of a first transfer roller and said ink removal system comprises a second transfer roller engaged with said first transfer roller.
15. The method of claim 14, wherein said second transfer roller has a wetting surface for receiving ink from said transfer surface.
16. The method of claim 15, wherein said second transfer roller is a metal roller.
17. The method of claim 15, wherein a cleaning pad is in contact with said second transfer roller.