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Inkjet printhead protection apparatus

Abstract

Some embodiments of a protector apparatus for protecting a printhead having a nozzle plate include a protection layer, a spacer layer, a flexible magnetic layer having a first surface and a second surface opposing the first surface, and a handle connected to one end of the flexible magnetic layer. The spacer layer is sandwiched between the protection layer and the first surface of the flexible magnetic layer. The handle is connected to the second surface of the flexible magnetic layer. The protector apparatus can be magnetically attached to the printhead in such a manner that the first protection layer covers the nozzle plate.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application claims the benefit of U.S. Application No. 63/305,871, which was filed on Feb. 2, 2022.

BACKGROUND

Field

(1) The present disclosure concerns inkjet printheads, and more specifically a protection apparatus for an inkjet printhead.

Description of the Related Art

(2) Inkjet-printhead nozzle plates can easily be damaged if they come in contact with objects that can dent, scratch, or otherwise physically damage the delicate surface of the inkjet-printhead nozzle plates. Additionally, it is known to keep the printhead nozzles on the plate moist and free from debris.

(3) Existing devices to mitigate such damage include a heavy, structurally sound mechanical device (plate) that is installed onto the printhead over the nozzle plate to protect the nozzle plate's surface. The device (protector/protection device) is fastened to the printhead using screws at each end of the printhead structure. The protector has a metal base plate, a low durometer pad that has an elevated fence of the same material around its perimeter, a first plastic foil that is positioned over the fence and that is secured over the pad. Additionally, a second plastic foil is applied directly to a moistened and clean nozzle plate and is secured by the surface tension of the moisture.

(4) Within the protector, the printhead is mated to the low durometer pad that has an elevated perimeter fence. The perimeter surface of the printhead, which is absent of nozzles, mates with the elevated perimeter fence, and the first and second plastic foils are mated. When attached to the protector, the printhead-nozzle plate perimeter rests on the low durometer perimeter with the first and second foils in between to form a protector that has a moisture seal.

(5) This protector is useful for shipping and storage; however, it cannot remain installed on the printhead during printhead installation or removal on many printers. Therefore, the printhead is exposed and unprotected during installation and removal.

SUMMARY

(6) According to one aspect of the present disclosure is a protector apparatus for protecting a printhead having a nozzle plate. The protector apparatus includes a protection layer, a spacer layer, a flexible magnetic layer having a first surface and a second surface opposing the first surface, and a handle connected to one end of the flexible magnetic layer. The spacer layer is sandwiched between the protection layer and the first surface of the flexible magnetic layer. The handle is connected to the second surface of the flexible magnetic layer. The protector apparatus can be magnetically attached to the printhead in such a manner that the protection layer covers the nozzle plate.

(7) According to another aspect of the present disclosure is a protector apparatus for protecting a printhead having a nozzle plate. The protector apparatus includes a flexible magnetic layer having a first side, a second side opposing the first side, and a perimeter, wherein the flexible magnetic layer has a platform that lies along the perimeter of the first side to define a depression in a central portion of the first side. The protector apparatus also includes a protection layer. The protection layer is provided on the platform. A handle is connected to one end of the flexible magnetic layer on the second side. The platform and the cavity are sized such that, when the platform contacts a printhead, a nozzle plate of the printhead does not contact the platform.

(8) According to another aspect of the present disclosure is an apparatus that comprises a printhead and a protector apparatus. The printhead has a nozzle plate on a nozzle-plate side. The protector apparatus is magnetically held to the nozzle-plate side of the printhead. And the protector apparatus includes a protection layer, a flexible magnetic layer having a first surface on a first side and a second surface on a second side opposite to the first side, and a handle connected to one end of the protector apparatus. The protection layer is on the first side of the flexible magnetic layer. The handle is on the second side of the flexible magnetic layer. The first side of the protector apparatus faces the nozzle-plate side of the printhead. A length of the protector apparatus does not exceed a length of the nozzle-plate side, and a width of the protector apparatus does not exceed a width of the nozzle-plate side.

(9) Further features of the present disclosure will become apparent from the following description of exemplary embodiments (with reference to the attached drawings).

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. 1A illustrates an example embodiment of a printer.

- (2) FIG. 1B is a perspective view of an example embodiment of a printhead.
- (3) FIG. 2A illustrates an example embodiment of a printhead bay.
- (4) FIG. 2B illustrates an example embodiment of a printhead compartment.
- (5) FIG. 3A illustrates an example embodiment of a printhead compartment.
- (6) FIG. 3B illustrates an example embodiment of a printhead compartment in which a printhead has been installed.
- (7) FIG. 4A illustrates an example embodiment of a printhead and a flexible protector apparatus.
- (8) FIG. 4B illustrates another view of the protector apparatus from FIG. 4A.
- (9) FIG. 4C illustrates another view of the protector apparatus from FIG. 4A.
- (10) FIG. 4D illustrates another view of the printhead from FIG. 4A.
- (11) FIG. 5A illustrates a cutaway view of the protector apparatus from FIGS. 4A-4C.
- (12) FIG. 5B illustrates a cutaway view of an example embodiment of a protector apparatus.
- (13) FIG. 5C illustrates a cutaway view of an example embodiment of a protector apparatus.
- (14) FIG. 5D illustrates a cutaway view of an example embodiment of a protector apparatus.
- (15) FIG. 6A illustrates an example embodiment of a printhead and a flexible protector apparatus.
- (16) FIG. 6B illustrates an example embodiment of a printhead and a flexible protector apparatus.
- (17) FIG. 7A illustrates an example embodiment of a printhead and a flexible protector apparatus.
- (18) FIG. 7B illustrates another view of the protector apparatus from FIG. 7A.
- (19) FIG. 7C illustrates another view of the protector apparatus from FIG. 7A.
- (20) FIG. 7D illustrates another view of the printhead from FIG. 7A.
- (21) FIG. 8A illustrates a cutaway view of the protector apparatus from FIGS. 7A-7C.
- (22) FIG. 8B illustrates an example embodiment of a protector apparatus.
- (23) FIG. 8C illustrates a cutaway view of the protector apparatus from FIG. 8B.
- (24) FIG. 9A illustrates a cutaway view of an example embodiment of a protector apparatus.
- (25) FIG. 9B illustrates a cutaway view of an example embodiment of a protector apparatus.
- (26) FIG. 9C illustrates a cutaway view of an example embodiment of a protector apparatus.
- (27) FIG. 10A illustrates an example embodiment of a printhead and a flexible protector apparatus.
- (28) FIG. 10B illustrates an example embodiment of a printhead and a flexible protector apparatus.
- (29) FIG. 11A illustrates an example embodiment of a protector apparatus.
- (30) FIG. 11B illustrates a cutaway view of the protector apparatus from FIG. 11A.
- (31) FIG. 11C illustrates a cutaway view of an example embodiment of a protector apparatus.
- (32) FIG. 12 illustrates an example embodiment of a printhead and a rigid protector.
- (33) FIG. 13A illustrates an example embodiment of a printhead and a rigid protector.
- (34) FIG. 13B illustrates another view of the rigid protector from FIG. 13A.

DETAILED DESCRIPTION

(35) The following paragraphs describe certain explanatory embodiments. Other embodiments may include alternatives, equivalents, and modifications. Additionally, the explanatory embodiments may include several features, and a particular feature may not be essential to some embodiments of the devices, systems, and methods that are described herein. Furthermore, some embodiments include features from two or more of the following explanatory embodiments.

(36) Also, as used herein, the conjunction “or” generally refers to an inclusive “or,” though “or” may refer to an exclusive “or” if expressly indicated or if the context indicates that the “or” must be an exclusive “or.” And, as used herein, the terms “first,” “second,” and so on, do not necessarily denote any ordinal, sequential, or priority relation and may be used to more clearly distinguish one member, operation, element, group, collection, set, etc. from another without expressing any ordinal, sequential, or priority relation.

(37) FIG. 1A illustrates an example embodiment of a printer. The printer **90** is configured to form images, graphics, and text on various print media by applying ink to the print media. The printer **90** uses one or more printheads to apply the ink.

(38) FIG. 1B is a perspective view of an example embodiment of a printhead **10**. The printhead **10**

includes a nozzle plate **102**, which includes a nozzle area that has a plurality of nozzles, and two mounting members **104**, which include respective openings. The nozzle plate **102** is located on a nozzle-plate side **108** of the printhead **10**, which is the side of the printhead **10** that faces print media. The mounting members **104** can be affixed to mounting structures in the printer **90**, for example by screws (e.g., the screws **1033** in FIG. **4A**) that pass through the openings. In FIG. **1B**, a protection foil **106** covers the nozzle plate **102**.

(39) The printer **90** includes a printhead bay **91** that provides access to install and remove printheads **10**. For example, FIG. **2A** illustrates an example embodiment of a printhead bay **91**. This embodiment of a printhead bay **91** includes six printhead compartments **93**, although some embodiments include more or fewer printhead compartments **93**. Each printhead compartment **93** has a respective cover **931**. In FIG. **2A**, one of the covers **931** is open, which exposes the hardware (including the other (non-printhead) hardware **94**, which is described below) that is inside of the printhead compartment **93**. Also, one of the printhead compartments **93** has no cover and is empty.

(40) FIG. **2B** illustrates an example embodiment of a printhead compartment **93**. The printhead compartment **93** includes a mounting cutout **932**. When a printhead **10** is installed in the printhead compartment **93**, the nozzle plate **102** of the printhead **10** is aligned with or inserted through the mounting cutout **932**. This allows the nozzles of the printhead **10** to eject ink out of the printhead compartment **93** and onto print media. Also, the compartment **93** in FIG. **2B** includes an installed printhead **10**.

(41) The printhead compartment **93** also includes other hardware. For example, FIG. **3A** illustrates an example embodiment of a printhead compartment **93**, and FIG. **3A** shows the other hardware **94**, such as cables, other wires, and hoses. When a printhead **10** is installed in the printhead compartment **93**, the printhead **10** must be maneuvered through or around the other hardware **94**. For example, FIG. **3B** illustrates an example embodiment of a printhead compartment **93** in which a printhead **10** has been installed. As shown in FIG. **3B**, the installed printhead **10** had to be maneuvered through or around the other hardware **94** during installation. Also, because some of the other hardware **94** is positioned between the printhead **10** and the opening of the printhead compartment **93**, removing the printhead **10** requires maneuvering the printhead **10** through or around the other hardware **94**.

(42) Because the nozzle plate **102** (and the nozzle area **103** in particular) is very delicate, and because the printhead **10** has to be maneuvered through or around the other hardware **94** in the printhead compartment **93**, the nozzle plate **102** can easily be damaged during installation or removal.

(43) Accordingly, a flexible protector apparatus, as described below, can be used to protect the nozzle plate **102** during installation or removal of the printhead **10**. Also, the flexible protector apparatus can be used to protect the nozzle plate **102** while the printhead **10** is being transported or stored. Furthermore, the flexible protector apparatus can be used to keep the nozzle plate **102** moist and free from debris.

(44) FIG. **4A** illustrates an example embodiment of a printhead **10** and a flexible protector apparatus **20** (which is also referred to herein by “protector apparatus **20**”). And FIG. **4B** illustrates another view of the protector apparatus **20** from FIG. **4A**, from a viewpoint looking upward along the z axis; FIG. **4C** illustrates another view of the protector apparatus **20** from FIG. **4A**, from a viewpoint looking downward along the z axis; and FIG. **4D** illustrates another view of the printhead **10** from FIG. **4A**, from a viewpoint looking upward along the z axis. Thus, the views of FIGS. **4B-D** are orthogonal to the view of FIG. **4A**.

(45) The printhead **10** includes a nozzle plate **102**, which includes a nozzle area **103** that has a plurality of nozzles, and two mounting members **104**, which include respective openings **1044**. The nozzle plate **102** is located on a nozzle-plate side **108** of the printhead **10**, which is the side of the printhead **10** that faces print media. The mounting members **104** can be affixed to mounting structures in the printer **90**, for example by screws **1033** that pass through the openings **1044**.

(46) Also, FIG. 4A illustrates a protection foil **106** (e.g., a plastic foil) that can be applied to the nozzle plate **102** (e.g., the nozzle area **103**). The protection foil **106** can be placed on a moistened nozzle plate **102** and held to the nozzle plate **102** by the surface tension of the moisture.

(47) The protector apparatus **20** includes a magnetic layer **201**, a protection layer **202**, a spacer layer **203**, a distal layer **204**, and a handle **205**.

(48) The magnetic layer **201** is flexible and magnetic. The magnetic layer **201** may be composed of one or more flexible magnets. For example, flexible magnets include a high-coercivity ferrimagnetic or ferromagnetic compound that has been mixed with a plastic binder and extruded as a sheet, thereby forming a flexible magnetic sheet. And the magnetic layer **201** may include multiple layers (e.g., multiple flexible magnetic sheets that have been layered). Also, the magnetic layer **201** may be composed of a plurality of rigid magnets that are attached to each other at flexible joints such that that magnetic layer **201** can bend and the rigid magnets can articulate relative to each other.

(49) The thickness, durometer, and degree of flexibility of the magnetic layer **201** influence the level of protection from contact with objects that can damage the nozzle plate **102**. For example, in some embodiments the thickness of the magnetic layer **201** is 0.01, 0.02, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.12, 0.14, 0.16, 0.18, 0.2, 0.3, 0.5, 0.7, 0.9, or 1 inch.

(50) And the thickness of the magnetic layer **201** may be related to the flexibility: a thinner magnetic layer **201** may be more flexible, and accordingly a thinner magnetic layer **201** may have a smaller bending radius than a thicker magnetic layer **201**. A thinner magnetic layer **201** may make separating the protector apparatus **20** from the printhead **10** easier when compared to separating protector apparatuses **20** that have a thicker magnetic layer **201** from the printhead **10**. However, a thicker magnetic layer **201**, while stiffer, may provide greater protection from some kinds of damage. Therefore, the thickness of the magnetic layer **201** may vary between various embodiments according to the expected conditions of use of the protector apparatus **20**.

(51) Also, the magnetic strength of the magnetic layer **201** may be selected to avoid damaging the nozzle plate **102**. For example, the magnetic layer **201** may have a magnetic strength that is low enough to prevent the magnetic layer **201** from separating (e.g., delaminating, peeling off) some or all of the nozzle plate **102** (e.g., some or all of the nozzle area **103**) from the rest of the printhead **10** when the protector apparatus **20** is separated from the nozzle plate **102**, yet strong enough to hold the protector apparatus **20** to the printhead **10** until a user separates the protector apparatus **20** and the printhead **10**.

(52) The protection layer **202** is a foil (film), for example a low-friction flexible plastic foil. The protection layer **202** may also be thinner than the magnetic layer **201**, for example less than 0.01 inch (e.g., 0.005 inch). The surface of the protection layer **202** that faces the magnetic layer **201** (which is the surface opposite to the surface that faces the printhead **10**) may have an adhesive. Furthermore, the protection layer **202** may be slippery and may have a high molecular weight, for example an ultra-high molecular weight (UHMW) polyethylene film (or foil).

(53) When the protector apparatus **20** is attached to the printhead **10** (magnetically held in contact with the printhead **10**), the protection layer **202** contacts the nozzle plate **102** (when the printhead **10** does not have the plastic protection foil **106**) or contacts the plastic protection foil **106** (when the printhead does have the plastic protection foil **106**). The protection layer **202** may act as the plastic protection foil **106** when the printhead **10** does not have the plastic protection foil **106**, and thus the plastic protection foil **106** is unnecessary to protect or moisten the nozzle plate **102** in some embodiments.

(54) Accordingly, some embodiments of protector apparatuses **20** include a protection layer **202** that is a thin plastic foil lamination. Such protector apparatuses **20** have a smooth surface that can contact the nozzle plate **102** like the plastic protection foil **106**. Therefore, some embodiments of the protector apparatus **20** combine protection against contact damage with the protection layer **202** in an integrated unit. Also, some embodiments of the protector apparatus **20** can keep the nozzle

plate **102** wet without the plastic protection foil **106**.

(55) Furthermore, some embodiments may exclude the protection layer **202**, and the magnetic layer **201** can act as a moisture barrier. But, depending on the surface of the magnetic layer **201**, the protection layer **202** can further reduce wear to the nozzle plate **102** from friction caused by dragging the protector apparatus **20** across the nozzle plate **102** (e.g., during the installation or removal of the printhead **10**).

(56) The spacer layer **203** is sandwiched between the protection layer **202** and the magnetic layer **201**. The spacer layer **203** is composed of one or more flexible materials and may be a softer material (low-durometer material) that provides extra cushioning. Examples of materials that may be included in the spacer layer **203** include the following: paper, tape (e.g., blue tape, PVC electrical tape, polypropylene packaging tape), and plastic films (e.g., polyethylene).

(57) The spacer layer **203** may be used to adjust the magnetic strength that the magnetic layer **201** applies to the printhead **10** by increasing the distance between the magnetic layer **201** and the printhead **10**. Thus, the thickness and materials of the spacer layer **203** may be selected such that the magnetic strength that the magnetic layer **201** applies to the printhead **10** is within a desired range. Also, because even a slight increase in the distance between the magnetic layer **201** and the printhead **10** may significantly reduce the strength of the magnetic field at the printhead **10**, the spacer layer **203** can also be very thin.

(58) Some embodiments do not include the spacer layer **203**. To obtain a desired strength of the magnetic field at the printhead **10**, the thickness of the protection layer **202** can be adjusted. Thus, some embodiments of the protection layer **202** also perform the function of the spacer layer **203**. And the magnetic layer **201** can also be constructed to exert a desired magnetic strength on the printhead **10**.

(59) The distal layer **204** is located on the surface of the magnetic layer **201** that faces away from the printhead **10**. The distal layer **204** may have a higher durometer than the magnetic layer **201**, and thus may be harder than the magnetic layer **201**. The distal layer **204** may increase the protection provided by, as well as the thickness of, the protector apparatus **20**. Examples of materials that may be included in the distal layer **204** include plastic (e.g., PVC, polypropylene, polyethylene) and metal.

(60) The respective thicknesses of the magnetic layer **201** and the distal layer **204** may vary between embodiments. Embodiments of the protector apparatus **20** that have a thicker distal layer **204** may have a thinner magnetic layer **201**, and embodiments of the protector apparatus **20** that have a thinner distal layer **204** may have a thicker magnetic layer **201**. A thicker distal layer **204** with a thinner magnetic layer **201** may provide greater nozzle-plate protection for the same thickness of the protector apparatus **20**, but may also reduce the flexibility.

(61) A more-flexible protector apparatus **20** may be more advantageous in some circumstances, for example when the clearance around an installed printhead **10** is very small and the protector apparatus **20** is being removed after the printhead **10** is installed. For example, a protector apparatus **20** that is sufficiently flexible can be peeled off of the printhead **10**, rather than slid off. And, if a user (e.g., field technician) forgets to remove the protector apparatus **20**, a thinner protector apparatus **20** may cause less damage to the printer **90** if the printhead **10** is lowered to print media when the protector apparatus **20** is still magnetically held to the printhead **10**. Also, a less-flexible protector apparatus **20** may be advantageous in some circumstances, for example when a printhead **10** is going to be shipped a long distance or stored for a long time.

(62) The magnetic layer **201**, the protection layer **202**, the spacer layer **203**, and the distal layer **204** may be held together by one or more adhesives. The adhesive, as well as the thickness of the applied adhesive, may be selected according to their bonding strengths, rigidities (when cured), and chemical resistances. Examples of adhesives include epoxies, cyanoacrylates, rubber-based adhesives, acrylic-based adhesives, silicon-based adhesives, and hot-melt adhesives. Also, the spacer layer **203** may be formed from one or more adhesives that bond the protection layer **202** to

the magnetic layer **201**.

(63) A user can use the handle **205** to ease the removal and mounting of the protector apparatus **20** on the printhead **10**. In some embodiments, the handle **205** is a flag handle. The entire handle **205** may be flexible, or the handle **205** may be more rigid and have a pivot point where the handle **205** attaches to the distal layer **204** (or to the magnetic layer **201** in embodiments that exclude the distal layer **204**).

(64) Examples of materials that can constitute the handle **205** include the following: fabric, plastic (e.g., acrylonitrile butadiene styrene (ABS), polyvinyl chloride (PVC)), polypropylene, and metal. For example, the handle **205** may be composed of fabric or plastic to which an adhesive has been applied on one side (e.g., an adhesive tape). Also for example, in embodiments of the handle **205** in which the handle **205** has a T-shape and is made of tape, the handle **205** may be made as follows: The middle portion of a piece of tape is folded over itself so that the adhesive of one surface of the tape contacts the adhesive of the other surface of the tape. This creates a handle portion that is free of exposed adhesive. The remaining two ends, which have exposed adhesive, are affixed to the distal layer **204** or to the flexible magnetic layer **201** on the side of the protector apparatus **20** that does not contact the nozzle plate.

(65) Also, the handle may have an L-shape, for example where the short end of the “L” has an exposed adhesive that is affixed to the distal layer **204** or to the flexible magnetic layer **201** and the long end of the “L” has no exposed adhesive and is not affixed to either the distal layer **204** or the flexible magnetic layer **201**.

(66) The handle **205** is not necessary for the protector apparatus **20** to protect the printhead **10**. However, the handle **205** may improve user convenience and handling. In some circumstances, the handle **205** performs best by being placed close to a longitudinal end of the protector apparatus **20**. This placement may require the lowest pull force to separate the protector apparatus **20** from the printhead **10**.

(67) Additionally, the handle **205** may be rotated, in the xy plane, by 90 degrees relative to the position shown in FIGS. 4A-B. Thus, instead of longitudinally extending along the y axis as shown in FIGS. 4A-B, the handle **205** may longitudinally extend along the x axis (e.g., as shown in FIG. 8C).

(68) Embodiments of protector apparatuses **20** were applied to five different printheads **10** using different solutions on the printheads **10**. The printheads **10** were subjected to the chemicals for a period of seven weeks. The protector apparatuses **20** were removed weekly for inspection. No damage was observed on the nozzle plates **102**, and the data indicate that the protector apparatuses **20** did not cause damage (e.g., damaging reactions) to the nozzle plates **102** when applied for long periods.

(69) The five test configurations were as follows: A protector apparatus **20** that had slippery protection layer **202**, and a printhead **10** that was coated in storage solution. Another protector apparatus **20** that had a slippery protection layer **202**, and a printhead **10** that was coated in storage solution. A protector apparatus **20** that had no protection layer **202**, and a printhead **10** that was coated in storage solution. A protector apparatus **20** that had a slippery protection layer **202**, and a printhead **10** that was coated in ink. A protector apparatus **20** that had a slippery protection layer **202**, and a printhead **10** that was coated in 70% isopropyl alcohol.

(70) Additionally, the printheads **10** with the aforementioned protector apparatuses **20** were placed on screws and nuts and were bumped into pneumatic hoses, bolt heads, and other components found in the mounting location in the printer **90**. The protector apparatuses **20** prevented damage to the nozzle plates **102** that would have occurred if the protector apparatuses **20** were not in place.

(71) Furthermore, coloring the protector apparatus **20** in a bright color or a combination of colors (e.g., a color pattern) may make it easier to see the protector apparatus **20** when mounted on the nozzle plate **102**. This may make an installer less likely to leave the protector apparatus **20** on the nozzle plate **102** after installation. And adding a bright color or pattern (e.g., geometric or color

pattern) to the handle **205** may help the installer see the handle **205** and remember to remove the protector apparatus **20** from the printhead **10** after installation.

(72) FIG. 5A illustrates a cutaway view of the protector apparatus **20** from FIGS. 4A-4C. The cutaway view in FIG. 5A is taken from line AA in FIGS. 4B and 4C. This embodiment of the protector apparatus **20** includes a magnetic layer **201**, a protection layer **202**, a spacer layer **203**, a distal layer **204**, and a handle **205**. And, in this embodiment, the protector apparatus **20** includes a T-shaped handle **205**.

(73) FIG. 5B illustrates a cutaway view of an example embodiment of a protector apparatus. This embodiment includes a magnetic layer **201**, a protection layer **202**, and a handle **205**. Thus, this embodiment omits the spacer layer **203** and the distal layer **204**. Also, an adhesive that bonds the magnetic layer **201** to the protection layer **202** may operate as the spacer layer.

(74) FIG. 5C illustrates a cutaway view of an example embodiment of a protector apparatus. This embodiment includes a magnetic layer **201**, a protection layer **202**, a handle **205**, and a flange **208**. Thus, this embodiment does not include a spacer layer **203** and does not include a distal layer **204**. Also, in this embodiment, the handle **205** is L-shaped.

(75) This embodiment of a protector apparatus **20** has a length and a width that are sized such, when the protection layer **202** contacts the printhead **10**, the flange **208** extends along the sides of the printhead **10** that are parallel to the z axis and prevents the protection apparatus **20** from sliding, relative to the printhead **10**, along the x and y axes (e.g., as shown in FIG. 6B). Thus, the protector apparatus **20** is slightly longer and slightly wider than the nozzle plate **102**.

(76) FIG. 5D illustrates a cutaway view of an example embodiment of a protector apparatus. This embodiment includes a magnetic layer **201** and a handle **205**. In this embodiment, the surface of the magnetic layer **201** is smooth enough to prevent damage to the nozzle plate **102** when they are in contact with each other. Also, the surface of the magnetic layer **201** may have a very thin coating that makes the surface of the magnetic layer **201** smooth enough to avoid damaging the nozzle plate **102**.

(77) Thus, in some embodiments, the magnetic layer **201** has a relatively smooth surface and can directly contact the nozzle plate **102**, particularly when used with the procedure of wetting the nozzle plate **102** of the printhead **10** to flush away any debris that may have adhered to the nozzle plate **102**.

(78) Also, the form factor (the length, the width, the shape) of the of the protector apparatus **20** may be the same as the nozzle plate **102** (or the nozzle area **103**) of a printhead **10** that the protector apparatus **20** is specially configured to protect. Consequently, some embodiments of the protector apparatus **20** can be held to the printhead **10** without extending beyond the perimeter of the nozzle plate **102** (i.e., the edges of the protector apparatus **20** are flush with the edges of the nozzle plate **102**). This allows the protector apparatus **20** to remain in place on the printhead **10** while the nozzle plate **102** is pushed through a mounting cutout (e.g., the mounting cutout **932** in FIG. 2B) and the printhead **10** is secured in place in the printer **90**. And the protector apparatus **20** can remain in place on the printhead **10** regardless of the design of the mounting cutout **932** in the printer **90**. For example, some embodiments of protector apparatuses **20** can be used during installation and removal in printers that have a mounting cutout **932** that has very little clearance. And a protector apparatus **20** that can remain in place during installation and removal can be advantageous because often most of the damage to a nozzle plate **102** occurs during installation.

(79) In embodiments that include the flange **208**, the flange **208** may have a thickness (the distance between an outer perimeter of the flange **208** and an inner perimeter of the flange **208**) that is less than the clearance. Because the clearance between the printhead **10** and the mounting cutout **932** may be less than a millimeter on each side, some embodiments of the flange **208** have a thickness that is less than a millimeter. This allows the embodiments that include the flange **208** to be used during installation and removal of the printhead **10** when the clearance is so limited.

(80) FIG. 6A illustrates an example embodiment of a printhead and a flexible protector apparatus.

In FIG. 6A, the flexible protector apparatus **20** from FIG. 5A (which is also shown in cutaway view in FIG. 6A) is magnetically held to a printhead **10**. As shown in FIG. 6A, the protection layer **202** contacts the nozzle plate **102** of the printhead **10**.

(81) FIG. 6B illustrates an example embodiment of a printhead and a flexible protector apparatus. In FIG. 6B, the flexible protector apparatus **20** from FIG. 5C (which is also shown in cutaway view in FIG. 6B) is magnetically held to a printhead **10**. As shown in FIG. 6B, the protection layer **202** contacts the nozzle plate **102** of the printhead **10**. And the flange **208** prevents the protector apparatus **20** from moving in the xy plane relative to the printhead **10**.

(82) FIG. 7A illustrates an example embodiment of a printhead **10** and a flexible protector apparatus **20**. And FIG. 7B illustrates another view of the protector apparatus **20** from FIG. 7A, from a viewpoint looking upwards along the z axis; FIG. 7C illustrates another view of the protector apparatus **20** from FIG. 7A, from a viewpoint looking downwards along the z axis; and FIG. 7D illustrates another view of the printhead **10** from FIG. 7A, from a viewpoint looking upwards along the z axis. Thus, the views of FIGS. 7B-D are orthogonal to the view of FIG. 7A. Furthermore, FIG. 8A illustrates a cutaway view of the protector apparatus **20** from FIGS. 7A-C. The cutaway view in FIG. 8A is taken from line BB in FIGS. 7B and 7C.

(83) In the embodiment in FIGS. 7A-C and FIG. 8A, the protector apparatus **20** has a depression **206** (a recessed area) in a central portion of the surface that faces the printhead **10**. Also, the depression **206** is surrounded by a platform **207** (an area that is raised relative to the depression **206**). The platform **207** lies along the perimeter (e.g., traces the perimeter, inscribes the perimeter) of the surface that faces the printhead **10**. And, in this embodiment, the platform **207** is formed by the magnetic layer **201**. A protection layer **202** and a spacer layer **203** are positioned on the platform **207**, and thus can also be described as constituting part of the platform **207**.

(84) Also, on the nozzle plate **102** of the printhead **10**, the nozzle area **103** is surrounded by a nozzle-area border **107** that does not include nozzles. For example, in some embodiments of the nozzle plate **102**, each of the long sides (the sides that are parallel to the x axis in FIGS. 7A-D) has a 2 mm space that is void of nozzles, and each of the short sides (the sides that are parallel to the y axis in FIGS. 7A-D) has a 10 mm space that is void of nozzles.

(85) The depression **206** prevents the protector apparatus **20** from contacting the nozzle area **103** of the nozzle plate **102**. When the protector apparatus **20** is brought into contact with the printhead **10**, the platform **207** of the protector apparatus **20** contacts the nozzle-area border **107** on the nozzle plate **102** (or contacts a film or foil that has been applied to the nozzle-area border **107**). However, because the nozzle area **103** is positioned over the depression **206**, the protector apparatus **20** does not contact the nozzle area **103** (or a film or foil that has been applied to the nozzle area **103**). Thus, the depression **206** can reduce or prevent damage to the nozzles even if the nozzle plate **102** has some debris or contamination. Also, the protector apparatus **20** may be sized such that the outer edges of the platform **207** are flush with the edges of the nozzle plate **102** when the protector apparatus **20** is magnetically held to (and properly aligned with) the printhead **10**.

(86) FIG. 8B illustrates an example embodiment of a protector apparatus, and FIG. 8C illustrates a cutaway view of the protector apparatus from FIG. 8B, taken from the line CC in FIG. 8B. In this embodiment, the platform **207** of the protector apparatus **20** includes platform sections **2071** that are separated by gaps **2072**. The platform sections **2071** and the gaps **2072** may give the protector apparatus **20** extra flexibility or may reduce the wear on the platform **207** that is caused by repeated bending of the protector apparatus **20**. Also, other embodiments may include more or fewer gaps **2072**. In FIGS. 8B-C, the sides of the platform **207** that extend parallel to the longitudinal axis of the protector apparatus **20** include the gaps **2072** (in FIGS. 8B-C, the sides that are parallel to the longitudinal axis are parallel to the x axis). However, in some embodiments the sides of the platform **207** that extend perpendicular to the longitudinal axis of the protector apparatus **20** (in FIGS. 8B-C, the sides that are perpendicular to the longitudinal axis are parallel to the y axis) include gaps as well as, or in alternative to, the sides of the platform **207** that extend parallel to the

longitudinal axis of the protector apparatus **20**. Also, in FIG. **8C**, the handle **205** is rotated in the xy plane by 90 degrees relative to the handle **205** in FIG. **8A**.

(87) Furthermore, in FIGS. **8B-C**, the magnetic layer **201** includes multiple layers that are layered and bonded together. These layers are referred to herein as sublayers of the magnetic layer **201**. In this embodiment, a first magnetic sublayer **2011** forms the base (e.g., floor) of the depression **206**, and a second magnetic sublayer **2012** forms the platform **207**. For example, each of the platform sections **2071** may be formed, at least in part, by bonding a respective smaller flexible magnetic sheet (which constitutes part of the second sublayer **2012**) to a larger magnetic sheet (which constitutes the first sublayer **2011**). Also, the platform sections **2071** may each include a protection layer **202** or a spacer layer **203**.

(88) FIG. **9A** illustrates a cutaway view of an example embodiment of a protector apparatus. This embodiment of the protector apparatus **20** includes a magnetic layer **201**, a protection layer **202**, a distal layer **204**, a handle **205**, a depression **206**, a platform **207**, and a flange **208**. Thus, this embodiment omits the spacer layer **203**. Also, in this embodiment, the flange **208** consists of non-magnetic material. And a first magnetic sublayer **2011** forms the base of the depression **206**, and a second magnetic sublayer **2012** forms part of the platform **207**.

(89) FIG. **9B** illustrates a cutaway view of an example embodiment of a protector apparatus. This embodiment of the protector apparatus **20** includes a magnetic layer **201**, a protection layer **202**, a spacer layer **203**, a handle **205**, a depression **206**, and a platform **207**.

(90) FIG. **9C** illustrates a cutaway view of an example embodiment of a protector apparatus. This embodiment of the protector apparatus **20** includes a magnetic layer **201**, a protection layer **202**, a handle **205**, a depression **206**, and a platform **207**.

(91) Accordingly, as shown by the foregoing embodiments, some embodiments of protector apparatuses **20** can be coupled (magnetically held) to a printhead **10** without the use of a fastener (e.g., a screw) or other additional hardware (straps, clamps), which allows the protector apparatuses **20** to be quickly attached and removed. Moreover, the handle **205** can reduce the pull force needed to remove the protector apparatus **20**, which also reduces the overall pull force applied to the nozzle plate **102**.

(92) FIG. **10A** illustrates an example embodiment of a printhead and a flexible protector apparatus. In FIG. **10A**, the flexible protector apparatus **20** from FIG. **8A** (which is also shown in cutaway view in FIG. **10A**) is magnetically held to a printhead **10**. The protection layer **202** on the platform **207** of the protector apparatus **20** contacts the nozzle-area border **107** of the nozzle plate **102**. The nozzle area **103** is held over the depression **206** of the protector apparatus **20**. Thus, the protector apparatus **20** does not contact the nozzle area **103**.

(93) FIG. **10B** illustrates an example embodiment of a printhead and a flexible protector apparatus. In FIG. **10B**, the flexible protector apparatus **20** from FIG. **9A** (which is also shown in cutaway view in FIG. **10B**) is magnetically held to a printhead **10**. The protection layer **202** on the platform **207** of the protector apparatus **20** contacts the nozzle-area border **107** of the nozzle plate **102**. The nozzle area **103** of the printhead **10** is held over the depression **206** of the protector apparatus **20**. Thus, the protector apparatus **20** does not contact the nozzle area **103**. And the flange **208** prevents the protector apparatus **20** from moving in the xy plane relative to the printhead **10**.

(94) FIG. **11A** illustrates an example embodiment of a protector apparatus, and FIG. **11B** illustrates a cutaway view of the protector apparatus from FIG. **11A**. In this embodiment, the magnetic layer **201** is composed of independent segments that are each affixed to a distal layer **204** and that do not contact each other. And each of the independent segments of the magnetic layer **201** forms a part of a respective platform section **2071**. Also, the distal layer **204** forms the base of the depression **206**.

(95) FIG. **11C** illustrates a cutaway view of an example embodiment of a protector apparatus. In this embodiment, the distal layer **204** also extends upward around the periphery of the protector apparatus **20** to form the flange **208**. The upward-extending portions of the distal layer **204** may have cuts or breaks to allow the upward-extending portions to bend more easily.

(96) FIG. 12 illustrates an example embodiment of a printhead **10** and a rigid protector **40**. In this embodiment, the rigid protector **40** includes a rigid metal body **401**, a protection foil **402**, a compressible pad **403**, and two screw holes **404**. The screw holes **404** can be used to attach the rigid protector **40** to the printhead **10** by using screws **1033** that are inserted through the two mounting members **104** into the two screw holes **404**.

(97) The rigid metal body **401** may provide good protection during shipping and storage. However, because the rigid protector **40** must extend at least to the openings **1044** in the two mounting members **104**, the rigid protector **40** is longer (on the x axis in FIG. 12) than the length of the nozzle plate **102** of the printhead **10** and is longer than the distance between the two openings **1044**. Consequently, this rigid protector **40** will not fit in a mounting cutout **932**, and this rigid protector **40** must be removed before the printhead **10** is installed in a printer **90**. Therefore, the printhead **10** is exposed and unprotected during installation and removal, and the nozzle plate **102** can be damaged when it contacts an object on its route to its mounting position.

(98) FIG. 13A illustrates an example embodiment of a printhead and a rigid protector. And FIG. 13B illustrates another view of the rigid protector from FIG. 13A.

(99) In this embodiment, the rigid protector **50** includes a rigid metal body **501**, a depression **502**, a platform **503**, and two screw holes **504**. The screw holes **504** can be used to attach the rigid protector **50** to the printhead **10** by using screws **1033** that are inserted through the two screw holes **504** into the openings **1044** in the two mounting members **104**. The depression **502** is large enough to accommodate the entire nozzle plate **102** of the printhead **10**. And the depression **502** is so deep that, when the rigid protector **50** is attached to the printhead **10**, the bottom surface of the depression **502** does not contact the nozzle plate **102**.

(100) Some printers may have a mounting cutout **932** that is large enough to accommodate this rigid protector **50**. So this rigid protector **50** can be used during removal and installation of the printhead **10**, but only in printers that were designed with the larger mounting cutouts **932**. And, because this rigid protector **50** is attached to the printhead **10** by screws, this rigid protector **50** requires more time to attach and remove. Additionally, this rigid protector **50** does not have a moisture barrier surface that contacts the nozzle plate **102**, so installers have less time before they need to be concerned about the nozzle plate drying out.

(101) Also, some embodiments of the protector apparatuses **20** in FIGS. 4A-C, 5A-D, 6A-B, 7A-C, 8A-C, 9A-C, 10A-B, and 11A-C can be used with the rigid protector **40** in FIG. 12 or with the rigid protector **50** in FIGS. 13A-B. Such combinations can reduce or eliminate nozzle-plate damage when mounting the printhead **10** to the rigid protector **40** in FIG. 12 or to the rigid protector **50** in FIGS. 13A-B. For example, when a printhead **10** is being packed for shipment, a flexible protector apparatus **20** may first be attached to the printhead **10**, and then the printhead **10**, with the attached protector apparatus **20**, may be attached to a rigid protector **40**. During installation, the rigid protector **40** can be removed, and the printhead **10** can be installed while still attached to the flexible protector apparatus **20**. This means that, from the time of packing the printhead **10** through shipping and installation, the printhead **10** will be protected. And attaching a flexible protector apparatus **20** at the factory or point of packaging for transportation reduces field-service time by eliminating the need to attach a flexible protector apparatus **20** in the field before installing the printhead **10**.

(102) While the present disclosure has described exemplary embodiments, it is to be understood that some embodiments are not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all modifications, equivalent structures and functions

Claims

1. A protector apparatus for protecting a printhead having a nozzle plate, the protector apparatus comprising: a protection layer; a spacer layer; a flexible magnetic layer having a first surface and a second surface opposing the first surface; and a handle connected to one end of the flexible magnetic layer, wherein the spacer layer is sandwiched between the protection layer and the first surface of the flexible magnetic layer such that the spacer layer is interposed between the protection layer and the first surface of the flexible magnetic layer, wherein the handle is connected to the second surface of the flexible magnetic layer, and wherein the protector apparatus can be magnetically attached to the printhead in such a manner that the first protection layer covers the nozzle plate.
2. The protector apparatus of claim 1, wherein the protection layer is a plastic foil.
3. The protector apparatus of claim 1, wherein the handle has a flexible body.
4. The protector apparatus of claim 1, wherein the handle is composed of plastic or fabric.
5. The protector apparatus of claim 1, wherein the spacer layer is composed of an adhesive that bonds the protection layer to the flexible magnetic layer.
6. The protector apparatus of claim 1, wherein the spacer layer is composed of a low-durometer material.
7. The protector apparatus of claim 1, wherein the flexible magnetic layer includes one or more flexible magnets.
8. The protector apparatus of claim 1, wherein the flexible magnetic layer includes a plurality of rigid magnets with flexible joints therebetween that allow the flexible magnetic layer to bend at the flexible joints.
9. A protector apparatus for protecting a printhead having a nozzle plate, the protector apparatus comprising: a flexible magnetic layer having a first side, a second side opposing the first side, and a perimeter, wherein the flexible magnetic layer has a platform that lies along the perimeter of the first side to define a depression in a central portion of the first side; a protection layer, wherein the protection layer is positioned on the platform; and a handle connected to one end of the protector apparatus, wherein the platform and the cavity are sized such that, when the platform contacts a printhead, a nozzle plate of the printhead does not contact the platform.
10. The protector apparatus of claim 9, further comprising: a spacer layer that is sandwiched between the protection layer and the flexible magnetic layer.
11. The protector apparatus of claim 9, wherein the handle is connected to the second side of the flexible magnetic layer.
12. The protector apparatus of claim 9, further comprising: a distal layer that lies on the second side of the flexible magnetic layer, wherein the handle is connected to the distal layer.
13. An apparatus comprising: a printhead, wherein the printhead has a nozzle plate on a nozzle-plate side; and a protector apparatus that is magnetically held to the nozzle-plate side of the printhead, wherein the protector apparatus includes: a protection layer; a flexible magnetic layer having a first surface on a first side and a second surface on a second side opposite to the first side; and a handle connected to one end of the protector apparatus, wherein the protection layer is on the first side of the flexible magnetic layer, wherein the handle is on the second side of the flexible magnetic layer, wherein the first side of the flexible magnetic layer faces the nozzle-plate side of the printhead, wherein a length of the protector apparatus does not exceed a length of the nozzle-plate side, and wherein a width of the protector apparatus does not exceed a width of the nozzle-plate side.
14. The apparatus of claim 13, wherein the protection layer is a plastic foil.
15. The apparatus of claim 13, wherein the handle is flexible.
16. The apparatus of claim 13, wherein the handle is composed of plastic or fabric.
17. The apparatus of claim 13, wherein the flexible magnetic layer includes one or more flexible magnets.

