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(54) INK CARTRIDGE INK AMOUNT CALCULATIONS BASED ON MOTOR CHARACTERISTICS

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(52) **U.S. Cl.**
CPC ***B41J 2/17566*** (2013.01)

(58) **Field of Classification Search**
CPC B41J 2/17566; B41J 2002/17569; B41J 2002/17589; B41J 29/38; B41J 29/393; B41J 19/202; B29C 64/393; B33Y 50/02
See application file for complete search history.

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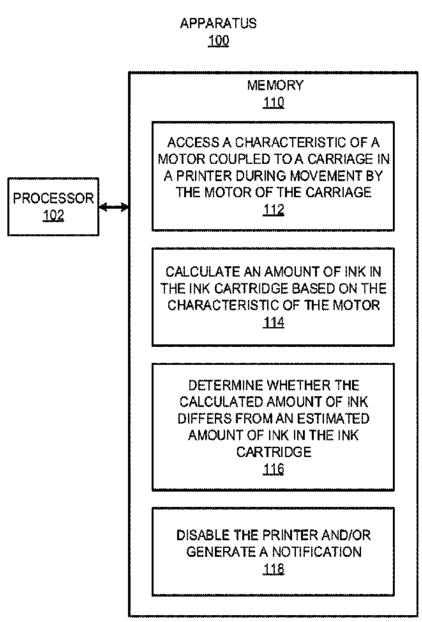
(57) **ABSTRACT**

According to examples, an apparatus may include a processor and a memory on which are stored computer-readable instructions that, when executed by the processor, may cause the processor to access a characteristic of a motor coupled to a carriage in a printer. In this regard, an ink cartridge may be mounted on the carriage and the characteristic may be of the motor during movement by the motor of the carriage. The processor may calculate an amount of ink in the ink cartridge based on the characteristic of the motor and may determine whether the calculated amount of ink differs from an estimated amount of ink in the ink cartridge. In some examples, based on the amount of ink in the ink cartridge differing from the estimated amount of ink in the ink cartridge, the processor may disable the printer and/or generate a notification.

17 Claims, 4 Drawing Sheets



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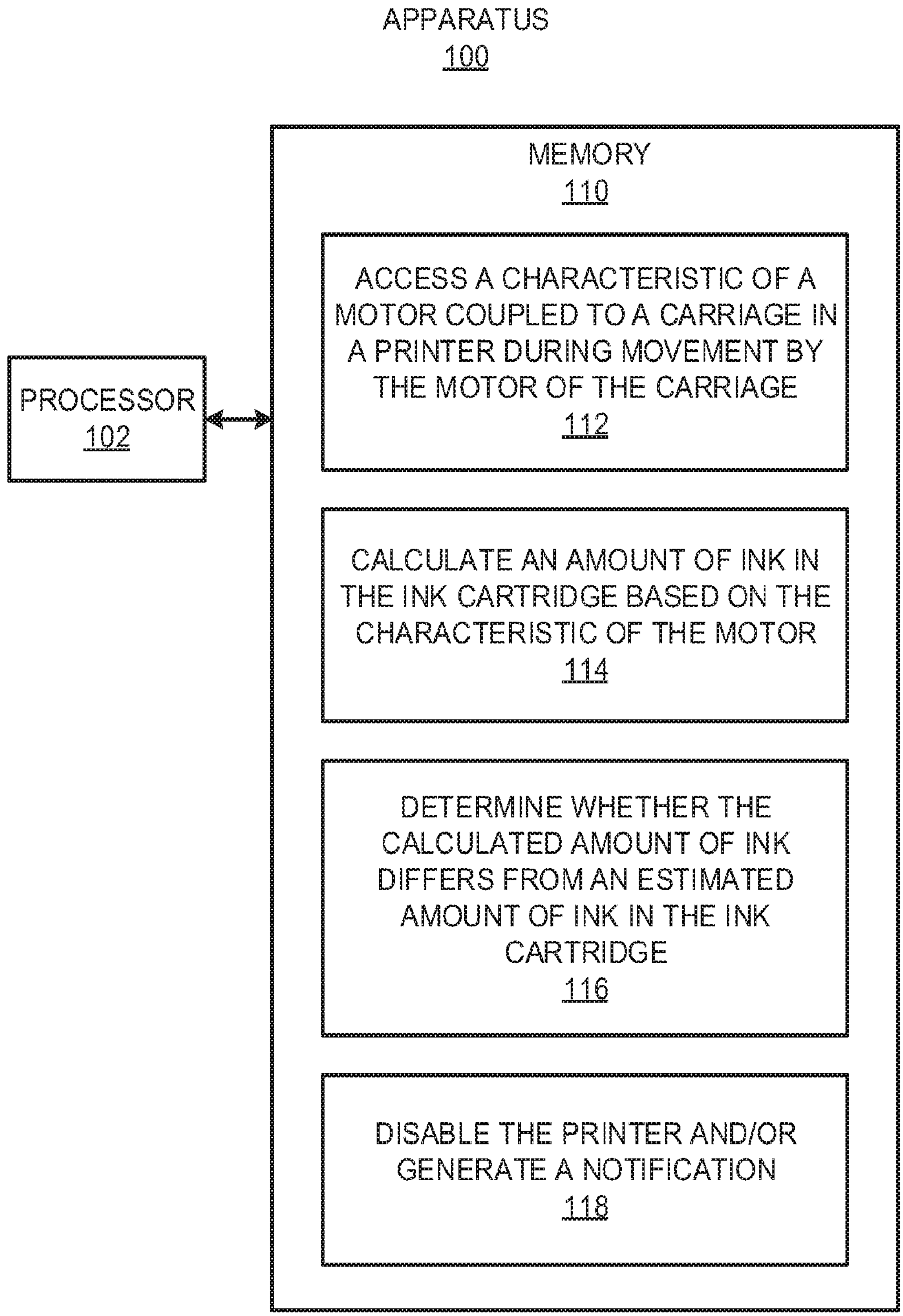
APPARATUS
100
MEMORY
110
PROCESSOR
102
ACCESS A CHARACTERISTIC OF A MOTOR COUPLED TO A CARRIAGE IN A PRINTER DURING MOVEMENT BY THE MOTOR OF THE CARRIAGE
112
CALCULATE AN AMOUNT OF INK IN THE INK CARTRIDGE BASED ON THE CHARACTERISTIC OF THE MOTOR
114
DETERMINE WHETHER THE CALCULATED AMOUNT OF INK DIFFERS FROM AN ESTIMATED AMOUNT OF INK IN THE INK CARTRIDGE
116
DISABLE THE PRINTER AND/OR GENERATE A NOTIFICATION
118

FIG. 1

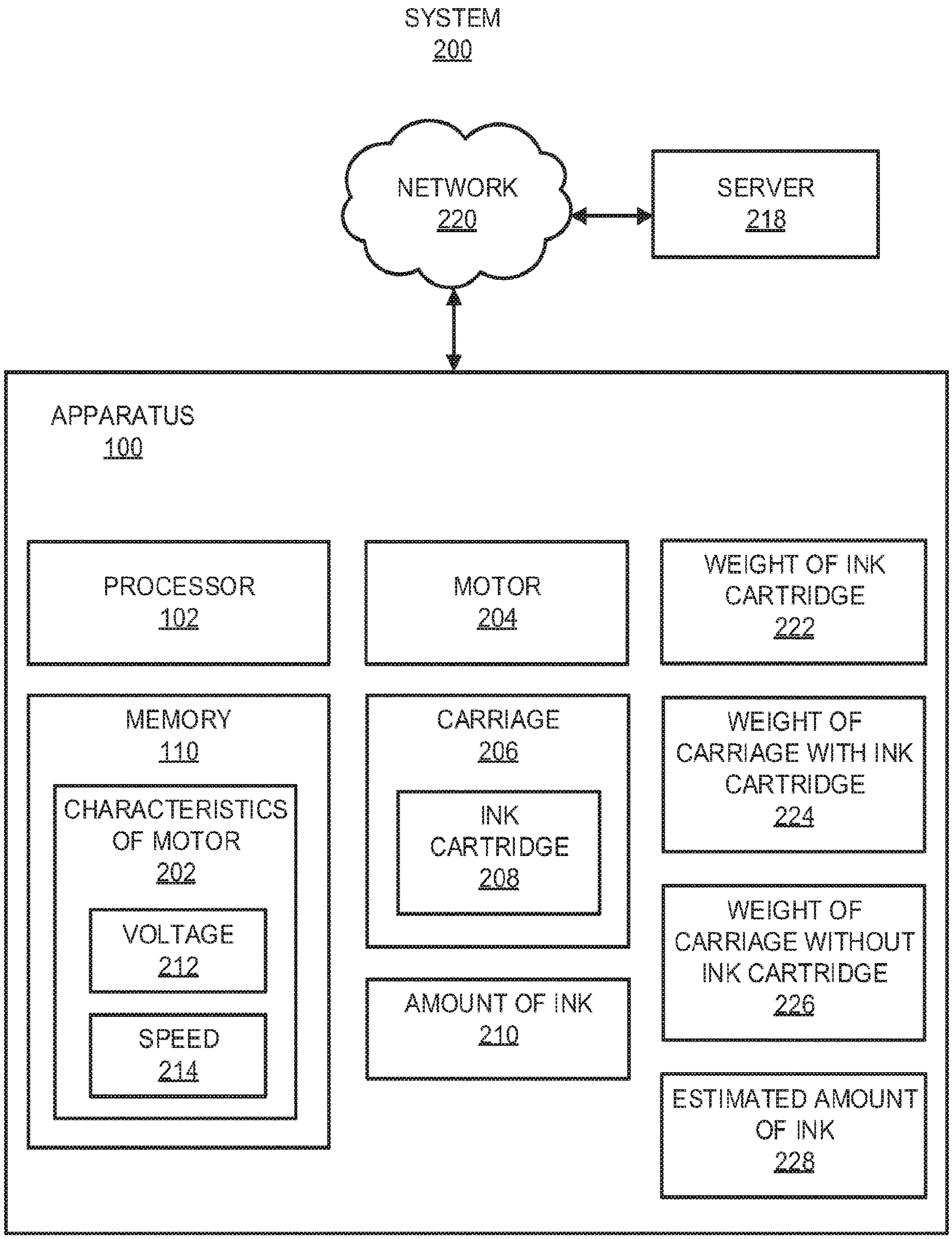
SYSTEM
200
NETWORK
220
SERVER
218
APPARATUS
100
PROCESSOR
102
MOTOR
204
WEIGHT OF INK CARTRIDGE
222
MEMORY
110
CHARACTERISTICS OF MOTOR
202
VOLTAGE
212
SPEED
214
CARRIAGE
206
INK CARTRIDGE
208
AMOUNT OF INK
210
WEIGHT OF CARRIAGE WITH INK CARTRIDGE
224
WEIGHT OF CARRIAGE WITHOUT INK CARTRIDGE
226
ESTIMATED AMOUNT OF INK
228

FIG. 2

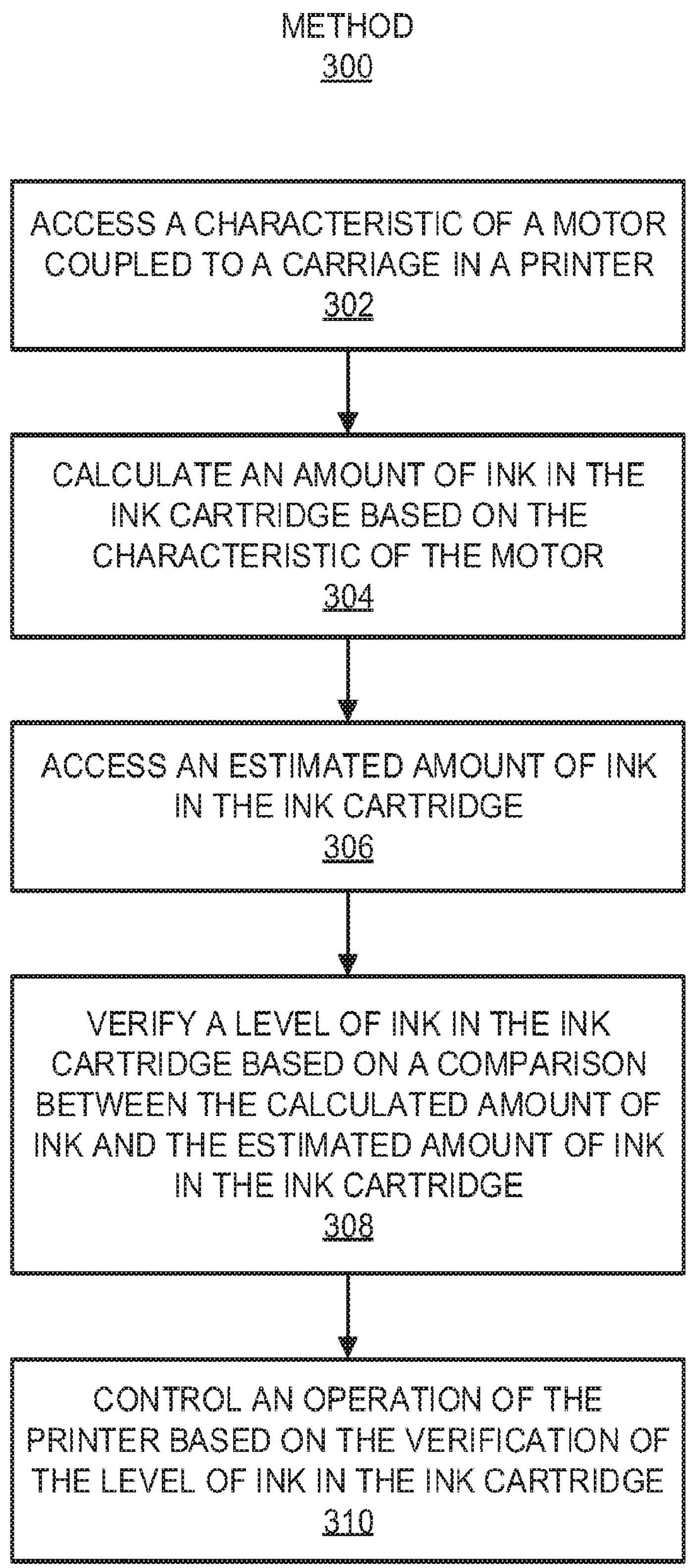
METHOD
300
ACCESS A CHARACTERISTIC OF A MOTOR COUPLED TO A CARRIAGE IN A PRINTER
302
CALCULATE AN AMOUNT OF INK IN THE INK CARTRIDGE BASED ON THE CHARACTERISTIC OF THE MOTOR
304
ACCESS AN ESTIMATED AMOUNT OF INK IN THE INK CARTRIDGE
306
VERIFY A LEVEL OF INK IN THE INK CARTRIDGE BASED ON A COMPARISON BETWEEN THE CALCULATED AMOUNT OF INK AND THE ESTIMATED AMOUNT OF INK IN THE INK CARTRIDGE
308
CONTROL AN OPERATION OF THE PRINTER BASED ON THE VERIFICATION OF THE LEVEL OF INK IN THE INK CARTRIDGE
310

FIG. 3

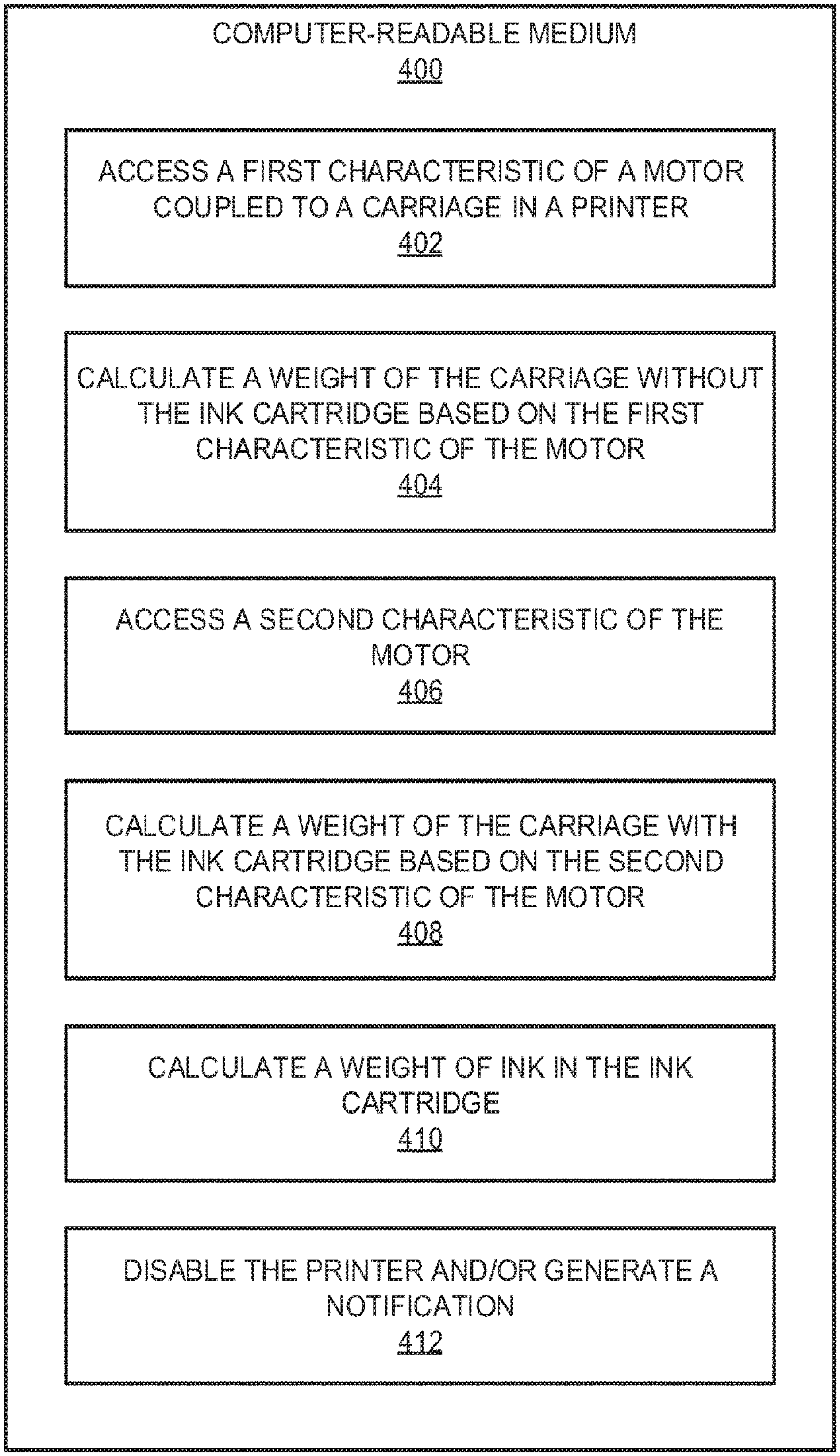
COMPUTER-READABLE MEDIUM
400
ACCESS A FIRST CHARACTERISTIC OF A MOTOR COUPLED TO A CARRIAGE IN A PRINTER
402
CALCULATE A WEIGHT OF THE CARRIAGE WITHOUT THE INK CARTRIDGE BASED ON THE FIRST CHARACTERISTIC OF THE MOTOR
404
ACCESS A SECOND CHARACTERISTIC OF THE MOTOR
406
CALCULATE A WEIGHT OF THE CARRIAGE WITH THE INK CARTRIDGE BASED ON THE SECOND CHARACTERISTIC OF THE MOTOR
408
CALCULATE A WEIGHT OF INK IN THE INK CARTRIDGE
410
DISABLE THE PRINTER AND/OR GENERATE A NOTIFICATION
412

FIG. 4

INK CARTRIDGE INK AMOUNT CALCULATIONS BASED ON MOTOR CHARACTERISTICS

BACKGROUND

Printers, such as inkjet printers, may include ink cartridges. The ink cartridges may be mounted on a carriage, which may be moved across a print media by a motor during printing operations in which the ink cartridges may be deposited onto the print media.

BRIEF DESCRIPTION OF THE DRAWINGS

Features of the present disclosure are illustrated by way of example and not limited in the following figure(s), in which like numerals indicate like elements, in which:

FIG. **1** depicts a block diagram of an example apparatus that may calculate an amount of ink in an ink cartridge based on a characteristic of a motor;

FIG. **2** shows a block diagram of an example system within which the example apparatus depicted in FIG. **1** may be implemented;

FIG. **3** shows a flow diagram of an example method for calculating an amount of ink in an ink cartridge based on a characteristic of a motor and verifying an amount of ink in the ink cartridge based on the calculated amount of ink and an estimated amount of ink; and

FIG. **4** depicts a block diagram of an example non-transitory computer-readable medium that may have stored thereon computer-readable instructions to calculate a weight of ink in an ink cartridge based on characteristics of a motor during movement of the carriage by the motor.

DETAILED DESCRIPTION

For simplicity and illustrative purposes, the present disclosure is described by referring mainly to examples. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. It will be readily apparent however, that the present disclosure may be practiced without limitation to these specific details. In other instances, some methods and structures have not been described in detail so as not to unnecessarily obscure the present disclosure.

Throughout the present disclosure, the terms "a" and "an" are intended to denote at least one of a particular element. As used herein, the term "includes" means includes but not limited to, the term "including" means including but not limited to. The term "based on" means based at least in part on.

Printers, such as inkjet printers, may include a carriage that may support an ink cartridge, such as a one-time fill type ink cartridge. In some examples, the level of ink in the ink cartridge may be estimated, for instance, by tracking printer use. In some examples, a number of printed drops fired from the ink cartridge may be counted and a corresponding amount of ink used may be estimated based on the number of drops fired. However, in some cases, a concern with estimating an ink level in an ink cartridge may be that the estimation may assume that the ink cartridge has not been modified or tampered with, for instance, by adding ink into the ink cartridge, by adding a continuous ink supply into the ink cartridge, and/or the like. In some instances, the addition of ink into the ink cartridge may violate terms of an agreement that a user may have with a supplier of the ink cartridge.

Disclosed herein are apparatuses, systems, methods, and computer-readable media in which a processor may calculate an ink level or an amount of ink in an ink cartridge using, for instance, a motor-based calculation of the mass and/or weight of the ink cartridge. In some printers, an electric motor under feedback control may control the movement of a carriage upon which the ink cartridge is mounted by, for instance, a servo that may include a motor for precise control of angular and/or linear motion/position and sensors to enable feedback control. As the ink cartridge empties, the mass of the feedback controlled carriage may change, and a calibration algorithm in firmware may detect that change in mass through use of characteristics of the motor while the motor is moving the carriage. The processor may use the calculated difference in mass to calculate the amount of ink in the ink cartridge.

In some examples, the amount of ink calculated to be in the ink cartridge using the mass of the ink cartridge may be compared against another method of estimating the amount of ink in the ink cartridge. In some examples, the calculated amount of ink may be compared against an estimation of the amount of ink in the ink cartridge based on a number of drops of ink fired from the ink cartridge. In some examples, when the two values do not agree beyond a predefined difference level, the processor may determine, for instance, that the ink cartridge has been tampered with, and may disable the printer and/or generate a notification.

By enabling a determination of ink levels using motor characteristics as discussed in the present disclosure, ink level estimations may be based on actual hardware present in the printer, which may be more accurate than other methods of tracking and estimating ink levels. For instance, the determination of ink levels as discussed in the present disclosure may, for instance, be more accurate than methods that count a number of drops of ink fired from the ink cartridge. In some instances, the processor may more reliably determine whether an ink cartridge has been tampered with, for instance, to add ink to the ink cartridge, since the calculated amount of ink is based on actual measurements of the ink cartridge. In this regard, the processor may more reliably take remedial action, including disabling the printer and/or sending a notification to the user. Furthermore, the features of the present disclosure may be implemented in firmware, which may be less costly and simpler to manufacture than other solutions based on hardware modifications for determining tampering and/or modification of the ink cartridge hardware, for instance, hardware modifications to add features to ink cartridges to determine how much ink is present in the ink cartridges.

Reference is first made to FIGS. **1** and **2**. FIG. **1** shows a block diagram of an example apparatus **100** that may calculate an amount of ink in an ink cartridge based on a characteristic of a motor. FIG. **2** shows a block diagram of an example system **200** within which the example apparatus **100** depicted in FIG. **1** may be implemented. It should be understood that the apparatus **100** depicted in FIG. **1** and/or the system **200** depicted in FIG. **2** may include additional features and that some of the features described herein may be removed and/or modified without departing from the scopes of the apparatus **100** and/or the system **200**.

In some examples, the apparatus **100** may be implemented in a printer, such as a thermal inkjet printer, a piezoelectric inkjet printer, or the like. As shown, the apparatus **100** may include a processor **102** and a non-transitory computer-readable medium, e.g., a memory **110**. The processor **102** may be a semiconductor-based microprocessor, a central processing unit (CPU), an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA), and/or other hardware device. Although the apparatus **100** is depicted as having a single processor **102**, it should be understood that the apparatus **100** may include additional processors and/or cores without departing from a scope of the apparatus **100** and/or system **200**. In this regard, references to a single processor **102** as well as to a single memory **110** may be understood to additionally or alternatively pertain to multiple processors **102** and/or multiple memories **110**.

The memory **110** may be an electronic, magnetic, optical, or other physical storage device that contains or stores executable instructions. The memory **110** may be, for example, Read Only Memory (ROM), flash memory, solid state drive, Random Access memory (RAM), an Electrically Erasable Programmable Read-Only Memory (EEPROM), a storage device, an optical disc, or the like. The memory **110** may be a non-transitory computer-readable medium. The term "non-transitory" does not encompass transitory propagating signals.

As shown in FIG. **1**, the processor **102** may execute instructions **112-118** to calculate an amount of ink in an ink cartridge based on a characteristic of a motor. The instructions **112-118** may be computer-readable instructions, e.g., non-transitory computer-readable instructions. In other examples, the apparatus **100** may include hardware logic blocks or a combination of instructions and hardware logic blocks to implement or execute functions corresponding to the instructions **112-118**.

The processor **102** may fetch, decode, and execute the instructions **112** to access a characteristic **202** of a motor **204** coupled to a carriage **206** in the apparatus **100**. In some examples, an ink cartridge **208** may be mounted on the carriage **206** and the motor **204** may control movement of the carriage **206**, and thus movement of the ink cartridge **208**, over a print media. The characteristic **202** of the motor **204** may be a characteristic that may be determined during movement by the motor **204** of the carriage **206**. In some examples, the characteristic **202** may be used to calculate a weight of the carriage **206**, which in turn may be used to calculate a weight of the ink cartridge **208**, and which in turn may be used to calculate a weight of the ink stored in the ink cartridge **208** as the volume of ink in the ink cartridge **208** may change over time.

By way of particular example and for purposes of illustration, the ink cartridge **208** may be mounted on the carriage **206**, which may be moved linearly across the apparatus **100** by an electric motor, such as the motor **204** as depicted in FIG. **2**, under feedback control. In this example, the motor **204** may be connected to the carriage **206** through a pulley (not shown) that drives a belt (not shown), which may be connected directly to the carriage **206**. The processor **102** may calculate an estimation of an inertia of the carriage **206** by determining an amount of motor torque used to accelerate the carriage **206** at a given rate.

In some examples, the characteristic **202** of the motor **204** may include a motor voltage level **212**, a motor speed **214**, a motor current, a motor torque constant, a motor resistance measured during movement by the motor **204** of the carriage **206**, and/or the like. In this regard, the motor torque may be an estimation based on the motor voltage level **212** and the motor speed **214**.

By way of particular example and for purposes of illustration, when a resistance (R) and a reactance (X) of the motor **204** are known, an overall impedance (Z) of the motor **204** at different motor speeds **214** (speed) may be calculated by:

$$Z=\sqrt{(R^2+(X^*\text{speed})^2} \qquad \text{Equation 1}$$

In some examples, the motor current may be calculated as:

$$I=\frac{(V_{in}-V_{bemf})}{Z} \qquad \text{Equation 2}$$

where:

$$V_{bemf}=k_e{}^*\text{speed} \qquad \text{Equation 3}$$

In this instance, V_{in} may be the motor voltage level **212** and k_e may be a back-electromotive force (back EMF) constant of the motor **204**.

Once current I is known, the motor torque (Trq) may be calculated using the motor torque constant, k_t: based on:

$$Trp=k_t{}^*I \qquad \text{Equation 4}$$

In this regard, the processor **102** may estimate the inertia of the carriage **206** based on an amount of the motor torque (Trq) used to accelerate the carriage **206** at a given rate, and subtracting a torque due to friction. In some examples, the amount of torque due to friction may vary linearly to motor speeds **214**, and as such, the processor **102** may run the motor **204** at, for instance, three different speeds and may capture an amount of motor torque (Trq) to run at a steady state velocity for each of the three different speeds. In some examples, a relationship between velocity and friction may be calculated by taking a least square regression of the three different speeds. As such, the processor **102** may calculate a weight of the carriage **206** based on characteristics **202** of the motor **204** including, for instance, the motor voltage level **212** and the motor speed **214**.

As depicted in FIG. **2**, the system **200** may include a server **218** with which the apparatus **100** may be in communication via a network **220**. In some examples, the characteristics **202** of the motor **204** may be stored in the memory **110** on the apparatus **100**, on the server **218** connected over the network **220**, and/or the like. In some examples, the characteristics **202** of the motor **204**, including the resistance (R) of the motor **204**, the reactance (X) of the motor **204**, the back EMF constant, the motor voltage level **212**, and/or the motor speed **214** may be measured during operation of the motor **204**, and in some instances, may be stored on the memory **110**, on the server **218**, and/or the like.

In some examples, the processor **102** may adjust the characteristics **202** of the motor **204** based on changes in temperature of the motor, for instance, changes in resistance (R) of the motor **204** based on changes in temperatures of the windings of the motor **204**. In this regard, a relationship between the motor current, the motor torque (Trq), and thermal characteristics of the motor **204** may be defined to improve accuracy, and modified characteristics **202** of the motor **204** reflecting this relationship may be user-defined, based on testing/experimentation on the motor **204**, prior knowledge, and/or the like.

The processor **102** may fetch, decode, and execute the instructions **114** to calculate an amount (e.g., volume) of ink **210** in the ink cartridge **208** based on the characteristics **202** of the motor **204**. In some examples, the processor **102** may calculate a weight **222** of the ink cartridge **208** based on a difference between a calculated weight **224** of the carriage **206** with the ink cartridge **208** and a calculated weight **226** of the carriage **206** without the ink cartridge **208**. The processor **102** may calculate the amount of ink **210** currently in the ink cartridge **208** based on the determined weight **222** of the ink cartridge **208**, for instance, based on a difference between the determined weight **222** of the ink cartridge **208** and a known weight of an empty ink cartridge **208**.

In some examples, the processor **102** may calculate the weight **226** of the carriage **206** without the ink cartridge **208** during an initial calibration of the apparatus **100**. In some instances, the weight **226** of the carriage **206** without the ink cartridge **208** may be stored in the memory **110** or at the server **218**, and may be accessed by the processor **102** to calculate the amount of ink **210**.

In some examples, the processor **102** may periodically calculate the weight **224** of the carriage with the ink cartridge **208** based on the characteristic **202** of the motor **204**. The processor **102** may periodically calculate the amount of ink **210** in the ink cartridge **208** based on a difference between the calculated weight **226** of the carriage **206** without the ink cartridge **208** and the periodically calculated weight **224** of the carriage **206** with the ink cartridge **208**. As such, the processor **102** may calculate a real-time value of the amount of ink **210** in the ink cartridge **208** based on the characteristic **202** of the motor **204**.

The processor **102** may fetch, decode, and execute the instructions **116** to determine whether the calculated amount of ink **210** differs from an estimated amount of ink **228** in the ink cartridge **208**. The processor **102** may calculate the estimated amount of ink **228**, or in some instances, the processor **102** may access stored values of the estimated amount of ink **228** from the memory **110**, the server **218**, and/or the like. The processor **102** may compare the calculated amount of ink **210** in the ink cartridge **208** with the estimated amount of ink **228** in the ink cartridge **208**.

In some examples, the estimated amount of ink **228** may be based on a number of drops fired from the ink cartridge **208** from a certain point, for instance when the ink cartridge **208** is full, and a known weight per drop of ink. In some examples, the processor **102** may track the number of drops fired from the ink cartridge **208**. Alternatively or additionally, the number of drops fired from the ink cartridge **208** may be monitored and stored by another device, for instance, by the server **218**.

The processor **102** may fetch, decode, and execute the instructions **118** to disable the printer and/or generate a notification based on the amount of ink **210** in the ink cartridge **208** differing from the estimated amount of ink **228** in the ink cartridge **208**, for instance, by a predefined difference level. The predefined difference level may be determined through testing, modeling, prior knowledge, and/or the like. By way of particular example and for purposes of illustration, the processor **102** may determine that the ink cartridge **208** has been tampered with or altered, for instance, through addition of more ink and/or through modification of the ink cartridge **208** such that the ink cartridge **208** is connected to a continuous ink supply, in cases where the calculated amount of ink **210** is different than the estimated amount of ink **228** by a predetermined amount or more.

Various manners in which the processor **102** may operate are discussed in greater detail with respect to the method **300** depicted in FIG. **3**. FIG. **3** depicts a flow diagram of an example method **300** for calculating an amount of ink **210** in an ink cartridge **208** based on a characteristic **202** of a motor **204** and verifying an amount of ink **210** in the ink cartridge **208** based on a comparison between the calculated amount of ink **210** and an estimated amount of ink **228**. It should be understood that the method **300** depicted in FIG. **3** may include additional operations and that some of the operations described therein may be removed and/or modified without departing from the scope of the method **300**. The description of the method **300** is made with reference to the features depicted in FIGS. **1** and **2** for purposes of illustration.

At block **302**, the processor **102** may access a characteristic **202** of a motor **204** coupled to a carriage **206** in a printer. In some examples, the carriage **206** may support an ink cartridge **208** such that the motor **204** may control movement of the ink cartridge **208** in the printer. The characteristic **202** of the motor **204** may be a characteristic during movement of the carriage **206** by the motor **204**.

At block **304**, the processor **102** may calculate an amount of ink **210** in the ink cartridge **208** based on the accessed characteristic **202** of the motor **204**. In some examples, the processor **102** may calculate a weight **222** of the ink cartridge **208** based on the accessed characteristic **202** of the motor **204**. In this regard, the processor **102** may calculate the weight **222** of the ink cartridge **208** based on a difference between a calculated weight **224** of the carriage **206** with the ink cartridge **208** and a calculated weight **226** of the carriage **206** without the ink cartridge **208**. As such, the processor **102** may calculate the amount of ink **210** in the ink cartridge **208** based on the calculated weight **222** of the ink cartridge **208**.

In some examples, the processor **102** may access a motor voltage **212** and a motor speed **214** respectively depicted in FIG. **2**, during movement of the carriage **206** by the motor **204**. The processor **102** may calculate a motor torque (Trq) based on the motor voltage level **212** and the motor speed **214**, and based on the calculated motor torque (Trq), the processor **102** may calculate the weight **224** of the carriage **206** with the ink cartridge **208** based on the determined motor torque resulting from movement of the carriage **206** with the ink cartridge **208**.

At block **306**, the processor **102** may access an estimated amount of ink **228** in the ink cartridge **208**. In some examples, the processor **102** may determine a number of drops fired from the ink cartridge **208** from a certain point, for instance, from a point at which the ink cartridge **208** is full. In this instance, the processor **102** may determine the estimated amount of ink **228** in the ink cartridge **208** based on the determined number of drops fired from the ink cartridge **208** from the certain point and a predetermined capacity of the ink cartridge **208**.

In some examples, the processor **102** may estimate a weight of ink in the ink cartridge **208** based on a difference between a predetermined initial weight of ink in the ink cartridge **208** and a weight of the number of drops of ink fired from the ink cartridge **208**. In addition, the processor **102** may determine the estimated amount of ink **228** in the ink cartridge **208** based on the estimated weight of ink in the ink cartridge **208**.

At block **308**, the processor **102** may verify that the estimated level of ink in the ink cartridge **208** is accurate based on a comparison between the calculated amount of ink **210** and the estimated amount of ink **228** in the ink cartridge **208**. In some examples, the processor **102** may verify that the estimated amount of ink **228** is accurate based on a determination that the estimated amount of ink **228** is within a predetermined range of the calculated amount of ink **210**, which is calculated based on the characteristic **202** of the motor **204**.

At block **310**, the processor **102** may control an operation of the printer based on the verification of the level of ink in the ink cartridge **208**. In some examples, based on a determination that the calculated amount of ink **210** in the ink cartridge **208** does not correspond to the estimated amount of ink **228**, the processor **102** may disable the printer and/or generate a notification.

Some or all of the operations set forth in the method **300** may be included as utilities, programs, or subprograms, in any desired computer accessible medium. In addition, the method **300** may be embodied by computer programs, which may exist in a variety of forms both active and inactive. For example, they may exist as computer-readable instructions, including source code, object code, executable code or other formats. Any of the above may be embodied on a non-transitory computer-readable storage medium.

Examples of non-transitory computer-readable storage media include computer system RAM, ROM, EPROM, EEPROM, and magnetic or optical disks or tapes. It is therefore to be understood that any electronic device capable of executing the above-described functions may perform those functions enumerated above.

Turning now to FIG. **4**, there is shown a block diagram of a non-transitory computer-readable medium **400** that may have stored thereon computer-readable instructions to calculate a weight of ink in an ink cartridge **208** based on characteristics **202** of a motor **204** during movement of the carriage **206** by the motor **204**. It should be understood that the computer-readable medium **400** depicted in FIG. **4** may include additional instructions and that some of the instructions described herein may be removed and/or modified without departing from the scope of the computer-readable medium **400** disclosed herein. The computer-readable medium **400** may be a non-transitory computer-readable medium. The term "non-transitory" does not encompass transitory propagating signals.

The computer-readable medium **400** may have stored thereon computer-readable instructions **402-412** that a processor, such as the processor **102** depicted in FIGS. **1-2**, may execute. The computer-readable medium **400** may be an electronic, magnetic, optical, or other physical storage device that contains or stores executable instructions. The computer-readable medium **400** may be, for example, Random-Access memory (RAM), an Electrically Erasable Programmable Read-Only Memory (EEPROM), a storage device, an optical disc, or the like.

The processor may fetch, decode, and execute the instructions **402** to access a first characteristic of a motor **204**, such as the characteristic **202** depicted in FIG. **2**, coupled to a carriage **206** in a printer. In some examples, the carriage **206** may support an ink cartridge **208**. The first characteristic **202** may be a characteristic of the motor **204** during movement of the carriage **206** without the ink cartridge **208** by the motor **204**.

The processor may fetch, decode, and execute the instructions **404** to calculate a weight **226** of the carriage **206** without the ink cartridge based on the first characteristic **202** of the motor **204**. In some examples, the weight **226** of the carriage **206** without the ink cartridge **208** may be a calibrated weight of the carriage **206** that is measured and stored in the memory **110** during an initial calibration process.

The processor may fetch, decode, and execute the instructions **406** to access a second characteristic of the motor **204**, such as the characteristic **202** depicted in FIG. **2**. The second characteristic **202** may be a characteristic of the motor **204** during movement of the carriage **206** with the ink cartridge **208** by the motor **204**. In some examples, the second characteristic **202** may be a characteristic of the motor **204** obtained, for instance, at periodic intervals and based on a changing weight **224** of the carriage **206** due to falling levels of ink in the ink cartridge **208**.

The processor may fetch, decode, and execute the instructions **408** to calculate a weight **224** of the carriage **206** with the ink cartridge **208** based on the second characteristic **202** of the motor **204**. In this regard, the calculated weight **224** of the carriage **206** may reflect a changing weight of the carriage **206** caused by falling levels of ink in the ink cartridge **208**.

The processor may fetch, decode, and execute the instructions **410** to calculate a weight of ink in the ink cartridge **208** based on a difference between the weight **226** of the carriage **206** without the ink cartridge **208** and the weight **224** of the carriage **206** with the ink cartridge **208**. In some examples, the processor may calculate the amount of ink **210** in the ink cartridge **208** based on the calculated weight of ink in the ink cartridge **208**.

The processor may fetch, decode, and execute the instructions **412** to disable the printer and/or generate a notification based on a determination that the calculated weight of ink in the ink cartridge is outside a predetermined range. In this regard, the calculated weight of ink may be similar to the calculated amount of ink **210** depicted in FIG. **2**. In some examples, the processor **102** may determine that the weight of ink in the ink cartridge **208** is outside the predetermined range based on a comparison to an estimation of an amount of ink expected in the ink cartridge **208**.

In some examples, the processor **102** may access an estimated weight of ink in the ink cartridge **208**. In some examples, the estimated weight of ink may be similar to the estimated amount of ink **228** depicted in FIG. **2**. The estimated weight of ink may be based on a number of drops fired from the ink cartridge **208** from a certain point, for instance, a full state. In some examples, the processor **102** may compare the estimated weight of ink against the calculated weight of ink in the ink cartridge **208**. The processor **102** may disable the printer and/or generate the notification based on a determination that the estimated weight of ink differs from the calculated weight of ink by a predetermined amount.

Although described specifically throughout the entirety of the instant disclosure, representative examples of the present disclosure have utility over a wide range of applications, and the above discussion is not intended and should not be construed to be limiting, but is offered as an illustrative discussion of aspects of the disclosure.

What has been described and illustrated herein is an example of the disclosure along with some of its variations. The terms, descriptions and figures used herein are set forth by way of illustration and are not meant as limitations. Many variations are possible within the scope of the disclosure, which is intended to be defined by the following claims—and their equivalents—in which all terms are meant in their broadest reasonable sense unless otherwise indicated.

What is claimed is:

1. An apparatus comprising:

a processor; and

a memory on which are stored computer-readable instructions that when executed by the processor, cause the processor to:

access a characteristic of a motor coupled to a carriage in a printer, an ink cartridge being mounted on the carriage, and the characteristic of the motor is measured during movement by the motor of the carriage;

calculate an amount of ink in the ink cartridge based on the characteristic of the motor;

determine whether the calculated amount of ink differs from an estimated amount of ink in the ink cartridge; and

based on the calculated amount of ink in the ink cartridge differing from the estimated amount of ink in the ink cartridge, generate a notification.

2. The apparatus of claim **1**, wherein the instructions cause the processor to:

calculate the amount of ink in the ink cartridge based on a difference between a calculated weight of the carriage with the ink cartridge and a calculated weight of the carriage without the ink cartridge.

3. The apparatus of claim **2**, wherein the instructions cause the processor to:

access the characteristic of the motor, the characteristic including a motor voltage and a motor speed during movement by the motor of the carriage;

determine a motor torque based on the motor voltage and the motor speed; and

calculate the weight of the carriage with the ink cartridge based on the determined motor torque resulting from movement of the carriage with the ink cartridge and resulting from movement of the carriage without the ink cartridge.

4. The apparatus of claim **1**, wherein the instructions cause the processor to:

determine a weight of the ink cartridge based on the accessed characteristic of the motor; and

calculate the amount of ink in the ink cartridge based on the determined weight of the ink cartridge.

5. The apparatus of claim **1**, wherein the characteristic of the motor includes a motor voltage level, a motor speed, a motor current, a motor torque constant, and/or a motor resistance measured during movement by the motor of the carriage.

6. The apparatus of claim **1**, wherein the instructions cause the processor to:

access the estimated amount of ink in the ink cartridge, the estimated amount of ink being based on a number of drops fired from the ink cartridge from a certain point; and

determine whether the calculated amount of ink differs from the estimated amount based on a comparison of the calculated amount of ink against the estimated amount of ink in the ink cartridge.

7. The apparatus of claim **1**, wherein the instructions cause the processor to:

calculate a weight of the carriage without the ink cartridge based on the characteristic of the motor;

periodically calculate a weight of the carriage with the ink cartridge based on the characteristic of the motor;

periodically calculate the amount of ink in the ink cartridge based on a difference between the calculated weight of the carriage without the ink cartridge and the periodically calculated weight of the carriage with the ink cartridge; and

compare the calculated amount of ink in the ink cartridge with the estimated amount of ink in the ink cartridge.

8. A method comprising:

accessing, by a processor, a characteristic of a motor coupled to a carriage in a printer, the carriage supporting an ink cartridge, and the characteristic of the motor is measured during movement of the carriage by the motor;

calculating, by the processor, an amount of ink in the ink cartridge based on the characteristic of the motor;

accessing, by the processor, an estimated amount of ink in the ink cartridge;

verifying, by the processor, a level of ink in the ink cartridge based on a comparison between the calculated amount of ink and the estimated amount of ink in the ink cartridge; and

controlling, by the processor, an operation of the printer based on the verification of the level of ink in the ink cartridge.

9. The method of claim **8**, further comprising:

calculating a weight of the ink cartridge based on a difference between a calculated weight of the carriage with the ink cartridge and a calculated weight of the carriage without the ink cartridge; and

calculating the amount of ink in the ink cartridge based on the calculated weight of the ink cartridge.

10. The method of claim **9**, further comprising:

accessing a motor voltage and a motor speed during movement of the carriage by the motor;

calculate a motor torque based on the motor voltage and the motor speed; and

calculating the weight of the carriage with the ink cartridge based on the calculated motor torque resulting from movement of the carriage with the ink cartridge.

11. The method of claim **8**, further comprising:

calculating a weight of the ink cartridge based on the accessed characteristic of the motor; and

calculating the amount of ink in the ink cartridge based on the calculated weight of the ink cartridge.

12. The method of claim **8**, further comprising:

determining a number of drops fired from the ink cartridge from a certain point;

determining the estimated amount of ink in the ink cartridge based on the determined number of drops fired from the ink cartridge from the certain point and a predetermined capacity of the ink cartridge; and

based on a determination that the calculated amount of ink in the ink cartridge does not correspond to the estimated amount of ink, disabling the printer and/or generating a notification.

13. The method of claim **8**, further comprising:

estimating a weight of ink in the ink cartridge based on a difference between a predetermined initial weight of ink in the cartridge and a weight of a number of drops of ink fired from the ink cartridge, wherein the estimated amount of ink in the ink cartridge is based on the estimated weight of ink in the ink cartridge.

14. A non-transitory computer readable medium on which is stored computer-readable instructions that, when executed by a processor, cause the processor to:

access a first characteristic of a motor coupled to a carriage in a printer, the carriage to support an ink cartridge, the first characteristic of the motor is measured during movement of the carriage without the ink cartridge by the motor;

calculate a weight of the carriage without the ink cartridge based on the first characteristic of the motor;

access a second characteristic of the motor, the second characteristic of the motor is measured during movement of the carriage with the ink cartridge by the motor;

calculate a weight of the carriage with the ink cartridge based on the second characteristic of the motor;

calculate a weight of ink in the ink cartridge based on a difference between the weight of the carriage without the ink cartridge and the weight of the carriage with the ink cartridge; and

based on a determination that the calculated weight of ink in the ink cartridge is outside a predetermined range, generate a notification.

15. The non-transitory computer readable medium of claim **14**, wherein the instructions cause the processor to:

access an estimated weight of ink in the ink cartridge, the estimated weight of ink being based on a number of drops fired from the ink cartridge from a certain point;

compare the estimated weight of ink against the calculated weight of ink in the ink cartridge; and

disable the printer and/or generate the notification based on a determination that the estimated weight of ink differs from the calculated weight of ink by a predetermined amount.

16. The apparatus of claim **1**, wherein the instructions cause the processor to calculate a real-time value of the amount of ink in the ink cartridge based on the characteristic of the motor.

17. The apparatus of claim **1**, wherein the instructions cause the processor to determine that the ink cartridge has been tampered with based on the amount of ink in the ink cartridge differing from the estimated amount of ink in the ink cartridge by a predetermined amount.

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