

FEED MECHANISM FOR MAINTAINING CONSTANT WEB TENSION IN A WIDE FORMAT
PRINTER

5 Field of the Invention

This invention relates to wide format printers and improvements thereto for allowing high-speed pagewidth inkjet printing.

Cross References to Related Applications

- 10 Various methods, systems and apparatus relating to the present invention are disclosed in the following co-pending applications filed by the applicant or assignee of the present invention. The disclosures of all of these co-pending applications and granted patents are incorporated herein by cross-reference.

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Background of the Invention

Wide format printers are well known for printing large sized images onto a web of print media. They may be used, for example, in printing billboards or large office spreadsheets. Examples of popular wide format printers, which have been commercially available for many years, are the Hewlett Packard (HP) 1000/5000, the HP 3000/3500 and the Epson 7000/10 000.

All commercially available wide format printers have a moving printhead that traverses across a print medium whilst depositing ink. The print medium is necessarily stationary as the printhead traverses across it. When one line of an image has been printed the web incrementally advances ready for the next line to be printed.

An inherent disadvantage of current wide format printers is their slowness. High volume, high resolution printing is an objective that has been sought by the manufacturers of wide format printers for some time. Central to the problem of achieving high printing speeds is the ability to provide a printhead, which does not traverse across a stationary print medium and which is capable of generating the necessary number of ink dots at a suitable rate. Pagewidth printheads would avoid the need for a traversing printhead and allow high-speed printing. However, commercially available bubble jet and piezoelectric printheads suffer from excessive heat build up and energy consumption, and are therefore unsuitable for use in a pagewidth configuration. A number of disadvantages associated with such printheads are set out in U.S. Patent No. 6,443,555.

The present Applicant has developed pagewidth printheads capable of producing images having a resolution as high as 1600 dpi. These printheads are manufactured using integrated circuit fabrication techniques. Details of these printheads are the subject of a number of granted US patents and pending US patent applications, which are listed in the cross reference section above.

The pagewidth printheads developed by the present Applicant are extremely suitable for use in wide format printers, because they can operate at high speeds and can be driven at an extremely high cyclical rate. Accordingly, the present Applicant has developed a wide format printer employing a

pagewidth printhead. An example of such a wide format printer is described in US Patent No. 6,672,706 (Silverbrook), which is incorporated herein by reference. This printer makes high-speed wide format printing possible by "printing-on-the-fly" – that is, continuously feeding a web past the printhead and simultaneously printing without the web having to stationary at any stage.

5 It will be appreciated that, in order to achieve "printing-on-the-fly" at high speed with consistent print quality, it is important that feeding of the web is finely controlled. Any variation in web speed or web tension will result in a deterioration in print quality in the form of, for example, a distorted image. Accordingly, it would be desirable to provide a feed mechanism which achieves substantially constant tension in a web as it passes a printhead.

10 It would be further desirable to avoid of slippage of the web relative to drive rollers in the feed mechanism in order to maintain a constant web speed. It would be further desirable to provide drive rollers having sufficient traction with the web to avoid slippage, but which also maintain this traction after repeated uses of the feed mechanism over long periods of time.

15 It would be further desirable to provide a feed mechanism which minimizes folding, creasing or crumpling of the web before it reaches a printhead.

20 It will also be appreciated that, in order to achieve "printing-on-the-fly" at high speed with consistent print quality, it is important that a constant distance is maintained between the printhead and the web onto which the printhead prints. Usually, inkjet printing is performed by printing onto a web in a print zone, with the web being supported by a platen. However, with pagewidth printheads secured to a metal carrier frame, there is a tendency for the metal frame to sag across its width relative to the platen. This sagging causes variation in the distance between the printhead and the web across the width of the printhead, which results in a deterioration in print quality. Accordingly, it would be desirable to provide a printhead arrangement, which minimizes any variation in distance between the printhead and the web.

25 It would be desirable to provide a spool, such as a supply spool for a printer, which minimizes slippage of the rolled web of print media relative to a spindle on which it is mounted. It would be particularly desirable to maximize transmission of a force from a braking motor to a roll of print media so that tension in the web can be generated and accurately controlled.

30 Current methods for securing the print media to the take-up spool are cumbersome and, moreover, do not allow convenient removal of the print media from the take-up spool once printing has finished. The usual method is to fit a cardboard core (from a previously used paper roll) onto the take-up spool and fasten the web to the cardboard core using adhesive tape. Printing can then begin by actuating the printhead whilst automatically feeding print media from the supply spool to the take-up spool using a motorized feed mechanism. After printing, the web is cut adjacent the printhead, and the

cardboard core (with the printed paper wound on it) is removed by sliding it off the take-up spool. The printed paper roll is trimmed to size on a trimming machine and the cardboard core is recovered for re-use. Instead of recovering and re-using the cardboard core, a supply of fresh cardboard core may be used for successive print runs.

5 A problem with this method of loading and unloading the take-up spool is that the user needs to use adhesive tape or similar, which is awkward and not always conveniently available. A further problem is that a supply of empty take-up spools is required in order to run successive print jobs.

It would be desirable to provide a spool, such as a take-up spool for a wide format printer, which simplifies the operation of removing a web of material therefrom enabling the spool to be easily
10 re-used in successive print runs.

It would further be desirable to provide a spool, such as a take-up spool for a wide-format printer, which simplifies the operation of releasably securing a web of material thereto. It would be particularly desirable to provide a spool, which obviates the need for adhesive tape or similar when securing a web thereto.

15

Summary of the Invention

In a first aspect, there is provided a feed mechanism for a wide format printer, the feed mechanism comprising:

- a supply spool;
 - 20 a take-up spool;
 - a take-up motor operatively connected to the take-up spool;
 - a take-up control system for controlling the torque of the take-up motor;
 - a drive roller system positioned between the supply spool and the take-up spool; and
 - a drive motor operatively connected to the drive roller system,
- 25 wherein, in use, a web fed from the drive roller system to the take-up spool is maintained under substantially constant tension by regulating the torque of the take-up motor using the take-up control system.

In a second aspect, there is provided a method of printing onto a web of print media, wherein the web is continuously fed past a printhead at a substantially constant predetermined tension.

30 In a third aspect, there is provided a drive roller system for a wide format printer, the drive roller system comprising:

- a first drive roller having a rigid gritted surface, the first drive roller being operatively connected to a drive motor; and

a second drive roller having a flexible gripping surface grippingly engageable with the first drive roller,

wherein, in use, the rigid gritted surface and the flexible gripping surface cooperate to grip a web fed therebetween.

5 In a fourth aspect, there is provided a feed mechanism for a wide format printer, the feed mechanism comprising:

a supply spool;

a take-up spool;

a take-up motor operatively connected to the take-up spool; and

10 a drive roller system positioned between the supply spool and the take-up spool, wherein the drive roller system is as defined above.

In a fifth aspect, there is provided a method of printing onto a web of print media, wherein the web is continuously fed past a printhead at a substantially constant predetermined speed.

15 In a sixth aspect, there is provided drive roller system for a wide format printer, the drive roller system comprising:

a first drive roller operatively connected to a drive motor; and

a second drive roller releasably grippingly engageable with the first drive roller,

wherein, in use, the web is fed between the first and second drive rollers.

20 In a seventh aspect, there is provided a feed mechanism for a wide format printer, the feed mechanism comprising:

a supply spool;

a take-up spool;

a take-up motor operatively connected to the take-up spool; and

25 a drive roller system positioned between the supply spool and the take-up spool, wherein the drive roller system is as defined above.

In an eighth aspect, there is provided a method of extending the lifetime of a drive roller in a drive roller system for a wide format printer comprising the steps of: (a) providing a pair of grippingly engageable drive rollers; and (b) moving one of the drive rollers from a grippingly engaged position to a disengaged position when the printer is not in use.

30 In a ninth aspect, there is provided a feed mechanism for a wide format printer, the feed mechanism comprising:

a supply spool;

a braking mechanism operatively connected to the supply spool;

a take-up spool;

a take-up motor operatively connected to the take-up spool; and
a drive roller system positioned between the supply spool and the take-up spool,
wherein, in use, the braking mechanism generates tension in a web fed from the supply spool to the drive roller system.

- 5 In a tenth aspect, there is provided a method of minimizing web crumpling in a wide format printer comprising the steps of: (a) continuously feeding a web of print media from a supply spool and past a printhead using a drive roller system; and (b) tensioning the web between the supply spool and the drive roller system.

- In an eleventh aspect, there is provided a printer comprising:
10 a printhead having a corresponding print zone, the print zone being defined by a plane adjacent the printhead; and
 a feed mechanism for continuously feeding a web of print media through the print zone, wherein the web is unsupported in the print zone.

- In a twelfth aspect, there is provided a method of printing onto a web of print media, wherein
15 the web is continuously fed unsupported past a printhead.

- In a thirteenth aspect, there is provided a printer comprising:
 a printhead assembly, the printhead assembly comprising a printhead mounted on a printhead carrier;
 and
 a feed mechanism for continuously feeding a web of print media past the printhead,
20 wherein the printhead assembly is positioned in the path of the web such that, in use, the web is tensioned around the printhead assembly.

- In a fourteenth aspect, there is provided a method of printing onto a web of print media, wherein the web is continuously fed past a printhead mounted in a printhead assembly, the printhead assembly being positioned in the path of the web such that the web is tensioned around the printhead
25 assembly.

- In a fifteenth aspect, there is provided a printhead assembly for a wide format printer, the printhead assembly comprising:
 a printhead carrier;
 a printhead mounted on the carrier, the printhead having a print zone defined by a plane adjacent the
30 printhead; and
 a guide for guiding a web through the print zone, the guide being connected to the carrier.

 In a sixteenth aspect, there is provided a method of printing onto a web of print media, wherein the web is continuously guided under tension past a printhead by a guide, the guide forming part of a printhead assembly in which the printhead is mounted.

The feed mechanism may advantageously maintain constant tension in the web between the drive roller system and the take-up spool. In a wide format printer, the printhead is typically positioned immediately downstream of the drive rollers. When "printing-on-the-fly", it is especially important that the tension of the web is constant as it passes the printhead in the print zone. Any variation in web tension will result in stretching or shrinking of the web and, since the web is not stationary during printing, this would lead to distorted printed images. Hence, the present invention improves print quality in a high-speed wide format printer by maintaining constant tension in the web in the print zone.

Furthermore, the feed mechanism may advantageously minimize the risk of web crumpling by providing a braking mechanism for tensioning the web between the supply spool and the drive roller system. Without a braking mechanism, the supply spool would be free to rotate under the action of the drive roller system drawing the web therefrom. Free and uncontrolled rotation of the supply spool is usual in most commercially available wide format printers. However, in high-speed wide format printers, it has been found that free rotation of the supply spool is undesirable, because it results in a much greater propensity for the web to become crumpled or folded when it is fed at high speeds. The braking mechanism provides a counter-rotational force against the force of the drive roller system drawing the web from the supply spool and, hence, generates tension in the web. By generating tension in the web between the supply spool and the drive roller system, the likelihood of paper crumpling and, ultimately, printer malfunction, is reduced.

The drive roller system may advantageously maintain constant speed in the web between the drive roller system and the take-up spool by minimizing slippage of the web relative to the drive rollers. In a wide format printer, the printhead is typically positioned immediately downstream of the drive rollers. When "printing-on-the-fly", it is especially important that the speed of the web is constant as it passes the printhead in the print zone. By minimizing slippage of the web relative to the drive roller system, the present invention improves print quality in a high-speed wide format printer by maintaining constant speed of the web in the print zone.

Releasable gripping engagement of the second drive roller with the first drive roller advantageously allows the second drive roller to be released from gripping engagement when the printer is not in use, thereby extending the lifetime of the drive rollers. If the second drive roller (typically having a soft, flexible surface) is allowed to remain in gripping engagement with the first drive roller (typically having a hard surface) in a static position for long periods of time, then permanent deformation of the surface of the second drive roller may result. Such permanent deformation undesirably takes the form of "flat spots" on the surface of the second drive roller. These

flat spots can cause uneven gripping engagement with the first drive roller, which potentially results in periodic slippage of the web as it is fed through the drive roller system. Slippage of the web when performing high-speed "printing-on-the-fly" is highly undesirable and leads to variable web speeds, which typically manifests in distorted printed images.

5 The printer may advantageously obviate the need for a platen. In prior art wide format printers, the web is supported by a platen in the print zone. The web typically rests on the platen whilst the printhead traverses across it depositing ink to form one line of an image. Hence, the distance from the printhead to the print zone is governed by the distance from the printhead to the platen.

10 The Applicant has found that with pagewidth wide format printers (typically having a pagewidth printhead of about 36 inches in length), there is a tendency for the distance between the printhead and the platen to vary across the width of the web. This problem is caused by two factors. Firstly, the printhead carrier, being formed from metal, experiences bowing (or sagging) in its middle portion due to the effect of gravity in this unsupported region. This bowing effect is transferred to the printhead mounted at the base of the carrier. Secondly, the platen, being formed from relatively thick
15 metal and/or being supported across its length, does not experience the same bowing effect. The result is that the relative distance between the printhead and the platen is smaller in the middle region than it is at the end regions of the printhead. This variation is highly undesirable in terms of achieving consistently high print quality at high speeds.

20 In order to address this problem, the Applicant has devised a novel printer, wherein the web is unsupported in the print zone. An advantage of the web not being supported by a platen is that there is no possibility of variations in distance between the printhead and the platen (such as variations caused by bowing across the printhead carrier) affecting the critical distance between the printhead and the print zone.

25 Furthermore, the printhead assembly may be positioned in the path of the web such that the web is tensioned around the printhead assembly. An advantage of this arrangement is that the web is self-supporting as it passes the printhead and allows the distance between the printhead and the web to be controlled by surface features on the printhead assembly. Accordingly, the possibility of the distance between the printhead and the web varying due to bowing across the printhead carrier is minimized.

30 Furthermore, the printhead assembly may comprise a guide, which guides a web under tension through the print zone. The web is typically tensioned around the guide by a suitable feed mechanism. An advantage of this arrangement is that the web is self-supporting as it passes the printhead and allows the distance between the printhead and the web to be controlled by the guide, which is an integral part of the printhead assembly.

Optional Features of the Invention

The supply spool and take-up spool may be of any suitable type, generally having a spindle, which can accommodate a roll of print media, supported between a pair of end mountings. However, since the web is under tension in the present invention, it is preferred that the supply and take-up spools are designed to minimize any slippage of the web relative to spools. Furthermore, the supply and take-up spools should optionally allow facile loading and unloading of print media. The present Applicant has developed several supply and take-up spools suitable for use in the present invention and these are described in the following copending patent applications, filed concurrently with the present application.

WFP004

WFP005

WFP006

These copending patent applications are all incorporated herein by reference and are temporarily identified by the Applicant's docket numbers.

In the present invention, it is desired to maintain a constant predetermined tension in the web between the drive roller system and the take-up spool. Typically, the required tension is in the range of 20 to 100 N. Specifically, it has been found that a constant tension of about 60 N provides good print quality with the Applicant's preferred printhead arrangement (see below). However, the feed mechanism of the present invention can, of course, be used to provide any required tension in the web and maintain this tension at a constant level.

The take-up control system will typically be a computer system, which is able to vary the current in the take-up motor and, hence, vary the torque of the take-up motor in a controlled manner. It is necessary to regulate the torque of the take-up motor, because its radius increases as the web is wound on during printing. Torque is defined by the equation:

$$T = F \times r$$

where F is the tangential force and r is the radius of the spool.

Thus, in order to maintain a constant tension F in the web, it is necessary to increase the torque T in the take-up motor as the radius r of the take-up spool increases. The take-up control system, therefore, contains or receives information relating to the radius of the take-up spool and uses this information to regulate the torque of the take-up motor accordingly. For example, in one embodiment, the take-up control system may be programmed with information regarding the initial unloaded radius r^1 and the final loaded radius r^2 of the take-up spool for a particular print job. Each of r^1 and r^2 will have a corresponding torque T^1 and T^2 , respectively, which is necessary to maintain a constant tension

in the web. Accordingly, the take-up control system may be programmed to increase the take-up motor torque linearly from T^1 to T^2 over the duration of a particular print job. To a good approximation, this linear increase in torque will be sufficient to maintain a constant tension in the web.

Alternatively, the take-up motor may be fitted with an encoder, which provides data to the take-up control system regarding the speed of the take-up motor. If the take-up control system is programmed with data regarding the thickness of the web, it can calculate the exact radius of the take-up spool at any given moment during printing. Hence, in this alternative embodiment, the take-up control system can accurately control the take-up motor torque in response to dynamic information received from the encoder.

By contrast, it is preferred that the drive motor, which drives the drive roller system, maintains a constant speed under torque load. The drive motor controls the speed of the web as it passes the printhead and it is important the speed of the web, as well as the tension, in the web is constant to maintain good print quality. Optionally, the drive motor is a four-quadrant motor, which will be well known to the person skilled in the art.

Optionally, the drive roller system comprises:

- a first drive roller operatively connected to the drive motor; and
- a second drive roller grippingly engaged with the first drive roller,

wherein, in use, the web is fed between the first and second drive rollers.

Typically, the second roller is an idle roller without a corresponding motor. It is driven by virtue of being grippingly engaged with the first drive roller which is, in turn, driven by the drive motor. Optionally, the first drive roller is positioned below the second drive roller.

Optionally, the first drive roller has a hard, rigid gritted surface, whilst the second drive roller has a soft, flexible gripping surface. Typically, the first drive roller is formed from aluminium or steel having a machined or surface-treated outer surface. The outer surface of the first drive roller is a grit surface, which maximizes traction with the web in combination with the second drive roller. Typically, the second drive roller has an outer surface comprised of a soft, flexible gripping material. This gripping material may be plastics, rubber or another suitable material. The second drive roller may, for example, have a thick (e.g. 5 to 20 mm) layer of polyurethane around its outer surface, which can capture and grip the web in combination with the first drive roller.

Optionally, the first and second drive rollers are releasably grippingly engaged with each other. Releasable gripping engagement is preferred, because it is desirable to release the second drive roller from gripping engagement when the feed mechanism is not in use. If the second drive roller, having a soft, flexible surface, is allowed to remain in gripping engagement with the first drive roller, having a hard surface, in a static position for long periods of time, then permanent deformation of the surface of

the second drive roller may result. Such permanent deformation undesirably takes the form of "flat spots" on the surface of the second drive roller. These flat spots can cause uneven gripping engagement with the first drive roller, which potentially results in periodic slippage of the web as it is fed through the drive roller system. As already discussed, slippage of the web when performing high-speed "printing-on-the-fly" is highly undesirable and typically manifests in distorted printed images.

5 Optionally, the second drive roller is moveable between an operational position, in which it is grippingly engaged with the first drive roller, and an idle position, in which it is disengaged (*i.e.* spaced apart) from the first drive roller. Such movement of the second drive roller may be either manually or automatically performed. Optionally, the feed mechanism includes a suitable automated mechanism for moving the second drive roller to its idle position during idle periods. Optionally, the drive roller system comprises a solenoid (*e.g.* a latching solenoid) coupled to the second drive roller for automatically moving it from the operational position to the idle position when the feed mechanism is not in use, thereby minimizing permanent deformation of the flexible surface of the second drive roller. The skilled person will be able to envisage a number of suitable solenoid arrangements for automatically disengaging the second drive roller from the first drive roller.

10 Typically, the feed mechanism also includes an idle roller positioned between the drive roller system and the take-up spool. The idle roller allows the feed mechanism to adopt a convenient upright configuration with the supply and take-up spools being easily accessible by the user.

20 Optionally, the supply spool is operatively connected to a braking mechanism for generating tension in the web between the supply spool and the drive roller system. The braking mechanism may take the form of a friction brake acting against rotation of the supply spool. Optionally, the braking mechanism takes the form of a braking motor connected to the supply spool. The braking motor may be connected by means of a gear wheel at one end of the supply spool, which engages with a complementary gear wheel on the motor.

25 Without a braking mechanism, the supply spool would be free to rotate under the action of the drive roller system drawing the web therefrom. Free and uncontrolled rotation of the supply spool is usual in most commercially available wide format printers. However, in high-speed wide format printers, it has been found that free rotation of the supply spool is undesirable, because it results in a much greater propensity for the web to become crumpled or folded when it is fed at high speeds. The braking mechanism provides a counter-rotational force against the force of the drive roller system drawing the web from the supply spool and, hence, generates tension in the web. By generating tension in the web between the supply spool and the drive roller system, the likelihood of paper crumpling and, ultimately, printer malfunction, is reduced.

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In practice, it has been found that a relatively small amount of tension in the web between the supply spool and the drive roller system is sufficient to minimize paper crumpling. Typically, the braking mechanism is required to generate about 1 to 10 N of tension in the web, optionally about 5 N. In contrast to the take-up side of the drive rollers described above, it is not critical that the tension on the supply side is kept absolutely constant. Small variations in tension due to a decreasing radius of the supply spool can be accommodated without adversely affecting the operation of the feed mechanism or printer.

The feed mechanism of the present invention is specifically adapted for use in a wide format printer. Accordingly, a wide format printer is also provided having a pagewidth printhead positioned so that the printhead prints onto a web of print media being fed past it by the feed mechanism.

The printhead is optionally positioned downstream of the drive rollers. By "downstream", it is meant the take-up side of the drive rollers, which is maintained at constant tension in the present invention. Since the take-up side of the drive rollers is under a relatively high tension (*e.g.* 60 N), the printhead is optionally positioned proximal to the drive rollers in order to minimize the effect of any stretching between the drive rollers and the printhead.

The "print zone" is defined by a plane adjacent (and parallel to) the printhead onto which the printhead prints. In use, the web is typically fed continuously through the print zone, which is at a predetermined distance below the printhead. The distance from the printhead to the print zone is critical to maintain good print quality. In the preferred embodiment, this distance is from 0.2 to 1.5 mm, optionally 0.5 to 0.9 mm or optionally about 0.7 mm. Any variation, even a small variation, in the distance of the print zone from the printhead results in a deterioration in print quality, which is highly undesirable.

Generally, the printhead forms part of a printhead assembly. The printhead assembly typically comprises the printhead mounted at the base of a printhead carrier. Typically, the printhead carrier is in the form of a metal frame, which also houses ink delivery systems, associated electronics for the printhead, and other printhead support components.

Optionally, the printhead is a pagewidth inkjet printhead. Examples of suitable pagewidth printheads may be found in the patents and patent applications cross-referenced herein.

In prior art wide format printers, the web is supported by a platen in the print zone. The web typically rests on the platen whilst the printhead traverses across it depositing ink to form one line of an image. Hence, the distance from the printhead to the print zone is governed by the distance from the printhead to the platen.

The Applicant has found that with pagewidth wide format printers (typically having a pagewidth printhead of about 36 inches in length), there is a tendency for the distance between the

printhead and the platen to vary across the width of the web. This problem is caused by two factors. Firstly, the printhead carrier, being formed from metal, experiences bowing (or sagging) in its middle portion due to the effect of gravity in this unsupported region. This bowing effect is transferred to the printhead mounted at the base of the carrier. Secondly, the platen, being formed from relatively thick metal and/or being supported across its length, does not experience the same bowing effect. The result is that the relative distance between the printhead and the platen is smaller in the middle region than it is at the end regions of the printhead. As discussed above, this variation is highly undesirable in terms of achieving consistently high print quality at high speeds.

In order to address this problem, the Applicant has devised a novel printer, wherein the web is unsupported in the print zone. The feed mechanism described above, which provides a constant high tension on the take-up side of the drive roller system, is highly suitable for use in this printer. An advantage of the web not being supported by a platen is that there is no possibility of variations in distance between the printhead and the platen (such as variations caused by bowing across the printhead carrier) affecting the critical distance between the printhead and the print zone.

Optionally, the web is self-supporting in the print zone by virtue of tension in the web generated by the feed mechanism and, in particular, the take-up motor. Optionally, the printhead carrier comprises a guide for guiding the web through the print zone. In use, the printhead assembly is optionally positioned in the path of the web such that the web is tensioned around the guide. An advantage of this arrangement is that the guide forms part of the printhead carrier. Therefore, with the web tensioned around the guide, any bowing across the printhead carrier is generally replicated in the guide. The result is that a substantially constant distance between the printhead and the web is maintained, irrespective of any bowing or sagging across the printhead carrier.

In a further aspect, the present invention provides a spool for a printer, said spool comprising:

a spindle for slidably receiving an outer shaft, said spindle having first and second ends; and

a first resiliently deformable gripping ring circumferentially mounted about said spindle; and

a compression mechanism for axially compressing said gripping ring, wherein said axial compression causes radial expansion of said gripping ring, thereby urging said gripping ring into gripping engagement with said outer shaft received on said spindle.

In another aspect, the present invention provides a printer comprising:

a printhead; and

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a feed mechanism for feeding a web of print media past the printhead, the feed mechanism comprising:

a supply spool;
a take-up spool; and

5 a take-up motor operatively connected to said take-up spool,
wherein the supply spool and/or the take-up spool is a spool as defined above.

An advantage of the present invention is that the gripping ring(s) mounted on the spindle are adapted for gripping engagement with an outer shaft, which is usually the cardboard core of a roll of print media. Specifically, the gripping rings are radially expandable to maximize gripping engagement and thereby minimize rotation of the spindle relative to the roll of print media. Gripping engagement is achieved by any suitable grips on the gripping rings, such as friction grips formed from rubber, plastics and the like; biting grips formed from teeth; or clawing grips formed from claws. When used as a supply spool, the gripping engagement allows the spool to transmit reliably a counter-rotational force to the roll of print media when the spool is rotating freely. A counter-rotational force may be applied to the spool by a braking motor operatively connected to one end of the spool. As mentioned above, the use of a braking motor is especially important in high-speed wide format printing for minimizing print media crumpling between the supply spool and the drive rollers.

The advantages of the present invention are fully realized when the spool is used as a supply spool. However, the spool of the present invention may also be used as a take-up spool, if desired. For example, the spindle may receive an "empty" cardboard shaft to which the gripping rings can be grippingly engaged. With a leading edge of a web of print media fastened to this cardboard shaft, the spool may be used as take-up spool in a printer. Such an arrangement is advantageous, because it is important to avoid slippage in the take-up spool as well as in the supply spool during high-speed printing. Hence, whilst the spool of the present invention will be described primarily as a supply spool with reference to a roll of print media, it will be readily appreciated that the spool may also be used as a take-up spool.

The spindle may have a plurality of gripping rings mounted thereon. Optionally, the spool comprises a pair of gripping rings, each being radially expandable and mounted at respective ends of the spindle. The use of a pair of gripping rings advantageously maximizes traction between the spindle and the roll of print media. This is especially important in elongate spindles, which are typically used in wide-format printing.

Optionally, the gripping rings are radially expandable by compression. It will be readily apparent that a compression force acting on the annular surface(s) of a ring will tend to cause radial expansion of the ring. Accordingly, the gripping rings are optionally formed from a resiliently

deformable material, such as rubber. The gripping rings are typically mounted on the spindle in coaxial alignment therewith. Hence, a longitudinal compression force, acting along the spindle, on the annular surface of the gripping ring will generally cause radial expansion of the ring. This compression may be conveniently provided by, for example, engagement of an end-plate with the spindle.

5 Optionally, the gripping rings are formed from a frictional material for frictional gripping engagement with a roll of print media. As mentioned above, commercially available rolls of print media typically have a cardboard core and the gripping rings are advantageously formed from a material, which provides a complementary frictional gripping engagement with cardboard. Optionally, the gripping rings are formed from rubber, which is resiliently deformable under compression and
10 which grips cardboard with sufficient traction to minimize slippage.

 Optionally, the spool comprises a compression mechanism for compressing the gripping ring(s). The skilled person will be able to envisage many different types of compression mechanisms, which may be used for compressing and, hence, radially expanding the gripping ring(s). One form of the spool according to the present invention comprises:

15 a thrust end-plate releasably engageable with the first end of the spindle;
 a first abutment surface, positioned towards the first end of the spindle, for providing a reaction against the thrust end-plate; and
 a first gripping ring mounted between the thrust end-plate and the first abutment surface, wherein, upon thrusting engagement of the thrust end-plate with the spindle, the first gripping ring is
20 compressed against the first abutment surface.

 This form of the spool advantageously compresses the gripping ring when the end-plate engages with the spindle. Hence, as the spool is assembled with a roll of print media received thereon, the gripping ring is brought into gripping engagement with the roll of print media by engagement of the thrust end-plate. In other words, the user is not required to perform any separate operation in order
25 to achieve radial expansion of the gripping ring – this is achieved simultaneously with assembly of the spool.

 The thrust end-plate is typically releasably engageable to allow a roll of print media to be slid on and off the spindle, as required. Releasable engagement may be by means of threaded engagement, friction-fitting engagement, snap-lock engagement, bayonet engagement *etc.* Optionally, the first end
30 of the spindle is threaded and the thrust end-plate is threadedly engaged therewith. Threaded engagement is advantageous, because it provides secure fastening, facile design/construction and facile assembly of the spool by a screwing action, which gradually compresses and expands the gripping ring.

The first abutment surface may be formed on, for example, a circumferential flange or a collar mounted on the spindle. Optionally, the first abutment surface is formed on a collar and the first gripping ring bears against an annular end surface of the collar.

Optionally, the spool further comprises a first washer positioned between the first gripping ring
5 and the thrust end-plate. The washer distributes evenly a compression force from the thrust end-plate onto the first gripping ring. The washer typically takes the form of an annular ring having an annulus of similar dimensions to the annulus of the first gripping ring and the collar. Furthermore, the thrust end-plate typically comprises an annular thrusting projection having an annulus of similar dimensions to the annulus of the first washer. This annular thrusting projection, in combination with the first
10 washer, advantageously transmits a maximum compression force onto the first gripping ring, which bears against the first abutment surface. In this way, maximum radial expansion of the first gripping ring may be achieved when the thrust end-plate engages with the spindle.

As mentioned above, the spool optionally comprises a pair of gripping rings, each of which is radially expandable by compression. Optionally, both gripping rings will be compressed
15 simultaneously by the compression mechanism, and optionally in a manner which involves minimal user effort. Accordingly, the spool may further comprise:

- an inner shaft telescopically engaged in the spindle, the inner shaft having first and second ends corresponding to the first and second ends of the spindle;

- at least one lug projecting radially outwards from the inner shaft, the at least one lug being
20 longitudinally slidably engaged in a complementary longitudinal slot in the spindle;

- a second abutment surface, positioned at a second end of the spindle, for providing a reaction against the at least one lug; and

- a second gripping ring mounted between the at least one lug and the second abutment surface, wherein, upon longitudinal sliding of the inner shaft relative to the spindle, the second gripping ring is
25 compressed against the second abutment surface by the at least one lug.

This form of the spool provides compression, and therefore radial expansion, of the second gripping ring by longitudinally sliding an inner shaft. This advantageously obviates the need for a removable end-plate at the second end of the spindle. With a permanent end-plate at the second end, the spindle can be operatively connected to a motor without having to disconnect both end-plates each
30 time the roll of print media needs changing. Hence, this compression mechanism advantageously allows a simple process for exchanging a spent roll of print media for a fresh one.

The inner shaft is typically longer than the spindle such that both its ends protrude from the spindle. Accordingly, support mountings may be connected to either end of the inner shaft for fitting the spool in a printer.

The engagement of the lug(s) with their complementary longitudinal slots in the spindle inhibits rotation of the inner shaft relative to the spindle. However, a degree of longitudinal sliding is permitted by the longitudinal slot(s), thereby allowing compression of the second gripping plug by the lug(s) against the second abutment surface. Optionally, the inner shaft comprises a pair of diametrically opposed lugs, each being slidably engaged in a respective complementary longitudinal slot in the spindle. Diametrically opposed lugs ensure greater security with the spindle and more even distribution of the compression force generated by relative longitudinal sliding.

The second abutment surface may be formed on, for example, a circumferential flange, a collar or a circumferential lip. Optionally, the second abutment surface is formed on a circumferential lip at the second end of the spindle, and the second gripping ring bears against the annular surface of the lip.

Optionally, the spool further comprises a second washer positioned between the second gripping ring and the lugs. The washer distributes evenly a compression force from the lugs onto the second gripping ring. The washer typically takes the form of an annular ring having an annulus of similar dimensions to the annulus of the second gripping ring and the lip. In this way, maximum radial expansion of the second gripping ring may be achieved when the lugs exert a compression force on the second washer and, thence, the second gripping ring, which bears against the lip.

Optionally, the relative longitudinal sliding is telescopic expansion of the inner shaft relative to the spindle. Optionally, this telescopic expansion is caused by engagement of the thrust end-plate with the first end of the spindle. Such telescopic expansion may be caused, for example, by a rigid linkage between the thrust end-plate and the inner shaft. One form of rigid linkage may be the outer shaft itself being urged by the thrust end-plate against a reaction end-plate fixed to the second end of the inner shaft.

The spool may, therefore, further comprise a reaction end-plate fixed to the second end of the inner shaft, wherein one end of an outer shaft received on the spindle is urged against the reaction end-plate by the thrust end-plate thrusting against an opposite end of the outer shaft, thereby causing telescopic expansion.

In use, a roll of print media may be wedged in between the thrust end-plate and the reaction end plate. The end-plates cooperate to retain the web on the spool. Moreover, engagement of the thrust end-plate with the spindle, together with the telescopic expansion caused by thrusting abutment of the roll of print media against the reaction end-plate, result in compression and, therefore, radial expansion of both gripping plugs simultaneously.

When the roll of print media is spent or needs to be removed, the thrust end-plate is simply disengaged, which relaxes longitudinal tension along the spindle. This relaxation results in contraction of the gripping plugs and the spent roll of print media can be simply slid off the spindle.

Optionally, the reaction end-plate comprises a connector arm for operatively connecting the spool to a motor. Operative connection may be by, for example, a gear wheel on the connector arm, which intermeshes with a gear wheel on the motor and rotates the spool. Usually, the connector arm also comprises a bearing, allowing free rotation of spool when mounted in a printer. Likewise, the first
5 end of the inner shaft, which typically protrudes from the first end of the spindle, will optionally comprise a bearing, allowing the spool to rotate when mounted in a printer.

In a further aspect, the present invention provides a spool for a printer comprising:
a radially expandable shaft; and
at least one expander releasably engageable with the shaft,
10 wherein engagement of the expander with the shaft radially expands at least part of the shaft.

In another aspect, the present invention provides a printer comprising:
a printhead; and
a feed mechanism for feeding a web of print media past said printhead, said feed
mechanism comprising:
15 a supply spool;
a take-up spool as described above; and
a take-up motor operatively connected to said take-up spool.

In a further aspect, the present invention provides a method of printing comprising the steps of:
(i) feeding a web of print media from a supply spool to a radially expanded take-
20 up spool, whilst simultaneously printing onto said print media, thereby providing a printed roll of print
media wound onto said radially expanded take-up spool;
(ii) radially contracting said take-up spool once printing is completed; and
(iii) removing said printed roll of print media from said radially contracted take-up
spool.

In another aspect, the present invention provides a method of printing comprising:
(i) providing a printhead;
(ii) providing a feed mechanism for feeding a web of print media past said printhead, said
feed mechanism comprising:
25 a supply spool;
a radially expanded take-up spool; and
a take-up motor operatively connected to said take-up spool;
(iii) feeding a web of print media from said supply spool to said radially expanded take-up
spool whilst simultaneously printing onto said print media using said printhead;
30 (iv) radially contracting said take-up spool once printing is completed; and

- (v) removing said print media from said radially contracted take-up spool.

The spool of the present invention advantageously allows facile removal of a web of material wound thereon by having a radially expandable shaft. Before winding a material onto the spool, the shaft is radially expanded thereby increasing its diameter. Once the material has been wound onto the spool, the shaft is radially contracted thereby decreasing its diameter. Since the wound material maintains its relatively large core diameter after the shaft has been radially contracted, the result is that the wound material can be easily removed from the shaft by longitudinally sliding the shaft relative to the wound material.

Optionally, the shaft is expandable from a radially contracted configuration to a radially expanded configuration, the shaft being resiliently biased towards the radially contracted configuration. Resilient biasing of the shaft may be achieved by appropriate selection of the shaft material. Accordingly, the shaft is optionally formed from a resilient material, such as steel, aluminium or resilient plastics.

Optionally, the spool comprises two expanders, each expander being releasably engageable with a respective end of the shaft. Optionally, each of the expanders radially expands its respective end region of the shaft. In a typical elongate shaft, the central region may remain relatively unexpanded by the two expanders. However, provided that the two end regions are radially expanded, a wound material will easily slide off longitudinally once these end regions have been radially contracted by removal of the expanders. In practice, it is not necessary to expand radially the entire length of the shaft in order to achieve facile removal of the wound material.

Optionally, the shaft is hollow and the expanders take the form of expander plugs releasably engageable in each end of the shaft. Hence, in this form of the invention, the hollow ends of the shaft act as sockets for releasably receiving the expander plugs. The expander plugs are usually rigid relative to the shaft so that insertion of the plugs in the hollow ends of the shaft urges the corresponding end regions into radially expanded configurations. The plugs may be made relatively rigid either by selection of a more rigid material than the shaft material, or by simply having a greater thickness than the shaft material. For example, a thin-walled hollow steel shaft may be radially expanded by a thick-walled hollow steel plug or, indeed, a solid steel plug having a suitable diameter. Since, as explained above, it is only necessary to expand radially an end region of the shaft, the plug(s) usually take the form of relatively short stubs.

Optionally, the expander plug(s) are friction-fitted in the shaft. Friction-fitting provides a facile release mechanism for the plug(s). Optionally, the plugs(s) are tapered to assist friction-fitting engagement and for urging the shaft into a radially expanded configuration as the plug(s) are inserted into each end of the shaft. The amount of radial expansion in the shaft is determined by the widest

diameter of each plug. Usually, the degree of radial expansion necessary at each end of the shaft to achieve facile removal of a wound material is less than about 10 mm, and typically about 2 mm. Hence, the widest diameter of each plug is selected appropriately and tapered to allow facile insertion in the shaft. The force required to insert the plug(s) is not too great and can be easily applied by the user.

Optionally, the plug(s) include a flange for guiding a web of material wound onto the spool. The flange may be in the form of a circular end-plate at one end of the plug so that the end-plate lies flush against the end of the shaft, forming a flange therewith, when the plug is inserted in the shaft. The diameter of the end-plate should be suitable for retaining an anticipated volume of material wound onto the spool. For example, in wide format printing applications, the end-plate typically has a diameter of from 5 to 30 cm.

Optionally, the shaft has a longitudinal slit. The longitudinal slit optionally extends along the entire length of the shaft and has several functions. Firstly, it allows facile radial expansion of the shaft when, for example, expander plugs are inserted in each end. Secondly, the slit allows a web of material to be securely captured by the spool without the need for adhesive tape or the like. By simply inserting a leading edge of the web inside the slit and rotating the spool, the web can be initially secured to the spool by the frictional gripping action of a longitudinal edge of the slit with a surface of the web in contact therewith. Thereafter, successive overlaying of the web against itself ensures security with the shaft.

An additional advantage of the longitudinal slit is that the web of material is, at least to some extent, naturally self-aligning once inserted in the slit. By "self-aligning", it is meant that the material will evenly overlay against itself when the spool rotates, rather than skewing in one direction as the roll of wound material builds up on the spool. Self-alignment may be assisted by appropriate flanges. The flanges may be at each end of the shaft and, as mentioned above, the expander plugs may comprise suitable flanges. In cases where the web of material has a relatively small width dimension, the shaft may be equipped with circumferential flange(s) slidably movable along the length of the shaft. Such slidably movable circumferential flange(s) may be positioned to guide the web of material onto the spool during initial loading and/or during subsequent printing.

Optionally, the expander plug(s) are hollow, each having a slit corresponding with and alignable with the longitudinal slit in the shaft. An advantage of this slit in the plug(s) is that the web of material can be secured to the shaft along its entire length, thereby allowing the material to lie flush against flanges at each end of the shaft. Hence, the plug slits advantageously avoid "dead space" at each end of the spool.

Optionally, the shaft and the expander plugs(s) comprise complementary guides for aligning their respective slits. The optional guides key the plug(s) into a suitably aligned orientation in the shaft. Furthermore, the guides are optionally configured to minimize rotational movement of the plug(s) relative to the shaft. The guides may take the form of, for example, complementary surface features
5 (e.g. grooves) on the inner surface of the hollow shaft and the outer surface of the plug(s).

The spool of the present invention is preferably a take-up spool in a printer, more preferably a take-up spool in a wide format printer. However, the spool of the present invention may be used in any application where facile loading and unloading of a wound material is desired. When the spool is used as a take-up spool in a printer, at least one (preferably one) expander will optionally comprise a
10 connector arm for operatively connecting the spool to a take-up motor. Operative connection may be by, for example a gear wheel on the connector arm, which intermeshes with a gear wheel on the motor and rotates the spool. Other standard means for connecting the spool to a motor will be readily apparent to the skilled person.

15 Brief Description of Drawings

A specific form of the invention will now be described in detail, with reference to the following drawings, in which:-

Figure 1 is a perspective view of a wide format printer according to the invention;

Figure 2 is a cutaway perspective view of a wide format printer;

20 Figure 3 is a schematic side view of a printhead and feed mechanism for a wide format printer;

Figure 4 is a perspective view of the spool according to the invention supported between mountings at its first and second ends;

Figure 5 is a perspective view of the spool according to the invention, with the thrust end-plate removed, supported by a mounting at its second end;

25 Figure 6 is a side view of the first end of the spindle;

Figure 7 is a perspective view of the thrust end-plate;

Figure 8 is a side view of the second end of the spool according to the invention;

Figure 9 is a side view of the second end of the spindle; and

30 Figure 10 is a side view of the second end of the spindle with the second gripping ring and second washer removed.

Figure 11 is a perspective view of the take-up spool according to the invention;

Figure 12 is a perspective view of the take-up spool according to the invention;

Figure 13 is a perspective view of an expander plug;

Figure 14 is a side view of the expander plug shown in Figure 13.

Figure 15 is a schematic side view of a feed mechanism according to the invention with a printhead assembly;

Figure 16 is a schematic view of the take-up spool, take-up motor, take-up control system and
5 encoder;

Figure 17 is a schematic side view of the drive roller system and printhead assembly; and

Figure 18 is a schematic side view of the printhead assembly.

Detailed Description of a Specific Embodiment

10 Referring to Figure 1, there is shown a wide format printer 1 comprising a frame 2, which supports a print engine 3, a supply spool 4 and a take-up spool 5.

The supply spool 4 takes the form of a spindle 6 mounted between a pair of end mountings 7 and 8, which are each supported by the frame 2. The supply spool 4 rotates relative to the frame 2 by virtue of bearings (not shown) in the end mountings 7 and 8. The supply spool 4 is positioned
15 relatively proximal to the print engine 3, in order to minimize the risk of web crumpling. Rolls of print media (not shown) may be conveniently loaded onto the supply spool 4 by the user.

Referring to Figures 2 and 3 there is shown a wide format printer 101 comprising a support structure 102, which supports a feed mechanism 103 and a printhead 104. The feed mechanism 103 comprises a system of motorized rollers for feeding a web of print media 105 past the printhead 104. The printhead
20 104 is a pagewidth inkjet printhead, which ejects droplets of ink onto the web 105 as it is fed through a print zone adjacent the printhead 104. The direction of feed is shown by arrows on the web 105.

Figure 3 shows in more detail the feed mechanism 103 comprising a supply spool assembly 106, a drive roller system 107, an idle roller 108 and a take-up spool 109. The supply spool assembly 106 comprises a supply spool loaded with a web 105 of print media, which is fed to the drive roller
25 system 107. The drive roller system 107 comprises an upper drive roller 110 in gripping engagement with a lower drive roller 111, the web 105 being fed between the upper drive roller 110 and the lower drive roller 111. From the drive roller system 107, the web is fed past the printhead 104, over the idle roller 108, and onto the take-up spool 109.

Various motors control the feeding of the web 105 through the feed mechanism 103. The
30 supply spool assembly 106 is connected to a braking motor 112, which provides a resistive force and generates tension in the web 105. The main driving force in the feed mechanism 103 is provided by a drive motor 113 connected to the lower drive roller 111. The lower drive roller 111, in combination with the upper driver roller 110 grippingly engaged therewith, drives the web 105 past the printhead 104 at a constant rate.

A take-up motor 114 is connected to the take-up spool 109. The combination of the braking motor 112, the drive motor 113 and the take-up motor 114 maintains constant tension in the web 105 during printing. The maintenance of constant tension in the web 105 is particularly important in high-speed printing in order to avoid paper crumpling and/or poor print quality.

5 Referring to Figures 4 and 5, there is shown the supply spool comprising a spindle 115 for slidably receiving a roll of print media (not shown). The spindle 115 has a first end 116 and a second end 117, with a first gripping ring 118 mounted on the spindle at the first end and a second gripping ring 119 mounted on the spindle at the second end. The gripping rings 118 and 119 are radially expandable such when the core of a roll of print media (not shown) is received on the spindle 115,
10 radial expansion of the gripping rings urges them into gripping engagement with the inner walls of the core.

The gripping rings 118 and 119 are formed from rubber and are radially expandable by a compression force acting on their annular end surfaces. Hence, the gripping rings 118 and 119 are radially expandable by a compression force acting along the longitudinal axis of the spindle 115.

15 Referring to Figure 6, there is shown the first end 116 of the spindle 115. This first end the spindle has a threaded portion 120 for threadably receiving a thrust end plate 121 (Figure 7). As shown in Figure 7, the thrust end-plate 121 comprises a thrusting projection in the form of a cylindrical stub 122. The stub 122 has a wide circumferential flange 123 at one end, which forms the body of the thrust end-plate 121. At the other end, the stub 122 has a thrusting annular surface 124. A threaded bore 125
20 in the thrust end-plate 121 is configured such that the thrust end-plate can be screwed onto the threaded portion 120 of the spindle 115.

Returning to Figure 6, one annular surface of the first gripping ring 118 bears against an abutment surface formed on a collar 126. The other annular surface of the first gripping ring 118 is adjacent a first washer 127. As the thrust end-plate 121 is screwed onto the threaded portion 120, a
25 compression force F' urges the thrusting annular surface 124 of the stub 122 against the first washer 127, which, in turn, urges against an annular surface of the first gripping ring 118. A reaction force R' is provided by the collar 126 and this acts against the other annular surface of the first gripping ring 118. The result is that when the thrust end-plate 121 engages with the first end 116 of the spindle 115, the first gripping ring 118 is compressed and consequently radially expands.

30 Referring to Figure 8, at the second end 117 there is shown an inner shaft 128 telescopically engaged with the spindle 115. The inner shaft 128 has a pair of diametrically opposed lugs 129 (only one shown in Figure 8), which project radially outwards from the inner shaft. Each lug 129 is longitudinally slidably engaged in a respective complementary slot 130 in the spindle 115. A second

abutment surface is provided by the annular surface of a circumferential lip 131 at the second end of the spindle 115.

One annular surface of the second gripping ring 119 bears against the lip 131. The other annular surface of the second gripping ring 119 is adjacent a second washer 132. As the inner shaft 128 telescopically expands from the spindle 115, a compression force F^2 urges the lugs 129 against the second washer 132, which, in turn, urges against an annular surface of the second gripping ring 119. A reaction force R^2 is provided by the lip 131 and this acts against the other annular surface of the second gripping ring 119. The result is that when the inner shaft 128 telescopically expands from the second end 117 of the spindle 115, the second gripping ring 119 is compressed and consequently radially expands.

As shown in Figure 8, a reaction end-plate 133 having a flange 134 is fixed to the second end 117 of the inner shaft 128. From Figure 4, it can be seen that when a roll of print media (not shown) is received on the spindle 115, one end of the roll will bear against the flange 134 on the reaction end-plate 133. As the thrust end-plate 121 is screwed onto the first end 116, its flange 123 thrusts against the other end of the roll. Since the roll is rigid, this thrusting force is transmitted to the flange 134 on the reaction end-plate 133, thereby causing telescopic expansion of the inner shaft 128 from the spindle 115. The overall result is that both gripping rings 118 and 119 are compressed, and consequently radially expanded, when a roll of print media (not shown) is received on the spindle 115 and the thrust end-plate 121 is screwed onto the first end 116 to form a supply spool assembly.

The supply spool assembly thus formed experiences minimal slippage between the roll of print media and the spool due to the radially expanded gripping rings 118 and 119 frictionally gripping the inner walls of the core of the roll of print media (not shown).

Returning to Figure 8, the reaction end-plate 133 further comprises a connector arm 135 extending from its outer face. The connector arm 135 comprises a gear wheel 136, which operatively connects the spool 106 to a braking motor 112 when the spool is mounted in the printer 101.

To enable the spool 106 to rotate freely when mounted in the printer 101, the spool is provided with a first bearing 137 and a second bearing 138. The first bearing 137 is mounted at the first end 116 of the inner shaft 128 (see Figure 5). The second bearing 138 is mounted on the connector arm 135, which extends from the reaction end-plate 133 (see Figure 8). These bearings 137 and 138 cooperatively allow the spool to rotate relative to their respective mountings 139 and 140.

A typical supply spool-loading and printing operation will now be described, which utilizes the advantageous features of the present invention. A roll of print media (not shown) is slid onto a spool having its thrust end-plate 121 removed, as shown in Figure 5. The thrust end-plate 121 is then screwed onto the first end 116 of the spindle 115, which simultaneously radially expands the gripping

rings 118 and 119 into gripping engagement with the core of the print media by the mechanism described above. The supply spool assembly 106 thus formed is mounted into the printer 101, with the reaction end-plate 133 operatively connected to the braking motor 112 via its gear wheel 136.

5 The printer 101 is set up for printing by manually feeding the web 105 from the supply spool assembly 106, through the drive rollers 110 and 111, past the printhead 104 and over the idle roller 108. The web 105 is then secured to the take-up spool 109 ready for printing. During printing, the feed mechanism 103 feeds the web 105 past the printhead 104 by drawing the web from the supply spool assembly 106 using the drive roller system 107. The supply spool assembly 106 unwinds in an anticlockwise direction as the web 105 is drawn between the drive rollers 110 and 111. Tension in the
10 web 105 between the supply spool and the drive roller system 107 is generated and controlled by the braking motor 112, which imparts a clockwise rotational force onto the reaction end-plate 133 and, hence, onto the spindle 115. The clockwise rotational force is transmitted to the web 105 by frictional engagement of the gripping rings 118 and 119 against the cardboard core of the roll of print media. Hence, the braking force from the braking motor 112 is reliably transmitted to the roll of print media
15 and, hence, the web 105.

Once the roll of print media is used up, the spent cardboard core is removed from the supply spool by simply unscrewing the thrust end-plate 133 and sliding the cardboard core from the spindle 115.

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

Likewise, the take-up spool 5 takes the form of a spindle 9 mounted between a pair of end mountings 10 and 11, which are each supported by the frame 2. The take-up spool rotates relative to the frame 2 by virtue of bearings (not shown) in the end mountings 10 and 11. The take-up spool
25 receives a web of print media (not shown) after an image has been printed onto the web in the print engine 3. The printed web is wound around the take-up spool 5, from where it can be unloaded by the user. The take-up spool is positioned relatively distal from the print engine 3 in order to maximize ink drying time.

The take-up spool 209 will now be described in further detail with reference to Figures 11 to
30 14. The take-up spool 209 comprises a radially expandable shaft 215 and a pair of expander plugs 216 and 217, each expander plug engaged with a respective end of the shaft. The expander plugs 216 and 217 are releasably engaged in the ends of the shaft 215 by sliding friction-fitting engagement. The expander plugs 216 and 217 are shaped so that the shaft 215 is urged into a radially expanded

configuration when the expander plugs are inserted in the ends of the shaft. The radial expansion is maximal at the ends of the shaft and minimal (or virtually negligible) at the centre of the shaft.

The shaft 215 is formed from a resilient material so that when the expander plugs 216 and 217 are removed from the shaft, it springs back to a radially contracted configuration. By contrast, the
5 expander plugs 216 and 217 are relatively rigid so that their engagement with the shaft urges the shaft into a radially expanded configuration. In this preferred embodiment, both the shaft 215 and the expander plugs 216 and 217 are formed from aluminium, the expander plugs being relatively more rigid than the shaft by virtue of their thick-walled construction.

A longitudinal slit 218 extends along the length of the shaft 215. The longitudinal slit 218
10 facilitates radial expansion of the shaft. The longitudinal edges of the slit 18 are urged apart, increasing the slit width, when the expander plugs 216 and 217 are inserted in each end of the shaft. The longitudinal slit 218 additionally assists in capturing the web 205 on the take-up spool 209. This will be described in more detail below.

Turning now to Figure 13 and 14, the expander plug 216 comprises a hollow stub 219 having a
15 circumferential flange 220 formed by a circular end-plate 221 at one end of the stub. It can be seen from Figure 11 that the flange 220 lies flush against one end of the shaft 215 and serves to guide the web 205 onto the take-up spool 209 as the web is being wound onto the spool. The stub 219 takes the form of a relatively thick-walled cylinder having tapered side walls 222. The side walls 222 taper inwardly at the distal end of the stub relative to the circular end-plate 221. The tapered side walls 222 allow the
20 plug 216 to be easily inserted into the end of the shaft 215. As the plug is inserted, sliding abutment of the tapered side walls 222 against a circumferential end rim (not shown) of the shaft 215 urges the shaft into a radially expanded configuration.

The hollow stub 219 has a slit 223, which aligns with the longitudinal slit 218 in the shaft 215 when the expander plug 216 is inserted in the shaft. The stub 219 and the shaft 215 have
25 complementary guides (not shown) for aligning the slits 218 and 223, and for minimizing rotational movement of the expander plug 216 relative to the shaft 215 as the take-up spool 209 is rotated.

Figure 14 shows a connector arm 224 extending from the opposite face of the circular end-plate 221 relative to the stub 219. The connector arm 224 operatively connects the take-up spool 209 to the take-up motor 214 via a gear wheel 225 on the connector arm. The connector arm 224 also has a
30 bearing 226, which facilitates free rotation of the connector arm and, hence, the take-up spool 209. The expander plug 217 also has a connector arm (not shown). However, the expander plug 217 is not operatively connected to the take-up motor 214 and, hence, its connector arm comprises only a bearing (not shown) and not a gear wheel.

A typical printing operation will now be described, which utilizes the advantageous features of the present invention. The take-up spool 209 is fitted in the wide format printer 201 and is operatively connected to the take-up motor 214 via gear wheel 225. The take-up spool 09 is in a radially expanded configuration by virtue of the two expander plugs 216 and 217 engaged at either end of the elongate shaft 215. Further, the slits 223 in each expander plug are aligned with the longitudinal slit 218 in the shaft 215.

A leading edge of the web 205 is fed manually into the longitudinal slit 218. After a portion of the web 205 is inserted in the longitudinal slit 218, the take-up spool 209 is then rotated manually until the web 205 is secured onto the take-up spool. Once the web 205 is secured to the take-up spool 209, automated printing is started by simultaneously feeding the web past the printhead 204 using the feed mechanism 203 whilst ejecting ink droplets from the printhead 204. A computer control system (not shown) controls the motors 212, 213 and 214 and also controls firing of the plurality of ink ejection nozzles (not shown) in the printhead 204. The web 205 having an image printed thereon is wound onto the take-up spool 209 during printing.

Once printing is completed, the web 205 is cut, if required, between the idle roller 208 and the take-up spool 209. The take-up spool 209 is then removed from the printer 201 and the expander plugs 216 and 217 removed from the shaft 215. Removal of the expander plugs 216 and 217 causes the shaft 215 to contract radially by virtue of the resilient biasing of the shaft. The roll of printed web, having a core diameter greater than that of the shaft 215, is then removed from the shaft by longitudinally sliding the shaft relative to the roll of printed web. The expander plugs 216 and 217 are then reinserted in the shaft 215 and the take-up spool 209 placed back in the printer 201 ready for the next print job.

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

The printer 1 includes a control panel 13, which provides a user interface with the printer. The control panel 13 takes the form of a touch-sensitive screen with menu options for controlling various printing parameters.

The major components of the print engine 3 are shown in the boxed section of Figure 2. The print engine 3 comprises a printhead 21, a drive roller system 22 and an idle roller 23. The drive roller system 22 and the idle roller 23 form part of the feed mechanism 20, which is described in more detail below.

Feed Mechanism

Referring to Figure 2, the feed mechanism 20 continuously feeds a web 24 past the printhead 21 under constant speed and tension when the printer 1 is operating. In this specific embodiment, the feed mechanism comprises a supply spool 4 having a corresponding braking motor 25, a drive roller system 22 having a corresponding drive motor 26, an idle roller 23, a take-up spool 5 having a corresponding take-up motor 27, and a take-up control system 30.

The drive roller system 22 is positioned between the supply spool 4 and the take-up spool 5, with the drive motor 26 being responsible for providing the main drive for the feed mechanism 20. The braking motor 25 is responsible for controlling tension in the web 24 on the supply side of the drive roller system 22. The take-up motor 27, in combination with the take-up control system 30, is responsible for controlling tension in the web 24 on the take-up side of the drive roller system 22.

The idle roller 23 is positioned between the drive roller system 22 and the take-up spool 5 in the print engine 3. The idle roller 23 does not affect the tension in the web 24; it merely provides a directional change in the web 24, thereby allowing the printer 1 to have a generally upright configuration with the supply spool 4 and take-up spool 5 positioned conveniently and accessibly below the print engine 3.

Take-Up Spool

Referring to Figure 2, the take-up spool 5 comprises a corresponding gear wheel 31, which connects it to the take-up motor 27. The take-up motor 27 is controlled by the take-up control system 30, which controls the current in the take-up motor and, therefore, controls the take-up motor torque. The take-up motor torque is controlled to provide a constant tension of about 60 N in the web 24 between the take-up spool 5 and the drive roller system 22. A tension of about 60 N has been found to be optimal for the preferred printhead arrangement described in more detail below.

Due to the increasing radius of the take-up spool 5, as the web 24 is wound on, the take-up motor torque needs to be continuously increased to compensate for this increase in radius and maintain a constant tension of 60 N in the web

In one embodiment, the take-up control system 30 is programmed with data regarding the initial radius r^1 and final radius r^2 of the take-up spool 5. These initial and final radii correspond to an initial torque T^1 and final torque T^2 , which are necessary to maintain a tension of 60 N in the web 24. During a print job, the take-up control system 30 increases the take-up motor torque linearly from T^1 to T^2 . This linear increase in torque ensures, at least to a very good approximation, that a constant tension is maintained in the web 24 between the take-up spool 5 and the drive roller system 22 throughout the duration of the print job.

30

In an alternative embodiment, shown in Figure 3, the take-up motor 27 is fitted with an encoder 32. The encoder 32 is configured to determine the speed of the take-up motor 27 during a print job. Data regarding the speed of the take-up motor 27 is fed from the encoder 32 to the take-up control system 30, which allows the take-up control system to calculate the number of revolutions completed by the take-up motor. The take-up control system 30 is programmed with data regarding the thickness of the web 24. Therefore, the take-up control system can calculate the radius of the take-up spool 5 at any given time using the data received from the encoder 32 in combination with its programmed data regarding the thickness of the web 24. Using this calculated radius, the take-up control system 30 can vary the take-up motor torque during a print job so as to maintain a constant tension of 60 N in the web 24 between the take-up spool 5 and the drive motor system 22.

Drive Roller System

The drive roller system 22 is located in the print engine 3 and provides the main drive for the feed mechanism 20. Referring to Figure 4, the drive roller system 22 comprises a pair of rollers, one positioned on top of the other. A lower drive roller 40 is operatively connected to a drive motor 26 and an upper drive roller 41 is grippingly engaged with the lower drive roller. The upper drive roller 41 is essentially idle and is driven by virtue of its gripping engagement with the lower drive roller 40. The web 24 is fed from the supply spool 4, between the lower and upper drive rollers 40 and 41, and towards the printhead 21.

The drive motor 26 is a four-quadrant motor, which maintains a constant speed under torque load. The drive motor 26 controls the speed of the web 24 as it exits the drive roller system 22 and passes the printhead 21. The drive motor 26 experiences a torque load from the tension in the web 24 and maintains a constant rotational speed under this load. Hence, the speed of the web 24 as it passes the printhead 21 is constant, irrespective of the tension in the web.

Since the web 24 is tensioned on either side of the drive roller system 22, it is important that the web does not slip relative to the pair of drive rollers 40 and 41 so as to maintain a constant web speed. Accordingly, the surfaces of the drive rollers 40 and 41 are configured to maximize traction with the web 24 in a complementary fashion. The lower drive roller 40 is formed from aluminium having a hard, gritted surface 43. The upper drive roller 41 has a thick polyurethane surface 44. These two surfaces cooperate to grip firmly the web 24 fed between the pair of rollers 40 and 41, thereby minimizing slippage.

During printing, it is important that the upper drive roller 41 is grippingly engaged with the lower drive roller 40 in order to maximize traction with the web 24. However, when the printer 1 is not in use, a region of the polyurethane surface 44 on the upper drive roller 41 can become permanently

deformed by being compressed against the lower drive roller 40. When the drive rollers 40 and 41 are not rotating, a static compression force against the upper drive roller 41 can cause "flat spots" on the soft polyurethane surface 44.

Accordingly, the upper drive roller 41 is releasably grippingly engageable with the lower drive roller 40, having both an operational position in which it is grippingly engaged with the lower drive roller 40 and an idle position in which it is disengaged from the lower drive roller 40. To facilitate releasable gripping engagement, the drive roller system 22 includes a latching solenoid 45 coupled to the upper drive roller 41, which is configured to disengage the upper drive roller from the lower drive roller 40. The latching solenoid 45 automatically moves the upper drive roller 41 upwards relative to the lower drive roller 40 when the printer 1 is not in use. Hence, during idle periods, the polyurethane surface 44 does not experience a permanent compression force from the hard surface 43 of the lower drive roller 40.

Supply Spool

Referring to Figure 2, the supply spool 4 comprises a corresponding gear wheel 33, which connects it to the braking motor 25. The braking motor 25 acts on the supply spool 4 to provide tension in the web 24 between the drive motor system 22 and the supply spool. Hence, the braking motor 25 provides resistance to free rotation of the supply spool 4, which is caused by the drive roller system 22 drawing the web 24 from the supply spool.

The braking motor 25 is configured to provide a web tension of about 5 N, which is generally sufficient to minimize folding or crumpling of the web 24 before it reaches the drive roller system 22. This tension may increase as the web 24 is fed from the supply spool 4 and the radius of the supply spool decreases under constant braking motor torque. However, in contrast to the take-up side of the feed mechanism 20, it is not critical that the web tension on the supply side is maintained absolutely constant throughout the duration of each print job.

Printhead Assembly

Referring to Figure 2, a printhead assembly 50 is located in the print engine 3 and positioned between the drive roller system 22 and the idle roller 23. The printhead assembly 50 is positioned proximal to and downstream of the drive roller system 22 in order to minimize any variations in web speed as the web 24 passes the printhead 21.

Referring to Figure 5, the printhead assembly 50 comprises a pagewidth printhead 21 mounted at the base 51 of a carrier frame 52. The pagewidth printhead 21 may be any one of the printheads described in the cross-referenced patents and patent applications.

The carrier frame 52 also houses support systems for the printhead 21, such as ink delivery systems and associated electronic drive circuitry (not shown).

A print zone 53 is defined by a plane parallel to the plane of the printhead 21 and located 0.7 mm below the printhead. The web 24 is fed continuously through the print zone 53 during a print job.

- 5 In order to maintain a constant distance between the pagewidth printhead 21 and the web 24 across the entire printhead, the web is not supported by a platen in the print zone 53, as is the case in conventional wide format printers. Instead, the web 24 is self-supporting in the print zone by virtue of the 60 N tension generated in the web by the take-up motor 27.

- 10 A guide 54 is fixed to the carrier frame 52 and forms an integral part of the printhead assembly 50. The guide 54 comprises two parts: an approach guide 54a and an exit guide 54b, both parts being configured to guide the web 24 through the print zone 53 located below the printhead 21. The approach guide 54a is fixed to a front side 60 of the printhead assembly 50 and curves underneath the base 51 of the carrier frame 52, terminating upstream of the print zone 53. The exit guide 54b is fixed to a back side 61 of the printhead assembly and curves underneath the base 51 of the carrier frame 52,
15 terminating downstream of the print zone 53.

The web 24 is tensioned around the guide 54 and follows a path defined by its smooth lower surface, formed from polished steel. As shown in Figure 5, the approach guide 54a has a leading angular edge 55 which abuts with the approaching web 24, such that the natural path of the web is deflected downwards and around the guide.

- 20 The guide 54, which forms an integral part of the printhead assembly 50, generally replicates any bowing across the base 51 of the carrier frame 52. Hence, the guide 54 assists in maintaining a constant distance between the printhead 21 and the web 24, irrespective of any bowing across the base 51 of the carrier frame 52.

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

Claims

1. A wide format printer comprising:

(A) a feed mechanism comprising:

- 5 a supply spool;
- a take-up spool;
- a take-up motor operatively connected to the take-up spool;
- a take-up control system for controlling the torque of the take-up motor;
- a drive roller system positioned between the supply spool and the take-up spool;

10 and

- a drive motor operatively connected to the drive roller system, wherein
- a web fed from the drive roller system to the take-up spool is maintained under substantially constant tension by regulating the torque of the take-up motor using the take-up control system; and

15 (B) a printhead assembly operatively positioned in the path of the web, said printhead assembly comprising:

- a printhead carrier;
- a pagewidth printhead mounted on the printhead carrier for ejecting ink onto the web; and

20 a guide connected to the printhead carrier for guiding the web through a print zone, wherein

the web is tensioned around the guide and unsupported in the print zone.

2. The printer of claim 1, wherein the take-up control system increases the torque of the take-up motor as the radius of the take-up spool increases, thereby maintaining a substantially
25 constant tension in the web between the take-up spool and the drive roller system.

3. The printer of claim 2, wherein the take-up control system maintains a predetermined tension in the web between the take-up spool and the drive roller system.

30 4. The printer of claim 2, wherein the take-up spool has:

- an initial unloaded radius of r^I corresponding to an initial torque of T^I ; and

a final loaded radius of r^2 corresponding to a final torque of T^2 ,
wherein the torque of the take-up motor is increased linearly from T^1 to T^2 during a print job.

5. The printer of claim 2, wherein the take-up motor comprises an encoder for providing
5 data to the take-up spool control system regarding the speed of the take-up motor.
6. The printer of claim 5, wherein the take-up control system is programmed with data
regarding the thickness of the web and uses data received from the encoder to calculate the
radius of the take-up spool during printing.
- 10 7. The printer of claim 6, wherein the take-up control system increases the torque of the
take-up motor accordingly as the calculated radius of the take-up spool increases, thereby
maintaining a substantially constant tension in the web between the take-up spool and the drive
roller system.
- 15 8. The printer of claim 1, wherein the drive motor maintains a constant speed under torque
load.
9. The printer of claim 1, wherein the drive motor is a four-quadrant motor.