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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *of inventorship (Rule 4.17(iv))*

Published:

- *with international search report (Art. 21(3))*

INKING SYSTEM WITH MINIMAL INK STORAGE

FIELD OF THE INVENTION

The invention is related to rotary printing machines, like flexographic or rotogravure presses, and in particular to the inking system used in those machines.

5 TECHNICAL BACKGROUND

A common rotogravure printing unit is made of a gravure cylinder (or *printing cylinder*) in contact with a second cylinder, which is usually a rubber cylinder, also called the impression roller. The gravure cylinder exhibits a collection of tiny cells on its surface whose distribution defines the image to be printed. These cells are filled with ink which
10 is transferred onto a printing support by contact. The support (paper, cardboard or polymer film) is sandwiched between the printing cylinder and the impression roller.

A common flexographic printing unit is made of an anilox cylinder, which transfers the ink to a cliché carrying cylinder (or *printing cylinder*) which in turn is in contact with the impression roller. The printing support is, like in the rotogravure case, sandwiched
15 between the printing cylinder and the impression roller. The anilox cylinder is made of tiny cells on its surface whose function is to carry the ink to the printing cylinder.

An inking system is used to fill the cells of an etched cylinder with ink, the etched cylinder being the gravure cylinder of a rotogravure printing unit or the anilox of a flexographic printing unit. A common inking system uses an inking roller (or *inking cylinder*) to fill the
20 cells, which partially or totally dips into a pan filled with ink, rolls against the etched cylinder and provides the necessary pressure to fill the cells completely. During printing, a doctor blade removes the excess of ink from the surface of the etched cylinder while leaving the ink inside the cells.

The function of the inking roller is to avoid air bubbles inside the cells of the etched
25 cylinder. Another function of the inking roller is to perform a pre-cleaning of the etched cylinder surface, in particular removing the dried ink from the etched cylinder surface. The inking roller is in freewheel in some systems, or is driven by a motor in some other systems; in most cases, the inking roller runs slower than the etched cylinder. The speed

mismatch (mismatch in speed direction or amplitude) allows fulfilling the above-mentioned functions.

The existing system with an inking cylinder use an ink pan as a source of ink to the inking system. The use of the ink pan requires that a large amount of ink is used during printing.

5 The main aim of the invention is about using a minimal amount of ink in the inking system. There are many advantages in using an inking system that uses little ink. For example, the waste generated by an ink change, or by a washing of the cylinder is reduced. Also, the time needed for the ink to travel from the source of ink to the support is reduced, reducing the feedback loop lag in systems that adjust the printing
10 characteristics by monitoring the printed support and changing the ink composition.

US 3,283,712 discloses a system to generate an ink layer on an inking roller with uniform thickness. Despite the fact that their system looks structurally similar to our invention, the functions and properties of the elements at stake are very different. The system is not suitable for inking an etched cylinder, nor for using a minimal amount of ink.

15 DE 10 2004 056 539 discloses an inking system where the inking is performed in two places: first at the nip between an inking roller and the gravure cylinder, then by dripping the gravure cylinder into an ink pan. The system uses a large amount of ink to wet the gravure cylinder. There is no control of the amount of ink used in the nip.

JP59093351 discloses an inking system in a nip between an anilox and a rubber roller.
20 The two rollers are configured to turn in opposite directions, pushing the ink downwards. Ink is transported by the anilox through the nip, thereby requiring a bucket to collect the ink surplus below the rollers and a recirculating circuit to recuperate said ink and put it back in the system.

SUMMARY OF THE INVENTION

25 The invention is implemented by retaining all the ink used for inking in the little space close to the contact line between the inking cylinder and the etched cylinder, which we call the nip area.

The objectives of invention are achieved by the system and method defined in the claims.

In particular, these objectives are achieved by an inking system where an inking cylinder is positioned against the etched cylinder and configured to retain the ink in the area of contact between the two cylinders (i.e. in the nip area). An ink outlet is used to pour the ink either directly or indirectly into the nip area (The ink may be poured onto the inking cylinder and then transported toward the nip area by said cylinder). Also, a system is used to control the level of the ink in the nip area to set and maintain an acceptable amount of ink. The rotation of the inking cylinder may be controlled by a spinning system, for example a motor or a gearing system connected to the etched cylinder. The inking roller is configured to spin in the same direction as the etched cylinder, thereby causing the surface of both cylinders to slide over each other in opposite directions.

Advantageously, a printing unit is provided with a single of such inking system so as to further minimise the amount of ink used for inking.

Advantageously, a doctor blade is positioned on the etched cylinder such that the ink that is removed from the etched cylinder top surface (by the doctor blade) falls back into the nip area without the need of a recirculation circuit.

Advantageously, the inking roller is spun in a direction that causes the ink to be carried toward the nip area. Equivalently, the etched cylinder is spun in a direction that pushes the ink above the nip area.

Advantageously, the nip area is located above the contact line between the inking cylinder and the etched cylinder.

The objectives of the invention are also met by a method, for inking the etched cylinder of the printing unit, that provides ink through the ink outlet to the nip area, spins the inking cylinder in the same direction than the etched cylinder (thereby causing their respective surfaces to slide over each other and bringing and/or retaining the ink in the nip area), and controlling the ink level in the nip area by adding ink when necessary.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows a schematic view of the inking system according to the invention.

Figure 2 shows a schematic view of the inking system for a flexographic printing machine where the etched cylinder is an anilox.

5 Figure 3 shows a schematic view of the inking system for a rotogravure printing machine, where the etched cylinder is a gravure cylinder.

Figure 4a to 4c shows several alternative placements of the inking system compared to the one shown in figure 1; We assume that the gravity is directed along the page height.

10 Figure 5 shows a detailed view of the ink level setting and of the doctor blade assembly, as well as the pinched canal toward the doctor blade.

Figure 6 shows the inking system as a block diagram with the connections to the control system.

DETAILED DESCRIPTION OF THE INVENTION AND OF SOME OF ITS EMBODIMENTS

15 Figure 1 shows the principle of implementation of the invention. The inking cylinder 3 is in contact with the etched cylinder 2. A nip area 8 is formed between the two cylinders (2,3) and is configured to retain the ink 10. The ink is brought through an ink outlet 5 that drops the ink on the inking cylinder 2 or directly into the nip area 8 (or on the etched cylinder). Fundamentally, the ink outlet is configured to drop the ink in a location where the ink ends in the nip area 8 (without going through any ink buffer). A sensor 7 monitors
20 the level of the ink 10 in the nip 8 to ensure a proper inking of the etched cylinder while the printing machine is consuming ink. Advantageously, a system 70 controls the level of the ink 10 in the nip area. Advantageously, the level of the ink is kept as low as possible while ensuring an optimal print quality.

25 The nip area 8 is defined as the volume between the inking cylinder 3 and the etched cylinder 2 in the vicinity of the contact line 32 where it is possible to retain ink by the sole use of said cylinders (and some side walls and doctor blade(s)). Ink is present in the nip area 8 when the printing machine is running. The contact line is the generatrix of the

etched cylinder 2 in contact with the inking cylinder 3 (it is a line located at the top surface of the etched cylinder; the line is parallel to the rotation axis of the cylinder).

Advantageously, the etched cylinder 2 is turning according to direction 21, pushing the ink upwards. In this configuration, the surface of cylinder 2 travels first in an ink free zone 80, then reaches the contact line 32, then reaches the ink 10 in the nip area 8. Finally, the surface reaches the doctor blade 40, then transfers the ink to the next cylinder (or to the printing support) and ends in the ink-free zone 80 again, etc.

Equivalently, the inking cylinder 3 is spun in a direction 31 that pushes the ink 10 toward the nip area (i.e. toward the etched cylinder 2 by first traveling through the nip area). This rotation configuration is illustrated in the Figures 4A to 4C. In other words, the inking cylinder 3 is rotated in the clockwise direction when said cylinder 3 is positioned on the left of the etched cylinder 2 (or equivalently in counter-clockwise direction when positioned to the right of the etched cylinder 2). In this way, the ink 10 is retained in the nip area 8 without having to use any blade on the inking cylinder. Also, the ink can be delivered directly on the inking cylinder, which will drive the ink toward the nip area 8. It may also be poured directly into the nip area 8. By directly we mean without using an intermediate buffer, like an ink pan or an ink chamber with a double doctor blade (the ink buffer would defeat the goal of having little ink in the system).

Please note that the air-ink interface in the Figures is represented by an approximately straight line. In practice, it is usually a convex line, whose shape depends on parameters like the rotation speed and the direction of the etched and inking cylinders (2,3), on the ink viscosity and on the friction properties of the cylinder surfaces. Thus, the level 100 of the ink, meaning the height of the ink at a particular location (measured along a line which is not necessarily vertical), cannot be mapped directly to the amount of ink present in the nip area 8, without taking into account said parameters. In practice, however, given a range of rotation speeds and viscosity of the values, a minimal acceptable 101 and maximal acceptable level 102 of ink can be determined by trial and error, by ensuring that the print quality is good and the reactivity of the global inking

system is also good if the ink level is comprised between these two boundary values (101,102).

The inking cylinder is driven by a spinning system, which is configured to control the rotation of the inking cylinder 3. The spinning system may comprises a motor which runs
5 independently from the one driving the etched cylinder. The spinning system may also be a mechanical gearing system between the motor of the etched cylinder 2 and the inking cylinder. Said mechanical gearing system imposes a constant speed ratio between the inking and the etched cylinder and is cheaper to implement than by using an additional motor.

10 In order to ensure an optimal filling of the cells of the etched cylinder with ink, the inking cylinder is configured to slide on the etched cylinder. In other words, the surface of both cylinders travel in opposite directions at the contact line 32. This sliding pushes ink onto the etched cylinder cells. It also cleans the top surface of the etched cylinder, and removes spurious dried ink that might be present on the etched cylinder top surface (in
15 this sense it has a redundant function with the doctor blade, thereby increasing the reliability of the inking against defects caused by dried ink).

The inking cylinder 3 can be rotated, for example, at a speed (amplitude) comprised between 5% and 50% of the rotation speed (amplitude) of the etched cylinder; the rotation speed is measured as the (linear) speed of the cylinder surface. Please note
20 however that the speed amplitude of the inking cylinder 3 can be slower, equal or greater than the speed amplitude of the etched cylinder without affecting significantly the inking quality. Slower speed of the inking cylinder 3 is preferred to limit mechanical wear of the inking cylinder.

Figure 2 shows how the invention is implemented in a flexographic machine, using the
25 inking cylinder 3 against the anilox 2, which transfers ink to the printing cylinder. The printing cylinder 22 is pressed against the support 4 thanks to the impression cylinder 20 resulting in the cliché being printed on the support.

Figure 3 shows how the invention is implemented on a rotogravure printing machine. Compared to the embodiment shown in Figure 2, the inking system transfers the ink directly into the gravure cylinder, which carries the image to be printed. Thus it uses fewer cylinders, but the inking system can be used in the same way.

5 Figure 4 shows some variations of the position of the nip area 8. Figure 4A and 4B show two embodiments where the ink does not leave the nip area from its wide side thanks to the gravity forces (because the nip area is located above the contact line 32). Figure 4C shows an alternative where the ink is pushed upwards by the inking cylinder thereby preventing it from leaving the nip area from its wide side (the wide side is at the opposite
10 side of the nip area compared to the contact line 32). The inking cylinder turns in the direction 31 as shown in the figures to retain the ink. As mentioned in the summary of the invention, embodiments 4A and 4B are preferred over embodiments 4C which is more delicate to control.

Figure 5 shows a detailed view of an embodiment according to the invention. In this
15 embodiment, there is a pinching device 41 holding the doctor blade 40. The pinching device exhibits a surface 42, whose distance (43,44) to the etched cylinder reduces when approaching the doctor blade. At the entrance of the device, the distance 44 is larger than the distance 43 close to the doctor blade. This pinching surface 42 creates a compression which pushes the ink into the etched cylinder cells, to fill the cells that did
20 not get filled at 100% when passing the contact line 32. As an example, the distance 44 may be set to 3mm and the distance 43 to 1mm.

Optionally, the pinching device can also be configured to define the minimal level 101 of the ink present in the nip area. Here, keeping the ink above level 101, i.e. above the inlet to the pinching area, ensures that there is no air introduced underneath the
25 pinching surface (in practice a control system would take a margin in order to ensure that the level never goes below level 101). The sensor 7, which measures the ink level, can be placed next to the pinching device. It may be positioned such that its tip is at the maximum level 102 of the ink, when using an air sensor, or positioned more remotely when using optical, ultrasound or capacitive devices.

The doctor blade can also be used without any pinching device. It can conveniently be placed above the nip area such that the ink removed from the etched cylinder 2 surface drops back toward the nip area 8 (the placement of the doctor blade in the embodiment of Figure 5 exhibits the same advantage).

5 The sensor 7 used to measure the level of the ink in the nip area can be of various kind. It may be a device that blows air through an air conduct 72, combined with a pressure sensor 71 positioned anywhere in the air conduct or in a pump 73 that blows the air into said conduct. The use of the pump 73 is optional if there is a source of compressed air already available in the printing machine. The sensor 7 may be a capacitive device that
10 is sensitive to the proximity of the air-ink interface. It might also be a time of flight sensor, which measures the time for a wave to exit the sensor and bounce back from the air-ink interface. The wave can be an ultrasound wave, a radar wave or an optical wave. In the case of an optical wave, the sensor must be protected from spills of ink (the optical time of flight sensors include direct time-of-flight, range-gated imaging, and phase detection
15 sensors). The advantage in using the sensor that blows air is its self-cleaning capability.

To maintain the ink level 100 in the nip area 8 between two predefined values 101,102 while the printing machine is running, the printing machine has a control system connected to the sensor 7 and to the ink refill system 6. Whenever the ink level 100 approaches the lower value 101, the system activates the ink refill system 6 that
20 provides additional ink through the ink outlet 5, while ensuring that the refill stops before that the level exceeds the upper value 102. As an alternative, the ink refill can also be performed using a constant rate which is adjusted whenever the ink level approaches one of the boundary values 101, 102. Actually, any well-known control technique can be used to maintain the ink level between the two predefined values
25 101,102, or around a (predefined) average value 100.

To ensure that the inking of the etched cylinder 2 is performed well, the inking cylinder 3 must be in contact with the etched cylinder 2. By contact between two cylinders, we mean that the inking cylinder 3 is pressed against the etched cylinder 2, or that there is a tiny space of a few microns in-between the two, which is set such that the ink does

not leak through the nip area. In many cases, if the spacing exceeds 100 microns, then the ink tends to leak between the two cylinders. However, with some viscous inks, the gap can be up to 1 mm without having the ink leaking. A typical setting of the gap is, for example, 10 microns. In any case, when setting the gap to 10 mm (gap adjustable), the ink is flushed between the cylinders. There is a compromise to find between the pressure between the two cylinders and the risk of ink leakage (even if there is a tiny space between the cylinders, there is a pressure caused by the presence of the ink at the contact line 32). The more pressure, the larger the wearing of the cylinders, the larger the power consumption, the smaller the risk of leakage. This compromise is found by trial and error and is ink dependent. In other words, the inking system is suitable for setting the gap between 0 microns and 1000 microns, and is suitable for setting the flushing gap to a larger distance, for example, 5mm, 10mm, 20mm or more. (Technically, the system is even suitable to set the gap to a negative value, thereby having the possibility to set a pressure value determined by the cylinder elasticity or for compensating the wearing of the inking cylinder over time, or for compensating the difference in diameter between two printing cylinders). The inking cylinder is covered with rubber, generic polymers or even metal or plastic depending on the application.

To set the pressure and/or the distance between the inking cylinder, one possible embodiment uses an abutment 54, coupled with a piston 52 and a pivoting arm 53. The goal is to set the pressure to a value P or to set the distance between the two cylinders to a given value by adjusting the position of the abutment 54 and making sure that the pressure Q provided by the piston to the arm at the abutment location is large enough. The pressure is large enough when the arm 53 is kept in contact with the abutment 54 under any normal printing conditions.

The use of a piston and a pivoting arm allows some special operations of the inking system 1. For example, it allows to temporarily create a gap between the inking cylinder 3 and the etched cylinder 2 to cause the leakage of the ink. This ink leakage allows to partially or completely replace the ink 10 in the nip area 8 in a very short amount of time (for example less than 1 second). Replacing the ink in a very short time might be

necessary to correct the ink composition in order to achieve a given printing characteristics.

Please note that in order to fulfil one of the main goals of the invention, namely to have the least possible amount of ink present in the inking system, the inking disclosed in this invention is preferably the only one used to ink the etched cylinder. If we would use an additional ink pan, by using a configuration similar to the invention disclosed in DE 10 2004 056 539 Figure 1, then the invention would lose most of its interest. By using a single inking system that uses the nip area 8, the total amount of ink in the inking system can be easily lower than 500g per meter of etched cylinder width, is typically lower than 250g per meter of etched cylinder width, is reasonably around 80g per meter of etched cylinder width (or smaller than 120g per meter of etched cylinder width) and can be as low as 40g per meter of etched cylinder width when having optimal ink characteristics. Please note that, in some difficult situations, one could use two of the disclosed inking systems for a single etched system, which would still result in less ink used compared to the solution using an ink pan.

By total amount of ink in the inking system, we mean the total amount of ink passed the point where the ink is not easily removed without creating waste, or not easily replaced by a new one. It is the amount of ink that must be consumed by the printing system (or discarded) before being replaced by ink with corrected (or different) characteristics. Here, it includes the ink outlet 5 and the ink in the nip area. It excludes any ink reservoir connected to the ink outlet, because, the ink reservoir is designed to be replaced, and the ink inside the reservoir can be easily reused. In a more traditional inking system using an ink pan or an ink chamber with a double doctor blade, the ink in the pan or in the double doctor blade chamber is part of the total amount of ink in the inking system, since it is not easy to remove and replace this ink (without waste) with new ink.

Please note that the invention can be implemented as a retrofit to existing printing machines. To do so, one needs to provide (at least) an inking cylinder, an ink outlet and

a sensor to measure the ink level in the nip area created by placing the inking cylinder in contact with the already-existing etched cylinder of the printing machine.

Please note that a printing unit is a part of a printing machine whose function is to print a single colour of a printing job. For example, there might be a printing unit for printing
5 yellow, another for printing black, etc. There exist also printing units that are printing gloss. The final print is obtained by passing the support/paper/web through several printing units in the printing machine.

CLAIMS

1. An inking system (1), for a rotary printing unit, comprising
 - an inking cylinder (3) and an etched cylinder (2) arranged to retain ink (10) between them in a nip area (8);
 - 5 - an ink outlet (5) configured to provide the nip area (8) with ink (10);
 - a sensor (7) configured to measure an ink level (100) in the nip area (8),wherein the inking cylinder (3) and the etched cylinder (2) are configured to turn in the same direction (31,21).
2. The inking system according to claim 1 further comprising a control system (70)
10 functionally connected to the sensor (7) and configured to control the ink level (100) in the nip area (8).
3. The inking system according to claim 2, wherein the control system (70) is configured to maintain the ink level (100) in the nip area (8) between two predefined values (101,102).
- 15 4. The inking system according to any preceding claim, wherein the inking cylinder (3) is configured to rotate in the direction (31) suitable for carrying ink through the nip area (8) toward the etched cylinder (2).
5. The inking system according to claim 4, further comprising a doctor blade (40) configured to remove the ink from the top surface of the etched cylinder (2) and
20 positioned above the nip area (8).
6. The inking system according to any preceding claim, further comprising a mechanical system (52,53,54) to control the pressure (P) or the gap between the etched cylinder (2) and the inking cylinder (3).
7. The inking system according to any preceding claim, wherein the sensor (7) comprises
25 an air conduct (72) that blows air toward the nip area (8) and a pressure sensor (71) to sense the pressure of said air, the conduct being positioned such that the air pressure varies with the level of ink (100) in the nip area (8).

8. The inking system according to any claim 1-6, wherein the sensor (7) is an optical time-of-flight sensor.
9. Printing unit comprising the inking system according to any preceding claim.
10. Printing unit having a single inking system, wherein said inking system is characterised by any claim 1-8.
11. Method for inking an etched cylinder (2) using a minimal amount of ink (10), for a printing unit comprising an inking cylinder (3) kept in contact with the etched cylinder (2) along a contact line (32) and an ink outlet (5), the method comprises
- providing ink through the ink outlet (5) to a nip area (8) located between the ink outlet (5) and the contact line (32)
 - spinning the inking cylinder (3) in the same direction than the etched cylinder (2) to retain the ink (10) in the nip area (8);
 - controlling the ink level (100) in the nip area (8) by adding ink when necessary.
12. The method according to claim 11, wherein the etched cylinder (2) is rotated in the direction (21) that pushes the ink above the nip area (8).
13. The method according to claim 11 or 12, wherein the ink level (100) is set such that the total amount of ink in contact with the etched cylinder (2) does not exceed 500 grams per meter of etched cylinder width.
14. The method according to claim 11, 12 or 13, wherein the ink is poured from the ink outlet (5) directly into the nip area (8) or directly onto the inking cylinder (3).

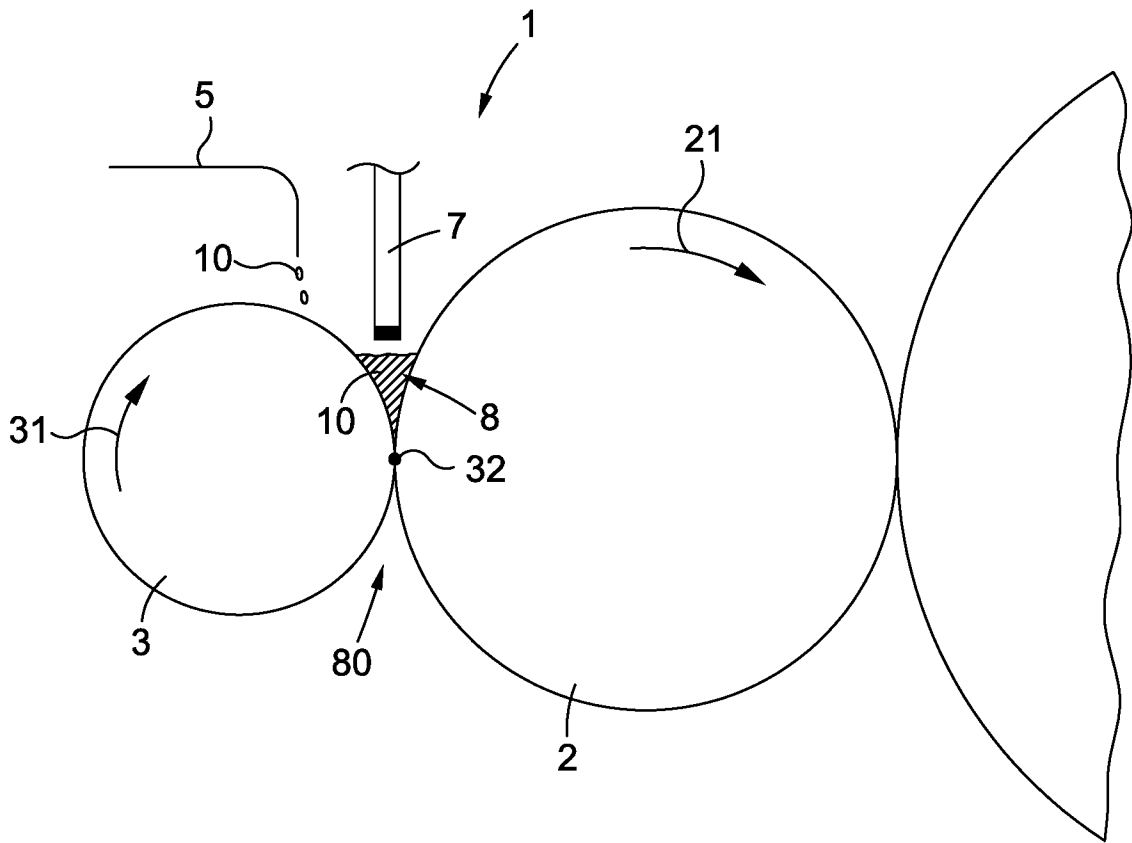


FIG. 1

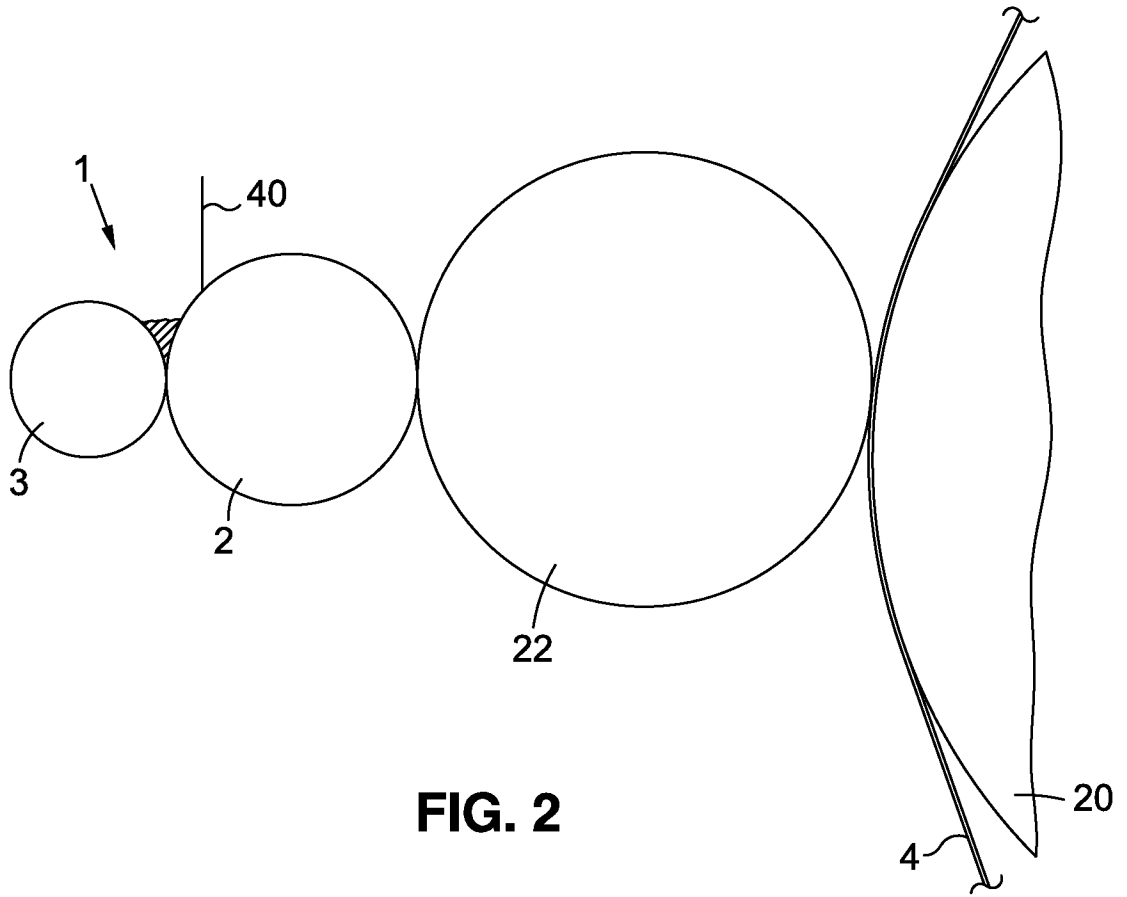


FIG. 2

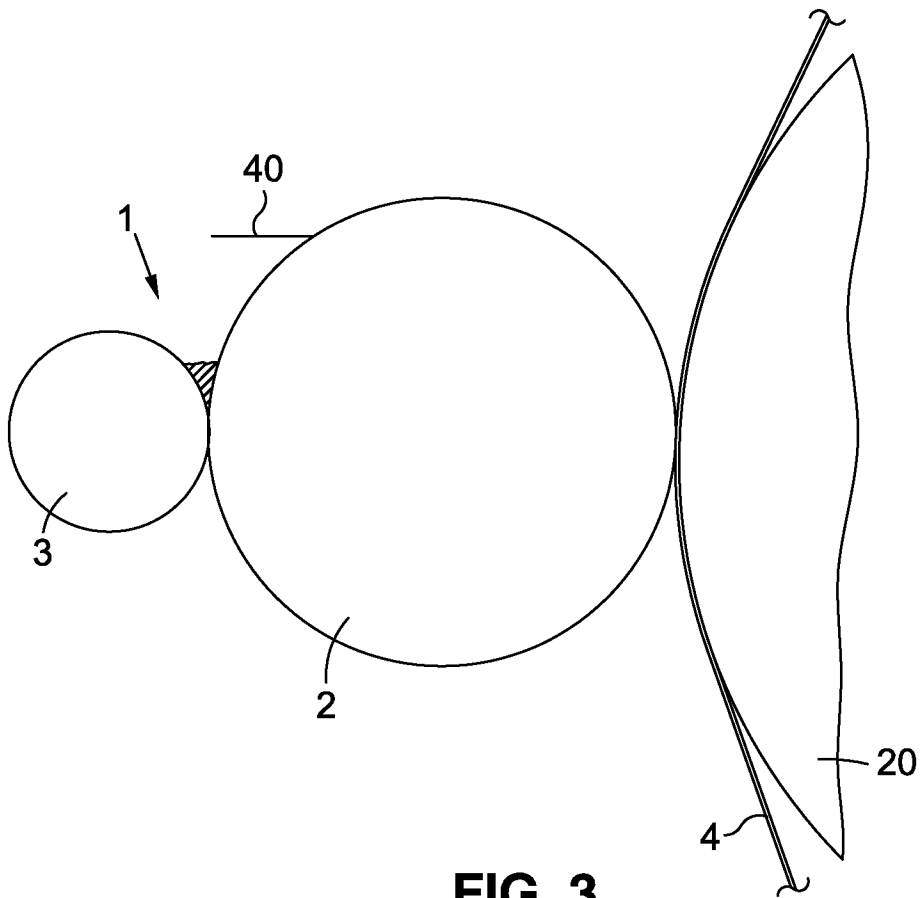


FIG. 3

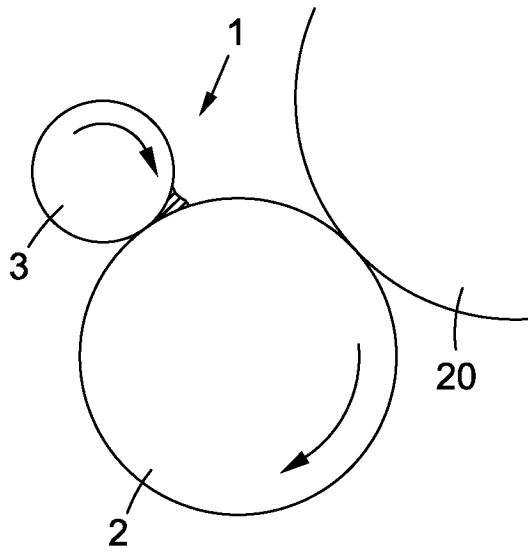


FIG. 4A

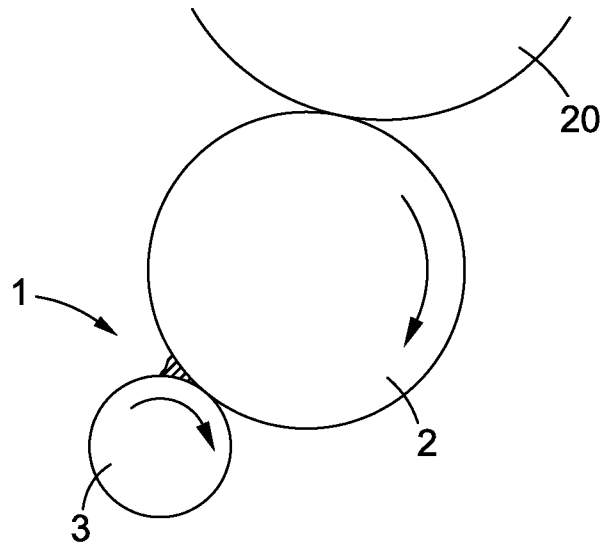


FIG. 4B

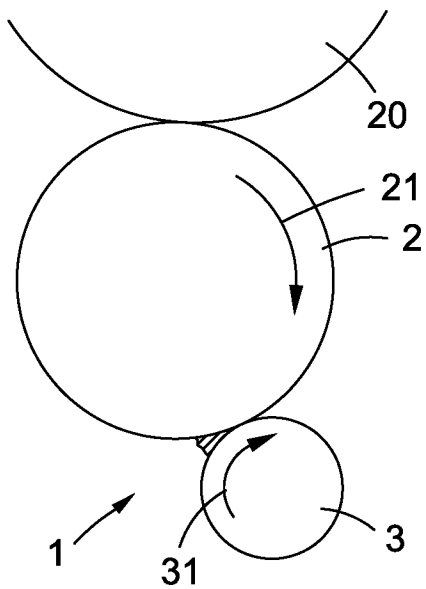


FIG. 4C

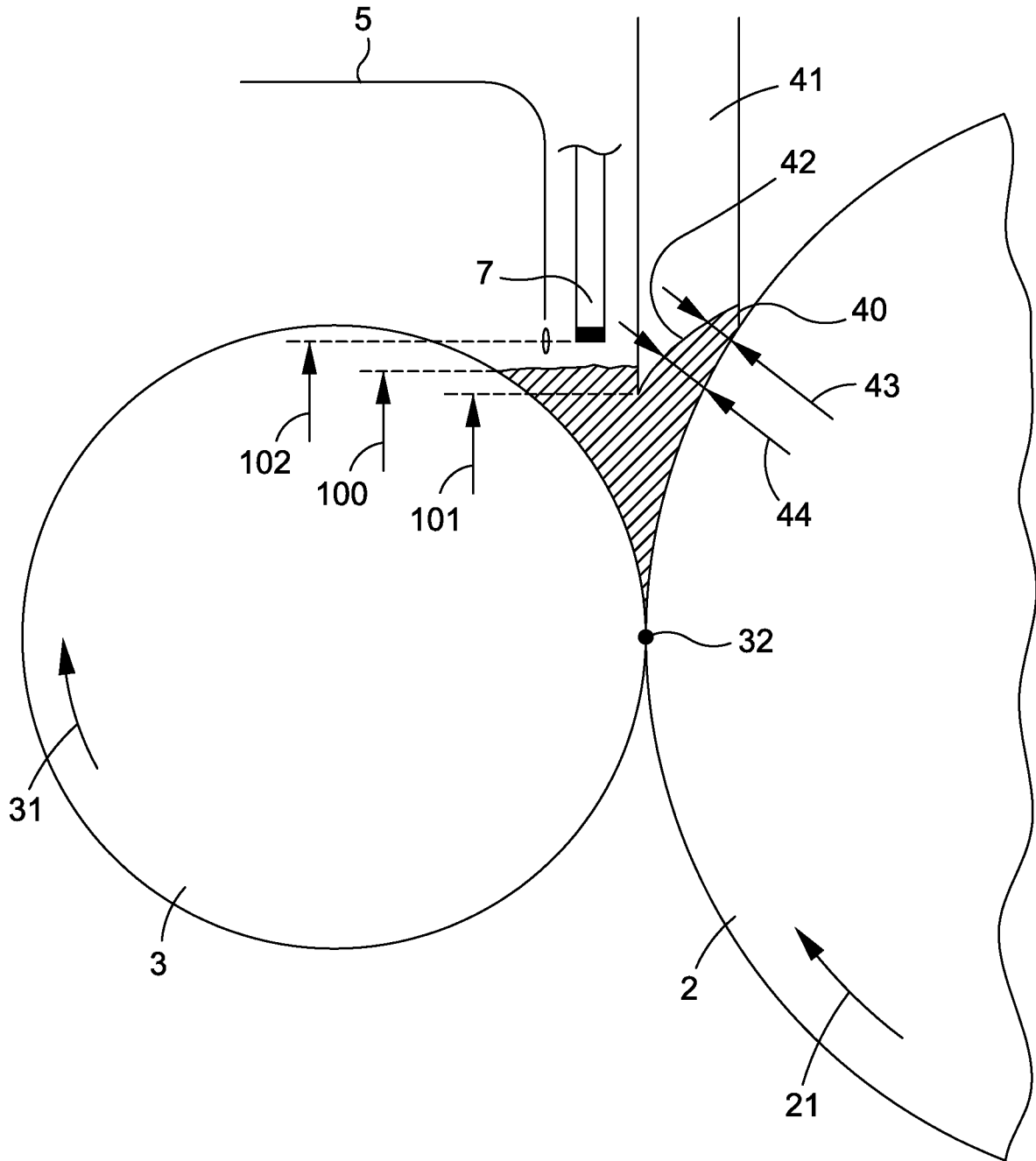


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/025242

A. CLASSIFICATION OF SUBJECT MATTER
INV. B41F31/02 B41F9/06 B41F9/10
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
B41F

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP S59 93351 A (ISOWA INDUSTRY CO) 29 May 1984 (1984-05-29)	1-4,6, 8-14
Y	figures 1,2 paragraph [0001]	1,5,7,11
Y	GB 1 432 677 A (DAHLGREN MFG CO) 22 April 1976 (1976-04-22) figures 15,16 page 8, lines 119-129	1,5,11
Y	WO 79/00955 A1 (BALDWIN GEGENHEIMER CORP [US]) 15 November 1979 (1979-11-15) page 4, lines 11-17	7
Y	JP S59 93352 A (ISOWA INDUSTRY CO) 29 May 1984 (1984-05-29) figure 3 paragraph [0001]	7
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Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
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- "O" document referring to an oral disclosure, use, exhibition or other means
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Date of the actual completion of the international search 23 October 2018	Date of mailing of the international search report 12/11/2018
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Hajji, Mohamed-Karim
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/025242

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

International application No

PCT/EP2018/025242

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