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Clark et al.

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(54) **DEFORMABLE PADS FOR ROTARY PAD PRINTING, APPARATUS AND METHOD**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 704 days.

(21) Appl. No.: **11/852,301**

(22) Filed: **Sep. 8, 2007**

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(51) **Int. Cl.**
B41F 17/34 (2006.01)

(52) **U.S. Cl.** **101/41**; 101/42; 101/44; 101/33; 101/35

(58) **Field of Classification Search** 101/41, 101/42, 44, 33, 35
See application file for complete search history.

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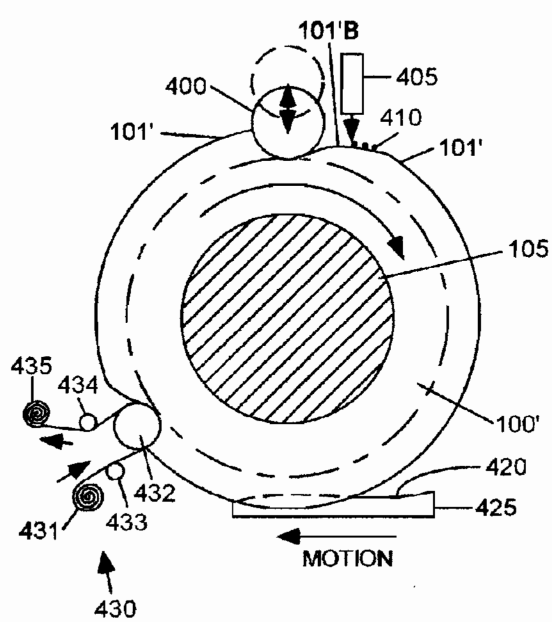
Primary Examiner—Ren Yan
Assistant Examiner—Shema T Freeman

(57) **ABSTRACT**

A rotary pad for pad printing comprises a cylinder (**100'**) or a belt (**1105**). The pad can be either flat or crowned in its relaxed condition. An ink applicator (**405**, etc.) applies an ink image (**701**) to the pad for subsequent transfer to a receiving object (**425**, etc.). If not initially flat, the pad can be flattened during application of the ink image, then forced to bulge for transfer to a receiving object. The pad can be flattened or caused to bulge by rollers (**400**, etc.) or by vacuum or pneumatic pressure. In one embodiment, an ink image is temporarily applied to the outer surface (**510**) of a flat cylindrical pad, then as the pad rotates, the sides of the pad are squeezed by rollers (**520**, **525**), forcing the pad to bulge during transfer of the ink image to a receiving object (**600**). In another embodiment, a crowned pad (**100'**) is flattened while accepting an ink image, then allowed to resume its original crowned shape for transfer to a receiving object (**425**).

17 Claims, 14 Drawing Sheets



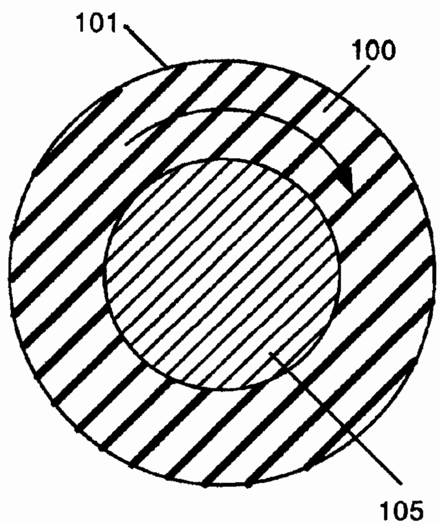


Fig. 1A--Prior Art

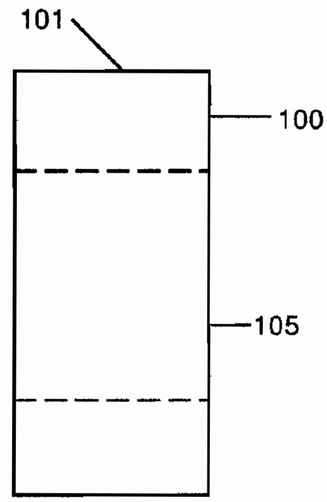


Fig. 1B--Prior Art

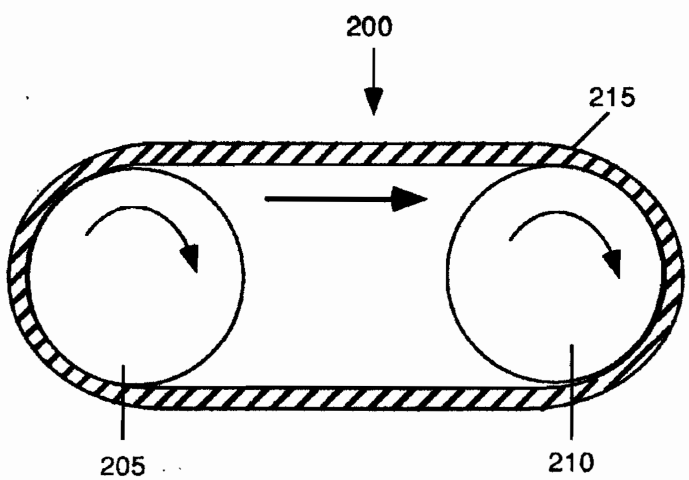


Fig. 2A--Prior Art

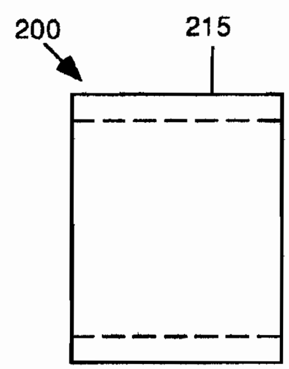


Fig. 2B--Prior Art

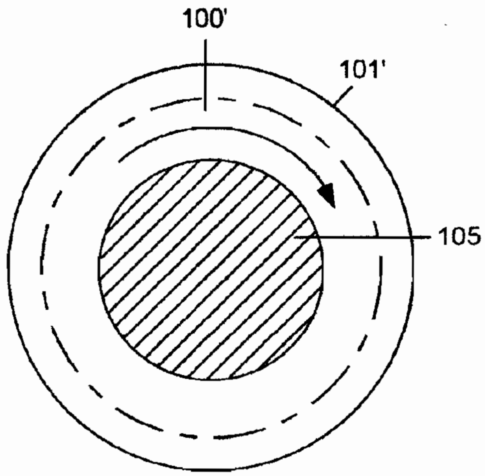


Fig. 3A

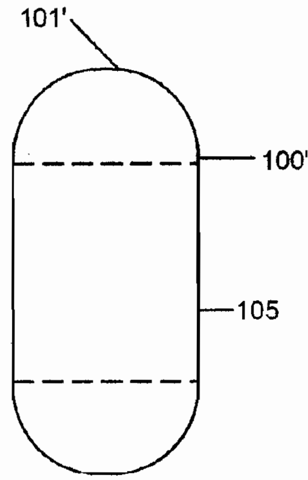


Fig. 3B

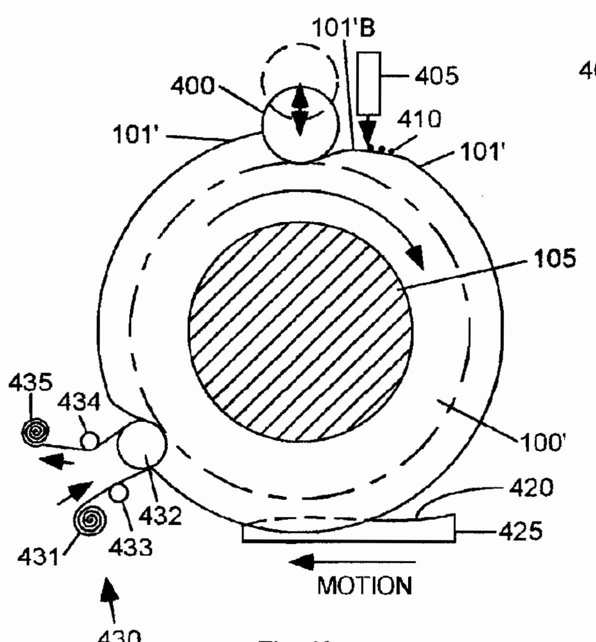


Fig. 4A

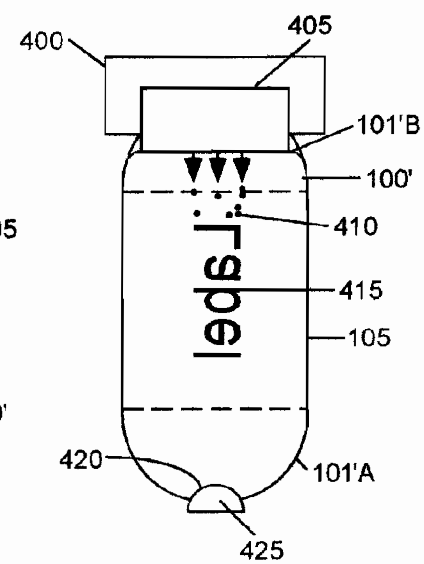


Fig. 4B

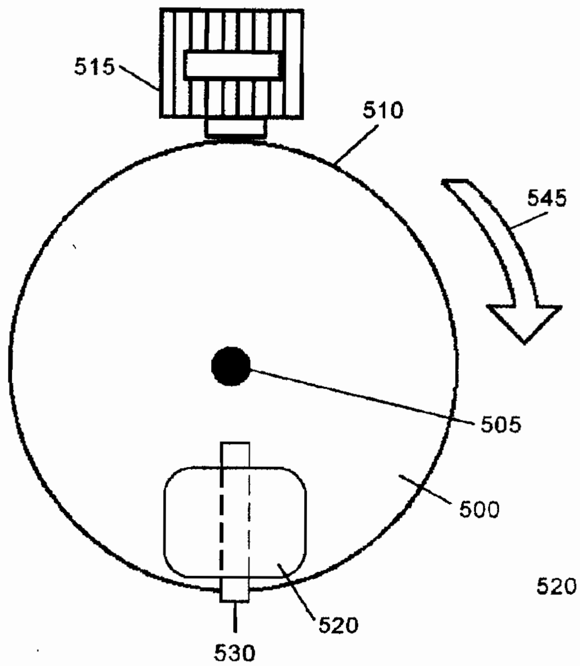


Fig. 5

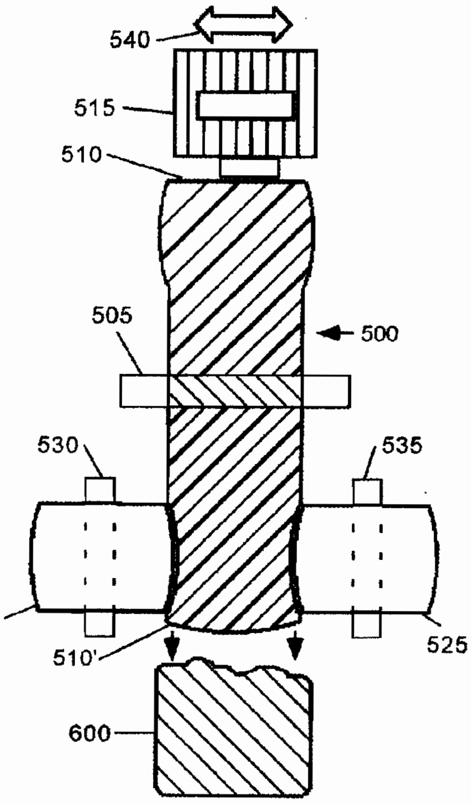


Fig. 6A

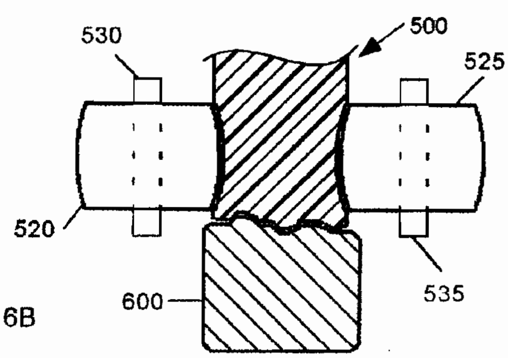


Fig. 6B

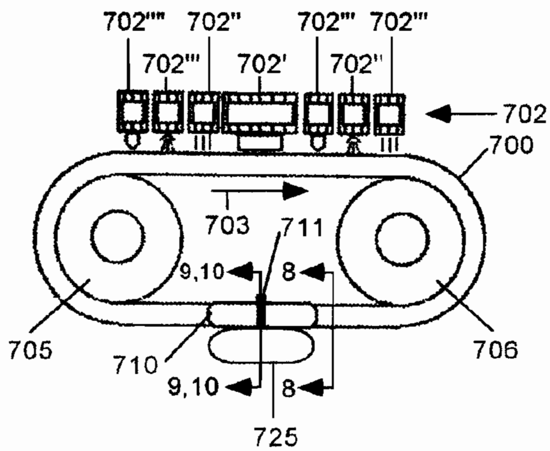


Fig. 7

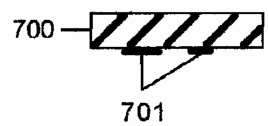
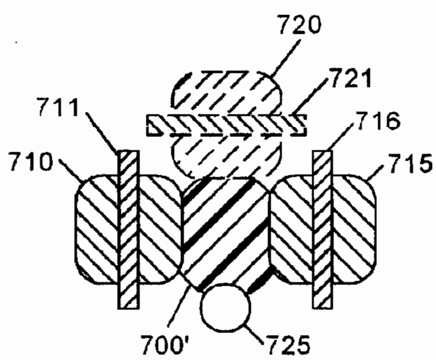


Fig. 8



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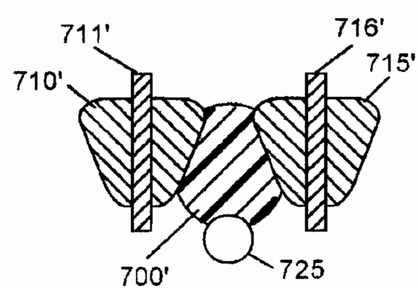

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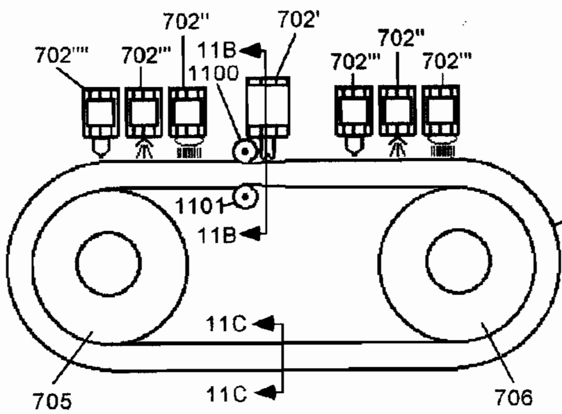


Fig. 11A

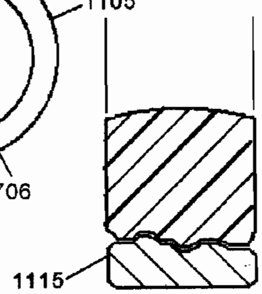


Fig. 11C

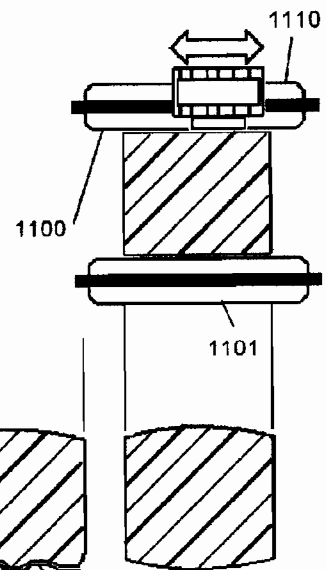


Fig. 11B

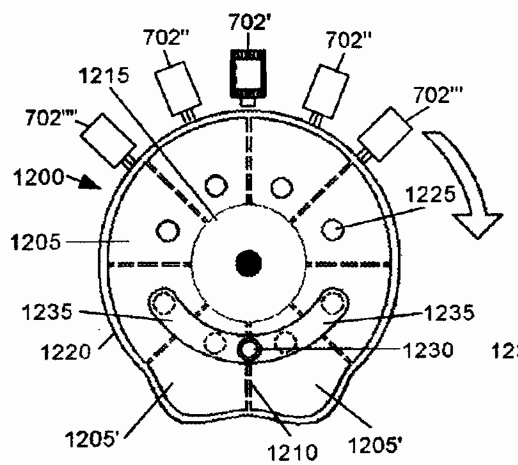


Fig. 12A

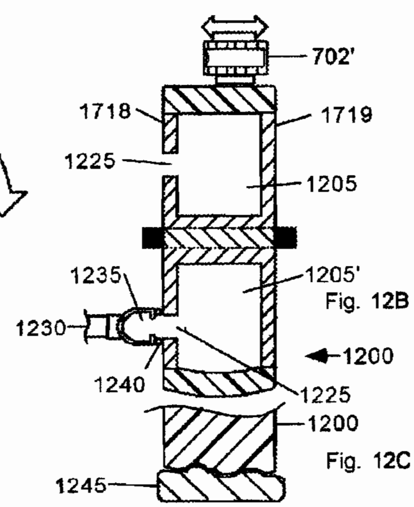


Fig. 12B

Fig. 12C

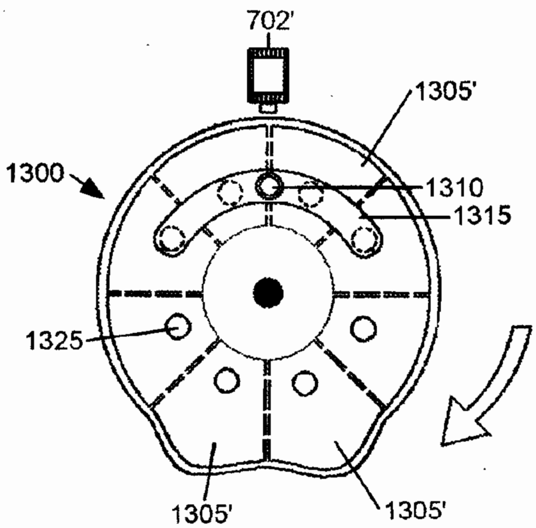
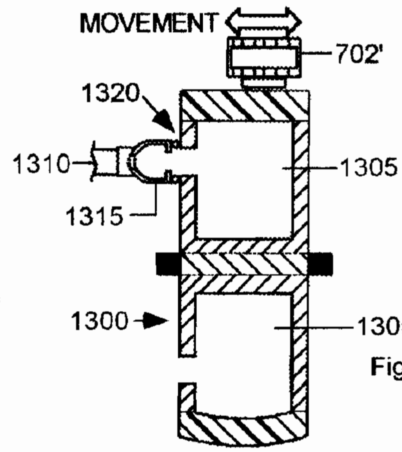


Fig. 13A



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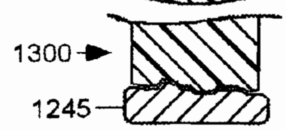


Fig. 13C

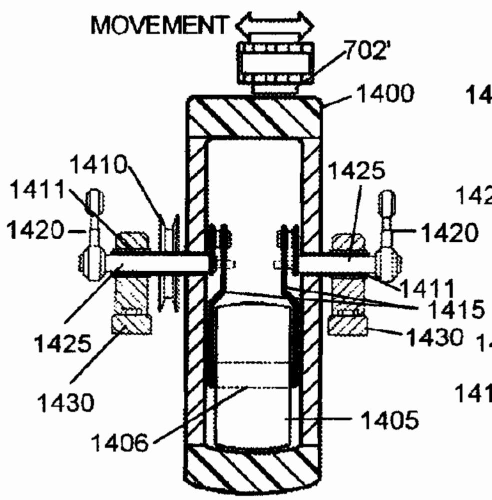


Fig. 14A

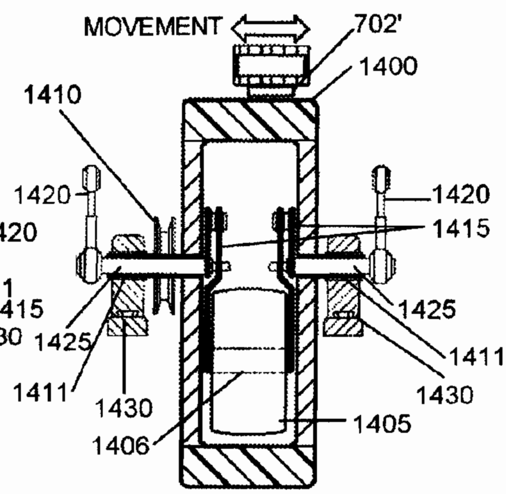
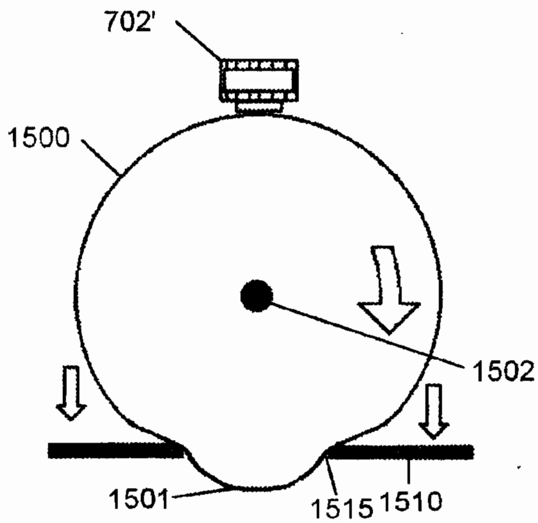


Fig. 14B



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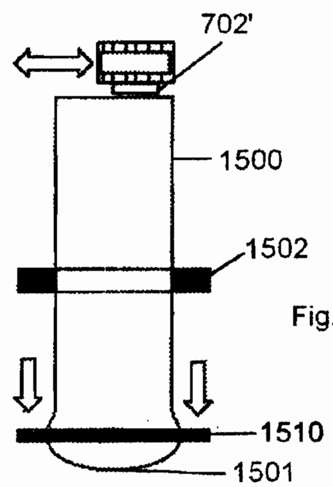
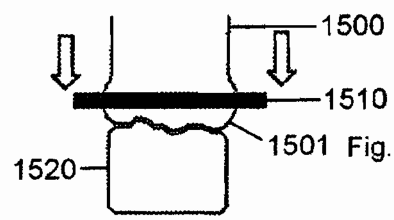


Fig. 15B



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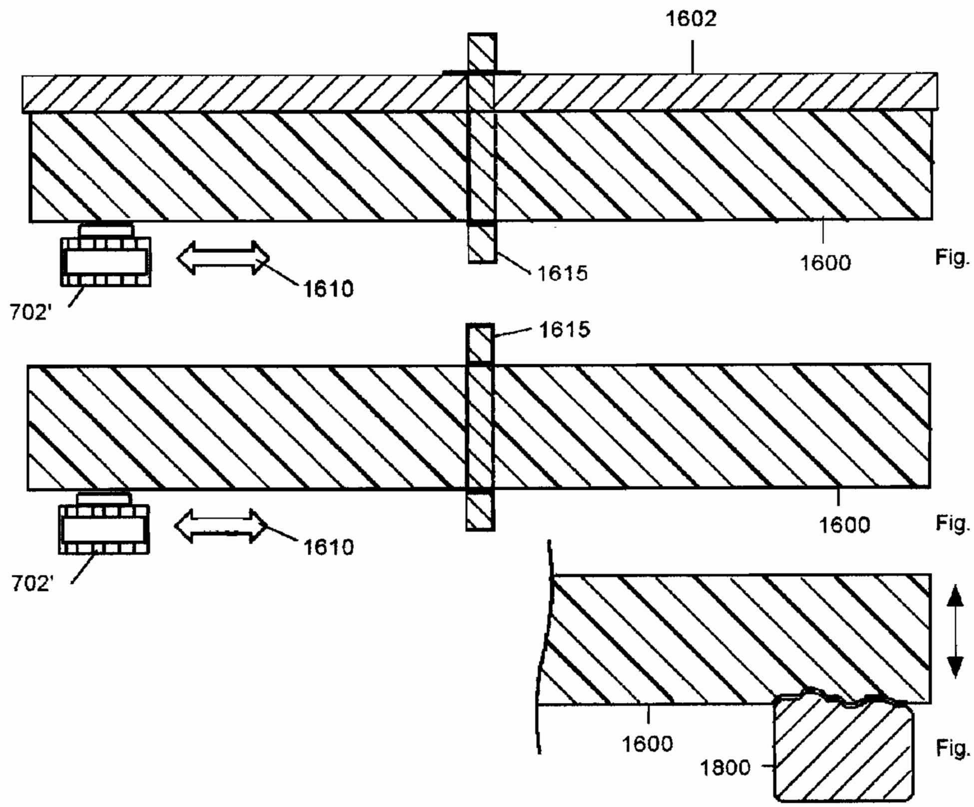
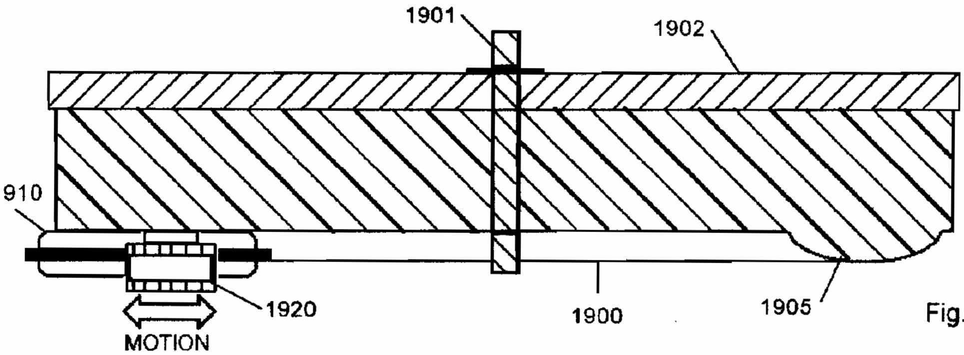


Fig. 16

Fig. 17

Fig. 18



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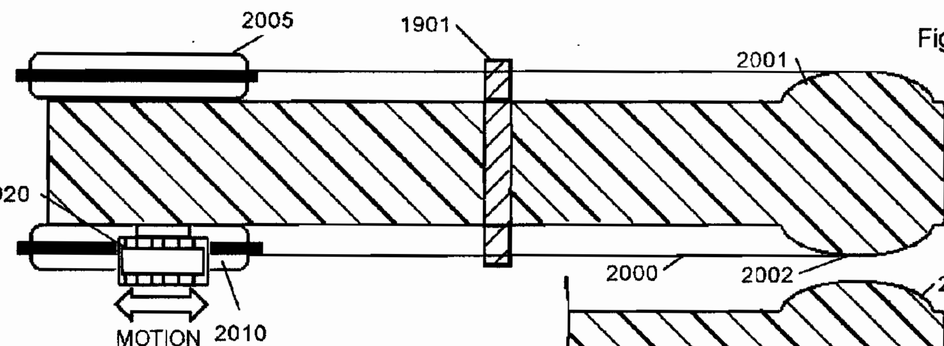

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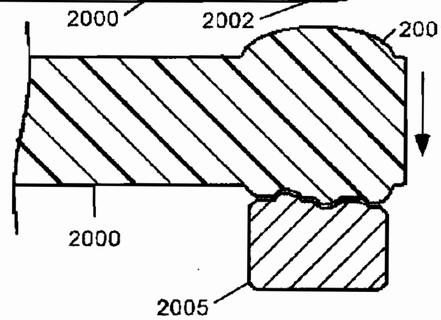

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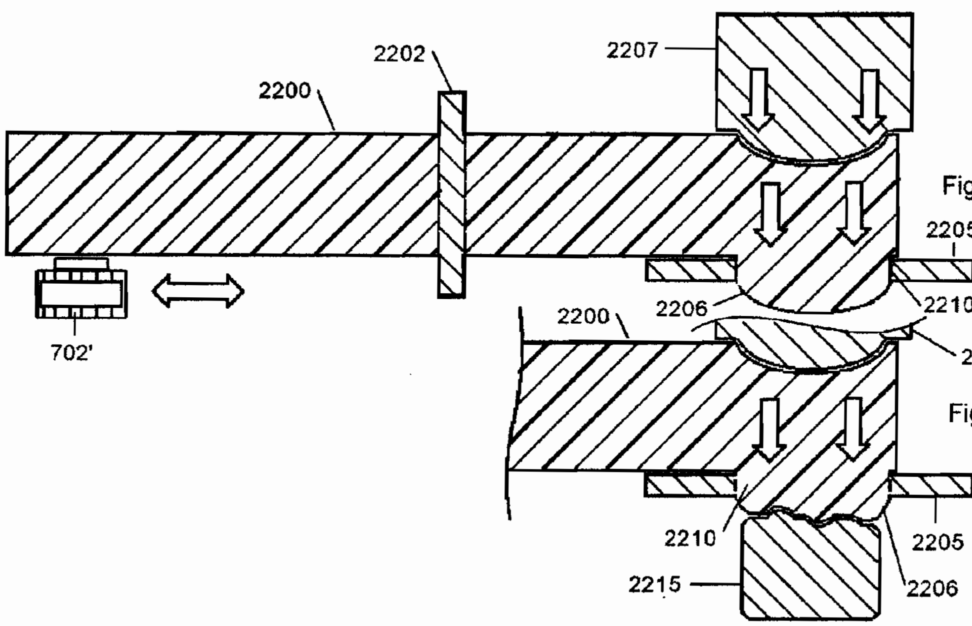
2207
2202
2200
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702'
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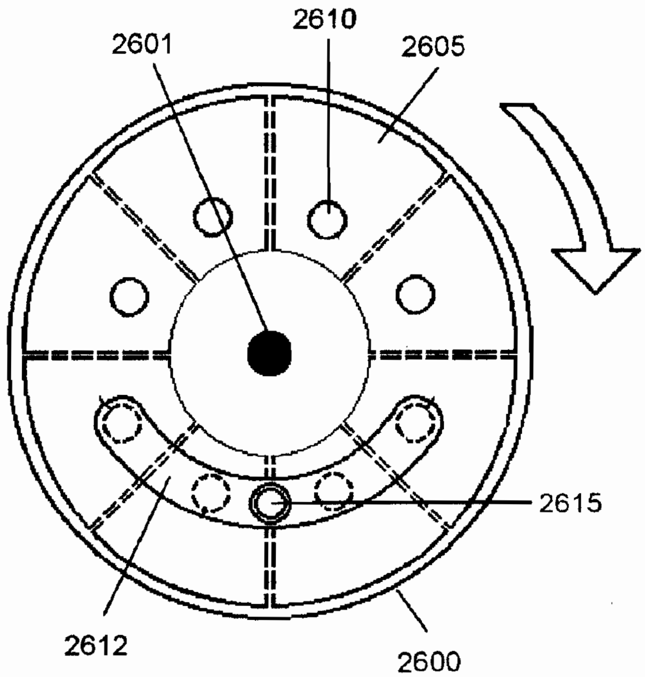
2215
2206

Fig. 22

Fig. 23



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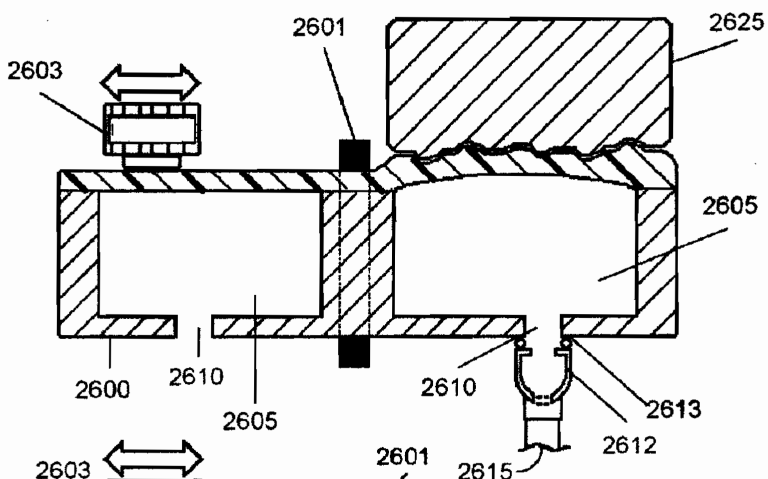


Fig. 26

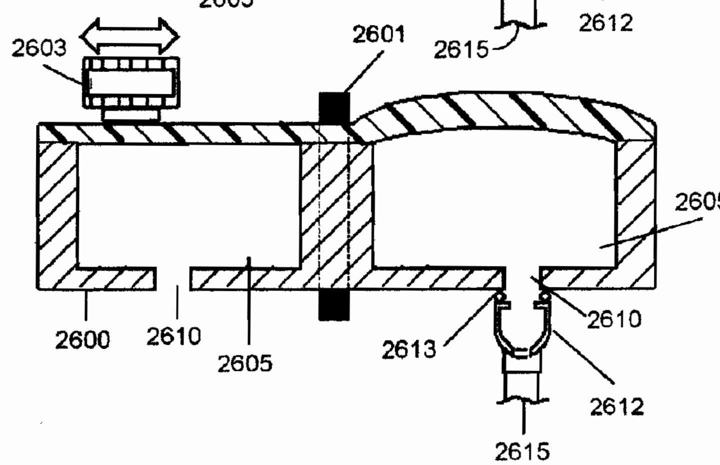


Fig. 25

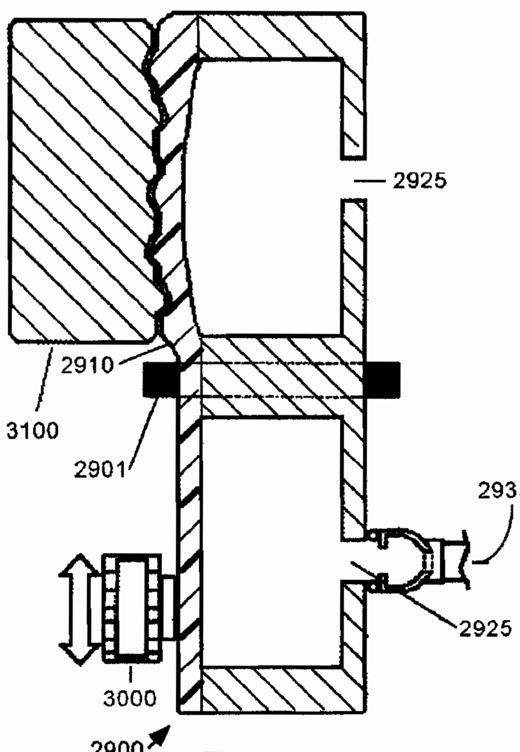
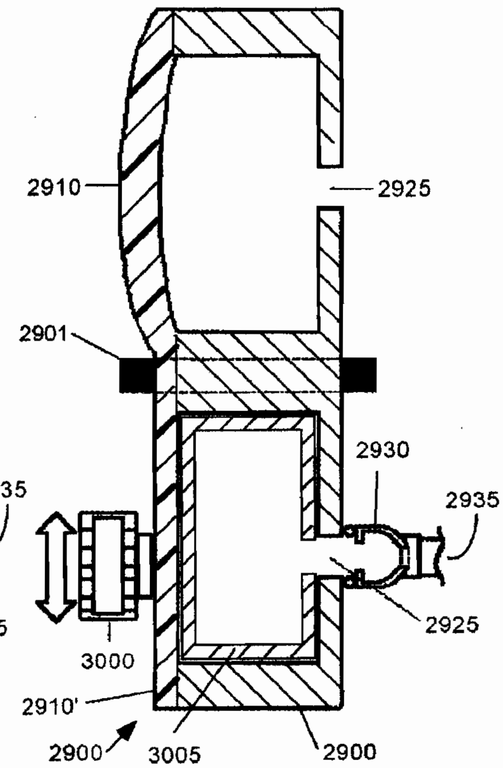


Fig. 29



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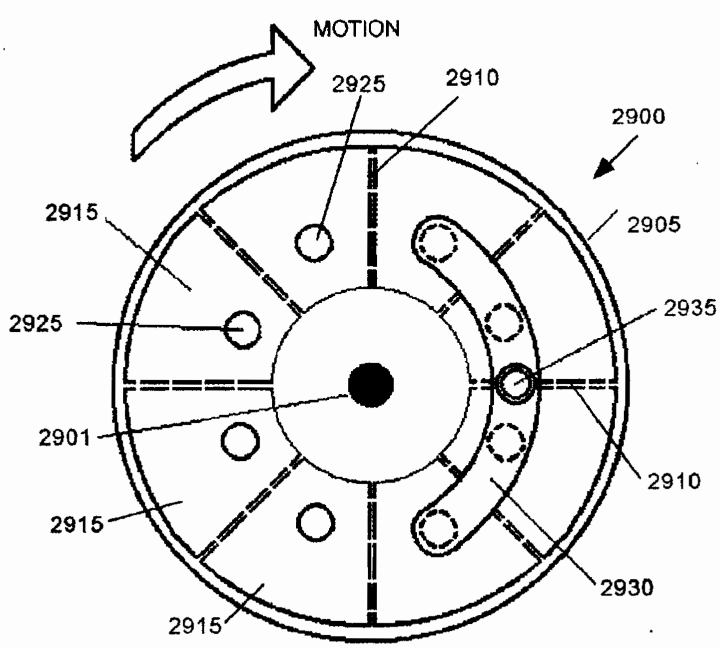


Fig. 27

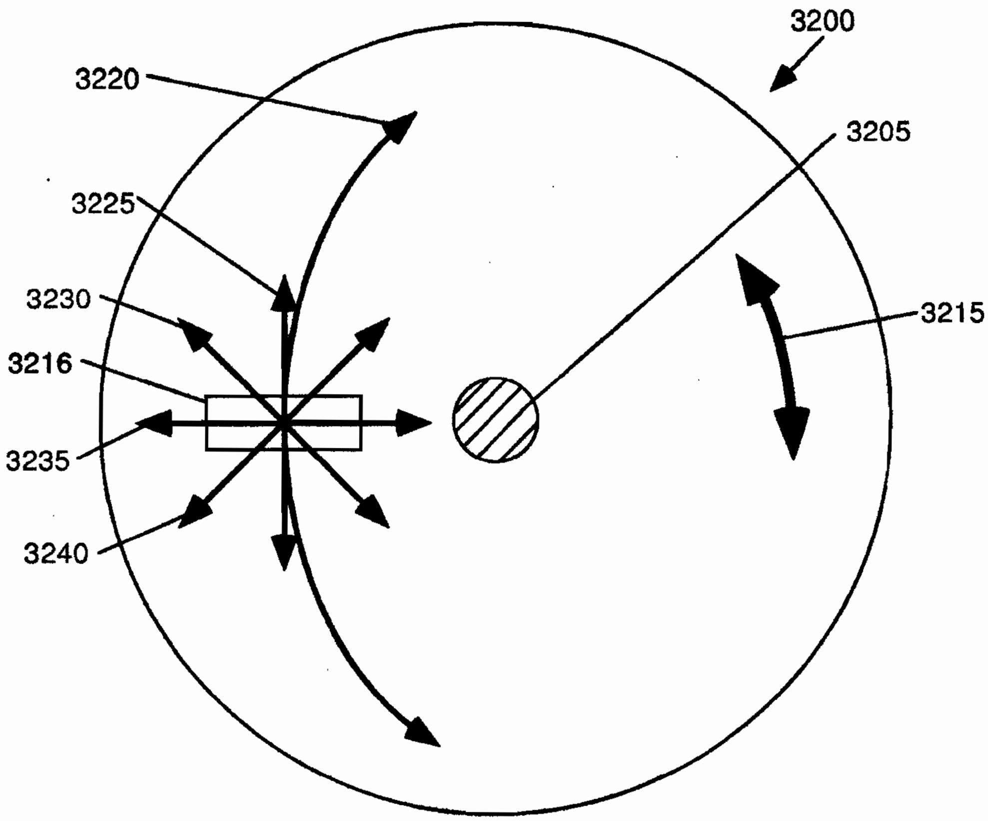
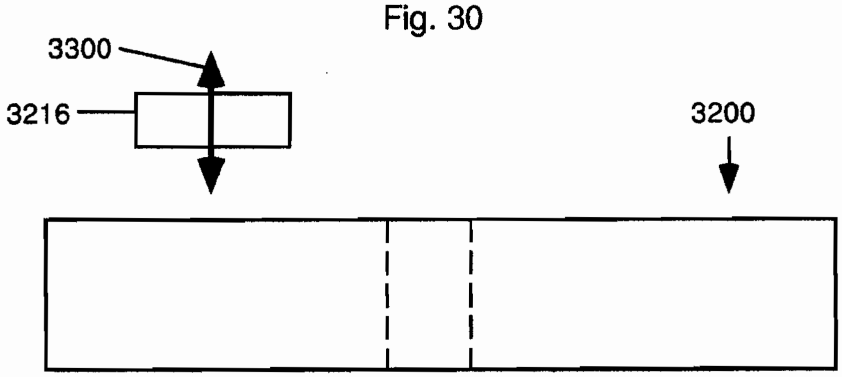


Fig. 30



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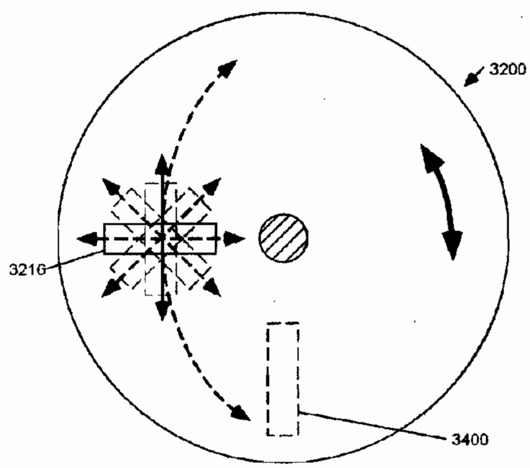

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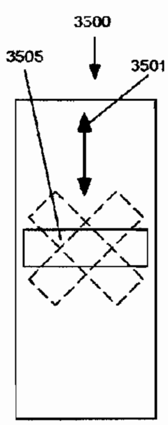

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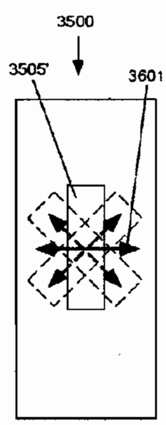

Fig. 34

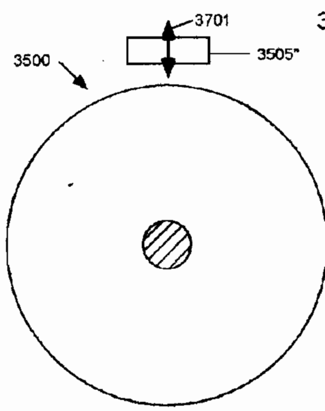

Fig. 35

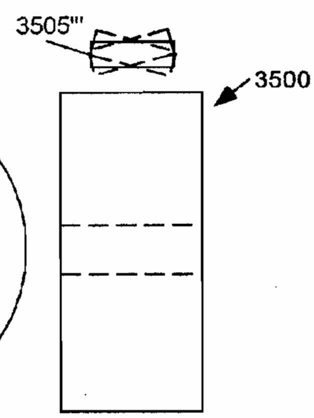

Fig. 36

DEFORMABLE PADS FOR ROTARY PAD PRINTING, APPARATUS AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority of our provisional patent application Ser. No. 60/825,304, filed Sep. 12, 2006. This application is related to and incorporates for reference purposes our U.S. Pat. No. 6,840,167 (2005) and our pending U.S. patent application Ser. No. 11/464,203, filed Aug. 13, 2006, Ser. No. 11/558,911, filed Nov. 11, 2006, Ser. No. 11/697,171, filed Apr. 5, 2007, and Ser. No. 11/777,166, filed Jul. 12, 2007.

BACKGROUND

1. Field

The field is pad printing, and in particular rotary transfer pad printing.

2. Prior Art

Fixed Pad Printing

Prior-art, fixed-pad printing is used to apply images and text to either flat or uneven surfaces ranging from poker chips and golf balls to household appliance panels. Such printing usually employs a domed pad. The pad is made of an elastomeric material such as gelatin or a silicone rubber. The surface of a flat, metal or plastic plate is etched to a depth of about 0.025 mm with an image. The etched plate is called a cliché. The pad is pressed against the cliché, flattening the domed portion and contacting the ink in the image. The pad is then lifted away from the cliché, carrying the ink image with it. The pad is then moved to a position in proximity with a receiving surface. The pad is then pressed against the receiving surface, again deforming its domed shape, until all image areas are in contact with the receiving surface. The pad is then lifted away from the receiving surface, leaving behind the ink image on the surface. This completes the transfer of the image from the cliché to the receiving surface.

The pad is domed to prevent the entrapment of air during the inking and transfer steps. Air entrapped during these operations would form pockets which would be undesirable since such pockets could release their contents in unpredictable ways, causing the ink image to smear across the surface of the cliché or the receiving surface.

Pad printing is most useful when the surface to be printed is uneven, i.e., wavy or contoured. The pad can carry the ink image to all points on the receiving surface since it is deformable and thus can conform to such points.

Pad Printing

Our U.S. Pat. No. 6,840,167 (2005) teaches a multicolor and multi-layer apparatus for pad printing using a deformable pad. This apparatus is generally limited to printing images that are the same size or smaller than the pad itself.

Rotary Pad Printing

In the past, rotary pad printing has been used to decorate objects by printing images or text thereon. In its simplest form, a rotary pad printing apparatus comprises a rotary pad that comprises a multi-layer, right-circular cylinder having a compressible surface that is usually made of silicone rubber. The cylinder is first inked using a cliché and then brought into rolling contact with a receiving surface such as a bottle or a syringe. This method of pad printing is best used with monochrome images that are applied over a limited area.

Co-Pending Application

In our above co-pending application Ser. No. 11/777,166, we teach a method and apparatus for rotary pad printing that

overcomes many of the prior-art limitations. Although this system provides a significant improvement in pad printing technology, there remains at least one area for improvement. In the prior-art rotary pad printing systems, the surface of the pad remains flat in its axial direction. I.e., the rotary pad assembly comprises a right-circular cylinder. In another aspect of the embodiment, the rotary pad is replaced by a belt. The belt offers the same opportunity for improvement.

Rotary Pad Printing Apparatus—FIGS. 1 and 2

A prior art rotary pad printing wheel, as shown in FIGS. **1**A and 1B, comprises a silicone rubber cylinder **100** having an outer surface **101** and formed around a metal shaft **105**. In use, ink is applied image-wise to surface **101** at a known inking station (not shown), and then subsequently transferred to a receiving surface (not shown) as the pad rotates in contact with the receiving surface.

Similarly, a prior art rotary belt, taught in our above co-pending application Ser. No. 11/777,166 and indicated in FIGS. 2A and 2B, comprises a silicone rubber belt **200** having a surface **215**, and rollers **205** and **210**. One or both of rollers **205** and **210** propel and support belt **200**. An inking station (not shown) applies an ink image to surface **215** of belt **200** at one location, and the ink is subsequently applied to a receiving surface (not shown) as belt **200** traverses its path and comes into contact with the receiving surface.

In both of the above-described cases, the receiving surface and the surface of the pad or belt are stationary with respect to one-another during transfer to avoid smearing of the ink image. This apparatus is best suited to printing cylindrical surfaces whose axis is either parallel to or perpendicular to the axis of rotation of the pad wheel or belt.

SUMMARY

In accordance with one aspect of a first embodiment, a pad for use in a rotary pad printing apparatus is provided that remains unbulged or optionally transitions between a non-bulged state and a bulged state. In accordance with one aspect of another embodiment, a pad belt for use in rotary pad printing apparatus is provided that remains unbulged or optionally transitions between a non-bulged state and a bulged state. By bulging in a direction normal to the direction of travel of the surface of the pad wheel or belt, an improved non-moving pad is achieved. The best aspects of both rotary and fixed pad printing are combined. In addition, an image can be printed whose length is greater than the circumference of the pad.

DRAWING FIGURES

FIGS. **1**A and **1**B show cross-sectional and side views, respectively, of a prior-art, rotary pad printing pad.

FIGS. **2**A and **2**B show cross-sectional and side views of a pad printing belt, as taught in our above co-pending application Ser. No. 11/777,166.

FIGS. **3**A and **3**B show side and front views of a rotary pad printing pad according to a first aspect of a first embodiment.

FIGS. **4**A and **4**B show side and front views of a system for temporarily flattening a portion of a pad printing pad according to an aspect of the first embodiment.

FIGS. **5**, **6**A, and **6**B show side and cross-sectional views of a system for temporarily bulging a non-crowned rotary printing pad.

FIGS. **7** through **10** show side and cross-sectional views of a system for temporarily bulging a normally flat pad printing belt.

FIGS. 11A through 11C show side and cross-sectional views of a normally crowned belt pad that is flattened for application of an ink image and optional coatings and treatments.

FIGS. 12A through 12C show side and cross-sectional views of a pad that is deformable by the application of gas pressure.

FIGS. 13A through 13C show side and cross-sectional views of a pad that is flattened by the application of a vacuum.

FIGS. 14A and 14B show cross-sectional views of a pad that is bulged by an internal mechanical mechanism.

FIGS. 15A through 15C show side and frontal views of a rotary pad that is radially bulged by forcing it against a hole in a plate.

FIGS. 16 through 18 show cross-sectional views of pads configured for side-of-the-pad writing and transfer.

FIGS. 19 through 21 show cross-sectional views of a bulged variation of the pads in FIGS. 16-18.

FIGS. 22 and 23 show cross-sectional views of a pad that is axially-bulged by forcing it against a hole in a plate.

FIGS. 24 through 26 show side and cross-sectional views of a normally flat, axial-writing and transferring pad that is activated by application of gas pressure to internal chambers.

FIGS. 27 through 29 show side and cross-sectional views of a normally bulged, axial writing and transferring pad that is flattened during the ink, coatings, and treatments writing process by application of a vacuum to internal chambers.

FIGS. 30 through 31 show various orientations and movements of writing heads and the pad during application of inks, coatings, and treatments to the side of a pad.

FIGS. 32 through 36 show various orientations and movements of a writing head and the pad during application of inks, coatings, and treatments to the outside surface of a pad wheel.

DRAWING FIGURE REFERENCE NUMERALS

DRAWING FIGURE REFERENCE NUMERALS	
100	Pad
101	Surface
105	Shaft
200	Belt
205	Roller
210	Roller
215	Surface
400	Roller
405	Source
410	Drop
415	Image
420	Surface
425	Object
430	Station
431	Roll
432	Shaft
433	Guide
434	Guide
435	Roll
500	Pad
505	Axle
510	Surface
515	Assembly
520	Roller
525	Roller
530	Axle
535	Axle
540	Arrow
600	Object
700	Belt

-continued

DRAWING FIGURE REFERENCE NUMERALS	
701	Image
702	Station
705	Wheel
706	Wheel
710	Roller
711	Axis
715	Roller
720	Roller
721	Axis
725	Axis
1100	Roller
1105	Belt
1115	Object
1200	Pad
1205	Chamber
1210	Wall
1215	Portion
1220	Wall
1225	Hole
1230	Source
1235	Plenum
1240	Seal
1300	Pad
1305	Chamber
1315	Plenum
1320	Joint
1325	Hole
1400	Pad
1405	Wheel
1406	Shaft
1410	Pulley
1411	Axle
1415	Arm
1420	Arm
1425	Shaft
1430	Bearing
1435	Head
1500	Pad
1501	Portion
1502	Axle
1505	Head
1510	Plate
1515	Hole
1520	Object
1600	Pad
1602	Plate
1605	Head
1610	Arrow
1615	Axle
1718	Wall
1719	Wall
1800	Object
1900	Pad
1902	Plate
1905	Region
1910	Surface
1920	Head
2000	Pad
2001	Bulge
2002	Bulge
2005	Roller
2010	Roller
2200	Pad
2202	Axis
2204	Head
2205	Plate
2206	Region
2207	Anvil
2210	Aperture
2215	Object
2400	Pad
2600	Pad
2601	Axis
2603	Station
2605	Chamber
2610	Hole
2612	Plenum

-continued

DRAWING FIGURE REFERENCE NUMERALS	
2613	Sea
2615	Source
2620	Object
2625	Object
2900	Pad
2901	Axis
2905	Wall
2910	Wall
2915	Chamber
2925	Hole
2930	Plenum
2935	Fitting
3000	Station
3005	Support
3010	Surface
3100	Object
3200	Pad
3205	Axis
3215	Arrow
3216	Station
3220-3240	Arrow
3250	Head
3300	Head
3500	Pad
3501	Arrow
3505	Station

DESCRIPTION

First Embodiment

FIGS. 3A and 3B

FIGS. **3A** and **3B** show side and front views, respectively, of a rotary pad according to a first aspect of a first embodiment. In this aspect, the volume of flexible material comprising pad **100'** (FIG. **3A**) has a crowned surface **101'**. Instead of having a right-circular cylindrical surface **101** (FIG. 1), surface **101'** of pad **100'** is bulged in its relaxed state. As in the prior-art pad, pad **100'** is bonded to a shaft **105**. Shaft **105** is urged to rotate by a rotary drive mechanism (not shown). Pad **100'** and shaft **105** turn together in the direction indicated by the arrow. Pad **100'** is made of a resilient elastomer such as silicone rubber. The outer diameter of the pad is typically between one and 20 cm, although other sizes can be used. The width of the pad in the axial direction is typically between 0.5 and 10 cm, although other sizes can be used.

A pad according to this embodiment is useful in a system such as the one disclosed in our above co-pending patent application Ser. No. 11/777,166. In this application, an ink source, such as an inkjet printing head, is used to apply one or more inks or other optional substances and treatments to surface **101'** of pad **100'** for subsequent transfer to a receiving surface (not shown).

An inkjet printing head has a maximum "throw" distance of approximately 3 mm. This is the distance over which ink droplets can be sent from the inkjet head to a receiving surface without significantly deviating from their path. If the droplets deviate from their path, the printed image will be distorted. Therefore, if an inkjet head (not shown) is used to apply ink to surface **101'**, as taught in our previously-mentioned pending application, the curvature of surface **101'** must be limited. In cases where the curvature of surface **101'** cannot be limited to a value small enough to prevent distortion of an ink image, then surface **101'** must be flattened at the point where an ink image is applied. FIGS. **4A** and **4B** show this flattening in detail.

Operation

First Embodiment

FIGS. 4A and 4B

FIGS. **4A** and **4B** show side and front views, respectively, of a system for temporarily flattening a crowned pad. One aspect of this embodiment comprises pad **100'** with a crowned surface **101'**, a roller **400**, and an ink source **405** for printing an image comprising droplets or spots of ink **410** (shown greatly enlarged) that optionally coalesce into an image **415** (FIG. **4B**). Drops **410** and image **415** are to be transferred to a surface **420** of a receiving object **425**, such as a toothbrush handle, syringe, thermometer, etc. During transfer of image **415** and drops **410** to surface **420**, object **425** is urged into contact with pad **100'** in such a way that their surface speeds are equal, thus preventing smearing of ink drops **410** and image **415**.

A well-known controller (not shown), generally comprising a microprocessor or microcomputer, monitors and controls all aspects of the printing operation of this embodiment.

Roller **400** rotates about its axis and is supported by bearings (not shown). During printing, it is urged into contact with pad **100'**. The surfaces of roller **400** and pad **100'** move at the same speed, thereby avoiding undue wear on pad **100'**. Roller **400** can be made of a metal or sturdy plastic, or a combination of the two. Alternatively, for short-term use, roller **400** can be a non-rotating rod with a smooth surface capable of sliding on surface **101'**. In another aspect, roller **400** can be raised above surface **101'** when it is not necessary to deform pad **100'**. Raising and lowering roller **400** can be done manually or automatically under the control of a well-known control unit (not shown).

Roller **400** locally compresses surface **101'** of roller **100'**, thereby locally and temporarily creating a depression and changing its shape from that indicated at **101'** to the concave or depressed, trough-like shape indicated at **101'**B. At **101'**B, the surface of roller **100'** is nearly flat. In this condition, the throw distance of ink source **405** is not exceeded and it can successfully apply an image to roller **100'**.

As pad **100'** turns, the part of surface **101'** not underneath roller **400** becomes convex or crowned again due to the resilience of pad **100'**. Image **415** and drops **410** move downward and are finally applied to surface **420** of object **425**. The crown and circumferential curvatures of pad **100'** enable printing on surface **420**, provided pad **100'** is sufficiently flexible to conform intimately to surface **420**.

After transfer of image **415** and droplets **410** to surface **420**, surface **101'** of pad **100'** is optionally cleaned using a cleaning applicator, in well-known fashion. This is normally done using a web of adhesive tape, blotting paper or the like, that is pressed against surface **101'**. A cleaning station **430** is shown in FIG. **4A**. Adhesive tape or blotting paper from a supply roll **431** is fed around a shaft **432** using optional guides **433** and **434**. Shaft **432** is positioned so that the adhesive surface of the tape or blotting surface of the blotting paper is brought into contact with the image area on pad **100'** after the image is transferred to surface **420** of object **425**. The surface speeds of roller **100'** and the tape or blotting paper are equal, i.e. there is no slippage between the two. Any residual ink droplets **410** and image areas **415** remaining after transfer of the droplets and image to surface **420** of object **425** are removed by the tape or blotting paper. Shaft **432** can either turn or remain stationary.

Using this embodiment, images **415** can be of any length and continuously transferred to surface **420**, thereby enabling printing on objects **425** whose length is greater than the circumference of roller **100'**. In addition, crowned surface **101'** can conform to curved surface **420**, thereby enabling printing over the full width of object **425**.

DESCRIPTION AND OPERATION

Alternative Embodiment

FIGS. **5** through **6B**

FIGS. **5**, **6A** and **6B** show side and cross-sectional views of a system for temporarily bulging a non-crowned, rotary printing pad. Instead of a normally bulged surface, the present embodiment comprises a normally right-circular cylindrically shaped pad that is temporarily bulged for transfer of an ink image (not shown) to a receiving object. This embodiment includes an elastomeric rotary pad **500** with an axle **505**, a flat surface portion **510**, an ink, coatings, and treatments applicator assembly **515**, and deforming pinch rollers **520** and **525** having axles **530** and **535**, respectively. Arrow **545** (FIG. **5**) indicates the direction of rotation of pad **500** during operation. As pad **500** rotates, rollers **520** and **525** squeeze a portion of pad **500**, temporarily causing surface **510'** to assume a bulged shape during transfer of an ink image (not shown) to the surface of an object **600** (FIG. **6A**). Assembly **515** is optionally arranged to move in a direction parallel to axis **505** of pad **500** in order to provide full coverage over surface **510**, as indicated by arrow **540** (FIG. **6A**). FIG. **6A** shows an object **600** about to receive ink from pad **500**. FIG. **6B** shows object **600** in contact with pad **500**, receiving an image.

In use, pad **500** rotates on axle **505**. Applicator assembly **515** applies an image and any optional coatings and treatments to surface **510** of pad **500** while surface **510** is flat. Coatings include shellac, varnish, plastic resins, paints, catalysts, and any other coating that is compatible with an ink image. These can be applied as undercoatings or overcoatings. Treatments include plasma, corona, electromagnetic radiation of any kind, sonic and ultrasonic radiation, heat, cold, gases, sprays, and powders. Portion **510'** of pad **500** is deformed as it passes through pinch rollers **520** and **525**. Rollers **520** and **525** rotate on axles **530** and **535**, respectively. Axles **530** and **535** are supported by an external mechanism (not shown) and they can be urged closer together or farther apart, as required, to adjust the amount of pinch, and therefore the extent of the bulge, on pad **500**. More pinching force applied between rollers **520** and **525** will cause pad **500** to bulge more, while less pinching force will cause pad **500** to bulge less.

After application of an ink image (not shown) by assembly **515**, the ink image eventually reaches the bottom of rotary pad **500**, whereupon surface **510'** bulges under the urging of rollers **520** and **525**. At this point, the surface of object **600** is brought into contact with surface **510** and the ink image is transferred to the surface of object **600** (FIG. **6B**).

In a first aspect, pad **500** continues to rotate during transfer. In this case, object **600** is caused to move so that its surface and that of pad **500** move at the same speed to avoid smearing the image. In an alternative aspect, an ink image is applied to pad **500**, pad **500** is rotated so that its surface is curved by pinch rollers **520** and **525** at the position of the ink image, and pad **500** is then stopped. While pad **500** is stopped, object **600** is placed at a stationary position beneath pad **500** and surface **510'** is urged against the surface of object **600**, thereby transferring the image.

Pad **500** is made of any durable elastomer, such as silicone rubber, that has properties suitable for pad printing. Its hardness value is in the range of 5 to 85 durometer (Shore), although other hardnesses can be used. In this aspect of the embodiment, the diameter and width of pad **500** are 20 cm and 5 cm, respectively, although other sizes can be used. All other components are scaled accordingly as indicated in FIGS. **5**, **6A**, and **6B**. Rollers **520** and **525** can be made of a metal such as steel, or a sturdy plastic material. The speed of rotation of pad **500** is between 0.1 and 100 RPM, although other speeds can be used.

The present embodiment permits writing of an ink image while surface **510** of pad **500** is parallel and in close proximity to ink applicator assembly **515**, thereby minimizing the ink throw distance between assembly **515** and surface **510** and resulting in a high-quality image. At the transfer step, surface **510'** is bulged, thereby avoiding entrapment of air at the transfer step and permitting surface **510'** to fully conform to the surface of object **600**, resulting in a high-quality transferred image.

Alternative Embodiment

FIGS. **7** through **10**

Instead of a pad wheel, a belt, as taught in our above-mentioned co-pending application, can be used. This arrangement is advantageous in that ink, treating, and coating apparatus can be organized in a linear arrangement, instead of a curved one. FIGS. **7** through **10** show side and cross-sectional views of a system for temporarily bulging a flat pad printing belt. The volume of flexible material comprising the belt is flat while the image is applied, and then caused to bulge at the point of transfer of the image to the surface of a receiving object.

As shown in FIGS. **7** through **10**, this aspect comprises at least the following: a belt **700**, one or more application stations **702** optionally including an ink source **702'**, a coating source **702"**, a treatment station **702'"**, a cleaning station **702""**, and the like, pads 705 and 706, pinch rollers **710**, **715**, and optionally pad **720**, which turn on axes **711**, **716**, and **721**, respectively, and an object **725** to be printed or decorated. As above, belt **700** comprises an elastomeric material that is suitable for use in this mechanical arrangement and also suitable for use with pad printing.

In operation, belt **700** is supported by rollers **705** and **706**. One or both of rollers **705** and **706** is driven by an external mechanism (not shown). If only one roller is driven, the other roller coasts. Stations **702** apply ink and optional coatings and treatments to the top of belt **700** as it moves in a direction indicated by arrow **703** (FIG. **7**). An ink image **701** (FIG. **8**) has been applied and optionally treated by one or more stations **702**. As ink image **701** (FIG. **8**)*nears* the bottom of belt **700**, object **725** is urged into contact with belt **700**. Object **725** moves with belt **700** to prevent smearing of image **701**. Alternatively, the printing system moves across the object at a speed equal to the rotating belt to prevent smearing of image **701**. In another aspect, belt **700** is stopped when image **701** reaches the bottom and object **725** is pressed against belt **700** in order to transfer the image from belt **700** to object **725**.

FIG. **8** shows an ink image **701**, plus any treatments and coatings, on belt **700**.

FIGS. **9** and **10** show the condition of belt **700** as it is squeezed from the side by rollers **710** and **715**. In FIG. **9**, an optional roller **720** is added to further restrain belt **700** and urge it into contact with object **725**. Rollers **710**, **715**, and **720** rotate with axles **711**, **716**, and **721** that are held in place in an external mount (not shown).

FIG. **10** shows a variation of the system of FIG. **9**. Instead of rollers **710** and **715** being cylindrical as in FIG. **9**, they are conical sections, as shown in FIG. **10**. The use of conical rollers causes belt **700'** to be squeezed and also restrained from moving vertically in a direction away from receiving object **725**. Therefore, belt **700'** maintains contact with object **725** and the force between them provides sufficient pressure to transfer image **701** from belt **720** to object **725**.

This embodiment permits arrangement of applicators **702** in a linear array above belt **700**, thereby simplifying assembly of the embodiment. The surface of belt **700** is flat during application of image **701** (FIG. **8**), resulting in a minimal throw distance for ink droplets comprising image **701**, while belt **700** is bulged at the transfer step (FIGS. **9** and **10**) for a high-quality transfer of image **701** to the surface of object **725**.

Alternative Embodiment

FIGS. 11A through 11C

Instead of a normally flat surfaced belt, a normally bulged belt can be used. FIGS. **11A-11C** show side and cross-sectional views of a normally crowned belt pad that is flattened for application of an ink image and optional coatings and treatments. In this aspect, a normally-crowned or bulged belt **1105** is used. Rollers **1100** and **1101** temporarily compress a crowned belt **1105** in the vicinity of a print head **1110**, as shown in detail in FIG. **11B**. This is similar to the flattening of pad **100'** in FIGS. **4A** and **4B**. An ink image is applied to belt **1105** and optionally coated and treated as described above in connection with the various embodiments. Belt **1105** continues to rotate and is finally pressed into non-sliding contact with an object **1115**, as shown in FIG. **11C**, whereupon the image is transferred to object **1115**.

This embodiment permits the use of belt **1105** that is formed into a crowned shape, then flattened for application of an ink image (not shown) by applicator **702'**. A short ink throw distance is maintained by rollers **1100** and **1101**, while the crowned shape of belt **1105** ensures a high-quality transfer of ink image and coatings to the surface of object **1115** (FIG. **11C**).

Alternative Embodiment

FIGS. 12A through 12C

Instead of a rotary, bulging pad or belt, a rotary, bulging wheel can be used. FIGS. **12A** through **12C** show side and cross-sectional views of a pad wheel **1200** comprising a series of chambers **1205**. Chambers **1205** are bounded by rigid inner walls **1210**, a central annular portion **1215**, and a flexible outer wall **1220**. Wall **1220** is made of silicone rubber, for example. Walls **1210** and portion **1215** can be made of metal, plastic, or wood. Side walls **1718** and **1719** (FIG. **12B**) of pad wheel **1200** are rigid. Each chamber **1205** is provided with an air hole **1225**. As wheel **1200** rotates, holes **1225** are sequentially coupled to an air source **1230** via a plenum **1235**. An O-ring seal **1240** (FIG. **12B**) prevents leakage of air while plenum **1235** is connected to any of holes **1225**. Chambers **1205** are normally not bulged. Bulged chambers **1205'** are shown at the bottom of FIG. **12A**. Not-bulged chambers **1205** comprise the remainder.

In operation, an ink image and treatments are applied to the image and the surface of wheel **1200**, as described in connection with the above embodiments. As wheel **1200** rotates, chambers **1205'** are forced to bulge by the injection of compressed air from source **1230** (FIGS. **12A** and **12B**). As in the previous embodiments, the bulged surfaces of chambers **1205'** are brought into non-sliding contact with the surface of a receiving object **1245** and the image is transferred to the receiving object (FIG. **12C**).

Alternative Embodiment

FIGS. 13A through 13C

Instead of a pad wheel that is normally flat and temporarily bulges under pressure, a pad wheel that is normally bulged, and temporarily flattened using a vacuum can be used. FIGS. **13A-13C** show side and cross-sectional views of a pad that is flattened by a vacuum. The embodiment shown in FIGS. **13A-13C** operates in a manner similar to that of the embodiment in FIGS. **12A-12C**. In FIGS. **13A** and **13B**, a pad wheel **1300** comprises a series of chambers **1305**. Chambers **1305** are normally in a bulged condition. Instead of a pressure source that causes chambers **1300** to bulge, a vacuum source **1310** is coupled to chambers **1305'** through a plenum **1315** and sliding joint **1320** that sequentially mates with holes **1325** as wheel **1300** turns. When source **1310** is connected to a chamber **1305'** via a hole **1325**, chamber **1305'** becomes flat and able to accept ink from head **702'**. When hole **1325** is open to ambient air pressure, chamber **1305'** is bulged and can transfer an image (not shown) to the surface of a receiving object **1245** (FIG. **13C**).

Alternative Embodiment

FIGS. 14A and 14B

Instead of using pressure or a vacuum to change the surface shape of a pad wheel, an internal mechanism can be used. FIGS. **14A** and **14B** show cross-sectional views of a rotary pad wheel **1400** with an internal bulging wheel **1405**. Wheel **1400** is driven to rotate about its central axis by a drive pulley **1410** connected to one of hollow axles **1411**. Internal bulging wheel **1405** is connected to external actuating levers by arms **1415**. Bulging wheel **1405** rotates on bearings (not shown) connected to the ends of arms **1415**. Arms **1415** are connected to external lever arms **1420** by shafts **1425**. Axles **1411** and shafts **1425** are supported by support bearings **1430**.

In use, a print head **702'** applies an ink image (not shown) to pad **1400** as pad **1400** rotates. When it is desired to transfer an image to a receiving surface (not shown), wheel **1400** is bulged by rotating arms **1420** until bulging wheel **1405** causes pad **1400** to bulge outward, as shown in FIG. **14A**. When it is desired to leave pad **1400** in a not-bulged condition, lever arms **1420** are rotated about shafts **1425** until wheel **1405** no longer contacts the inside surface of pad **1400**. Arms **1420** can be actuated manually or by an external mechanism (not shown).

Alternative Embodiment

FIGS. 15A through 15C

Instead of temporarily bulging the pad using internal forces (including vacuum, pressure, and mechanical means as described above), the pad can be bulged by forcing it against an external constraint. FIGS. **15A** through **15C** show side and frontal views of a rotary pad that is radially bulged by forcing it against a hole in a plate. In this aspect, a pad wheel **1500** receives an ink image and treatments from a print head **702'** and other treatment stations (not shown). Wheel **1500** is suspended above a plate **1510** having a hole **1515**. Hole **1515** can be circular, square, oval, hexagonal, rectangular, and the like. When the ink image reaches the bottom region **1501**, the axle **1502** of pad **1500** stops rotating and is urged downward against plate **1510** by an external mechanism (not shown), causing pad **1500** to bulge through hole **1515**. While pad **1500** is so bulged and projecting through hole **1515**, pad **1500** and plate **1510** are moved downward together and bulged surface portion **1501** carrying the ink image is forced against the top surface of a receiving object **1520**. The ink image is thereby transferred to the surface of object **1520**, completing the print job (FIG. **15C**). After transfer, pad **1500** is removed from contact with plate **1510**, permitting portion **1501** to retract through hole **1515**, and pad **1500** again assumes a circular shape. In this condition, pad **1500** is again ready to receive a new ink image.

Alternative Embodiment

FIGS. **16** through **18**

Instead of writing onto and transferring from the circumferential surface of a pad, the side of the pad can be used. FIGS. **16** through **18** show cross-sectional views of pads configured for side-of-the-pad writing and transfer. In this aspect, a pad wheel **1600** comprises silicone rubber or other suitable pad printing material. Wheel **1600** is shown in a side view in FIGS. **16** through **18**. Wheel **1600** is supported by and rotates on an axle **1615**. Instead of writing on the outer circumference of the wheel, as described above, a print head **702'** which employs inkjet or another printing modality such as electrostatic, spray, or the like, is positioned adjacent the side of wheel **1600**. Head **702'** also incorporates any treatment stations such as described above, including but not limited to radiative, spray, inkjet, electrostatic, and the like. Head **702'** can be arranged to move radially as shown by arrow **1610** in order to print an image over a greater extent of the side of wheel **1600** than reachable by the width of head **1605** alone. Other possible trajectories for head **1605** are discussed below in connection with FIGS. **29-31**.

FIG. **16** shows pad wheel **1600** reinforced by a backing plate **1602**. Plate **1602** rotates on axle **1615**. Plate **1602** can be made of metal, plastic, or wood. In cases where little force is required to transfer an image to a receiving object, plate **1602** can be omitted. FIG. **17** shows wheel **1600** without a backing plate. Plate **1602** and wheel can be any suitable diameter from as little as one cm to 25 or more cm. Pad **1600** can be any thickness from less than one centimeter to 10 or more cm. Backing plate **1602** can be any thickness from about 0.5 to one or more cm, as required to support pad **1600** during transfer of the image (described below).

In use, an ink image and any required treatments are applied to the side of wheel **1600** as it rotates about axis **1615**. During application of an image to wheel **1600**, wheel **1600** can rotate 180 degrees or more, as required to complete the application of an image and any required coatings and treatments. When the image and treatments are complete, wheel **1600** is brought into stationary or non-smearing contact with the surface of a receiving object **1800** (FIG. **18**). The image and any desired coatings and treatments are thereby transferred to object **1800**. This completes the transfer process. After transfer, wheel **1600** can be cleaned, if necessary, and another image and any desired treatments and coatings applied in preparation for another transfer. Each image, each coating, and each treatment can be different, if required.

Alternative Embodiment

FIGS. **19** through **21**

In some cases, printing of images can be accomplished using the side of a pad wheel that is normally bulged and temporarily flattened for application of an ink image. FIGS. **19** through **21** show cross-sectional views of a bulged variation of the pads in FIGS. **16-18**. FIG. **19** shows a normally bulged pad wheel **1900** with a bulged region **1905** and a backing plate **1902**, similar to plate **1602**, and an axle **1901**, similar to axle **1615** (FIG. **16**). A roller or other flattening agent such as a flat sliding surface **1910** flattens bulged region **1905** in the neighborhood of a print head, coating, and treatment station **1920** in order to permit application of an image and any desired coatings and treatments to the surface of wheel **1900** while it is flat. After rotating away from the region of station **1920**, wheel **1900** is allowed to bulge again. This aspect of the embodiment operates in a manner similar to that shown in FIGS. **4A** and **4B** in which the curvature of the wheel is temporarily flattened to permit application of the ink image and any treatments or coatings to a flat surface.

FIG. **19** shows pad **1900** with bulge **1905** on one side only. The other side of pad **1900** is backed with backing plate **1902**. Pad **1900** and plate **1902** have the same or similar dimensions to those given above in the previous aspect shown in FIGS. **16-18**.

As in the previous aspect, wheel **1900** turns about axis **1901** while head station **1920** applies an image and any desired coatings and treatments to the surface of pad wheel **1900**. When the image is ready for transfer, pad **1900** is pressed against the surface of a receiving object **2005** (FIG. **21**), as described in connection with the previously described aspect.

FIG. **20** shows an aspect similar to that in FIG. **19**, except pad wheel **2000** contains bulges **2001** and **2002** on two surfaces and there is no backing plate. Rollers **2005** and **2010** temporarily compress bulges **2001** and **2002** in wheel **2000** in the region of print head **1920'**, thereby providing a flat surface for head **1920'** to optionally apply ink, treatments, and coatings to the surface of wheel **2000**. As in the previous embodiment, head **1920** can be moved over the surface of pad **1900** in order to create an image that is larger than the length of head **1920**.

FIG. **21** shows pad **2000** being pressed against the surface of a receiving object **2005** in order to transfer the previously-applied image and optionally any coatings or treatments to object **2005**. Alternately, pressure may be applied to bulge **2001** at the time of image transfer by mechanical means (not shown) to prevent distortion of pad **2000** and facilitate a solid transfer of the image to the object.

Alternative Embodiment

FIGS. **22** and **23**

In another variation, FIGS. **22** and **23** show cross-sectional views of a pad that is axially-bulged by forcing it against a hole in a plate. In this aspect, a pressure anvil **2207** and a plate **2205** with an aperture **2210** are added to the embodiment of FIG. **17**. As in the previous aspects, an elastomeric pad wheel **2200** rotates about an axis **2202** and receives an ink image plus any optional treatments and coatings from head station **702'**. When the image and treatments are complete, pad **2200** rotates until the image to be transferred is located over aperture **2210**. At this point, the rotation of pad **2200** with respect to aperture **2210** is stopped. Anvil **2207** moves downward against pad **2200**, forcing a bulged region **2206** to temporarily extrude through aperture **2210** and beneath plate **2205**. FIG. **23** shows the urging of bulged region **2206** of pad **2200** against the surface of a receiving object **2215**, whereupon the image and any predetermined treatments and coatings are transferred. After transfer, anvil **2207** moves upward until it no longer contacts pad **2200**. Pad **2200** can then rotate, receive an image, and be positioned for a subsequent transfer.

Alternative Embodiments

FIGS. 24 through 29

Pressure and Vacuum Activated Axial-Direction Bulges on Pad Wheels

Pressure Activation

FIGS. **24** through **26** are side and cross-sectional views of a pad that bulges axially, instead of radially as in FIGS. **12A-12C**, when pneumatic or hydraulic pressure is applied to the interior of the pad.

In this aspect, a pad wheel **2600** is provided with inner chambers **2605** and an axis **2601**. One or more of chambers **2605** further includes an air hole **2610** through which compressed air is supplied via a plenum **2612** from an air source **2615**. A sliding seal **2613** prevents air leakage. The side of wheel **2600** that is opposite plenum **212** is made of a flexible pad-printing material such as silicone rubber. The remainder of wheel **2600** is made of rigid plastic, metal, or wood. The flexible and rigid materials are bonded together at their interface. The normally flat, flexible surface of wheel **2600** is arranged to bulge when air pressure is applied through any of holes **2610** (FIGS. **27** and **28**).

In use, a writing, treating, and coating station **2603** (FIG. **25**) applies an image and any desired coatings and treatments (not shown) to the flat, flexible surface of wheel **2600**. After application of the image and any treatments, wheel **2600** rotates about axis **2601** until the image is adjacent the surface of a receiving object **2620**. Next, compressed air from source **2615** is supplied to chamber **2605** through plenum **2612**, causing the flexible portion of pad **2600** to bulge in the region of pressurized chamber **2605**. The act of bulging can bring the image on the surface of wheel **2600** into contact with a receiving object **2625**, or object **2625** and wheel **2600** can be urged into contact through another means (not shown), thereby transferring the image and any desired coatings or treatments to object **2625**.

Vacuum Activation

FIGS. **27** through **29** are side and cross-sectional views of a pad that bulges axially, instead of radially when a vacuum is selectively applied to the interior of the pad. FIG. **28** shows a normally bulged pad wheel **2900**, capable of turning on an axis **2901**, and having a rigid exterior wall **2905** and a series of rigid, inner walls **2910** forming and separating a series of chambers **2915**. Each chamber **2915** has a flexible, normally-bulged top surface **2910'** (FIG. **28**). The remaining boundary surfaces of wheel **2900** are rigid.

Each of chambers **2915** further includes a hole **2925** enabling the passage of gas into and out of chambers **2915**. A plenum **2930**, fixed in space relative to the rotation of wheel **2900**, communicates with chambers **2915** via holes **2925** as each of holes **2925** passes beneath plenum **2920**. A fitting **2935** in plenum **2930** communicates with an external vacuum source (not shown). When any of holes **2925** are adjacent plenum **2930**, the vacuum applied at fitting **2935** removes a portion of the gas within the associated chambers **2915**. When gas is removed from a chamber **2915**, bulged top surface **3010** (FIG. **28**) flattens to a flat surface **2910'**.

FIG. **28** shows pad wheel **2900** in a condition to receive an ink image, coatings, and various treatments from a head station **3000**. A mesh support **3005** is optionally contained within each of chambers **2915** to render the top surface **3010'** flat when a vacuum is drawn from within the chamber. Plenum **2930** is located opposite head **3000**. Thus when any of chambers **2915** are in the vicinity of head **3000**, plenum **2930** accesses holes **2925** of chambers **2915** in that same vicinity, causing the associated bulges **2910** to temporarily assume their flattened shape **2910'**, thereby permitting application of ink, coatings, and treatments to surface **2910'** by head **3000**. As wheel **2900** continues to rotate, as shown by the arrow in FIG. **27**, air enters holes **2925** not covered by plenum **2930** and surface **2910** again bulges.

FIG. **29** shows a receiving object **3100** in contact with bulged surface **32910** of pad wheel **2900**. By this contact, an ink, coating, and transfer image (not shown) is transferred from wheel **2900** to object **3100**. Further treatments such as heating, coating, treating, and the like can be applied to object **3100**, if desired.

In another aspect of this embodiment, a second plenum can be provided that applies pressure to bulged chambers **2915** in order to increase their rigidity.

FIGS. 30 through 32

FIGS. **30** through **32** show various orientations and movements of writing heads and the pad during application of inks, coatings, and treatments to the side of a pad. FIGS. **30** and **31** show plan views of a pad wheel **3200** capable of rotating around an axis **3205** in the direction of arrow **3215**. The motion of wheel **3200** as indicated by arrow **3215** can be continuous, or intermittent, forwards or backwards. A writing, coating, and treating station **3216** is positioned above wheel **3200** (FIG. **31**), as described in connection with the various aspects of the embodiments shown above. The illustration in this embodiment applies equally to all previously-described aspects of the various embodiments shown.

In use, station **3216** can be stationary or can follow a number of possible trajectories. Arrows **3220-3240** in FIG. **32** indicate a number of possible trajectories for head **3250** to follow as it deposits ink, coatings, and treatments onto wheel **3200**. Any predetermined trajectory of combination of trajectories can be used.

FIG. **31** shows a side view of head station **3216** and pad wheel **3200**. In addition to the trajectories shown in FIG. **30**, head **3216** can also move toward or away from wheel **3200** during operation. The motion of head **3216** can be continuous, intermittent, up, or down relative to the surface of wheel **3200**.

FIG. **32** shows a number of possible orientations of head **3216** with respect to wheel **3200**. The orientation of head and its position can be stationary or can change during application of an ink image, treatments and coatings to wheel **3200**.

Wheel 3200, and heads 3216 and 3100 are supported and moved by external mechanisms (not shown) under the control of a control unit (not shown).

FIGS. 33 through 36

FIGS. 33 through 36 show various alternative motions and orientations of a pad wheel 3500 and a writing, coating, and treatment station 3505.

In FIG. 33, a pad wheel 3500 rotates either forward or backward, as indicated by arrow 3501. During the writing process in which an ink image and optional coatings and treatments (not shown) are applied to wheel 3500, station 3505 can assume any angular orientation desired, as indicated by its outline in dashed lines. Station 3505 can rotate to different angles during writing, and wheel 3500 can start and stop, as required to deposit the desired image.

In FIG. 34, wheel 3500 is optionally stopped while station 3505' applies inks, coatings, and treatments to wheel 3500. Station 3505' can rotate and move in any direction with respect to wheel 3500. The rotation and motion can be continuous or intermittent. Wheel 3500 can also move during the writing process, if required.

In FIG. 35, station 3505" is moved toward or away from wheel 3500 during writing, as required to write, coat, and treat an image. The motion of station 3505" relative to wheel 3500 can be fixed, or variable under control of a control unit (not shown). Again, the relative motions of wheel 3500 and station 3505" can be intermittent or continuous, as required to form and later transfer the desired image, coatings, and treatments on wheel 3500.

In FIG. 36, station 3505''' can tilt with respect to the surface of wheel 3500. The degree of tilt can be fixed, or variable under control of a control unit (not shown).

CONCLUSIONS, RAMIFICATIONS, AND SCOPE

The embodiments shown in various aspects of our improved pad printing methods and apparatuses incorporate an inking station and a flexible, moving surface. An inking head, such as an inkjet, applies an ink image to the moving surface. The ink image on the surface is further optionally treated by one or more stations comprising emissive and radiative sources, spray sources, vapor sources, and the like. These sources provide overcoats, undercoats, additional chemical reactants and catalysts, additional ink colors, heat, infrared, visible, and ultraviolet light, and flames.

As described, the pads and belts that convey the ink image and any treatments and coatings, are caused to bulge in order to facilitate transfer of the image, and coatings and treatments, to a receiving object. By bulging, the pads and belts avoid trapping of air at the transfer surface, thereby permitting application of a high-quality image. Alternatively, the pads and belts that convey the ink image and any treatments and coatings, may not be caused to bulge in order to facilitate transfer of the image, and any coatings and treatments to a receiving object. Instead, they can be left in their not-bulged condition if desired. The embodiments described work within the requirements of ink image sources, such as inkjet heads, by assuming a flat condition along at least a line beneath the source. At the point of transfer of the ink image and any coatings to a receiving surface, the pads are bulged in order to faithfully transfer a high-quality image to the receiving surface. Alternatively, the pads can be flat, if desired.

While the above description contains many specificities, these should not be considered limiting but merely exemplary. Many variations and ramifications are possible. The pads can be made of a variety of materials including natural and silicone rubbers, gelatin, plastics, and the like. They can be large, on the order of tens or hundreds of centimeters in width and diameter, or small, less than a centimeter in width and diameter, or any size in-between as determined by the size of the image to be transferred. The embodiments can be operated at high or low temperatures, humidities, and pressures.

While the present system employs elements which are well known to those skilled in the art of pad printing, it combines these elements in a novel way which produces one or more new results which we believe have not heretofore been discovered. Accordingly the scope should be determined, not by the embodiments illustrated, but by the appended claims and their legal equivalents.

The invention claimed is:

1. An apparatus for rotary pad printing of an image onto an object, comprising:

an ink applicator having a predetermined length and is capable of applying an ink image,

a rotary pad with a deformable surface that is capable of assuming a bulged shape,

means for rotating said rotary pad so that a portion of said surface of said rotary pad is adjacent said ink applicator at a first time and adjacent said object at a second time,

first shaping means for temporarily shaping said portion of said surface of said rotary pad while said portion of said surface of said rotary pad is adjacent said ink applicator so that said portion of said surface of said rotary pad adjacent said ink applicator is substantially parallel to and equidistant from said ink applicator along the length of said ink applicator,

means for causing said ink applicator to apply said ink image directly to said portion of said surface of said rotary pad while said portion of said surface of said rotary pad is adjacent said ink applicator,

second shaping means for causing said portion of said surface of said rotary pad to assume said bulged shape,

means for urging said portion of said surface of said rotary pad against said object while said portion of said surface of said rotary pad has said bulged shape,

whereby said ink image can be applied to said portion of said surface of said rotary pad while said portion of said surface of said rotary pad is adjacent said ink applicator and then said portion of said surface of said rotary pad can be brought into contact with said object while said portion of said surface of said rotary pad has said bulged shape, thereby transferring said ink image to said object.

2. The apparatus of claim 1 wherein said rotary pad is selected from the group consisting of cylinders and belts.

3. The apparatus of claim 1, further including at least one additional applicator selected from the group consisting of treatment, coating, and cleaning applicators.

4. The apparatus of claim 3, further including means for moving said additional applicator relative to said surface of said rotary pad.

5. The apparatus of claim 1 wherein said rotary pad is capable of motion, said motion selected from the group consisting of intermittent and continuous motions.

6. The apparatus of claim 1, further including means for moving said applicator relative to said surface of said rotary pad.

7. A method for pad printing an ink image onto an object, comprising:

providing a rotary pad with a resilient deformable surface,

providing an ink applicator for applying an ink image to said rotary pad, positioning said ink applicator a predetermined distance from said rotary pad, providing a first shaping mechanism for temporarily causing a portion of said surface of said pad to assume a first shape that is parallel to and at said predetermined distance from said ink applicator while said portion of said surface of said pad is adjacent said ink applicator,

causing said ink applicator to apply said ink image to said rotary pad while said portion of said surface of said rotary pad has said first shape,

providing a second shaping mechanism for temporarily causing said portion of said surface of said rotary pad to assume a second shape that is bulged,

causing said second shaping mechanism to cause a said portion of said surface to assume said bulged shape, and

urging said portion of said surface of said rotary pad containing said ink image into contact with said object, thereby transferring said ink image to said object.

8. The method of claim **7** wherein said ink applicator is an inkjet.

9. The method of claim **7** wherein said rotary pad is selected from the group consisting of cylinders and belts.

10. The method of claim **7**, wherein said second shaping mechanism for temporarily causing said portion of said surface to assume said second shape is selected from the group consisting of rollers, rods, vacuum, pressure, and apertures.

11. The method of claim **7**, further including at least one additional applicator selected from the group consisting of treatment, coating, and cleaning applicators.

12. The method of claim **7** wherein said rotary pad is capable of motion, said motion selected from the group consisting of intermittent and continuous motions.

13. The method of claim **7**, further including means for moving said applicator relative to said surface of said rotary pad.

14. An apparatus for rotary pad printing an ink image onto an object, comprising:

a volume of resilient material having a configuration selected from the group consisting of belts and cylinders, said volume of resilient material having an outer surface capable of being urged to assume first and second shapes at respective predetermined first and second locations on said outer surface, said first shape being formed so that a portion of said surface at said first location assumes a not-bulged shape, said second shape being bulged,

said volume of resilient material further being rotatable, an ink applicator connected to an ink source,

means for positioning said ink applicator within a predetermined distance from said volume of resilient material,

means for causing said ink applicator to apply said ink image directly to said volume of resilient material when said portion of said surface of said volume of resilient material assumes said first shape within a predetermined distance from said ink applicator,

means for urging said portion of said surface of said volume of resilient material to assume said first shape at said first location thereon,

said means for urging said portion of said surface to assume said first shape arranged to cause said surface of said volume of resilient material to assume said not-bulged shape so that said ink applicator can apply an ink image directly to said volume of resilient material, and

means for urging said portion of said surface of said volume of resilient material to assume said second shape at said second location thereon,

said means for urging said portion of said surface to assume said second shape arranged to cause said volume of resilient material to assume said second shape when said ink image on said portion of said surface is in the vicinity of said object with a receiving surface capable of receiving said ink image,

means for urging said volume of resilient material to rotate and move said portion of said surface thereof within said predetermined distance from said ink applicator,

whereby while said volume of resilient material rotates, said ink image is printed onto said portion of said surface of said volume of resilient material at said first location where said portion of said surface is in said first shape and then said ink image is transferred to said receiving surface by urging said portion of said surface of said volume of resilient material into contact with said receiving surface while said surface of said volume of resilient material is in said second shape.

15. The apparatus of claim **14** wherein said ink applicator is an inkjet.

16. The apparatus of claim **14** wherein said volume of resilient material is capable of temporarily receiving and later releasing applications selected from the group consisting of treatment, coating, and cleaning applications.

17. The apparatus of claim **14**, further including means for supporting said volume of resilient material.

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