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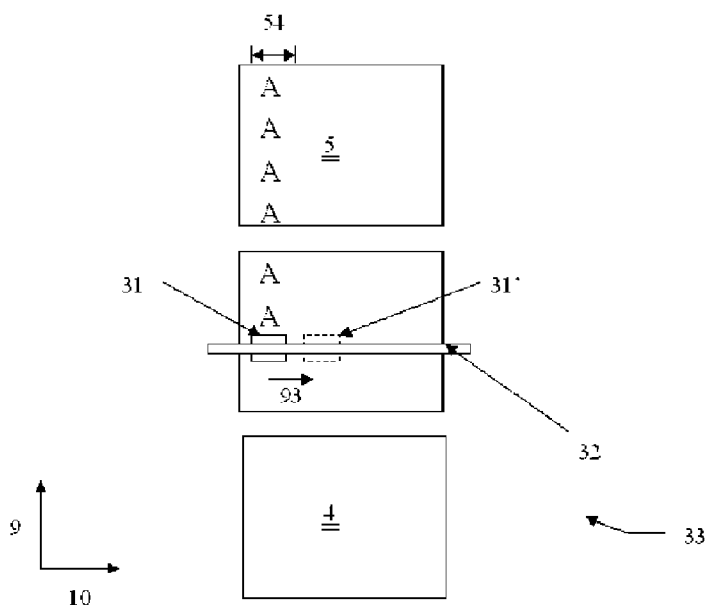
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(54) Title: METHOD AND APPARATUS FOR PRINTING SHEET METAL



(57) Abstract: A method of digitally printing onto a plurality of flat sheets, providing a high quality replacement for offset lithography whereby only a portion of each sheet (4) is printed during each pass. A print head (31) prints a lane (54) of images onto each sheet, the sheets are collected and returned to the print site (33), the print head is displaced along a gantry (32), and during a second pass, a print head (31') prints a second lane of images, the process being repeated for as many times as required.

Description

METHOD AND APPARATUS FOR PRINTING SHEET METAL

Technical Field

[0001] The present invention provides an improved method and apparatus for transferring an image onto a flat sheet of material, for example leather, metal or plastic.

Background Art

[0002] In the metal packaging industry, containers are usually printed as flat sheets prior to being formed into shaped containers. The printing technique is referred to as "offset lithography" and has been employed in its most basic form for over a hundred years.

[0003] In offset lithography, a photographic film of the desired image is placed in contact with a print plate, which has a photosensitive coating, and the plate is exposed to light. After development, the coating is removed with the exception of the image area, which is now a duplicate of the original film image. The plate now has two chemically different surfaces, the image that is receptive to printing inks but repels water and the background that is receptive to water. After the plate making process, the plate is affixed to a cylindrical drum on the printing press. During printing, two sets of rollers apply a water mixture and ink to the plate; the water covers the background portions of the plate preventing the ink being transferred and therefore the ink adheres only to the image areas. The plate rolls against a cylindrical drum covered with a rubber surfaced canvas blanket, which picks up the ink. Metal sheets pass between the blanket drum and the impression cylinder as it rotates and the image is transferred to the metal sheet.

[0004] Conventionally, the image is repeated according to a regular array across the length and breadth of the printing plate, producing columns ("lanes") and rows of images respectively. Post printing, each repeated image on the metal sheet is called a "blank" and these blanks will be made into packaging containers, for example, an aerosol can. A sheet can be used to produce a number of blanks, typically between four and thirty, depending on the size of the blank.

[0005] Offset lithography provides a means of providing a high quality image on a flat metal sheet and is by far the most dominant form of commercial printing today within the industry. Improvements in pre-processing, and plate and ink materials have helped to maximise the technique's superior production speed and plate durability, making it an ideal choice for medium to high volume runs. Its disadvantage, however, is that it uses apparatus that is inflexible and a change-over from one design to another is slow (1-2 hours), which is uneconomic for use on a high speed packaging production line when

run lengths are below 2,000 sheets, i.e. for low volume runs.

[0006] Digital printing has long been held to be the future of printing since it has significant demand and cost advantages over traditional printing techniques, especially for low volume runs.

Patent Citation 0001: US 6135654 (TETRA LAVAL HOLDINGS & FINANCE, SA). 2000-10-24.

describes a method and apparatus for printing digital graphic images directly onto a bottle. First, an electronically storable and retrievable digital image is generated. Next, the digital image is transferred to a printing site. Finally, the digital image is digitally printed using inkjet printing directly onto bottle at the printing site.

[0007] In the metal packaging industry, to achieve a high print resolution, typically 150-175 lines per inch (lpi), containers are normally printed whilst they are in their flat sheet form, i.e. before they are shaped into containers, as in this form it is easier to control the pressure between the plate cylinder and the metal substrate and also to align the printed inks with each other on the substrate. In contrast, beverage containers are normally printed "in the round" i.e. after being shaped into containers, but since they are low priced, commodity items they only demand a relatively low print resolution, typically 85-100lpi.

[0008] To improve the offset lithography process by applying the teaching of Tetra Laval requires that the conventional offset lithography printing press be replaced with a digital "print head", which must be wide enough to print across the full width of a sheet. A print head has a nozzle plate with at least one row of nozzles, each row ejecting different coloured ink and conventionally cyan, magenta, yellow and black colours are used, together with any special colours. To achieve a print resolution of 300 dots per inch requires a print head to contain 300 nozzles per inch. With the industry using metal sheets with a typical width of approximately 1m (40 inches), 12,000 nozzles or more would be necessary on each print head and individual control of such a number of nozzles would demand a computer with very high processing capabilities.

[0009] To match the print resolution and speed of offset lithography, an optimum number of nozzles are required as is the associated highly powered computer. However, since the metal packaging industry is limited by the costs that it can pass on to its customers and these costs would only be augmented by a single large print head, this solution is unsatisfactory.

[0010] During their development work, the inventors realised that the whole sheet does not

need to be printed in once pass. The use of a smaller print head would avoid the need for a highly powered computer and would reduce the number of nozzles to control. There are two ways of executing this notion. The first is to supply “strips” to the print head, whereby the strip width is generally similar to that of a lane. The print head only ever prints one lane on the sheet and so the printing process could be included both inline and offline with the container making process. The second way is to use the one print head to print the entire sheet. Two techniques in particular are already well used in the paper and board printing industries.

[0011] “Uni-directional printing” is a scanning technique whereby a flat sheet is printed in its entirety; the print head moves whilst the sheet remains stationary until printing is complete. The print head initially sits at a “head” of the sheet, which is the leading edge of the sheet in a transport axis. The “transport axis” is the axis of movement of the conveying means used to carry the sheets through the printing process. The print head moves negatively in the transport axis, depositing ink on the way until it reaches a foot of the sheet. The “foot” of the sheet is the trailing edge of the sheet as the sheet travels positively in the transport axis. The print head pauses at the foot of the sheet and is then positively indexed in a scan axis. The “scan axis” is orthogonal to the transport axis. The print head pauses once more. It then travels positively in the transport axis and returns to the head of the sheet and pauses again, without printing on its way. After that, the print head once more travels towards the foot of the sheet whilst printing, and without being indexed, and then pauses. It is then indexed positively again in the scan axis and pauses. It travels back towards the head of the sheet without printing, and then pauses. This process is repeated for as many times as required until the entire sheet is printed.

[0012] The problem with this, however, is that useful printing time is lost each time the print head pauses and returns which means a significant reduction in potential printing volume.

[0013] “Bi-directional printing” is another scanning technique that partially reduces this lost time. The technique is similar to Uni-directional printing; the key difference being that the print head deposits ink as it is travelling both towards and away from the foot of the sheet. The print head initially sits at the head of the sheet before moving towards the foot of the sheet whilst simultaneously printing. It pauses at the foot, is then indexed positively in the scan axis and then returns to the head of the sheet whilst printing. It pauses once more, is indexed positively in the scan axis, pauses, and then travels towards the foot of the sheet whilst printing. It pauses, travels back to the head

of the sheet whilst printing and pauses once more. This process is repeated for as many times as required until the entire sheet is printed.

[0014] As with Uni-directional printing, the technique does still however require a pause after each period of travelling.

[0015] Although the two scanning techniques have the capability to produce an excellent print quality it is normally with a trade off against throughput and cost. Techniques such as these inevitably demand a pause whilst the print head prepares to change direction and although for one sheet the dwell time may be insignificant, when the total number of sheets passing through the line are considered, the total dwell time rapidly increments.

[0016] In the metal packaging industry, where sheet handling lines typically run at 3000 sheets per hour, this dwell time would considerably slow down a sheet handling line and reduce the volume of container production.

[0017] In the field of paper printing,

Patent Citation 0002: US 6935738 B (LORENZ ET AL). 2004-02-26.

discloses a method of printing image material in an inkjet printer which seemingly overcomes the drawbacks of bi-directional printing. However, here individual sheets are transported through the print site and they are printed whilst aligned in rows (see Figures). To apply the teaching of this document to printing in the metal packaging industry would lead to an impractically large print apparatus since the sheets that are used to make metal packaging have dimensions that are typically no less than 1m x 1m.

Disclosure of Invention

[0018] Accordingly, the invention provides an apparatus for printing a plurality of flat sheets comprising

- a printing site and
- a conveying system adapted to move the plurality of flat sheets sequentially into alignment with the printing site

characterised in that

the printing site comprises a computer, for electronically storing and retrieving an image, and a print head comprising a plurality of nozzles connected to a plurality of inks, wherein

the computer is adapted to control the transfer of inks from the nozzles onto each flat sheet to print one row of images on each sheet.

[0019] The advantage of this is that a large print head is not needed to print across the whole

of the sheet at once; a smaller print head is cheaper to buy, easier to manoeuvre and less complicated to control since it carries fewer nozzles in total than a large print head.

[0020] A second embodiment of the invention provides an apparatus wherein the conveying system is adapted to move the flat sheets in a scan direction, orthogonal to a transport direction.

[0021] This alternative arrangement is advantageous for locations where movement along the transport direction is limited.

[0022] A further embodiment of the invention provides an apparatus wherein the print head is adapted to move in a scan direction, orthogonal to a transport direction.

[0023] Where space is at a premium in a factory, this arrangement is useful since the print head moves instead of the conveying system.

[0024] Yet another embodiment of the invention provides an apparatus wherein the printing site comprises a plurality of print heads, each print head adapted to print a corresponding row of images onto the flat sheet.

[0025] With multiple print heads each printing a different image, the overall processing issues are less significant than with an apparatus consisting of a single print head that alternates the designs it prints on each sheet. Simultaneously, the number of images that can be printed on a sheet during any one pass past the print head is increased. This flexibility of print means that designs of small run lengths may be produced at a cheaper unit cost than with traditional offset lithography for the same run lengths since there is no time wasted changing over the designs on the print press by physically changing the print plates, washing up the print blankets or any other normal tasks required during a design changeover.

[0026] An alternative embodiment of the invention provides for a method of printing a plurality of flat sheets, comprising the steps of:

- preparing a plurality of flat sheets,
- transporting the plurality of flat sheets sequentially past a printing site in a transport direction using a conveying system characterised in that
 - the printing site comprises a computer for electronically storing and retrieving an image and a print head, constrained from movement in the transport direction, and
 - the print head prints one row of images on each flat sheet.

[0027] When the print head is constrained from movement in the transport direction, the arrangement becomes particularly suitable for inks that are sensitive to movement. Such

inks normally require a dwell time after movement to allow for settlement.

[0028] An alternative embodiment of the invention provides for a method wherein

- the plurality of flat sheets is divided into a batch,
- a row of images is printed on the batch of the flat sheets,
- the batch of flat sheets is collected after printing and returned to the printing site by the conveying system and
- another row of images is printed onto the batch of flat sheets.

[0029] By collecting the sheets after printing and returning them to the print site for re-printing, the only dwell time in the process occurs at the end of the print run when the sheets are being collected and transported and not after each individual sheet.

[0030] Another embodiment of the invention provides a method of printing a plurality of flat sheets wherein the conveying system re-aligns the batch of sheets after printing the row of images to ensure that the next row of images is separate from the previous row.

[0031] The advantage of this embodiment is that the print head does not have to move at all, thus prolonging the life of the print head.

[0032] Yet another embodiment of the invention provides a method of printing a plurality of flat sheets, wherein

- the conveying system is constrained to move in a transport direction, and
 - the print head moves in a scan direction, orthogonal to the transport direction,
- whilst the conveying system returns the batch of flat sheets to the printing site.

[0033] This arrangement is excellent for locations where it is physically not possible to alter the layout of the conveying system and it is more practical to move the print head instead.

[0034] A further embodiment of the invention provides for a method of printing a plurality of flat sheets, wherein the step of preparing a plurality of flat sheets includes cutting the flat sheets into strips, the width of each strip determined by the width of the image.

[0035] This method of printing is advantageous for manufacturing plants that are restricted in floor space; strip printing can be carried out inline with container manufacture. Also no dwell time at all will be needed, as no indexing of the print head or flat sheets is necessary. This configuration of the invention provides the greatest throughput of sheets on a print line.

Brief Description of the Drawings

[0036] Prior art and the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

[0037] Figure 1 is a schematic of the prior art lithographic printing press.

- [0038] Figure 2 is a schematic of a prior art printing plate.
- [0039] Figure 3 is a schematic of prior art uni-directional printing.
- [0040] Figure 4 is a schematic of prior art bi-directional printing.
- [0041] Figure 5 is a schematic of an embodiment of the invention.
- [0042] Figure 6 is a schematic of another embodiment of the invention.
- [0043] Figure 7 is a schematic of a further embodiment of the invention.
- [0044] As depicted in Figure 1, in traditional offset lithography the printing plate 2 is wrapped around and attached to the cylindrical plate cylinder 1. Ink and water are supplied to the printing plate from the inkwell and water reservoir respectively to the printing plate via rollers. An ink roller system 7 controls the ink flow and volume; a dampening roller system 8 controls water flow and volume. Ink is carried on the photographically developed parts of the plate and water washes over the non-developed areas, as explained in the Background Art. The printing plate 2, attached to the plate cylinder 1, carries the image to the blanket cylinder 3 where the image is transferred to the rubber-covered blanket. As sheets pass between the blanket cylinder 3 and the impression cylinder 6, the image is transferred from the blanket cylinder 3 to the sheet 4. The impression cylinder 6 provides pressure to the sheet assisting this last image transfer step.
- [0045] The image may be a single image or it may be repeated many times across the breadth 51 and length 52 of the printed sheet 5. Figure 2 shows an example layout of a printed sheet 5 where the image of the letter A is repeated in a regular array of columns 54 and rows 53 respectively. The lithography process can print up to 3000 sheets per hour, with each sheet 5 containing typically 30 images. When these sheets are used for can making, up to 90,000 containers can be printed in an hour. However during a design changeover, the inks may need to be changed depending on how similar the designs are and whether or not they use the same colours. Also, the ink rollers 7 will need to be washed down, the printing plate 2 changed and the blanket 3 and impression cylinders 6 cleaned, or otherwise remains of the previous design will appear on the new design. This changeover can mean that the printer is unable to print for 1-2 hours, equating to a loss of up to 180,000 containers. This ultimately means that the printer is unable to respond quickly to a change in design, which may be necessary when a customer requires a batch of printed cans at short notice.
- [0046] Figure 3 is a schematic of uni-directional printing. The print head initially sits at the head 56 of the sheet. It then moves negatively in the transport axis 9, depositing ink on the way 91 until it reaches the foot 57 of the sheet. The print head pauses at the foot 57

of the sheet and is then indexed in the scan axis without printing 93. The print head pauses once more. It then travels positively in the transport axis 9 and returns to the head 56 of the sheet without printing 92 and pauses again. After that, the print head once more travels towards the foot 57 of the sheet whilst printing 91, and without being indexed, and then pauses. It is then indexed again in the scan axis without printing 93 and pauses. It travels back towards the head 56 of the sheet without printing 92, and then pauses. This process is repeated for as many times as required until the entire sheet is printed. Each time the print head changes direction, a short dwell time is needed to allow the inks to resettle within the print head. If, for example, the print head takes 2 seconds to print, 0.5 second to be indexed, 0.5 second for a dwell time, 1.5 seconds to travel the length of the sheet without printing, and there are 5 lanes to print, one sheet would take: $(17 \times 0.5) + (2 \times 5) + (4 \times 1.5) = 24.5$ seconds to print. For a run length of 150,000, this job would take: $(150,000 \times 24.5)/(60 \times 60) = 1020.8$ hrs.

[0047] Figure 4 is used to illustrate bi-directional printing. Typically, the print head begins at the head 56 of the sheet and prints whilst travelling 91 towards the foot 57 of the sheet. It is then indexed in the scan axis without printing 93 and prints whilst travelling 91 back towards the head 56 of the sheet. The print head is indexed in the scan axis without printing 93. The process is then repeated as many times as required. Using the same travelling times as previously used, using bi-directional printing technique one sheet would take for printing: $(0.5 \times 13) + (5 \times 2) = 16.5$ seconds to print. For a run length of 150,000, this job would take: $(150,000 \times 16.5)/(60 \times 60) = 687.5$ hrs.

[0048] In contrast, in this invention a lane is printed whilst the sheet is moving (not the print head as in uni or bi-directional printing). Figure 5 shows an embodiment of the invention. An unprinted sheet 4 travels in the transport axis 9, arrives at the print site 33 and then passes underneath the print head 31. The print head 31 remains stationary in the scan axis 10 and transfers ink onto the sheet 4 as the sheet continues to move in the transport axis 9. The print head prints a lane 54 of images and the sheet 5 leaves the print site 33. The sheets are collected and returned to the print site 33. The conveying system is displaced 94 in the scan axis 10. The print head 31 remains in its original position. A second lane 54 of images is then printed and the sheets are collected. The process is repeated for as many times as required. If each lane per sheet takes 2 seconds to print, then printing 5 lanes on each of 150,000 sheets will take: $(150,000 \times 2 \times 5)/(60 \times 60) = 416.2$ hrs in total plus recirculation time and time to displace the conveying system. This is still a significant reduction in printing time and

is possible due to the absence of dwell time after the printing of each individual sheet.

[0049] In Figure 6, a second embodiment of the invention is shown. An unprinted sheet 4 travels in the transport axis 9, arrives at a print site 33 and then passes underneath a print head 31. The print head 31 remains stationary in a scan axis 10 and transfers ink onto the sheet 4 as the sheet continues to move in a transport axis 9. The print head 31 prints a lane 54 of images and the sheet 5 leaves the print site 33. The sheets are collected and returned to the print site 33. The print head 31 is displaced in the scan axis 10 along a gantry 32, whereas the conveying system remains in its original position. A print head 31' prints a second lane 54 of images, the sheets 5 leave the print site 33 and are then collected. The process is repeated for as many times as required. This embodiment requires the same basic amount of time as the previous example but requires time to displace the print head instead of the conveying system. Ideally however, the sheets would be returned to the print site whilst simultaneously the print head is moved, thus reducing the overall time taken between passes.

[0050] In Figure 7, a further embodiment of the invention is shown. In preparation of its arrival at a print site 33, an unprinted sheet 4 is cut into strips 4'. A strip 4' arrives at the print site 33, travelling in a transport axis 9. A print head 31 transfers ink onto the strip 4', whilst the strip 4' continues to move in the transport axis 9. The print head 31 remains fixed on the gantry 32 and does not move in a scan axis 10. The strips 4' leave the print site 33 and are not collected for recirculation. This embodiment requires no dwell time at all.

Claims

- [0001] An apparatus for printing a plurality of flat sheets comprising
- a printing site and
 - a conveying system adapted to move the plurality of flat sheets sequentially into alignment with the printing site
- characterised in that
- the printing site comprises a computer, for ~~electronically~~ storing and retrieving an image, and a print head comprising a plurality of nozzles connected to a plurality of inks, wherein
- the computer is adapted to control the transfer of inks from the nozzles onto each flat sheet to print one row of images on each sheet.
- [0002] An apparatus according to claim 1, wherein the conveying system is adapted to move the flat sheets in a scan direction, orthogonal to a transport direction.
- [0003] An apparatus according to claim 1, wherein the print head is adapted to move in a scan direction, orthogonal to a transport direction.
- [0004] An apparatus according to any of the preceding claims, wherein the printing site comprises a plurality of print heads, each print head adapted to print a corresponding row of images onto the flat sheet.
- [0005] A method of printing a plurality of flat sheets, comprising the steps of:
- preparing a plurality of flat sheets,
 - transporting the plurality of flat sheets sequentially past a printing site in a transport direction using a conveying system
- characterised in that
- the printing site comprises a computer for ~~electronically~~ storing and retrieving an image and a print head, constrained from movement in the transport direction, and
 - the print head prints one row of images on each flat sheet.
- [0006] A method of printing a plurality of flat sheets according to claim 5, wherein
- the plurality of flat sheets is divided into a batch,
 - a row of images is printed on the batch of the flat sheets,
 - the batch of flat sheets is collected after printing and returned to the printing site by the conveying system and
 - another row of images is printed onto the batch of flat sheets.
- [0007] A method of printing a plurality of flat sheets according to claim 6, wherein the

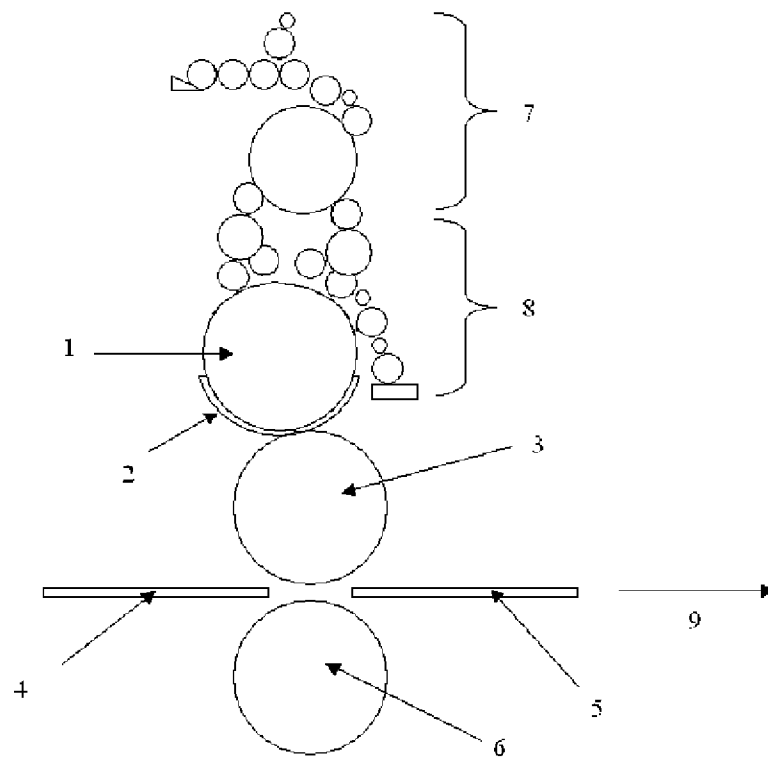
conveying system re-aligns the batch of sheets after printing the row of images to ensure that the next row of images is separate from the previous row.

[0008] A method of printing a plurality of flat sheets according to claim **6**, wherein

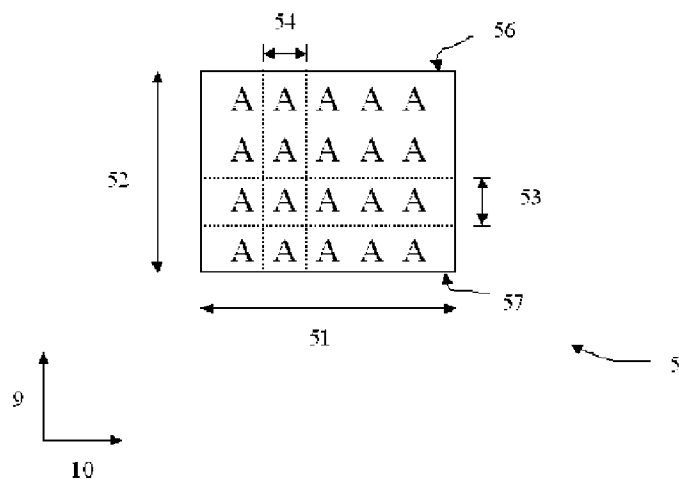
- the conveying system is constrained to move in the transport direction, and
- the print head moves in a scan direction, orthogonal to the transport direction, whilst the conveying system returns the batch of flat sheets to the printing site.

[0009] A method of printing a plurality of flat sheets according to claim **5**, wherein the step of preparing a plurality of flat sheets includes cutting the flat sheets into strips, the width of each strip determined by the width of the image or by the width of the desired blanks.

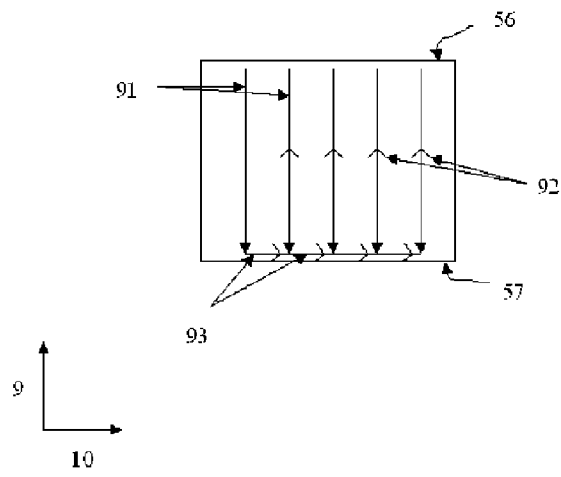
[Fig. 1]



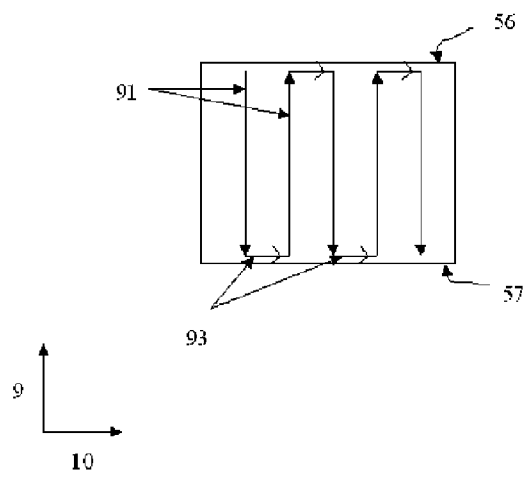
[Fig. 2]



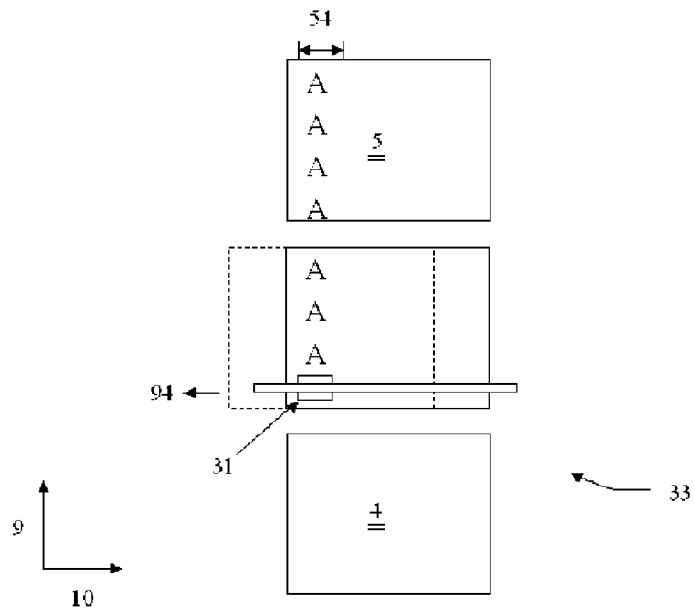
[Fig. 3]



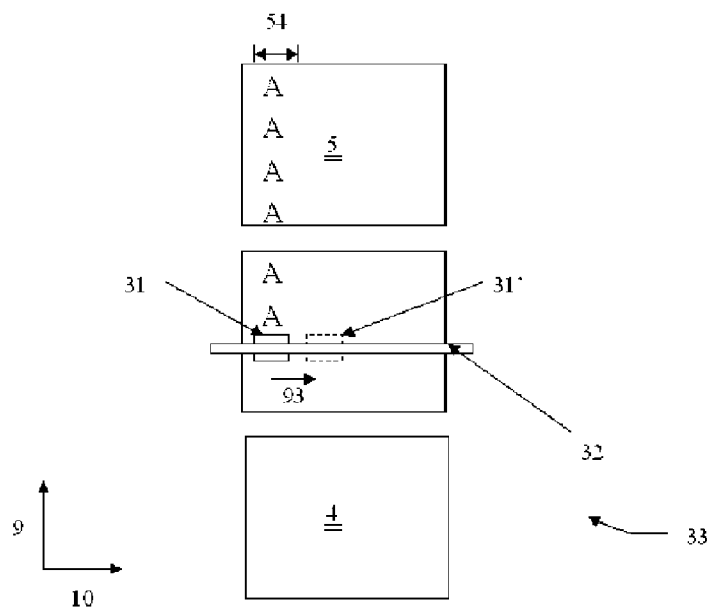
[Fig. 4]



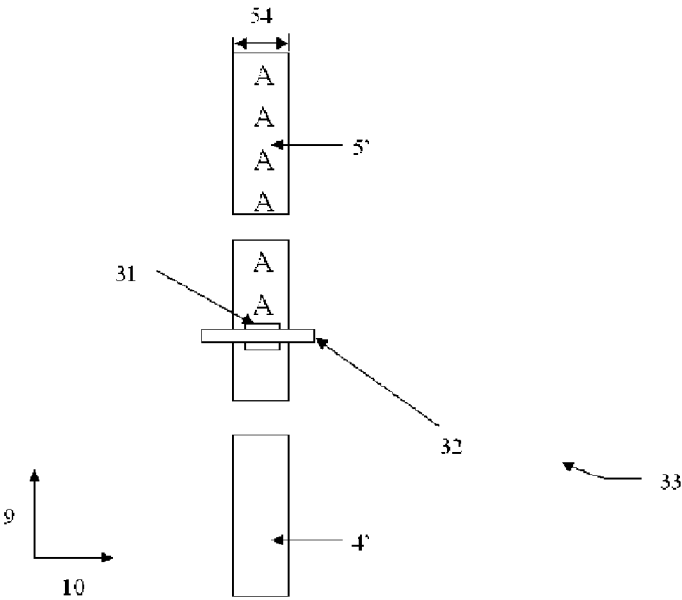
[Fig. 5]



[Fig. 6]



[Fig. 7]



INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2007/057633

A. CLASSIFICATION OF SUBJECT MATTER

INV. B41J3/28 B41J13/00 B41J3/54

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)

B41J

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/036738 A1 (LORENZ BERNARD [DE] ET AL LORENZ BERNHARD [DE] ET AL) 26 February 2004 (2004-02-26) paragraph [0009]; figure 1 -----	1-5
X	JP 2003 127352 A (KONISHIROKU PHOTO IND) 8 May 2003 (2003-05-08) abstract; figures -----	1, 3, 4
X	EP 1 531 054 A (SOLAR COMM INC [US]) 18 May 2005 (2005-05-18) paragraph [0099]; figure 16a -----	1, 5



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See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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