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(54) Title: DIGITAL PRINTING SYSTEM FOR CYLINDRICAL CONTAINERS

(57) Abstract: A digital printing system for cylindrical containers having a plurality of print stations for each section of the cylindrical container being printed. Each of the four stations is dedicated to one of four specific colors, Cyan, Magenta, Yellow and Black (CMYK).

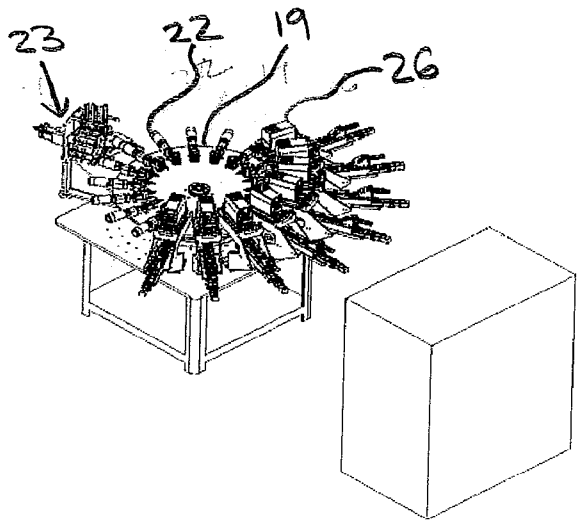


Fig 2

DIGITAL PRINTING SYSTEM FOR CYLINDRICAL CONTAINERS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to application number 62/028,464, filed on July 24, 2014, which is currently pending. The patent application identified above is incorporated herein by reference in its entirety to provide continuity of disclosure.

FIELD OF THE INVENTION

This invention relates generally to cylindrical can decorating and printing equipment and more particularly to a digital printing system using process color printing for printing labels on cylindrical containers for the beverage, cosmetic, medical and consumer packaging industries.

BACKGROUND OF THE INVENTION

Conventional methods for printing labels on cylindrical containers use spot color printing, in which specific colored inks are used to generate the colors appearing on paper. However, spot color printing is expensive and time consuming as it requires specific colors to be individually mixed or prepared prior to or during printing and each printed using an individual printing plate. It also requires that each individual color be applied to a substrate individually.

Therefore, a need exists for a system of printing cylindrical containers in which the colors are produced during the printing process using process color printing and printed using a limited number of printing stations.

SUMMARY OF THE INVENTION

The primary object of the present invention is to provide a digital printing system that uses four process color printing as opposed to spot color printing to produce high resolution images on cylindrical containers for the beverage, cosmetic, medical and consumer packaging industries.

An additional object of the present invention is to provide a digital printing system that prints various sizes and shapes of cylindrical containers using a plurality of printing heads to print on angled necks and multiple substrates.

The present invention fulfills the above and other objects by providing a digital printing system having a multi station indexing table that is loaded from a servo driven gravity fed star-wheel. The table is driven by a servo motor system to provide rigidity and accuracy to the system while cylindrical containers are moved through one of four print stations for each section of the cylindrical container being printed. Each of the four stations is dedicated to one of four specific colors, Cyan, Magenta, Yellow and Black (CMYK). The size and shape of the cylindrical containers being printed in a production run determines the number of groupings stations being used during the printing process. For example, a 24oz. can having an angled neck will travel through four stations having angled print heads to print the neck, four print stations to print the upper half of the flat surface of the can and four stations to print the lower half of the flat surface of the can. Station may be activated or deactivated during a production run depending on the size and shape of the can. The use of four process color printing allows any color to be printed on the can using (CMYK) without the need for preparing each individual color ink as is currently required with conventional spot printing.

The above and other objects, features and advantages of the present invention should become even more readily apparent to those skilled in the art upon a reading of the following detailed description in conjunction with the drawings wherein there is shown and described illustrative embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following detailed description, reference will be made to the attached drawings in which:

FIG. 1 is a top view of a machine module layout showing multiple digital printing system tables of the present invention arranged in a production line;

FIG. 2 is a side perspective view of a digital printing system of the present invention and ink management system;

FIG. 3 is a top view of a digital printing system table of the present invention showing various stations located around the table that a container passes through during the printing process;

FIG. 4 is a side perspective view of an infeed station and a discharge station of the present invention;

FIG. 5 is a side perspective view of a printing station of the present invention;

FIG. 6 is a partial cutaway side view of a neck printing station of the present invention;

FIG. 7 is a detailed view of section **A** of **FIG. 6**;

FIG. 8 is a side view of a cylindrical container having an angled neck; and

FIG. 9 is a side perspective view of a clear coating system of the present invention;

FIG. 10 is a side view of a digital printing system table and vacuum system of the present invention;

FIG. 11 is a cutaway side view of a digital printing system table and vacuum system of the present invention along lines **A-A** of **FIG. 10**;

FIG. 12 is a cutaway side view of a digital printing system table and vacuum system of the present invention along lines **A-A** of **FIG. 10** showing the vacuum supply;

FIG. 13 is a side perspective view of a digital printing system table and vacuum system of the present invention; and

FIG. 14 is a side view of an inspection system station of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

For purposes of describing the preferred embodiment, the terminology used in reference to the numbered accessories in the drawings is as follows:

1. digital printing system station one
2. digital printing system station two
3. digital printing system station three
4. digital printing system station four
5. digital printing system station five
6. digital printing system station six
7. digital printing system station seven
8. digital printing system station eight
9. digital printing system station nine
10. digital printing system station ten
11. digital printing system station eleven
12. digital printing system station twelve

13. digital printing system station thirteen
14. digital printing system station fourteen
15. digital printing system station fifteen
16. digital printing system station sixteen
17. digital printing system station seventeen
18. digital printing system station eighteen
19. indexing table (digital printing system)
20. infeed station mechanism
21. servo motor
22. mandrel
23. vacuum
24. drive shaft
25. cylindrical container
26. print head
27. vacuum pick and place system
28. suction cup
29. transfer system
30. indexing table (clear coating system)
31. clear coating system station one
32. clear coating system station two
33. clear coating system station three
34. clear coating system station four
35. clear coating system station five
36. clear coating system station six
37. clear coating system station seven
38. clear coating system station eight
39. slide
40. ported plate
41. valve
42. valve body
43. tubing

44. check valve

45. micrometer transmitter

46. receiver

47. amplifier

48. mirror

49. laser beam

50. air purge nozzle

With reference to **FIGS. 1-7,** various views of digital printing system tables **19** of the present invention are illustrated. As illustrated here, the digital printing system comprises an eighteen station **1-18** indexing table **19** preferably comprising the following stations, each of which may be activated or deactivated during the printing process depending on the size of a cylindrical container **25** being printed or a desired design being printed on the cylindrical container **25.**

Printing Index Sequence

Station No.	Operation
1	Infeed
2	Inspect / Clean
3	Contour (Neck) Printing Process Color one
4	Contour (Neck) Printing Process Color two
5	Contour (Neck) Printing Process Color three
6	Contour (Neck) Printing Process Color four – UV Cure
7	Body Printing Process Color one – 0-140 mm Length
8	Body Printing Process Color two – 0-140 mm Length
9	Body Printing Process Color three– 0-140 mm Length
10	Body Printing Process Color four –0- 140 mm Length
11	Body Printing Process Color one – 140 mm - 200 mm Length
12	Body Printing Process Color two – 140 mm - 200 mm Length
13	Body Printing Process Color three – 140 mm - 200 mm Length
14	Body Printing Process Color four – 140 mm - 200 mm Length
15	Spot Color

16	Spot Color
17	Inspect/Reject
18	Discharge

Cylindrical containers **25** are loaded from an infeed mechanism **20** comprising a servo motor driven gravity fed star-wheel with interchangeable pockets (as illustrated in **FIG. 4**) that can be designed to match a container shape and size and has easily adjustable guide rails to allow for product size change-over. The table **19** is driven by a servo motor **21** system to provide rigidity and accuracy to the digital printing system.

Each cylindrical container **25** is inspected in station **2** to ensure there are no defects and the cylindrical container **25** is loaded concentrically. In addition, each cylindrical container **25** is cleaned in station **2** using an atmospheric plasma cleaning process to remove any residue that would prevent the inks from adhering to the substrate.

The indexing table **19** is mounted horizontally and supports eighteen separate servo motor **21** driven mandrel assemblies **22**. Each mandrel **22** is supplied with a vacuum **23** through the center of a drive shaft **24** and will hold one cylindrical container **25** and rotate the cylindrical container **25** under print heads **26** at a constant speed through multiple revolutions as needed to achieve up to 600 dpi resolution. The print heads **26** may be operated to print during four revolutions of a substrate or printing surface of the cylindrical container **25** while the index table **19** is stationary or in a "dwell period." However, the operation of the print heads **26** and revolutions of the cylindrical container **25** may be varied by a computer operated motion control system to achieve multiple combinations of speed and positioning programmed to obtain various print effects such as holograms, tactile surface and so forth.

Each print head **26** is dedicated to one of four specific colors, Cyan, Magenta, Yellow and Black (CMYK).

Contour printing is achieved using four angled piezoelectric print heads **26** (as illustrated in **FIG. 6**) and Ultra Violet (UV) cured inks in index table **19** in stations **3** thru **6** with final UV cure happening in station **6**.

The straight sides of the product are printed in stations **7** thru **14** and are cured in stations **15** and **16** where an additional spot color or other process may be applied if desired.

The length of the print heads **26** used to print the straight sides or body of the cylindrical containers **25** has a maximum length of 104 mm. Therefore in order to print patterns longer than 104mm the print heads **26** must be staggered around the table **19** in relation to the position of the cylindrical container **25** on the mandrel **22**. Therefore, stations **7-10** have print heads **26** positioned to print a top part of the substrate of the cylindrical container **25** up to 104mm in length and print heads **26** in stations **11-14** are designated to print the bottom portion of the cylindrical container **25** up to 200mm total length or remain idle if cylindrical container **25** having a shorter height are being printed. Therefore, cylindrical containers **25** having various sizes, such as 12oz. 20oz., 32oz. and so forth, may be printed using this staggered configuration

A final quality inspection is done in station **17** for each printed cylindrical container **25** thus providing 100% visual inspection prior to being discharged from the indexing table **19** (as illustrated further in **FIG. 14**).

Once the inspected product is indexed into station **18**, the vacuum source **23** is disconnected and compressed air is supplied to the mandrel drive shaft **24** to eject the cylindrical container **25** from the mandrel **22** horizontally or vertically utilizing a vacuum pick and place system **27** (as illustrated in **FIG. 4**) that is easily integrated into any production line. A suction cup **28** is simultaneously positioned to receive the cylindrical container **25** and guide it off the mandrel **22**. Once a transfer system **29** has received the cylindrical container **25**, the table **19** indexes the empty mandrel **22** to be reloaded at the first station **1**.

With reference to **FIG. 9**, a side perspective view of a clear coating system of the present invention is illustrated. After printing, the transfer system **29** places the cylindrical container **25** onto a second indexing table **30** with eight stations containing servo motor **21** driven mandrel assemblies **22** on which a clear over coating is applied and cured. First, the cylindrical container **25** is loaded at station one **31.** Then, a clear coating is applied at station two **32.** The clear coating is cured at stations three through seven **33-37.** Finally, the cylindrical container **25** is discharged at station eight **38.**

Clear Coat Index Sequence

Station No.	Operation
1	Infeed
2	Clear coat Application
3	Curing
4	Curing
5	Curing
6	Curing
7	Curing
8	Discharge

With reference to **FIGS. 10-13**, a vacuum system of the present invention is illustrated. Cans or cylindrical containers are loaded onto the support mandrels **22** with vacuum supplied through the mandrel drive shaft **24**. There are preferably two sources of vacuum in the system, holding vacuum and high vacuum. High vacuum is connected to the mandrel drive shaft **24** when a pneumatically operated slide **39** extends a ported plate **40** with a seal which contacts the bottom of a valve **41** and lifts the valve **41** which is closely guided in a valve body **42** until a matching tapered seat inside the valve body **42** is opened and allows air to flow past sealing surfaces. This operation occurs when the rotary index table **19** is stationary during the printing sequence. There is preferably a valve assembly **41** located under each mandrel station on both indexing tables **19** and **30**.

There are preferably at least three locations in the system where high vacuum is used:

1. Infeed Can Load on the Print Table **1**;
2. Transfer system Rotary Indexer **29**; and
3. Infeed Can Load on the Over Varnish System **31.**

The holding vacuum is used on each of the plurality of mandrels **22** to maintain registration of the can on each mandrel **22** during indexing and printing/coating operations. The holding vacuum is supplied through a rotary union located above the

center of the indexing table **19** mounted to a manifold which distributes the vacuum to each mandrel assembly via tubing **43** and a check valve assembly **44**.

During indexing, each valve assembly **41**, which is connected to the rotary table, provides a seal so the holding vacuum is isolated from a high vacuum port which is open to atmosphere.

There are preferably three locations where the system needs to alternate between vacuum for loading or holding registration and compressed air to blow the can off the mandrel **22** when printing is finished or the can is determined to be out of specification due to a damaged profile or unacceptable graphics.

The blow-off locations may be:

1. Infeed station **1**;
2. Inspection station **2**;
3. Graphics inspection station **17**; and
4. Finished can discharge **18**.

During a blow-off function, the check valve **44** prevents an compressed air pulse from disturbing other cans under vacuum and directs the compressed air through the intended mandrel shaft **24**. The check valve **44** also closes when there are no cans on the mandrels **22** to prevent a vacuum leak during start-up when there are no cans in the system, or when a can has been rejected or transferred.

With reference to **FIG. 14**, a side view of an inspection system station **2** of the present invention is illustrated. The infeed inspection system **2** is designed to detect damaged cylindrical containers **25** and remove them from the system. The inspection station **2** is located directly adjacent to the infeed station **1** and prior to the first printing station **3** on the printing rotary table or indexing table **19**.

When a cylindrical container **25** is loaded onto a mandrel **22**in the infeed station **1**, it is possible for the cylindrical container **25** to have a dented side wall and still load onto the mandrel **22** due to the shape of the necked cylindrical container **25**. The neck opening is smaller than the body diameter necessitating a smaller mandrel than the inside dimension of the cylindrical container **25** body be used to locate and support the container during printing/coating.

To eliminate potential damage of a print head due to the close proximity of the print head to the surface of the cylindrical container **25**, an inspection system **2** has been developed as illustrated here.

The inspection system **2** consists of a laser micrometer transmitter **45**, receiver **46**, amplifier **47**, and mirror **48** configured so a transmitted laser beam path **49** intersects the side wall of the inspection system **2** and measure any dimensional variations as the container is rotated by the mandrel assembly **22**.

When the indexing table **19** moves a inspection system **2** into position, the mandrel **22** rotates the inspection system **2** at least one full circumference in the beam path **49** and is measured. If the measurements fall outside set parameters, the control system indexes the rotary table **19** to a reject position and the out of spec. inspection system **2** is blown off, and the system continues to normal operation.

The laser micrometer system has been selected due to its 28mm wide beam path which allows for a range of container sizes to be run through the system without the need to physically adjust the beam path location. All that is necessary to change product sizes is to alter the control system computer program menu and select the appropriate container size for inspection set up.

An air purge nozzle **50** is located inside the inspection system enclosure to provide a positive, clean, dry, air flow across the optics to help keep them clean.

It is to be understood that while a preferred embodiment of the invention is illustrated, it is not to be limited to the specific form or arrangement of parts herein described and shown. It will be apparent to those skilled in the art that various changes may be made without departing from the scope of the invention and the invention is not to be considered limited to what is shown and described in the specification and drawings.

CLAIMS

Having thus described my invention, I claim:

1. A digital printing system for cylindrical containers comprising:

an indexing table having a plurality of stations and at least one mandrel for supporting a cylindrical container as the cylindrical container is moved through the plurality of stations;

at least one motor for controlling movement of the indexing table;

said plurality of stations includes a first printing station wherein a first predetermined color is applied to the cylindrical container;

said plurality of stations includes a second printing station wherein a predetermined color is applied to the cylindrical container;

said plurality of stations includes a third printing station wherein a predetermined color is applied to the cylindrical container; and

said plurality of stations includes a fourth printing station wherein a predetermined color is applied to the cylindrical container.

2. The digital printing system for cylindrical containers of claim **1** wherein:

said predetermined colors being applied by the first printing station, the second printing station, the third printing station and the fourth printing station comprise cyan, magenta, yellow and black.

3. The digital printing system for cylindrical containers of claim **1** wherein:

said plurality of stations further comprises an infeed station wherein the cylindrical container is placed on the at least one mandrel.

4. The digital printing system for cylindrical containers of claim **1** wherein:

said plurality of stations further comprises an inspection station wherein cylindrical container is inspected for defects.

5. The digital printing system for cylindrical containers of claim **1** wherein:

said plurality of stations further comprises an inspection station wherein cylindrical container is inspected for defects.

6. The digital printing system for cylindrical containers of claim **1** wherein:
said predetermined colors being applied by the first printing station, the second printing station, the third printing station and the fourth printing station are being applied to a neck of the cylindrical container.

7. The digital printing system for cylindrical containers of claim **2** wherein:
said predetermined colors being applied by the first printing station, the second printing station, the third printing station and the fourth printing station are being applied to a neck of the cylindrical container.

8. The digital printing system for cylindrical containers of claim **1** wherein:
said predetermined colors being applied by the first printing station, the second printing station, the third printing station and the fourth printing station are being applied to a body of the cylindrical container.

9. The digital printing system for cylindrical containers of claim **2** wherein:
said predetermined colors being applied by the first printing station, the second printing station, the third printing station and the fourth printing station are being applied to a body of the cylindrical container.

10. The digital printing system for cylindrical containers of claim **1** wherein:
said plurality of stations further comprises discharge station.

11. The digital printing system for cylindrical containers of claim **1** further comprising:
at least one vacuum for holding the cylindrical container on the at least one mandrel.

12. The digital printing system for cylindrical containers of claim **1** further comprising:

at least one vacuum for discharging the cylindrical container off of the at least one mandrel.

13. A digital printing system for cylindrical containers comprising:

at least one mandrel for supporting a cylindrical container while colors are applied to a cylindrical container;

a first printing head for applying a predetermined color;

a second printing head for applying a predetermined color;

a third printing head for applying a predetermined color; and

a fourth printing head for applying a predetermined color.

14. The digital printing system for cylindrical containers of claim **13** wherein:

said predetermined colors being applied by the first printing head, the second printing head, the third printing head and the fourth printing head comprise cyan, magenta, yellow and black.

15. The digital printing system for cylindrical containers of claim **13** wherein:

said predetermined colors being applied by the first printing head, the second printing head, the third printing head and the fourth printing are being applied to a body of the cylindrical container.

16. The digital printing system for cylindrical containers of claim **14** wherein:

said predetermined colors being applied by the first printing head, the second printing head, the third printing head and the fourth printing are being applied to a body of the cylindrical container.

17. The digital printing system for cylindrical containers of claim **13** wherein:

said predetermined colors being applied by the first printing head, the second printing head, the third printing head and the fourth printing are being applied to a neck of the cylindrical container.

18. The digital printing system for cylindrical containers of claim **14** wherein: said predetermined colors being applied by the first printing head, the second printing head, the third printing head and the fourth printing are being applied to a neck of the cylindrical container.

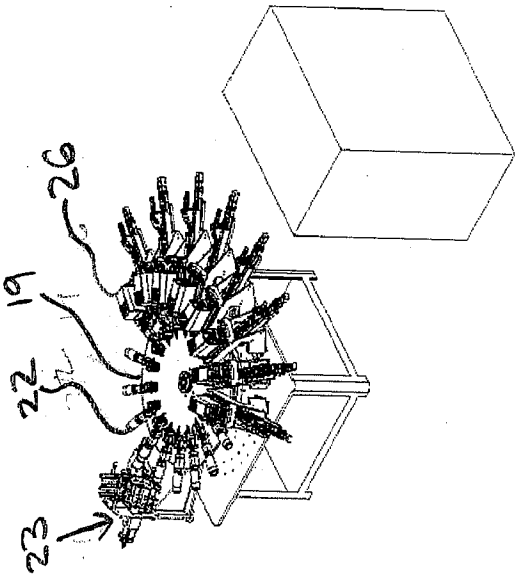


Fig 2

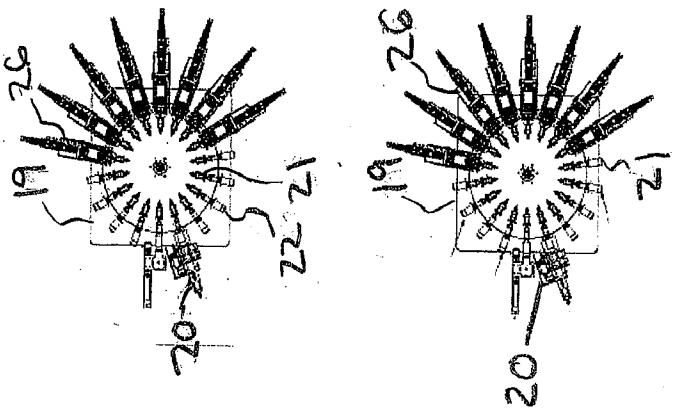


Fig 1

Fig 7

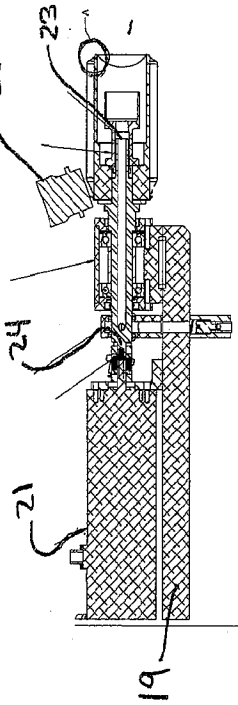


Fig 6

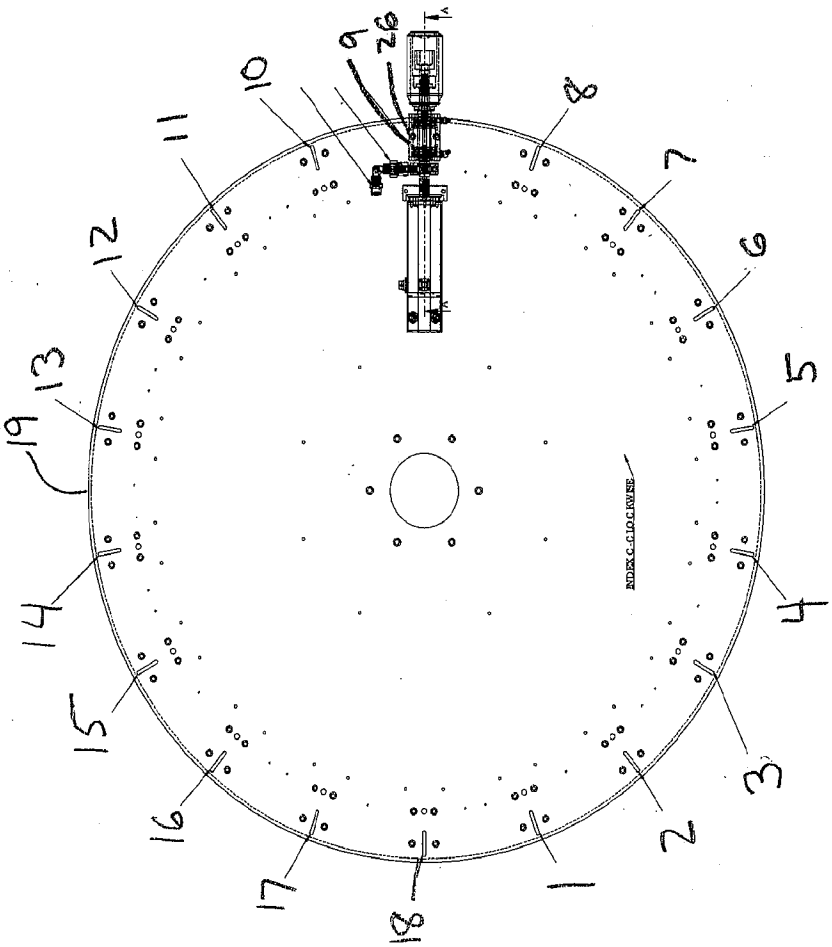
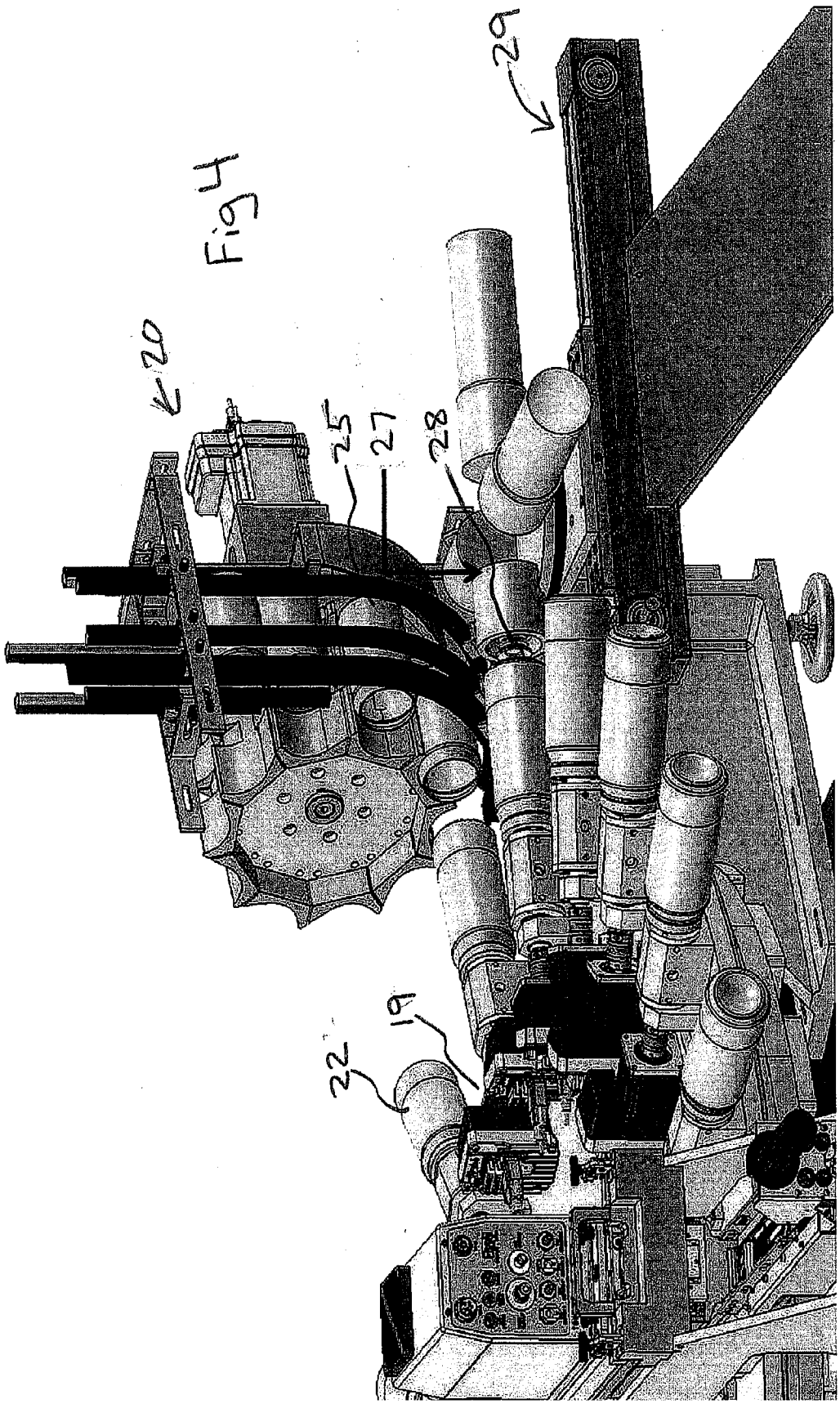


Fig 3

Fig. 4



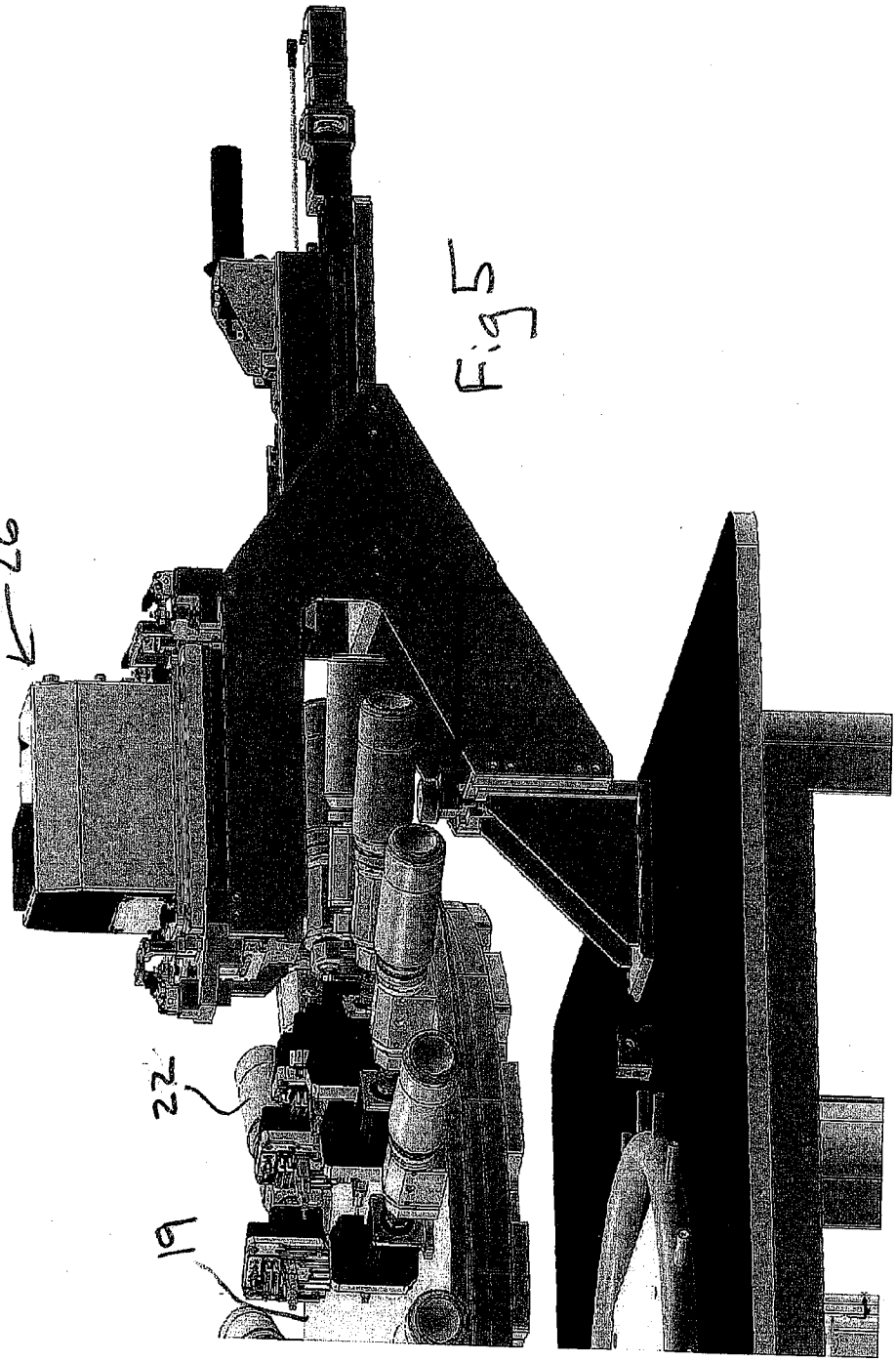


Fig 5
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19

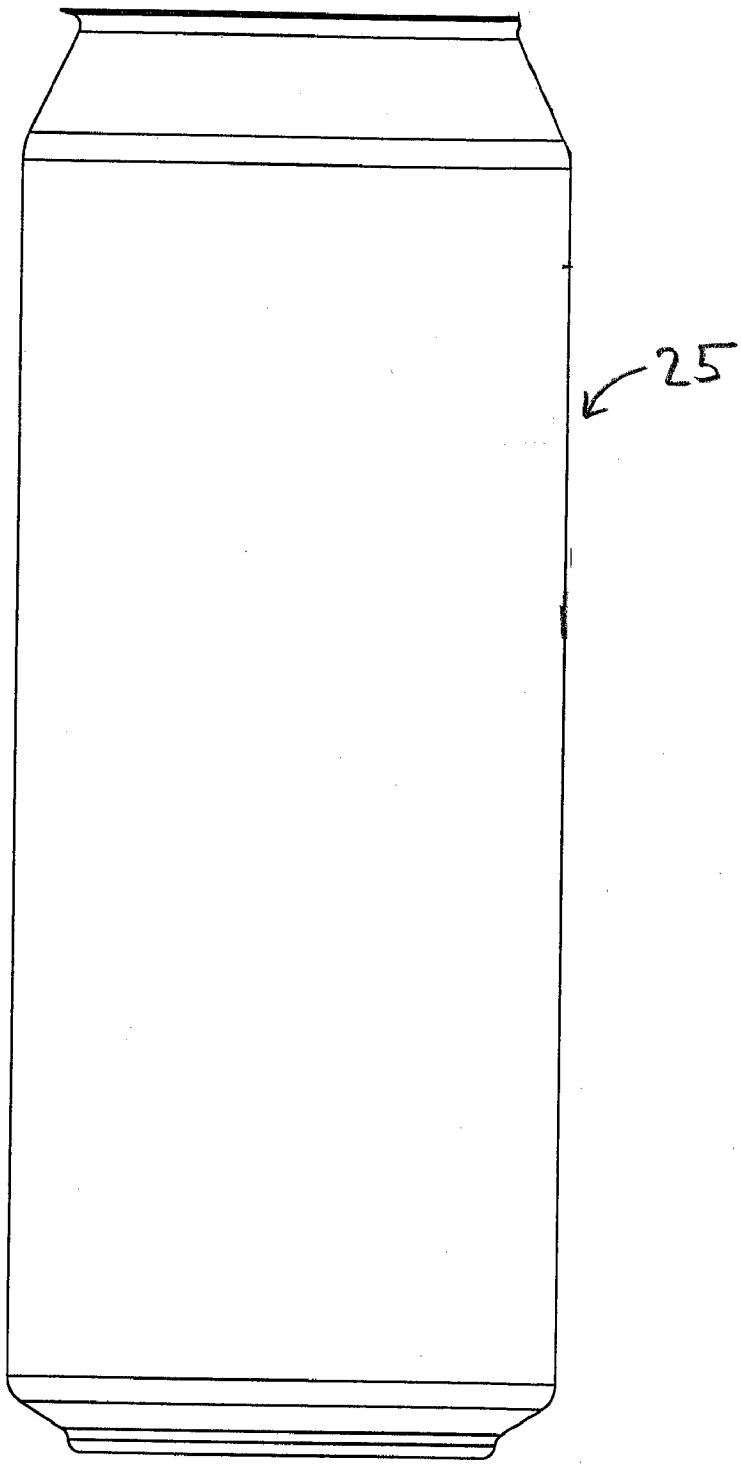

Fig 8

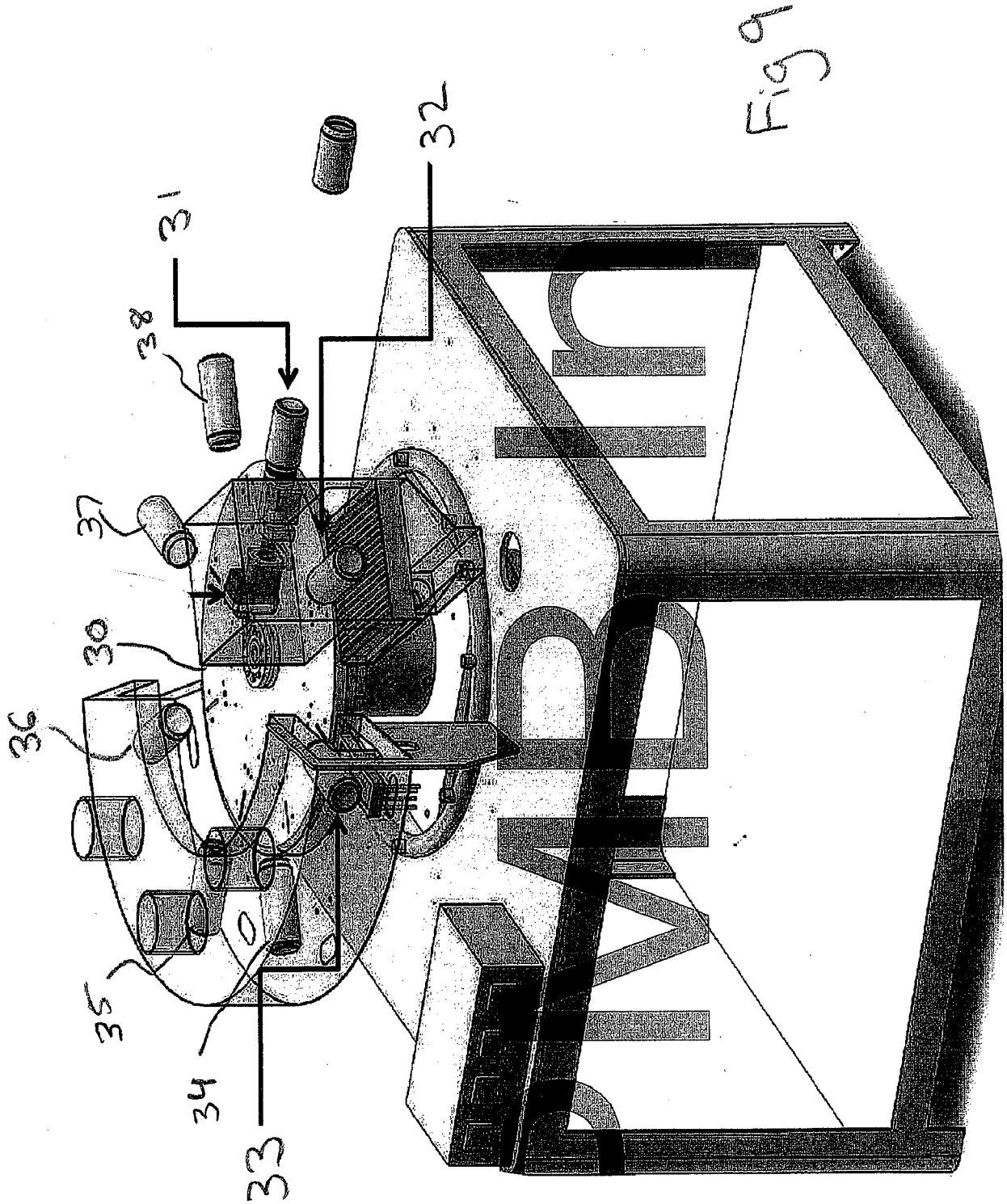
Fig 5
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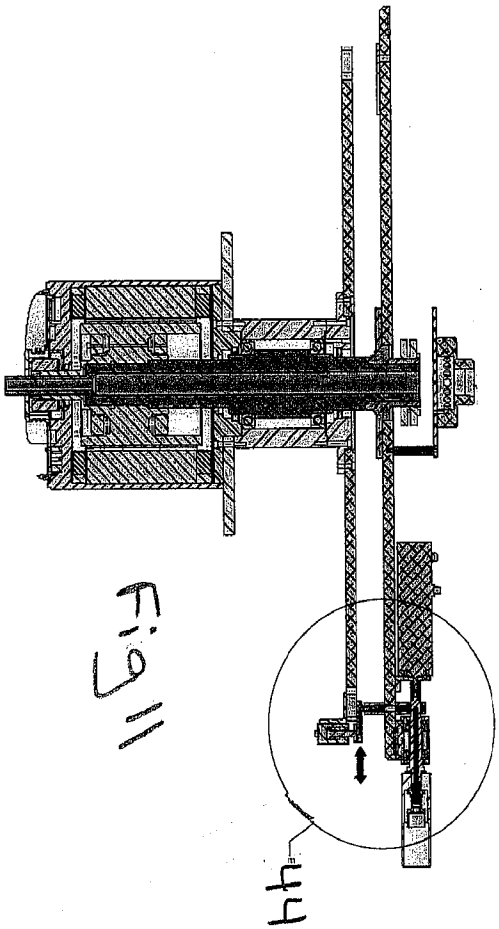

Fig 11

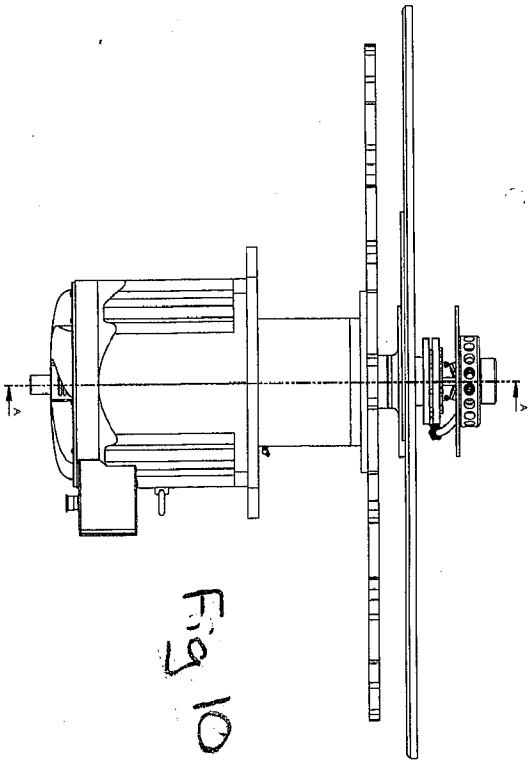

Fig 10

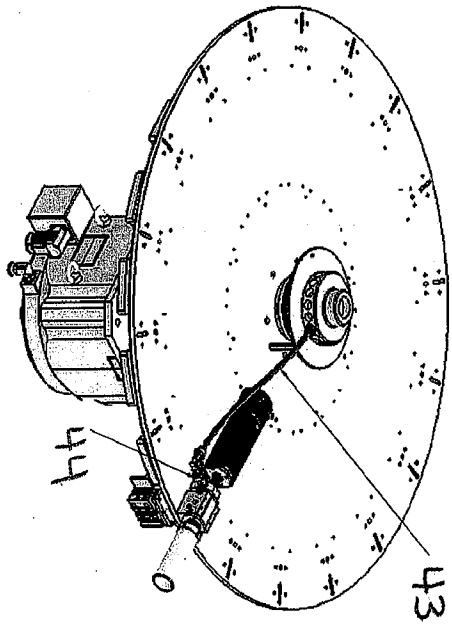

Fig 13

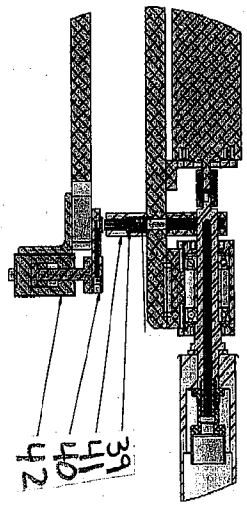

Fig 12

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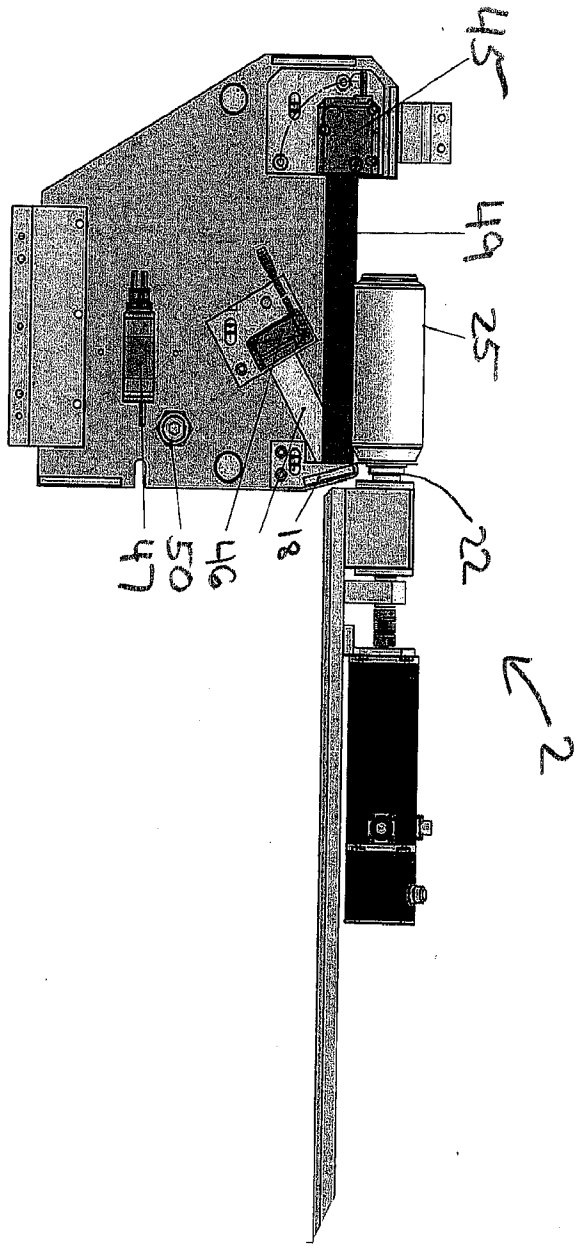

Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US15/42025

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B41J 3/4073 (2015.01)
CPC - B41J 3/4073
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)
IPC(8) Classification(s): B41J 3/4073, 11/00, 3/543, 2/00 (2015.01)
CPC Classification(s): B41J 3/4073, 11/002, 3/543, 2/175, 2/16552, 2/16526, 11/008, 2/06, 29/377, 2/18

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); Google; Google Scholar; ProQuest; IP.com; keywords: digital printing, multi station, multi color, can, container, cylinder, cylindrical, inspection station

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,769,357 B1 (FINAN) August 3, 2004; figure 1, 2; column 3, lines 1-7, lines 53-56; column 4, lines 15-25, lines 23-25, lines 34-37, lines 34-37; column 5, lines 10-20, lines 28-34; column 6, lines 24-25	1-11, 13-18
X	US 3,960,073 (RUSH) June 1, 1976; column 7, lines 30-35	1, 12
A	US 2013/0107293 A1 (UPTERGROVE et al.) May 2, 2013; entire document	1-18
A	US 5,799,575 (AIROLDI) September 1, 1998; entire document	1-18

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
28 September 2015 (28.09.2015)	20 OCT 2015
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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