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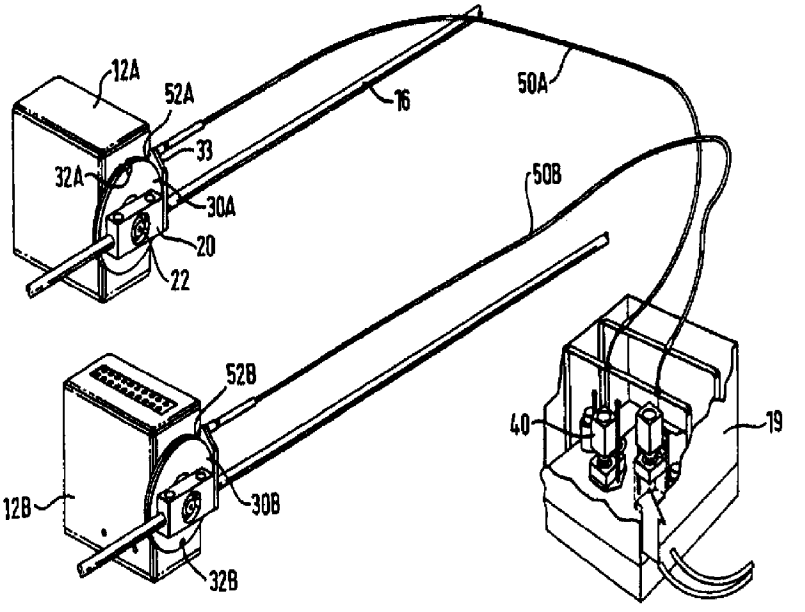
(54) **APPAREIL SERVANT A MAINTENIR LA PRESSION HYDROSTATIQUE DANS UNE TETE D'IMPRESSION A JET D'ENCRE**

(54) **APPARATUS FOR MAINTAINING HYDROSTATIC PRESSURE IN AN INK JET PRINTHEAD**



(57) Système d'alimentation en encre destiné à un dispositif d'impression à jet d'encre dans lequel la hauteur du réservoir (40) d'encre est réglée en fonction de la hauteur à laquelle se trouvent les orifices (31) de la tête d'impression. Dans une forme de réalisation préférée le réservoir (40) d'encre est monté sur un chariot élévateur (60A, 60B) qui est mécaniquement relié à la tête d'impression (12) par un câble Bowden (50A, 50B). Le câble coopère avec une poulie (30A, 30B) située sur la tête d'impression (12) de sorte que la rotation de la tête d'impression (12) provoque un mouvement de translation du chariot élévateur (60A, 60B). Les

(57) An ink supply system for an ink jet printing device in which the elevation of the ink reservoir (40) is controlled as a function of the elevation of the printhead orifices (31). In a preferred embodiment, the ink reservoir (40) is mounted on an elevating carriage (60A, 60B) which is mechanically linked to the printhead (12) via a Bowden cable (50A, 50B). The cable cooperates with a pulley (30A, 30B) on the printhead (12) such that rotation of the printhead (12) results in translational movement of the elevating carriage (60A, 60B). The dimensions of the pulley (30A, 30B) are selected such that the elevational changes in the reservoir ink level

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dimensions de la poulie (30A, 30B) sont sélectionnées pour que les variations de hauteur du niveau d'encre du réservoir correspondent directement aux variations de hauteur des orifices (31) de la tête d'impression. La pression hydrostatique reste donc constante au niveau des orifices (31) de la tête d'impression lorsque cette dernière (12) est tournée.

correspond directly with the elevational changes in the printhead orifices (31). Thus, the hydrostatic pressure at the printhead orifices (31) remains constant as the printhead (12) is rotated.

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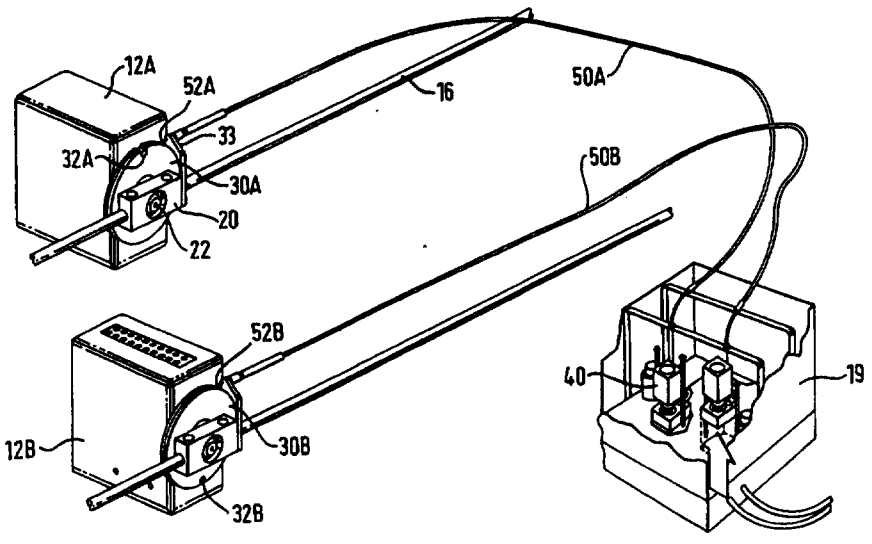


(57) Abstract

An ink supply system for an ink jet printing device in which the elevation of the ink reservoir (40) is controlled as a function of the elevation of the printhead orifices (31). In a preferred embodiment, the ink reservoir (40) is mounted on an elevating carriage (60A, 60B) which is mechanically linked to the printhead (12) via a Bowden cable (50A, 50B). The cable cooperates with a pulley (30A, 30B) on the printhead (12) such that rotation of the printhead (12) results in translational movement of the elevating carriage (60A, 60B). The dimensions of the pulley (30A, 30B) are selected such that the elevational changes in the reservoir ink level correspond directly with the elevational changes in the printhead orifices (31). Thus, the hydrostatic pressure at the printhead orifices (31) remains constant as the printhead (12) is rotated.

APPARATUS FOR MAINTAINING HYDROSTATIC PRESSURE IN AN INK JET PRINTHEAD

The invention relates generally to the field of ink jet printing devices, particularly the field of drop-on-demand type printing devices. Specifically, the invention relates to an apparatus for maintaining substantially constant hydrostatic pressure at the orifices of a drop-on-demand ink jet printhead.

Ink jet printers are in widespread use in addressing of mail pieces, i.e., projecting images down onto passing mail pieces, and container and package labeling. These applications require relatively large images and often incorporate a number of printheads, each having a plurality of nozzles and being about one inch long, to provide the necessary image size. Typically, the printheads are stationary, while the substrate, i.e. the top or side of a container, moves by on a conveyor belt past the printheads.

Ink jet printing is typically accomplished using one of two techniques: drop-on-demand or continuous stream. In both techniques, the ink jet printer creates very small liquid ink droplets used to form an image on a substrate. Drop-on-demand printing differs from continuous stream printing in that the former uses capillary forces to convey ink to the printhead nozzles and tiny variations in pressure at the printhead nozzle to produce droplets while the latter continuously pumps the ink to the nozzles. Precise control of the pressure at the printhead nozzle orifices is thus critical to the operation of drop-on-demand printers.

In drop-on-demand printing, ink is conveyed to the nozzle orifices by capillary action. Ink is supplied to each print head from a remote reservoir via a flexible capillary tube. The hydrostatic pressure of the ink at the nozzle orifices is a function of the elevation of the orifice with respect to the ink in the remote reservoir. It is also a function of the surface tension and density of the ink being used. Thus, when changes occur in the type of ink being used, in the elevation of the nozzle orifices, or in the ink level in the remote reservoir, variations in the hydrostatic pressure at the nozzle orifices are

experienced. These variations include excess hydrostatic pressure, which results in "weeping" or leakage of ink from the orifices, and insufficient hydrostatic pressure (negative pressure that is too low) which results in retreat of the ink into the printhead orifice and/or the ingestion of air within the printhead Hydrostatic pressure at the printhead orifices is usually maintained at a small negative pressure of about one to three inches of water. Negative pressure is achieved by locating the remote ink reservoir such that the top of the ink level (the plane of the top surface of the stored ink) in the reservoir is at a slightly lower elevation than the printhead orifices. The pressure pulses that produce ink droplets are usually induced by piezoelectric or thermal deformation of small chambers within the printhead which cause droplets to issue from the tiny orifices. The presence of air within the printhead is undesirable because it affects droplet generation.

Air is purged from the printhead by first re-orienting it such that the orifices are disposed upwardly and then flushing the printhead with ink. Re-orientation is also used to clean or service the printheads. Since printhead priming is a matter of routine service for most drop-on-demand printing devices, the printheads are often mounted in bearings that permit in situ rotation of the printhead. Rotation of the printhead, from a home position in which the orifices point downwardly to a priming position in which the orifices point upwardly, will change the elevation of the orifices by four to six inches. After the printhead nozzles are oriented upwardly, a positive pressure is applied to the ink (usually by way of a pump associated with the ink reservoir) to flush out the orifices such that any trapped air is expelled.

Priming and rotation of the printhead present a rather vexing problem: the ink reservoir level must be adjusted after the printhead is primed (and after the priming pump is turned off) such that the proper hydrostatic pressure is maintained at the printhead orifices while the printhead is rotated back to its home position. As described above, while the printhead is rotated to expose the orifices, the elevation of the nozzle orifices, and thus the hydrostatic pressure, are changing. After the priming pump is turned off, adjustment of the reservoir ink level is necessary to prevent excess negative pressure, which will again draw air into the printhead on the other hand, if the pump is kept running during printhead

rotation, the printhead nozzles will flood with ink. Thus, the priming process is somewhat complex and requires the judgement of a skilled technician.

There are no known devices which specifically address the particular problems described above. Some prior art devices have addressed related problems in the general field of controlling hydrostatic pressure in an ink jet printer. For example, German patent application No. DE 32 04 661 A1 discloses a device which permits changes in the relative elevation of the ink reservoir or printhead in order to achieve a controlled amount of ink seepage from the orifices to prevent tip drying. European patent application No. EP 23 77 87 discloses an ink jet printing system that incorporates a suspension spring to adjust the height of the ink reservoir to maintain the hydrostatic pressure as the ink supply depletes. The prior aft, however, has not addressed the specific problems associated with movement of the printhead orifices relative to the level in the ink reservoir during priming, adjustment, cleaning or other maintenance.

JP-A-3277555 discloses an ink jet recording device including an ink supply tank, a recording head, a conduit to supply ink from the tank to the recording head, a cam mounted underneath the tank to adjust the height of the tank relative to the recording head, and a control device which controls a difference in the height from the lower end of the recording head to an ink surface inside the tank.

According to the present invention there is provided an apparatus for maintaining the hydrostatic pressure in an ink jet printhead comprising:

(a) an ink reservoir for containing a supply of ink;

(b) a printhead having orifices from which droplets are projected, the orifices being disposed at a predetermined elevation with respect to the top of the ink level in the ink reservoir to create a desired hydrostatic pressure;

(c) a flexible conduit for conducting ink from the reservoir to the printhead; characterised by:

(d) means for mounting the printhead such that the elevation of the orifices can be changed; and

(e) means for adjusting the vertical position of the reservoir such that the predetermined elevation is maintained even when the orifices are moved.

In a preferred embodiment, the ink reservoir is mounted on an elevating carriage which is mechanically linked to the printhead via a Bowden cable. The cable cooperates with a pulley on the printhead such that rotation of the printhead results in corresponding movement of the elevating carriage. The configuration of the pulley is selected such that the elevational changes in the reservoir ink level correspond directly with the elevational changes in the printhead orifices. The hydrostatic pressure head at the printhead orifices

whereby the difference in vertical separation between the printhead orifices and the top plane level of the ink in the reservoir is maintained within a predetermined range at all times as the printhead is moved between said first and second positions.

According to a fourth aspect of the present invention there is provided in an inkjet printing system which has a printhead with a plurality of orifices for projecting ink drops toward a substrate to mark the latter and an ink reservoir that is connected to the printhead and filled with ink to a predetermined top plane level, the combination comprising:

means for mounting the printhead for movement between first and second positions, respectively, the printhead being operative to mark the substrate;

means for supporting the reservoir for movement between third and fourth positions, respectively, to maintain a hydrostatic ink pressure at the printhead within a predetermined range; and

means coupling said printhead mounting means and said reservoir support means responsive to vertical movement of the printhead to initiate vertical movement of the reservoir;

whereby the difference in vertical separation between the printhead orifices and the top plane level of the ink in the reservoir is maintained within said predetermined range at all times as the printhead is moved between said first and second positions.

In a preferred embodiment, the ink reservoir is mounted on an elevating carriage which is mechanically linked to the printhead via a Bowden cable. The cable cooperates with a pulley on the printhead such that rotation of the printhead results in corresponding movement of the elevating carriage. The configuration of the pulley is selected such that the elevational changes in the reservoir ink level correspond directly with the elevational changes in the printhead orifices. The hydrostatic pressure head at the printhead orifices

thus remains within a predetermined range as the printhead is rotated from its operating position to the priming position, with the orifices exposed, and back again.

The invention will now be described by way of example with reference to the accompanying drawings in which:-

Figs. 1A-1C illustrate an ink jet printing device to which the present invention may be adapted;

Fig. 2 illustrates a preferred embodiment of an ink jet printing device incorporating a linkage according to the present invention;

Fig. 3 illustrates an ink reservoir mounting configuration in accordance with a preferred embodiment of the invention; and

Fig. 4 illustrates the mechanical details of an ink jet printing device incorporating the present invention.

An ink jet printing device 10, suitable for implementing the present invention is illustrated in Figs. 1A-1C. The device comprises a number of printheads 12 mounted in a known manner on laterally extending support rods 16. In the device shown, four printheads 12 are arranged to provide an image on mail pieces, such as envelopes or packages (not shown) which pass under the printheads 12 on transport surface 17 via conveyor belts 18. Printheads 12 remain stationary with respect to the moving mail pieces and the lateral position of the printheads on support rods 16, as well as the height of the printheads above the transport surface 17, may be adjusted in a known manner. The printheads 12 include journals 25 which are mounted in bearings 22 within support blocks 20 as shown in detail in Figs. 1B and 1C. Bearings 22 permit rotation of the printheads 12 in the direction of arrow A, from a home position, shown in Fig. 1B, to a priming position shown in Fig. 1C, where the orifices 31 are facing upward in an exposed

orientation. The mounting details illustrated in Fig. 1A should be ignored to the extent that they do not correspond with the details shown in Figs. 1B and 1C.

Referring to Fig. 1A, ink is supplied to printheads 12 from ink reservoirs which are housed in housing 19. Ink feed lines 21 (which are shown cut-off in Fig. 1A for clarity) extend from the reservoirs to the printheads 12, with a single reservoir and feed line assigned to each printhead 12. The printheads 12 are drop-on-demand type printheads that are commercially available, such as the Ultrajet printhead, sold by Trident, Inc.

Referring to Figs. 2-4, the present invention provides a system for automatically adjusting the height of ink reservoirs 40 when the printheads 12 are rotated. In Figure 2, two printheads are illustrated, one in the home position 12A, and one in the priming or servicing position 12B. Each printhead is provided width a pulley 30A and 30B, respectively, which is attached to the printhead for rotation therewith. Separate Bowden cables 50A and 50B, which comprise a wire, usually made of spring steel and enclosed in a casing or sheath, are independently attached to the pulleys 30A and 30B, respectively, via tab members 32A and 32B which are attached to the individual wires 52A and 52B of the Bowden cables 50A and 50B. The outer sheath of the Bowden cable is secured to the mounting block 20 via bracket 33. Thus, rotational movement of printhead 12 results in translation of the wires 52A and 52B within the casing and vertical movement of ink reservoir 40 as will be explained below.

Referring to Fig. 3, the opposite respective ends of wire 52A and 52B are secured to movable carriages 60A and GOB, which are mounted for vertical sliding movement on guide posts 62. Each carriage 60A and 60B includes a lower flanged portion 67A and 67B, respectively, which is provided with a pair of guide holes (not visible in Fig. 3) that receive guide posts 62. Coil springs 64 surround each guide post 62 and abut lower flanged portion 67 to bias carriage 60 downward. The upper ends of springs 64 abut washer elements that are secured via threaded fasteners to the guide posts 62. Carriage 60A is controlled by cable 50A and slides vertically on guide posts 62 to permit reservoir 40A to travel up and down. Reservoir 40A is shown in a lower position

corresponding to printhead 12A (Fig. 2) which is in the home or operating position. Reservoir 40B is shown in a raised position corresponding to printhead 12B, which is in the priming or servicing position.

Referring to Fig. 4, carriage 60A is secured to wire 52 by a bracket 65 that extends generally horizontally. Wire 52 is fastened to bracket 55 in a known manner, for example, using a tab member attached to the end of wire 52 and interlocked within a recess in bracket 65. The sheath of cable 50 is secured to cross-member 66 which extends upward from base 70 of housing 19 (Figs. 1 and 2). Suitable adjustment means 68 may be provided to adjust the tension in or effective length of Bowden cables 50 in a known manner.

As can be seen in Figs. 2 and 4, rotational movement of printhead 12 results in translational movement of wire 52 of Bowden cable 50 which, in turn, causes translational movement of carriage 60 on guide posts 452. The dimensions of pulley 30 are chosen such that the translational movement of wire 52 equals the elevational change experienced by the printhead orifices as the printhead is rotated.

Other uses and modification of the foregoing embodiments will be apparent to those of ordinary skill without departing from the spirit and scope of the invention. For example, the invention is also applicable to printing systems in which the printhead height, with respect to the transport surface is adjustable. In that case, each printhead is oriented to project droplets substantially horizontally and undergoes linear, rather than rotational, movement as it is adjusted upward or downward relative to the transport surface, for example, in order to accommodate the imaging of containers of different heights. Those of ordinary skill will recognize that the invention may be adapted for use in such situations by securing the Bowden cable to the printhead in a suitable manner.

CLAIMS:

1. An apparatus for maintaining the hydrostatic pressure in an ink jet printhead comprising:

(a) an ink reservoir (40) for containing a supply of ink;

(b) a printhead (12) having orifices (31) from which droplets are projected, the orifices being disposed at a predetermined elevation with respect to the top of the ink level in the ink reservoir (40) to create a desired hydrostatic pressure;

(c) a flexible conduit (21) for conducting ink from the reservoir (40) to the printhead (12); characterised by:

(d) means (20, 22, 25) for mounting the printhead (12) such that the elevation of the orifices can be changed; and

(e) means (50A, 50B) for adjusting the vertical position of the reservoir (40) such that the predetermined elevation is maintained even when the orifices are moved.

2. An apparatus as claimed in claim 1, wherein the orifices (31) undergo a change in elevation as the printhead (12) is rotated.

3. An apparatus as claimed in claim 1 or 2, wherein the means (50A, 50B) for adjusting comprises a Bowden cable.

4. An apparatus as claimed in claim 1 or 2, further comprising a pulley (30A, 30B) mounted for movement with the printhead (12) and wherein the means for adjusting comprises a Bowden cable (50A, 50B) secured to the pulley (30A, 30B) such that rotation of the printhead (12) causes translational movement of the cable.

5. An apparatus as claimed in claim 3 or 4, wherein the reservoir (40) is mounted on a movable carriage (60A, 60B) which is secured to the Bowden cable (50A, 50B).

6. An apparatus as claimed in any one of claims 1 to 4, wherein the printhead is moveable between first and second positions, respectively, the printhead being operative to mark a substrate in said first position and being exposed for servicing in said second position; and the apparatus further includes means (60A, 60B, 62) for supporting the reservoir (40) for movement between third and fourth positions, respectively, to maintain hydrostatic ink pressure at the printhead (12) within a predetermined range; said reservoir (40) in said third position maintaining said hydrostatic ink pressure at the printhead (12) in said first position for marking operation and said reservoir (40) in said fourth position maintaining said hydrostatic ink pressure at the printhead in said second position for servicing of the latter, and said adjusting means (50A, 50B) and said reservoir support means being responsive to vertical movement of the printhead (12) to initiate vertical movement of the reservoir; whereby the difference in vertical separation between the printhead orifices (31) and the top plane level of the ink in the reservoir is maintained within a predetermined range at all times as the printhead is moved between said first and second positions.

7. An ink jet printing system including an apparatus as claimed in any one of the preceding claims.

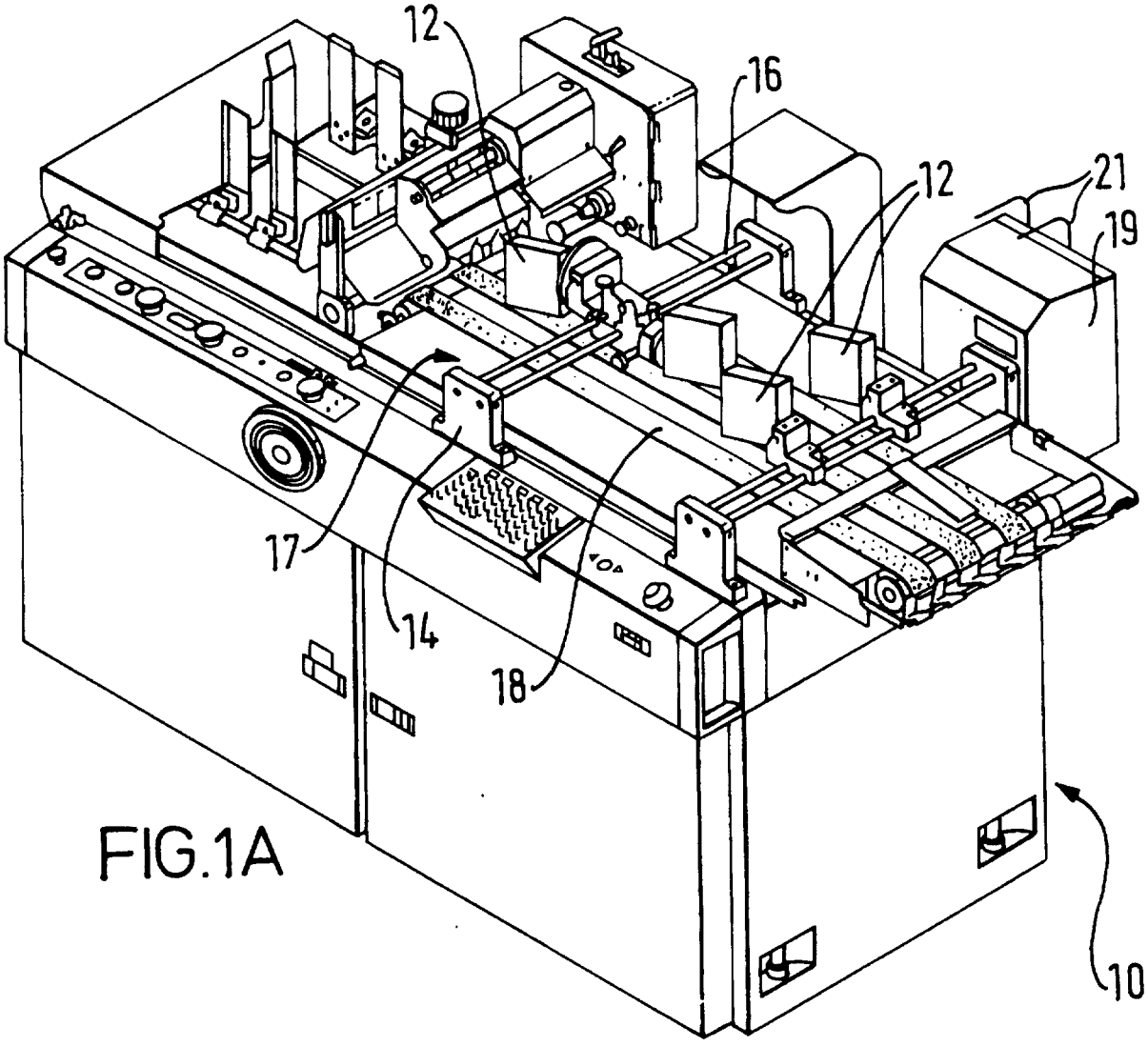


FIG.1A

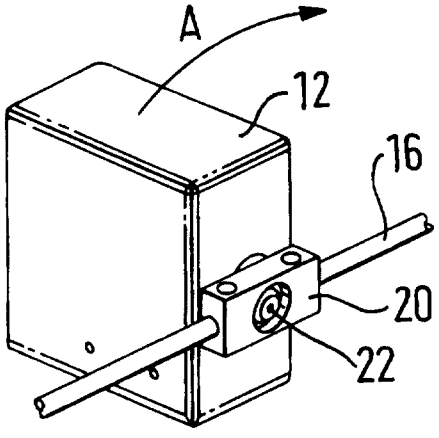


FIG.1B

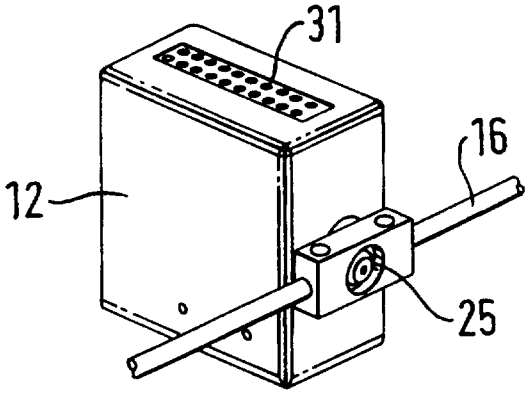


FIG.1C

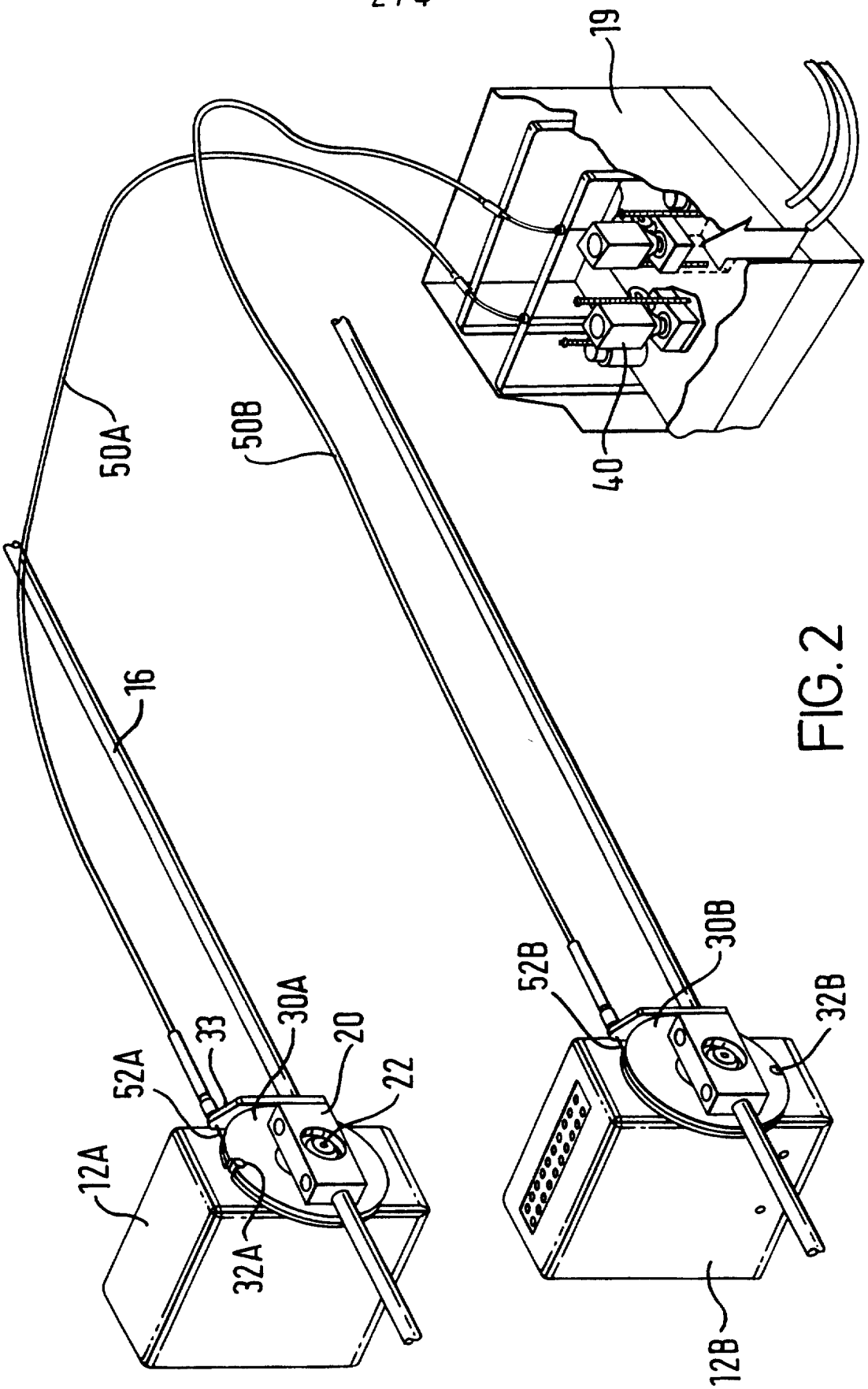


FIG. 2

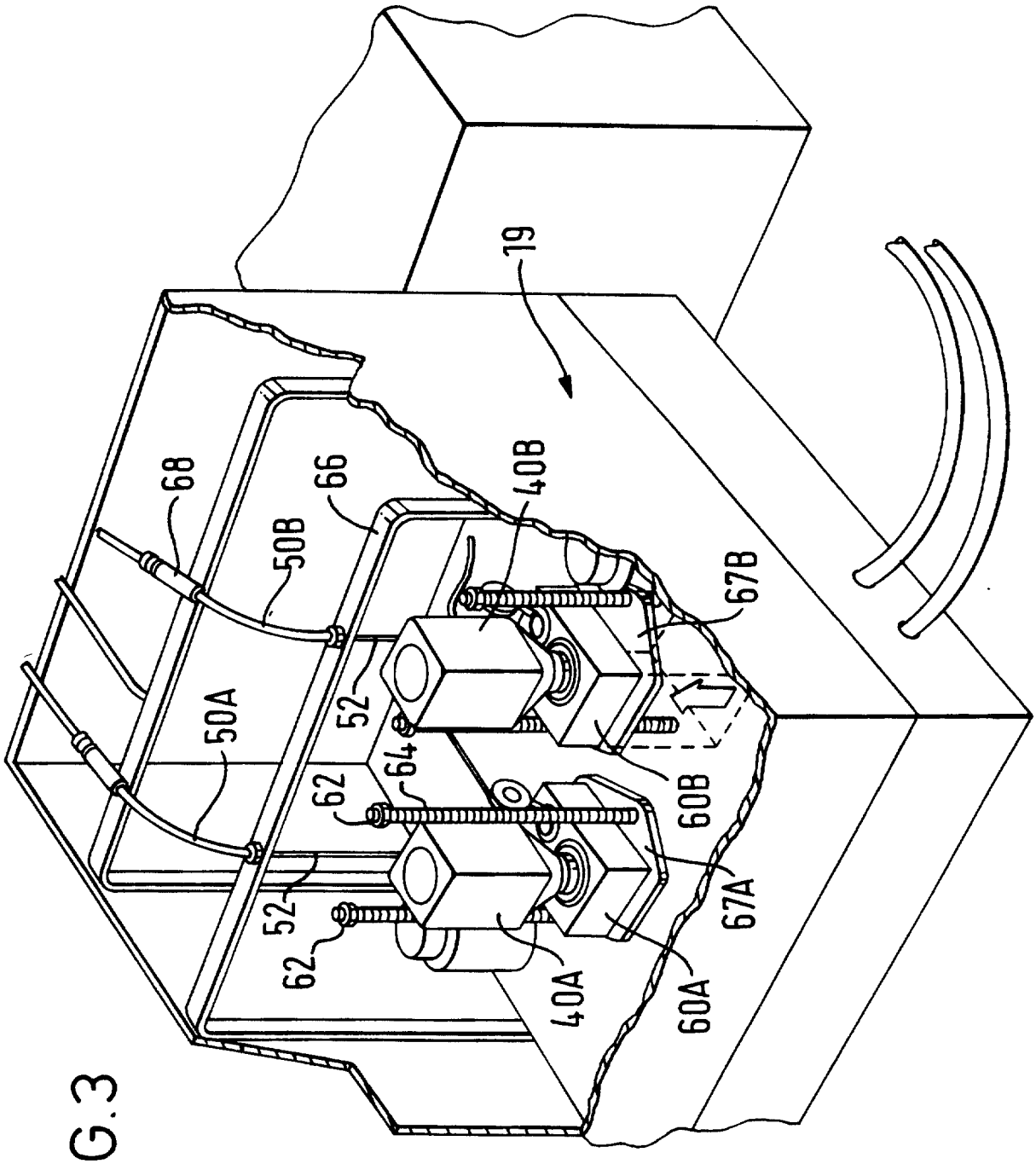


FIG.3

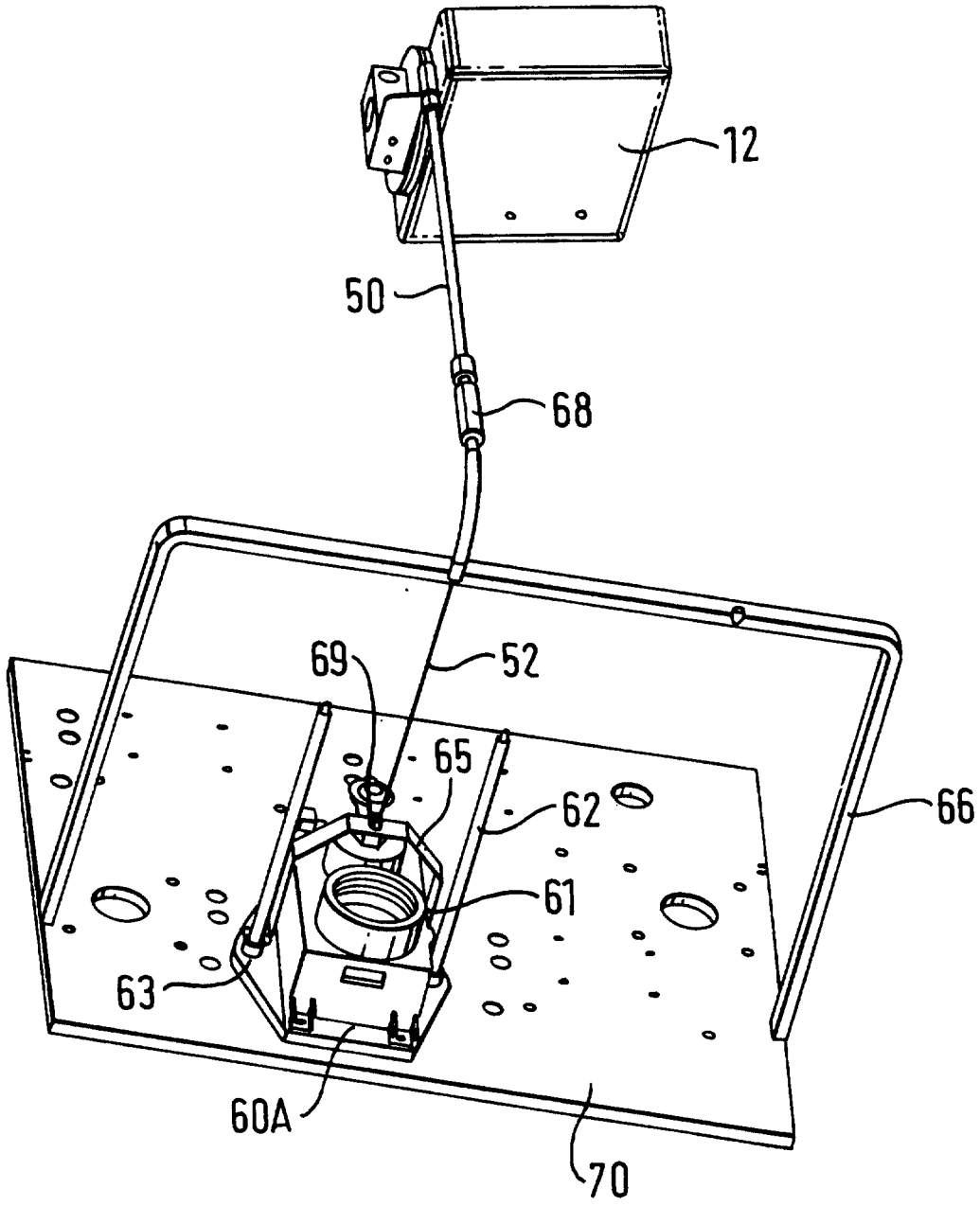
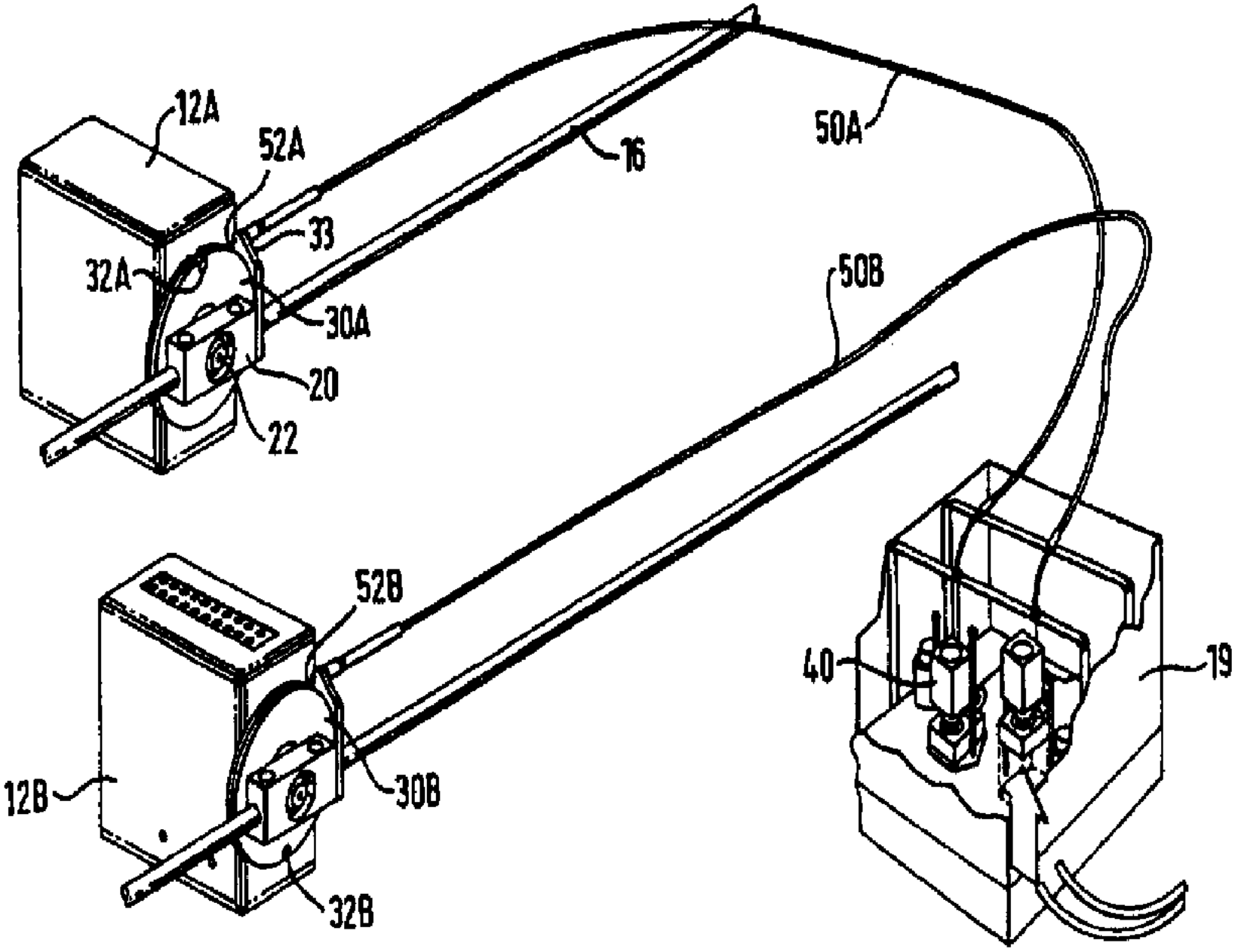


FIG. 4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