



(51) International Patent Classification:

B41J 29/393 (2006.01) *B33Y 40/00* (2015.01)
B29C 64/30 (2017.01) *F17D 5/02* (2006.01)

(21) International Application Number:

PCT/US2018/043322

(22) International Filing Date:

23 July 2018 (23.07.2018)

(25) Filing Language:

English

(26) Publication Language:

English

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(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,

(54) Title: DETECTING CONNECTIONS AT FLUIDIC INTERCONNECTS

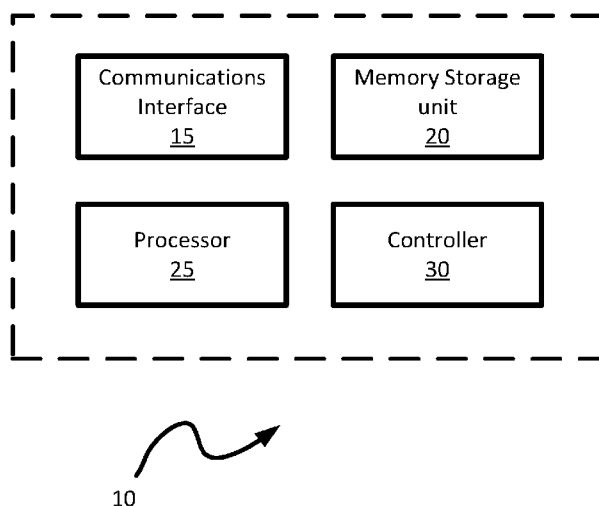


Fig. 1

(57) Abstract: An example of a method involving monitoring a plurality of liquid connectors in a printing device. Each liquid connector of the plurality of liquid connectors may provide an indicator of a state of a connection. The connection is to deliver a print fluid. The method involves analyzing a plurality of indicators to determine whether a poor fluidic connection exists. In addition, the method further involves transmitting a command to stop a process when the poor fluidic connection exists.

TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to the identity of the inventor (Rule 4.17(i))*
- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

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

DETECTING CONNECTIONS AT FLUIDIC INTERCONNECTS

BACKGROUND

[0001] Printing devices are often used to present information. In particular, printing devices may be used to generate output that may be easily handled and viewed or read by users. Accordingly, the generation of output from printing devices from electronic form is used for the presentation and handling of information. Printing devices, such as three-dimensional printing devices may deliver various print fluids to components or subassemblies throughout the printing device. Accordingly, print fluids may be transferred within the printing devices using various fluidic channels during operation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Reference will now be made, by way of example only, to the accompanying drawings in which:

- [0003] Figure 1 is a block diagram of an example apparatus to operate a printing device;
- [0004] Figure 2 is a flowchart of an example of a method of a process;
- [0005] Figure 3 is a flowchart of another example of a method with continued monitoring;
- [0006] Figure 4 is a block diagram of a printing device according to one example;
- [0007] Figure 5 is representation of a liquid connector in an open state according to one example; and
- [0008] Figure 6 is representation of a liquid connector in a closed state after mating with a complimentary connector

according to one example.

DETAILED DESCRIPTION

[0009] Some printing devices use liquids to generate output. In such printing devices, liquid delivery systems are generally used to deliver a liquid, such as a print fluid, from one part of the printing device, such as a reservoir to a print head where output is generated. Large printing devices may have large and complex delivery systems for various print fluids. Due to the size, complexity and serviceability requirements the printing device, the printing device may be divided into components or subassemblies, such as a fluid supply station, a dynamic e-chain assembly, and a reservoir pump system. Fluidic interconnects may be used to join various subassemblies to deliver liquid throughout the printing device. The fluidic interconnects allow for independent replacement of the subassemblies. In some examples, needle septa header connectors may be used to reduce costs and to provide clean disconnections and reconnections during a service event. For example, a service event may involve replacing a fluid supply station by disconnecting the fluid supply station from the on-board reservoirs. As another example, a reservoir system may be disconnected from the e-chain subassembly for replacement.

[0010] In the event that a printing device is powered on and starts to circulate print fluid when a liquid connector is disconnected, print fluid may leak and expose other components to print fluid. The rate at which print fluid may leak may be as high as 100 cc/min. If this were to occur the print fluid may be pumped into the inside of the printing device and cause the failure of electrical components within the printing device. In addition, print fluid may leak out of the printing device causing a mess and may affect nearby equipment.

[0011] Referring to figure 1, an apparatus to operate a printing device is shown at 10. The apparatus may be a part of the printing device or a separate component to operate on the printing device. The apparatus 10 may include additional components, such as various additional interfaces and/or displays to interact with a user or administrator of the apparatus. In the specific example, the apparatus 10 is to operate a liquid delivery system within the printing device

by receiving and processing data from sensors to control the flow of print fluid through the printing device. In the present example, the apparatus 10 includes a communications interface 15, a memory storage unit 20, a processor 25, and a controller 30.

[0012] The communications interface 15 is to communicate with a liquid connector in the printing device. In the present example, the communications interface 15 is to receive signals from a sensor disposed on the liquid connector, such as during a startup process. The sensor may provide an indication of the state of a connection at the liquid connector from which the signal originated. Accordingly, the signals may provide indicators of the state the connection and whether a leak may be present or is likely to occur. It is to be appreciated that the communications interface 15 may receive signals from a plurality of liquid connectors throughout the printing device. Each of the liquid connectors may have an associated identifier and the identifier may also be transmitted from the liquid connector to the communication interface 15. Although the present example receives indicators during a startup process, it is to be appreciated that the communications interface 15 may be used to receive indicators and signals outside of the startup process, such as during normal operations of the printing device.

[0013] The manner by which the communications interface 15 receives the signals from the liquid connectors is not limited and may include receiving an electrical signal via a wired connection. In other examples, the communications interface 15 may receive wireless signals such as via a Bluetooth connection. In the examples, the communications interface 15 may receive radio signals or infrared signals.

[0014] The memory storage unit 20 is coupled to the processor 25 and may include a non-transitory machine-readable storage medium that may be any electronic, magnetic, optical, or other physical storage device. In the present example, the memory storage unit 20 is to maintain a database to store the plurality of indicators received via the communications interface 15. The indicators may include raw data received from each liquid connector. In some examples, an identifier associated with the liquid connector from which the

indicator is received may also be stored. In the present example, the state of the connection may include a binary indicator to indicate whether the fluidic connection at the liquid connector is satisfactory or not. In other examples, the indicator may provide additional information such as pressure readings or more states that characterize the connection. Furthermore, some liquid connectors may include more than one fluidic connection. In these liquid connectors, additional data may be provided for each fluidic connection.

[0015] The memory storage unit 20 may also store executable instructions. In the present example, the executable instructions may include a set of instructions to execute a printing device startup process, a set of instructions to operate a continual monitoring process of a liquid connector, a set of instructions to operate a fluidic pump (not shown) or valve (not shown) to circulate and to control a flow of liquid via channels that deliver the liquid to components of the printing device.

[0016] The non-transitory machine-readable storage medium may include, for example, random access memory (RAM), electrically-erasable programmable read-only memory (EEPROM), flash memory, a storage drive, an optical disc, and the like. The machine-readable storage medium may be encoded with executable instructions to operate the communication interface 15, the controller 30, or other hardware in communication with the processor 25. In addition, the machine-readable storage medium may also be encoded with data to store generated rules subsequent use.

[0017] The memory storage unit 20 may also store an operating system that is executable by the processor 25 to provide general functionality to the apparatus 10, for example, functionality to support various applications such as a user interface to access various features of the apparatus 10. Examples of operating systems include Windows™, macOS™, iOS™, Android™, Linux™, and Unix™. The memory storage unit 20 may additionally store applications that are executable by the processor 25 to provide specific functionality to the apparatus 10, such as functionality to detect a leak location and to provide corrective steps to an operator to correct the leak.

[0018] The processor 25 may include a central processing unit (CPU), a

microcontroller, a microprocessor, a processing core, a field-programmable gate array (FPGA), an application-specific integrated circuit (ASIC), or similar. The processor 25 and the memory storage unit 20 may cooperate to execute various instructions. In particular, the processor 25 is connected to the memory storage unit 20. The processor 25 may execute instructions stored on the memory storage unit 20 to implement a startup process prior to delivery of print fluid across the liquid connectors. In other examples, the processor 25 may also be used to implement an ongoing monitoring process to identify leaks or indicators of a leak during operation. The monitoring process is not limited and may involve monitoring periodic signals from the liquid connectors to indicate the health of each monitored fluidic connection. In other examples, the monitoring process may involve detecting a signal from a liquid connector transmitting an indication upon failure of a fluidic connection.

[0019] In the present example, the processor 25 is to retrieve the indicators stored in the memory storage unit 20 and to analyze the plurality of indicators to determine whether a poor fluidic connection or a poor startup condition exists. The manner by which the processor 25 makes the determination is not particularly limited and the threshold for the determination of a poor startup condition may vary based on the application and the printing device. For example, when the indicators received from the liquid connectors is a binary indicator, the presence of a single failed fluidic connection may be sufficient to make the determination of a poor startup condition. In other examples, where additional data is provided, such as a pressure reading at a fluidic connection, predetermined threshold values for each fluidic connection may be used to determine if a failed fluidic connection is present.

[0020] In further examples, the printing device may be tolerant to more than one failed liquid connectors. Accordingly, in these examples, the printing device may allow for the failure of a liquid connector without affecting the startup process. Therefore, the determination of a poor startup condition may not be made unless a specified number of liquid connectors have failed. In addition, it is to be appreciated that not all liquid connectors may be considered equal. Some liquid connectors may be in closer proximity to sensitive components of

the printing device, such a special liquid connector near internal electronics, than to other liquid connectors. Accordingly, the failure of a special liquid connector may result in the determination of a poor startup condition whereas a single failure of non-special liquid connectors may not result in a determination of a poor startup condition.

[0021] The controller 30 is in communication with the processor 25 and is to receive commands from the processor 25. The controller 30 executes the commands to control the liquid flowing through various channels in the printing device. The manner by which the controller 30 controls the liquid flow is not limited. For example, the controller 30 may be in communication with various pumps and valves in the printing device. By controlling the pumps and valves, the controller 30 may control the flow of liquid throughout the printing device. For example, if processor 25 directs the controller 30 to stop the liquid in the printing device, the controller 30 may turn off pumps in the printing device and close valves to stop the liquid from flowing. As another example, the processor 25 may direct the controller 30 to isolate a portion of the printing device where a liquid connector has failed. In such an example, the controller 30 may selectively turn off pumps and close valves to isolate that portion of the printing device. By isolating a portion of the printing device, the failed liquid connector may be inspected and corrected or replaced without shutting down other portions of the printing device.

[0022] Although the present example shows the controller 30 and the processor 25 as separate components, in other examples, the controller 30 and the processor 25 may be combined and may be part of the same physical component, such as a microprocessor configured to carry out multiple functions. In other examples, the components may be operated separately on separate processors, separate devices, or over a cloud processor.

[0023] Once a poor condition is determined to exist, for example, during a startup process, the processor 25 may direct the controller 30 to transmit a command to stop the startup process. In the present example, the controller may transmit a command to various hardware components, such as a pump, to shut down the components of the printing device associated with liquid delivery.

In other examples, the controller 30 may transmit a command back to the processor 25 to stop the startup process when hardware components, such as a pump in the printing device have not started.

[0024] In some examples, once the command to stop the startup process has been provided by the controller 30, the processor 25 may generate instructions to rectify the failure to an operator of the printing device. For example, the processor 25 may generate an error code and display the error code on an output device, such as a light or a display screen of the printing device. In other examples, the processor 25 may send a message to the operator. In examples where the communications interface 15 receives data about each liquid connector, the processor 25 may identify a location of a failed liquid connector such that the operator may directly adjust the liquid connector without having to perform additional diagnostic tests.

[0025] Referring to figure 2, a flowchart of a method to operate a printing device is shown at 100. In order to assist in the explanation of method 100, it will be assumed that method 100 may be performed with the apparatus 10 shown in figure 1. The method 100 may be one way in which apparatus 10 may be configured. It is to be appreciated that the following discussion of apparatus 10 may lead to a further understanding of the apparatus 10 and its various components. Furthermore, it is to be emphasized, that method 100 may not be performed in the exact sequence as shown, and various blocks may be performed in parallel rather than in sequence, or in a different sequence altogether.

[0026] Beginning at block 110, a plurality of liquid connectors is monitored by the apparatus 10, such as during a startup process or during an operation of the apparatus. In some examples, the startup process is not limited and may include a series of actions that the printing device carries out prior to receiving the first print job. For example, a startup process may carry out various checks of subsystems of the printing device. One of the component checks that may be part of the startup process are the liquid connectors in the printing device. It is to be appreciated that each of the liquid connectors may be to make a fluidic connection between two fluid lines that may lead to or from various components

of the printing device. For example, the liquid connectors may connect a reservoir or pump to an e-chain assembly. As another example, liquid connectors may connect a fluid supply station to the reservoir or pump.

[0027] In the present example, each of the liquid connectors may provide an indicator of the state of the connection at the liquid connector. The indicator is not particularly limited and may be an electrical signal or wireless signal received by the communications interface 15 of the apparatus 10. Accordingly, since each liquid connector is to be monitor, the apparatus 10 is to receive a plurality of indicators, where each liquid connector is to provide an indicator of the state of the connection at the specific liquid connector.

[0028] In the present example, the indicator may be generated from a switch disposed on the liquid connector as described in more detail below. The switch may have two states where an open state occurs when no fluidic connection is made. For example, the when the liquid connector is disengaged, such as during a service event at the printing device where a component is to be removed or replaced, the switch may be in an open state. Upon reconnecting the liquid connector to form a leak-proof seal, the switch will be moved to a closed state. It is to be appreciated that in some instances when an operator fails to connect the liquid connector properly, the leak-proof seal may not be formed. In such instances, the switch is to remain in the open state. The manner by which the switch is activated, such as changing from the open state to the closed state, is not limited and may include various mechanisms. For example, the switch may include an actuator that may be depressed during activation. In this example, the actuator may also be biased to the open state such that when the liquid connector is not engaged or not properly engage, the actuator is urged to the open state to provide an indication of a poor connector. In other examples, the switch may include a pair of magnets to couple magnetically to each other to trip a sensor, such as a pressure sensor or hall effect sensor, to indicate when a fluidic connection is present. Further examples may include using an optical flag switch, a reed switch, capacitive sensor, a membrane switch, or electrical contact pads.

[0029] Block 120 involves the analysis of the plurality of indicators received

at block 110. In the present example, the analysis is carried out by the processor 25 and may involve evaluating each indicator to determine whether an indicator in the plurality of indicators indicates a poor fluid connection exists, which in turn may lead to a poor startup condition.

[0030] Block 130 involves the processor 25 making a determination whether a poor fluidic connection exists in the printing device, such as during a startup process. In the present example, once the processor 25 identifies a poor fluidic connection exists, the entire printing device is considered to have a poor operating condition and that a process, such as a startup process, is to be stopped. Alternatively, if the processor 25 evaluates all the indicators received at block 110 and does not identify any indicators of a poor fluidic connection at the liquid connectors, the method 100 proceeds to block 140 where operation of the printing device process continues. In some examples, the process may involve evaluating the liquid connectors such that block 140 may be the completion of an operational process. In other examples, the printing device may continue to other processes, such as to calibrate or initialize various components of the printing device. After the method 100 is completed, the printing device may be used to generate output based on print data received at the printing device.

[0031] Continuing with the present example, if the processor 25 evaluates all the indicators received at block 110 and identifies an indicator of a poor fluidic connection at one of the liquid connectors, the method 100 proceeds to block 150. Block 150 involves the transmission of a command to stop the process when the poor fluidic connection is determined to exist. The manner by which the command is transmitted is not limited. For example, the processor 25 may transmit a command to a controller 30, such as a hardware controller to stop a process of the hardware. In other examples, the processor 25 may directly control the hardware and transmit commands to the hardware to stop the all processes. In further examples, the processor 25 may also just stop processes internally such that no other actions in the printing device will be carried out until the poor fluidic connection is rectified.

[0032] Since the present example deems the printing device to have a poor

fluidic connection based on a single indicator from a liquid connector. Accordingly, as soon as the indicator is detected, the method 100 may proceed to block 150 without analyzing any further indicators. In other examples, a single indicator may not be sufficient to determine a poor condition. Accordingly, in these examples, the processor may continue to process additional indicators until a threshold condition is satisfied.

[0033] Referring to figure 3, a flowchart of another method to operate a printing device is shown at 200. In order to assist in the explanation of method 200, it will be assumed that method 200 may be performed with the apparatus 10 shown in figure 1. The method 200 may be another way in which apparatus 10 may be configured. It is to be appreciated that the following discussion of apparatus 10 may lead to a further understanding of the apparatus 10 and its various components. Furthermore, it is to be emphasized, that method 200 may not be performed in the exact sequence as shown, and various blocks may be performed in parallel rather than in sequence, or in a different sequence altogether.

[0034] Beginning at block 210, a plurality of liquid connectors is monitored by the apparatus 10 during a startup process. The startup process is not limited and generally includes a series of actions that the printing device carries out prior to receiving the first print job. In the present example, block 210 may be carried out substantially similar to the execution of block 110 described above.

[0035] Block 220 involves the analysis of the plurality of indicators received at block 210. In the present example, the analysis is carried out by the processor 25 and may involve evaluating each indicator to determine whether an indicator in the plurality of indicators indicates a poor startup connection exists.

[0036] Block 230 involves the processor 25 making a determination whether a poor startup condition exists in the printing device. In the present example, block 230 may be carried out substantially similar to the execution of block 130 described above. If the processor 25 identifies a poor startup condition exists, the method advances to block 240 where a command to stop the startup process is transmitted in a similar manner as described above in block 150.

[0037] Alternatively, if the processor 25 evaluates all the indicators received at block 110 and does not identify any indicators of a poor startup condition at the liquid connectors, the method 200 completes the startup process and proceeds to block 250. In the present example, block 250 involves receiving a plurality of monitoring signals associated with the plurality of liquid connectors as the printing device is operating. The monitoring signals may be similar to the indicators received by the communications interface 15 during the startup process. For example, each liquid connector may be programmed to periodically send a signal to the apparatus 10 regarding the status of the fluidic connection at the fluid connector. Accordingly, the apparatus 10 may then carry out ongoing monitoring of the liquid connectors. The signals received at block 250 may be stored as data in the memory storage unit 20 upon receipt until the processor 25 is ready to analyze the signals. In other examples, each liquid connector may send a signal if the state of the connection is changed. In such examples, the liquid connector may actively self-monitor the quality of the fluidic connection and transmit a signal for the processor 25 when the quality passes a predetermined threshold.

[0038] Block 260 involves the analysis of the plurality of monitoring signals received at block 250 and stored in the memory storage unit 20. In the present example, the analysis is carried out by the processor 25 and may involve evaluating each signal to determine whether a poor operational connection exists.

[0039] Block 270 involves the processor 25 making a determination whether a poor startup condition exists in the printing device. In the present example, the threshold for a poor operational connection is similar to the threshold for a poor startup connection. In particular, the liquid connectors may provide a binary value in the monitoring signal. A single monitoring signal that indicates a poor fluidic connection may result in a determination that a poor operational condition exists and advance the method 200 to block 280.

[0040] Block 280 involves the transmission of a command to stop the operation of the printing device when the poor operating condition is determined to exist. The manner by which the command is transmitted is not limited. For

example, the processor 25 may transmit a command to a controller 30, such as a hardware controller to stop various components of the hardware of the printing device. In other examples, the processor 25 may directly control the hardware and transmit commands to the hardware to stop the operation of the printing device. In further examples, the processor 25 may also just stop the printing device after the completion of a print job such that the printing device may be shut down in an orderly manner to avoid damage to the printing device and wasted materials.

[0041] In some examples, where the signal received at block 250 includes an identifier of the liquid connector from which the signal originated, the processor 25 may be able to stop operations at the location of the poor operational connection. It is to be appreciated that if the liquid connector where the poor operational connection is located is not a special liquid connector, or if sufficient redundancies are provided in the system, the poor operation connection may be service while the printing device continues to operate to generate output to reduce down time of the printing device.

[0042] Alternatively, if the processor 25 evaluates all the signals received at block 250 and does not find any indication of a poor operating condition at the liquid connectors, the method 200 may loop back to block 250. It is to be appreciated that this loop will continue to operate as the printing device generates output. For example, blocks 250 to 270 may continuously be carried out in the background as the printing device generates output. This provides a continuous monitoring system to detect if a fluidic connection fails during operation such that the printing device may be shut down to avoid further damage.

[0043] Referring to figure 4, a printing device is shown at 50. The printing device 50 may include additional components, such as various additional interfaces and/or displays to interact with a user or administrator of the apparatus. In the specific example, the printing device includes a fluidic system having sensors to provide data for controlling the flow of print fluid through the printing device 50. In the present example, the printing device 50 includes the apparatus 10, a fluid supply station 55, a reservoir 60, and a print head 65. The

printing device further includes a plurality of liquid connectors 70 to receive a complimentary connector 80 to form a fluidic connection that is leak-proof. It is to be appreciated that the printing device 50 is not limited and that other printing devices may have additional liquid connectors 70 with complimentary connector 80. In the present example, the fluid supply station 55 is to receive liquid, such as print fluid from an external source. For example, liquid may be pumped into the fluid supply station 55 from a user replaceable fluid supply container. The liquid entering the printing device via the fluid supply station 55 is transferred to the reservoir 60 for storage.

[0044] The reservoir 60 allows for the printing device to generate output. It is to be appreciated that the reservoir 60 may include multiple containers to store various print fluids, such as print fluids having different colors or characteristics. To generate the output from the printing device 50, the print fluid is transferred to the print head 65. In some examples, the liquid may flow through a channel via an e-chain assembly. In other examples, the liquid may flow via flexible tubing or foxed tubing for applications where the print head does not move relative to the reservoir 60.

[0045] Referring to figure 5, the liquid connector 70 is shown in greater detail in the open state. In the present example, the liquid connector 70 includes a fluidic channel 72, an actuator 74, a coil spring 76 and a protective cover 78. As shown in figure 5, the liquid connector 70 is not connected to any other component and thus liquid flowing through the fluidic channel 72 may leak into the printing device 50. This may occur, for example, if the printing device 50 was serviced and an operator or technician fails to reconnect the liquid connector 70. Since the coil spring 76 urges the actuator 74 to the open state, the liquid connector 70 may provide an indication of a poor connection either at startup or during operation, such as if the complimentary connector 80 becomes dislodged during operation.

[0046] It is to be appreciated that variations of the liquid connector are contemplated. For example, the coil spring 76 may be replaced with another bias device such as another type of spring. In some examples, the coil spring 76 may be omitted and the actuator 74 may be a soft flexible material such that

is may be depressed without damage and returns to the original shape after the force used to depress the actuator 74 is removed. In other examples, the actuator itself may also be substituted with another mechanism of indicating that the quality of a seal between the liquid connector 70 and the complimentary connector 80.

[0047] Referring to figure 6, the liquid connector 70 is shown in greater detail in the closed state when engaged with the complimentary connector 80. In the present example, the complimentary connector 80 includes a fluidic channel 82, and a tab 84. It is to be appreciated that the complimentary connector 80 is designed to complement the liquid connector 70 to provide a leak-proof seal between the fluidic channel 72 and the fluidic channel 82.

[0048] In the present example, the tab 84 is to be depress the actuator 74 change the state of the switch on the liquid connector 70 from the open state to the closed state. It is to be appreciated that if the complimentary connector 80 is not properly mated with the liquid connector 70, the tab 84 may not be able to engage the actuator 74 sufficiently to change the state from the open state to the closed state. When the mating of the liquid connector 70 and the complimentary connector 80 is not sufficient, the fluidic channel 72 may not line up with the fluidic channel 82 resulting in lost print fluid and potential damage to the printing device.

[0049] In the present example, the tab 84 may be inserted under the protective cover 78. The protective cover 78 is to protect the actuator 74 from physical damage when the liquid connector 70 is not connected to anything. In other examples, the protective cover 78 may be substituted with another protective mechanism, such as plastic bosses to protect the actuator 74 from accidental depression. When mating with the complimentary connector 80, the protective cover 78 may also be used to apply additional force to the tab 84 to depress the actuator 74. In addition, the protective cover 78 may provide a friction fit to secure the tab 84 and the complimentary connector 80 in place during operation.

[0050] It should be recognized that features and aspects of the various examples provided above may be combined into further examples that also fall

within the scope of the present disclosure.

What is claimed is:

1. A method comprising:

monitoring a plurality of liquid connectors in a printing device, wherein each liquid connector of the plurality of liquid connectors provides an indicator of a state of a connection, wherein the connection is to deliver a print fluid;

analyzing a plurality of indicators to determine whether a poor fluidic connection exists; and

transmitting a command to stop a process when the poor fluidic connection exists.

2. The method of claim 1, wherein the indicator is generated from a switch, the switch to be activated when a leak-proof seal is formed.
3. The method of claim 2, wherein activating the switch comprises depressing an actuator.
4. The method of claim 3, further comprising applying a bias to the actuator to urge the actuator toward an extended position.
5. The method of claim 4, wherein a spring is used to apply the bias to the actuator to urge the actuator toward an extended position.
6. The method of claim 5, further comprising inserting a tab into a protective cover to depress the actuator opposite the protective cover.
7. The method of claim 2, wherein the switch is a membrane switch.

8. The method of claim 1, further comprising receiving a plurality of monitoring signals associated with the plurality of liquid connectors during operation.
9. The method of claim 8, further comprising analyzing the plurality of monitoring signals to determine whether a poor operational connection exists.
10. The method of claim 9, further comprising transmitting a command to stop the operation at the poor operational connection.
11. A printing apparatus comprising:
 - a communications interface to receive a plurality of indicators from a plurality of liquid connectors during a startup process, wherein each indicator is to indicate a state of a connection;
 - a memory storage unit to maintain a database to store the plurality of indicators received via the communications interface;
 - a processor connected to the memory storage unit to retrieve the plurality of indicators and to analyze the plurality of indicators to determine whether a poor startup connection exists; and
 - a controller to transmit a command to stop the startup process when a determination is made that the poor startup connection exists.
12. The apparatus of claim 11, further comprising a switch to generate an indicator of the plurality of indicators, the switch to be activated when a leak-proof seal is formed.
13. The apparatus of claim 12, wherein the switch is an actuator.

14. A non-transitory machine-readable storage medium encoded with instructions executable by a processor, the non-transitory machine-readable storage medium comprising:

instructions to receive a plurality of indicators from a plurality of liquid connectors during a startup process, wherein each liquid connector of the plurality of liquid connectors provides an indicator of a state of a connection;

instructions to analyze the plurality of indicators to determine whether a poor startup connection exists; and

instructions to stop the startup process when the poor startup connection is determined.

15. The non-transitory machine-readable storage medium of claim 14, further comprising instructions to receive a plurality of monitoring signals associated with the plurality of liquid connectors during operation.

1 / 6

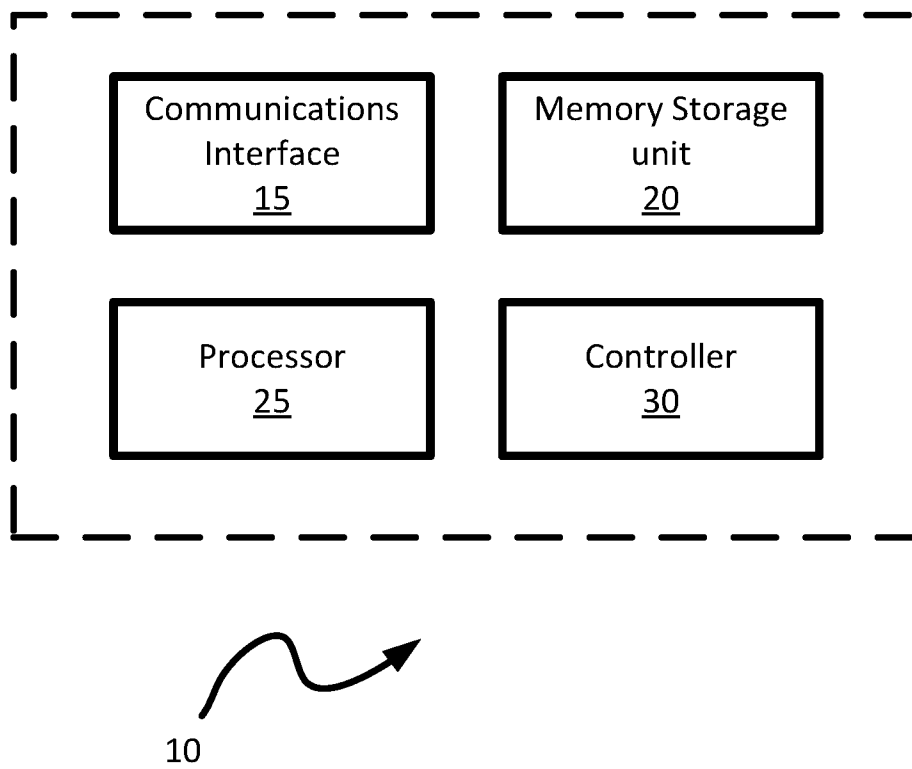


Fig. 1

2 / 6

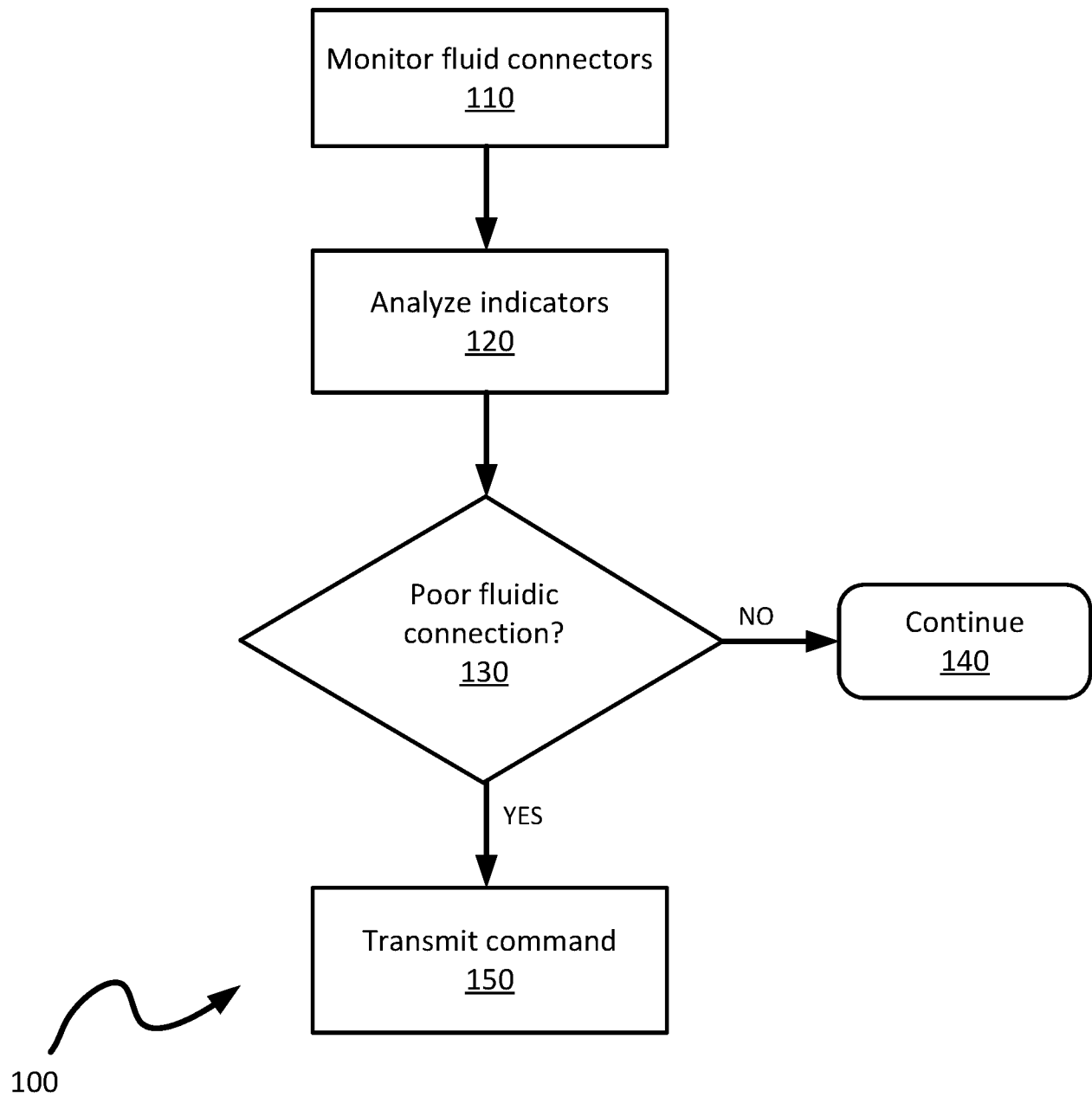


Fig. 2

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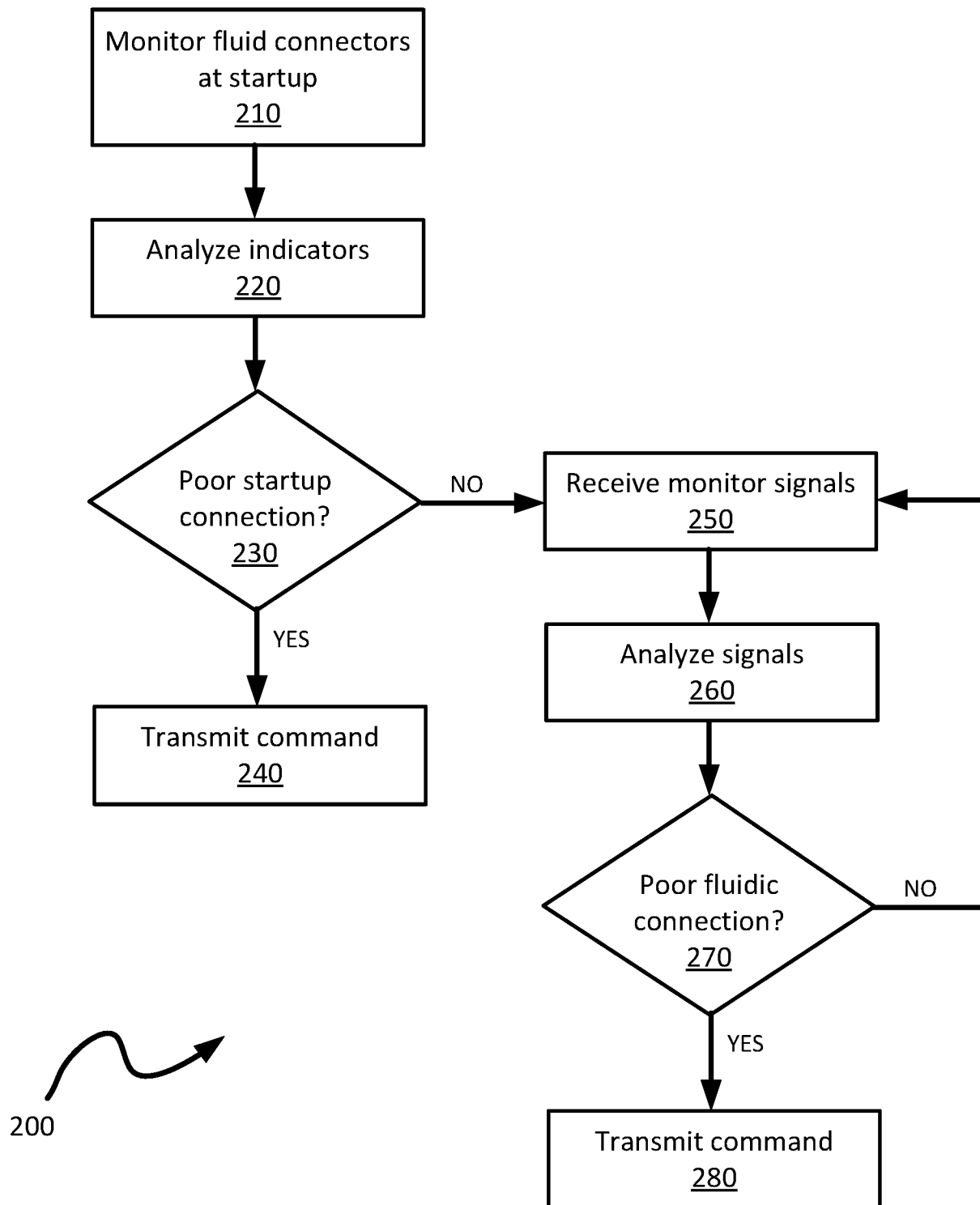


Fig. 3

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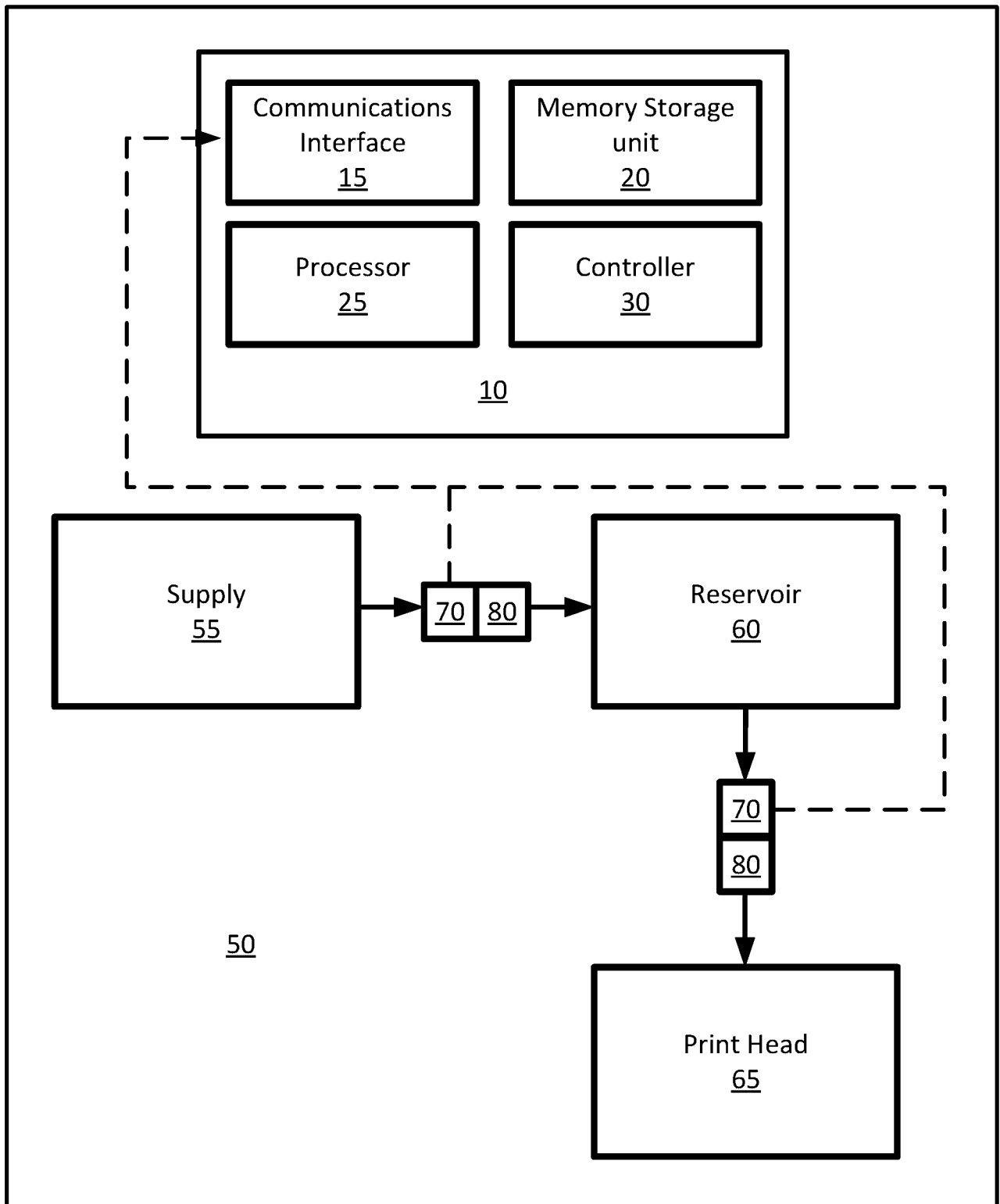


Fig. 4

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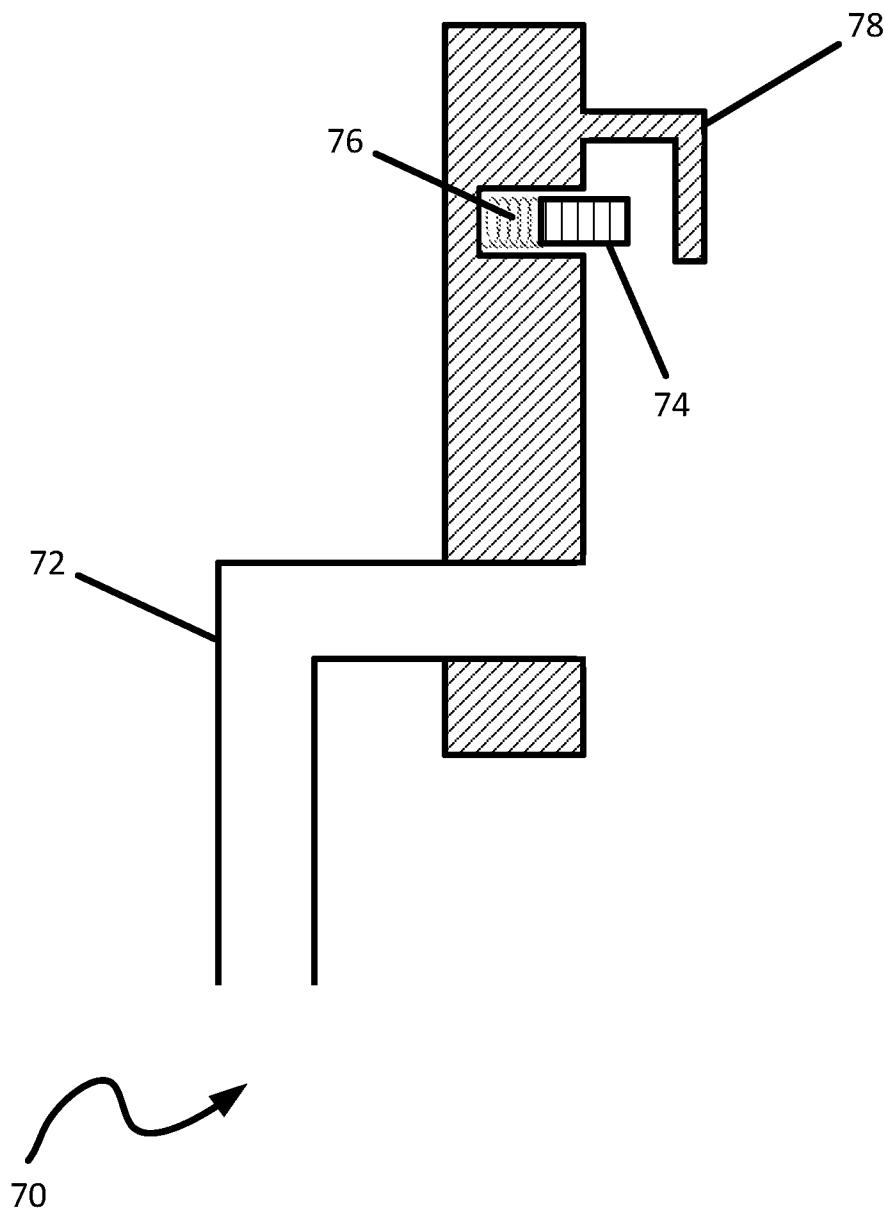


Fig. 5

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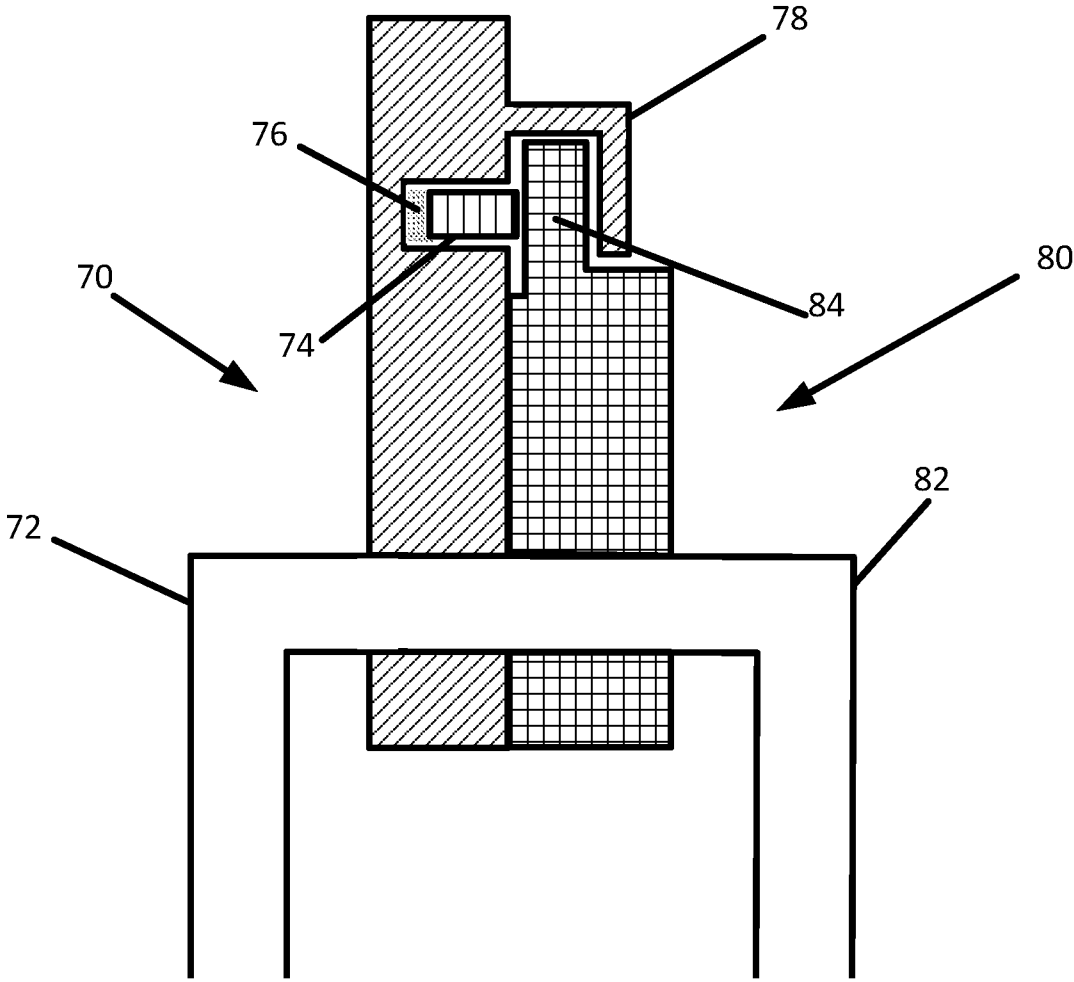


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2018/043322

A. CLASSIFICATION OF SUBJECT MATTER <i>B41J 29/393 (2006.01)</i> <i>B29C 64/30 (2017.01)</i> <i>B33Y 40/00 (2015.01)</i> <i>F17D 5/02 (2006.01)</i> 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 2/00-2/175, 5/00-5/30, 25/00-25/34, 29/00-29/393, B29C 64/00-64/30, B33Y 40/00, F17D 5/00-5/02 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) PatSearch (RUPTO Internal), USPTO, PAJ, Espacenet, Information Retrieval System of FIPS		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002/0113850 A1 (DAVID M. WHEELER et al.) 22.08.2002, paragraphs [0005], [0013], [0018], [0021], [0050], [0054], [0056], [0061] - [0079], [0109] – [0112], [0117]	1-15
A	US 2001/0028371 A1 (WEN-LI SU et al.) 11.10.2001	1-15
A	US 2007/0097160 A1 (DAN C. LYMAN et al.) 03.05.2007	1-15
A	EP 0940259 A3 (HEWLETT-PACKARD COMPANY) 08.09.1999	1-15
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
*	Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “E” earlier document but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed “T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art “&” document member of the same patent family	
Date of the actual completion of the international search	Date of mailing of the international search report	
19 March 2019 (19.03.2019)	04 April 2019 (04.04.2019)	
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37	Authorized officer T. Mamedov Telephone No. 8(495) 531-64-81	