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— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

(54) Title: APPARATUS FOR CLEANING A NOZZLE WITH A DISPENSER AND GANTRY FOR MOVING THE NOZZLE

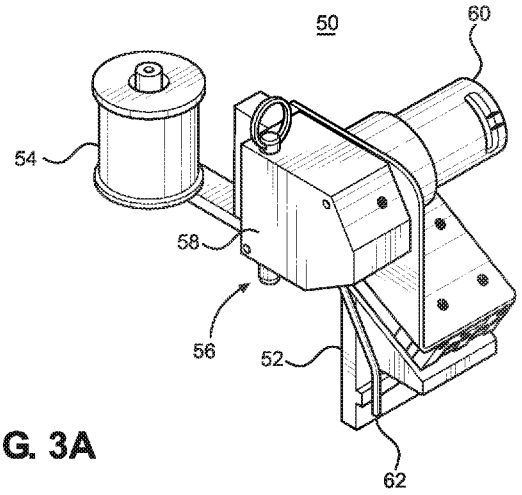

FIG. 3A

(57) Abstract: Apparatuses and a method for cleaning a nozzle by removing an accumulation of material from the surface of a nozzle are disclosed. The apparatus includes a dispenser (50) for dispensing a length of wire and a gantry configured to bring the nozzle into contact with the wire. The wire is in a preferred embodiment, a flux core lead free solder wire having an outer portion containing metal and an inner core containing flux. As the wire is brought into contact with the nozzle, the outer portion of the wire melts due to the heat of the liquid flowing from the nozzle, thereby exposing the chemical agent portion of the wire and removing the accumulation of material, such as dross, from the surface of the nozzle.

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APPARATUS FOR CLEANING A NOZZLE WITH A DISPENSER AND GANTRY FOR MOVING THE NOZZLE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of U.S. Provisional Patent App. No. 62/501,029, filed May 3, 2017, which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates generally to systems and methods for treating a nozzle of a soldering machine, and more particularly, to systems and methods for cleaning a nozzle of a soldering machine using an automatic nozzle tinner.

BACKGROUND

[0003] Dispensing of solder can become ineffective over time due to excessive accumulation of material on an exterior surface of a nozzle. For example, as solder is pumped through a solder nozzle and exposed to oxygen in the air, an accumulation of dross may form on the surface of the nozzle, preventing the flow of solder from the nozzle to the substrate and back into the solder pot. Excessive accumulation of the material can hinder the dispensing of solder and/or truncate the lifecycle of the soldering machine.

[0004] Maintenance of known machines often requires the operator to periodically pause the production cycle and manually inspect multiple nozzles to ensure that excessive accumulation has not occurred. Manual inspection and cleaning can be harmful to the production quality and output consistency of the nozzle due to the unpredictable frequency or duration of time an operator may need to perform the cleaning. In addition, a single operator is often responsible for multiple soldering machines, further increasing the variability of the cleaning process.

[0005] Therefore, there is a need for cleaning nozzles of a soldering machine more effectively and in an automated manner.

SUMMARY

[0006] The foregoing needs are met, to a great extent, by the systems and methods described herein. In one aspect, a system may include a dispenser for dispensing a length of wire. A portion of the wire may include a chemical agent, such as flux, for removing an accumulation of material from the nozzle. The system may further include a mechanism, such as a gantry, for bringing the nozzle into contact with the wire such that the chemical agent removes at least a portion of the accumulation of material from the nozzle.

[0007] In another aspect, an apparatus for applying molten solder to a substrate includes at least one nozzle for applying the molten solder to the substrate, a dispenser for dispensing a length of wire, a gantry configured to move the nozzle relative to the dispenser, and a controller. The wire includes a chemical agent for removing an accumulation of material from the nozzle. The controller is configured to generate one or more signals to determine that an accumulation of the material has formed on the nozzle, dispense a length of wire from the dispenser, and move the gantry in a direction such that the nozzle comes into contact with the chemical agent. The chemical agent then removes at least a portion of the accumulation of material from the nozzle.

[0008] In yet another aspect, a method for cleaning a nozzle of a soldering machine is disclosed. The method may include dispensing a length of wire. A portion of the wire may include a chemical agent, such as flux, for removing an accumulation of material from the nozzle. The method may further include bringing the nozzle into contact with the wire such that the chemical agent removes at least a portion of the accumulation of material from the nozzle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The following detailed description is better understood when read in conjunction with the appended drawings. For the purposes of illustration, examples are shown in the drawings; however, the subject matter is not limited to specific elements and instrumentalities disclosed. In the drawings:

[0010] FIG. 1 illustrates a schematic diagram of a soldering machine;

[0011] FIG. 2 illustrates an example soldering machine;

[0012] FIGS. 3A-3D illustrate an example automatic nozzle tinner;

[0013] FIG. 4 illustrates an example pinch roller mechanism;

[0014] FIG. 5 illustrates a number of circular soldering nozzles that can be used with the soldering machine;

[0015] FIG. 6 illustrates an example flux core solder wire;

[0016] FIG. 7 illustrates an example nozzle in contact with a wire of the automatic nozzle tinner;

[0017] FIG. 8 illustrates a flow chart of an example method for cleaning a nozzle of a soldering machine using a camera;

[0018] FIG. 9 illustrates a flow chart of an example method for cleaning a nozzle of a soldering machine using a flow meter; and

[0019] FIG. 10 illustrates a flow chart of an example method for cleaning a nozzle of a soldering machine using a probe.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0020] Systems and methods for cleaning a nozzle of a soldering machine by removing an accumulation of material from the surface of a nozzle are described herein. The system may include a dispenser for dispensing a length of wire and a gantry configured to bring the nozzle into contact with the wire. The wire may be, for example, a flux core lead free solder wire having an outer portion containing metal and an inner core containing flux. As the wire is brought into contact with the nozzle, the outer portion of the wire may melt due to the heat of the liquid flowing from the nozzle, thereby exposing the chemical agent portion of the wire and removing the accumulation of material (e.g., dross) from the surface of the nozzle.

[0021] With reference to FIGS. 1 and 2, a soldering machine 10 may include a conveyor mechanism 9 for moving a substrate 20 through the soldering machine 10. The conveyor mechanism 9 may be, for example, a dual-lane conveyor mechanism. The substrate 20 may be placed onto the conveyor mechanism 9 at a loading point, and the conveyor mechanism 9 may be configured to move the substrate 20 from one location to another location within the soldering machine 10.

[0022] As shown in FIG. 1, the soldering machine 10 may include a number of stations, zones, or stages, such as a soldering station 19, an inspection station 30, and a cleaning area 44. The soldering station 19 defines an area where molten solder may be applied to the substrate 20

by the nozzle 16. The soldering station 19 may include a position correcting device (not shown) to position the substrate 20 in a correct position on the conveyor mechanism 9 for soldering.

[0023] The soldering machine 10 includes a solder pot 22 for containing the molten solder 24. The solder pot is in fluid communication with the nozzle 16. The nozzle 16 and/or solder pot 22 may be moved in any of the x-direction, y-direction or z-direction by an x-y-z movement mechanism, such as the x-y-z gantry 26 illustrated in FIG. 1. Moving the nozzle 16 and/or solder pot 22 in the x-direction refers to moving the nozzle 16 and/or solder pot 22 in a direction along the axis of the conveyor mechanism 9. Moving the nozzle 16 and/or solder pot 22 in the y-direction refers to moving the nozzle 16 and/or solder pot 22 in a direction transverse to the axis of the conveyor mechanism 9 and perpendicular to the x-direction. Moving the nozzle 16 and/or solder pot in the z-direction refers to moving the nozzle 16 and/or solder pot towards the substrate in a direction perpendicular to the x-y plane.

[0024] The nozzle 16 may be a soldering nozzle, such as a circular soldering nozzle used to apply molten solder 24 to selected component pins on the substrate 20. The nozzle 16 is connected to a pump, such as pump 15 illustrated in FIG. 1. The pump 15 may be, for example, an impeller pump configured to move molten solder from the solder pot 22 through a solder channel (not shown) to the nozzle 16 such that the nozzle 16 can produce a column or fountain of molten solder 24 that extends above the top edge of the nozzle. The nozzle 16 may be moved in a direction towards and away from the substrate and the automatic nozzle tinner 50 independently of the solder pot 22. Independent vertical movement of the nozzle 16 can be implemented, for example, by using an air cylinder on the outside of the solder bath that is connected to a bracket that extends up along the side of solder bath, across the top of the solder bath and then down into the solder bath to be connected to the nozzle, and or the pump, which can be rigidly attached to the nozzle

[0025] The inspection station 30 may be configured to inspect the nozzle 16 to detect an accumulation of material on the nozzle 16. The inspection station 30 may include a camera 32, an angled mirror 34, and a transparent cover 36. The angled mirror 34 may be aligned with the camera 32 such that the angled mirror 34 may be configured to reflect a vertical image of the nozzle 16 horizontally to the camera 32. The transparent cover 36 may protect the angled mirror 34 from any fluid or viscous material that might drip from nozzle 16, as the transparent cover 36 may be easier to clean and/or replace than the angled mirror 34. Alternatively, the camera 32

may be aligned with the nozzle 16 with the transparent cover 36 there between, obviating the need for the angled mirror 34. The camera 32 may be configured to capture an image of the nozzle 16 and transmit the image to the controller 38. The controller 38 may process the image to determine an amount of material accumulated on the nozzle 16. For example, the camera 32 may capture the image in greyscale, and the controller 38 may process the image to generate a value indicating a pixel intensity of the image. In one embodiment, the camera 32 may be positioned on the gantry 26 such that the camera 32 may be moved to different locations in the soldering machine 10 along with the nozzle 16.

[0026] The soldering machine 10 may also include a controller 38 configured to provide overall control of the machine 10, including control over the nozzle 16, the solder pot 22 and the automatic nozzle tinner 50. The controller 38 may include a processor, a memory, and an input/output (I/O) interface. The processor may include one or more devices selected from microprocessors, micro-controllers, digital signal processors, microcomputers, central processing units, field programmable gate arrays, programmable logic devices, state machines, logic circuits, analog circuits, digital circuits, or any other devices that manipulate signals (analog or digital) based on operational instructions that are stored in the memory. The memory may be a single memory device or a plurality of memory devices including but not limited to read-only memory (ROM), random access memory (RAM), volatile memory, non-volatile memory, static random access memory (SRAM), dynamic random access memory (DRAM), flash memory, cache memory, or any other device capable of storing digital information. The memory may also include a mass storage device (not shown) such as a hard drive, optical drive, tape drive, non-volatile solid state device or any other device capable of storing digital information. The processor may operate under the control of an operating system that resides in memory. The operating system may manage controller resources so that computer program code embodied as one or more computer software applications.

[0027] A user interface 17 and/or a control panel 18 may be operatively coupled to the controller 38 to allow a system operator to interact with the controller 38. The user interface 17 may include a video monitor, alphanumeric displays, a touch screen, a speaker, and any other suitable audio and/or visual indicators capable of providing information to the system operator. The control panel 18 may include one or more input devices capable of accepting commands or input from the operator, such as an alphanumeric keyboard, a pointing device, keypads,

pushbuttons, control knobs, microphones. In this way, the user interface 17 and/or the control panel 18 may enable manual initiation of system functions, for example, during set-up, calibration, inspection, and/or cleaning.

[0028] The soldering machine 10 may include a flow meter 40 configured to measure output of the liquid solder from the nozzle 16. In one embodiment, the flow meter 40 may include a pair of rotatable gears and at least one sensor, such as a magnetic pick-up sensor, configured to measure an amount of the liquid solder flowing through the flow meter. The at least one sensor may be configured to measure rotation of the rotatable drive gears to determine an amount of solder flowing out of the nozzle 16.

[0029] In another embodiment, instead of using a flow meter, a probe 13, such as a titanium probe, can be used to determine whether the solder is being delivered at an appropriate height. For example, the titanium probe 13 may be positioned at a location above the nozzle 16 and the flow of solder may be verified based on the solder completing a closed loop between the source of the solder and the titanium probe 13. If the loop is closed, the continuity signal indicates that the height of the solder is at least the same height as the titanium probe 13 and, therefore, not clogged. The continuity signal may be sent to the controller 38 indicating that the solder generated from the nozzle 16 is making contact with the titanium probe 13.

[0030] FIGS. 3A-3D illustrate an example automatic nozzle tinner 50 configured to clean the nozzle 16 configured to apply molten solder to a substrate. As shown, the automatic nozzle tinner 50 may include a mounting bracket 52, a spool receiving unit 54, and a dispenser 56. The dispenser 56 may further include a pinch roller mechanism 58, a motor 60, and a tube 62.

[0031] The mounting bracket 52 may be used to mount the automatic nozzle tinner 50 to a position on the machine 10. Specifically, the mounting bracket 52 may contain one or more screw holes for mounting the automatic nozzle tinner 50 to a rail of the machine 10. The mounting bracket 52 may secure the automatic nozzle tinner 50 to a predetermined location on the rail, or it may allow for the automatic nozzle tinner 50 to be moved along the rail so that the automatic nozzle tinner 50 may come into contact with the nozzle 16.

[0032] The spool receiving unit 54 may be configured to receive a spool of wire, such as the wire 80 shown in FIG. 6. At least a portion of the wire may include a cleaning agent such as a chemical agent for removing an accumulation of material from the nozzle 16. As shown in

FIG. 6, the wire may have an outer portion 82 and an inner portion or "core" 84. The outer portion 82 of the wire 80 may be made of metal, such as tin. However, it is understood that any material may be used for the outer portion 82. The core 84 of the wire 80 may contain the chemical agent. The chemical agent may be a flux chemical agent configured to remove at least a portion of an accumulation of material from the nozzle 16, as discussed further herein. In one example, the wire 80 may be a flux core lead free solder wire. The spool receiving unit 54 may receive the spool of flux core lead free solder wire and may secure the spool of wire 80 to keep the spool in place.

[0033] The dispenser 56 may include a pinch roller mechanism 58, a motor 60 and a tube 62. An example pinch roller mechanism 58 is illustrated in further detail in FIG. 4. The pinch roller mechanism 58 may have at least one rotating gear for pulling the wire 80 through a tube, such as the tube 62. In the example of FIG. 4, the pinch roller mechanism 58 may include an opening 72, a first rotating gear 74 and a second rotating gear 76. The opening 72 may be configured to receive the wire 80 from the spool receiving unit 54. The wire may be fed through the opening 72 to a position between the first gear 74 and the second gear 76 such that the wire is compressed between the first gear 74 and the second gear 76. At least one of the first gear 74 and the second gear 76 may be connected to the motor 60. In the example that the first gear 74 is connected to the motor 60, the motor may be configured to rotate the gear 74 to dispense a length of wire. In another example, the motor may be configured to rotate both the first gear 74 and the second gear 76 to dispense the length of wire. The first gear 74 may be configured such that rotation of the first gear 74 pulls a length of wire from the spool receiving unit 54 through the opening 72 of the pinch roller mechanism 58 and out of the tube 62.

[0034] The length of wire 80 may be determined based on at least one of a type of the nozzle 16 or a size of the nozzle 16. In one embodiment, the nozzle 16 may be a circular soldering nozzle configured to selectively apply molten solder to the substrate 20. As shown in FIG. 5, the circular soldering nozzle may have a circular aperture with a diameter determined based on the substrate to be soldered. The length of wire 80 may increase with the size of the aperture of the nozzle 16, or alternatively, the width of the wire 80 may increase based on the size of the aperture of the nozzle 16. However, it is understood that the nozzle 16 may be any type and that the length and/or width of the wire 80 may be determined based on a number of factors.

[0035] The motor 60 may be configured to control movement of the rotating gear 74 in order to dispense a length of wire 80 through the tube 62. In one example, the motor may be a 24V DC motor. The motor may in communication with the controller 38 and may receive instructions from the controller 38 to control rotation of the gear 74 by a predetermined amount. For example, the controller 38 may instruct the motor 60 to turn the gear 74 one quarter of a turn. Turning the gear 74 one quarter of a turn may result in a "pulling" of one half of an inch of the wire 80 through the tube 62.

[0036] The tube 62 may be configured to receive a length of wire 80 from the pinch roller mechanism 58. In one example, a position of the tube 62 may be adjusted in order to come into contact with the nozzle 16. The automatic nozzle tinner 50 may be positioned such that, after the nozzle 16 is moved into the cleaning area 44, the length of wire sticking out of the tube 62 comes into contact with the nozzle 16 to remove at least a portion of an accumulation material from the nozzle 16.

[0037] As discussed herein, the nozzle 16 may be connected to a mechanism configured to move the nozzle 16 in any of the x-direction, y-direction or z-direction. In one embodiment, the mechanism may be a gantry, such as gantry 26 illustrated in FIG. 1. However, it is understood that the mechanism may be any type of mechanism configured to move the nozzle 16 into a predetermined location, such as the cleaning area 44, to be contacted by the automatic nozzle tinner 50. The gantry 26 may be configured to bring the nozzle 16 into contact with the wire 80 such that the chemical agent 84 removes at least a portion of an accumulation of material, such as dross, from the nozzle 16. The dross may be a metal oxide, such as tin oxide. In one embodiment, the gantry 26 may be configured to move the nozzle 16 relative to the dispenser 56 to bring the nozzle 16 into contact with the wire 80. In another embodiment, the gantry 26 may be configured to move the dispenser 56 relative to the nozzle 16 to bring the nozzle 16 into contact with the wire 80. In yet another embodiment, the gantry may be configured to move both the nozzle 16 and the dispenser 56 to bring the nozzle into contact with the wire 80.

[0038] FIG. 8 illustrates an exemplary flow chart depicting a method 800 of cleaning the nozzle 16 using a camera, such as camera 32 illustrated in FIG. 1. Each of the steps of method 800 may be performed based on one or more signals generated by the controller 38.

[0039] At step 802, the nozzle 16 may dispense a fluid or viscous material. In one embodiment, the nozzle 16 may be a soldering nozzle configured to apply molten solder to a substrate 20. For example, the nozzle 16 may be connected to a solder pot 22 containing molten solder and a pump 27 configured to move the molten solder through a channel and out of the nozzle 16. At least one of the solder pot 22 and the nozzle 16 may be movable in the x-y-z direction in order to selectively apply molten solder to the substrate 20.

[0040] At step 804, the nozzle 16 maybe inspected. The controller 38 may initiate inspection of the nozzle 16 by actuating the camera 32 and processing an image to generate a value. However, the inspecting of step 804 may be performed in a number different of other manners.

[0041] At step 806, the controller 38 may determine if the nozzle 16 is sufficiently clean. For example, step 806 may be performed by determining if the value is within a range relative to (e.g., greater than or equal to) a predetermined value indicating a clean nozzle 16. If the value is within the range indicating a clean nozzle 16, the controller 38 may return to step 802 to continue dispensing with the nozzle 16. However, if the value is not within the range indicating a clean nozzle 16, the controller 38 may proceed to step 808.

[0042] At step 808, in response to determining that the nozzle 16 is not sufficiently clean, the controller 38 may control movement of the nozzle 16 into the cleaning area 44. In one example, the controller 38 may control movement of an x-y-z mechanism, such as the gantry 26, in order to bring the solder pot 22 containing the nozzle 16 into the cleaning area 44. The nozzle 16 may also be independently movable in the x-y-z direction in order to bring the nozzle 16 into the cleaning area 44 and into contact with the automatic nozzle tinner 50.

[0043] At step 810, the automatic nozzle tinner 50 may be configured to remove at least a portion of an accumulation of material from the nozzle 16 while the nozzle is in the cleaning area 44. For example, as discussed herein, the motor 60 associated with the automatic nozzle tinner 50 may be configured to cause rotation of at least one gear of the pinch roller mechanism 58. Rotation of the at least one gear may cause output of a length of wire 80 from the tube 62 of the automatic nozzle tinner 50. The nozzle 16 may be in a position in the cleaning area 44 such that the length of wire contacts the nozzle 16 upon being dispensed from the tube 62. Additionally or alternatively, at least one of the solder pot 22 and the nozzle 16 may move within the cleaning area 44 in any of the x-direction, y-direction or z-direction in order to come into

contact with the wire 80 output from the tube 62. As the wire 80 contacts the molten solder flowing from the nozzle 16, an outer portion 82 of the wire 80 may melt, causing a chemical agent portion 84 of the wire to be exposed. The chemical agent portion 84 of the wire 80 may contain flux. As the chemical agent comes into contact with the molten solder flowing from the nozzle 16, the chemical agent may remove at least a portion of the accumulation of material from the nozzle 16.

[0044] At step 812, after a predetermined amount of time, the nozzle 16 may be inspected. The controller 38 may initiate inspection of the nozzle 16 by actuating the camera 32 and processing an image to generate a value, as discussed above in connection with step 804.

[0045] At step 814, the controller 38 may determine if the nozzle 16 is sufficiently clean. If the nozzle 16 is sufficiently clean ("YES"), the controller 38 may proceed to step 816. If the nozzle is not sufficiently clean ("NO"), the controller 38 may return to step 810 to dispense a second length of wire 80 and to bring the nozzle 16 into contact with the wire 80 for further removal of material from the nozzle 16. In one embodiment, the controller 38 may limit the number of times the nozzle 16 is cleaned before the controller 38 stops the clean and inspect process described in FIG. 8. For example, if the nozzle 16 is cleaned and inspected three times in a row and the controller determines that the nozzle 16 still is not sufficiently clean, the controller 38 may stop the clean and inspect process and alert an operator of the soldering machine 10.

[0046] At step 816, the nozzle 16 may be moved back into the soldering station 19 where the nozzle 16 may continue to dispense the fluid or viscous material onto the substrate 20. In the example that the nozzle 16 is a soldering nozzle, the nozzle 16 may continue to apply molten solder to the substrate 20 according to instructions contained in a computer program.

[0047] FIG. 9 illustrates an exemplary flow chart depicting a method 900 of cleaning the nozzle 16 using a flow meter, such as flow meter 46 illustrated in FIG. 1. Each of the steps of method 900 may be performed based on one or more signals generated by the controller 38.

[0048] At step 902, the nozzle 16 may dispense a fluid or viscous material. In one embodiment, the nozzle 16 may be a soldering nozzle configured to apply molten solder to a substrate 20. For example, the nozzle 16 may be connected to a solder pot 22 containing molten solder and a pump 27 configured to move the molten solder through a channel and out of the

nozzle 16. At least one of the solder pot 22 and the nozzle 16 may be movable in the x-y-z direction in order to selectively apply molten solder to the substrate 20.

[0049] At step 904, the flow meter 46 may measure a flow of liquid from the nozzle 16. In the example that the nozzle 16 is a soldering nozzle, the flow meter may be configured to measure the flow rate of solder from of the nozzle 16 to the substrate 20. In one embodiment, the flow meter 46 may measure an amount of solder flowing from the nozzle 16 per second. However, the measuring of step 904 may be performed in a number of different other manners. The flow meter may be configured to send the flow measurements to the controller 38.

[0050] At step 906, the controller 38 may compare the amount of liquid flowing from the nozzle 16 to a threshold. For example, step 906 may be performed by determining if the amount of liquid flowing from the nozzle 16 is within a range relative to (e.g., greater than or equal to) a predetermined value indicating a clean nozzle 16. If the value is within the range indicating a clean nozzle 16, the controller 38 may return to step 802 to continue dispensing with the nozzle 16. However, if the value is not within the range indicating a clean nozzle 16, the controller 38 may proceed to step 908.

[0051] At step 908, in response to determining that the nozzle 16 is not sufficiently clean, the controller 38 may control movement of the nozzle 16 into the cleaning area 44. In one example, the controller 38 may control movement of an x-y-z mechanism, such as the gantry 26, in order to bring the solder pot 22 containing the nozzle 16 into the cleaning area 44. The nozzle 16 may also be independently movable in the x-y-z direction in order to bring the nozzle 16 into the cleaning area 44 and into contact with the automatic nozzle tinner 50.

[0052] At step 910, the automatic nozzle tinner 50 may be configured to remove at least a portion of an accumulation of material from the nozzle 16 while the nozzle is in the cleaning area 44, as discussed above in connection with step 810 of FIG. 8.

[0053] At step 912, after a predetermined amount of time, the flow meter 46 may again measure an amount of liquid flowing from the nozzle 16, as discussed above in connection with step 904. The flow meter 46 may further be configured to send the flow measurements to the controller 38.

[0054] At step 914, the controller 38 may determine if the nozzle is sufficiently clean, as in step 908. If the nozzle 16 is sufficiently clean ("YES"), the controller 38 may proceed to step 916. If the nozzle is not sufficiently clean ("NO"), the controller 38 may return to step 910

to dispense a second length of wire 80 and to bring the nozzle 16 into contact with the wire 80 for further removal of material from the nozzle 16. In one embodiment, the controller 38 may limit the number of times the nozzle 16 is cleaned before the controller 38 stops the clean and inspect process described in FIG. 9. For example, if the nozzle 16 is cleaned and inspected three times in a row and the controller 38 determines that the nozzle 16 still is not sufficiently clean, the controller 38 may stop the clean and inspect process and alert an operator of the machine 10.

[0055] At step 916, the nozzle 16 may be moved back into the soldering station 19 where the nozzle 16 may continue to dispense the fluid or viscous material onto the substrate 20. In the example that the nozzle 16 is a soldering nozzle, the nozzle 16 may continue to apply molten solder to the substrate 20 according to instructions contained in a computer program.

[0056] FIG. 10 illustrates an exemplary flow chart depicting a method 1000 of cleaning the nozzle 16 using the probe 13. Each of the steps of method 1000 may be performed based on one or more signals generated by the controller 38.

[0057] At step 1002, the nozzle 16 may dispense a fluid or viscous material. In one embodiment, the nozzle 16 may be a soldering nozzle configured to apply molten solder to a substrate 20. For example, the nozzle 16 may be connected to a solder pot 22 containing molten solder and a pump 27 configured to move the molten solder through a channel and out of the nozzle 16. At least one of the solder pot 22 and the nozzle 16 may be movable in the x-y-z direction in order to selectively apply molten solder to the substrate 20.

[0058] At step 1004, the probe 13 may measure a height of the dispensed liquid from the nozzle 16 relative to the probe. In one example, the probe 13 may be located in a fixed position above the nozzle 16 and may determine whether the dispensed liquid from the nozzle 16 is making contact with the probe 13. In another example, the probe 13 may be moveable relative to the nozzle 16 and may be configured to measure an actual height of the dispensed liquid. The probe 13 may be configured to send to the controller 38 a continuity signal indicating that the probe 13 is in contact with the liquid dispensed from the nozzle 16.

[0059] At step 1006, the controller 38 may receive the signal from the probe 13 and determine whether the nozzle 16 needs to be cleaned. For example, if the continuity signal is not sent to the controller 38, thereby indicating that the dispensed liquid is not making contact with the probe 13, the controller 38 may determine that the nozzle needs cleaning. In another

example, if the dispensed liquid is making contact with the probe 13, than the controller 38 will receive the continuity signal and determine that the nozzle 16 is sufficiently clean.

[0060] At step 1008, in response to determining that the nozzle 16 is not sufficiently clean and needs cleaning, the controller 38 may control movement of the nozzle 16 into the cleaning area 44. In one example, the controller 38 may control movement of an x-y-z mechanism, such as the gantry 26, in order to bring the solder pot 22 containing the nozzle 16 into the cleaning area 44. The nozzle 16 may also be independently movable in the x-y-z direction in order to bring the nozzle 16 into the cleaning area and into contact with the automatic nozzle tinner 50.

[0061] At step 1010, the automatic nozzle tinner 50 may be configured to remove at least a portion of an accumulation of material from the nozzle 16 while the nozzle is in the cleaning area 44, as discussed above in connection with step 810 of FIG. 8.

[0062] At step 1012, after a predetermined amount of time, the probe 13 may again measure a height of the dispensed liquid from the nozzle 16 relative to the probe, as discussed above in connection with step 1004. The probe may further be configured to send the flow measurements to the controller 38.

[0063] At step 1014, the controller 38 may determine if the nozzle is sufficiently clean. If the nozzle 16 is sufficiently clean and does not require cleaning, the controller 38 may proceed to step 1016. If the nozzle is not sufficiently clean and does require cleaning, the controller 38 may return to step 1010 to dispense a second length of wire 80 and to bring the nozzle 16 into contact with the wire 80 for further removal of material from the nozzle 16. In one embodiment, the controller 38 may limit the number of times the nozzle 16 is cleaned before the controller 38 stops the clean and inspect process described in FIG. 10. For example, if the nozzle 16 is cleaned and inspected three times in a row and the controller 38 determines that the nozzle 16 still is not sufficiently clean, the controller 38 may stop the clean and inspect process and alert an operator of the machine 10.

[0064] At step 1016, the nozzle 16 may be moved back into the soldering station 19 where the nozzle 16 may continue to dispense a fluid or viscous material onto a substrate 20. In the example that the nozzle 16 is a soldering nozzle, the nozzle 16 may continue to apply molten solder to the substrate according to instructions contained in a computer program.

[0065] In one embodiment, the nozzle 16 may be cleaned at predetermined intervals according to instructions contained in a computer program. For example, as the nozzle 16 applies molten solder to the substrate 20, the molten solder may form a reaction with oxygen in the air, leading to the formation of dross on a surface of the nozzle 16. The nozzle 16 may be brought into contact with a wire 80 sticking out from a tube 62 of the automatic nozzle tinner 50 at predetermined intervals in order to remove the dross from the surface of the nozzle 16. The gantry 26 may be configured to automatically bring the nozzle 16 into contact with the wire 80 in response to a control signal indicating that the nozzle 16 requires cleaning. For example, a computer program may instruct the automatic nozzle tinner 50 to remove at least a portion of the accumulation of material from the nozzle 16 after a predetermined number of components have been soldered. In another example, the automatic nozzle tinner 50 may receive instructions to clean the nozzle 16 after every time a substrate 20 is soldered or after a predetermined number of substrates 20 have been soldered. In yet another example, the automatic nozzle tinner 50 may receive instructions to clean the nozzle 16 after a predetermined time period. However, it is understood that the instructions may cause the nozzle 16 to be cleaned by the automatic nozzle tinner 50 based on any number of factors or a combination of those factors.

[0066] In another embodiment, the control signal indicating that the nozzle 16 requires cleaning may be received from a user. For example, a user of the soldering machine 10 may provide instructions to clean the nozzle of the soldering machine through the user interface 17. In response to the control signal received through the user interface 17 indicating that the nozzle requires cleaning, the gantry 26 may be configured to automatically bring the nozzle 16 into the cleaning area 44 where a chemical agent 84 of the wire 80 may make contact with the wire 80.

[0067] While the disclosure has been described in connection with the various embodiments of the figures, it is to be understood that other similar embodiments can be used or modifications and additions can be made to the described embodiments. For example, while the nozzle 16 has been described as a soldering nozzle incorporated in a soldering machine 10, it is understood that the nozzle may be any type of nozzle. Therefore, the methods and systems as described herein should not be limited to any single embodiment, but rather should be construed in breadth and scope in accordance with the appended claims.

[0068] One or more of software modules incorporating the methods described above can be integrated into a computer system or non-transitory computer-readable media. Moreover,

while illustrative embodiments have been described herein, the scope includes any and all embodiments having equivalent elements, modifications, omissions, combinations (e.g., of aspects across various embodiments), adaptations or alterations based on the present disclosure. Further, the steps of the disclosed methods can be modified in any manner, including by reordering steps or inserting or deleting steps.

What is claimed is:

1. An apparatus for cleaning a nozzle, the apparatus comprising:

a dispenser for dispensing a length of wire, the wire comprising a chemical agent for removing an accumulation of material from the nozzle; and

a gantry configured to bring the nozzle to a position adjacent the dispenser such that the wire and the nozzle can be brought into contact to allow the chemical agent to remove at least a portion of the accumulation of material from the nozzle.

2. The apparatus of claim 1, wherein the nozzle is a soldering nozzle.

3. The apparatus of claim 2, wherein the nozzle is a circular selective soldering nozzle configured to apply molten solder to a substrate.

4. The apparatus of claim 1, wherein the chemical agent comprises flux.

5. The apparatus of claim 1, wherein the wire is a metal wire.

6. The apparatus of claim 5, wherein the metal wire comprises tin.

7. The apparatus of claim 1, wherein the wire comprises an outer surface and a core, the chemical agent being within the core.

8. The apparatus of claim 1, wherein the dispenser comprises a motor configured to rotate at least one rotating gear to dispense the length of wire.

9. The apparatus of claim 1, wherein the length or width of the wire is determined based on a type of the nozzle or a size of the nozzle.

10. The apparatus of claim 1, wherein the material comprises dross.

11. The apparatus of claim 10, wherein the dross is a metal oxide.

12. The apparatus of claim 11, wherein the metal oxide comprises tin oxide.

13. The apparatus of claim 1, wherein the nozzle is moved relative to the dispenser such that the wire and the nozzle can be brought into contact.

14. The apparatus of claim 1, wherein the dispenser is moved relative to the nozzle such that the wire and the nozzle can be brought into contact.

15. The apparatus of claim 1, wherein the nozzle and the dispenser are moved relative to each other such that the wire and the nozzle can be brought into contact.

16. The apparatus of claim 1, wherein the nozzle remains in contact with the wire for a predetermined time period.

17. The apparatus of claim 16, wherein the gantry is configured to move the nozzle away from the wire after the predetermined time period.

18. The apparatus of claim 17, wherein the dispenser is configured to dispense a second length of wire after the nozzle is moved away from the wire.

19. The apparatus of claim 1, wherein the gantry is configured to automatically bring the nozzle to a position adjacent the dispenser such that the wire and the nozzle can be brought into contact in response to a control signal indicating that the nozzle requires cleaning.

20. The apparatus of claim 19, wherein the control signal indicating that the nozzle requires cleaning is received from a user of the apparatus.

21. The apparatus of claim 19, wherein the control signal indicating that the nozzle requires cleaning is automatically determined based on application characteristics of the nozzle.

22. The apparatus of claim 19, wherein the control signal indicating that the nozzle requires cleaning is automatically determined based on processing of an image of the nozzle.

23. The apparatus of claim 19, wherein the control signal indicating that the nozzle requires cleaning is automatically determined based on termination of reception of a continuity signal received from a probe.

24. A method for cleaning a nozzle, the method comprising:

dispensing a length of wire, the wire comprising a chemical agent for removing an accumulation of material from the nozzle; and

bringing the nozzle to a position adjacent the dispenser such that the wire and the nozzle are brought into contact to allow the chemical agent to remove at least a portion of the accumulation of material from the nozzle.

25. The method of claim 24, wherein the nozzle is a soldering nozzle.

26. The method of claim 25, wherein the soldering nozzle is a circular selective soldering nozzle configured to apply molten solder to a substrate.

27. The method of claim 24, wherein the chemical agent comprises flux.

28. The method of claim 24, wherein the wire is a metal wire.

29. The method of claim 28, wherein the metal wire comprises tin.

30. The method of claim 24, wherein the wire comprises an outer surface and a core, the chemical agent being within the core.

31. The method of claim 24, wherein dispensing the length of wire comprises rotating at least one gear using a motor.

32. The method of claim 24, further comprising determining the length or width of the wire to dispense based on a type of the nozzle or a size of the nozzle.

33. The method of claim 24, wherein the material comprises dross.

34. The method of claim 33, wherein the dross is a metal oxide.

35. The method of claim 34, wherein the metal oxide comprises tin oxide.

36. The method of claim 24, wherein bringing the wire and the nozzle into contact comprises moving the nozzle relative to a dispenser of the wire.

37. The method of claim 24, wherein bringing the wire and the nozzle into contact comprises moving a dispenser of the wire relative to the nozzle.

38. The method of claim 24, wherein bringing the wire and the nozzle into contact comprises moving both the nozzle and a dispenser of the wire.

39. The method of claim 24, wherein bringing the nozzle into contact with the wire comprises maintaining the nozzle in contact with the wire for a predetermined time period.

40. The method of claim 39, further comprising moving the nozzle away from the wire after the predetermined time period.

41. The method of claim 40, further comprising dispensing a second length of wire after the nozzle is moved away from the wire.

42. The method of claim 24, wherein bringing the wire and the nozzle into contact comprises receiving a control signal indicating that the nozzle requires cleaning.

43. The method of claim 42, wherein receiving the control signal indicating that the nozzle requires cleaning comprises receiving the control signal from a user.

44. The method of claim 42, wherein receiving the control signal indicating that the nozzle requires cleaning comprises determining that the nozzle requires cleaning based on application characteristics of the nozzle.

45. The method of claim 42, wherein receiving the control signal indicating that the nozzle requires cleaning comprises determining that the nozzle requires cleaning based on processing of an image of the nozzle.

46. The method of claim 42, wherein receiving the control signal indicating that the nozzle requires cleaning comprises determining that a continuity signal received from a probe has been terminated.

47. An apparatus for applying molten solder to a substrate, the apparatus comprising:

at least one nozzle for applying the molten solder to the substrate;

a dispenser for dispensing a length of wire, the wire comprising a chemical agent for removing an accumulation of material from the nozzle;

a gantry configured to bring the nozzle to a position adjacent the dispenser; and

a controller configured to generate one or more signals to:

determine that an accumulation of the material has formed on the nozzle;

dispense an length of wire from the dispenser; and

move the gantry in a direction such that the wire and nozzle are brought into contact with the chemical agent, the chemical agent removing at least a portion of the accumulation of material from the nozzle.

48. The apparatus of claim 47, wherein the controller is configured to determine that the accumulation of material has formed on the nozzle by receiving input from a user of the apparatus.

49. The apparatus of claim 47, wherein the controller is configured to determine that the accumulation of material has formed on the nozzle by receiving input based on application characteristics of the nozzle.

50. The apparatus of claim 47, wherein the controller is configured to determine that the accumulation of material has formed on the nozzle by receiving input based on processing of an image of the nozzle.

51. The apparatus of claim 47, wherein the controller is configured to determine that the accumulation of material has formed on the nozzle based on termination of reception of a continuity signal received from a probe.

52. The apparatus of claim 47, wherein the dispenser comprises a motor configured to rotate at least one rotating gear.

53. The apparatus of claim 52, wherein the controller is configured to dispense the length of wire from the dispenser by generating one or more signals that cause the motor to rotate the at least one rotating gear to dispense the length of wire.

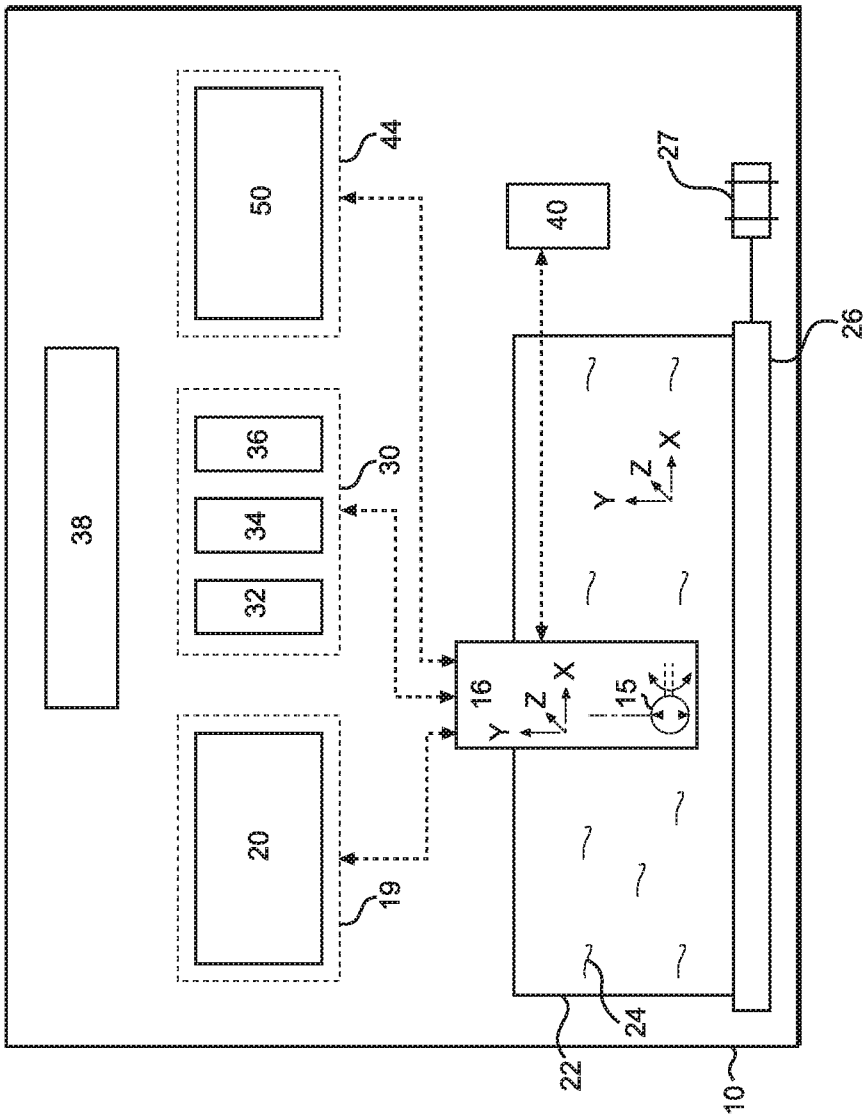

FIG. 1

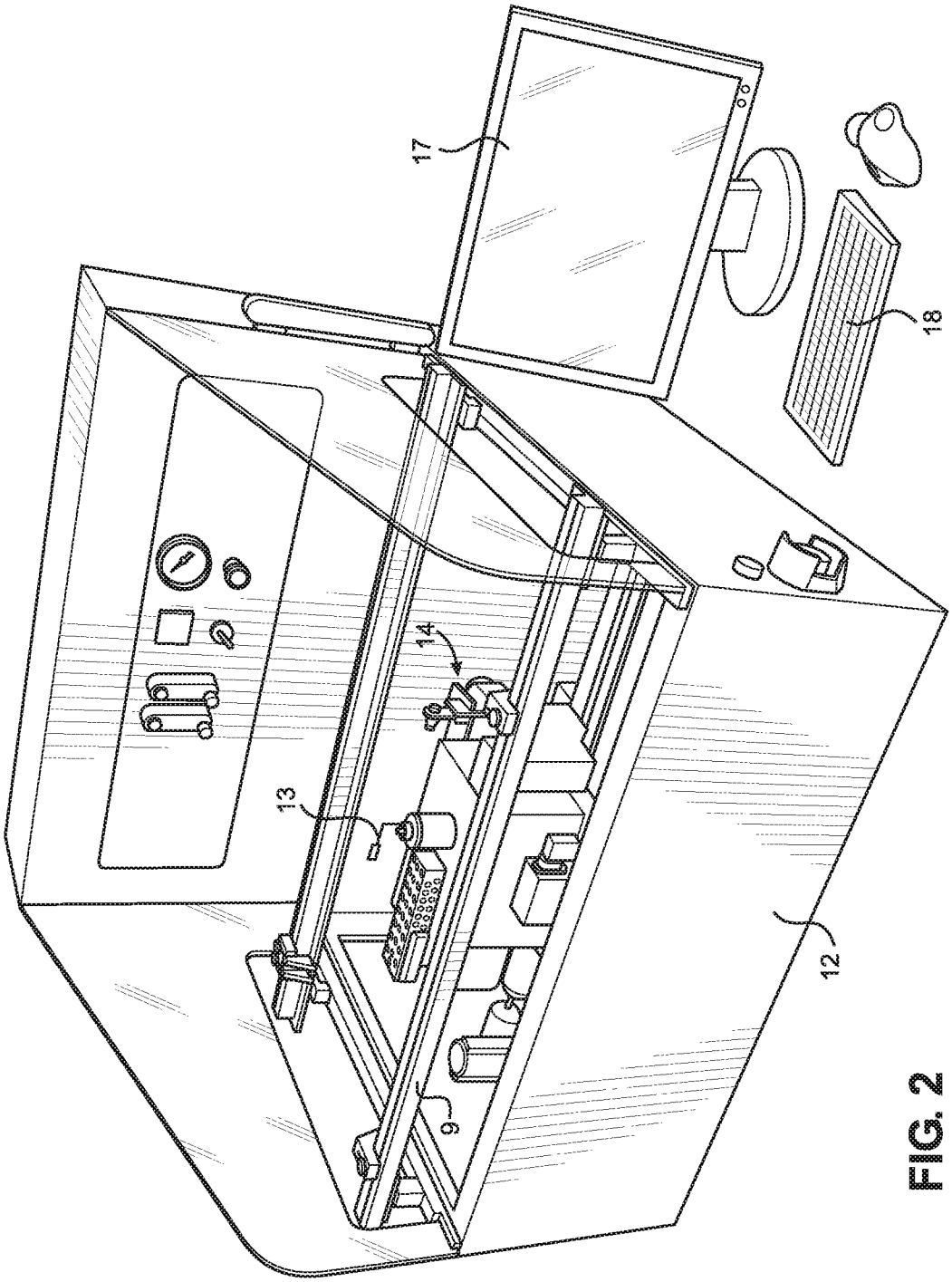

FIG. 2

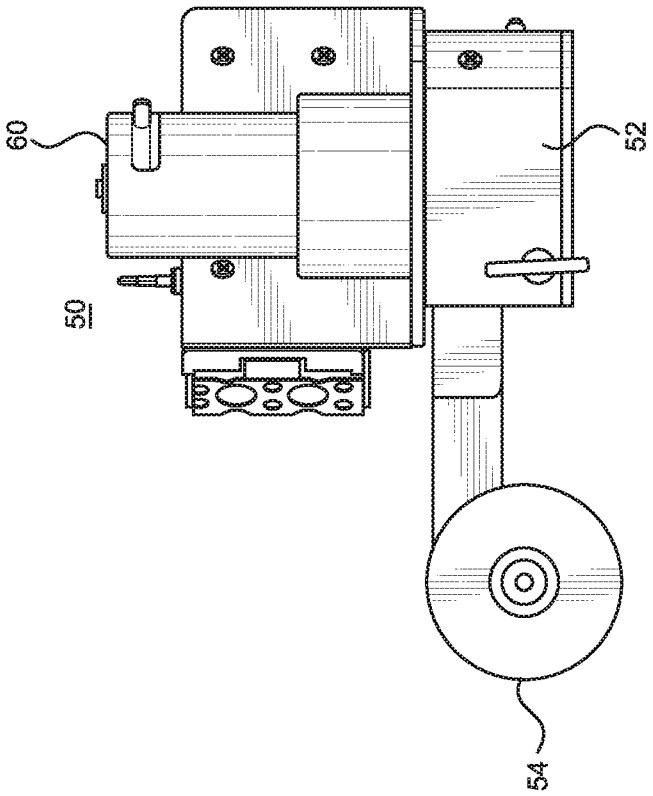

FIG. 3B

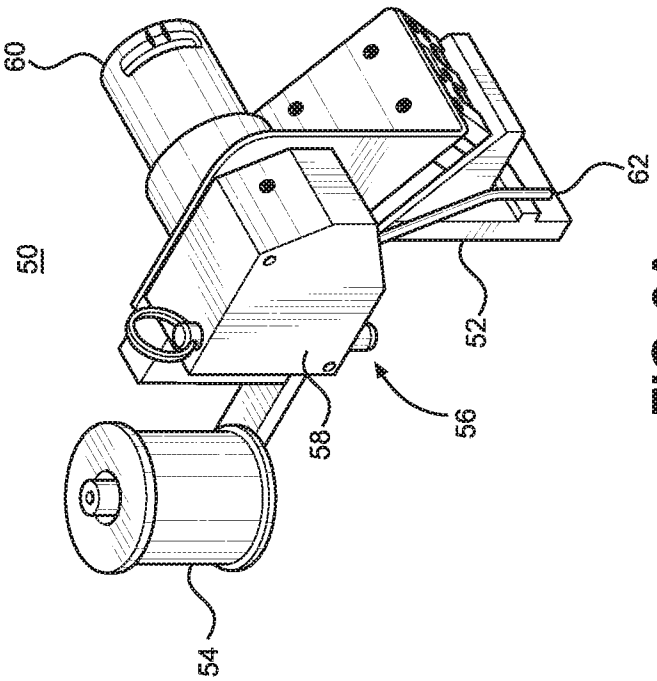

FIG. 3A

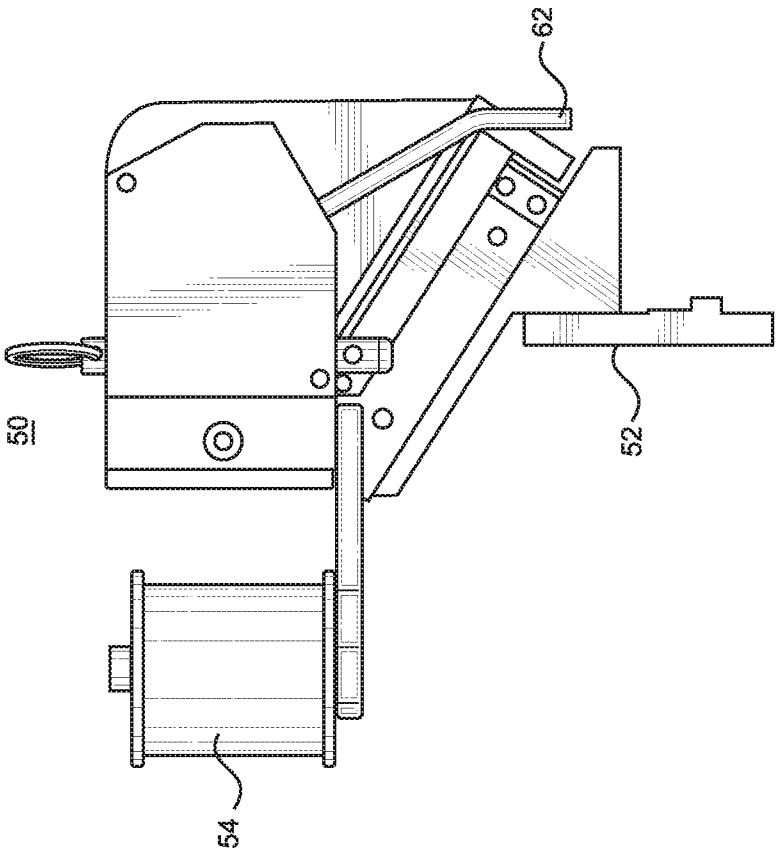

FIG. 3D

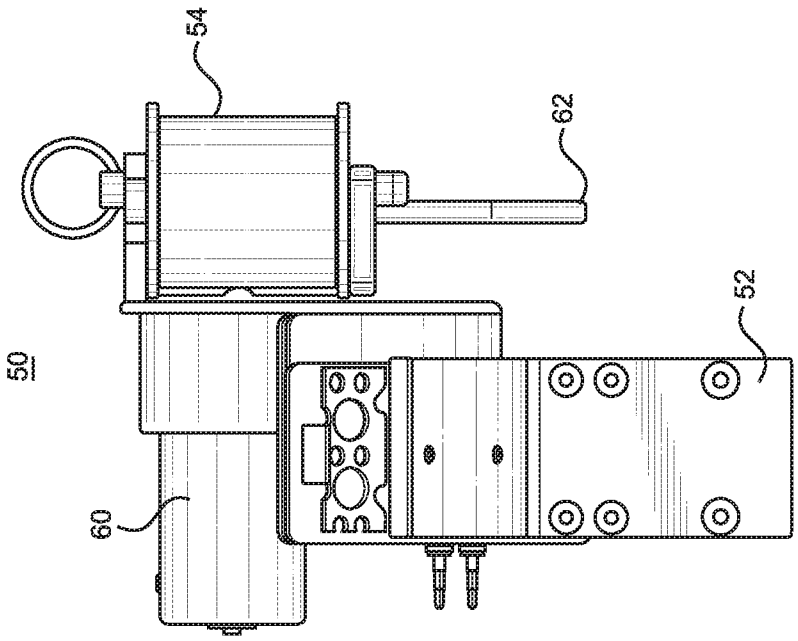

FIG. 3C

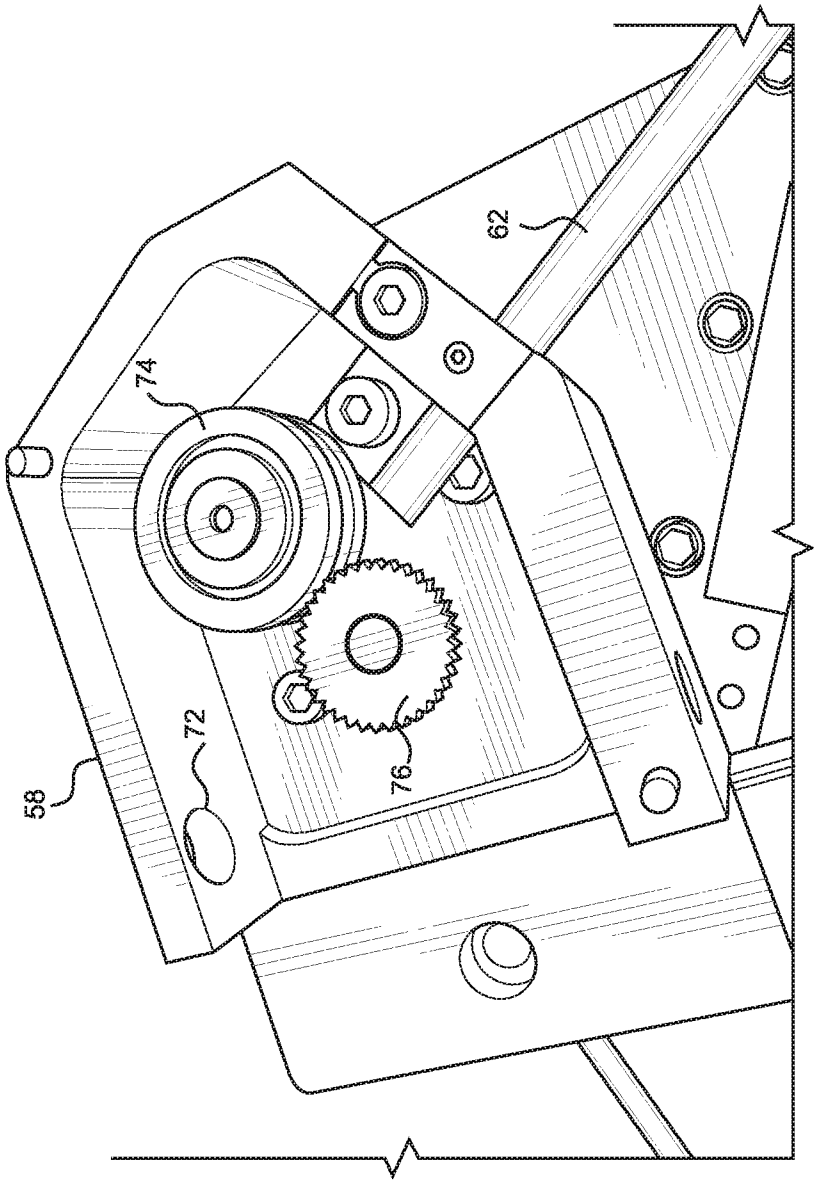

FIG. 4

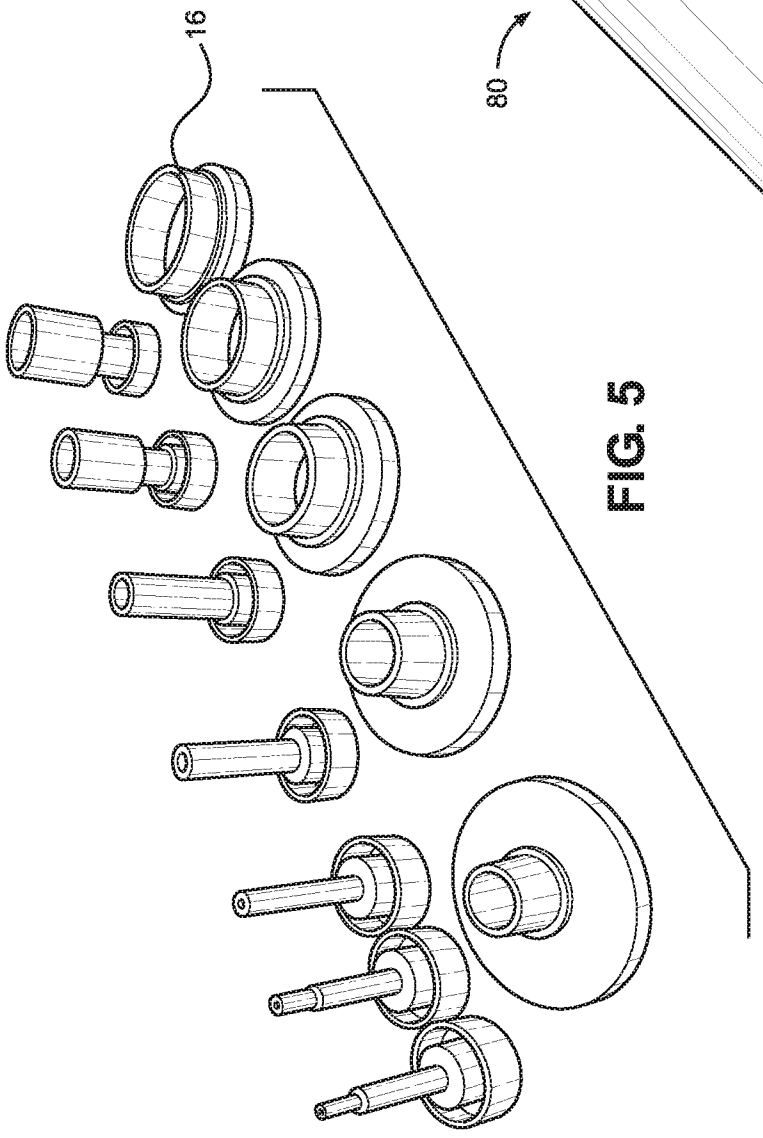

FIG. 5

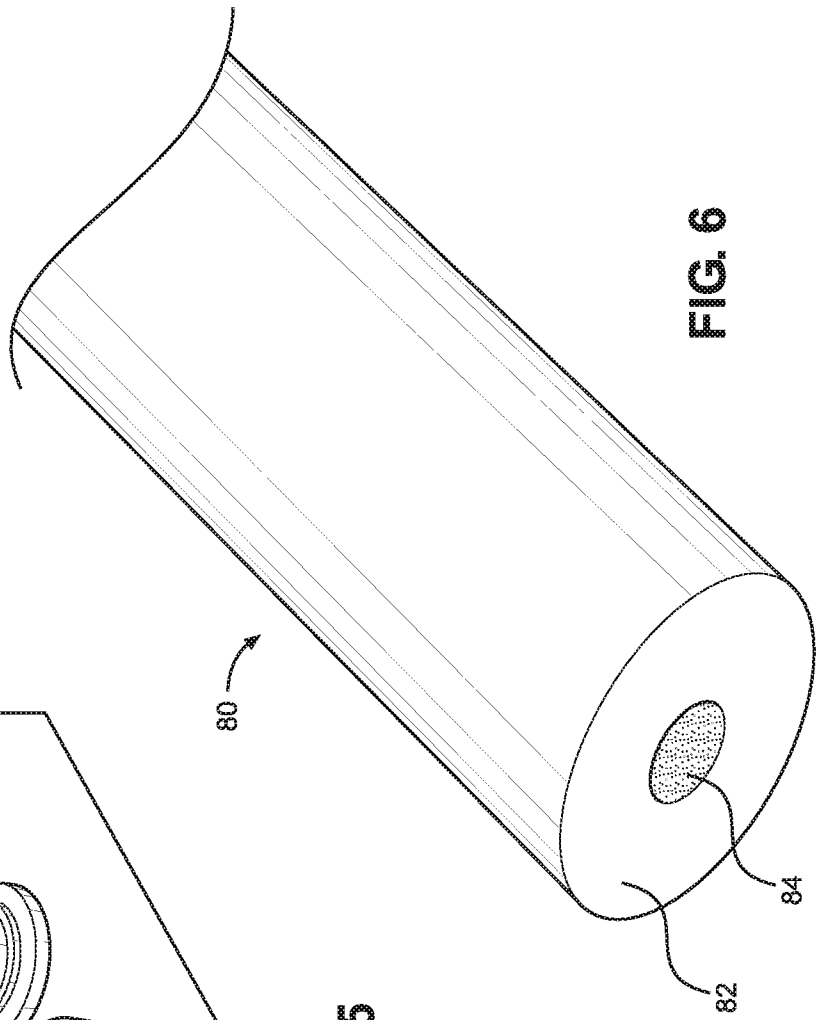

FIG. 6

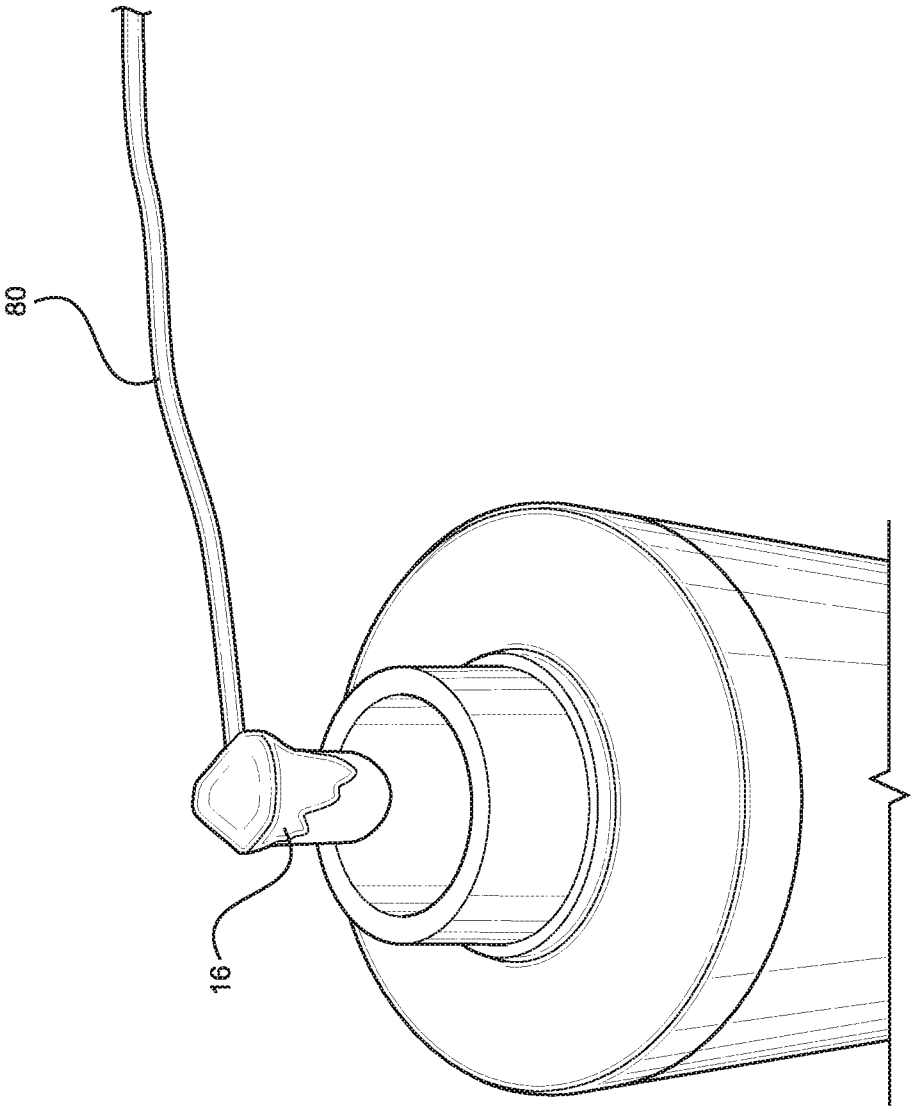

FIG. 7

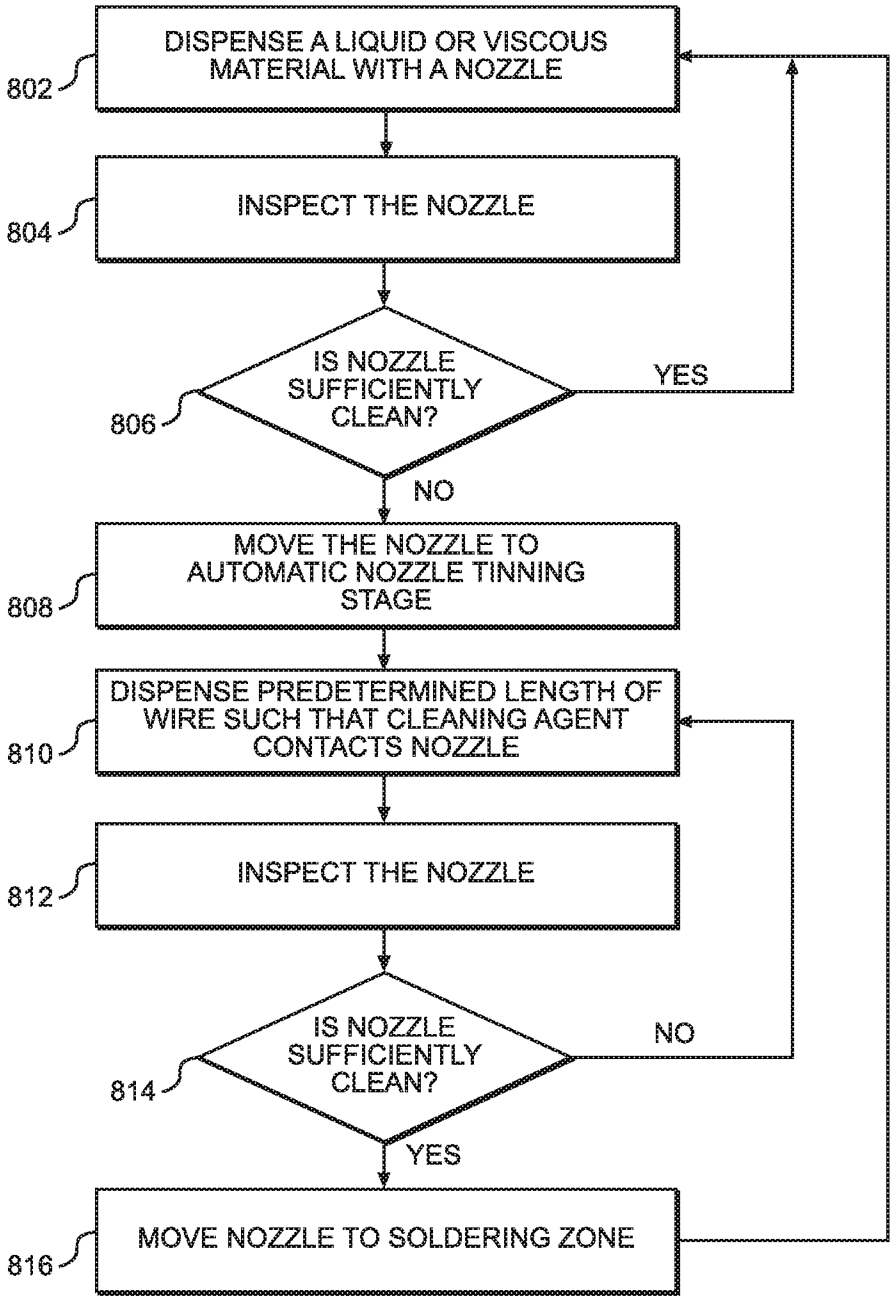
DISPENSE A LIQUID OR VISCOUS MATERIAL WITH A NOZZLE
802
INSPECT THE NOZZLE
804
IS NOZZLE SUFFICIENTLY CLEAN?
806
YES
NO
MOVE THE NOZZLE TO AUTOMATIC NOZZLE TINNING STAGE
808
DISPENSE PREDETERMINED LENGTH OF WIRE SUCH THAT CLEANING AGENT CONTACTS NOZZLE
810
INSPECT THE NOZZLE
812
IS NOZZLE SUFFICIENTLY CLEAN?
814
NO
YES
MOVE NOZZLE TO SOLDERING ZONE
816

FIG. 8

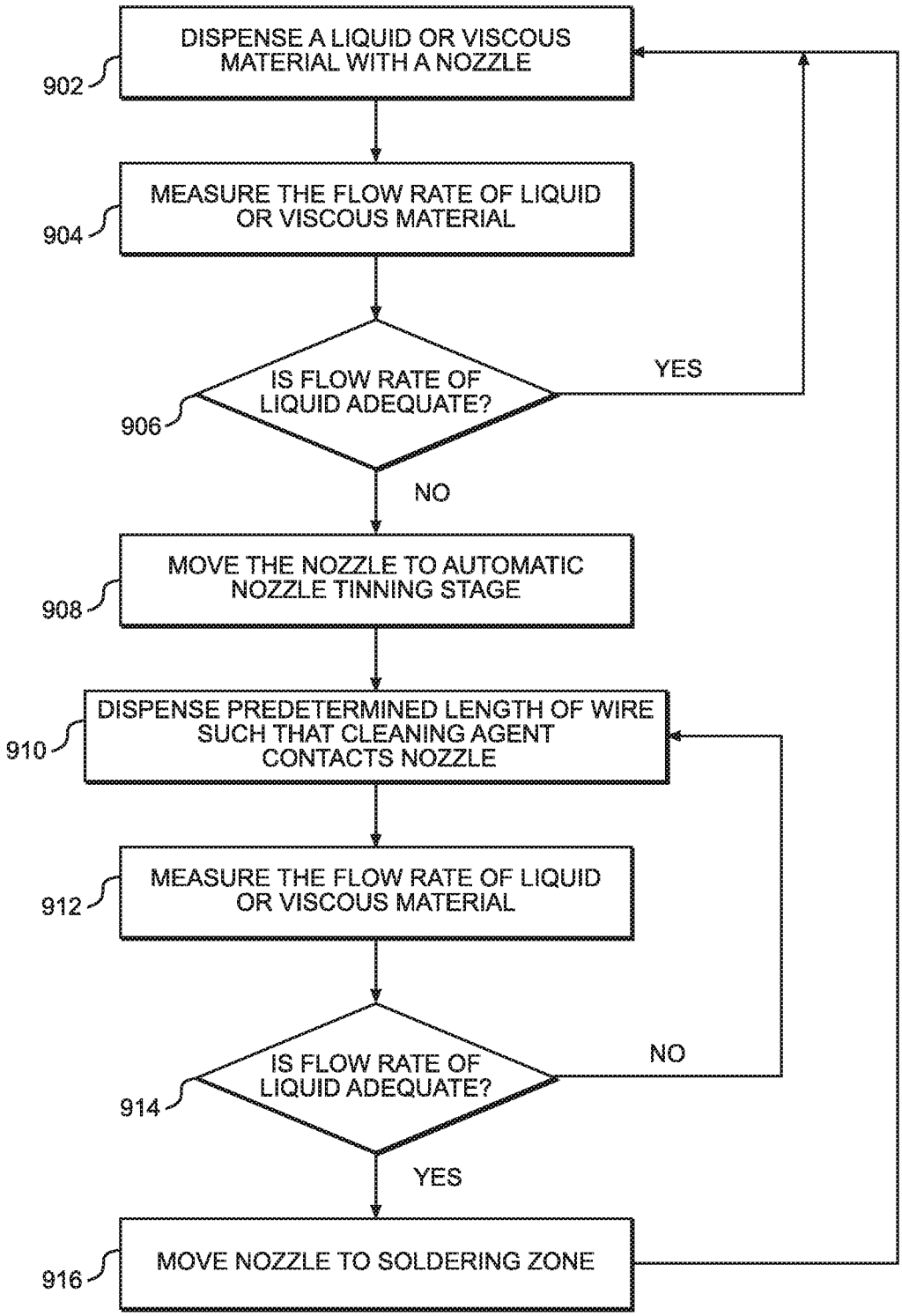
DISPENSE A LIQUID OR VISCOUS MATERIAL WITH A NOZZLE
902
MEASURE THE FLOW RATE OF LIQUID OR VISCOUS MATERIAL
904
IS FLOW RATE OF LIQUID ADEQUATE?
906
YES
NO
MOVE THE NOZZLE TO AUTOMATIC NOZZLE TINNING STAGE
908
DISPENSE PREDETERMINED LENGTH OF WIRE SUCH THAT CLEANING AGENT CONTACTS NOZZLE
910
MEASURE THE FLOW RATE OF LIQUID OR VISCOUS MATERIAL
912
IS FLOW RATE OF LIQUID ADEQUATE?
914
NO
YES
MOVE NOZZLE TO SOLDERING ZONE
916

FIG. 9

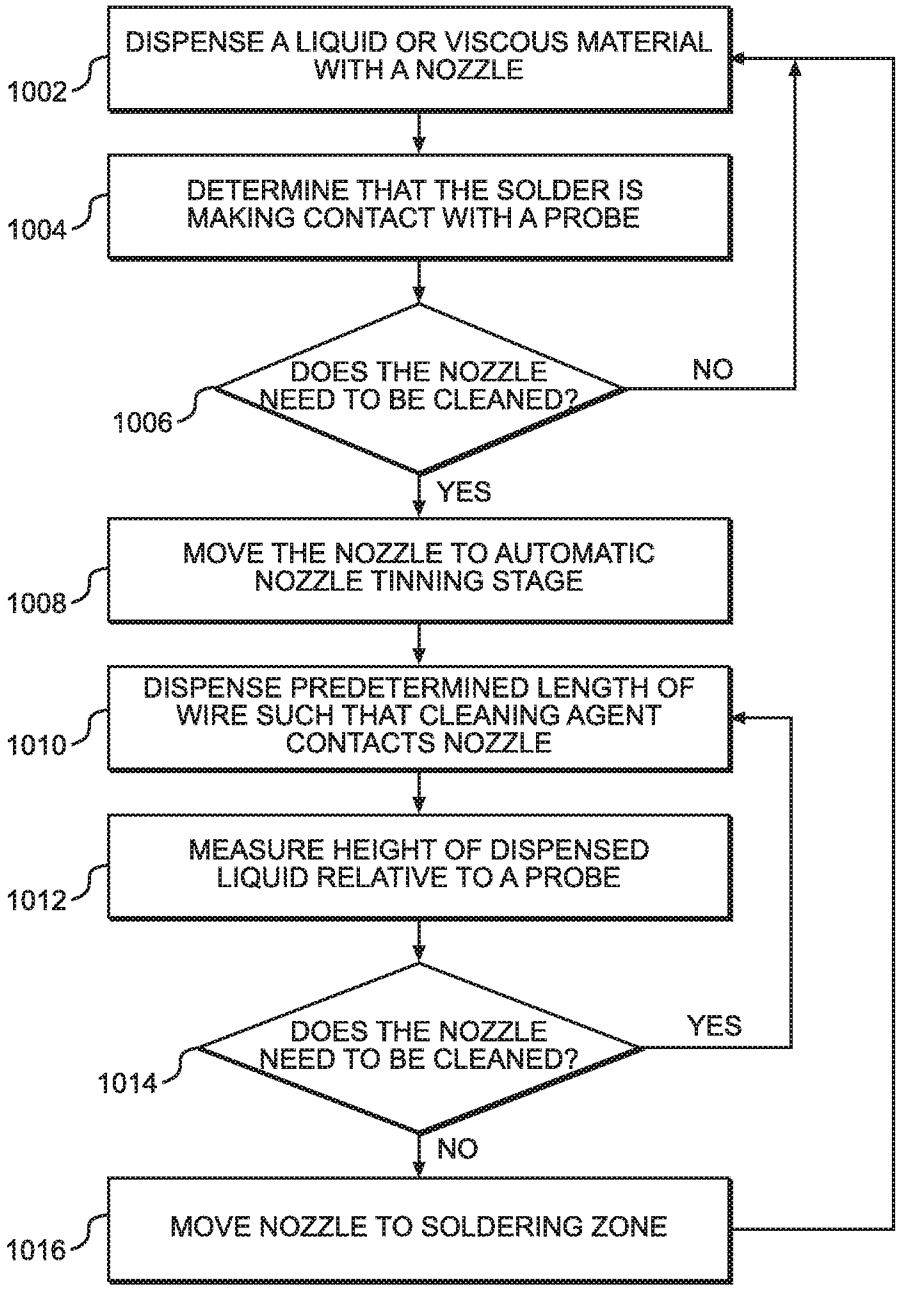
DISPENSE A LIQUID OR VISCOUS MATERIAL WITH A NOZZLE
1002
DETERMINE THAT THE SOLDER IS MAKING CONTACT WITH A PROBE
1004
DOES THE NOZZLE NEED TO BE CLEANED?
1006
NO
YES
MOVE THE NOZZLE TO AUTOMATIC NOZZLE TINNING STAGE
1008
DISPENSE PREDETERMINED LENGTH OF WIRE SUCH THAT CLEANING AGENT CONTACTS NOZZLE
1010
MEASURE HEIGHT OF DISPENSED LIQUID RELATIVE TO A PROBE
1012
DOES THE NOZZLE NEED TO BE CLEANED?
1014
YES
NO
MOVE NOZZLE TO SOLDERING ZONE
1016

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/030756

A. CLASSIFICATION OF SUBJECT MATTER
INV. B23K1/00 B08B7/00 B23K1/08 B23K3/02 B23K3/06 B23K3/08
ADD. B23K101/42
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)
B23K B08B

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP WO20 1316 8198 A1 (MITSUBISHI ELECTRIC CORP ET AL) 24 December 2015 (2015-12-24) paragraphs [0023], [0029], [0030], [0043] - [0052]; figures	1-53
Y	JP H11 277223 A (ANDO ELECTRIC) 12 October 1999 (1999-10-12) abstract paragraph [0009]; figures	1-53
A	DE 20 2009 002666 U1 (ERSA GMBH) 30 April 2009 (2009-04-30) paragraphs [0023] - [0025]; figures	1-53
A	JP 2002 134900 A (NIPPON COLUMBIA) 10 May 2002 (2002-05-10) abstract paragraph [0052]; figures	1-53

☐ 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

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"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
29 August 2018	11/09/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Jeggy, Thierry

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2018/030756

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP WO2013168198 A1	24-12-2015	JP 5583304 B2	03-09-2014
		JP WO2013168198 A1	24-12-2015
		WO 2013168198 A1	14-11-2013
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DE 202009002666 U1	30-04-2009	NONE	
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