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(54) **Method and apparatus for galvanizing an elongated object**

(57) A method and apparatus for galvanizing an elongated object, such as, but not limited to, a metal strip,

wire, or rod, using gaseous nitrogen, a mixture of gaseous and liquid nitrogen, and combinations thereof is described herein.

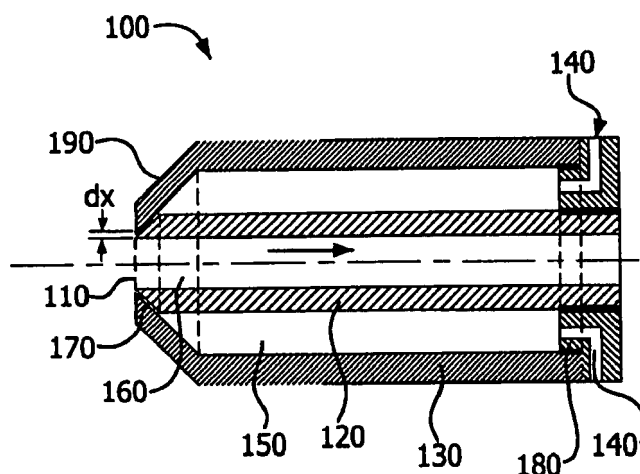


FIG. 1

Description

BACKGROUND OF THE INVENTION

[0001] Described herein are a method, apparatus, and system for galvanizing an object. More specifically, described herein is a method, apparatus, or rod for galvanizing an elongated object (e.g., an object having a relatively long length compared to width or diameter) such as, but not limited to, a metal strip, wire, rod, or tube.

[0002] Galvanizing is a process for applying a protective zinc coating over an iron or a steel object to reduce corrosion which aids in extending the useful life of the object. Corrosion is a physical and chemical deterioration of a material due to reaction with its environment, particularly oxygen. Corrosion resistance can be defined as the ability of the material to resist oxidation. Galvanizing is important to the life duration of an object that is subject to deterioration caused by the surrounding environment. The process of galvanizing consists of coating metals, such as iron and steel, with a thin protective layer of zinc. The layer of zinc provides protection to the metal from corrosion. The protective layer of zinc prevents the ferrous material from coming in contact with oxygen causing oxidation. The layer of zinc already has a naturally occurring zinc oxide film which protects the zinc layer against corrosion thereby making it corrosion resistant.

[0003] There are several ways to galvanize objects, such as, but not limited to hot dip zinc galvanizing, electroplating galvanizing, mechanical coating, zinc spraying, and zinc dust painting. Any one or more of these processes can be operated in a continuous manner or in a stationary manner. For example, hot dip zinc galvanizing can be run as a continuous process wherein the object starts as a raw material and ends as a finished good. Alternatively, stationary hot dip zinc galvanizing the individual objects are dipped into a zinc bath and then removed. A typical hot dip zinc galvanizing process, regardless of whether it is run in a continuous or stationary manner, may involved one or more of the following process steps: cleaning, pickling, pre fluxing, galvanizing, cooling, finishing, and inspecting, while the product is rinsed and air blown at various times throughout the process. In the cleaning step, surface residues such as oil, grease, paints, etc. are typically removed with a hot alkaline cleaner such as a lead bath or hot soapy water. The object is then rinsed to remove the cleaning residue and/or an air knife may be used to remove additional water and/or excess residue prior to pickling. In the pickling step, a bath of diluted hydrochloric or sulfuric acid is used to remove surface rust or mill scale and provide a chemically clean metallic surface. An intermittent rinse and/or air knife step may be used to dilute the acid concentration and/or remove residue that may be left on the object prior to the pre-fluxing step. During the pre-fluxing step, the object is immersed into a liquid flux to remove oxides and prevent oxidation prior to the galvanizing step. An example of a liquid flux used in this step is zinc am-

monium chloride solution which aids in the ability of the zinc to adhere to the surface of the object. During the galvanizing step, the object is immersed in or passed through a bath of molten zinc at a temperature which may range, for example, from about 437.5°C to about 455°C. At this temperature, the molten zinc adheres to the surface of the object to provide a layer, the gauge of which is determined by the length of time the object is contacted with the molten zinc. After the galvanizing step, the object is finished and cooled. During the finishing step, excess zinc is typically removed by draining, centrifuging, and/or wiping the object. During a portion of, or directly after the finishing step, the object is rapidly cooled typically using chiller units and/or high pressure air knives using nitrogen.

[0004] The galvanized object is then inspected to ensure that it meets one or more of the following criteria: tensile strength, yield strength, hardness, elongation, stress/strain, form/condition/ thermal conductivity, electrical resistance, coating weight and/or gauge, appearance, and combinations thereof. With regard to appearance, the object may be inspected to look for one or more of the following (which can be undesirable depending upon the application): dull gray color, rust stains, blisters, roughness, excessive thickness, lumpiness and runs, pimples, bare spots, and/or wet storage stains and bulky white deposits.

[0005] In addition to the above considerations, it is desirable that the galvanizing process, particularly for an elongated object such as a wire or tube, further provides one or more of the following desired objectives: a spherical and homogenous surface coating, a brighter surface finish, controllability of the coating thickness or gauge, a higher production speed or through put, and/or a reduction in the amount of zinc used in the process. It is desirable that the surface of the metal object, particularly a wire or tube, obtains a spherical and homogenous surface coating. During the galvanizing process with molten zinc, issues typically encountered relate to roundness and homogenous coverage of the coated surface of rods and wires, especially for horizontal coating systems. A homogeneous coating is necessary to get the same wire properties (i.e. corrosion resistance, diameter, etc.) at all points. It is desirable that the surface finish be bright and shiny in appearance. Control of coating thickness is desirable to the end user. In this regard, different coating thicknesses are desired for different applications with galvanized wires and rods. It is desirable that the galvanizing method allow for higher production speeds and through put. Lastly, there is a need in the art for saving or reusing the zinc during the coating step to reduce overall production costs.

[0006] Accordingly, there is a need for an improved galvanizing method and apparatus for an object, particularly for galvanizing an elongated object such as a metal strip, wire, rod, or tube, that fulfills one or more of foregoing objectives.

BRIEF SUMMARY OF THE INVENTION

[0007] The method, apparatus, and system described herein satisfy one or more of the foregoing objectives in the following manner. The method and apparatus described herein, compared to prior art methods involving air cooling, can provide a bright zinc surface finish that is achieved due to less oxidation of the surface at high temperature. The method and apparatus described herein provide a flexible wiping system to adjust the desired zinc coating thickness. The method and apparatus described herein may enhance productivity by improving the cooling of the elongated object such as the wire, rod or tube and the preheating temperature can also be reduced while good results are still obtained. Further, the method and apparatus described herein may reduce the cost of the zinc used by stripping surplus zinc from the wire or rod via the nozzle so that the surplus zinc can then be collected and reused if desired.

1. In one aspect, there is provided an apparatus for processing an elongated object comprising a molten coating, comprising: a nozzle comprising: a nozzle opening; an inner chamber defining a first volume wherein the elongated object passes therethrough; an outer chamber defining a second volume that is in fluid communication with a nitrogen source wherein gaseous nitrogen passes through the second volume at a pressure and a temperature and exits proximal to the nozzle opening and contacts the elongated object; and a concept pipe comprising: an porous inner chamber defining a third volume; an outer chamber defining a fourth volume wherein the fourth volume is in fluid communication with one or more inputs for a nitrogen mixture comprising gaseous and liquid nitrogen; and a temperature sensor to monitor a temperature of the nitrogen mixture, wherein the temperature sensor is in electrical communication with a programmable logic controller.

[0008] In another aspect, there is provided a method for processing an elongated object comprising a molten coating comprising: passing a the elongated object through a nozzle configured to direct gaseous nitrogen at the surface of the object and remove excess coating from the object; and passing the elongated object through a concept pipe configured to rapidly cool the elongated object and solidify the coating; wherein the nozzle comprises a nozzle opening; an inner chamber defining a first volume wherein the elongated object passes therethrough; an outer chamber defining a second volume that is in fluid communication with a nitrogen source wherein gaseous nitrogen passes through the second volume at a pressure and a temperature and exits proximal to the nozzle opening and contacts the elongated object; and wherein the concept pipe comprises an porous inner chamber defining a third volume; an outer chamber defining a fourth volume wherein the fourth volume is in

fluid communication with one or more inputs for a nitrogen mixture comprising gaseous and liquid nitrogen; and a temperature sensor to monitor a temperature of the nitrogen mixture, wherein the temperature sensor is in electrical communication with a programmable logic controller.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0009] The foregoing summary, as well as the following detailed description of the invention, will be better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, there is shown in the drawings a certain embodiment of the present invention. It should be understood, however, that the invention is not limited to the precise arrangements and instrumentalities shown. In the drawings:

[0010] Figure 1 is a side view of a nozzle that can be used with the apparatus and method described herein.

[0011] Figure 2 is a side view of a concept pipe that can be used to inject gaseous nitrogen, liquid nitrogen, or a combination thereof to the object.

[0012] Figure 3 is a schematic drawing of the system described herein for galvanizing an elongated object comprising a nozzle and concept pipe described herein.

[0013] Figure 4 is another embodiment of the system described herein.

DETAILED DESCRIPTION OF THE INVENTION

[0014] In describing the embodiments of the invention illustrated in the drawings, specific terminology will be used for the sake of clarity. However, the invention is not intended to be limited to the specific terms so selected, it being understood that each specific term includes all technical equivalents operating in similar manner to accomplish similar purpose. It is understood that the drawings are not drawn exactly to scale. The following describes particular embodiments of the present invention. It should be understood, however, that the invention is not limited to the embodiments detailed herein.

[0015] The present method and apparatus combines the benefits of the use of both gaseous nitrogen (GAN) and cryogenic liquid nitrogen (LIN) to remove or wipe excess molten zinc (Zn) from the surface of an elongated object such as a wire surface in the following manner. It has been known in molten metal atomizing methods (which involve the same phenomena and principles as zinc wiping) that high temperature of the atomizing gas improves shearing of molten metal due to retention of low viscosity of the metal as well as high viscosity of the gas. It is also believed that the use of warm or room temperature gas may be superior to the use of cryogenic or cool temperature gas. However, a just wiped zinc surface of steel wire needs to be cooled (and solidified) as fast as possible to offer desirable productivity and quality improvements. The method and apparatus described here-

in address these contradicting requirements by wiping (shearing off) excess molten metal, e.g. zinc, with a room-temperature gas and then chilling the thinner zinc coating in a subsequent production step. Further, the method and apparatus described herein may, in certain embodiments, allow for the control of zinc coating thickness not just by adjusting the aperture of the frontal (wiping) opening of the apparatus but, optionally, by controlling the gas temperature.

[0016] In this or other embodiments, the method and apparatus fulfills another challenging requirement in the field of wire wiping through the use of gas dynamics-based retention of the axial position of the wire during its travel through the atomizing and chilling sections of the wire wiping apparatus. Galvanized wires tend to vibrate, and if the wire accidentally touches the internal diameter surface of the apparatus, the final product may not be usable. The apparatus described herein uses one or more of the following aspects: a perfectly cylindrically-symmetrical gas aperture around the wire, a microporous pipe wall around the wire that assures the axial position of the wire, and/or any other gas apertures around the wire that mimic a concentric gas discharge pattern. The dynamic pressure of the discharged gas suspends the wire in the axial position and minimizes the risk of contact between the wire and the apparatus that would lead to product rejection. Consequently, the method and apparatus described herein, in certain embodiments, can be operated in a horizontal position as well as in the more commonly used vertical position. In this manner, end-users may experience a new degree of freedom in reconfiguring their wire galvanizing systems without further concerns about the gravity force acting on wiped wires.

[0017] Figure 1 provides a side view of the nozzle 100 that can be used with the galvanizing method, apparatus, or system described herein. Figure 2 provides a side view of a concept pipe 200 that can be used with the galvanizing method, apparatus, or system described herein. In one or more embodiments herein, the nozzle and concept pipe as depicted in Figures 1 and 2 are fastened together as shown in Figure 3 using a nozzle fixing plate 180. In other embodiments, however, the nozzle 100 and concept pipe 200 can be detached. Further, in the embodiments shown in Figures 1 and 2, the apparatus is operated in a horizontal, continuous process. However, in other embodiments, the nozzle 100, the concept pipe 200, or both the nozzle 100 and the concept pipe 200 can be operated in a vertical, continuous process. An elongated object such as a wire, rod, or tube is passed through the inner nozzle chamber 160 and inner concept pipe chamber 210 in the direction shown by the arrows. During operation, an elongated object such as a wire or rod (not shown) is preheated prior to entering a zinc bath (also not shown). After the elongated object is pre-heated and coated in the zinc bath, the object is passed through the nozzle 100 via an opening 110 where an adjustable gaseous nitrogen (GAN) knife flows through a nozzle split opening 170. The GAN knife 170 strips a surplus amount

of the zinc coating from the surface of the object while passing through the nozzle 100 and leaves the desired zinc coating thickness or gauge on the object. In the embodiment shown in Figure 1, the nozzle 100 has a spherical cross-section and in the side view depicted has a slanting edge 190 proximal to the nozzle opening 110 that allows for the excess zinc coating to be deflected away from the object or wire. GAN flows into the nozzle 100 via outer nozzle chamber 150 and passes out through the nozzle split opening 170 at the front of the nozzle 100.

[0018] Gaseous nitrogen (GAN) is pressurized at an external source (not shown in Figure 1) and enters into outer nozzle chamber 150 through one or more inputs 140, wherein its pressure is homogenized. The GAN then passes through the split opening 170 of the nozzle 100, exerting a uniform force upon the coated surface of the elongated object. The flow rate and pressure of the gaseous nitrogen may range from about 5 to about 30 m³/h. In this manner, the pressured gaseous nitrogen forms a GAN knife that acts to remove the surplus zinc from the coating of the galvanized object as it passes through the nozzle opening 110. The pressure force presses the molten zinc on to the wire/rod, distributing it uniformly on the surface area and stripping off any surplus zinc on the wire/rod, leaving an even, spherical coating on the objects' surface.

[0019] As previously mentioned, the elongated object such as a wire (not shown) is passed through the nozzle 100 through the nozzle opening 110 in the direction indicated by the arrow in Figure 1. The nozzle 100 shown in Figure 1 is comprised of the following elements: an inner nozzle enclosure 120 that defines an inner nozzle chamber 160 through which an elongated object such as a wire passes and an outer nozzle body enclosure 130 whose interior walls define an outer nozzle chamber 150 that allows for the flow of a pressurized fluid such as gaseous nitrogen into outer nozzle chamber 150 through one or more inputs 140 and out through a split opening 170. Split opening 170 has a length shown in Figure 1 as "dx". The length "dx" of the split opening 170 can be varied from about zero to about 12 mm, such as from about 0.01 to about 12 mm, or greater if required, to adjust the zinc coating on the surface of the elongated object to the desired thickness or gauge. In this regard, the desired thickness of the zinc coating can be then set by selecting the value "dx" of the split opening 170 on the nozzle 100. For example, the smaller the length of dx, the thinner the zinc coating or gauge of the zinc coating on the object. In certain embodiments of the nozzle described herein, the length "dx" of the split opening is set by turning the outer nozzle body enclosure 130 clockwise for a larger split opening "dx" and counter clockwise for a smaller split opening of "dx".

[0020] In addition to the foregoing advantages, an additional advantage of the nozzle 100 shown in Figure 1 is that it may allow for higher throughput. One of the bottlenecks in the galvanizing process is the time it takes to

pre-heat the zinc to the required temperature. The nozzle improves upon the cooling speed since a uniform pressure force is exerted on the molten coating as it is passed therethrough which allows for a more uniform zinc coating. Because a more uniform coating is obtained, it may allow the end-user to lower the preheating temperature and/or reduce the dwelling time in the zinc bath during the galvanizing step.

[0021] Figure 2 provides a side view of a concept pipe 200 that can be used with the method and system described herein. Concept pipe 200 is comprised of an inner concept pipe chamber 210 which is in fluid communication with one or more multiple liquid nitrogen (LIN) and/or gaseous nitrogen (GAN) inputs 220, a porous inner pipe 230, and an outer concept pipe 250 whose interior side-walls define an outer concept pipe chamber 240. The use of two or more concentric pipes (e.g., porous inner pipe 230 and outer concept pipe 250) wherein the pores of inner pipe 230 are in fluid communication with outer concept pipe chamber 240 and inner concept pipe chamber 210 provides a pressure drop and even pressure distribution to the innermost chamber or inner concept pipe chamber 210 when the coated object passes therethrough in the direction indicated by the arrow in Figure 2.

[0022] In the embodiment shown in Figure 2, both inner chamber 210 and outer chamber 240 contain a mixture of LIN and GAN which is provided from a blending pipe (shown in Figure 4). The temperature is measured and maintained at the desired level using a thermocouple 260 which is in electrical communication with a programmable logic controller (PLC) or temperature and electronic control panel (shown in Figures 4 and 5). The concept pipe 200 allows the elongated object passing therethrough to be "shock cooled," i.e. cooled very rapidly such that the molten zinc solidifies immediately or almost immediately. The inert atmosphere in inner chamber 210 of the concept pipe 200 keeps the surface of the elongated object passing therethrough oxide free, giving it a commercially desirable bright finish. Productivity is boosted by pre-cooling the elongated object in concept pipe 200, enhancing cooling speed.

[0023] Figure 3 depicts an apparatus in which the nozzle 100 and the concept pipe 200 are attached via nozzle fixing plate 180. As shown in Figure 3, the object being galvanized passes through nozzle 100, where the molten coating on the object is reduced to a specific desired thickness. The object then continues into the concept pipe 200, where the molten coating rapidly solidifies as a result of the drop in temperature due to the LIN/GAN atmosphere in the inner chamber 210 of the concept pipe 200. The temperature in the inner chamber 210 may range from about -50°C to about -150°C, and will depend on the thickness of the zinc coating. In embodiments where a thicker coating or gauge is desired, a lower temperature may also be desired. The desired temperature is obtained by mixing LIN, typically at about -196°C, with GAN at ambient temperature in a blending pipe. This is done by measuring the temperature in the inner chamber

210 or the concept pipe 200 at a thermocouple 260 and adding LIN to a GAN flow in a blending pipe (shown in Figure 4) which then flows into the concept pipe via one or more LIN/GAN inputs 220.

[0024] Figure 4 provides a view of the method and system described herein which includes a blending pipe 410. The blending pipe 410, electrical panel or programmable logic controller (PLC) 460 and LIN and GAN supplies aid in mixing of LIN & GAN at the blending pipe 410 to achieve the desired solidification energy in the concept pipe 200. Mixing of the LIN and GAN is controlled by the PLC 460 with input temperature measurement from the concept pipe 200 or thermocouple 260 shown in Figure 2. The PLC 460 controls the temperature in the concept pipe by tacking LIN (opening and closing the solenoid valve 470 in the LIN pipeline) into the blending pipe 410 (where the LIN is mixed with GAN via one or more conduits or openings 420) to achieve the set temperature. The mixed LIN and GAN at the set temperature then flow to the concept pipe 200 via mixed nitrogen line 440. Thus, the desired temperature in the concept pipe 200 is achieved by opening and closing of the solenoid/proportional valve 470 on the LIN supply line controlled by the PLC 460. In this or other embodiments, the GAN supply to the nozzle for wiping the surplus zinc and maintaining the set thickness of the coating on the wire/rod can also optionally be controlled by the PLC 460 (not shown). In some embodiments, the pressure and temperature of the mixed nitrogen line may be monitored via optional pressure and temperature sensors 430 and 450, respectively.

[0025] Figure 5 provides another embodiment of an apparatus and system 500 as described herein. In the system 500 shown in Figure 5, the nozzle 100 and concept pipe 200 are combined into an integrated unit. The front portion of the combined nozzle and concept pipe strips surplus molten zinc from an elongated object and the desired coating thickness on the object is set by adjusting the split opening of the nozzle as described above. The surplus or excess zinc may be collected and reused in the molten zinc bath as shown. After the elongated object is wiped via the pressured flow of GAN through the split opening of the nozzle 100, the coated object goes through the concept pipe 200 wherein the molten zinc coating instantly solidifies, leaving a uniform and spherical coating on the surface of the wire/rod. The combined LIN/GAN atmosphere in the concept pipe 200 also keeps the coating oxide free, giving it a bright finish. The temperature of the concept pipe is regulated by a PLC 460, keeping it constant by opening and closing the solenoid/proportional valve 470 on the LIN line in response to changes in the temperature input and the temperature measurement from thermocouple 260 in the concept pipe 200. The pressure of the inner chamber of the concept pipe 200 is kept low by using porous inner separating pipes. This also provides a uniform pressure distribution in the inner chamber of the concept pipe. Further, the process may be optionally also be monitored through one or more additional thermocouples located in various

points through the process. In the embodiment shown in Figure 5, the thermocouple 260 monitors the temperature as the object passes through the concept pipe. An optional temperature sensor 520 and electromagnetic thickness sensor 510 may be also employed to further regulate the process. Further, the PLC may also adjust the flow of GAN to the process by opening and closing optional valve 530 on the GAN line.

[0026] As such, an invention has been disclosed in terms of preferred embodiments and alternate embodiments thereof. Of course, various changes, modifications, and alterations from the teachings of the present invention may be contemplated by those skilled in the art without departing from the intended spirit and scope thereof.

Claims

1. An apparatus for processing an elongated object comprising a molten coating, comprising:

a nozzle comprising: a nozzle opening; an inner chamber defining a first volume wherein the elongated object passes therethrough; an outer chamber defining a second volume that is in fluid communication with a nitrogen source wherein gaseous nitrogen passes through the second volume at a pressure and a temperature and exits proximal to the nozzle opening and contacts the elongated object; and
a concept pipe comprising: an porous inner chamber defining a third volume; an outer chamber defining a fourth volume wherein the fourth volume is in fluid communication with one or more inputs for a nitrogen mixture comprising gaseous and liquid nitrogen; and a temperature sensor to monitor a temperature of the nitrogen mixture, wherein the temperature sensor is in electrical communication with a programmable logic controller.

2. The apparatus of claim 1, wherein the gaseous nitrogen passes through the second volume at a flow rate from about 5 to about 30 m³/h.
3. The apparatus of claim 1 or 2, wherein the gaseous nitrogen exits proximal to the nozzle opening via an adjustable split opening having a length dx.
4. The apparatus of claim 3, wherein dx is from about 0.01 to about 12 mm.
5. The apparatus according to any of the preceding claims, wherein the molten coating comprises zinc.
6. The apparatus according to any of the preceding claims, further comprising a blending pipe that com-

bines the gaseous nitrogen and the liquid nitrogen to form the nitrogen mixture and provides the nitrogen mixture to the outer chamber of the concept pipe.

7. The apparatus of claim 6, wherein the gaseous nitrogen is supplied to the blending pipe via a gaseous nitrogen line and the liquid nitrogen is supplied to the blending pipe via a liquid nitrogen line having a valve therein.

8. A method for processing an elongated object comprising a molten coating comprising:

passing a the elongated object through a nozzle configured to direct gaseous nitrogen at the surface of the object and remove excess coating from the object; and
passing the elongated object through a concept pipe configured to rapidly cool the elongated object and solidify the coating;
wherein the nozzle comprises a nozzle opening; an inner chamber defining a first volume wherein the elongated object passes therethrough; an outer chamber defining a second volume that is in fluid communication with a nitrogen source wherein gaseous nitrogen passes through the second volume at a pressure and a temperature and exits proximal to the nozzle opening and contacts the elongated object; and
wherein the concept pipe comprises an porous inner chamber defining a third volume; an outer chamber defining a fourth volume wherein the fourth volume is in fluid communication with one or more inputs for a nitrogen mixture comprising gaseous and liquid nitrogen; and a temperature sensor to monitor a temperature of the nitrogen mixture, wherein the temperature sensor is in electrical communication with a programmable logic controller.

9. The method of claim 8, wherein the gaseous nitrogen exits proximal to the nozzle opening via an adjustable split opening having a length dx.
10. The method of claim 9, further comprising adjusting the split opening to a length dx from about 0.1 to about 12 mm.

11. The method of any of claims 8 to 10, further comprising:

blending the gaseous nitrogen and the liquid nitrogen in a blending pipe to form the nitrogen mixture; and
supplying the nitrogen mixture to the outer chamber of the concept pipe.

12. The method of claim 11, further comprising supplied

gaseous nitrogen to the blending pipe via a gaseous nitrogen line, supplying liquid nitrogen to the blending pipe via a liquid nitrogen line having a valve therein, and adjusting the temperature of the nitrogen mixture supplied to the outer chamber of the concept pipe by opening or closing the valve in the liquid nitrogen line.

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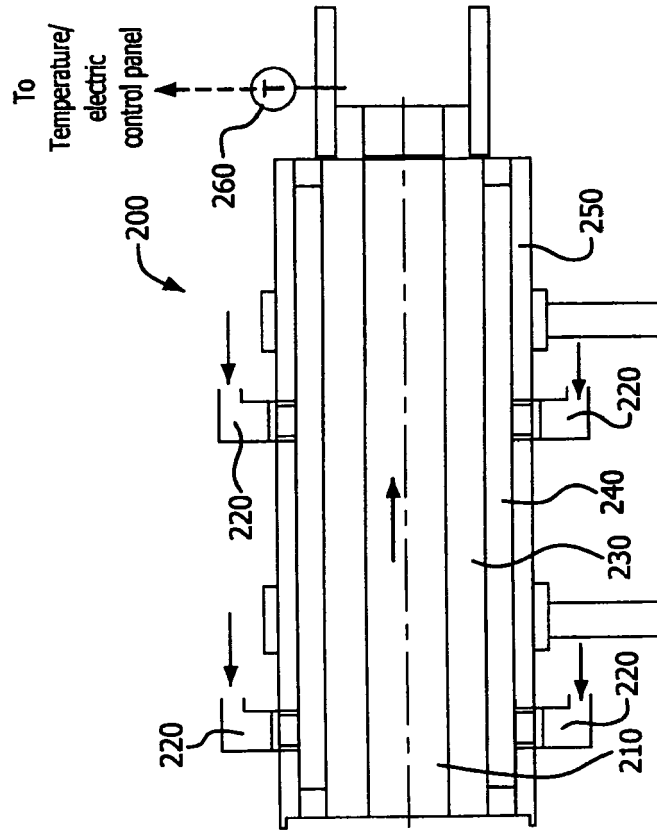


FIG. 2

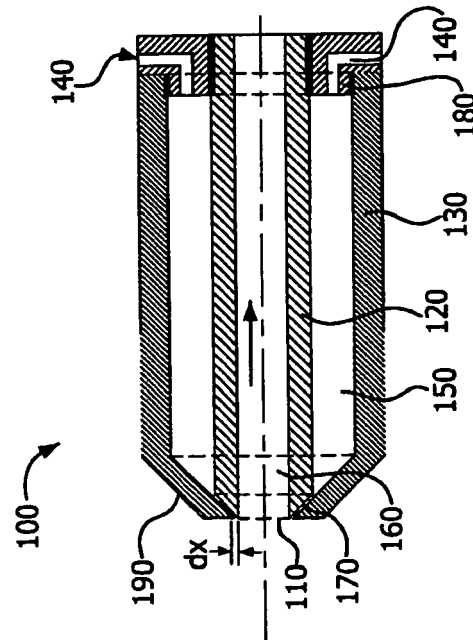


FIG. 1

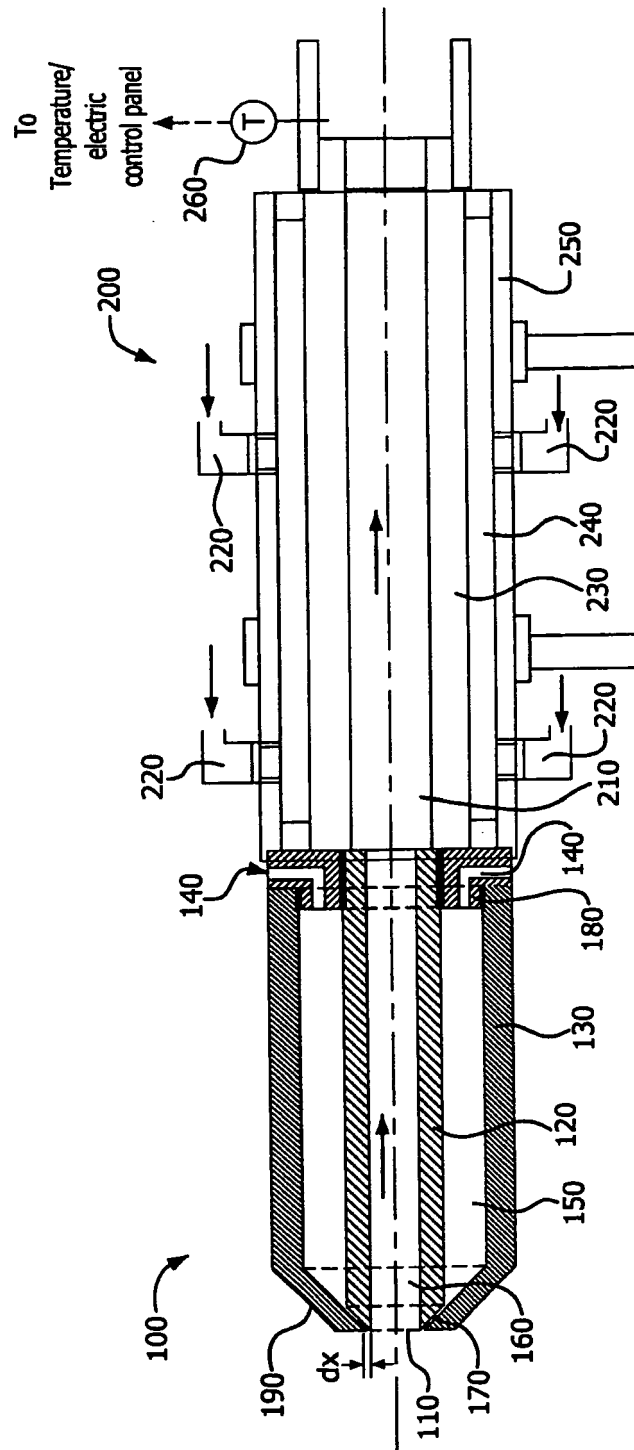


FIG. 3

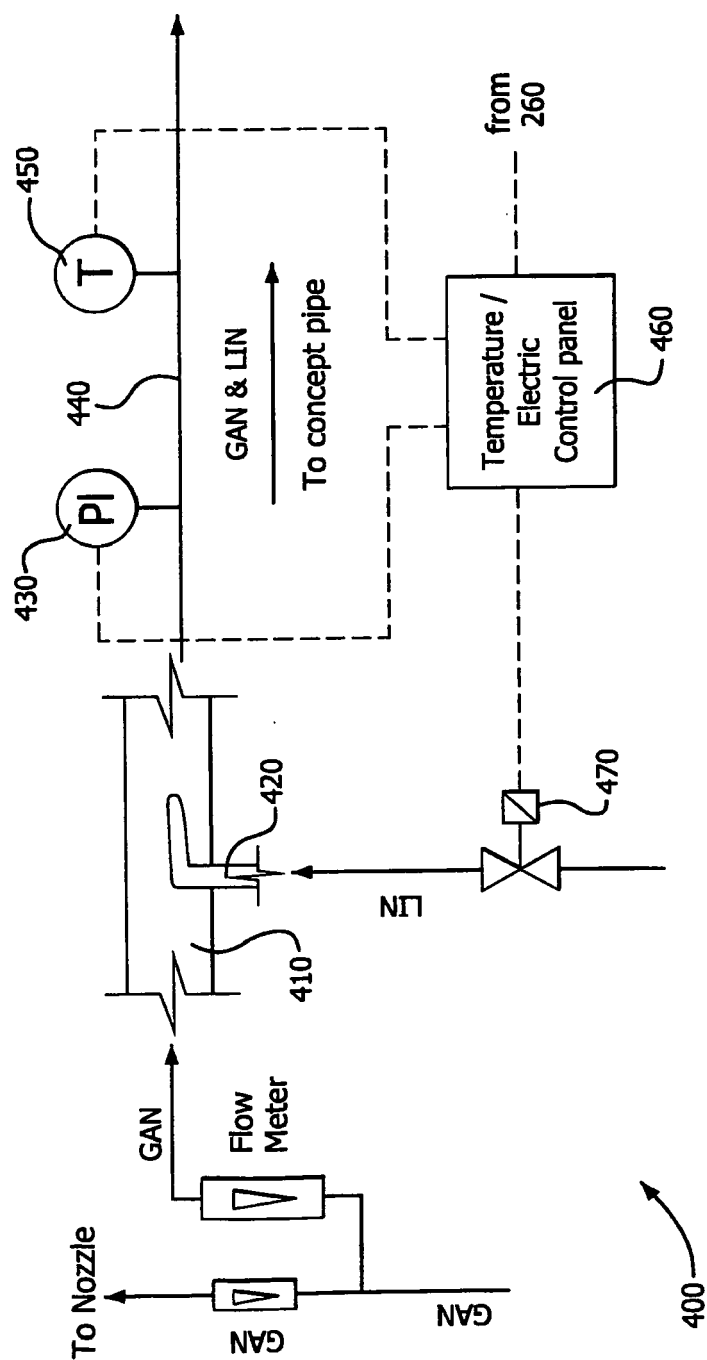


FIG. 4

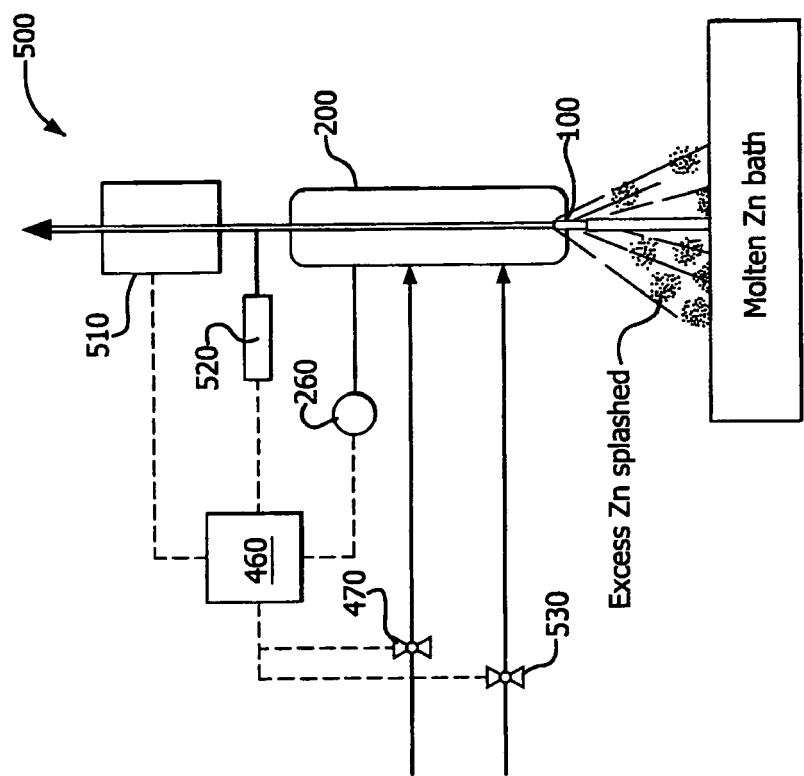


FIG. 5



EUROPEAN SEARCH REPORT

Application Number
EP 12 00 2824

DOCUMENTS CONSIDERED TO BE RELEVANT			
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 17 July 2012	Examiner Joffreau, P
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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 12 00 2824

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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