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(54) **A PRINTING HEAD**

DRUCKKOPF

TÊTE D'IMPRESSION

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Description

TECHNICAL FIELD

[0001] The present invention relates to printing heads.

BACKGROUND

[0002] Ink jet printing is a type of printing that recreates a digital image by propelling drops of ink onto paper, plastic, or other substrates. There are two main technologies in use: continuous (CIJ) and Drop-on-demand (DOD) inkjet.

[0003] In continuous inkjet technology, a high-pressure pump directs the liquid solution of ink and fast drying solvent from a reservoir through a gunbody and a microscopic nozzle, creating a continuous stream of ink drops via the Plateau-Rayleigh instability. A piezoelectric crystal creates an acoustic wave as it vibrates within the gunbody and causes the stream of liquid to break into drops at regular intervals. The ink drops are subjected to an electrostatic field created by a charging electrode as they form; the field varies according to the degree of drop deflection desired. This results in a controlled, variable electrostatic charge on each drop. Charged drops are separated by one or more uncharged "guard drops" to minimize electrostatic repulsion between neighboring drops. The charged drops pass through an electrostatic field and are directed (deflected) by electrostatic deflection plates to print on the receptor material (substrate), or allowed to continue on undeflected to a collection gutter for re-use. The more highly charged drops are deflected to a greater degree. Only a small fraction of the drops is used to print, the majority being recycled. The ink system requires active solvent regulation to counter solvent evaporation during the time of flight (time between nozzle ejection and gutter recycling), and from the venting process whereby air that is drawn into the gutter along with the unused drops is vented from the reservoir. Viscosity is monitored and a solvent (or solvent blend) is added to counteract solvent loss.

[0004] Drop-on-demand (DOD) may be divided into low resolution DOD printers using electro valves in order to eject comparatively big drops of inks on printed substrates, or high resolution DOD printers, may eject very small drops of ink by means of using either thermal DOD and piezoelectric DOD method of discharging the drop.

[0005] In the thermal inkjet process, the print cartridges contain a series of tiny chambers, each containing a heater. To eject a drop from each chamber, a pulse of current is passed through the heating element causing a rapid vaporization of the ink in the chamber to form a bubble, which causes a large pressure increase, propelling a drop of ink onto the paper. The ink's surface tension, as well as the condensation and thus contraction of the vapor bubble, pulls a further charge of ink into the chamber through a narrow channel attached to an ink reservoir. The inks used are usually water-based and use either pigments or dyes as the colorant. The inks used must have a volatile component to form the vapor bubble, otherwise drop ejection cannot occur.

[0006] Piezoelectric DOD use a piezoelectric material in an ink-filled chamber behind each nozzle instead of a heating element. When a voltage is applied, the piezoelectric material changes shape, which generates a pressure pulse in the fluid forcing a drop of ink from the nozzle. A DOD process uses software that directs the heads to apply between zero to eight drops of ink per dot, only where needed.

[0007] High resolution printers, alongside the office applications, are also being used in some applications of industrial coding and marking. Thermal Ink Jet more often is used in cartridge based printers mostly for smaller imprints, for example in pharmaceutical industry. Piezoelectric printheads of companies like Spectra or Xaar has been successfully used for high resolution case coding industrial printers.

[0008] All DOD printers share one feature in common: the discharged drops of ink have longer drying time compared to CIJ technology when applied on non porous substrate. The reason being fast drying solvent usage, which is well accepted by designed with fast drying solvent in mind CIJ technology, but which usage needs to be limited in DOD technology in general and high resolution DOD in particular. That is because fast drying inks would cause the dry back on the nozzles. In most of known applications the drying time of high resolution DOD printers' imprints on non porous substrates would be at least twice and usually well over three times as long as that of CIJ. This is a disadvantage in certain industrial coding applications, for instance very fast production lines where drying time of few seconds may expose the still wet (not dried) imprint for damage when gets in contact with other object.

[0009] Another disadvantage of high resolution DOD technology is limited drop energy, which requires the substrate to be guided very evenly and closely to printing nozzles. This also proves to be disadvantageous for some industrial applications. For example when coded surface is not flat, it cannot be all guided very close to nozzles.

[0010] CIJ technology also proves to have inherent limitations. So far CIJ has not been successfully used for high resolution imprints due to the fact it needs certain drop size in order to work well. The other well known disadvantage of CIJ technology is high usage of solvent. This causes not only high costs of supplies, but also may be hazardous for operators on environment, since most efficient solvents are poisonous, such as the widely used MEK (Methyl Ethyl Ketone).

[0011] The following documents illustrate various improvements to the ink jet printing technology.

[0012] An article ""Double-shot inkjet printing of donor-acceptor-type organic charge-transfer complexes: Wet/nonwet definition and its use for contact engineering" by T. Hasegawa et al (Thin Solid Films 518

(2010) pp. 3988-3991) presents a double-shot inkjet printing (DS-IJP) technique, wherein two kinds of picoliter-scale ink drops including soluble component donor (e.g. tetrathiafulvalene, TTF) and acceptor (e.g. tetracyanoquinodimethane, TCNQ) molecules are individually deposited at an identical position on the substrate surfaces to form hardly soluble metal compound films of TTF-TCNQ. The technique utilizes the wet/nonwet surface modification to confine the intermixed drops of individually printed donor and acceptor inks in a predefined area, which results in the picoliter-scale instantaneous complex formation.

[0013] A US patent US7429100 presents a method and a device for increasing the number of ink drops in an ink drop jet of a continuously operating inkjet printer, wherein ink drops of at least two separately produced ink drop jets are combined into one ink drop jet, so that the combined ink drop jet fully encloses the separate ink drops of the corresponding separate ink drop jets and therefore has a number of ink drops equal to the sum of the numbers of ink drops in the individual stream. The drops from the individual streams do not collide with each other and are not combined with each other, but remain separate drops in the combined drop jet.

[0014] A US patent application US20050174407 presents a method for depositing solid materials, wherein a pair of inkjet printing devices eject ink drops respectively in a direction such that they coincide during flight, forming mixed drops which continue onwards towards a substrate, wherein the mixed drops are formed outside the printing head.

[0015] A US patent US8092003 presents systems and methods for digitally printing images onto substrates using digital inks and catalysts which initiate and/or accelerate curing of the inks on the substrates. The ink and catalyst are kept separate from each other while inside the heads of an inkjet printer and combine only after being discharged from the head, i.e. outside the head. This may cause problems in precise control of coalescence of the drops in flight outside the head and corresponding lack of precise control over drop placement on the printed object.

[0016] There are known various arrangements for altering the velocity of the drop exiting the printing head by using electrodes for affecting charged drops, as described e.g. in patent documents US3657599, US20110193908 or US20080074477.

[0017] The US patent application US20080074477 discloses a system for controlling drop volume in continuous ink-jet printer, wherein a succession of ink drops, all ejected from a single nozzle, are projected along a longitudinal trajectory at a target substrate. A group of drops is selected from the succession in the trajectory, and this group of drops is combined by electrostatically accelerating upstream drops of the group and/or decelerating downstream drops of the group to combine into a single drop.

[0018] A German patent applications DE3416449 and DE350190 present CIJ printing heads comprising drop generators which generate a continuous stream of drops. The stream of drops is generated as a result of periodic pressure disturbances in the vicinity of the nozzles that decompose the emerging inkjets to droplets which have the same size and are equally spaced. The majority of drops are collected by gutters and fed back to the reservoirs supplying ink to the drop generators, as common in the CIJ technology.

[0019] A Japanese patent application JPS5658874 presents a CIJ printing head comprising nozzles generating continuous streams of drops, which are equally spaced, wherein some of the drops are collected by gutters and only some of the drops reach the surface to be printed. The paths of drops are altered by a set of electrodes such that the path of one drop is altered to cross the path of another drop.

[0020] A European patent application EP0775583 discloses an ink jet recording apparatus that has at least one ink chamber having an orifice through which ink drops are ejected, each ink drop having a variable amount of ink and being ejected at a timing corresponding to the amount of ink. The color ink chambers eject ink aiming at a point at which the ink drops are merged before they reach the print medium.

[0021] Due to substantial structural and technological differences between the CIJ and DOD technology print heads, these print heads are not compatible with each other and individual features are not transferrable between the technologies.

SUMMARY

[0022] The problem associated with DOD inkjet printing is the relatively long time of curing of the ink after its deposition on the surface remains actual. There is still a need to improve the DOD inkjet printing technology in order to shorten the time of curing of the ink after its deposition on the surface. In addition, it would be advantageous to obtain such result combined with higher drop energy and more precise drop placement in order to code different products of different substrates and shapes.

[0023] There is a need to improve the inkjet print technologies in attempt to decrease the drying (or curing) time of the imprint and to increase the energy of the printing drop being discharged from the printer. The present invention combines those two advantages and brings them to the level available so far only from CIJ printers and unavailable in the area of DOD technology in general (mainly when it comes to drying time) and high resolution DOD technology in particular, where both drying (curing) time and drop energy have been have been very much improved compared to the present state of technology. The present invention addresses also the main disadvantages of CIJ technology leading to min. 10 times reduction of solvent usage and allowing much smaller - compared to those of CIJ - drops to be discharged with higher velocity, while the resulting imprint could be consolidated on the wide variety of substrates still in a very short time and with very high adhesion.

[0024] There is presented herein a drop-on-demand inkjet printing head and a method for drop-on-demand inkjet printing according to the appended set of claims.

[0025] The printing head according to the invention can be used for domestic and industrial applications, for printing on a variety of substrates, in particular non-porous substrates.

BRIEF DESCRIPTION OF DRAWINGS

[0026] The invention is shown by means of exemplary embodiment on a drawing, in which:

Fig. 1 shows schematically a printing head;
Figs. 2A, 2B show schematically a nozzle assembly;
Figs. 3A-3E show schematically the process of combination of primary drops to a combined drop;
Fig. 4 shows schematically a set of electrodes for deflecting or correcting the path of drop movement at the output of the printing head;
Figs. 5, 6, 7 show different types of drop generating and propelling devices.

DETAILED DESCRIPTION

[0027] The inkjet printing head 100 according to the invention is shown in a schematic overview in Fig. 1 and in a detailed cross-sectional view on Figs. 2A and 2B, which show the same cross-sectional view, but for clarity of the drawing different elements have been referenced on different figures.

[0028] The inkjet printing head 100 may comprise one or more nozzle assemblies 110, each configured to produce a combined drop 122 formed of two primary drops 121A, 121B ejected from a pair of nozzles 111A, 111B. The printing head is of a drop-on-demand (DOD) type.

[0029] Fig. 1 shows a head with a plurality of nozzle assemblies 110 arranged in parallel to print multi-dot rows 191 on a substrate 190. It is worth noting that the printing head in alternative embodiments may comprise only a single nozzle assembly 110 or more nozzle assemblies, even as much as 256 nozzle assemblies or more for higher-resolution print.

[0030] Each nozzle 111A, 111B of the pair of nozzles in the nozzle assembly 110 has a channel 112A, 112B for conducting liquid from a reservoir 116A, 116B. At the nozzle outlet 113A, 113B the liquid is formed into primary drops 121A, 121B and ejected as a result of operation of drop generating and propelling devices 161A, 161B shown in a more detailed manner on Figs. 5, 6, 7. The drop generating and propelling devices may be for instance of thermal (Fig. 5), piezoelectric (Fig. 6) or valve (Fig. 7) type. In case of the valve the liquid would need to be delivered at some pressure. One nozzle 111A is arranged preferably in parallel to the main axis A_A of the printing head - for that reason, it will be called shortly a "parallel axis nozzle". The other nozzle 111B is arranged at an angle α to the first nozzle 111A - for that reason, it will be called shortly an "inclined axis nozzle". The nozzle outlets 113A, 113B are distanced from each other by a distance equal to at least the size of the larger of the primary drops generated at the outlets 113A, 113B, so that the primary drops 121A, 121B do not touch each other when they are still at the nozzle outlets 113A, 113B. This prevents forming of a combined drop at the nozzle outlets 113A, 113B and subsequent clogging the outlets 113A, 113B with a solidified ink. Preferably, the angle α is a narrow angle, preferably from 3 to 60 degrees, and more preferably from 5 to 25 degrees (which aids in alignment the two drops before coalescence). In such a case, the outlet 113A of the parallel axis nozzle 111A is distanced from the outlet of the printing head by a distance larger by "x" than the outlet 113B of the inclined axis nozzle 111B.

[0031] The liquid supplied by the two reservoirs 116A, 116B is preferably a reactive ink composed of an ink base (supplied from one of the reservoirs) and a catalyst (supplied from the other reservoir) for initiating curing of the ink base. The ink base may be composed of polymerizable monomers or polymer resins with rheology modifiers and colorant. The catalyst (which may be also called a curing agent) may be a cross-linking reagent in the case of polymer resins or polymerization catalyst in the case of polymerizable resins. The nature of the ink base and the curing agent is such that immediately after mixing a chemical reaction starts to occur leading to solidification of the mixture on the printed material surface, so that the ink may adhere more easily to the printed surface and/or cure more quickly at the printed surface.

[0032] For example, the ink may comprise acrylic acid ester (from 50 to 80 parts by weight), acrylic acid (from 5 to 15 parts by weight), pigment (from 3 to 40 parts by weight), surfactant (from 0 to 5 parts by weight), glycerin (from 0 to 5 parts by weight), viscosity modifier (from 0 to 5 parts by weight). The catalyst may comprise azaridine based curing agent (from 30 to 50 parts by weight), pigment (from 3 to 40 parts by weight), surfactant (from 0 to 5 parts by weight), glycerin (from 0 to 5 parts by weight), viscosity modifier (from 0 to 5 parts by weight), solvent (from 0 to 30 parts by weight). The liquids may have a viscosity from 1 to 30 mPas and surface tension from 20 - 50 mN/m. Other inks and catalysts known from the prior art can be used as well. Preferably, the solvent amounts to a maximum of 10%, preferably a maximum of 5% by weight of the combined drop. This allows to significantly decrease the content of the solvent in the printing process, which makes the technology according to the invention more environmentally-friendly than the current CIJ technologies, where the content of solvents usually exceeds 50% of the total mass of the drop during printing process. For this reason, the present invention is considered to be a green technology.

[0033] A variety of other substances may be used as components of primary drops. The following examples are to be treated as exemplary only and do not limit the scope of the invention:

- a combined drop of polyacrylate may be formed by chemical reaction between the primary drop of a monomer (for example: methyl methacrylate, ethyl methacrylate, propyl methacrylate, butyl methacrylate optionally with addition of colorant) and the second primary drop of an initiator (for example: catalyst such as trimethylolpropane, tris(1-aziridinepropionate) or azaridine, moreover UV light may be used as initiator agent)
- a combined drop of polyurethane may be formed by chemical reaction between the primary drop of a monomer (for example: 4,4'-methylenediphenyl diisocyanate (MDI) or different monomeric diisocyianates either aliphatic or cycloaliphatic) and the second primary drop of an initiator (for example: monohydric alcohol, dihydric alcohol or polyhydric alcohol such as glycerol or glycol; thiols, optionally with addition of colorant)
- a combined drop of polycarboimide may be formed by reaction between the primary drop of a monomer (for example: carbimides) and the second primary drop of an initiator (for example dicarboxylic acids such as adipic acid, optionally with addition of colorant)

[0034] In general, the first liquid may comprise a first polymer-forming system (preferably, one or more compounds such as a monomer, an oligomer (a resin), a polymer etc., or a mixture thereof) and the second liquid may comprise a second polymer-forming system (preferably, one or more compounds such as a monomer, an oligomer (a resin), a polymer, an initiator of a polymerization reaction, one or more crosslinkers ect., or a mixture thereof). The chemical reaction is preferably a polyreaction or copolyreaction, which may involve crosslinking, such as polycondensation, polyaddition, radical polymerization, ionic polymerization or coordination polymerization. In addition, the first liquid and the second liquid may comprise other substances such as solvents, dispersants etc.

[0035] In general, a chemical reaction is initiated between the component(s) of the first liquid forming the first primary drop and the component(s) of the second liquid forming the second primary drop when the primary drops coalesce to form the combined drop.

[0036] Thus, the chemical reaction transforming the first liquid and the second liquid into a reaction product is initiated within the print head enclosure. Therefore, a chemical reaction is initiated before the combined drop reaches the printed material surface.

[0037] Typically, the ink drop will be larger than the catalyst drop. In case the drops have different sizes, the smaller drop 121A is preferably ejected from the parallel axis nozzle 111A, while the larger drop 121B is preferably ejected from the inclined axis nozzle 111B, because it can accumulate higher electric charge and therefore it may be easier to control its path of movement. Preferably, the smaller drop 121A is ejected with a speed greater than the larger drop 121B.

[0038] The primary drops are preferably combined within the head 100, i.e. before the drops leave the outlet 185 of the head. The process of generation of primary drops 121A, 121B is controlled (by controlling their parameters, such as ejection time, force, temperature, etc) such that their path of movement can be predicted and arranged such that the primary drops combine to form a combined drop at a connection point 132.

[0039] The process of generation of primary drops 121A, 121B is controlled by a controller of the drop generating and propelling devices 161A, 161B (not shown in the drawing for clarity), which generates trigger signals. The primary drops are therefore generated on demand, in contrast to CIJ technology where a continuous stream of drops is generated at nozzle outlets. Each of the generated primary drops is then directed to the surface to be printed, in contrast to CIJ technology where only a portion of the drops is output and the other drops are fed back to a gutter.

[0040] In one embodiment, the head may be designed such that both drops 121A, 121B are ejected from the nozzle outlets 113A, 113B at the same time, i.e. the drop generating and propelling devices 161A, 161B can be triggered by a common signal.

[0041] In order to improve control over the coalescence process of two primary drops so that they integrate into one combined drop in a predictable and repeatable manner and also such as to achieve a predictable direction of flow of the combined drop 122, the paths of flow of the primary drops 121A, 121B are arranged to be in line with each other before or at the connection point 132. The primary drops are further configured to have different speeds before they reach the connection point 132, so that they may collide at the connection point 132. When two primary drops flowing with different speeds along the same axes collide, their coalescence is highly predictable and the combined drop will continue to flow along the same axis A_C.

[0042] The different speeds can be achieved by ejecting the primary drops from the nozzle outlets with different speeds. However in some embodiments it may be possible to eject the primary drops with substantially the same speed from both nozzle outlets. The fact that nozzles are arranged at an angle assures that the parallel component of velocity of the inclined drop will be smaller than the velocity of the parallel drop, while the speeds will change during the flow between the nozzle outlet and the connection point, e.g. due to flow resistance (e.g. related to drop size) or electrical field, etc.

[0043] The primary drop 121B output from the inclined axis nozzle outlet 113B has a non-zero electric charge and for that reason it will be called a charged primary drop 121B. The drop 121B may be charged in different ways. For example, the liquid in the reservoir 116B may be pre-charged. Alternatively, the liquid may be charged by charging electrodes located along the nozzle channel 112B or at the nozzle outlet 113B. Furthermore, the primary drop 121B may be charged after it is formed and/or ejected, along its path of movement, by charging electrodes located before the deflecting electrodes 141, 142.

[0044] A set of deflecting electrodes 141, 142 forming a capacitor is arranged along the path of flow of the charged primary drop 121B to alter the path of flight of the charged primary drop 121B, such as to align it in line with the path of flight of the primary drop 121A output from the other nozzle outlet 113A before or at the connection point 132. The electrodes 141, 142 are connected to controllable DC voltage sources and controllable according to known methods. Therefore, the path of flight of the charged primary drop 121B is affected over a distance d_1 of the range of operation of the electrodes. The distance d_x between the electrodes is designed such as to avoid breakdown voltage of the capacitor or any physical contact between the flying drop and the electrodes, yet allowing generation the electric field strong enough to change the path of movement of the charged primary drop 121B from an inclined to a parallel path.

[0045] In another embodiment, the electrodes 141 and 142 can be a part of one cylindrical electrode with the same charge as the charged primary drop 121B. The distance d_x will not be dependent on the capacitor breakdown voltage, as in the previous embodiment. Such embodiment will allow for higher tolerances of nozzle placement as well as enable parallel nozzle alignment. While it is less preferable from the point of view of stability of operations, it would require less precision of manufacturing.

[0046] It is also possible to align the nozzles 111A, 111B in parallel to each other and use a first set of electrodes to change the path of the charged drop 121B from parallel to inclined and a second set of electrodes to align the charged drop 121B with the parallel drop before the connection point 132.

[0047] It is also possible to combine both previous embodiments: to use a first stage of deflecting electrodes (to align drops in parallel to each other) 141, 142 as shown on Fig. 2A, followed by electrodes similar to set of electrodes 171 presented at fig. 2A and 4 to more precisely guide the charged drop (or charged drops), which would increase the accuracy and stability of the path of drop movement prior to connection point 132 in order to further improve coalescence conditions.

[0048] The parallel axis primary drop 121A has preferably a zero electrical charge, i.e. it is not charged.

[0049] However, other embodiments are possible, wherein the other primary drop 121A is also charged and ejected at an axis inclined with respect to the desired axis A_C of flow of the combined drop 122, and the printing head further comprises another deflecting electrodes assembly for aligning its axis of flow to axis A_C before the connection point 132.

[0050] In yet another embodiment, more than two primary drops may be generated, i.e. the combined drop 122 may be formed by coalescence (simultaneous or sequential) of more than two drops, e.g. three drops ejected from three nozzles, of which at least two have their axes inclined with respect to the desired axis of flow A_C of the combined drop 122.

[0051] The axis of flow A_C of the combined drop 122 is preferably the main axis of the printing head, but it can be another axis as well. The printing head may comprise additional means for improving drop placement control.

[0052] For example, the printing head may comprise a set of comb-like electrodes 151, 152 connected to controllable DC or AC voltage sources, configured to increase the speed of flow of the charged combined drop 122 before it exits the printing head outlet 185. The speed can be increased in a controllable manner by controlling the AC voltage sources connected to the electrodes 151, 152, in order to achieve a desired combined drop 122 outlet speed, to e.g. control the printing distance, which can be particularly useful when printing on uneven substrates. The set of accelerating electrodes 151, 152 should be placed at a distance d_3 from the deflecting electrodes 141, 142 which is large enough so that the electric fields generated by the electrodes do not interfere their operation in undesired manner. The distance d_2 and the number of accelerating electrode pairs where the combined drop 122 remains under the influence of accelerating force depends on the size of the combined drop 122 and the required increase of its speed. For some industrial printing applications the whole set of AC capacitors might be needed in order to preferably double or triple the combined drop speed, for example from 3 m/s to 9 m/s measured at the outlet 185 of the head. It is also possible to mount the DC electrodes as an accelerating unit. For office printer applications, no acceleration might be required.

[0053] Use of accelerating electrodes allows to eject primary drops from nozzle outlets with relatively small velocities, which helps in the coalescence (which occurs at certain optimal collision parameters depending on: relative speed of drops, their given surface tension, size, temperature etc.), and then to accelerate the combined drop in order to achieve desired printing conditions.

[0054] Furthermore, the printing head may comprise a set of electrodes 171 for deflecting or correcting (the path of drop movement) connected to a controllable DC voltage source, shown in a cross-section along line B-B of Fig. 2A in Fig. 4, which may controllably deflect the direction of the flow of the charged combined drop 122 in a desired direction to control drop placement in a manner equivalent to that known from CIJ technology or - in case of correcting electrodes - improve the alignment of the path of movement of the combined drop 122 parallel to the axis of head in order to improve drop placement accuracy.

[0055] Furthermore, the printing head may comprise means for speeding up the curing of the combined drop 122 before it leaves the printing head, e.g. a UV light source (not shown in the drawing) for affecting a UV-sensitive curing agent in the combined drop 122.

[0056] Therefore, the drop generation process is conducted as shown in details in Figs. 3A-3E. First, primary drops 121A, 121B are ejected from nozzle outlets 113A, 113B as shown in Fig. 3A. The path of flow of the inclined axis drop 121B is altered to bring in into alignment with the path of flow of the parallel axis drop 121A, as shown in Fig. 3B. Once the primary drops 121A, 121B are on aligned paths, they move with different speeds as shown in Fig. 3C and eventually collide at a connection point 132 to form a combined drop 122, as shown in Fig. 3D. The combined drop may thereafter be further accelerated and/or deflected by additional drop control means and finally ejected as shown in Fig. 3E.

[0057] The liquids in the reservoirs 116A, 116B may be preheated or the nozzle outlets can be heated by heaters installed at the nozzle outlets, such that the ejected primary drops have an increased temperature. The increased temperature of working fluids (i.e. ink and catalyst) may lead to improved coalescence process of primary drops and preferably increase adhesion and decrease the curing time of the combined drop 122 when applied on the substrate having a temperature lower than the temperature of the combined drop. The temperature of the ejected primary drops should therefore be higher than the temperature of the surface to be printed, wherein the temperature difference should be adjusted to particular working fluid properties. The rapid cooling of the coalesced drop after placement on the printing surface (having a temperature lower than the ink) increases the viscosity of the drop preventing drop flow due to gravitation.

[0058] The printing head may further comprise a cover 181 which protects the head components, in particular the nozzle outlets 113A, 113B, from the environment, for example prevents them from touching by the user or the printed substrate. Because the connection point 132 is within the printing head, i.e. within the cover 181, the process of combining primary drops can be precisely and predictably controlled, as the process occurs in an environment separated from the surrounding of the printing head. The environment within the printing head is controllable and the environment conditions (such as the air flow paths, pressure, temperature) are known and therefore the coalescence process can occur in a predictable manner.

[0059] Moreover, the cover 181 may comprise heating elements (not shown in the drawing) for heating the volume within the cover 181, i.e. the volume surrounding of the nozzle outlets 113A, 113B and liquid reservoirs 116A, 166B to a predetermined temperature elevated in respect to the ambient temperature, for example from 40°C to 80°C (other temperatures are possible as well, depending on the parameters of the drops), such as to provide stable conditions for combining of the drops. A temperature sensor 183 may be positioned within the cover 181 to sense the temperature. The higher temperature within the printing head facilitates better mixing of coalesced drop by means of diffusion. Additionally, the increased temperature increases the speed of chemical reaction starting at the moment of mixing. Ink reacting on the surface of printed material allows for better adhesion of the printed image.

[0060] Moreover, the printing head 110 may comprise gas-supplying nozzles (not shown in the drawing) for blowing gas (such as air or nitrogen), preferably heated, along the axes A_A, A_B and/or A_C, in order to decrease the curing time, increase the dynamics of movement of the drops and to blow away any residuals that could be formed at the nozzles outlets 113A, 113B or other components of the nozzle assembly.

Claims

1. A drop-on-demand inkjet printing head comprising a nozzle assembly having at least two nozzles (111A, 111B), each nozzle (111A, 111B) being connected through a channel (112A, 112B) with a separate liquid reservoir (116A, 116B) and having at its outlet (113A, 113B) a drop generating and propelling device (161A, 161B) for forming on demand a primary drop (121A, 121B) of liquid at a nozzle outlet (113A, 113B), wherein the first nozzle (111A) is configured to discharge a first primary drop (121A) along a first path and the second nozzle (111B) is configured to discharge a second primary drop (121B) along a second path which is not aligned with the first path, **characterized in that** the second primary drop (121B) has a non-zero electric charge, and the printing head further comprises a set of electrodes (141, 142) for altering the path of flight of the second primary drop (121B) to a path being in line with the path of flight of the first primary drop (121A) before or at a connection point (132) to allow the first primary drop (121A) to combine with the second primary drop (121B) at the connection point (132) into a combined drop (122), wherein each of the first primary drops (121A) and second primary drops (121B) are output to a surface to be printed.

2. The printing head according to claim 1, wherein the second primary drop (121B) is a charged drop or the liquid in the second reservoir (116B) connected with the second nozzle (111B) is charged.

3. The printing head according to any of previous claims, wherein the second nozzle (111B) comprises charging electrodes located along the nozzle channel or at the nozzle outlet for charging the liquid flowing through the nozzle channel (112B).

4. The printing head according to any of previous claims, further comprising charging electrodes for charging the second primary drop (121B) and locat-

ed along the path of flight of the second primary drop before the set of electrodes (141, 142) for altering the path of flight of the second primary drop (121B).

5. The printing head according to any of previous claims, wherein the second primary drop (121B) has a larger size than the first primary drop (121A).

6. The printing head according to any of previous claims, wherein the nozzles (111A, 111B) have their axes parallel to each other.

7. The printing head according to any of previous claims, wherein the nozzles (111A, 111B) have their axes inclined to each other, preferably at an angle α from 3 to 60 degrees, preferably from 5 to 25 degrees.

8. The printing head according to any of previous claims, further comprising another set of electrodes for altering the first path of flight of the first primary drop (111A).

9. The printing head according to any of previous claims, further comprising a set of electrodes (171) for deflecting and/or correcting the drop path of flight connected to a controllable DC voltage source and located downstream with respect to the connection point (132).

10. The printing head according to any of previous claims, further comprising a cover (181) enclosing the nozzle outlets (113A, 113B) and the connection point (132).

11. The printing head according to any of previous claims, wherein the liquid reservoir (116A) connected with the first nozzle (111A) comprises a first liquid and the liquid reservoir (116B) connected with the second nozzle (111B) comprises a second liquid, which when combined initiate a chemical reaction before the combined drop (122) reaches the surface to be printed.

12. The printing head according to claim 11, wherein the first liquid is an ink base and the second liquid is a catalyst for curing the ink base.

13. A method for drop-on-demand inkjet printing by use of the printing head according to any of previous claims, comprising:

- providing a first liquid in the liquid reservoir (116A) connected with the first nozzle (111A);
- providing a second liquid in the liquid reservoir (116B) connected with the second nozzle (111B);
- operating the inkjet printing head to combine the first primary drop (121A) of the first liquid with the second primary drop (121B) of the second liquid at the connection point (132) to initiate a chemical reaction in the combined drop (122) before it reaches the surface to be printed.

14. The method according to claim 13, wherein the first liquid is an ink base and the second liquid is a catalyst for curing the ink base.

15. The method according to any of claims 13-14, further comprising heating the interior of the printing head to a temperature higher than the ambient temperature or heating the primary drops (121A, 121B) to a temperature higher than the temperature of the surface to be printed.

Patentansprüche

1. Tintenstrahldruckkopf für Drop-on-Demand, der eine Düsenanordnung mit mindestens zwei Düsen (111A, 111B) umfasst, wobei jede Düse (111A, 111B) durch einen Kanal (112A, 112B) mit einem gesonderten Flüssigkeitsbehälter (116A, 116B) verbunden wird und an ihrem Auslass (113A, 113B) eine Einheit (161A, 161B) zum Erzeugen und Vorantreiben von Tropfen zum Bilden eines primären Flüssigkeitstropfens (121A, 121B) an einem Düsenauslass (113A, 113B) nach Bedarf aufweist, wobei die erste Düse (111A) konfiguriert wird, einen ersten primären Tropfen (121A) längs eines ersten Wegs abzugeben und die zweite Düse (111B) konfiguriert wird, einen zweiten primären Tropfen (121B) längs eines zweiten Wegs abzugeben, der nicht mit dem ersten Weg ausgerichtet ist, **dadurch gekennzeichnet, dass** der zweite primäre Tropfen (121B) eine elektrische Ladung ungleich Null aufweist und der Druckkopf des Weiteren einen Elektrodensatz (141, 142) zum Abändern des Flugwegs des zweiten primären Tropfens (121B) in einen Weg umfasst, der mit dem Flugweg des ersten primären Tropfens (121A) vor oder an einem Vereinigungspunkt (132) ausgerichtet ist, um dem ersten primären Tropfen (121A) zu ermöglichen, sich mit dem zweiten primären Tropfen (121B) an dem Vereinigungspunkt (132) in einen vereinigten Tropfen (122) zu vereinigen, wobei jeder der ersten primären Tropfen (121A) und zweiten primären Tropfen (121B) auf eine zu bedruckende Oberfläche ausgegeben wird.

2. Druckkopf nach Anspruch 1, wobei der zweite primäre Tropfen (121B) ein geladener Tropfen ist oder die Flüssigkeit in dem mit der zweiten Düse (111B) verbundenen zweiten Behälter (116B) geladen ist.

3. Druckkopf nach einem der vorhergehenden Ansprüche, wobei die zweite Düse (111B) Ladungselektroden umfasst, die längs des Düsenkanals oder an dem Düsenauslass zum Laden der Flüssigkeitsströmung durch den Düsenkanal (112B) angeordnet werden.

4. Druckkopf nach einem der vorhergehenden Ansprüche, der des Weiteren Ladungselektroden zum Laden des zweiten primären Tropfens (121B) umfasst und längs des Flugwegs des zweiten primären Tropfens vor dem Elektrodensatz (141, 142) zum Abändern des Flugwegs des zweiten primären Tropfens (121B) angeordnet wird.

5. Druckkopf nach einem der vorhergehenden Ansprüche, wobei der zweite primäre Tropfen (121B) ein größeres Ausmaß als der erste primäre Tropfen (121A) aufweist.

6. Druckkopf nach einem der vorhergehenden Ansprüche, wobei die Düsen (111A, 111B) ihre Achsen parallel zueinander aufweisen.

7. Druckkopf nach einem der vorhergehenden Ansprüche, wobei die Düsen (111A, 111B) ihre Achsen zueinander geneigt aufweisen, vorzugsweise mit einem Winkel α von 3 bis 60 Grad, vorzugsweise von 5 bis 25 Grad.

8. Druckkopf nach einem der vorhergehenden Ansprüche, der des Weiteren einen weiteren Elektrodensatz zum Abändern des ersten Flugwegs des ersten primären Tropfens (111A) umfasst.

9. Druckkopf nach einem der vorhergehenden Ansprüche, der des Weiteren zum Ablenken und/oder Korrigieren des Tropfenflugwegs einen Elektrodensatz (171) umfasst, der an eine steuerbare Gleichspannungsquelle angeschlossen und stromabwärts in Bezug auf den Vereinigungspunkt (132) angeordnet wird.

10. Druckkopf nach einem der vorhergehenden Ansprüche, der des Weiteren eine Abdeckung (181) umfasst, die den Düsenauslass (113A, 113B) und den Vereinigungspunkt (132) umschließt.

11. Druckkopf nach einem der vorhergehenden Ansprüche, wobei der mit der ersten Düse (111A) verbundene Flüssigkeitsbehälter (116A) eine erste Flüssigkeit umfasst und der mit der zweiten Düse (111B) verbundene Flüssigkeitsbehälter (116B) eine zweite Flüssigkeit umfasst, die, wenn sie vereinigt werden, eine chemische Reaktion initiieren, bevor der vereinigte Tropfen (122) die zu bedruckende Oberfläche erreicht.

12. Druckkopf nach Anspruch 11, wobei die erste Flüssigkeit eine Tintenbasis ist und die zweite Flüssigkeit ein Katalysator zum Aushärten der Tintenbasis ist.

13. Verfahren zum Tintenstrahldrucken für Drop-on-Demand durch Einsatz des Druckkopfs nach einem der vorhergehenden Ansprüche, umfassend:

- ein Bereitstellen einer ersten Flüssigkeit in dem mit der ersten Düse (111A) verbundenen Flüssigkeitsbehälter (116A);
- ein Bereitstellen einer zweiten Flüssigkeit in dem mit der zweiten Düse (111B) verbundenen Flüssigkeitsbehälter (116B);
- ein Betreiben des Tintenstrahldruckkopfs, um den ersten primären Tropfen (121A) der ersten Flüssigkeit mit dem zweiten primären Tropfen (121B) der zweiten Flüssigkeit an dem Vereinigungspunkt (132) zu vereinen, um eine chemische Reaktion in dem vereinigten Tropfen (122) zu initiieren, bevor er die zu bedruckende Oberfläche erreicht.

14. Verfahren nach Anspruch 13, wobei die erste Flüssigkeit eine Tintenbasis ist und die zweite Flüssigkeit ein Katalysator zum Aushärten der Tintenbasis ist.

15. Verfahren nach einem der Ansprüche 13 bis 14, das des Weiteren ein Aufheizen des Innenbereichs des Druckkopfs auf eine Temperatur höher als die Umgebungstemperatur oder ein Aufheizen der primären Tropfen (121A, 121B) auf eine Temperatur höher als die zu bedruckende Oberflächentemperatur umfasst.

Revendications

1. Tête d'impression à jet d'encre de type goutte à la demande comprenant un ensemble de buses possédant au moins deux buses (111A, 111B), chaque buse (111A, 111B) étant raccordée par un canal (112A, 112B) à un réservoir de liquide séparé (116A, 116B) et comportant au niveau de sa sortie (113A, 113B) un dispositif de génération et d'éjection de gouttes (161A, 161B) en vue de former à la demande une goutte primaire (121A, 121B) de liquide au niveau d'une sortie de buse (113A, 113B), ladite première buse (111A) étant conçue pour décharger une première goutte primaire (121A) le long d'une première trajectoire et ladite seconde buse (111B) étant conçue pour décharger une seconde goutte primaire (121B) le long d'une seconde trajectoire qui n'est pas alignée avec la première trajectoire, **caractérisée en ce que** la seconde goutte primaire (121B) possède une charge électrique non nulle et que la tête d'impression comprend en outre un ensemble d'électrodes (141, 142) destinées à modifier la trajectoire de vol de la seconde goutte primaire (121B) en une trajectoire alignée avec la trajectoire de vol de la première goutte primaire (121A) avant un point de raccordement (132), ou au niveau de celui-ci, pour permettre à la première goutte primaire (121A) de se combiner à la seconde goutte primaire (121B) au niveau du point de raccordement (132) en une goutte combinée (122), chacune des premières gouttes primaires (121A) et secondes gouttes primaires (121B) étant délivrée sur une surface à imprimer.

2. Tête d'impression selon la revendication 1, ladite seconde goutte primaire (121B) étant une goutte chargée ou le liquide dans le second réservoir (116B) raccordé à la seconde buse (111B) étant chargé.

3. Tête d'impression selon l'une quelconque des revendications précédentes, ladite seconde buse (111B) comprenant des électrodes de charge situées le long du canal de buse ou au niveau de la sortie de buse en vue de charger le liquide s'écoulant par le canal de buse (112B).

4. Tête d'impression selon l'une quelconque des revendications précédentes, comprenant en outre des électrodes de charge destinées à charger la seconde goutte primaire (121B) et situées le long de la trajectoire de vol de la seconde goutte primaire avant l'ensemble d'électrodes (141, 142) en vue de modifier la trajectoire de vol de la seconde goutte primaire (121B).

5. Tête d'impression selon l'une quelconque des revendications précédentes, ladite seconde goutte primaire (121B) possédant une taille plus grande que la première goutte primaire (121A).

6. Tête d'impression selon l'une quelconque des revendications précédentes, lesdites buses (111A, 111B) possédant leurs axes parallèles les uns aux autres.

7. Tête d'impression selon l'une quelconque des revendications précédentes, lesdites buses (111A, 111B) possédant leurs axes inclinés les uns par rapport aux autres, de préférence selon un angle α allant de 3 à 60 degrés, de préférence allant de 5 à 25 degrés.

8. Tête d'impression selon l'une quelconque des revendications précédentes, comprenant en outre un autre ensemble d'électrodes destinées à modifier la première trajectoire de vol de la première goutte primaire (111A).

9. Tête d'impression selon l'une quelconque des revendications précédentes, comprenant en outre un ensemble d'électrodes (171) destinées à dévier et/ou à corriger le trajectoire de vol de goutte raccordées à une source de tension continue pouvant être commandée et situées en aval par rapport au point de raccordement (132).

10. Tête d'impression selon l'une quelconque des revendications précédentes, comprenant en outre un couvercle (181) renfermant les sorties de buse (113A, 113B) et le point de raccordement (132).

11. Tête d'impression selon l'une quelconque des revendications précédentes, ledit réservoir de liquide (116A) raccordé à la première buse (111A) comprenant un premier liquide et ledit réservoir de liquide (116B) raccordé à la seconde buse (111B) comprenant un second liquide, qui, lorsqu'ils sont combinés, amorcent une réaction chimique avant que la goutte combinée (122) n'atteigne la surface à imprimer.

12. Tête d'impression selon la revendication 11, ledit premier liquide étant une base d'encre et ledit second liquide étant un catalyseur destiné à durcir la base d'encre.

13. Procédé permettant l'impression par jet d'encre de type goutte à la demande à l'aide d'une tête d'impression selon l'une quelconque des revendications précédentes, comprenant :

- la fourniture d'un premier liquide dans le réservoir de liquide (116A) raccordé à la première buse (111A) ;
- la fourniture d'un second liquide dans le réservoir de liquide (116B) raccordé à la seconde buse (111B) ;
- le fonctionnement de la tête d'impression à jet d'encre pour combiner la première goutte primaire (121A) du premier liquide avec la seconde goutte primaire (121B) du second liquide au niveau du point de raccordement (132) afin d'amorcer une réaction chimique dans la goutte combinée (122) avant que cette dernière n'atteigne la surface à imprimer.

14. Procédé selon la revendication 13, ledit premier liquide étant une base d'encre et ledit second liquide étant un catalyseur destiné à durcir la base d'encre.

15. Procédé selon l'une quelconque des revendications 13 à 14, comprenant en outre le chauffage de l'intérieur de la tête d'impression à une température qui est supérieure à la température ambiante ou le chauffage des gouttes primaires (121A, 121B) à une température qui est supérieure à la température de la surface à imprimer.

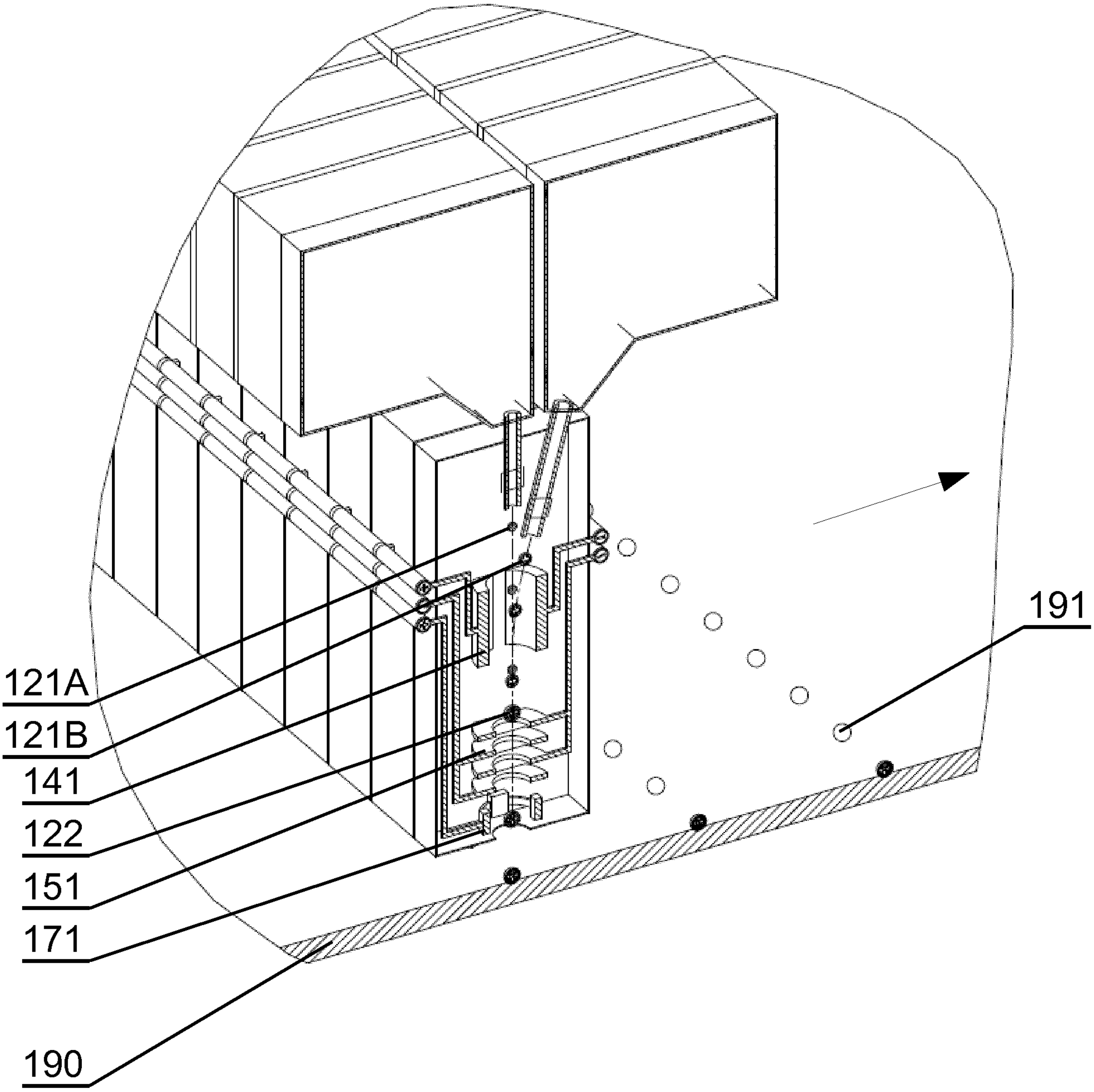

Fig. 1

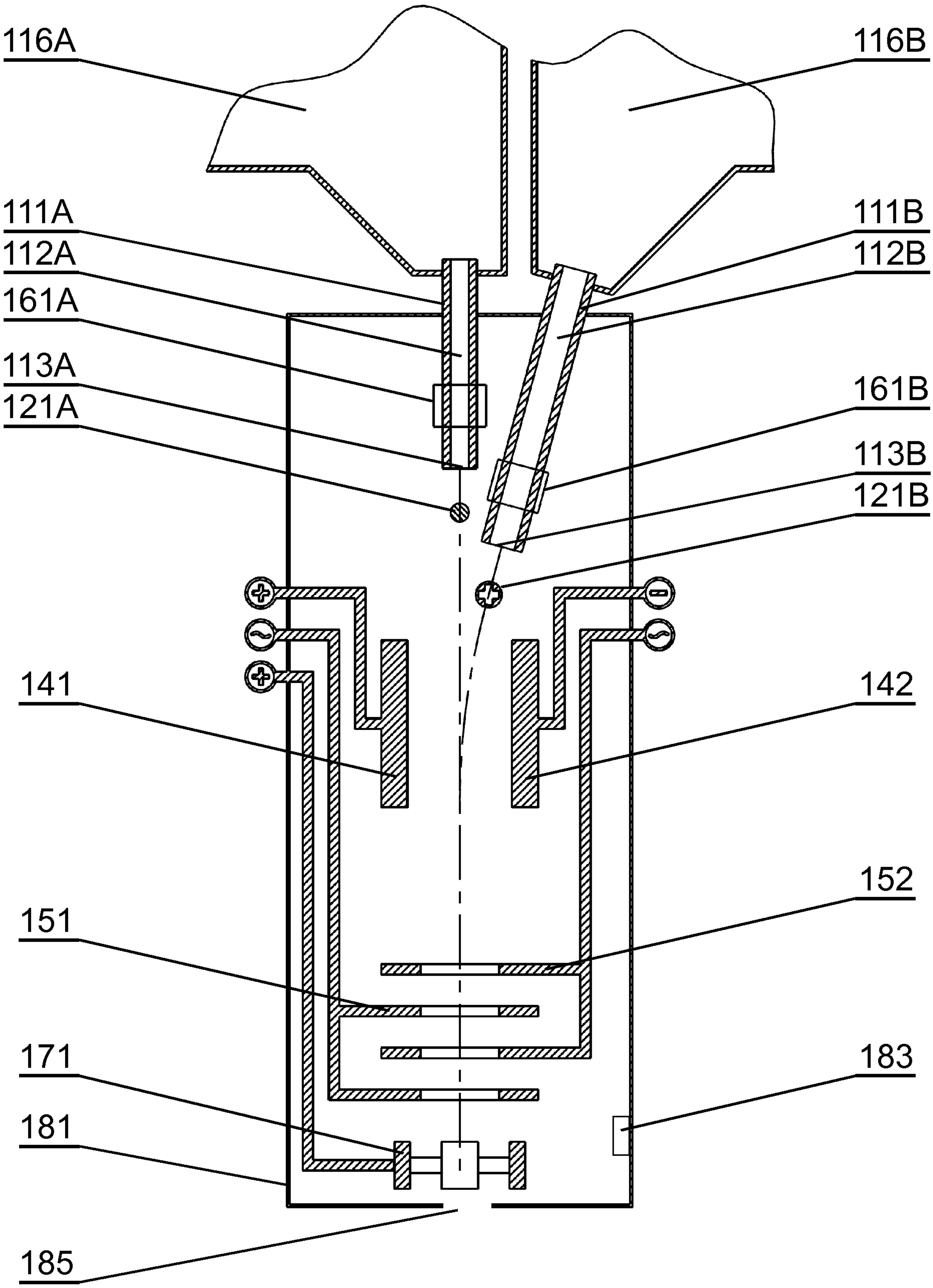
116A
116B
111A
112A
161A
113A
121A
111B
112B
161B
113B
121B
141
142
152
151
171
183
181
185

Fig. 2A

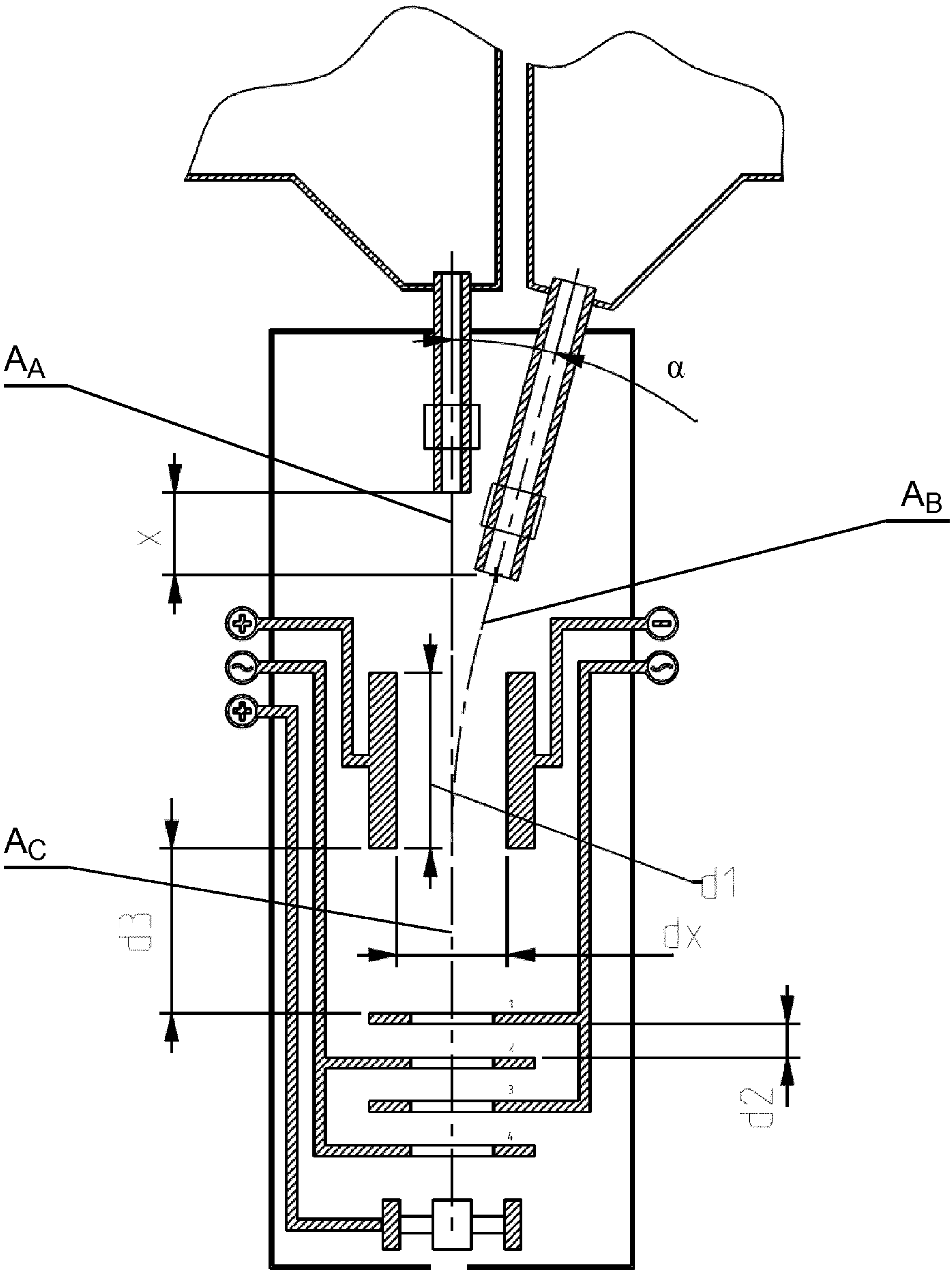

Fig. 2B

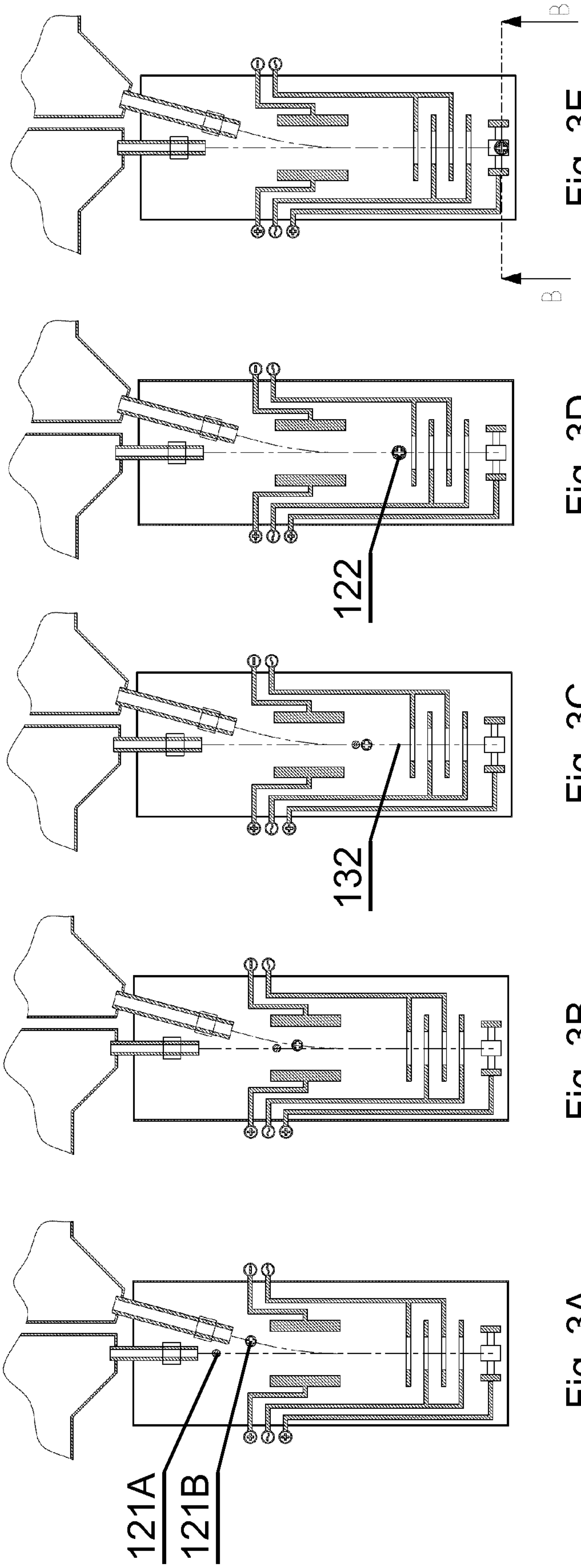

Fig. 3E

Fig. 3D

Fig. 3C

Fig. 3B

Fig. 3A

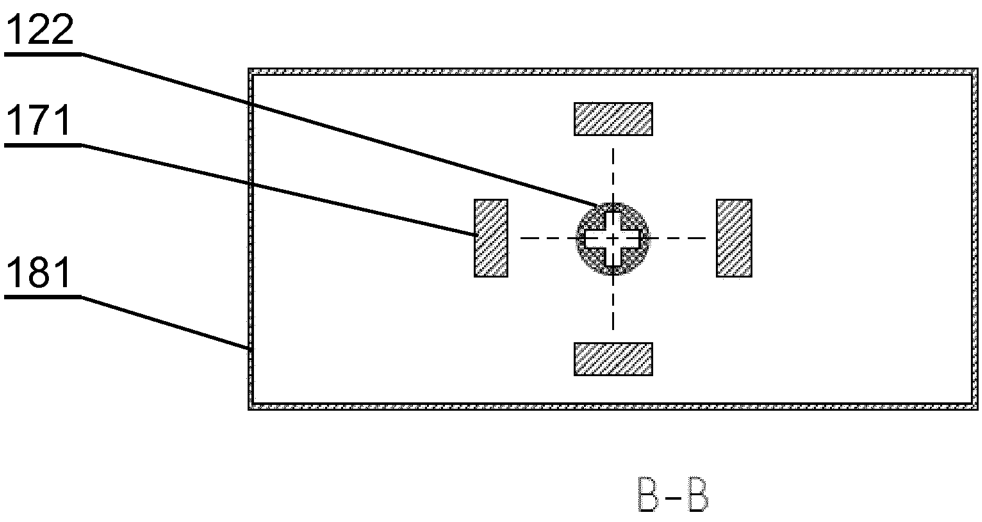

Fig. 4

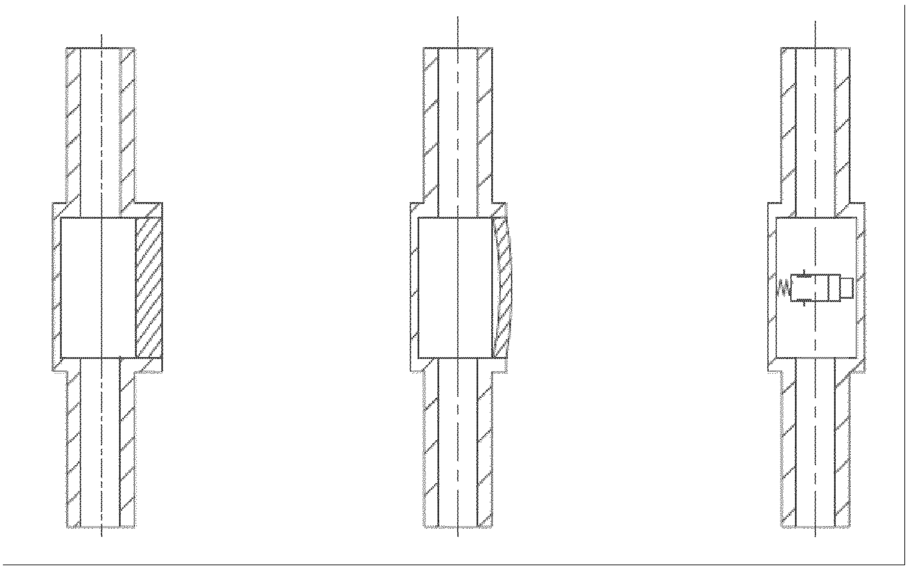

Fig. 5 Fig. 6 Fig. 7

REFERENCES CITED IN THE DESCRIPTION

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