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Sicking

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[54] **APPARATUS FOR APPLYING A LIQUID IN DROPLETS TO A SURFACE**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **346/140;** 222/420

[51] **Int. Cl.²** **G01D 15/16**

[58] **Field of Search** ..... 222/56, 207, 209, 214, 222/420, 422, 386.5, DIG. 1, 108, 109; 346/75, 140; 138/32, 33; 137/568; 73/362.4–362.6, 368

[56] **References Cited**

UNITED STATES PATENTS

2,487,686	11/1949	Zuehlke	73/362.5
2,846,884	8/1958	Daly	73/362.4
3,083,689	4/1963	Hegener	346/140
3,747,120	7/1973	Stemme	346/140
3,805,276	4/1974	Ishii	346/140
3,852,773	12/1974	Sicking	346/140

FOREIGN PATENTS OR APPLICATIONS

117,277	7/1943	Australia	73/362.4

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[57] **ABSTRACT**

In an apparatus for applying a liquid in droplets to a surface by momentarily pressurizing the liquid in a pressure chamber of an ejection head and thus discharging the liquid in pulses from the ejection head, there is provided an equalizing device to compensate for the pressure fluctuations of the liquid due to temperature fluctuations. The equalizing device includes a pressure equalizing chamber which communicates with the pressure chamber and which has a wall that is elastically deformable for varying the capacity of the pressure equalizing chamber.

2 Claims, 4 Drawing Figures

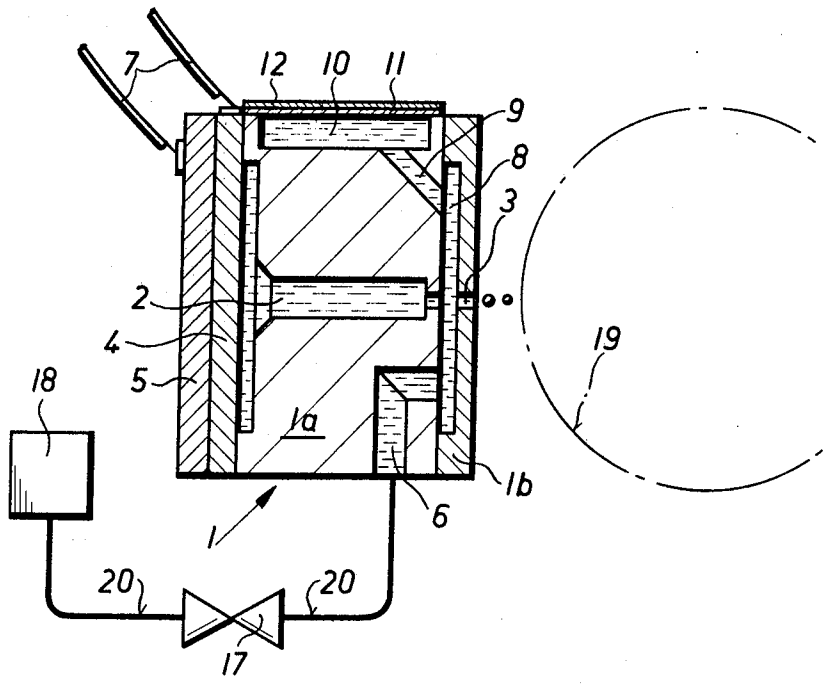


FIG.1

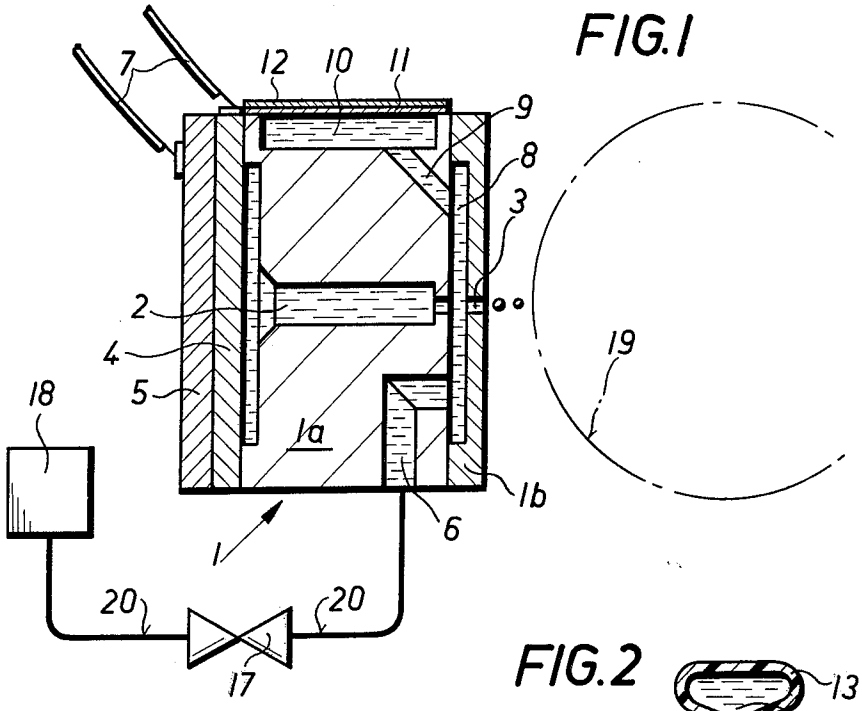
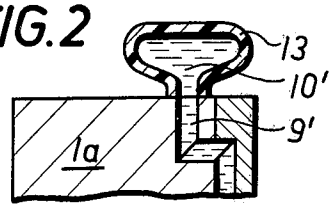


FIG.2



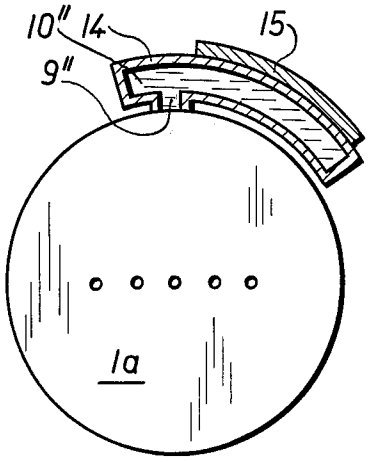
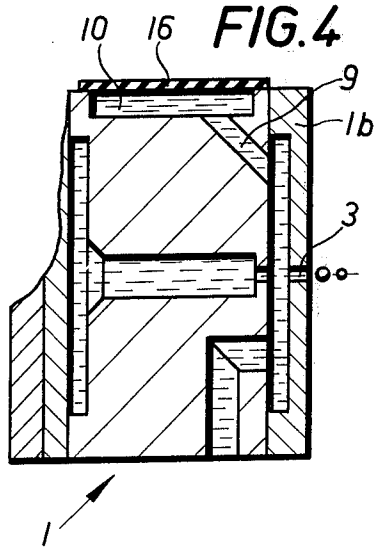


FIG.3

FIG.4



APPARATUS FOR APPLYING A LIQUID IN DROPLETS TO A SURFACE

BACKGROUND OF THE INVENTION

The present invention relates to an apparatus for applying a liquid in droplets to a surface, particularly a printer with an ink ejection head which is provided with an ejection system. The latter includes a pressure chamber provided with a discharge channel for the discharge of liquid and a supply channel for the liquid taken from a reservoir through a conduit and a device for effecting short-period, pulse like, momentary pressurizations of the liquid in the chamber.

In order to prevent backlashes upon a change of position of the ejection mechanism and a change in atmospheric pressure from the reservoir and the liquid conduit in the non-operating state of the printer, the liquid in the ejection head is separated from the liquid contained in the conduit and in the reservoir by a check valve inserted in the conduit. This measure prevents an equalization of the liquid between the ejection head and the reservoir. Because of the temperature differences of the ejection head during its operating state and non-operating state after switch-off and because of fluctuating room and radiation temperatures from heat sources, the volume of liquid fed into the ejection head changes faster than the capacity of the hollow spaces in the ejection system. If, for example, the ejection head and the liquid cools by 20°C, the volume of the liquid compared to the capacity of the cavities in the ejection head decreases to such an extent that pressure fluctuations are generated in the liquid which overcome the capillary forces in the discharge channels so that air enters into the cavities in the ejection head. This leads to a malfunctioning of the ejection head, so that it must be refilled with liquid in a vacuum device. If, on the other hand, a temperature increase occurs, the pressure increases which causes the liquid (ink) to flow out of the discharge channels which leads to soiling of the ejection head, the writing mechanism and the record carrier.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved apparatus for effecting a pressure equalization by means of an exchange of liquid in the switched-off ejection head.

This object and others to become apparent as the specification progresses are accomplished by the invention, according to which, briefly stated, there is provided a pressure equalizing device which is in communication with the pressure chamber and includes a pressure equalizing chamber filled with the liquid and has at least one wall portion which is elastically deformable to resiliently define the pressure equalizing chamber. In this manner, the capacity of the pressure equalizing chamber can be varied during pressure decreases and increases of the liquid in the ejection system due to the above-discussed causes.

The advantages of the present invention reside in that the pressure equalizing chamber of the pressure equalization device will be filled with the liquid at the same time as the ejection head, that the volume of the pressure equalizing chamber automatically adjusts itself directly to the actual pressure and that fluctuations in the level of the liquid in the ejection head, in the supply lines and in the reservoir are compensated in the operating state.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a liquid ejection head incorporating a preferred embodiment of the invention.

FIG. 2 is a fragmentary sectional view of an ejection head incorporating another preferred embodiment of the invention.

FIG. 3 is an end view of an ejection head incorporating still another embodiment of the invention which is illustrated in section.

FIG. 4 is a sectional view of an ejection head incorporating still a further embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Turning now to FIG. 1, there is illustrated in section an ejection head generally indicated at 1 which incorporates a preferred embodiment of the invention.

The ejection head 1 comprises a block 1*a* in which there is formed a pressure chamber 2 bounded and closed off by a diaphragm plate 4. From that end of the pressure chamber 2 which is remote from the diaphragm plate 4, there extends a discharge channel 3 through which a liquid, such as ink is adapted to be ejected in droplets onto a surface, such as an imprint carrier, only symbolically shown at 19. To the diaphragm plate 4 there is attached a transducer 5 which, when energized through external electric lead connection 7, causes the diaphragm plate 4 to deflect. In this manner, short-period, pulse-like, momentary pressurizations of the ink accommodated in the pressure chamber 2 are effected. As a result of such pressurizations, the ink is ejected through the outlet channel 3 in droplets.

For example, the transducer 5 may be a piezoelectric oscillating plate made of a ceramic material. The discharge channel 3 is partitioned by a capillary chamber 8 defined by wall portions of the block 1*a* and a closure 1*b* attached to the block 1*a*. Supply of ink to the ejection head 1 is effected through an inlet channel 6 which is formed in the head block 1*a* and which merges into the capillary chamber 8. To the inlet channel 6 there is coupled a supply conduit 20 which at its other end is connected to an ink reservoir 18. A valve 17 is inserted in the conduit 20.

The above-described components and the mode of operation of the ejection head are conventional.

Such ejection head is shown and discribed in the published German Patent application, No. 2,132,082 (U.S. Ser. No. 50,445).

The pressure equalizing device provided according to the invention includes an equalizing chamber 10 formed in the head block 1*a* and communicating with the capillary chamber 8 through a port 9 also formed in the block 1*a*. The equalizing chamber 10 is closed off by a resiliently flexible plate 11 attached to the head block 1*a*. As it may be observed in FIG. 1, the flexible plate 11 constitutes a wall of the equalization chamber 10. To that face of the flexible plate 11 which is oriented away from the equalization chamber 10, there is rigidly attached a second plate 12. The material of the first plate 11 has a lower coefficient of expansion than the material of the second plate 12. The plates 11 and 12 are made of metals of different coefficient of thermal expansion, for instance iron and copper. Upon

changes in temperature, these plates bend in such a way that the size of the equalizing chamber **10** is either decreased or enlarged by the value of the temperature-caused change in volume of the ink in the cavities of the ejection head, including the pressure equalizing chamber **10**.

According to the embodiment of the equalizing system illustrated in FIG. **2**, there is provided a vessel **13** attached externally of the ejection head block **1***a*. The vessel **13** defines an equalizing chamber **10'** which communicates with the ejection system (not shown in FIG. **2**) by means of a port **9'**. The vessel **13** is made of a plastic whose coefficient of expansion is higher than that of the ink, so that the volume in vessel **13** changes more rapidly than that of the ink.

The approximate value of the coefficient of thermal expansion of the liquids is similar to that of water.

Turning now to FIG. **3**, the equalizing system illustrated therein includes a Bourdon tube formed of a tubular spring **14**, the inside of which defines an equalizing chamber **10''** and which is attached to the head block **1***a* externally thereof. The equalizing chamber **10''** communicates with the ejection system (not shown in FIG. **3**) through a port **9''**. To the exterior of the tubular spring **14** there is attached a bimetal strip **15** having a coefficient of expansion that is smaller than that of the tubular spring **14**.

During decrease of temperature the bimetal **15** deforms in such a manner that the volume of the Bourdon tube will be smaller. The volume will be increased during increase of temperature.

The embodiment illustrated in FIG. **4** is similar to that of FIG. **1**, except that the plate assembly **11, 12** is replaced by a rubber-like diaphragm **16** which has a bending resistance that is smaller than the cohesive force that retains the ink in the discharge channel (or channels) **3**. As a result, a temperature-caused expansion of the ink volume within the ejection head **1** will be accommodated by an increase in the cavity volume and the ink will thus not be forced out through the discharge channels **3**. The cohesive force between the liquid and the outlet channel corresponds approximately to 60 mm column.

It is thus seen that in the FIG. **1** and FIG. **3** embodiments the volume of the equalizing chamber is changed directly as a function of a variable (temperature) which also causes the pressure variations in the liquid. In the FiG. **2** and FIG. **4** embodiments, on the other hand, the volume of the equalizing chamber is changed directly as a function of a variable (change of volume of the liquid) which, in turn, is a function of the temperature affecting the volume of the liquid.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

I claim:

1. In an apparatus for applying a liquid in droplets to a surface, including an ejection head having means forming a pressure chamber in the ejection head, means forming a discharge channel in the ejection head, the discharge channel communicating with the pressure chamber, means forming an inlet channel in the ejection head, the inlet channel communicating with the pressure chamber, the apparatus further including a reservoir for the liquid, conduit means coupling the reservoir with the inlet channel for supplying the pressure chamber with liquid and a device connected to the ejection head for effecting momentary pressurizations of the liquid in the pressure chamber, shutoff means in the conduit means, the shutoff means having an open position for maintaining communication between the reservoir and the ejection head in the operating state of the apparatus, the shutoff means having a closed position for blocking communication between the reservoir and the ejection head in the non-operating state of the apparatus, the improvement comprising a pressure equalizing device including wall means bounding and defining a pressure equalizing chamber entirely filled with the liquid, said pressure equalizing chamber being in communication with said pressure chamber, at least one portion of said wall means being constituted by a first plate deformable for varying the volume of said pressure equalizing chamber, said first plate being attached to said ejection head and being responsive to the temperature of the liquid in said pressure chamber and in said pressure equalizing chamber; a second plate affixed rigidly face-to-face to said first plate; the material of said first plate having a coefficient of thermal expansion that is smaller than that of said second plate for increasing and, respectively, decreasing said volume upon expansion and, respectively, contraction of the liquid in said ejection head in said closed position of said shutoff means.

2. In an apparatus for applying a liquid in droplets to a surface, including an ejection head having means forming a pressure chamber in the ejection head, means forming a discharge channel in the ejection head, the discharge channel communicating with the pressure chamber, means forming an inlet channel in the ejection head, the inlet channel communicating with the pressure chamber, the apparatus further including a reservoir for the liquid, conduit means coupling the reservoir with the inlet channel for supplying the pressure chamber with liquid and a device connected to the ejection head for effecting momentary pressurizations of the liquid in the pressure chamber, shutoff means in the conduit means, the shutoff means having an open position for maintaining communication between the reservoir, and the ejection head in the operating state of the apparatus, the shutoff means having a closed position for blocking communication between the reservoir and the ejection head in the non-operating state of the apparatus, the improvement comprising a pressure equalizing device including a Bourdon tube having a tubular spring enclosing an inner space defining a pressure equalizing chamber entirely filled with the liquid, said pressure equalizing chamber being in communication with said pressure chamber; said tubular spring being deformable for varying the volume of said pressure equalizing chamber and being responsive to the temperature of the liquid in said pressure chamber and in said pressure equalizing chamber; a bimetal strip attached to said tube spring and having a coefficient of expansion that is smaller than that of said tubular spring for increasing and, respectively, decreasing said volume upon expansion and, respectively, contraction of the liquid in said ejection head in said closed position of said shutoff means.

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