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FIG. 1

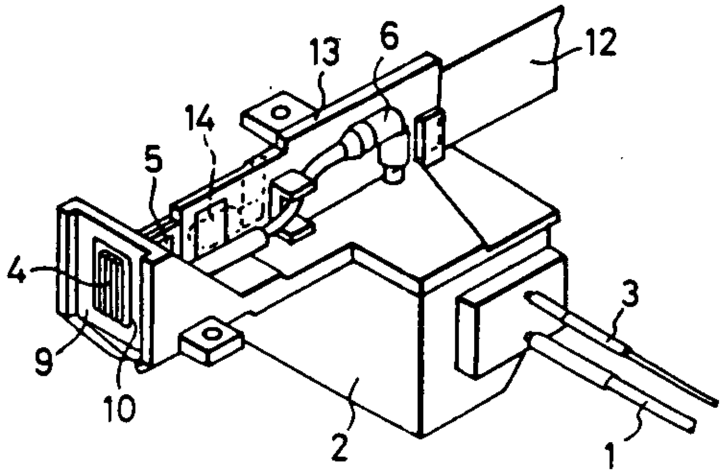

FIG. 2

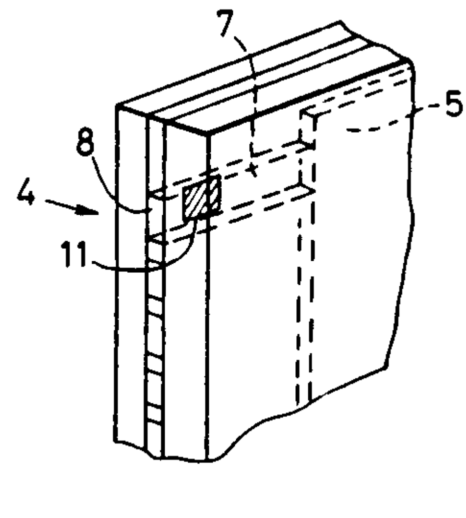

FIG. 3

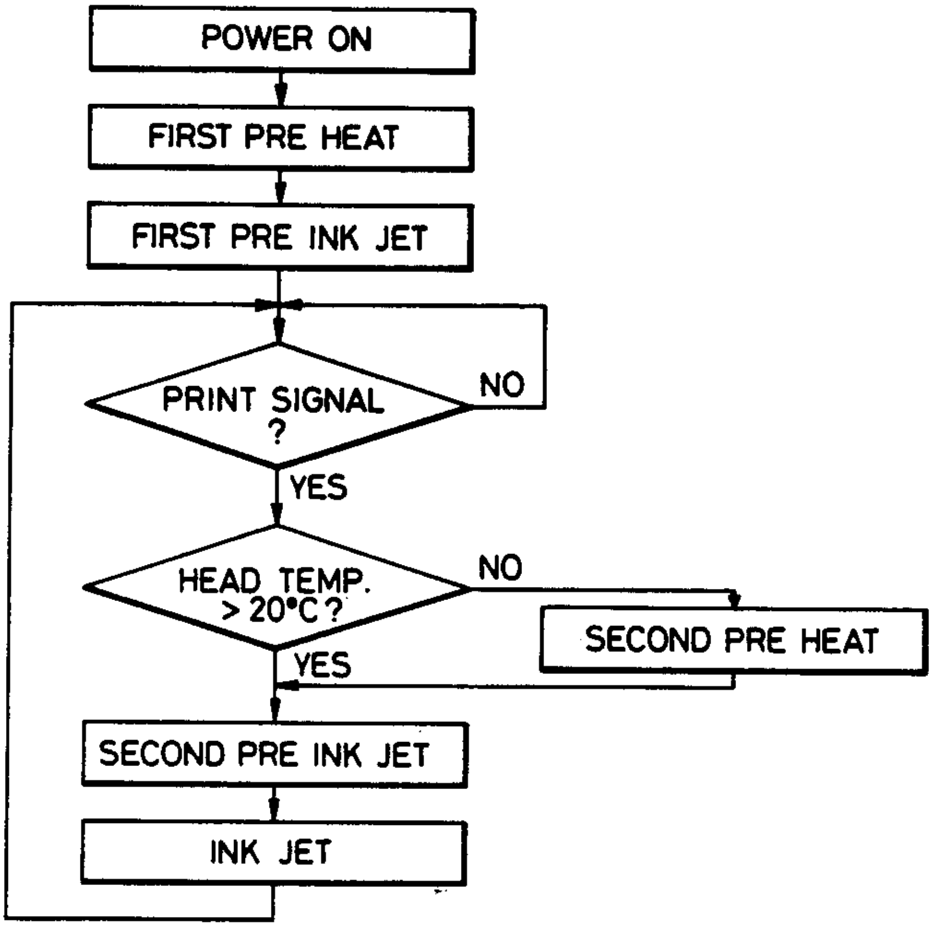
POWER ON
FIRST PRE HEAT
FIRST PRE INK JET
PRINT SIGNAL ?
NO
YES
HEAD TEMP. > 20°C ?
NO
SECOND PRE HEAT
YES
SECOND PRE INK JET
INK JET

FIG. 4

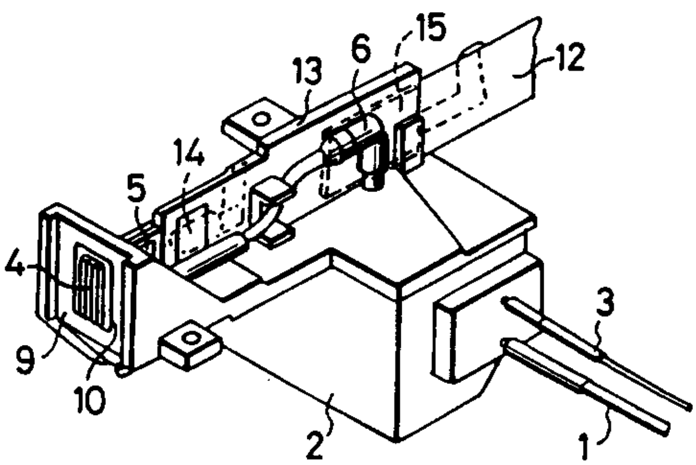
15
6
13
12
14
5
4
3
9
10
2
1

FIG. 5

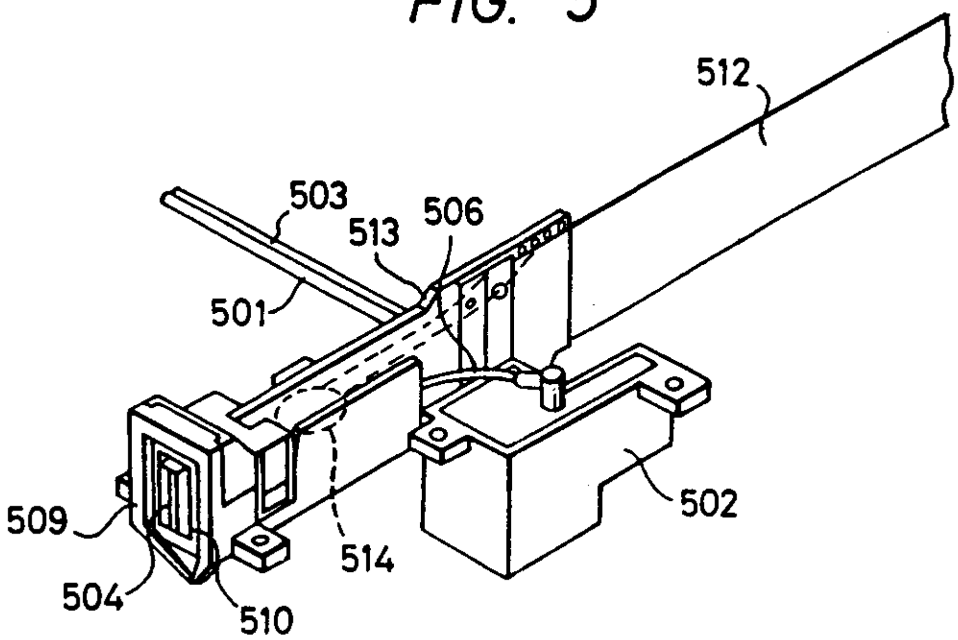

FIG. 6

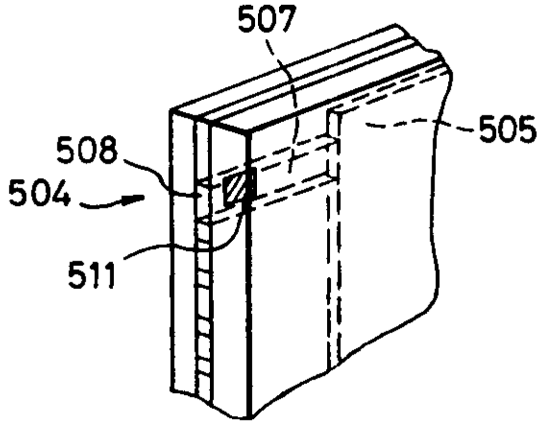

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FIG. 7

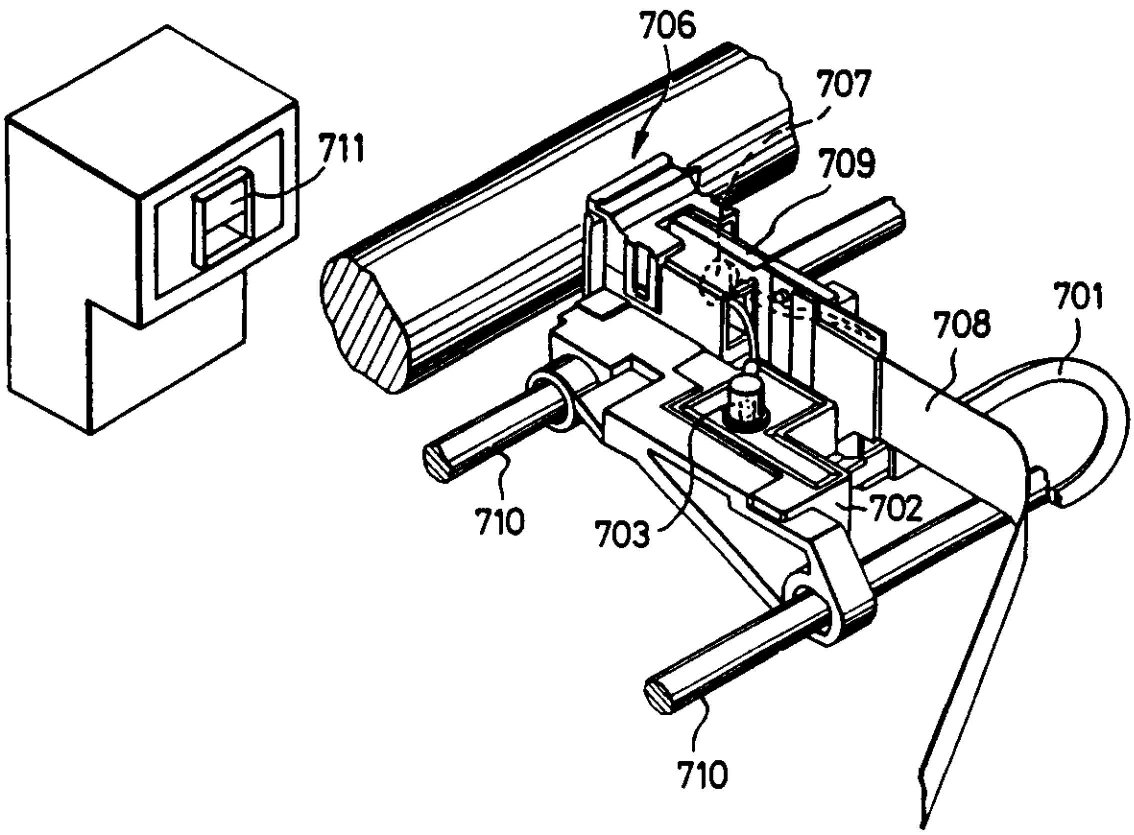


FIG. 8

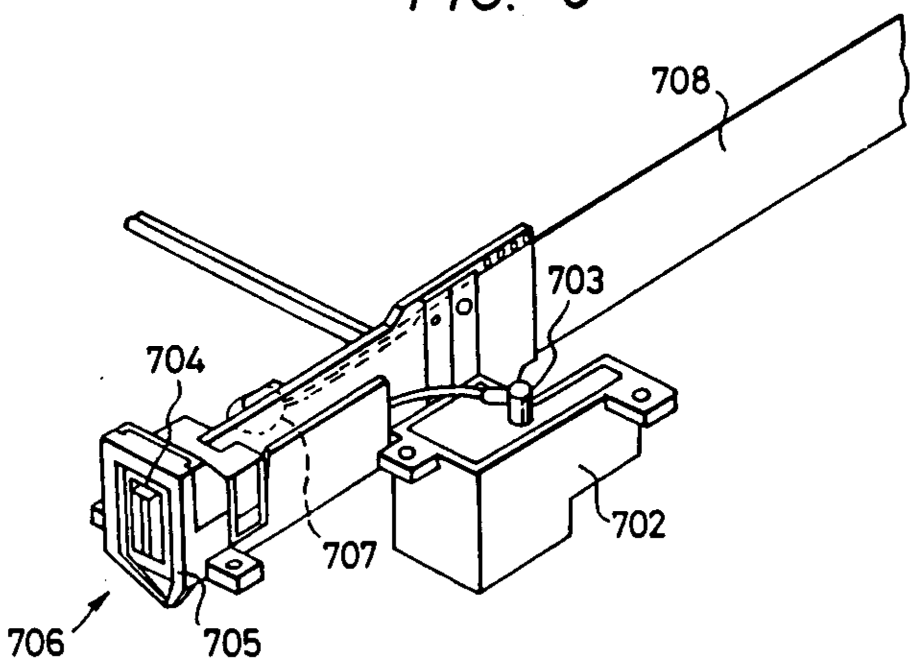


FIG. 9

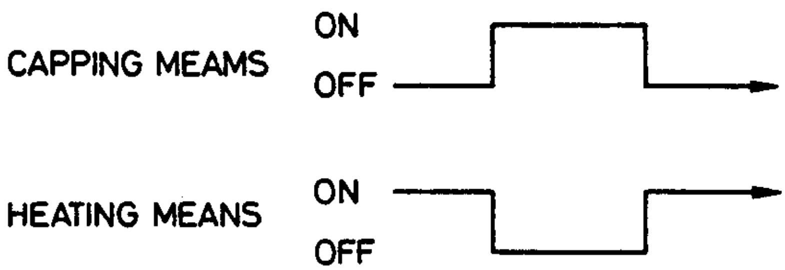
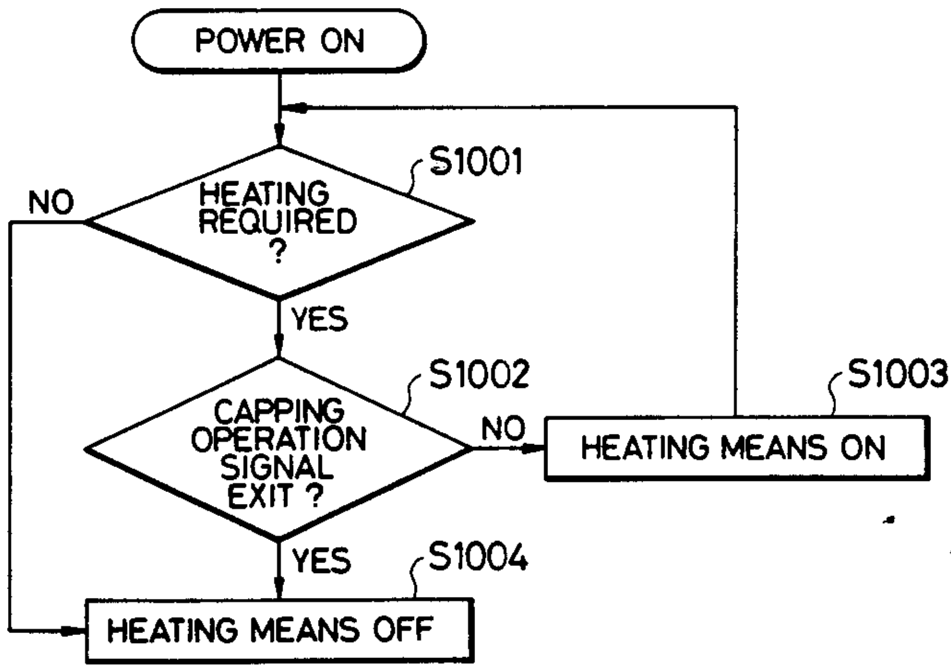

CAPPING MEAMS
ON
OFF
HEATING MEANS
ON
OFF

FIG. 10


POWER ON
S1001
HEATING REQUIRED ?
NO
YES
S1002
CAPPING OPERATION SIGNAL EXIT ?
NO
S1003
HEATING MEANS ON
YES
S1004
HEATING MEANS OFF

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Liquid-Discharge Recording Apparatus

The present invention relates to a liquid-discharge recording apparatus and, more particularly, to a liquid-discharge recording apparatus having the mechanism to maintain a viscosity of an ink to be emitted so as to be fitted for emission at least when the ink is emitted.

According to liquid-discharge recording apparatuses, a recording liquid (for example, ink) is held in an ink vessel, the ink is led to a recording head unit from this ink vessel, a nozzle provided in the recording head unit is driven in response to a print pattern signal, and at the same time the ink is emitted from a discharge opening at the head of the nozzle, thereby performing the recording such as the printing or the like on a recording material such as a paper or the like. The ink emitted forms a jet liquid droplet and is deposited on the recording material.

As methods of emitting the ink onto the recording material, the method whereby an electro-mechanical converter such as, e.g., a piezoelectric device or the like is used, the method whereby an electrothermal energy converter is used, and the like are known. According to the method whereby the electrothermal energy converter is used, the ink in the nozzle is heated by the electrothermal energy converter to cause a change in pressure of the ink, thereby emitting the ink.

In the liquid-discharge recording apparatuses to which the above-mentioned emitting methods and other conventional emitting methods are applied, it is a general manner that the discharge opening at the head of the nozzle to emit the ink is always open into the open air irrespective of whether the apparatus is operating or not. Therefore, in the case where the recording is not performed for a long time, the water and volatile organic solvent or the like which are the components of the ink evaporate into the open air from the inks remaining at the discharge opening and in the portion near the discharge opening. Thus, the viscosity of the residual ink increases and exceeds a range of viscosity necessary for emission, causing a problem such that no ink is emitted in spite of the fact that a print signal is applied immediately after the apparatus operated and the recording was restarted.

In addition, there is also another problem such that a temperature of the ink decreases at low temperatures in winter season or the like, so that the viscosity of the ink also increases.

To solve the problem of the increase of the viscosity of the ink mentioned above, there has been proposed the method whereby the ink is heated just before the recording is restarted, namely, just before the ink is again emitted, and the temperature of the ink is increased, thereby reducing the viscosity and maintaining it to a predetermined viscosity range.

Even when the environmental temperature is constant, the heating condition is also largely changed depending on the use state of the recording apparatus. Namely, due to the use of the recording apparatus, all of the thermal energy applied from the electrothermal energy converter to emit the ink droplets from the discharge opening, for example, is not necessarily used to form the ink droplets but a part of this thermal energy increases the temperature of the peripheral members of the electrothermal energy converter. Therefore, the temperature of the portion where the discharge opening is formed immediately after the completion of the recording is largely changed as compared with the temperature before the start of the recording, so that there is a problem such that, for instance, when the ink is heated at the restart of the recording just after the end of the recording, the ink is overheated and the viscosity overdecreases.

In order to take account of the above problem, the present invention provides a liquid-discharge recording apparatus comprising:

a recording head having electrothermal energy converting means for generating an energy which is used to emit a liquid in response to an emission signal;

emission signal generating means for generating said emission signal;

heating signal generating means for generating an electrical signal which has a level within a range such as not to emit any liquid but which is of a sufficient level to cause the liquid to be heated and is applied to said electrothermal energy converting means; and

wherein the content of said electrical signal which is applied within the range such as not to emit any liquid droplet is made to differ to bring about a first heating mode when the power supply of said apparatus is turned on and a second heating mode when recording is started after an interruption with the power supply of the apparatus turned on.

During preheating, the heating condition is largely changed due to the circumstances under which the recording apparatus is used. Namely, there is a drawback such that if the preheating condition is determined so as to obtain good emission of the ink droplets even under low temperature environment (for example, 5°C), the viscosity of the ink becomes too low due to the heating under high temperature environment (e.g., 35°C), so that the ink viscosity is out of the range necessary for good emission. On the contrary, in the case where the preheating condition is set so as to derive a good ink viscosity under high temperature environment, the necessary viscosity cannot be derived under low temperature environment.

In order to take account of this problem, in the apparatus of the present invention, there is preferably provided means for detecting a temperature of the liquid in the recording head, the heating signal generating means being driven on the basis of the temperature information detected by said temperature detecting means.

Reference is directed to United Kingdom Patent Application No 8531677 (GB 2169856A) from which this application is divided.

BRIEF DESCRIPTION OT THE DRAWINGS

Various embodiments of the invention will now be described, by way of example only, in the accompanying drawings, in which

Fig. 1 is a schematic perspective view of a recording head unit of a liquid-discharge recording apparatus for explaining the first embodiment of the present invention;

Fig. 2 is an enlarged diagram of a nozzle unit of Fig. 1;

Fig. 3 is a flowchart showing the heating and pre-ink-jet controls in the apparatus of Fig. 1;

Fig. 4 is a schematic perspective view of a recording head unit for use in another example;

Fig. 5 is a schematic perspective view of a recording head unit in a liquid-discharge recording apparatus for use in the second embodiment;

Fig. 6 is an enlarged perspective view of a nozzle unit in Fig. 5;

Fig. 7 is a rear perspective view of the main part of a liquid-discharge recording apparatus according to the third embodiment;

Fig. 8 is a front perspective view of a recording head unit in Fig. 7;

Fig. 9 is a timing chart showing examples of operation timings of capping means and heating means; and

Fig. 10 is a flowchart showing an example of an operation procedure for controlling the operation of the heating means on the basis of the operation of the capping means.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the case of the first embodiment of a liquid-discharge recording apparatus according to the present invention, a temperature sensor to detect a temperature of a recording head unit in which a discharge opening is formed is provided and the heating condition is selected on the basis of a detection signal of this temperature sensor.

An electrothermal energy converter for heating can also serve as an electrothermal energy converter for emission. Namely, in the recording apparatus of the type in which ink droplets are formed by heating and expanding the ink by the electrothermal energy converter for emission, two roles for emitting and heating can be achieved by changing a level of an electrical signal which is applied to the electrothermal energy converter. In this case, as compared with the case where another electrothermal energy converter for heating is separately provided, only the minimum portion which needs to be heated can be heated, so that the influence of the heat to the peripheral portion of the electrothermal energy converter can be suppressed to the minimum degree.

Various kinds of controlling methods can be considered with regard to how to control the electrothermal energy converter for heating in dependence on the temperature of the head unit detected by the temperature sensor. However, it is the most general method that the electrical signal for heating is applied to the electrothermal energy converter for heating until the temperature of the recording head unit near the nozzle becomes a predetermined temperature.

The heating is ordinarily performed immediately before the recording is started. It is desirable that the control of the electrothermal energy converter for heating is carried out by changing the level of the electrical signal in consideration of the recording interruption or stop period before the recording is started.

The first embodiment of the invention will then be described hereinbelow with reference to Figs. 1 to 3. Fig. 1 is a schematic perspective view of the recording head unit of the liquid-discharge recording apparatus according to the first embodiment. Fig. 2 is an enlarged diagram of the nozzle unit in Fig. 1.

In Fig. 1, an ink is led from a main tank (not shown) for storage of the ink to a sub-tank 2 for temporary storage of the ink by an ink supply tube 1. The ink a quality of which deteriorated and which could not be used is inhaled into a recovery pump (not shown) from the sub-tank 2 or the like through a suction tube 3. The sub-tank 2 is communicated with a liquid chamber 5 provided behind a nozzle unit 4 through an ink supply tube unit 6, thereby allowing the ink to be supplied and inhaled. In Fig. 2, twenty-four nozzles 7 are vertically arranged in front of the liquid chamber 5. The head of each of the nozzles 7 forms a discharge opening 8. The ink is emitted from the discharge opening 8 toward a recording material. Those plurality of nozzles 7 constitute the nozzle unit 4. The nozzle unit 4 is fixed to a bushing 10 locating at the center of a front plate 9 arranged in front of the recording head. An electrothermal energy converter 11 for both emitting ink droplets and heating the ink is provided in each nozzle 7. Electrical signals are supplied to the converters 11 through an electrical wiring section 12. The wiring section 12 and supply tube unit 6 are together supported to a base plate 13. A temperature sensor 14 consisting of a thermistor is attached near the liquid chamber 5 provided for the base plate 13.

A control method of the liquid-discharge recording apparatus having the above-mentioned arrangement will then be explained with reference to Fig. 3. As described above, the electrothermal energy converter 11 is used for both emitting and heating. The heating of the ink is carried out in two kinds of heating modes; namely, the first heating mode in that the heating is performed at the restart of the recording after the stop of the recording when a power supply of the apparatus is OFF; and the second heating mode in that the heating is performed at the restart of the recording after the stop of the recording when the power supply of the apparatus is ON. In this example, the pre-ink-jet of ink droplets is also carried out prior to performing the actual printing. The applying levels of the foregoing first and second heating electrical signals and of the emitting electrical signal are shown in Table 1.

TABLE 1

	Voltage (V)	Pulse width (μsec)	Frequency (kHz)	Applying time, the number of pulses, etc.
1st heating electrical signal	23.5	2	16	Apply until the recording head temperature becomes 45°C
2nd heating electrical signal	23.5	2	35	Apply for one second
Emitting electrical signal	23.5	10	2	
1st pre ink jet electrical signal	23.5	10	2	Apply 100 pulses
2nd pre ink jet electrical signal	23.5	10	2	Apply 100 pulses

TABLE 2 (Compositions of the ink)

C.I. direct black 19	2 weight parts
Diethylene glycol	30 weight parts
Water	70 weight parts

Namely, after the recording was stopped in the OFF state of the power supply of the apparatus, when this power supply is turned on, the first heating is performed and the first heating electrical signal of a voltage 23.5 V, a pulse width 2 μsec, and a frequency 16 kHz is applied until the temperature of the recording head becomes 45°C. Thereafter, to perform the pre-ink-jet which is not used for printing, the first pre-ink-jet electrical signal of a voltage 23.5 V, a pulse width of 10 μsec, and a frequency 2 kHz is applied by 100 pulses. The apparatus waits for a printing signal after completion of the preliminary emission of the ink. When the printing signal is applied, if the temperature of the recording head exceeds 20°C, the second pre-ink-jet is carried out. This is because a consideration is made to the case where the recording interruption period after the end of the first pre-ink-jet becomes long. The second pre-ink-jet is performed by applying 100 pulses of the second pre-ink-jet electrical signal of a voltage 25.5 V, a pulse width 10 μsec, and a frequency 2 kHz. After completion of the second pre-ink-jet, the inherent emission of ink droplets is carried out and the recording is started. When the temperature of the recording head is below 20°C, the second heating is performed and the recording head temperature is controlled so as to become 20°C or more. This second heating is executed by applying the second heating electrical signal of a voltage 23.5 V, a pulse width 2 μsec, and a frequency 35 kHz for one second.

To explain the effect of this embodiment, the inventors of this application have performed the experiments to compare the embodiment and Comparison Examples 1 and 2, which will be explained later.

Experimental conditions:

The environmental condition under which the liquid-discharge recording apparatus is used was set to two kinds: one is the condition at 10°C and 20%RH; and the other is the condition at 40°C and 20%RH. The compositions of the ink used are shown in Table 2. The condition before the recording is restarted is set to three kinds: the first condition is that the recording was interrupted for five seconds when the power supply of the apparatus was ON; the second condition is that the recording was interrupted for one hour when the power supply of the apparatus was ON; and the third condition is that the recording was stopped for 72 hours when the power supply of the apparatus was OFF. The dimensions of each of the 24 discharge openings are 50 x 40 μm and the recording unit in which they are vertically arranged in a line at regular intervals of 0.141 mm was used. It has been confirmed that when the signal to emit the ink droplets was applied for five minutes just before the recording is interrupted or stopped, the ink droplets were accurately emitted.

The control was performed in accordance with the flowchart of Fig. 3 as the experimental condition of the embodiment.

For Comparison Example 1, the recording was restarted without performing the first and second heating operations nor executing the first and second emitting operations.

For Comparison Example 2, in the case of restarting the recording in the recording stop state, the signal of the same voltage, pulse width, and frequency as those of the first heating electrical signal of the embodiment was heated for twenty seconds, and the same signals as the electrical signals for the pre-ink-jet of the embodiment were applied, and the heating and pre-ink-jet were carried out. In the case of restarting the recording in the recording interruption state, the electrical signal of the same voltage, pulse width, and frequency as those of the second heating electrical signal of the embodiment was applied for one second and the heating was performed.

The results of those three experiment examples are shown in Table 3 for comparison.

TABLE 3

The number of ink droplets which are not emitted until the ink droplets are emitted from all of 24 discharge openings

Recording interruption or stop period	Environment	Experiment 1	Comparison Example 1	Comparison Example 2
Recording interruption when the power supply of the recording apparatus is ON (5 seconds)	10°C 20%RH	o	o	o
	40°C 20%RH	o	o	No droplet is emitted from 5 discharge openings
Recording interruption when the power supply of the recording apparatus is ON (1 hour)	10°C 20%RH	o	2,000	o
	40°C 20%RH	o	o	o
Recording stop when the power supply of the recording apparatus is OFF (72 hours)	10°C 20%RH	o	No droplet is emitted from 3 discharge openings	o
	40°C 20%RH	o	o	No droplet is emitted from 5 discharge openings

It has been found from the results of the experiments shown in Table 3 that the case of the embodiment of the invention in which the control was performed in accordance with the flowchart of Fig. 3 is superior to Comparison Examples 1 and 2.

In the above embodiment, when the power supply of the apparatus is turned on in the recording stop state, the heating electrical signal is applied until the temperature of the recording head becomes a set value, and in the case where the recording is restarted in the recording interruption state, the content (voltage, pulse width, frequency, applying time) of the heating electrical signal is determined in accordance with the temperature of the recording head. Further, as a modified form of this embodiment, the recording stop or interruption period of the apparatus is counted and the supply of the heating electrical signal may be controlled on the basis of the count data of the recording stop or interruption period and the temperature data of the recording head. In addition, as shown in Fig. 4, the electrothermal energy converter for heating may be replaced by an external heater 15 which is separately provided.

In the case of the second embodiment of a liquid-discharge recording apparatus of the present invention, the foregoing object is accomplished by a constitution comprising: first heating signal generating means which has an electrothermal energy converter for heating a liquid to emit the liquid in response to the supply of an electrical signal and which generates an electrical signal which is applied within a range such as not to emit any liquid to the electrothermal energy converter; and second heating signal generating means for generating an electrical signal which is applied to an electrothermal energy converter provided to heat the liquid separately from the foregoing electrothermal energy converter, wherein the first and second heating signal generating means are constituted by the same means.

Namely, the electrothermal energy converter provided to form the ink droplets and the electrothermal energy converter separately provided to preheat are used to preheat the ink.

The liquid-discharge recording apparatus according to the second embodiment of the invention will then be described with reference to Figs. 5 and 6. Fig. 5 is a schematic perspective view of a recording head unit in the liquid-discharge recording apparatus and Fig. 6 is an enlarged diagram of a nozzle unit in Fig. 5.

In Fig. 5, the ink is led from a main tank (not shown) for storage of the ink to a sub-tank 502 for temporary storage of the ink through an ink supply tube 501. The ink a quality of which deteriorated and which could not be used is inhaled to a recovery pump (not shown) from the sub-tank 502 or the like through a suction tube 503. The sub-tank 502 is communicated with a liquid chamber 505 (see Fig. 6) arranged behind the nozzle unit 504 through an ink supply tube unit 506, thereby allowing the ink to be supplied and inhaled. In Fig. 6, a nozzle 507 is formed in front of the liquid chamber 505. For example, twenty-four nozzles 507 are vertically arranged. The head of each nozzle 507 forms an ink discharge opening, namely, an orifice 508. The ink is emitted toward a recording material from the orifice 508. Each nozzle 507 constitutes the nozzle unit 504. The nozzle unit 504 is fixed to a bushing 510 locating at the center of a front plate 509 arranged in front of the recording head.

An electrothermal energy converter 511 to emit the ink and form ink droplets is provided in each nozzle 507 and serves to emit the ink. Another electrothermal energy converter 514 is arranged near the liquid chamber 505. Electrical signals are supplied to the electrothermal energy converters 511 and 514 through an electrical wiring section 512. The electrical wiring section 512 and supply tube unit 506 are together supported by a base plate 513.

According to the liquid-discharge recording apparatus shown in Figs. 5 and 6 described above, the electrothermal energy converter 511 provided to form the ink droplets and the electrothermal energy converter 514 provided separately to preheat are together used to preheat the ink. The use of both of those converters makes it possible to reduce the preheating time and to prevent the heat from being concentrated to a single portion, so that the bad influence on the peripheral parts can be prevented. On one hand, the electrical signal which is applied is determined in accordance with various conditions such as the applying condition of the ink-jet signal in the liquid-discharge recording apparatus, temperature characteristic of the ink which is used, particularly, the temperature characteristic of the viscosity of the ink, viscosity change characteristic of the ink in the recording interruption or stop state, and the like. For example, it is necessary to individually control the voltage, frequency, pulse width, and the like of the electrical signal to predetermined values and then apply the signal.

As the heating electrical signal generating means for applying the electrical signals to those two kinds of electrothermal energy converters 511 and 514, one electrical signal generating means is commonly used. The heating electrical signal to heat the electrothermal energy converter 511 to form the ink droplets and the heating electrical signal to heat (i.e., preheat) the electrothermal energy converter 514 within a range such as not to emit any ink droplet are together generated from the common heating electrical signal generating means.

Various kinds of timings to preheat the ink are considered. As one of them, the preheating signal may be applied immediately before the ink-jet signal is applied. On one hand, the preheating signal may be also always applied in the ON state of the power supply of the recording apparatus although no recording is performed (in the recording interruption state). Or, the preheating signal may be applied for a temporary period when the power supply is again turned on after the state whereby the power supply of the recording apparatus is OFF (after the recording stop state). Further, the recording interruption period is automatically counted in the recording interruption state and after an expiration of the recording interruption period longer than a predetermined time, the preheating signal may be also applied.

To which extent the ink is preheated, namely, to which degree the level of the preheating electrical signal is controlled differs depending on various conditions. Namely, various cases are considered in dependence on the characteristic of the recording apparatus, the physical property of the ink, and the environmental condition such as the temperature, humidity, and the like at the location where the recording apparatus is installed and used. The level of the preheating electrical signal may be properly determined in accordance with the respective conditions or the like.

Next, an explanation will be made with respect to the results of the comparison experiments in the cases where the recording is restarted after the ink was preheated according to the embodiment of the invention using the liquid-discharge recording apparatus shown in Figs. 1 and 2 and where the recording is restarted without performing the preheating at all. As the ink used in the experiments, the ink of the compositions shown in Table 2 was used.

The dimensions of each of the 24 orifices (discharge openings) 507 are 50 x 40 µm. These orifices are vertically arranged in a line at regular intervals of 0.141 mm. The liquid-discharge (i.e., ink-jet) recording apparatus was used under the environment at 25°C and 30%RH. The ink-jet recording apparatus was kept in the recording interruption state for one hour. In this example, the electrical signal to heat (preheat) the ink was sent to the electro-thermal energy converter 511 to form the ink droplets (to emit the ink) during this interval and the heating electrical signal was also sent to the other electrothermal energy converter 514 which always operates within a range such as not to emit any ink. As the comparison example, the method whereby those preheating operations are not performed at all was used. Table 4 shows the voltages, pulse widths, and frequencies of those heating electrical signals and of the electrical signal to emit the ink (to form the ink droplets) to the electrothermal energy converter 511.

TABLE 4

	Voltage (V)	Pulse width (μsec)	Frequency kHz
Ink-jet electrical signal to the converter 511	23.5	10	2
Ink heating electrical signal to the converter 511	23.5	5	10
Heating electrical signal to the converter 514	23.5		

The results are as shown in Table 5.

TABLE 5

	Recording interruption period	The number of ink droplets which are not emitted until the ink droplets are emitted from all of 24 orifices
The embodiment	One hour	0
Comparison example	One hour	1000

In the case of the third embodiment of a liquid-discharge recording apparatus of the present invention, the viscosity of the ink is maintained by controlling the operation of heating means in response to the operation of capping means. Due to this, the unnecessary heating of the ink during the recording interruption period can be prevented and the viscosity range of the ink can be maintained to the necessary range.

The ink heating means mentioned above includes the means in which a heat generation level of an electrothermal energy converter (heating device) which is used to emit the ink and to form the ink droplets is reduced and this converter is used, the means in which a separate auxiliary heating device is used, and the means in which both of those electrothermal energy converter and auxiliary heating device are used. The capping means, on one hand, is not limited to the foregoing cap but an evaporating device containing an ink evaporation component may be positioned at a discharge opening.

An example of a structure of the liquid-discharge recording apparatus according to the third embodiment of the invention will then be explained with reference to Figs. 7 and 8. The ink is supplied from a main tank (not shown) for storage of the ink to a sub-tank 702 for temporary storage of the ink through a supply tube arranged in a tube 701. A suction tube, which will be explained hereinafter, to inhale the choked ink from a discharge opening or the like is also arranged in the tube 701 and connected to a suction pump (not shown). The sub-tank 702 is communicated with a liquid chamber arranged behind a nozzle, which will be explained hereinafter, by a supply tube unit 703. A plurality of nozzles are vertically arranged in front of the liquid chamber. The heads of the nozzles are supported by a bushing 704 and open. The bushing 704 is fixed to a front plate 705 and constitutes a nozzle unit 706. An electrothermal energy converter 707 provided in the liquid chamber (not shown) is used to keep the temperature of the ink constant. Electrical signals to apply energies to the electrothermal energy converter 707 and to a heating device, provided in correspondence to each discharge opening, for emitting the ink and forming the ink droplets are supplied through an electrical wiring section 708 consisting of an FPC (flexible printed circuit). The electrical wiring section 708, supply tube unit 703, and nozzle unit 706 are supported by a base plate 709. The case plate 709 and sub-tank 702 and the like constitute a recording head unit as a whole. This recording head unit moves along a shaft 710 and performs the recording operation.

This recording head unit is returned to a predetermined home position when the recording is interrupted. The nozzle unit 706 is covered with a cap 711 at the home position, thereby preventing the evaporation component of the ink from being evaporated from the head of the nozzle. No electrical signal is applied to the electrothermal energy converter 707 at the home position, so that the heating of the ink is stopped. Due to this, it is possible to prevent that the heating device 707 further operates in the state in that the cap 711 was coupled and the viscosity range of the ink exceeds the necessary range. It is further possible to prevent that the evaporation component of the ink which is heated and is likely to be evaporated leaks from the cap 711 when the recording is interrupted for a long time and the viscosity of the ink contrarily increases.

In the above example, another heating device 707 different from a heating device which is provided for a nozzle (not shown) and serves to form the ink droplets was used as the ink heating means. However, in this modified form, an electrical signal to this heating device is set to a low level and applied, thereby enabling the heating device to form the ink droplets to be also used as the heating means for keeping the ink temperature constant. On one hand, although the cap 711 was used as the capping means at the head of the nozzle in the foregoing example, in another modified form, further, an evaporating device containing an evaporation component of the ink may be allowed to exist in the cap 711 and may be also used as the capping means. In this case as well, it is possible to prevent that the ink evaporation component is evaporated at the home position when the recording is interrupted and the ink viscosity increases.

Therefore, the further heating of the ink can be stopped, so that the viscosity range of the ink can optimized.

As the above-mentioned evaporating device, the ink droplets emitted from the discharge opening may be preliminarily emitted into an absorption material such as a sponge or the like and the ink may permeate this absorption material. In this case, it is preferable to perform the pre-ink-jet immediately after the recording head unit was returned to the home position.

The operation of the heating means for maintaining the ink temperature to a predetermined value as mentioned above is controlled by control means in response to the operation of the capping means.

In this control means, the operation of the capping means is discriminated by, for example, an operation signal of the capping means or the ON/OFF of a switch which operates interlockingly with the movement of the capping means, or the like.

Fig. 9 is a timing chart showing an example of the operation timing between the capping means and the heating means. Under a fixed condition, it is possible to control in a manner such that the heating means is set to the inoperative mode (OFF state) when the capping means is operating (ON state) as shown in Fig. 9.

Fig. 10 is a flowchart showing an example of an operation procedure of the control means in the case of controlling the heating means in response to the operation of the capping means as shown in the timing chart of Fig. 9.

In Fig. 10, when the power supply of the apparatus is turned on, in step S1001, the ink temperature is first detected by a temperature sensor attached to the recording head unit, or the like, and a check is made to see if it is necessary to heat the ink or not. If YES, a check is then made in step S1002 to see if the capping means is operating or not. If the capping means is in the inoperative mode and no operation signal is supplied, namely, if NO in step S1002, the heating means is turned on to heat the ink in step S1003. When the heating means is ON, the operations in steps S1001 to S1003 are repeated and the heating operation is continued until the ink temperature reaches a predetermined value.

When it is determined that the ink temperature has increased and reached the temperature at which the heating is not required in step S1001, step S1004 follows irrespective of the presence and absence of the capping operation signal and the heating means is turned off to interrupt the heating.

On one hand, even if the ink temperature does not increase to the predetermined value yet, when the capping operation signal exists in step S1002, namely, when the capping means is operating, step S1004 follows and the heating means is turned off to interrupt the heating.

All of the above-described examples can be applied irrespective of the presence and absence of the sub-tank 2 or the presence and absence of the carriage, or the like.

As described above, the temperature of the recording head unit in which the ink discharge openings are formed is detected and the electrothermal energy converter for heating is controlled on the basis of this temperature. Therefore, the ink can be heated in consideration of the environmental condition under which the recording apparatus is used and of the recording interruption or stop period before the restart of the recording. In other words, since the operating environmental temperature and the recording interruption and stop periods are reflected in the temperature of the recording head unit, the optimum heating can be carried out by properly selecting the heating condition in accordance with the temperature of the recording head unit.

Further, as described above, the preheating of the ink which is performed when the recording is restarted is carried out using both the electrothermal energy converter provided to form the ink droplets and the electrothermal energy converter separately provided to preheat the ink. Thus, the preheating time can be reduced and it is further prevented that the heat for preheating is concentrated to a single portion, so that the bad influence on the peripheral parts can be prevented.

In addition, there is provided the control means for controlling the operation of the heating means for holding the ink temperature to a predetermined value on the basis of the operation of the capping means for covering the ink discharge opening. Therefore, it is possible to obtain the liquid-discharge recording apparatus which can automatically suppress that the ink viscosity changes to a value out of a desired viscosity range and can efficiently perform the recording with an excellent quality.

CLAIMS

1. A liquid-discharge recording apparatus comprising:

a recording head having electrothermal energy converting means for generating an energy which is used to emit a liquid in response to an emission signal;

emission signal generating means for generating said emission signal;

heating signal generating means for generating an electrical signal which has a level within a range such as not to emit any liquid but which is of a sufficient level to cause the liquid to be heated and is applied to said electrothermal energy converting means; and

wherein the content of said electrical signal which is applied within the range such as not to emit any liquid droplet is made to differ to bring about a first heating mode when the power supply of said apparatus is turned on and a second heating mode when recording is started after an interruption with the power supply of the apparatus turned on.

2. An apparatus as claimed in claim 1, further comprising means for detecting a temperature of the liquid in the recording head, the heating signal generating means being driven on the basis of the temperature information detected by said temperature detecting means.

3. A liquid-discharge recording apparatus according to claim 2, wherein said apparatus is arranged so that when a power supply of said apparatus is turned on, a temperature of said recording head reaches a set temperature by said electrical signal which is applied within the range such as not to emit any liquid droplet.

4. A liquid-discharge recording apparatus according to any preceding claim, wherein a frequency of the electrical signal applied within the range such as not to emit any liquid droplet at the time when said power supply is turned on is lower than a frequency of the electrical signal at the time when the recording is restarted.

5. A liquid-discharge recording apparatus according to any preceding claim, wherein after conducting the heating, the emission signal is applied to said

electrothermal energy converting means, so as to bring about preliminary emission irrelevant to the recording.

6. A liquid-discharge recording apparatus according to claim 5, wherein the emission irrelevant to the recording is conducted responsive to different emission signals at initial power-on and after a period of interruption of recording.

7. A liquid-discharge recording apparatus according to claim 6, wherein the signal for emission irrelevant to recording after a period of interruption of recording has a voltage level higher than that at power on.

8. A liquid-discharge recording apparatus according to any preceding claim, wherein another heating device different from said electrothermal energy converting means which is used to form liquid droplets is provided for said recording head.

9. A liquid-discharge recording apparatus according to any preceding claim, further comprising a subtank.

10. A liquid-discharge recording apparatus according to any preceding claim, further comprising a plurality of discharge openings for emitting liquids.

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