

2169855

1 TITLE OF THE INVENTION

LIQUID-DISCHARGE RECORDING APPARATUS AND
METHOD OF OPERATION THEREOF

BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to a liquid-discharge recording apparatus in which a liquid is emitted to form emission liquid droplets and these droplets are deposited on a recorded material such as a paper or the like and thereby to perform the recording and, more particularly, to a liquid-discharge recording apparatus in which an emission energy is given to the liquid to form flight liquid droplets.

Description of the Prior Art

15 A liquid-discharge recording method (ink-jet recording method) is a recording method whereby flight liquid droplets of a recording liquid are formed by various methods and these droplets are deposited on a recorded material such as a paper or the like and
20 thereby to perform the recording.

Among recording apparatuses (printers) to which such a recording method is applied, as an apparatus having a structure suitable for constituting a high-density multiorifice of the recording head, a
25 liquid-discharge recording apparatus of the type using the heat as an energy to form emission liquid droplets (hereinafter, referred to as an ink-jet printer) can be mentioned.

1 Such an ink-jet printer of the type using the
heat as the liquid droplet emission energy generally
comprises liquid droplet forming means and a recording
head. Namely, the liquid droplet forming means heats
5 the recording liquid and causes the deformation of the
recording liquid accompanied with a rapid increase in
volume and allows the recording liquid to be emitted
from an orifice (liquid droplet emission hole) of the
nozzle portion, thereby forming liquid droplets of the
10 recording liquid. The recording head has an
electrothermal energy converting device (hereinafter,
referred to as an emitting heater) which can generate
a heat to heat the recording liquid in response to the
supply of an electrical signal.

15 On one hand, as a recording liquid which is
used to record by the ink-jet printer, a water-base
recording liquid is mainly used in consideration of
the recording characteristic, safety, and the like.
This water-base recording liquid is generally formed
20 from the recording material component such as a
pigment, dye, or the like and the water or solvent
component mainly consisting of water and water soluble
organic solvent in order to dissolve or disperse the
recording material component.

25 In the foregoing printer using the heat as the
liquid droplet emission energy and printers to which
other liquid droplet forming methods are applied, in

1 many cases, the orifice formed at the end of the nozzle
from which the recording liquid is emitted is always
open toward the open air in the outside of the apparatus
irrespective of that the apparatus is driven or not.

5 Therefore, in the case where the apparatus is
not used for recording for a long time, the solvent
component such as, for example, water, volatile organic
solvent, or the like is evaporated from the orifice
into the open air from the recording liquid remaining
10 in the orifice and the portions near the orifice since
the water-base liquid is used as the recording liquid
as mentioned above. Thus, the recording material
component and the unvolatilizable solvent component
remain in the recording liquid, causing a viscosity of
15 the recording liquid remaining in this portion to
increase. Since the viscosity of the recording liquid
exceeds a range suitable for emission of the recording
liquid, there are problems such that immediately after
the recording was restarted, in spite of the fact that
20 an emitting signal is applied, a defective emission of
liquid droplets in which no liquid droplet is emitted
is likely to occur and a failure occurs in an initial
printing section or the like of a recording image.

 On one hand, although there have been proposed
25 the printers in which the emission surface where the
orifice is formed is capped when the apparatus is not
used such as in the case where the power supply is off

1 or the like, even if the emission surface is capped,
the orifice is not perfectly shut out from the open
air. Therefore, the foregoing problems are caused even
in this kind of printers.

5 On the other hand, in Japanese Patent
Unexamined Publication No. 187364/1983, there has been
proposed the recording method whereby even when the
liquid droplet emitting signal is not applied, an
electrical signal of such a level that no recording
10 liquid droplet is emitted is always applied to the
emitting heater and thereby to preheat the recording
liquid in a manner such that a temperature of the
recording liquid can always be maintained at a value
within a predetermined range in order to obtain a good
15 emitting state of liquid droplets for an increase in
viscosity of the recording liquid at low temperatures.

Even in the printer to which the above method
is applied, however, since the electrical signal is
applied to the emitting heater so that the recording
20 liquid is always maintained at high temperatures even
during a relatively long interruption or stop interval
of the recording operation as well, the solvent
component in the recording liquid can be more easily
evaporated, so that there is a problem such that the
25 defective liquid droplet emission is further likely to
occur at the restart of the recording as mentioned
above. In addition, according to this method, since

1 the peripheral portion of the emitting heater is
always heated, the following problems are caused.
Namely, durability of the peripheral members of the
emitting heater is lost. Physical properties of the
5 recording liquid remaining in the peripheral portion
of the emitting heater change due to the heat thereof
while the recording is interrupted, so that the color
of the recording liquid changes or a precipitate is
produced in the recording liquid and the orifice is
10 choked, causing the defective liquid droplet emission
or the like.

In addition, just after the power supply of the
printer was turned on, a temperature of the ink liquid
regarding the recording depends on the environmental
15 conditions such as a temperature of atmosphere and the
like. Therefore, it is undesirable to start the
recording by emitting the ink immediately after the
turn-on of the power supply for the purpose of
obtaining the stable printing state.

20 Therefore, it is considered to constitute the
ink-jet printer in a manner such that the preliminary
emission is performed before the start of the printing
operation after the turn-on of the power supply and the
old ink remaining in the head portion of the nozzle is
25 preliminarily discharged and thereby optimizing the
emission of the ink.

However, hitherto, the print output is carried out through an IC for a port from a microprocessing unit (MPU) for controlling each section of the printer. Therefore, according to the conventional constitution, it is extremely difficult to finely control such preliminary emission due to a problem of the processing time of the software, so that there is a problem such that the optimum preliminary emission cannot be performed.

SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention there is provided a liquid-discharge recording apparatus, comprising:

a liquid-discharge recording unit having emission energy generating means responsive to an electrical drive signal to impart energy to a recording liquid to form a flying liquid droplet which is emitted from the recording unit;

recording unit controlling means for causing such a drive signal to be supplied to the recording unit in response to input of a recording signal to cause a droplet to be emitted for deposition on a recording material in a normal recording operation;

pre-emission controlling means for causing such a drive signal to be supplied to the recording unit to cause droplet emission in a pre-emission mode before

a normal recording operation and for adjusting the drive signal such that a pre-emission condition ^{thereof} ~~caused~~ ~~thereby~~ is adjusted according to a circumstance affecting the viscosity of the recording liquid in the recording unit.

Reference is directed to United Kingdom Patent Application Nos 8828313.0 (GB 2210586A) divided from this application, and (8911913.5) (GB A) divided from No 8828313.0.

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BRIEF DESCRIPTION OF THE DRAWINGS

10 Figs. 1 to 13 are diagrams showing whole arrangements of liquid-discharge recording apparatuses, in which the figure 11 arrangement is in accordance with the present invention, but the figure 1 to 10, 12 and 13 arrangements are not;

Fig. 14 is a perspective view showing an example of a constitution of an ink-jet printer according to the invention;

15 Figs. 15A and 15B are an enlarged perspective view of a head unit in the printers shown in Figs. 1 to 13 and an enlarged perspective view of a nozzle unit thereof, respectively;

20 Fig. 16 is a block diagram showing an example of an internal circuit arrangement of the ink-jet printer according to the invention;

Figs. 17A and 17B are flowcharts showing an example of the printing state optimizing process procedure;

25 Figs. 18 and 19 are flowcharts showing an example of a preliminary heating process procedure and

1 an example of a preliminary emitting process procedure
in the processes shown in Figs. 17A and 17B,
respectively;

Fig. 20 is a waveform diagram for explaining a
5 print output signal which is supplied to the head unit;
and

Fig. 21 is a graph of characteristic curves
showing the relation between the supply time and the
temperature in which a frequency of the print output
10 signal which is supplied to the head unit is used as
a parameter.

In figures 14 and 15, the following references are used:

HU...	Liquid-discharge recording unit (head unit),
C...	Carriage,
15 R...	Guide rail,
TB ₁ , TB ₂ ...	Supply tubes,
FC...	Flexible cable,
ST...	Sub-tank,
CAP...	Cap member,
20 P...	Recorded material,
PL...	Platen,
S...	Carriage running direction,
f...	Conveying direction of the recorded material,
H...	Home position,
25 NZ...	Nozzle unit,
FP...	Front plate,
IR...	Liquid chamber,

- 1 ICH... Ink channel,
OR... Orifice,
TS... Temperature sensor,
HTR... External heater,
5 ET... Emitting heater,
M₁, M₂, M₃... Motors,

1... Programmable peripheral interface (PPI),
2... Microprocessing unit (MPU),
10 3... Line buffer RAM,
4... Font generating ROM,
5... Control ROM,
6... Console,
7... Home position sensor,
15 8... Cap mode switch,
9... Paper sensor,
10... Head unit controller,
11, 14, 18, 21, 22, 24... Drivers,
13... Protective circuit,
20 15... Temperature comparing device,
16... Font switch,
17... Input selector.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

25 Figs. 1 to 13 show diagrammatical arrangement views showing whole arrangements of liquid-discharge recording apparatuses, ~~by which the objects of the present invention are accomplished, respectively.~~

1 The liquid-discharge recording apparatus of
the first example shown in Fig. 1 comprises a liquid-
discharge recording unit 100, recording unit
controlling means 110, and emission controlling means
5 150. The recording unit 100 has emission energy
generating means 102 which can allow an energy to act
on the liquid to form flight liquid droplets in
response to the supply of an electrical signal. This
recording unit flies and emits the liquid droplets and
10 allows them to be deposited on a recorded material P,
thereby performing the recording. The controlling
means 110 can set the electrical signal and supplies
the electrical signal to form the flight liquid
droplets to the emission energy generating means 102
15 in response to the input of a recording signal SA.
The controlling means 150 sets the electrical signal
to form the flight liquid droplets to the recording
unit controlling means 110 when the power supply is
turned on, thereby allowing the recording unit 100 to
20 fly and emit the liquid droplets.

 The liquid-discharge recording apparatus of
the second example shown in Fig. 2 comprises the
liquid-discharge recording unit 100, recording unit
controlling means 110, heating means 120, and heat
25 controlling means 140. The recording unit 100 has the
emission energy generating means 102 including an
electrothermal energy converting device which can heat

1 the liquid to form flight liquid droplets in response
to the supply of an electrical signal. This recording
unit flies and emits these liquid droplets and allows
them to be deposited on the recorded material P,
5 thereby performing the recording. The controlling
means 110 can set the electrical signal and supplies
the electrical signal to form the flight liquid
droplets to the emission energy generating means 102
in response to the input of the recording signal SA.
10 The heating means 120 is provided in the recording
unit 100 and heats the liquid from the outside. The
heat controlling means 140 allows the heating means
120 to heat the liquid and/or sets an electrical signal
within a range such as not to form any flight liquid
15 droplet to the recording unit controlling means 110
and thereby to heat the liquid in accordance with the
environmental conditions when a power supply SW is
turned on.

The liquid-discharge recording apparatus of
20 the third example shown in Fig. 3 comprises the
liquid-discharge recording unit 100, recording unit
controlling means 110, heating means 120, heat
controlling means 140, emission controlling means 150,
and sequence controlling means 160. The recording unit
25 100 has the emission energy generating means 102
including an electrothermal energy converting device
which can heat the liquid in response to the supply of

1 an electrical signal to form flight liquid droplets.
This recording unit flies and emits the liquid droplets
and allows them to be deposited on the recorded
material P, thereby performing the recording. The
5 recording unit controlling means 110 can set the
electrical signal and supplies the electrical signal to
form the flight liquid droplets to the emission energy
generating means 102 in response to the input of the
recording signal SA. The heating means 120 is
10 provided in the recording unit 100 and heats the liquid
from the outside. The heat controlling means 140
allows the heating means 120 to heat the liquid and/or
sets an electrical signal within a range such as not to
form any flight liquid droplet to the recording unit
15 controlling means 110 and thereby to heat the liquid
in accordance with the environmental conditions. The
emission controlling means 150 sets an electrical
signal to form the flight liquid droplets to the
controlling means 110, thereby allowing the recording
20 unit 100 to emit the flight liquid droplets. The
sequence controlling means 160 drives the heat
controlling means 140 when the power supply SW is
turned on and then drives the emission controlling
means 150.

25 The liquid-discharge recording apparatus of
the fourth example shown in Fig. 4 comprises the
liquid-discharge recording unit 100, recording unit

1 controlling means 110, and control means 190. The
recording unit 100 has the emission energy generating
means 102 which can allow an energy to act on the
liquid to form flight liquid droplets in response to
5 the supply of an electrical signal. This recording
unit flies and emits these liquid droplets and allows
them to be deposited on the recorded material P. The
recording unit controlling means 110 can set the
electrical signal and supplies the electrical signal
10 to form the flight liquid droplets to the emission
energy generating means 102 in response to the input
of the recording signal SA. The control means 190 sets
the electrical signal to form the flight liquid
droplets to the recording unit controlling means 110 in
15 response to the input of the recording signal SA in the
case where the environmental conditions are fitted for
recording, thereby allowing the recording unit 100 to
preliminarily emit the flight liquid droplets, and
then generates a command signal.

20 The liquid-discharge recording apparatus of the
fifth example shown in Fig. 5 comprises the liquid-
discharge recording unit 100, recording unit controlling
means 110, heating means 120, heat controlling means
140, emission controlling means 150, and sequence
25 controlling means 160. The recording unit 100 has the
emission energy generating means 102 including an

1 electrothermal energy converting device which can heat
the liquid to form flight liquid droplets in response
to the supply of an electrical signal. This recording
unit flies and emits these liquid droplets and records
5 on the recorded material P. The recording unit
controlling means 110 can set the electrical signal
and supplies the electrical signal to form the flight
liquid droplets to the emission energy generating means
102 in response to a command signal to start the
10 recording in response to the input of the recording
signal SA. The heating means 120 is provided in the
recording unit 100 and heats the liquid from the
outside. The heat controlling means 140 allows the
heating means 120 to heat the liquid and/or sets an
15 electrical signal within a range such as not to form
any flight liquid droplet to the recording unit
controlling means 110 and thereby to heat the liquid
in accordance with the environmental condition. The
emission controlling means 150 sets the electrical
20 signal to form the flight liquid droplets to the
recording unit controlling means 110, thereby allowing
the recording unit 100 to emit the flight liquid
droplets. The sequence controlling means 160 drives
the heat controlling means 140 in response to the input
25 of the recording signal and drives the emission
controlling means 150, then generates a command signal.

1 The liquid-discharge recording apparatus of
the sixth example shown in Fig. 6 comprises the
liquid-discharge recording unit 100, recording unit
controlling means 110, heating means 120, capping
5 means 180, and control means 200. The recording unit
100 has the emission energy generating means 102 which
can allow an emission energy to act on the liquid to
form flight liquid droplets in response to the supply
of an electrical signal. This recording unit flies
10 and emits these liquid droplets, thereby recording on
the recorded material P. The recording unit controlling
means 110 supplies the electrical signal to form the
flight liquid droplets to the emission energy
generating means 102 in response to the input of the
15 recording signal SA. The heating means 120 is provided
in the recording unit 100 and heats the liquid from the
outside. The capping means 180 can be coupled with the
recording unit 100. The control means 200 instructs a
heating process to the heating means 120 when the
20 environmental conditions are improper for a recording
process in conjunction with a single recording process
by the recording unit 100. When the next recording
signal is inputted even after an expiration of a set
time after completion of the single recording process,
25 the control means 200 instructs the stop of heating to
the heating means 120 and at the same time drives the
capping means 180, thereby coupling the capping means
180 with the recording unit 100.

1 The liquid-discharge recording apparatus of
the seventh example shown in Fig. 7 comprises the
liquid-discharge recording unit 100, recording unit
controlling means 110, heating means 120, heat
5 controlling means 140, emission controlling means 150,
and sequence controlling means 160. The recording
unit 100 has the emission energy generating means 102
including an electrothermal energy converting device
which can heat the liquid to form flight liquid
10 droplets in response to the supply of an electrical
signal. This recording unit 100 flies and emits these
liquid droplets, thereby recording on the recorded
material P. The recording unit controlling means 110
can set the electrical signal and supplies the
15 electrical signal to form the flight liquid droplets
to the emission energy generating means 102 in response
to the input of the recording signal SA. The heating
means 120 is provided in the recording unit 100 and
heats the liquid from the outside. The heat
20 controlling means 140 allows the heating means 120 to
heat the liquid and/or sets an electrical signal
within a range such as not to form any flight liquid
droplet to the recording unit controlling means 110
and thereby to heat the liquid in accordance with the
25 environmental conditions. The emission controlling
means 150 sets the electrical signal to form the flight
liquid droplets to the recording unit controlling means

1 110, thereby allowing the recording unit 100 to emit
the flight liquid droplets. The sequence controlling
means 160 drives the heat controlling means 140 in
response to the turn-on of the power supply SW and/or
5 the input of the recording signal SA. After driving
the heat controlling means 140, the sequence
controlling means 160 stands by for a set time and then
drives the emission controlling means 150.

The liquid-discharge recording apparatus of
10 the eighth example shown in Fig. 8 comprises the
liquid-discharge recording unit 100, recording unit
controlling means 110, and heat controlling means 140.
The recording unit 100 has the emission energy
generating means 102 including an electrothermal energy
15 converting device which can heat the liquid to form
flight liquid droplets in response to the supply of an
electrical signal. This recording unit flies and
emits these liquid droplets, thereby recording on the
recorded material P. The recording unit controlling
20 means 110 can set a pulse width of the electrical
signal and supplies the electrical signal to form the
flight liquid droplets to the emission energy
generating means 102 in response to the input of the
recording signal SA. The heat controlling means 140
25 has pulse width setting means 142 for setting a pulse
width to the recording unit controlling means 110.
This heat controlling means sets an electrical signal

1 of a pulse width within a range such as not to form
any flight liquid droplet to the recording unit
controlling means 110 and thereby to heat the liquid
in accordance with the environmental conditions.

5 The liquid-discharge recording apparatus of
the ninth example shown in Fig. 9 comprises the
liquid-discharge recording unit 100, recording unit
controlling means 110, and heat controlling means 140.
The recording unit 100 has the emission energy
10 generating means 102 including an electrothermal
energy converting device which can heat the liquid to
form flight liquid droplets in response to the supply
of an electrical signal. This recording unit flies
and emits these liquid droplets, thereby recording on
15 the recorded material P. The recording unit controlling
means 110 can set a frequency of the electrical signal
and supplies the electrical signal to form the flight
liquid droplets to the emission energy generating means
102 in response to the input of the recording signal
20 SA. The heat controlling means 140 has frequency
setting means 144 for setting a frequency to the
recording unit controlling means 110. This heat
controlling means sets an electrical signal which lies
within a range such as not to form any flight liquid
25 droplet and a frequency of which is higher than the
frequency of an electrical signal upon recording to
the recording unit controlling means 110 and thereby

1 to heat the liquid in accordance with the environmental conditions.

The liquid-discharge recording apparatus of the tenth example shown in Fig. 10 comprises the
5 liquid-discharge recording unit 100, recording unit controlling means 110, and heat controlling means 140. The recording unit 100 has the emission energy generating means 102 including an electrothermal energy converting device which can heat the liquid to form
10 flight liquid droplets in response to the supply of an electrical signal. This recording unit flies and emits these liquid droplets, thereby recording on the recorded material P. The recording unit controlling means 110 can set a voltage of the electrical signal
15 and supplies the electrical signal to form the flight liquid droplets to the emission energy generating means 102 in response to the input of the recording signal SA. The heat controlling means 140 has voltage setting means 146 for setting a voltage to the recording unit
20 controlling means 110. This heat controlling means sets an electrical signal of a voltage within a range such as not to form any flight liquid droplet to the recording unit controlling means 110 and thereby to heat the liquid in accordance with the environmental
25 conditions.

The liquid-discharge recording apparatus of the eleventh example shown in Fig. 11 comprises the

1 liquid-discharge recording unit 100, recording unit
controlling means 110, and emission controlling means
150. The recording unit 100 has the emission energy
generating means 102 which can allow an energy to act
5 on the liquid to form flight liquid droplets in
response to the supply of an electrical signal. This
recording unit flies and emits these liquid droplets,
thereby recording on the recorded material P. The
recording unit controlling means 110 can set the
10 number of emission times and supplies the electrical
signal to form the flight liquid droplets to the
emission energy generating means 102 in response to
the input of the recording signal SA. The emission
controlling means 150 has times of emission setting
15 means 154 for setting the number of emission times in
accordance with the environmental conditions. This
emission controlling means sets the electrical signal
to form the flight liquid droplets to the recording
unit controlling means 110, thereby allowing the
20 recording unit 100 to preliminarily emit the flight
liquid droplets by an amount as many as the number of
emission times set.

The liquid-discharge recording apparatus of
the twelfth example shown in Fig. 12 comprises the
25 liquid-discharge recording unit 100, driving means 210,
and heat controlling means 220. The recording unit 100
has the emission energy generating means 102 for

1 allowing an energy to act on the liquid to form flight
liquid droplets in response to the supply of an
electrical signal. This recording unit flies and
emits these liquid droplets, thereby recording on the
5 recorded material P. The driving means 210 moves the
recording unit 100 in a predetermined direction with
regard to the recorded paper P. The heat controlling
means 220 heats the liquid existing in the recording
unit 100 when the driving means 210 is stopped.

10 The liquid-discharge recording apparatus of
the thirteenth example shown in Fig. 13 comprises the
liquid-discharge recording unit 100, recording unit
controlling means 110, heat controlling means 140, and
emission controlling means 150. The recording unit
15 100 has the emission energy generating means 102
including an electrothermal energy converting device
which can heat the liquid to form flight liquid
droplets in response to the supply of an electrical
signal. This recording unit flies and emits these
20 liquid droplets, thereby recording on the recorded
material P. The recording unit controlling means 110
can set the electrical signal and supplies the
electrical signal to form the flight liquid droplets
to the emission energy generating means 102 in
25 response to the input of the recording signal SA. The
heat controlling means 140 sets an electrical signal
within a range such as not to form any flight liquid

1 droplet to the recording unit controlling means 110
and thereby to heat the liquid in accordance with the
environmental conditions. The emission controlling
means 150 has the frequency setting means 144 for
5 setting a frequency of the electrical signal to the
recording unit controlling means 110. This emission
controlling means sets the electrical signal to form
flight liquid droplets after the heating and a
frequency of which is below a frequency of the
10 electrical signal at the time of the recording thereby
allowing the recording unit 100 to emit flight liquid
droplets.

The present invention will then be described
in detail hereinbelow with reference to the drawings.

15 Fig. 14 illustrates an example of a
constitution of the recording units of the ink-jet
printers to which the invention can be applied, which
have been shown in Figs. 1 to 13 as the examples of
arrangements, respectively. This example is applied
20 to the ink-jet printer of the format in which a head
unit is mounted to a carriage which moves in a
predetermined direction with regard to a recording
surface. Figs. 15A and 15B are an enlarged diagram of
the heat unit in Fig. 14 and an enlarged diagram of a
25 nozzle unit thereof, respectively.

In Figs. 14, 15A, and 15B, HU denotes a
liquid-discharge recording unit mounted on a carriage

1 C. It is also possible to provide the liquid-discharge
recording units HU as many as the number of colors of
inks which are used. FC indicates a flexible cable
consisting of a set of signal lines to control the
5 emission of the ink by the recording unit HU and the
like.

The carriage C is fixed to, for example, a belt
or the like and moves in the directions indicated by
arrows S in Fig. 14 by driving means such as a motor or
10 the like. The guide rails R guide the carriage C so
that it moves in the directions S.

P denotes the recorded material such as a paper
or the like which is conveyed in the direction indicated
by an arrow f in Fig. 14. PL represents a platen to
15 form the recording surface of the recording paper P.
Namely, the carriage C moves in the directions S in the
diagram by the driving means along the guide rails R,
thereby making it possible to record on the recording
surface of the recording paper P.

20 ST denotes a sub-tank provided in the carriage
C; TB_1 is an ink supply tube for communicating a main
tank (not shown) with the sub-tank ST; and TB_2 is an
ink supply tube unit for communicating the sub-tank ST
with a liquid chamber IR in the head unit HU.

25 In addition, CAP is a cap member arranged to
face the recording unit HU at a home position H of the
carriage C in the directions S. When the carriage C

1 is located at the home position, the cap member CAP
can move toward the recording unit HU by driving means
such as a motor or the like and can abut on the
emitting surface thereof. A collecting member SP abuts
5 on the emitting surface of the recording unit HU and
collects the ink and is formed of, for example, a
water absorption porous material.

In Fig. 15A, BP is a base plate on and over
which the supply tube unit TB₂, the liquid chamber IR,
10 a nozzle unit NZ, the flexible cable FC, etc. are
arranged and by which these components are supported.
BSH denotes an elastic member for supporting the
peripheral portion of the nozzle unit; FP is a front
plate; TS is a temperature sensor such as a thermistor
15 or the like to detect a temperature; and HTR is a
heater consisting of, for instance, an electrothermal
energy converter such as a positive characteristic
thermistor or the like attached to the heat unit HU in
order to heat the ink and keep it warm from the outside.
20 A heat conducting plate is also provided.

On one hand, in Fig. 15B, OR denotes an orifice
serving as an ink emitting hole. In this embodiment,
a predetermined number of orifices OR are vertically
arranged in the nozzle unit NZ. ICH is a liquid
25 channel for communicating the orifices OR with the
liquid chamber IR. ET is an emitting heater serving as
an emission energy generating device for applying a

1 thermal energy for emission to the ink existing in the
liquid channel ICH.

To record using the above-mentioned recording
apparatus, the ink is first supplied to the sub-tank
5 ST from the main tank through the supply tube TB_1 .
Further, the liquid chamber IR and liquid channel ICH
are filled with the recording liquid through the
supply tube unit TB_2 . Next, an electrical signal is
applied to the emitting heater ET through the flexible
10 cable FC from liquid droplet emitting signal generating
means which will be explained hereinafter, thereby
energizing the heater ET. Thus, the heater ET
generates a heat energy and this heat energy is applied
to the recording liquid existing in the liquid channel
15 ICH near the heater ET, causing an air bubble to be
produced in the recording liquid which is accompanied
with an instantaneous increase in volume of the
recording liquid in that portion. The recording liquid
existing in the downstream portion of the emitting
20 heater ET is emitted from the orifice OR, so that the
liquid droplet of the recording liquid is formed.
This recording liquid droplet is deposited on the
recorded material P such as a paper or the like fed in
front of the nozzle unit, so that the recording is
25 performed.

Fig. 16 shows an example of an arrangement of
a control apparatus of the ink-jet printer of the

1 invention. For example, it is assumed that this
control apparatus receives print data from a host
computer and stores the print data of one line and
controls a printing head by a controller of the head
5 unit HU, thereby printing.

In Fig. 16, a programmable peripheral interface
(hereinafter, referred to as a PPI) 1 first receives in
parallel the print data which is sent from the host
computer of the printer according to the embodiment
10 and transmits the print data to a microprocessing unit
(hereinafter, referred to as an MPU) 2. The PPI 1
also controls a console 6 and performs an inputting
process of a home position sensor 7. The MPU 2
controls each section in the printer and executes a
15 processing procedure which will be explained
hereinafter. A RAM 3 serves as a line buffer memory
for storing the print data received by the PPI 1 by an
amount of one line. Reference numeral 4 denotes a ROM
to generate fonts of print output characters, and 5 is
20 a control ROM in which processing procedures (Figs. 5
to 7) which are executed by the MPU 2 are stored.
Those components 1 to 5 are connected through an
address bus AB and a data bus DB.

The console 6 has a keyboard switch, an
25 indicating lamp, and the like. The home position
sensor 7 is disposed near the home position of the
carriage C. A cap-mode sensor 8 senses the state of the

1 cap member CAP, namely, detects whether the cap member
CAP is coupled with the head unit HU or not. A paper
sensor 9 detects the absence of the printing paper.

A head-unit controller 10 latches the print
5 data and print output time and starts the print output
in response to a command from the MPU 2. Namely, in
this embodiment, the controller 10 is used as a
dedicated integrated circuit (IC), thereby realizing a
high processing speed. For example, the controller
10 disclosed in Japanese Patent Application No. 162802/
1984 by the same applicant as this application may be
used as the controller 10. The print data which has
once latched is outputted as it is, unless otherwise a
change is requested.

15 Reference numeral 11 denotes a driver to drive
the head unit HU in response to the controller 10; 13
is a protective circuit of the head unit HU; 14 a
driver to drive the heater HTR for heating the ink and
keeping it warm which is provided for the head unit
20 HU; 15 a temperature comparing device of the ink
temperature sensor TS provided for the head unit HU;
16 a font switch to instruct the switching of the
print font; and 17 an input selector to switch signals
of the device 15 and switch 16 and is controlled by
25 the MPU 2.

Numerical 18 denotes a driver to drive a motor
M₃ for moving the cap member CAP with respect to the

1 head unit HU; 22 and 24 are drivers to drive a motor
M₁ for feeding the paper and a motor M₂ for moving the
carriage, respectively; and 20 and 21 are a solenoid
for a valve and a driver thereof which are used to
5 remove the air in the head unit HU, respectively.

The outline of the processes in the case of
the ink-jet printer shown in Figs. 14 to 16 according
to this embodiment will then be described. In this
embodiment, when the power supply of the printer is
10 turned on and when the printing is started, the head
unit HU is subjected to a preheating process and a
preliminary emitting process, thereby obtaining a good
ink emitting state. In addition, the capping to the
head unit HU is properly controlled in conjunction
15 with those processes. It is assumed that the
preheating process includes the execution of an
external heating process and/or an internal heating
process.

In this case, the external heating denotes
20 that the ink is heated from the outside of the head
unit HU by driving the heater HTR and the internal
heating denotes that the ink is heated in the head
unit HU by supplying a print output pulse within a
range such as not to emit any ink from the head unit
25 HU to the emission energy generating device. A print
output start signal is sent to the head-unit controller
10 at every set frequency during the internal heating.

1 When the preheating, particularly, the
internal heating is performed, it is desirable to apply
a print output of proper pulse width, frequency, and
voltage to the head unit HU. However, the use of the
5 head-unit controller 10 enables the sufficient
processes to be carried out even at an ordinary
processing speed of the MPU. Namely, according to this
embodiment, parameters of respective print outputs can
be freely changed and set in accordance with the
10 necessity, so that the head unit can be heated in the
optimum manner and the software can be simplified and
a high processing speed can be realized.

On one hand, even in the case of performing the
preliminary emission as well, it is preferable to apply
15 a suitable print output having a pulse width, a
frequency, and a voltage as parameters to the head unit
HU similarly to the above. In this embodiment, those
parameters and the number of emission times are changed
in accordance with the environmental conditions. The
20 embodiment can easily cope with such a case by the
software and the optimum preliminary emission can be
performed. In addition, in this embodiment, all dots
of the print outputs at the time of the preliminary
emission are set to "1" using the head-unit controller
25 10. Therefore, there is no need to change the print
data every time with respect to the print data in this
case, so that the software can be simplified and a high
processing speed can be realized.

1 Printing state optimizing processes in this
embodiment will then be described hereinbelow.

 Figs. 17A and 17B show an example of the
printing state optimizing process procedure according
5 to the present invention.

 Immediately after the turn-on of the power
supply of the printer, as an initializing process, the
PPI 1 and head-unit controller 10 of the hardware are
initialized and, for the software, the line buffer
10 memory RAM 3 is initialized and the operation of the
control ROM 5 is checked, and the respective parameters
which are used for processing are initialized (step S1).

 After completion of the initializing process,
the head cap motor M_3 is driven to open the head cap
15 while monitoring the cap-mode sensor 8 by the MPU 2
(step S2). Monitoring the home position sensor 7, the
carriage motor M_2 is driven to return the carriage C
to the home position H (step S3). Then, monitoring
the sensor 8, the cap motor M_3 is driven to close the
20 head cap to the head unit HU (step S4). Further, the
motor M_1 is driven to feed the recording paper by an
amount of, e.g., one line (step S5). After those
processes, the head unit HU is initialized.

 In the initializing process, the preheating
25 process (step SH) of the head unit HU is first started.

 Fig. 18 shows an example of the preheating
processing procedure for performing the external

1 heating and internal heating. As mentioned above, for
the internal heating, an output of a pulse width, a
voltage, and a high frequency within ranges such as not
to emit any ink is applied to the head unit HU from the
5 controller 10, thereby allowing the heat to be generated
in the head unit HU. For the external heating, the
heater HTR provided for the head unit HU is used as a
heating member and the driver 14 is turned on by the
MPU 2, thereby heating the head unit HU. The external
10 heating is started in step SH1 and the head-unit
controller 10 is set into the external heating mode in
step SH2. In the next step SH3, the print outputs of
all dots are set to "1". The internal heating is
started in step SH4. In the case of performing the
15 internal heating, the pulse width, voltage, and
frequency of the print output are properly set as will
be explained hereinlater.

After the preheating of the head has been
started in this manner, a temperature of the head unit
20 HU is checked to see if ^{it exceeds or} ~~the upper temperature of the~~
~~head-unit HU exceeds~~ a constant temperature or not
(step SH5). If YES, the preheating is finished. If
NO, step SH6 follows and the preheating is started and
a check is made to see if a predetermined time has
25 passed after the start of the external or internal
heating (step SH6). If YES in step SH6, namely, when
the ~~upper~~ ^{upper} temperature does not exceed the ^{upper} constant

1 temperature even after an expiration of the
predetermined time, step SH7 follows. In step SH7, a
command to stop the internal heating is sent to the
controller 10 to prevent the head from being thermally
5 broken, thereby stopping the internal heating. In the
next step SH8, the driver 14 is turned off to stop the
external heating. Namely, in this case, the preheating
is stopped and the processing routine is returned to
step S6 in Fig. 17A. The ^{upper} constant temperature ~~on the~~
10 ~~upper side~~ denotes the upper limit operating
temperature of the head unit HU (for example, 42°C).
It will be obvious that the sequence of the start and
stop of the external heating and internal heating may
be changed.

15 Referring again to Fig. 17A, after the
preheating was stopped, the apparatus stands by for a
predetermined time and the temperature distribution in
the heat unit HU locally heated is averaged (step S6).
After an elapse of the predetermined standby time, the
20 preliminary emitting process is performed (step SJ).
In the case where the sudden heating process was
executed for the preheating at the time of turn-on of
the power supply, the standby time may be set to a
relatively long time. In this case, it may be set to,
25 e.g., 500 msec.

Fig. 19 shows an example of the preliminary
emitting process procedure. The emission condition

1 is first set to the head-unit controller 10 in step
SJ1. Then, the print outputs of all dots are set to
"1" in step SJ2. In step SJ3, the print output is
applied to the head unit HU to emit the ink. This
5 operation is repeated for a predetermined number of
emission times due to the process in step SJ4.
Thereafter, the processing routine is returned to step
S10 in Fig. 17A and the apparatus enters the print
standby state. Namely, the initializing process for
10 the head unit HU is finished in this manner. Then,
the procedure is shifted to the print standby state
from the host computer. On one hand, the specified
number of emission times and the parameters of the
emission condition can be properly set in accordance
15 with the environmental conditions as will be explained
hereinafter.

When a printing signal is supplied from the
host computer in the standby state of a printing signal
(step S10), the print data is latched into the PPI 1
20 and transferred to the line buffer RAM 3. A signal
from the temperature sensor TS provided for the head
unit HU is detected by the temperature comparing
device 15 and a check is made to see if the ~~lower~~
temperature is more than a ^{lower} constant temperature, e.g.,
25 higher than 20°C or not (step S11). If YES, the
head-cap motor M₃ is driven to open the cap (step S12).
Then, the controller 10 is set to the ordinary printing

1 mode to perform the preliminary emission (steps SJ;
refer to Fig. 19). On the contrary, if NO in step S11,
namely, when it is determined that the lower temperature
is lower than the ^{lower} constant temperature, the cap is
5 ^{opened} ~~closed~~ (step S13) and then the preheating process
(steps SH; refer to Fig. 18) is performed. After the
standby state for the predetermined time (step S15),
the emission condition and the number of emission
times are further set to the controller 10 and the
10 preliminary emission is performed (steps SJ; refer to
Fig. 19).

In this case, the standby time can be set to
be shorter than the above-mentioned standby time when
the sudden heating such as at the time of actuation of
15 the recording unit is not performed. The ^{lower} constant
~~temperature on the lower temperature side~~ means the
lower limit operating temperature of the head unit HU.

Next, the driver 14 is turned off to stop the
external heating (step S16) and the apparatus enters
20 the printing state. Namely, the heating process is
not executed during the printing operation when the
carriage motor M_2 is driven.

1 In addition, the heating process can be
also performed without increasing an electric
power consumption in conjunction with the printing
process in step S20. Namely, during the moving
5 operation of the carriage, when the moving direction
is changed at both ends of the movement range of
the carriage, the carriage C once stops at these
turning points; therefore, the heating process may
be executed at this time.

10 After the start of the printing, when the
printing of, for example, one line is carried out
and the carriage motor M_2 stops (step S20), a
check is then made to see if the ~~lower~~ temperature
of the head unit HU is more than the ^{lower} constant
15 temperature or not (step S21). If YES, step S22
follows. If NO, the driver 14 is driven to perform
the external heating (step S22) and then step S23
follows. That is, a check is made to see if the
~~upper~~ temperature of the head unit HU is more than
20 the ^{upper} ~~constant~~ temperature or not (step S23). If YES,
the external heating is immediately stopped (step
S25). If NO, the apparatus stands by for a pre-
determined time (e.g., 200 msec) (step S24) and
thereafter the external heating is stopped (step
25 S25).

Next, as shown in Fig. 17B, the paper
feed motor M_1 is driven to feed the paper (step S30)

1 and processes in steps S31 and S32 similar to those
in steps S21 and S22 are executed and then step S40
follows. Namely, the internal timer is turned on
by the MPU2 and a check is made to see if the print
5 data has been latched in the PPI 1 within a pre-
determined time (for example, within five seconds)
or not (steps S40 and S41). If YES, step S16 in
Fig. 17A follows. If NO, the driver 14 is turned
off to stop the external heating (step S42). The
10 carriage motor M_2 is driven to return the carriage
C to the home position H (step S43). Then, the cap
motor M_3 is driven to close the cap (step S44)
and the processing routine is returned to step
S10 in Fig. 17A.

15 In this manner, according to this embodi-
ment, after the preheating process has been executed,
the preliminary emitting process to emit the liquid
droplets which are not used for the recording is
carried out. Thus, the recording interruption or
20 stop interval becomes very long and even in the case
where the viscosity of the recording liquid
remarkably increases due to the evaporation of the
solvent component as well, the emitting operation
upon printing can be optimized. That is, the
25 portion of a high viscosity of the recording liquid
is first heated due to the preheating process and
its temperature increases, so that the viscosity of

1 the recording liquid is reduced to a value such that
the liquid droplets can be emitted. By subsequently
performing the preliminary emitting process in this
state, the recording liquid in this portion is
5 drained to the outside of the liquid channel ICH, so
that the recording liquid a viscosity of which
lies within a range suitable to emit is supplied
to the portion near the emitting heater ET and
thereafter the good emitting state of the recording
10 liquid is derived. To confirm stability of this
emitting state, the applicant of this application
has performed the following experiments.

[Experiment using the embodiment]

The ink-jet printer according to this
15 embodiment having the recording head unit as shown
in Fig. 15B was used, in which twenty-four orifices
(a diameter of each orifice is $50 \times 40 \mu\text{m}$) are
vertically arranged in a line at regular intervals
of 0.141 mm in the recording head unit. This
20 recording apparatus was filled with the recording
liquid containing the following compositions. At
the restart of the recording after an expiration of
the recording interruption period of twelve hours
under circumstances at 25°C and 30 %RH, the signal
25 of a voltage 23.5 V, a pulse width 5 μsec , and a
frequency 10 kHz was applied to the emitting heater
ET when the preheating was performed. Next, the

1 signal of a voltage 23.5 V, a pulse width 10 μ sec,
and a frequency 2 kHz was applied to the emitting
heater ET by an amount of a hundred pulses, thereby
emitting the liquid droplets which are not used for
5 recording. The recording apparatus regarding the
defective emission after the recording interruption
was evaluated by measuring the number of liquid
droplets which were not emitted in response to the
recording signal until the liquid droplets of the
10 recording liquid for use in the recording have
been emitted from all of twenty-four orifices.
The result is shown in Table 1.

The compositions of the recording liquid
used for recording are as follows.

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

[Experiment using the comparison example]

The recording apparatus having a constitu-
20 tion similar to the embodiment and in which only
an electrical signal to emit recording liquid
droplets for use in recording is applied to the
emitting heater upon recording was used. This
recording apparatus was filled with the above-
25 mentioned recording liquid. At the restart of the
recording after an expiration of the recording
interruption period of twelve hours under

1 circumstances at 25°C and 30 %RH, only the
electrical signal of a voltage 23.5 V, a pulse
width 10 μ sec, and a frequency 2 kHz to emit
liquid droplets was applied to the emitting heater
5 and the recording was performed. The recording
apparatus after the recording interruption with
regard to the defective emission was evaluated in
a manner similar to the experiment using the
embodiment. The result is shown in Table 1.

10

Table 1

15

	The number of liquid droplets which are not emitted until the liquid droplets are emitted from all of 24 orifices	Recording interruption period time
Embodi- ment	0	12
20 Compa- rison example	The liquid droplets were not emitted from two of 24 orifices.	12

25

It will be understood from Table 1 that
even at the restart of the recording after the
elapse of such a particularly long recording
interruption or stop period, the good and stable

1 emitting state of liquid droplets can be always
obtained.

Next, explanation will be made with respect
to the setting of the parameters of the pulse width,
5 frequency, voltage, etc. of the print output in
the preheating process and preliminary emitting
process.

The degree of deviation of the viscosity
of the recording liquid existing in the liquid
10 channel ICH, particularly, near the orifices OR
from the proper range due to the recording inter-
ruption or stop period individually differs in
dependence on the characteristic of the apparatus
which is used, the physical property of the record-
15 ing liquid, the environmental conditions such as
temperature, humidity, and the like of the
location where the apparatus is installed and
used, and the like. Thus, the parameters of the
print output in the preheating process, particularly,
20 in the internal heating process are suitably
selected in accordance with the individual
apparatuses and their use conditions.

On one hand, the signal which is supplied
to the emitting heater ET in the preliminary
25 emitting process is applied under the conditions
such that the recording liquid whose viscosity is
out of a range suitable to emit the liquid

1 droplets upon recording can be emitted and removed
to the outside of the liquid channel ICH.

Further, the number of emission times in
the preliminary emitting process can be varied in
5 accordance with the environmental conditions at
that time, thereby enabling the process to be
efficiently executed.

Fig. 20 shows an electrical signal which
is applied to the emitting heater ET. In this
10 diagram, V_0 denotes a voltage and w_i is a pulse
width. When the signal is supplied to the emitting
heater ET in the preheating process, if bubbles are
produced due to the heating, there might have
occurred the case where the subsequent emission of
15 liquid droplets becomes unstable or no droplet is
emitted in the worst case. Therefore, the
electrical signal which is applied to the emitting
heater ET upon preheating must lie within a range
such as not to produce any bubble on the emitting
20 heater ET.

On the other hand, since those preheating
processes are set when the power supply of the
printer is turned on and when the printing is
started, the preheating is fairly frequently
25 executed. Therefore, the deterioration in
durability of the emitting heater ET due to those
preheating processes must be avoided. The inventors

1 of this application have studied the durability of
the emitting heater ET when an electric power (W)
which is applied to the emitting heater ET was
kept constant and the pulse width w_i and applied
5 voltage v_0 in the preheating processes using the
emitting heater ET were changed. Thus, it was
confirmed that the durability of the heater ET
is improved as the pulse width w_i and applied
voltage v_0 are small.

10 On the other hand, the time required to
heat the head unit HU to a desired temperature is
determined by the electric power (W) which is
applied to the emitting heater ET. However, as
the actual performance of the recording apparatus,
15 it is desirable that the time needed until the
printing is started, namely, the waiting time is
as short as possible.

In spite of such a purpose, it is undesirable
to thoughtlessly increase the voltage which is
20 applied to the emitting heater ET in terms of the
durability of the heater as mentioned above.
Further, since the production of a bubble on the
emitting heater ET upon preheating causes the
subsequent defective printing state or non-
25 emission, it is difficult to increase the pulse
width as well.

Therefore, to raise the temperature of the

1 heat unit to a desired temperature for a short time
and within a range such that the preheating processes
do not influence the durability of the emitting
heater ET and no bubble is produced on the heater,
5 it is effective to increase the frequency of the
electrical signal which is supplied to the emitting
heater ET.

Fig. 21 shows an example of the relation
between the time (minute) and the head temperature
10 ($^{\circ}\text{C}$), in which the frequency of the preheating
signal which is applied to the emitting heater ET
is used as a parameter. In this example, the
applied voltage v_0 was set to 24 V, the pulse width
 w_i was set to 5 μsec , and the frequency was set to
15 10 kHz, 5kHz, and 2kHz. The head temperature was
detected by the temperature sensor TS.

The applicant of this application has
performed the following two experiments by changing
the voltage, pulse width, and frequency from the
20 viewpoints mentioned above.

(Example 1)

The ink-jet printer according to the
embodiment having the nozzle unit NZ as shown in
Fig. 15B in which twenty-four orifices (a diameter
25 of each orifice is $50 \times 40 \mu\text{m}$) are vertically
arranged in a line at regular intervals of 0.141 mm
was used. The recording apparatus was filled with

1 the recording liquid having compositions similar to
the above. The electrical signal was supplied to
the emitting heater ET under the conditions as
shown in Table 2 and the preheating was performed.

5 Presence and absence of production of
bubbles were checked by observing on the heater
using an optical microscope. The result is shown
in Table 2.

Table 2

10

Applying conditions when recording		
Voltage	Frequency	Pulse width
24 V	2 kHz	10 μ s

15

Applying conditions when preheating				
Vol- tage	Frequen- cy	Pulse width	Applying time	Production of bubbles on the heater
26V	3.7 kHz	5.0 μ s	15s	Bubbles were produced
24V	2.7 kHz	7.5 μ s	15s	Bubbles were produced
24V	10 kHz	2.0 μ s	15s	No bubble
15V	5.0 kHz	10 μ s	15s	No bubble
10V	11.6 kHz	10 μ s	15s	No bubble

20

25

(These conditions are determined by setting
the electric power consumption constant.)

1 (Example 2)

The ink-jet printer similar to (Example 1) was used and the recording apparatus was filled with the recording liquid containing the foregoing
5 compositions. The signal was applied to the emitting heater ET under the conditions as shown in Table 3. The preheating processes were repeated to examine the durability of the heater ET. The result is shown in Table 3.

10

Table 3

15

20

Preheating					
Voltage	Frequency	Pulse width	Applying time	Number of repetition times	Number of disconnection of the heater
24V	10 kHz	2.0 μ s	15 sec	10 ⁵	Nil
15V	5.0 kHz	10 μ s	ditto	ditto	Nil
10V	11.6 kHz	10 μ s	ditto	ditto	Nil

It will be understood from Table 3 that the pulse width of the electrical signal which is supplied to the emitting heater ET in the pre-
25 heating processes is preferably set to be smaller than that of the electrical signal upon recording. As the result of further detailed experiments by

1 the present applicant, it has been found that it is
desired to set the pulse width to be a width
within a range of 1 to 1/20 of the pulse width upon
recording.

5 In addition, it will be appreciated that it
is preferable to set the applied voltage of the
electrical signal which is supplied to the emitting
heater ET in the preheating processes to be equal
or lower than the applied voltage upon recording.

10 Moreover, by setting the frequency of the
electrical signal in the preheating processes to
be higher than that upon recording, the time
required for heating can be reduced.

Those parameters and the number of pulses
15 can be very easily set by using the controller 10
as mentioned above.

The emission condition in the preliminary
emitting processes will then be explained.

In the case where the recording has been
20 interrupted or stopped for a long time, the viscosi-
ty of the ink remaining in and near the orifices
OR increases due to the evaporation of the water and
valatile organic solvent and the like, so that the
ink is less likely to be emitted. Although the
25 viscosity of the residual ink can be reduced due
to the above-mentioned preheating processes, its
viscosity is higher than the ink fitted for

1 recording and the sizes, speeds, and the like of
the liquid droplets differ and this residual ink
is improper for recording. Therefore, in this
embodiment, the preliminary emission is carried
5 out subsequent to the preheating.

Upon preliminary emitting processes, the
ink is not always emitted in response to the first
pulse of the signal which is applied to the emitting
heater ET at that time. Therefore, by increasing
10 the energy of the signal upon preliminary emission
than the energy of the signal upon printing and by
varying the emitting time in accordance with the
environmental conditions, the time required for
the preliminary emission can be reduced and a high
15 efficient emission can be realized.

The increase in the energy of the signal
upon preliminary emission may be accomplished by
practically increasing the voltage and/or pulse
width than those upon recording. Namely, assuming
20 that the voltage and pulse width of the signal which
is applied to the emitting heater ET upon printing
are respectively 24 V and 10 μ sec, the voltage and/
or pulse width of the signal upon preliminary
emission may be set to be larger than those values.
25 According to the experiments by the present
applicant, the good result was obtained when the
voltage was set to be one to five times, preferably,

1 one to two times larger than that upon printing and
the pulse width was likewise set to be one to five
times, preferably, one to two times larger than
that upon printing.

5 With respect to the emitting time, it is
desirable to set the number of emission times,
namely, the number of pulses in accordance with the
environmental conditions. According to the
experiments by the present applicant, in the pre-
10 liminary emission (steps SJ subsequent to step S6
in Fig. 17A) before the start of the printing
after the turn-on of the power supply, when 100
to 150 pulses were applied to the emitting heater
ET, a good printing quality could be derived after
15 that. After the start of the printing, the
viscosity of the ink is high at low temperatures
and the emission is more difficult to become
stable as compared with the case at high tempera-
tures; therefore, it is preferable to properly
20 set the number of ink emission times. According
to the experiments by the present applicant, in
the preliminary emission when the ~~lower~~
temperature is more than the ^{lower} constant temperature
(e.g., 20°C) (when YES in step S11 in Fig. 17A), it
25 has been confirmed that the stable emission was
obtained when 20 to 50 pulses were applied to the
emitting heater ET. On the contrary, in the

1 preliminary emission when the lower temperature is
lower than the ^{lower} constant temperature (when NO in
step S11), the stable emission was derived when 50
to 100 pulses were applied to the heater ET.

5 The emission conditions in those pre-
liminary emitting processes can be also easily set
by using the controller 10 upon processing. The
processes can be properly executed at a high speed
without increasing the burden of the MPU 2.

10 On the other hand, if the region where the
printer according to this embodiment is used is
limited and is preliminarily and clearly known,
the number of emission times can be also changed
for every region. For example, in the region at
15 a high temperature and at a low humidity, the
temperature is always high and the ink is remarkably
dried. Therefore, an amount of preliminary emission
on the upper temperature side is increased than
that on the lower temperature side to stabilize the
20 emission of the ink. Also, by changing the above-
mentioned numeric values of the number of emission
times, the stable ink emission can be derived.

 Although the ink-jet printer of the type
in which the head unit is mounted on the carriage
25 has been described in this embodiment, the present
invention is not limited to this but may be
apparently applied to the ink-jet printer of what

1 is called a full-multi type in which a plurality of
head units are arranged in the direction of width
of the recording paper.

In addition, the respective parameters
5 in the preheating processes and the respective
parameters and the number of emission times in
the preliminary emitting processes have been set
in accordance with the temperature condition as
mentioned in the embodiment. However, the
10 invention is not limited to this method but can be
also applied to the method whereby, for example,
those parameters and the number of emission times
are set in accordance with the environmental
conditions such as humidity, pressure, or the like.

15 Moreover, although the electrothermal
energy converting device was used as the emission
energy generating means in this embodiment, for
example, a piezoelectric element may be used.

As described above, ~~according to the~~
20 ~~present invention~~, before the start of the printing
after the turn-on of the power supply, the proper
emission condition is set to the head-unit
controller and the preliminary emitting processes
are performed. Therefore, there is an effect
25 such that it is possible to realize a liquid-
discharge recording apparatus in which the
software can be simplified and the printing state

1 can be promptly and easily optimized.

In addition, the ^{apparatus}~~invention~~ also has an effect such that the emission condition can be easily changed.

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CLAIMS

1. A liquid-discharge recording apparatus, comprising:
- 5 a liquid-discharge recording unit having emission energy generating means responsive to an electrical drive signal to impart energy to a recording liquid to form a flying liquid droplet which is emitted from the recording unit;
- 10 recording unit controlling means for causing such a drive signal to be supplied to the recording unit in response to input of a recording signal to cause a droplet to be emitted for deposition on a recording material in a normal recording operation;
- 15 pre-emission controlling means for causing such a drive signal to be supplied to the recording unit to cause droplet emission in a pre-emission mode before a normal recording operation and for adjusting the drive signal such that a pre-emission condition ^{hereof} ~~caused~~
- 20 ~~thereby~~ is adjusted according to a circumstance affecting the viscosity of the recording liquid in the recording unit.



2. An apparatus as claimed in claim 1, wherein such a pre-emission condition is adjusted according to an environmental condition.

5 3. An apparatus as claimed in claim 2, wherein such a pre-emission condition is adjusted according to temperature.

10 4. An apparatus as claimed in claim 3, wherein such a pre-emission condition is adjusted according to the temperature of the recording unit.

15 5. An apparatus as claimed in any of claims 2 to 4, wherein such a pre-emission condition is adjusted according to pressure and/or humidity.

20 6. An apparatus according to any preceding claim, wherein such a pre-emission condition is adjusted according to whether the succeeding normal recording operation is an initial recording operation or a subsequent normal recording operation.

25 7. An apparatus as claimed in any preceding claim, wherein the pre-emission controlling means is operable to adjust a number of pulses of the drive signal.



8. An apparatus as claimed in any preceding claim, wherein the pre-emission controlling means is operable to adjust a pulse width of pulses of the drive signal.

5

9. An apparatus as claimed in any preceding claim, wherein the pre-emission controlling means is operable to adjust a frequency of the drive signal.

10

10. An apparatus as claimed in any preceding claim, wherein the pre-emission controlling means is operable to adjust a voltage of the drive signal.

15

11. A liquid-discharge recording apparatus according to any preceding claim wherein the pre-emission controlling means is operable in a mode in which the pulse-form of the drive signal for preliminary emission is different to that for a normal recording operation.

20

12. An apparatus as claimed in claim 11, wherein the pulse-form of the drive signal for preliminary emission has a different pulse width to that for a normal recording operation.

25



13. An apparatus as claimed in claim 11 or 12,
wherein the pulse-form for preliminary emission is a
series of pulses having a different frequency to that
for a series of pulses in a normal recording
5 operation.

14. An apparatus as claimed in any of claims 11 to
13, wherein the pulse-form for preliminary emission
has a different voltage to that for a normal recording
10 operation.

15. An apparatus as claimed in any preceding claim,
further comprising processing means for setting the
drive signal for pre-emission and a control memory
15 associated with the processing means for supplying
data used by the processing means and determining the
setting of the drive signal, the processing means
being operable to set the drive signal for each
pre-emission operation prior to the beginning of that
20 pre-emission operation.

16. An apparatus as claimed in any preceding claim,
wherein said emission energy generating means includes
an electro-thermal conversion element for generating
25 heat energy according to said electrical drive signal



to form a bubble for droplet emission, the drive signal caused by said pre-emission controlling means being applied to said electro-thermal conversion element to form a bubble for droplet emission in the pre-emission mode.

17. An apparatus as claimed in any preceding claim, further comprising pre-heating means for heating the recording liquid prior to pre-emission of the recording liquid.

18. An apparatus as claimed in claim 17, wherein *the pre-heating means is provided by* ~~the emission energy generating means, is operable to heat the recording liquid, and wherein the pre-heating means is operable to activate the energy emission generating means for pre-heating the recording liquid.~~

19. An apparatus as claimed in claim 17 or 18, *wherein the pre-heating means is provided by* ~~further comprising a heater which is distinct from the energy emission generating means, the pre-heating means being operable to activate said heater for pre-heating the recording liquid.~~



20. An apparatus substantially as described with reference to figure 11 and figures 14 to 21 of the drawings.

- 5 21. A method of operation of an apparatus as claimed in any preceding claim, and including the step of adjusting the drive signal for preliminary emission in accordance with the location where the apparatus is to be used.
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