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1 Serial Recording Apparatus for Bidirectional Recording

BACKGROUND OF THE INVENTION

Field of the Invention

5 The present invention relates to a serial recording apparatus for performing bidirectional recording upon reciprocal movement of a recording head.

Related Background Art

10 In a conventional serial recording apparatus, a recording head is reciprocated to perform high-speed bidirectional recording. In this serial recording apparatus, when a drive signal (i.e., drive pulses when a recording head is to be moved using a pulse motor) necessary for moving a recording head is applied, a
15 delay time occurs until the recording head reaches a target position. Print errors occur during bidirectional recording due to various types of electrical and mechanical variations.

20 In order to correct positional errors in both directions in a conventional apparatus, as described in Japanese Patent Publication No. 61-27194, pulses and time are shifted using a DIP switch or jumper wire while an operator observes an actual print result, thereby adjusting such an error in each apparatus.

25 The above conventional recording apparatus poses the following problems.

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1 (1) Extra circuit parts such as a DIP switch or
jumper wire are required.

 (2) Adjustment is time-consuming since it is
performed while the operator observes the print result.

5 (3) When a load varies due to deteriorations over
time, an initial adjustment value is changed, resulting
in an unstable state.

 On the other hand, in recent years, an ink-jet
recording apparatus for causing a change in state
10 (e.g., film boiling) of an ink by heat energy, for
ejecting the ink to a recording medium by using
bubbles generated by the change in state of the ink,
and for recording a character or graphic image has been
developed. The size of a heating resistor (heater)
15 arranged in each ejection port is considerably smaller
than that of a piezoelectric element used in a
conventional ink-jet recording apparatus. For this
reason, a high-density multiple arrangement of
ejection ports can be obtained, a high-quality
20 recording image can be obtained, and characteristics
such as a high-speed operation and low noise can be
obtained.

 Of various types of ink-jet recording apparatuses,
there is provided an apparatus using a recording head
25 which has an ink tank and is detachable from a
carriage. In this ink-jet recording apparatus, when
bidirectional recording is performed to achieve

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1 recording at a higher speed, the following problems are
posed.

Since the weight of the ink within the ink tank is
changed (decreased) by use of the ink, a drive load of
5 a carriage motor greatly varies. For this reason, the
problem (3) becomes more conspicuous.

SUMMARY OF THE INVENTION

It is an object of the present invention to
provide a serial recording apparatus capable of
10 reciprocating a recording head with high precision.

It is another object of the present invention to
provide a serial recording apparatus capable of
performing bidirectional recording with high precision.

It is still another object of the present
15 invention to provide a serial recording apparatus
capable of performing bidirectional recording with high
precision regardless of load variations in a carriage
motor.

It is still another object of the present
20 invention to provide a serial recording apparatus
capable of automatically adjusting a recording error in
bidirectional recording.

In order to achieve the above objects of the
present invention, there is provided a serial recording
25 apparatus for reciprocating a recording head with
respect to a recording medium to perform bidirectional
recording, comprising:

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1 position detecting means for detecting a reference
position of the recording head;

driving means for reciprocating the recording head
within a predetermined area including the reference
5 position;

means for calculating a difference between
reference positions detected by the position detecting
means by reciprocal movement when the recording head is
reciprocated by the driving means within the
10 predetermined area; and

means for correcting a positional error in
bidirectional recording on the basis of the difference
calculated by the calculating means.

According to the present invention, upon a
15 power-on operation or switching from an off-line mode
to an on-line mode, since the difference between the
reference positions detected by the position detecting
means in both the directions is calculated, a print
position error in bidirectional recording can be
20 automatically adjusted by using the difference.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partially cutaway perspective view
showing an arrangement of an ink-jet recording
apparatus according to the first embodiment of the
25 present invention;

Fig. 2 is a perspective view showing an
arrangement of a recording head shown in Fig. 1;



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1 Fig. 3 is a block diagram showing a recording head
drive system of the first embodiment;

 Fig. 4 is a flow chart showing a correction value
detection operation of the first embodiment;

5 Fig. 5 is a view showing the correction value
detection operation of the first embodiment;

 Fig. 6 is a flow chart showing a recording
operation of the first embodiment;

 Figs. 7 and 8 are views showing a recording
10 operation of the first embodiment;

 Fig. 9 is a block diagram showing a recording head
drive system according to the second embodiment of the
present invention;

 Fig. 10 is a flow chart showing a correction value
15 detection operation according to the second embodiment
of the present invention;

 Fig. 11 is a view showing a correction value
detection operation of the second embodiment;

 Fig. 12 is a flow chart showing a recording
20 operation of the second embodiment;

 Fig. 13 is a view showing a correction value
detection operation of the second embodiment;

 Fig. 14 is a schematic block diagram showing an
arrangement obtained when the present invention is
25 applied to a data processing apparatus; and

 Figs. 15 and 16 are perspective views of the data
processing apparatus shown in Fig. 14.

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1 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Serial recording apparatuses according to preferred embodiments of the present invention will be described with reference to the accompanying drawings.

5 Fig. 1 shows an arrangement of the first embodiment obtained when the present invention is applied to an ink-jet recording apparatus, Fig. 2 shows an arrangement of its recording head, and Fig. 3 is a block diagram showing an electrical arrangement of a
10 recording head drive system.

Referring to Fig. 1, in the ink-jet recording apparatus, a head cartridge 14 has an integral structure consisting of a recording head H constituted by using a heater board to be described with reference
15 to Fig. 2 later, and an ink tank serving as an ink supply source. The head cartridge 14 is fixed on a carriage 15 by a press member 41. These members can be reciprocated along shafts 21 along their longitudinal direction. An ink ejected from the recording head
20 reaches a recording medium 18, whose recording surface is regulated by a platen 19, through a small gap formed with the recording head H, thereby forming an image on the recording medium 18.

An ejection signal corresponding to image data is
25 supplied from an appropriate data supply source to the recording head H through a cable 16 and a terminal connected to it. At least one head cartridge (two in

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1 the illustrated embodiment) can be arranged in
accordance with the number of ink colors.

Referring to Fig. 1, the ink-jet recording
apparatus also includes a pulse motor 17 for scanning
5 the carriage 15 along the shafts 21, and a wire 22 for
transmitting a driving force of the motor 17 to the
carriage 15. This apparatus further includes a feed
motor 20, connected to a platen roller 19, for feeding
the recording medium 18, and an HP (home position)
10 sensor 4 for detecting the home position of the
carriage 15. The HP sensor 4 is turned off when the
carriage 15 is located in a positive direction with
respect to the HP sensor 4.

Fig. 2 shows an arrangement of the recording head
15 H. A heater board 1 comprises an electro-thermal
conversion unit (ejection heater) 5 formed on a
silicon substrate and a wiring 6 made of Al or the like
to supply power to the electro-thermal conversion unit
in accordance with film formation techniques. A
20 ceiling plate 30 having partition walls for defining
liquid paths (nozzles) 25 for a recording liquid is
adhered to the heater board 1 to constitute the ink-jet
type recording head H.

A recording liquid (ink) is supplied to a common
25 liquid chamber from a supply port 24 formed in the
ceiling plate 30 and is supplied to each nozzle 25.
When the heater 5 is heated upon its energization, a



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1 bubbling phenomenon occurs in the ink filled in the
nozzles 25. An ink droplet is ejected from each
ejection port 26 upon growth and contraction of the
bubble.

5 As shown in Fig. 3, a pulse motor drive circuit 31
drives the pulse motor 17. A CPU 32 supplies a control
signal to the pulse motor drive circuit 31 to drive the
pulse motor 17, as will be described later. A ROM 33
stores a control sequence (to be described later) of
10 the CPU 32. A RAM 34 has a counter (to be described
later) and temporary data storage areas A and M, and
the like.

A correction value detection operation
(preliminary scanning) of the embodiment having the
15 above arrangement will be described with reference to a
flow chart of Fig. 4 and a recording head movement
diagram shown in Fig. 5.

As shown in Fig. 4, initialization (101) is
performed upon a power-on operation, and then
20 direction-acceleration processing (102) is performed in
which the pulse motor 17 is driven to drive the
carriage 15 (recording head H) in a positive direction
at a speed equal to acceleration in the recording mode
(point A to point B in Fig. 5).

25 The counter A in the RAM 34 is set at "1" (105).
Every time the recording head H is moved by one pulse
at a constant speed (106), the level of the HP sensor 4

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1 is detected (107). When the HP sensor 4 is not ON, the
counter A is incremented by one (108). When the HP
sensor 4 is turned on (point C in Fig. 5), the head H
is moved by an arbitrary number of pulses N (109)
5 (point D in Fig. 5). At this time, the counter A
retains pulses between points B and C. Thereafter,
positive direction-deceleration processing is performed
(110), and movement of the recording head H is stopped
(point E in Fig. 5).

10 Negative direction-acceleration processing (111)
in which the pulse motor 17 is driven in a reverse or
negative direction by the same number of pulses as in
positive direction-acceleration processing is performed
(point E to point F in Fig. 5). The counter M
15 different from the counter A in the RAM 34 is set at
"1" (112). Every time the recording head H is moved by
one pulse (113), the level of the HP sensor 4 is
detected (114). If the HP sensor 4 is not set in the
OFF state, the counter M is incremented by one (115).

20 When the HP sensor 4 is set in the OFF state
(point H in Fig. 5), the counter M has the number of
pulses between points F and H. At this time, the
number of pulses applied to the pulse motor 17 must be
equal to that of pulses in an ideal drive system, i.e.,
25 $M = N$. However, since movement of the recording head H
does not immediately correspond to the number of pulses
applied to the pulse motor, a switching position error



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1 of the HP sensor 4 occurs, and $M > N$ is obtained. In
addition, this error varies in accordance with a change
in weight of an ink tank of the recording head H, i.e.,
a change in drive load over time.

5 In practice, the drive system is not an ideal
rigid member and has a play, and has error factors such
as the hysteresis of the HP sensor 4 and a circuit
delay. These error factors are given as a
characteristic value B, and an error amount is stored
10 in the RAM 34 as $X = M - N - B$ (116). In order to
adjust the positive or negative movement amount of the
recording head H, the recording head H is moved by $(A +$
 $N - N)$ pulses (117), and deceleration processing (118)
is performed by the same number of pulses as that in
15 positive direction-acceleration processing (point A in
Fig. 5A). Note that characteristics in consideration
of the characteristic value B caused by a play and the
like are indicated by a dotted line in Fig. 5. An
error amount X with respect to the load upon power-on
20 operation is determined as described above.

An actual recording operation (recording scanning)
will be described with reference to a flow chart in
Fig. 6 and a movement diagram of the recording head in
Fig. 5.

25 Upon reception of a recording or print instruction
(301), positive direction-acceleration processing (302)
is performed. In order to ensure a correction area,

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1 the recording head H is driven by K pulses (303) (point
I in Fig. 7). Recording (304) is performed on the
basis of data (point J in Fig. 7). Deceleration
processing (305) is performed, and then the paper is
5 fed (306).

When the print instruction (307) of the next line
is input, negative direction-acceleration processing
(308) is performed (point O in Fig. 7), and the
recording head H is moved by X correction pulses (309)
10 (point P in Fig. 7). Data of the next line is recorded
(310) (point R in Fig. 7). The recording head H is
moved by $(K - X)$ pulses (311), and deceleration
processing (312) is performed.

The above operations are repeated to perform
15 one-page recording.

Fig. 7 illustrates the above operations. The
actual recording head positions are plotted along the
abscissa. The point (i.e., point O) upon completion of
acceleration processing in the negative direction is
20 sifted to the right from the point (i.e., point J) of
the end of printing in the positive direction. By
moving the recording head H by X pulses, the printing
range P-R upon completion of correction almost
coincides with the printing range I-J in the positive
25 direction.

As described above, according to this embodiment,
the recording head H is moved in the positive and

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1 negative directions under the same conditions as in the
recording mode upon the power-on operation. The
numbers of pulses until a moment at which the recording
head H crosses the HP sensor 4 are counted, and print
5 error correction in both the directions is performed in
accordance with the calculated difference. Without
increasing cost or performing adjustment, print error
correction with high precision in both the directions
can be performed. In addition, since the above
10 correction operation is always performed upon each
power-on operation, appropriate correction can be
performed against variations in drive load and
particularly changes in ink tank weight over time.

In addition to the difference in numbers of
15 pulses, error correction in consideration of the
characteristic value unique to the head drive system is
performed in this embodiment. Therefore, print error
correction in both the directions can be performed with
high precision.

20 In this embodiment, the positive recording area is
set to be equal to the negative recording area.
However, these areas may be different from each other,
and printing with a minimum distance can be similarly
performed.

25 As shown in Fig. 4, when the state is changed from
an off-line state to an on-line state (102), the same



1 control as in (104) to (118) can be performed upon
initialization (103) to update correction data.

In this embodiment, correction is performed when
the recording head is moved in the negative direction.
5 However, correction may be performed when the recording
head is moved in the positive direction, as shown in
Fig. 8.

More specifically, after positive
direction-acceleration processing is performed, the
10 recording head is moved by the X pulses corresponding
to the correction value. In this state, recording is
performed, and the recording head is moved by $(K - X)$
pulses. Thereafter, the recording head is decelerated
and finally stopped. In printing in the negative
15 direction, upon completion of acceleration processing,
the recording head is moved by K pulses to ensure a
correction area. Recording is then performed, and the
recording head is decelerated and finally stopped. In
this manner, even if the recording head is moved by
20 pulses in the positive direction, the same effect as in
the above embodiment can be obtained.

The second embodiment of the present invention
will be described below.

This embodiment has the same mechanical structure
25 as in the embodiment shown in Fig. 1, and the block
diagram of an electrical arrangement of a drive system
for a recording head H is shown in Fig. 9.



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1 Referring to Fig. 9, the drive system includes a
pulse motor drive circuit 31 for driving a pulse motor
17, a CPU 32 for supplying a control signal to the
pulse motor drive circuit 31 to drive the pulse motor
5 17, as will be described later, a ROM 33 for storing a
control sequence (to be described later), and a RAM 94
having counters (to be described later) or temporary
data storage areas P, Q, and X, and the like.

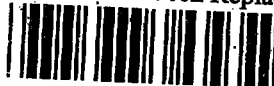
The pulse motor 17 has a resolution per pulse
10 corresponding to a drive amount of $1/60$ " of the
recording head H. A print area corresponds to 480
pulses (8").

A correction value detection operation
(preliminary scanning) of this embodiment will be
15 described with reference to a flow chart in Fig. 10 and
a movement diagram of the recording head shown in
Fig. 11.

As shown in Fig. 10, initialization (401) is
performed upon power-on operation, and positive
20 direction-acceleration processing (402; point A to
point B in Fig. 11) is performed wherein the pulse
motor 17 is driven to drive a carriage 15 (recording
head H) in a positive direction at a speed equal to
that in a recording mode.

25 A movement pulse count V (e.g., $180\frac{1}{3}$ of 480
pulses corresponding to the print area) in the positive
direction is set in a movement pulse counter U in the

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1 RAM 94 (403). In this case, the count V is a value
stored in the ROM 33 and corresponding to a pulse count
representing a distance up to point E sufficiently
spaced apart from point B in Fig. 11, passing through
5 an HP sensor 4. The counter P is set to be "0" (404).
Every time the recording head H is moved by one pulse
at a constant speed (405), the level of the HP sensor 4
is detected (406). If the HP sensor 4 is set in the
OFF state, the counter P is incremented by one (407).
10 This operation is repeated by V pulses (408 and 409).
At this time, the counter P represents a pulse count
from point D to point E in Fig. 11, i.e., a period
during which the sensor level is changed from the ON
state to the OFF state. Upon completion of movement by
15 V pulses, positive direction-deceleration processing
(410) is performed, and movement of the recording head
H is stopped (points E and F in Fig. 11).

The pulse motor 17 is driven in the negative or
reverse direction, and negative direction-deceleration
20 processing (411; point G to point H in Fig. 11) is
performed by the same pulse count as that in the
positive direction-deceleration processing. The same
value V as in positive movement is set as a movement
pulse count in the negative direction in the movement
25 pulse counter U (412). The counter Q is set to be "0"
(413). Every time the recording head H is moved by one
pulse at a constant speed (414), the level of the HP

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1 sensor is detected (415). When the level of the HP
sensor is set in the OFF state, the counter Q is
incremented by one (461). This processing is repeated
by V pulses (417 and 418). At this time, the counter Q
5 stores a pulse count from point H to point J in Fig. 11
during which the level of the sensor is changed from
the OFF state to the ON state. Upon completion of
movement of the recording head by V pulses, negative
direction-deceleration processing is performed by the
10 same pulse count as in the positive
direction-acceleration processing (419), and movement
of the recording head H is stopped (point K to point L
in Fig. 11).

When the above processing is completed, condition
15 $P = Q$ must be obtained in an ideal drive system. In
practice, however, since the drive system is not an
ideal rigid body, the drive system has a characteristic
value Y (points A to L and points F to G in Fig. 11)
such as a play. In addition, since the recording head
20 H cannot immediately respond to the pulses supplied to
the pulse motor 17, a level inversion position of the
HP sensor 4 is shifted from point C to point D in the
positive direction and from point I to point J in the
negative position, thereby obtaining condition $Q > P$.
25 When this error value is given as X, the value X in the
positive direction is regarded to be equal to that in
the negative direction, so that the error value can be

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1 calculated by $X = (Q - P - Q)/Y$. This value is stored
in the RAM 94 as a correction value (420). The error
amount X for the load upon the power-on operation can
thus be obtained.

5 In this embodiment, since $P = 145$, $Q = 150$, and Y
 $= 1$, then $X = 2$. Alternatively, the above operations
are repeated a plurality of times to obtain a plurality
of correction values, an average value of the plurality
of correction values is calculated, and the average
10 value may be stored in the RAM 94 as a correction
value.

A correction sequence (recording scanning) during
actual recording will be described with reference to a
flow chart in Fig. 12 and a recording head movement
15 chart shown in Fig. 13.

During actual recording, as shown in Fig. 12, upon
reception of a print instruction (501), positive
direction-acceleration processing is performed (502;
point A to point B in Fig. 13). The recording head is
20 moved by Z pulses to obtain an area for ensuring a
correction area, and the recording head is moved by the
correction value corresponding to X pulses (503; from
point B to points C and D in Fig. 13). At this time,
the area Z is set to have a larger value than a sum of
25 a maximum value of the assumed correction value X and
the characteristic value Y caused by a play.



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1 Recording is then performed in accordance with
recording data (504; point D to point E in Fig. 13),
and the recording head is moved by $(Z - X)$ pulses to
adjust the correction area upon recording (505; point E
5 to point F in Fig. 13). After positive
direction-deceleration processing is performed (506;
point F to point G in Fig. 13), the paper is fed (507).

When a print instruction of the next line is
received (508), negative direction-acceleration
10 processing is performed by the same pulse count as in
the positive direction-deceleration processing (509;
point H to point I in Fig. 13). The recording head is
moved by Z pulses to obtain an area for assuring the
correction area, and then the recording head is moved
15 by Y pulses as the characteristic value Y caused by a
play and the like. In addition, the recording head is
moved by X pulses as the correction value (510; from
point I to points J, K, and L in Fig. 13).

Recording is then performed in accordance with
20 recording data (511; point L to point M in Fig. 13).
In order to adjust the correction area upon recording,
the recording head is moved by $(Z - X - Y)$ pulses (505;
point M to point N in Fig. 13). Negative
direction-deceleration processing is performed by the
25 same pulse count as in the positive
direction-acceleration processing (513).

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1 The above operations are repeated to perform
one-page recording.

Fig. 13 illustrates the positions of the recording
heads H in the above operations. This processing is
5 performed so that the printing range in the positive
direction falls between point D and point E, and that
in the negative direction falls between point M and
point L. In practice, however, an error corresponding
to X occurs as in detection of the correction value.
10 The printing range in the positive direction falls
between point C and point E', and that in the negative
direction falls between point M' and point K.

An actual print start position can be kept to be
point C even if the correction value X upon detection
15 is changed by load variations such as differences
between apparatuses and deteriorations over time. This
is because error correction is performed in both the
positive and negative directions.

In this embodiment, the positive recording area is
20 set to be equal to that of the negative recording area.
However, the positive recording area may be different
in size from the negative recording area, and printing
with a minimum distance can be performed.

When the off-line state is changed to the on-line
25 state, as shown in Figs. 410 (421, 402 to 420), the same
control as described above can be performed to update
the correction value. In addition to the case wherein



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1 the apparatus is powered on, or is changed from the
off-line state to the on-line state, the correction
value calculation control described above can be
performed prior to recording.

5 In this embodiment, the pulse count (i.e., a
switching count of excitation phases) of the pulse
motor 17 is counted. However, when ink ejection (dot)
is performed at timings each obtained by dividing
(e.g., six divisions) one phase of the pulse, the
10 number of dots may be counted. In this case, error
correction precision can be given as $1/360^\circ$, thereby
further improving error correction precision.

In a recording apparatus having a plurality of
print speeds, correction values $X_1, X_2, \dots$
15 corresponding to the respective speeds are obtained,
thereby performing optimal error correction at the
respective speeds.

The present invention is not limited to a pulse
motor as a drive source for the recording head
20 (carriage), but can employ, e.g., a DC motor.

The HP sensor can be arranged outside the
acceleration or deceleration processing area.

A preliminary scanning amount is not limited to a
specific value. However, in consideration of
25 preliminary scanning time and precision, this amount is
preferably set to be $1/2$ to $1/4$, particularly $1/3$, of
the recording width.

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1 The present invention can equally applied to,
e.g., a thermal transfer recording system using a
thermal head, a heat-sensitive recording system, and an
impact recording system using a daisy wheel, a wire
5 dot, or the like. When the ink-jet recording system is
employed, an excellent effect can be obtained in the
ink-jet recording apparatus utilizing heat energy, as
described in the above embodiments. According to this
system, high-density, high-precision recording can be
10 performed.

As to its representative constitution and
principle, for example, one practiced by use of the
basic principle disclosed in, for example, U.S. Patents
4,723,129 and 4,740,796 is preferred. This system is
15 applicable to either of the so called on-demand type
and the continuous type. Particularly, the case of the
on-demand type is effective because, by applying at
least one driving signal which gives rapid temperature
elevation exceeding nucleus boiling corresponding to
20 the recording information on an electricity-heat
converters arranged corresponding to the sheets or
liquid channels holding liquid (ink), heat energy is
generated at the electricity-heat converters to effect
film boiling at the heat acting surface of the
25 recording head, and consequently the bubbles within the
liquid (ink) can be formed corresponding one by one to
the driving signals. By discharging the liquid (ink)

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1 through an opening for discharging by growth and
shrinkage of the bubble, at least one droplet is
formed. By making the driving signals into pulse
shapes, growth and shrinkage of the bubble can be
5 effected instantly and adequately to accomplish more
preferably discharging of the liquid (ink) particularly
excellent in response characteristic. As the driving
signals of such pulse shape, those as disclosed in U.S.
Patents 4,463,359 and 4,345,262 are suitable. Further
10 excellent recording can be performed by employment of
the conditions described in U.S. Patent 4,313,124 of
the invention concerning the temperature elevation rate
of the above-mentioned heat acting surface.

As the constitution of the recording head, in
15 addition to the combination constitutions of
discharging orifice, liquid channel, electricity-heat
converter (linear liquid channel or right angle liquid
channel) as disclosed in the above-mentioned respective
specifications, the constitution by use of U.S. Patent
20 4,558,333, 4,459,600 disclosing the constitution having
the heat acting portion arranged in the flexed region
is also included in the present invention. In
addition, the present invention can be also effectively
made the constitution as disclosed in Japanese Patent
25 Laid-Open Application No. 59-123670 which discloses the
constitution using a slit common to a plurality of
electricity-heat converters as the discharging portion



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1 of the electricity-heat converter or Japanese Patent
Laid-Open Application No. 59-138461 which discloses the
constitution having the opening for absorbing pressure
wave of heat energy correspondent to the discharging
5 portion.

Further, as the recording head of the full line
type having a length corresponding to the maximum width
of recording medium which can be recorded by the
recording device, either the constitution which
10 satisfies its length by combination of a plurality of
recording heads as disclosed in the above-mentioned
specifications or the constitution as one recording
head integrally formed may be used, and the present
invention can exhibit the effects as described above
15 further effectively.

In addition, the present invention is effective
for a recording head of the freely exchangeable chip
type which enables electrical connection to the main
device or supply of ink from the main device by being
20 mounted on the main device, or for the case by use of a
recording head of the cartridge type provided
integrally on the recording head itself.

Also, addition of a restoration means for the
recording head, a preliminary auxiliary means, etc.
25 provided as the constitution of the recording device of
the present invention is preferable, because the effect
of the present invention can be further stabilized.

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1 Specific examples of these may include, for the
recording head, capping means, cleaning means,
pressurization or aspiration means, electricity-heat
converters or another heating element or preliminary
5 heating means according to a combination of these, and
it is also effective for performing stable recording to
perform preliminary mode which performs discharging
separate from recording.

Further, as the recording mode of the recording
10 device, the present invention is extremely effective
for not only the recording mode only of a primary color
such as black etc., but also a device equipped with at
least one of plural different colors or full color by
color mixing, whether the recording heat may be either
15 integrally constituted or combined in plural number.

In each embodiment described above, the ink is
exemplified as a liquid. However, an ink which is
solidified at room temperature or less is generally
temperature-controlled to be softened or liquefied at
20 room temperature or in a temperature range of 30°C to
70°C, thereby controlling the viscosity of the ink to
fall within a stable ejection range. For this reason,
an ink need only be in a liquid phase when a recording
signal is applied. Alternatively, by using an ink
25 which positively prevents temperature increase by heat
energy by using it as energy for changing a state from
a solid phase to a liquid phase of the ink, or by using



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1 an ink which is solidified in an exposed state for the
purpose of evaporation prevention, heat energy is
applied to the ink in accordance with a recording
signal, and the liquefied ink is ejected. An ink
5 which starts solidifying before it reaches the surface
of a recording medium may also be used. That is, an
ink which is liquefied only upon application of heat
energy may be used in the present invention. In
addition, as described in Japanese Patent Laid-Open
10 Application No. 54-56874 or 60-71260, an ink as a
liquid or solid body stored in a recess or through hole
of a porous sheet may be opposed to an electricity-heat
converter. According to the present invention, a most
effective method for each ink is a film boiling method.

15 In addition, the ink-jet recording apparatus
according to the present invention is used in an
application form as an image output terminal of data
processing equipment such as a computer, a copying
apparatus in combination with a reader and the like,
20 and a facsimile apparatus having transmission and
reception functions.

Fig. 14 is a schematic block diagram in which a
recording apparatus of the present invention is applied
to a data processing apparatus having functions as a
25 wordprocessor, a personal computer, a facsimile
apparatus, and a copying apparatus.

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1 A controller 201 controls the overall operation of
the apparatus and includes a CPU (e.g., a
microprocessor) and has various I/O ports. The
controller 201 outputs control and data signals to the
5 respective circuit components or receives control and
data signals from these components. A display 202
displays various menus, document information, and image
data read by an image reader 207 on the display screen.
A transparent pressure-sensitive touch panel 203 is
10 arranged on the display 202. When the surface of the
touch panel 203 is pressed with a finger or the like, a
desired item or a coordinate position can be input on
the display 202.

 An FM (Frequency Modulation) sound source 204
15 stores music information generated by a music editor or
the like in a memory 210 or an external memory device
212 in the form of digital data, reads out stored data
from the memory and the like, and performs FM
modulation of the readout data. An electrical signal
20 from the FM sound source 204 can be produced as sounds
from a speaker 205. A printer 206 is constituted by
the recording apparatus of the present invention as an
output terminal for a wordprocessor, a personal
computer, a facsimile apparatus, and a copying machine.

25 The image reader 207 photoelectrically reads
original data and inputs the read data. The image
reader 207 is arranged in an original convey path and



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1 reads a facsimile original, a copying original, and
various other originals. A FAX transmitter-receiver
208 performs facsimile transmission of original data
read by the image reader 207, receives a transmitted
5 facsimile signal, and decodes the received facsimile
signal. The FAX transmitter-receiver 208 has an
interface function with an external device. A
telephone 209 has various telephone functions such as
normal telephone functions and automatic telephone
10 answering functions.

The memory 210 includes a ROM for storing a system
program, a manager program, other application programs,
character fonts, and a dictionary, and a video RAM, and
further stores application programs loaded from the
15 external memory device 212 and document information.

A keyboard 211 is used to input document
information and various commands.

The external memory device 212 uses a memory
medium such as a floppy or hard disk. Document
20 information, music or voice information, and user
application programs are stored in the external memory
device 212.

Fig. 15 is an external perspective view of the
data processing apparatus shown in Fig. 14.

25 A flag display panel 301 is obtained by using a
liquid crystal or the like and displays various menus,
graphic data, and document data. The touch panel 203

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1 is formed on the display 301. Upon depression of the
surface of the touch panel 203 with a finger or the
like, coordinate data or an item can be input. A
handset 302 is used when the apparatus serves as a
5 telephone. A keyboard 303 is detachably connected to
the main body through a cord and is used to input
various document data and other data. The keyboard 303
has various function keys 304. A floppy disk slot 305
is formed in the main body for accessing data from the
10 external memory device 212.

An original is placed on an original table 306 and
is read by the image reader 207. The read original is
discharged from the rear portion of the apparatus. In
a facsimile reception mode or the like, the received
15 data is recorded at an ink-jet printer 307.

The display 202 may be constituted by a CRT
display. However, a flat panel such as a liquid
crystal display utilizing a ferromagnetic liquid
crystal is preferred to obtain a compact, low-profile,
20 lightweight display.

When the data processing apparatus is used as a
personal computer or a wordprocessor, various data
input from the keyboard 211 is processed by the
controller 201 in accordance with a predetermined
25 program. The processed data is output as an image at
the printer 206.

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1 When the apparatus serves as a receiver of the
facsimile apparatus, facsimile data input from the FAX
transmitter-receiver 208 through a communication line
is received and processed by the controller 201 in
5 accordance with a predetermined program. The processed
data is output as a reception image at the printer 206.

 When the apparatus serves as a copying machine, an
original is read by the image reader 207, and the read
original data is output as a copy image at the printer
10 206 through the controller 201. When the apparatus
serves as a transmitter of the facsimile apparatus,
original data read by the image reader 207 is
transmitted by the controller 201 in accordance with a
predetermined program. The processed data is sent to
15 the transmission line through the FAX
transmitter-receiver 208.

 The data processing apparatus may be an integral
unit including an ink-jet printer, as shown in Fig. 16.
In this case, a more portable apparatus can be
20 obtained. The same reference numerals as in Fig. 15
denote the same parts in Fig. 16.

 As described above, the recording apparatus of the
present invention is applied to the multifunctional
data processing apparatus as described above to obtain
25 a high-quality recorded image with low noise at high
speed, thereby further improving the functions of the
data processing apparatus.

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1 As has been described above, according to the
present invention, the positions of the recording head
in the positive and negative directions can be
accurately controlled regardless of drive load
5 variations.

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1 WHAT IS CLAIMED IS:

1. A serial recording apparatus for reciprocating a recording head with respect to a recording medium to perform bidirectional recording, comprising:

5 position detecting means for detecting a reference position of said recording head;

driving means for reciprocating said recording head within a predetermined area including the reference position;

10 means for calculating a difference between reference positions detected by said position detecting means by reciprocal movement when said recording head is reciprocated by said driving means within the predetermined area; and

15 means for correcting a positional error in bidirectional recording on the basis of the difference calculated by said calculating means.

2. An apparatus according to claim 1, wherein
20 said correcting means corrects a positional error on the basis of a difference calculated by said calculating means and a characteristic value of said driving means.

25 3. An apparatus according to claim 1, wherein said correcting means corrects a positional error while

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1 said recording head is moved for recording in one
direction or the other direction.

4. An apparatus according to claim 1, wherein
5 said correcting means corrects the positional error
during movement of said recording head for recording in
both directions.

5. An apparatus according to claim 1, wherein
10 said driving means includes a pulse motor, and said
calculating means calculates the difference between the
detected reference positions by the number of pulses
for driving said pulse motor.

15 6. An apparatus according to claim 1, wherein
said driving means includes a pulse motor, and said
calculating means calculates the difference between the
detected reference positions in accordance with a
plurality of phases obtained by dividing the pulse for
20 driving said pulse motor.

7. An apparatus according to claim 1, wherein
said driving means drives to reciprocate said recording
head to cause said calculating means to calculate the
25 difference between the detected reference positions
upon a power-on operation.

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1 8. An apparatus according to claim 1, wherein
said driving means drives to reciprocate said recording
head to cause said calculating means to calculate the
difference between the detected reference positions in
5 an on-line mode.

 9. An apparatus according to claim 1, wherein
said calculating means calculates the differences
between the detected reference positions at a plurality
10 of speeds.

 10. An apparatus according to claim 1, wherein the
predetermined area is about $1/3$ the recording area.

15 11. An apparatus according to claim 1, wherein
said recording head is an ink-jet recording head for
ejecting an ink droplet to perform recording.

 12. An apparatus according to claim 1, wherein
20 said recording head is a bubble-jet recording head for
ejecting an ink droplet to perform recording upon
growth and shrinkage of a bubble.

 13. An apparatus according to claim 1, wherein
25 said recording head comprises a plurality of ejection
ports for ejecting an ink, and heat energy generating
means, respectively arranged in correspondence with





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1 said plurality of ejection ports, for causing a change
in state in the ink by heat and ejecting the ink from
said ejection ports to form flying liquid droplets on
the basis of the change in state.

5

14. An apparatus according to claim 1, wherein
said recording head is interchangeable with respect to
said serial recording apparatus.

10

15. An apparatus according to claim 14, wherein
said recording head is an ink-jet recording head for
ejecting an ink droplet to perform recording.

15

16. An apparatus according to claim 15, wherein
said recording head comprises a tank for storing an
ink.

20

17. A serial recording method of reciprocating a
recording head with respect to a recording medium to
perform bidirectional recording, comprising the steps
of:

reciprocating said recording head within a
predetermined area including a reference position prior
to recording;

25

detecting the reference positions in both movement
directions during reciprocal movement and calculating a
difference between the detected reference positions; and

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1 correcting a positional error to perform
bidirectional recording on the basis of the calculated
difference.

5 18. A method according to claim 17, wherein the
step of performing bidirectional recording comprises
the step of correcting the positional error while said
recording head performs recording in one direction or
the other direction.

10

19. A method according to claim 17, wherein the
step of performing bidirectional recording comprises
the step of correcting the positional error during
recording of said recording head in both directions.

15

20. An apparatus according to claim 17, wherein
the predetermined area is about $1/3$ the recording area.

20

21. An apparatus according to claim 17, wherein
said recording head is an ink-jet recording head for
ejecting an ink droplet to perform recording.

25

22. An apparatus according to claim 17, wherein
said recording head is a bubble-jet recording head for
ejecting an ink droplet to perform recording upon
growth and shrinkage of a bubble.

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1 23. An apparatus according to claim 17, wherein
said recording head comprises a plurality of ejection
ports for ejecting an ink, and heat energy generating
means, respectively arranged in correspondence with
5 said plurality of ejection ports, for causing a change
in state in the ink by heat and ejecting the ink from
said ejection ports to form flying liquid droplets on
the basis of the change in state.

10 24. An apparatus according to claim 17, wherein
said recording head is interchangeable with respect to
said serial recording apparatus.

15 25. An apparatus according to claim 24, wherein
said recording head is an ink-jet recording head for
ejecting an ink droplet to perform recording.

20 26. An apparatus according to claim 25, wherein
said recording head comprises a tank for storing an
ink.

25 27. A serial recording apparatus for
reciprocating a recording head with respect to a
recording medium to perform by directional recording
characterised in that there are means for calibrating
the recording head in response to variations in load
on the recording head and means responsive to the
calibration in order to correct any positional errors
of the bidirectional recording head caused by
variations in the load.

SERIAL RECORDING APPARATUS FOR BIDIRECTIONAL RECORDING

1 ABSTRACT OF THE DISCLOSURE

A serial recording apparatus for reciprocating a recording head with respect to a recording medium to perform bidirectional recording includes a position
5 detector for detecting a reference position of the recording head, a driving unit for reciprocating the recording head within a predetermined area including the reference position, a calculating unit for
calculating a difference between reference positions
10 detected by the position detector by reciprocal movement when the recording head is reciprocated by the driving unit within the predetermined area, and a
correcting unit for correcting a positional error in bidirectional recording on the basis of the difference
15 calculated by the calculating unit.

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FIG. 1

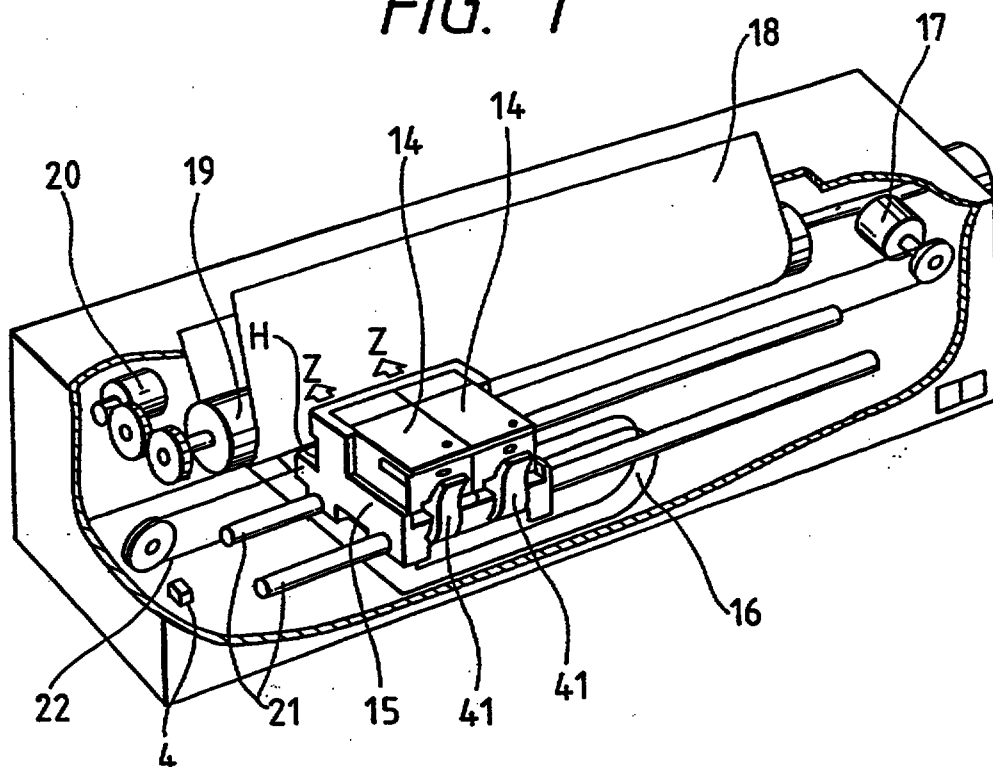
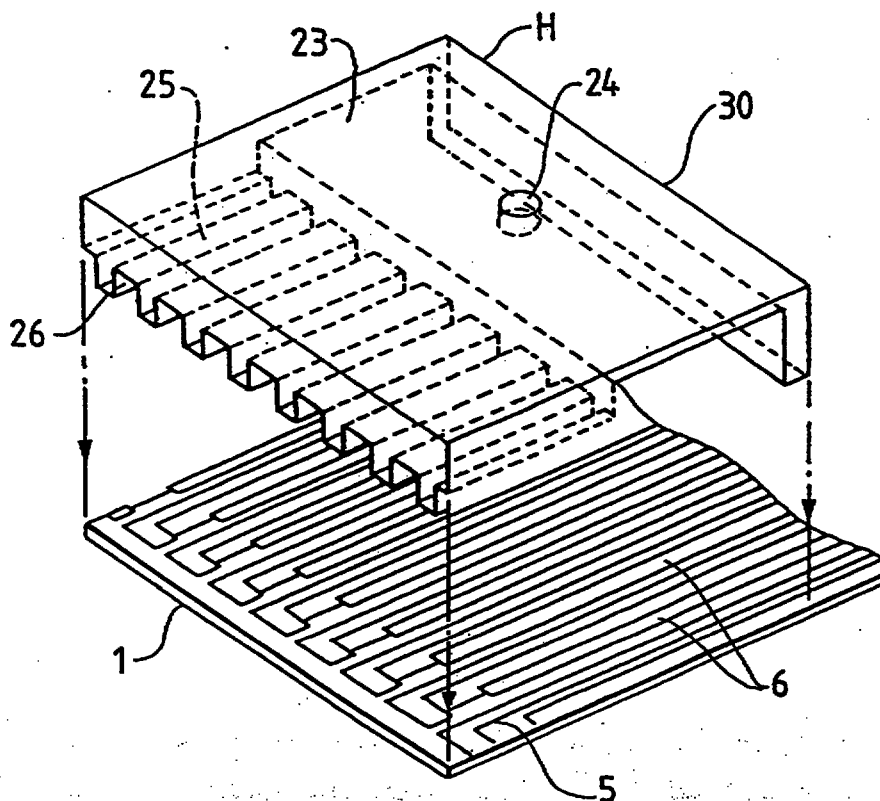


FIG. 2



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FIG. 3

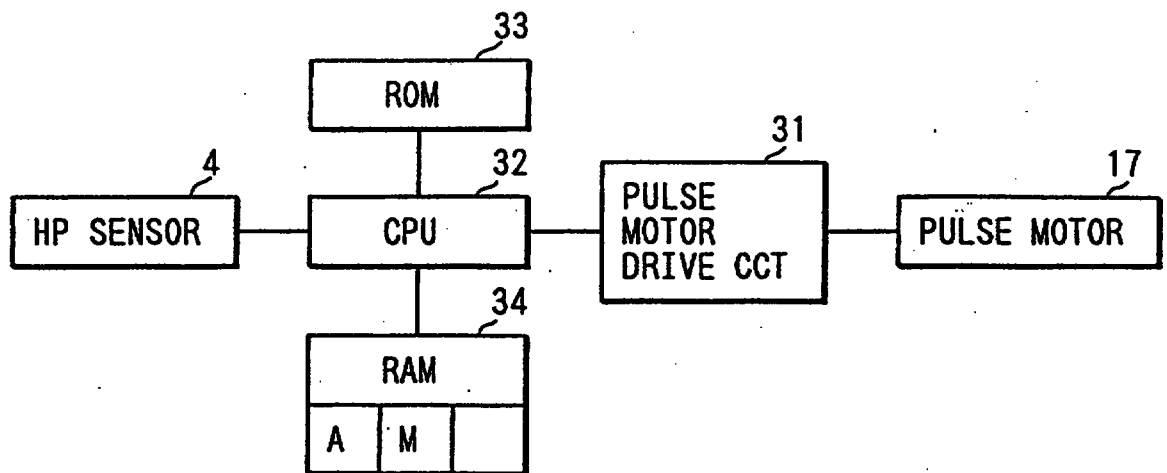
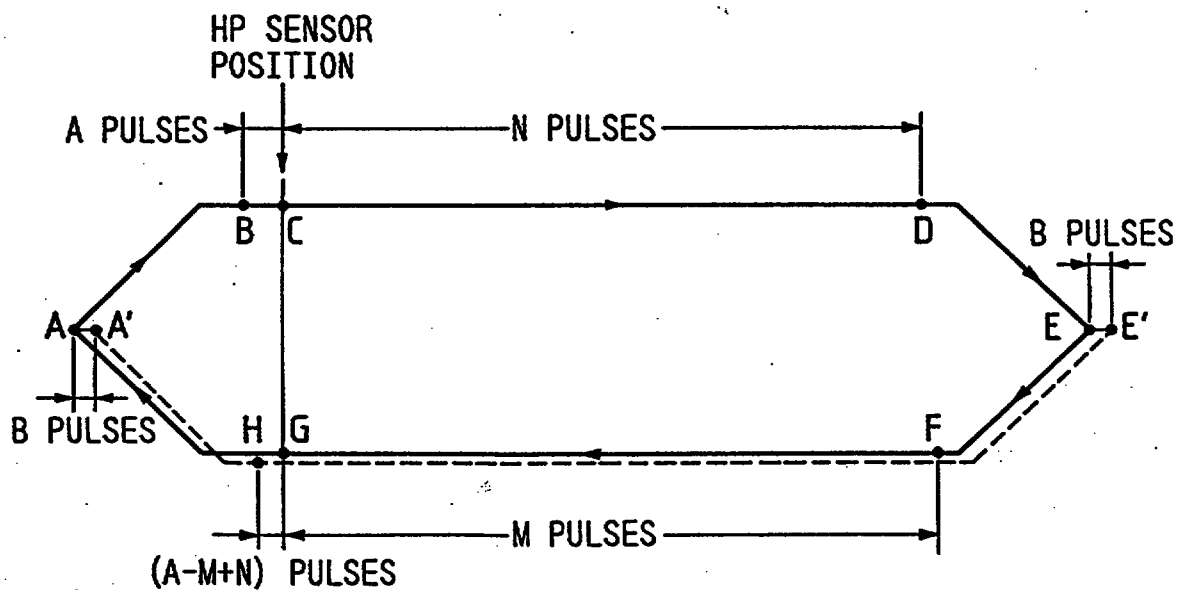


FIG. 5

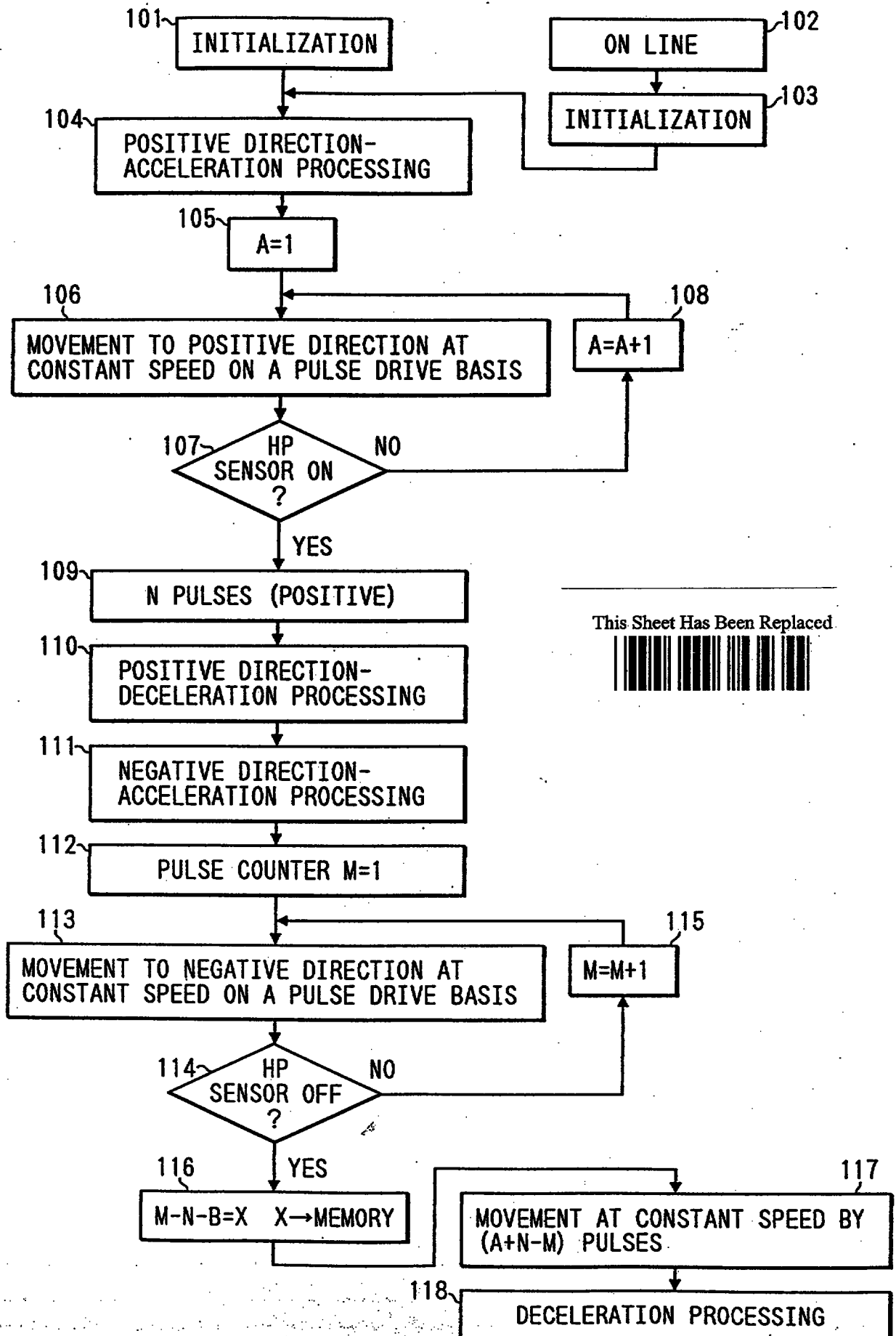


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FIG. 4

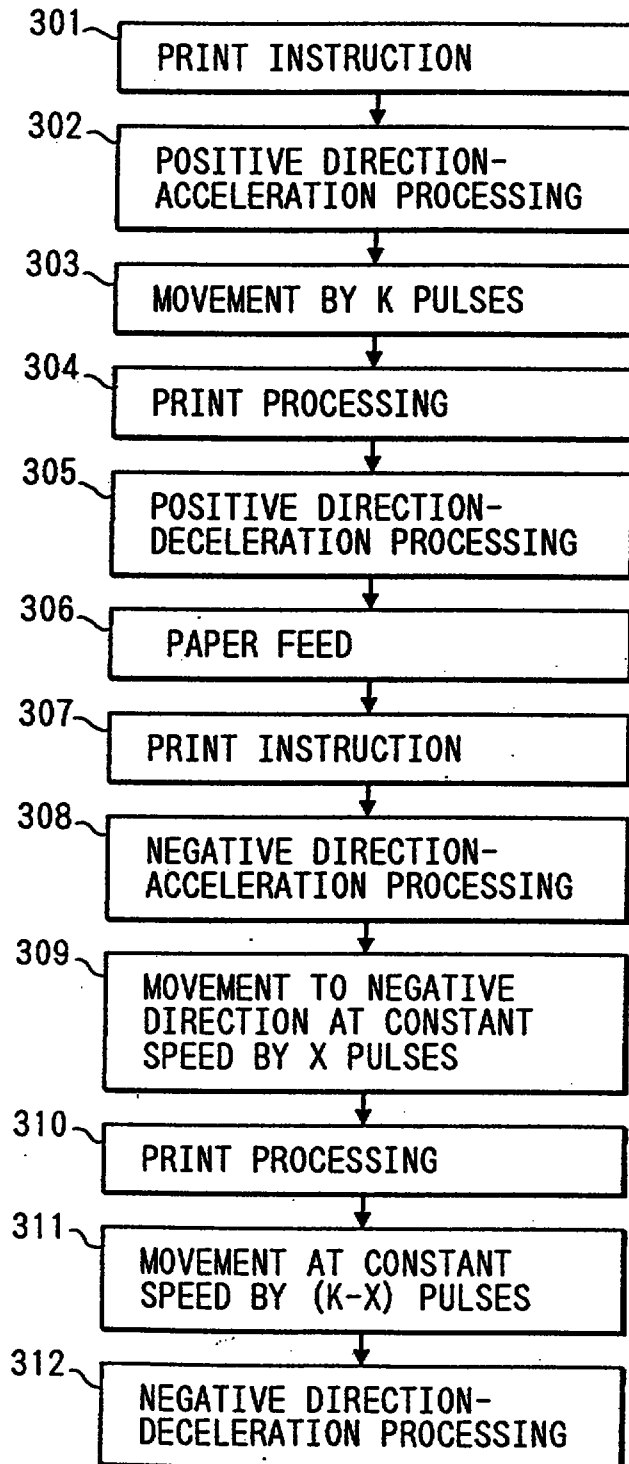
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FIG. 6

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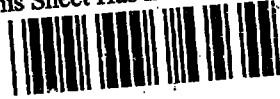
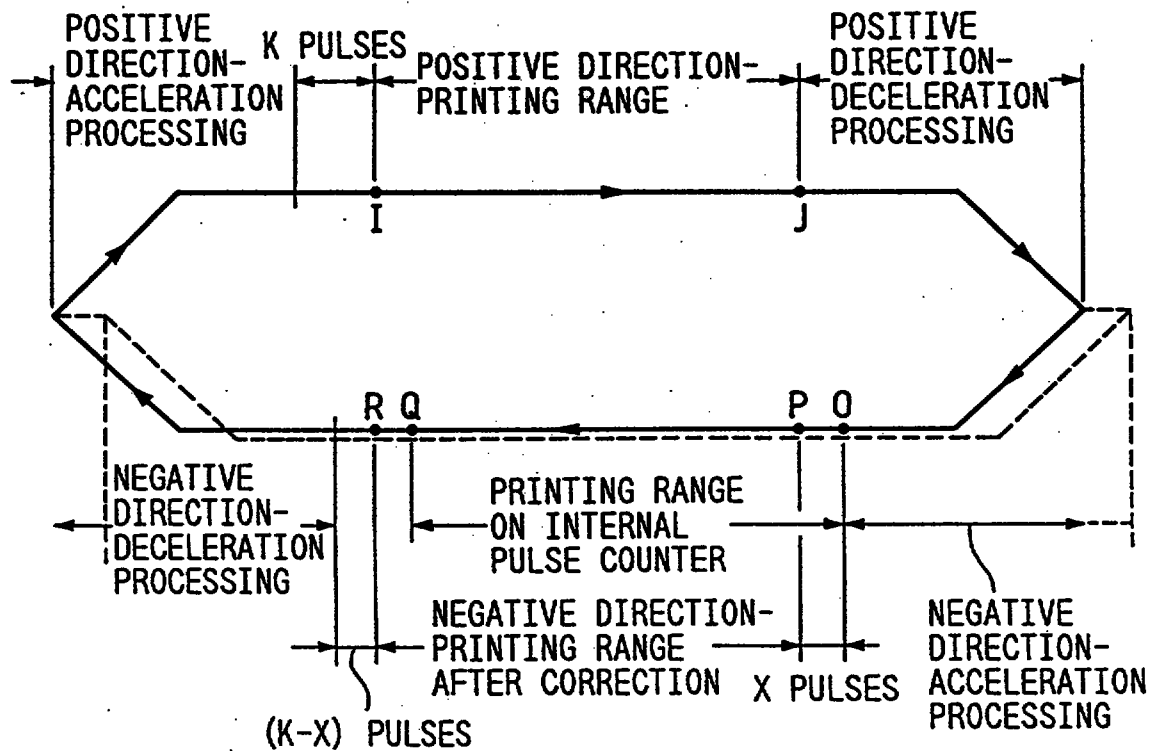
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FIG. 7



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FIG. 8

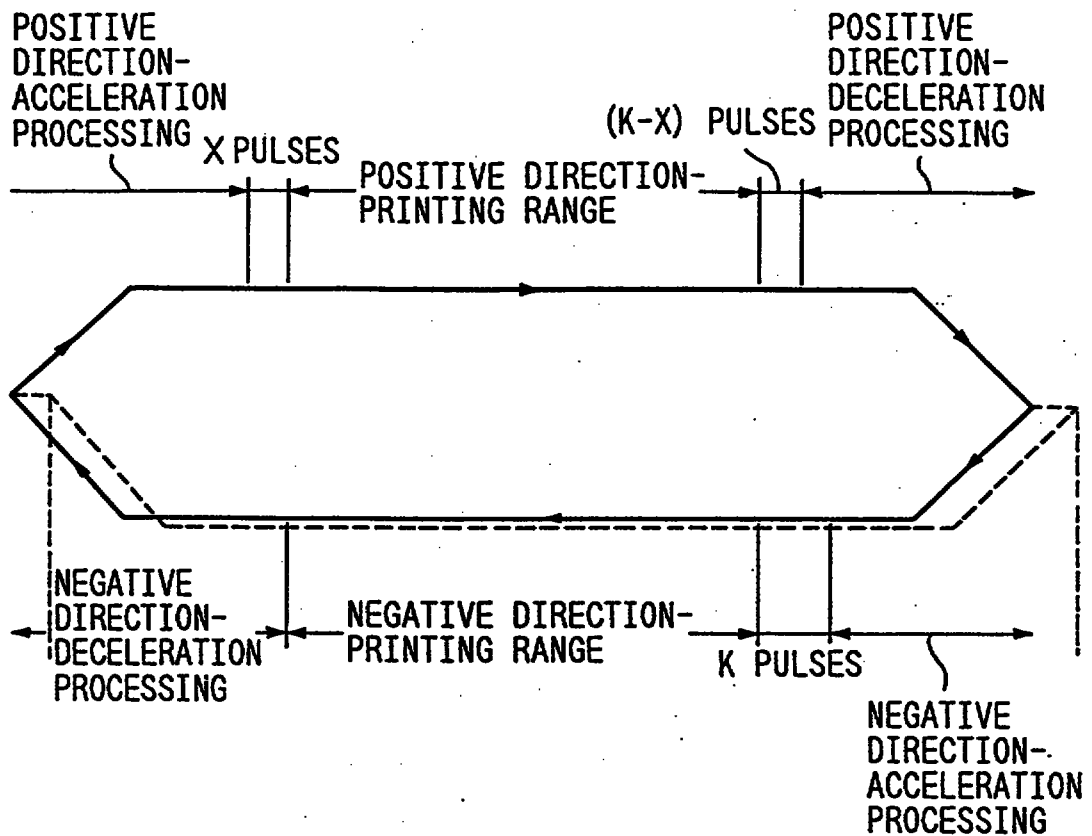
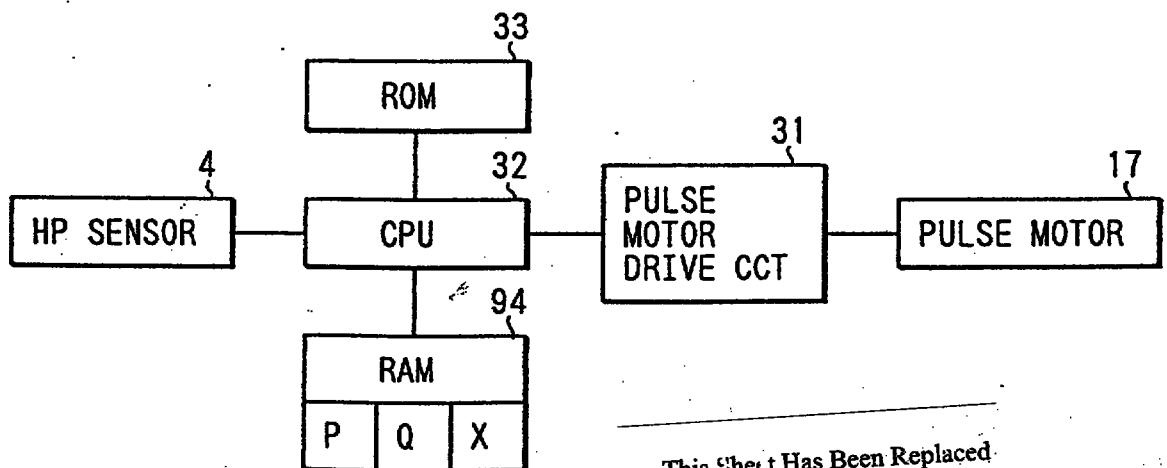
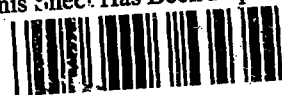


FIG. 9



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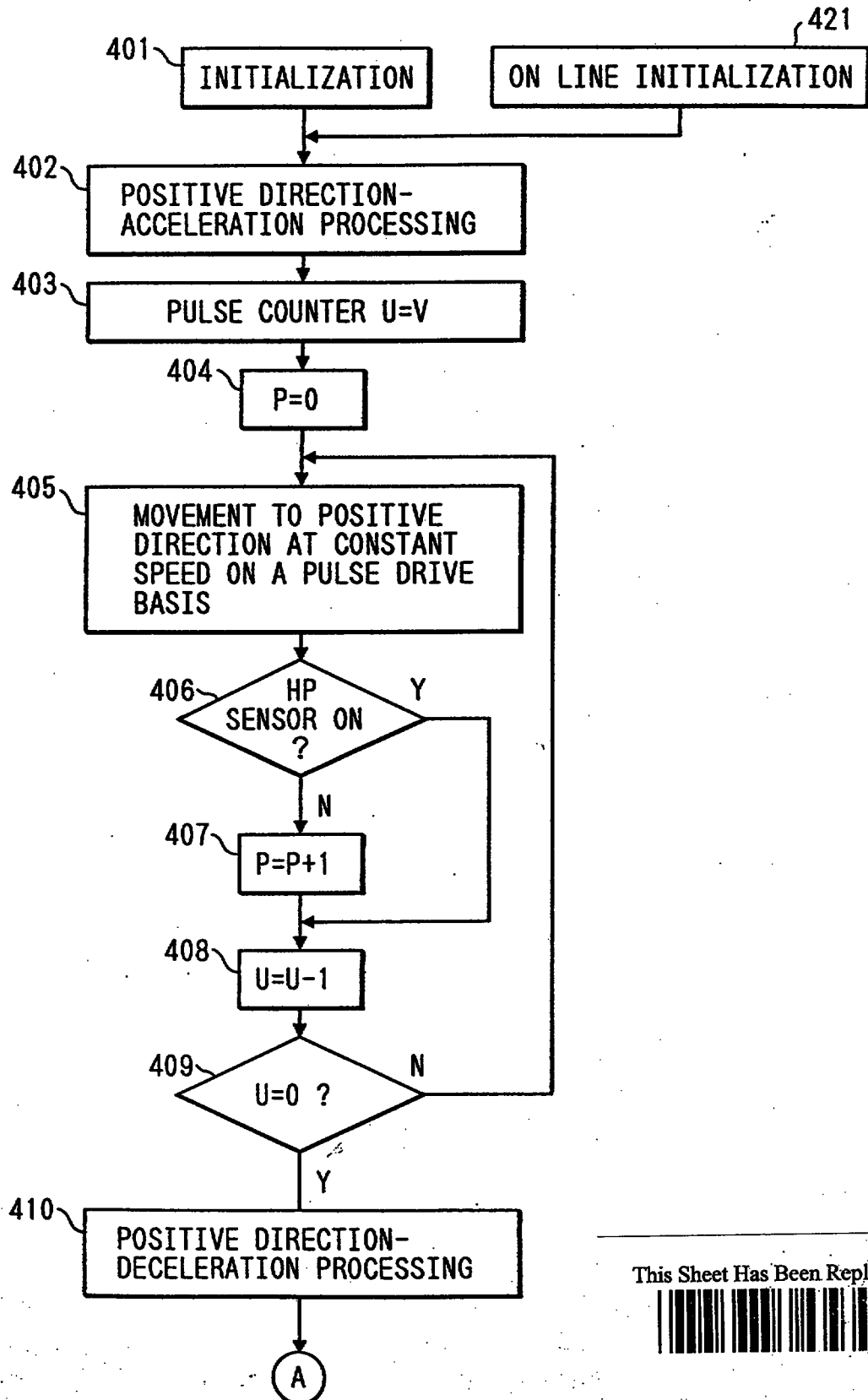
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FIG. 10

FIG. 10A

FIG. 10B

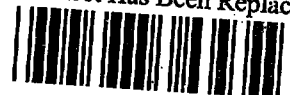
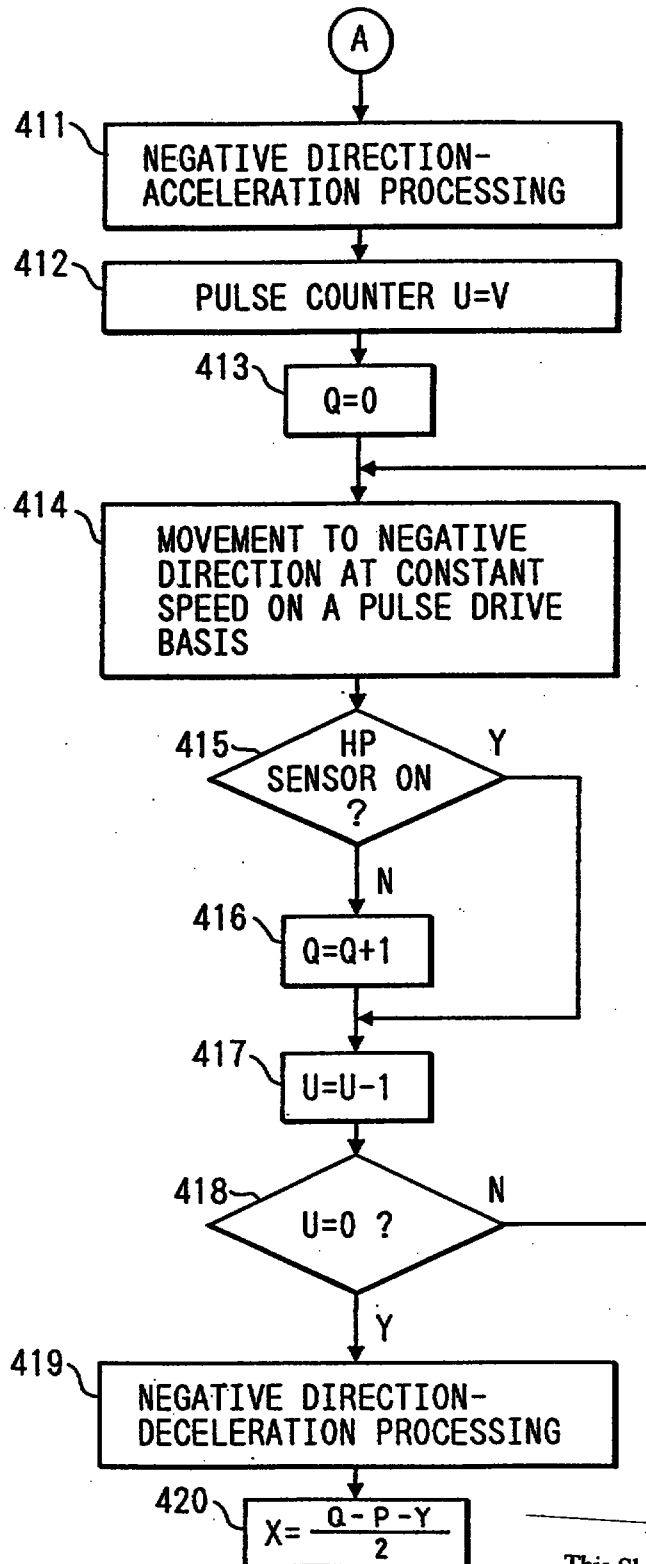
FIG. 10A



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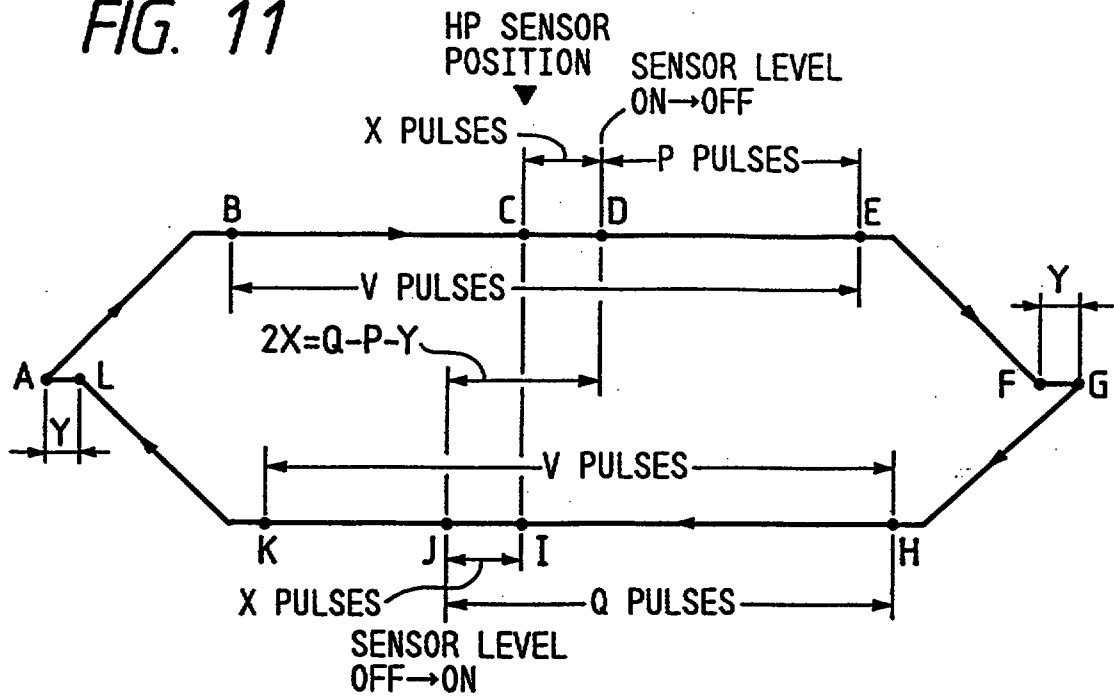
FIG. 10B



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FIG. 11



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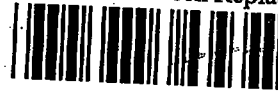
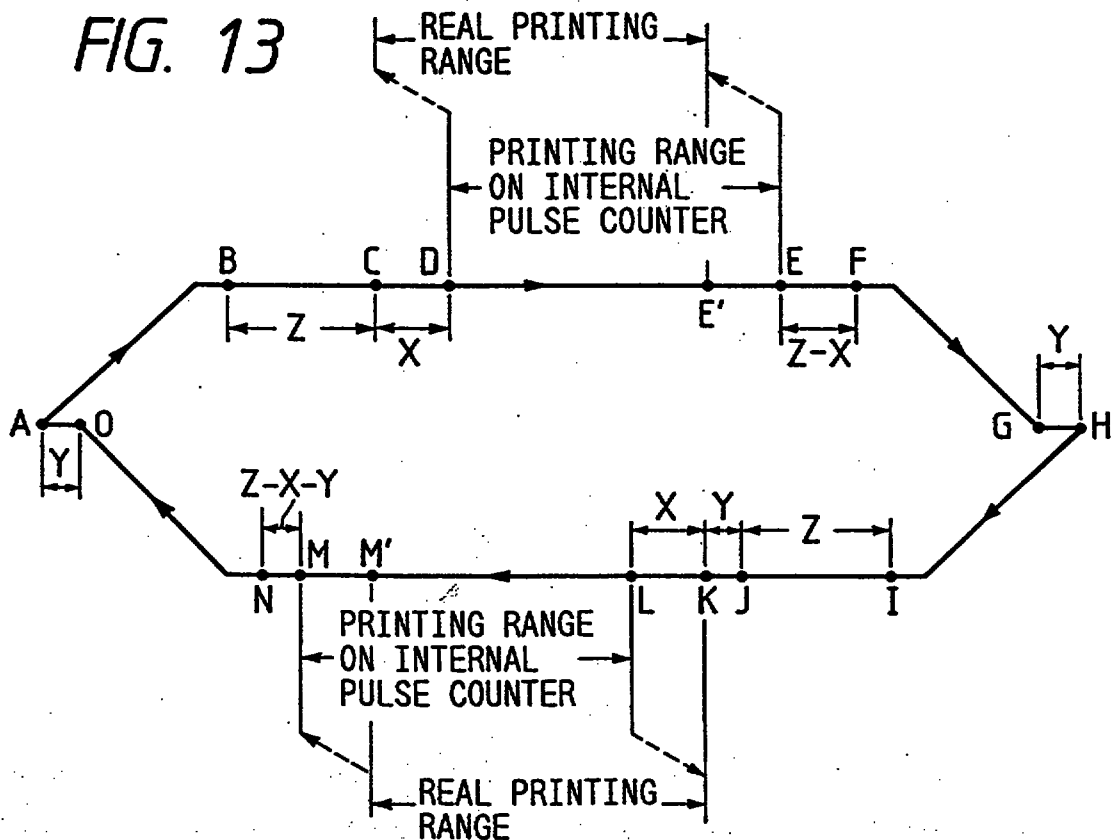


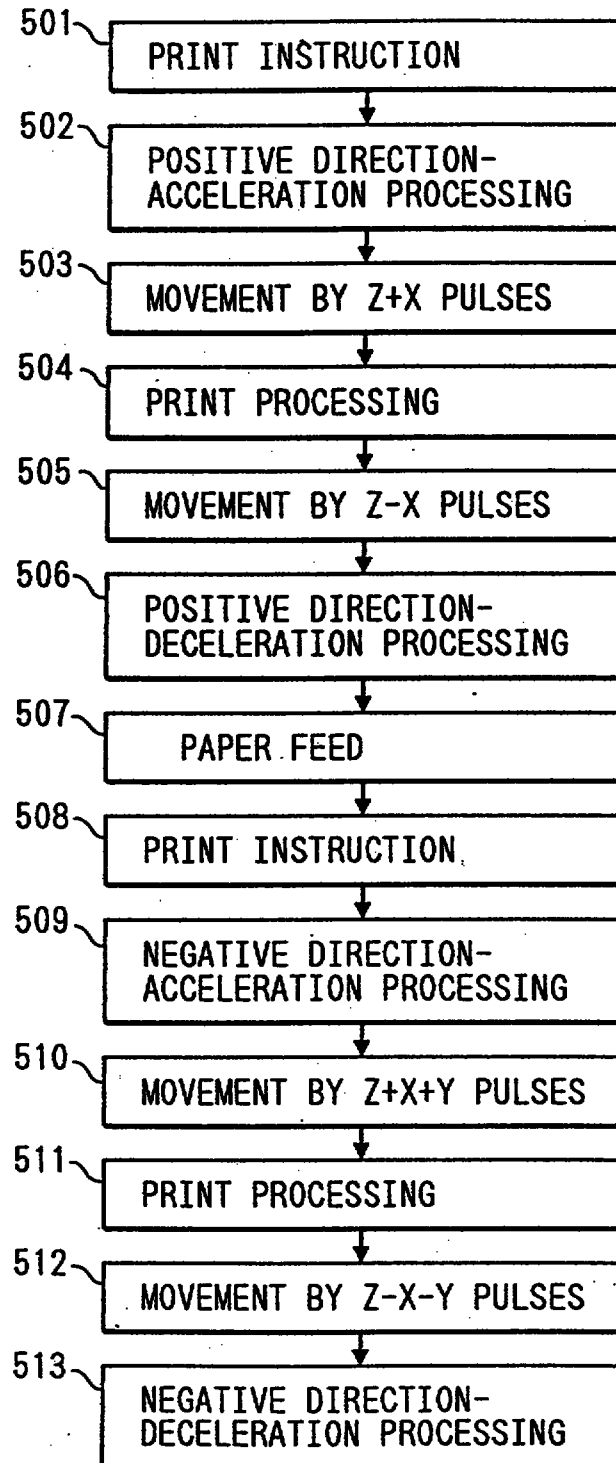
FIG. 13



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FIG. 12

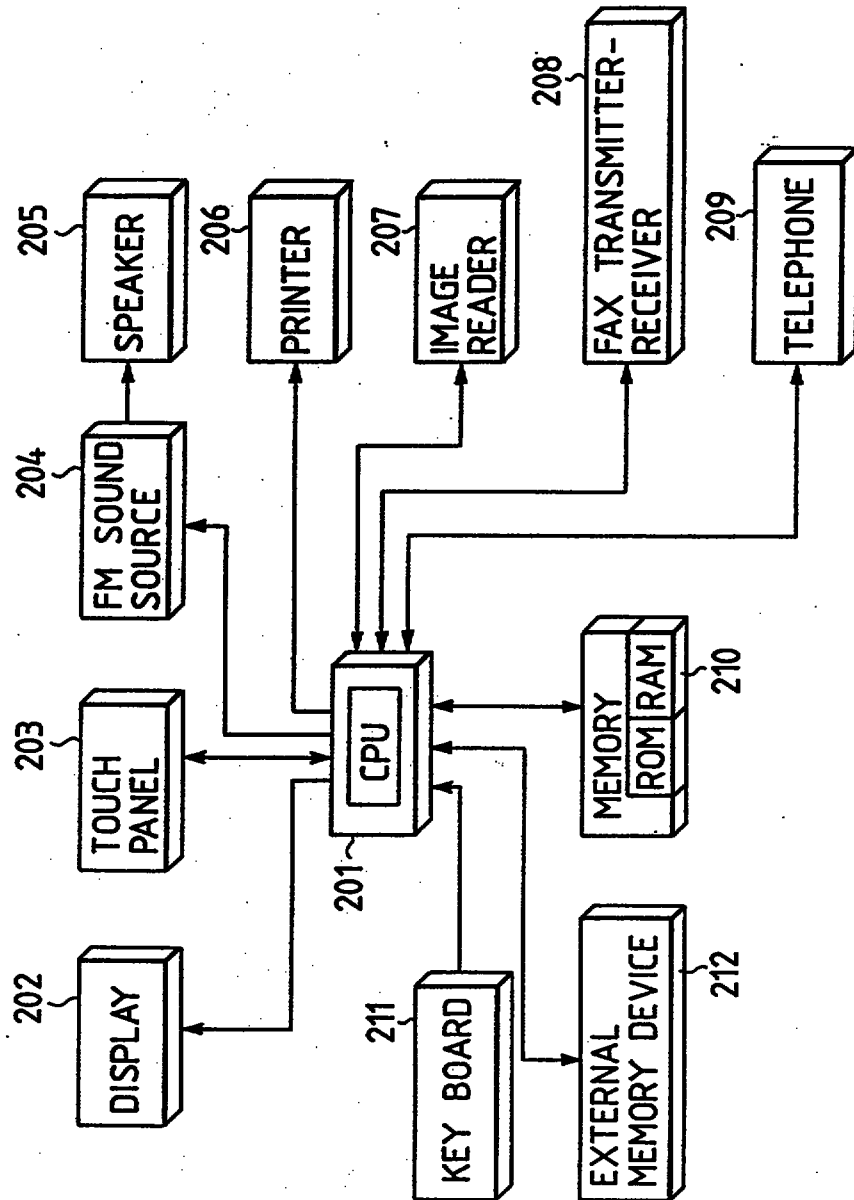


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FIG. 14

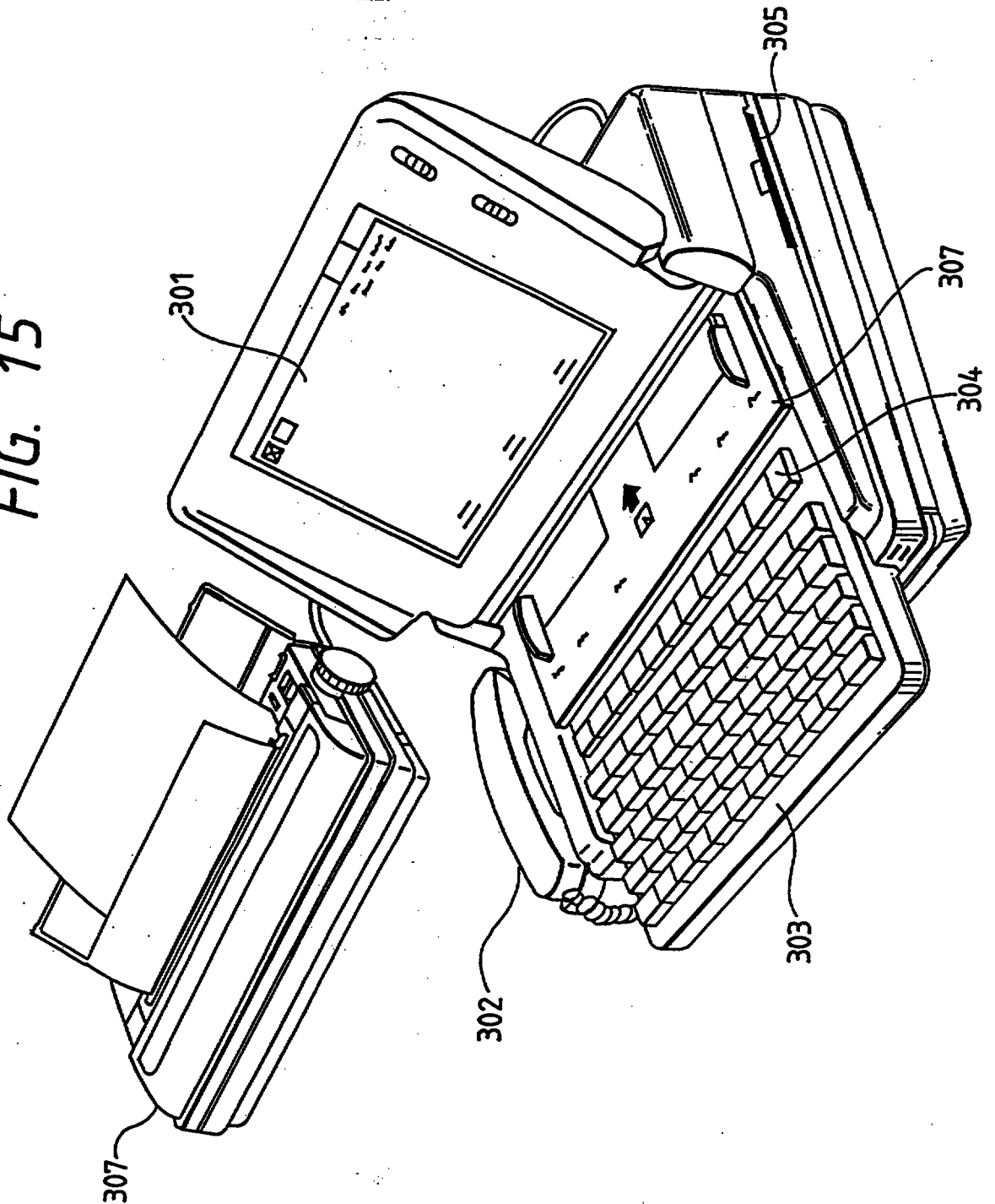


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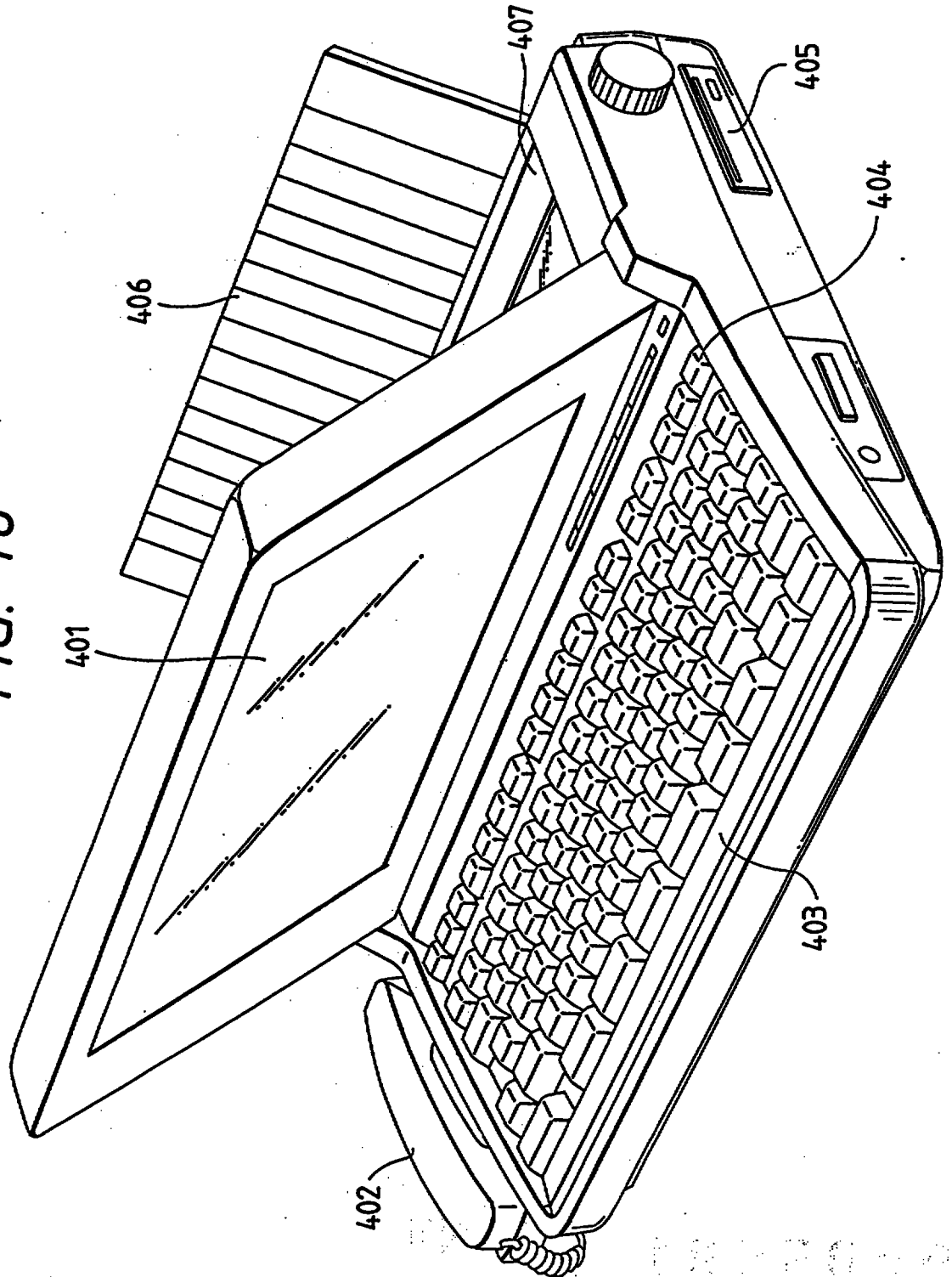
FIG. 15



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FIG. 16



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1 Serial Recording Apparatus for Bidirectional Recording

BACKGROUND OF THE INVENTIONField of the Invention

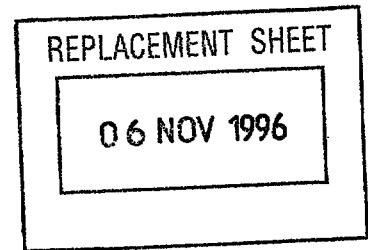
5 The present invention relates to a serial recording apparatus for performing bidirectional recording upon reciprocal movement of a recording head.

Related Background Art

10 In a conventional serial recording apparatus, a recording head is reciprocated to perform high-speed bidirectional recording. In this serial recording apparatus, when a drive signal (i.e., drive pulses when a recording head is to be moved using a pulse motor) necessary for moving a recording head is applied, a
15 delay time occurs until the recording head reaches a target position. Print errors occur during bidirectional recording due to various types of electrical and mechanical variations.

20 In order to correct positional errors in both directions in a conventional apparatus, as described in Japanese Patent Publication No. 61-27194, pulses and time are shifted using a DIP switch or jumper wire while an operator observes an actual print result, thereby adjusting such an error in each apparatus.

25 The above conventional recording apparatus poses the following problems.



1 (1) Extra circuit parts such as a DIP switch or
jumper wire are required.

 (2) Adjustment is time-consuming since it is
performed while the operator observes the print result.

5 (3) When a load varies due to deteriorations over
time, an initial adjustment value is changed, resulting
in an unstable state.

 On the other hand, in recent years, an ink-jet
recording apparatus for causing a change in state
10 (e.g., film boiling) of an ink by heat energy, for
ejecting the ink to a recording medium by using
bubbles generated by the change in state of the ink,
and for recording a character or graphic image has been
developed. The size of a heating resistor (heater)
15 arranged in each ejection port is considerably smaller
than that of a piezoelectric element used in a
conventional ink-jet recording apparatus. For this
reason, a high-density multiple arrangement of
ejection ports can be obtained, a high-quality
20 recording image can be obtained, and characteristics
such as a high-speed operation and low noise can be
obtained.

 Of various types of ink-jet recording apparatuses,
there is provided an apparatus using a recording head
25 which has an ink tank and is detachable from a
carriage. In this ink-jet recording apparatus, when
bidirectional recording is performed to achieve

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1 recording at a higher speed, the following problems are posed.

Since the weight of the ink within the ink tank is changed (decreased) by use of the ink, a drive load of
5 a carriage motor greatly varies. For this reason, the problem (3) becomes more conspicuous.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a serial recording apparatus capable of
10 reciprocating a recording head with high precision.

It is another object of the present invention to provide a serial recording apparatus capable of performing bidirectional recording with high precision.

It is still another object of the present
15 invention to provide a serial recording apparatus capable of performing bidirectional recording with high precision regardless of load variations in a carriage motor.

It is still another object of the present
20 invention to provide a serial recording apparatus capable of automatically adjusting a recording error in bidirectional recording.

In order to achieve the above objects of the present invention, there is provided a serial recording
25 apparatus for reciprocating a recording head with respect to a recording medium to perform bidirectional recording, comprising:

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1 position detecting means for detecting a reference
position of the recording head;

driving means for reciprocating the recording head
within a predetermined area including the reference
5 position;

means for calculating a difference between
reference positions detected by the position detecting
means by reciprocal movement when the recording head is
reciprocated by the driving means within the
10 predetermined area; and

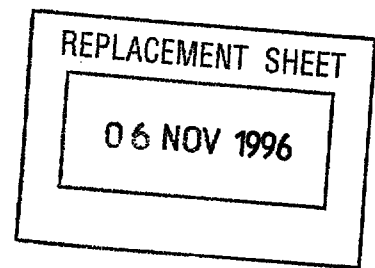
means for correcting a positional error in
bidirectional recording on the basis of the difference
calculated by the calculating means.

According to the present invention, upon a
15 power-on operation or switching from an off-line mode
to an on-line mode, since the difference between the
reference positions detected by the position detecting
means in both the directions is calculated, a print
position error in bidirectional recording can be
20 automatically adjusted by using the difference.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partially cutaway perspective view
showing an arrangement of an ink-jet recording
apparatus according to the first embodiment of the
25 present invention;

Fig. 2 is a perspective view showing an
arrangement of a recording head shown in Fig. 1;



1 Fig. 3 is a block diagram showing a recording head
drive system of the first embodiment;

 Fig. 4 is a flow chart showing a correction value
detection operation of the first embodiment;

5 Fig. 5 is a view showing the correction value
detection operation of the first embodiment;

 Fig. 6 is a flow chart showing a recording
operation of the first embodiment;

 Figs. 7 and 8 are views showing a recording
10 operation of the first embodiment;

 Fig. 9 is a block diagram showing a recording head
drive system according to the second embodiment of the
present invention;

 Fig. 10 is a flow chart showing a correction value
15 detection operation according to the second embodiment
of the present invention;

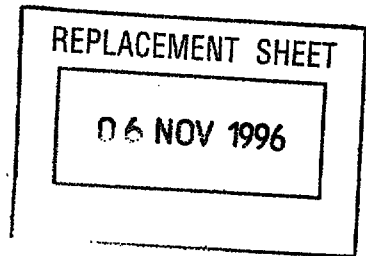
 Fig. 11 is a view showing a correction value
detection operation of the second embodiment;

 Fig. 12 is a flow chart showing a recording
20 operation of the second embodiment;

 Fig. 13 is a view showing a correction value
detection operation of the second embodiment;

 Fig. 14 is a schematic block diagram showing an
arrangement obtained when the present invention is
25 applied to a data processing apparatus; and

 Figs. 15 and 16 are perspective views of the data
processing apparatus shown in Fig. 14.



1 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Serial recording apparatuses according to preferred embodiments of the present invention will be described with reference to the accompanying drawings.

5 Fig. 1 shows an arrangement of the first embodiment obtained when the present invention is applied to an ink-jet recording apparatus, Fig. 2 shows an arrangement of its recording head, and Fig. 3 is a block diagram showing an electrical arrangement of a
10 recording head drive system.

Referring to Fig. 1, in the ink-jet recording apparatus, a head cartridge 14 has an integral structure consisting of a recording head H constituted by using a heater board to be described with reference
15 to Fig. 2 later, and an ink tank serving as an ink supply source. The head cartridge 14 is fixed on a carriage 15 by a press member 41. These members can be reciprocated along shafts 21 along their longitudinal direction. An ink ejected from the recording head
20 reaches a recording medium 18, whose recording surface is regulated by a platen 19, through a small gap formed with the recording head H, thereby forming an image on the recording medium 18.

An ejection signal corresponding to image data is
25 supplied from an appropriate data supply source to the recording head H through a cable 16 and a terminal connected to it. At least one head cartridge (two in

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1 the illustrated embodiment) can be arranged in
accordance with the number of ink colors.

Referring to Fig. 1, the ink-jet recording
apparatus also includes a pulse motor 17 for scanning
5 the carriage 15 along the shafts 21, and a wire 22 for
transmitting a driving force of the motor 17 to the
carriage 15. This apparatus further includes a feed
motor 20, connected to a platen roller 19, for feeding
the recording medium 18, and an HP (home position)
10 sensor 4 for detecting the home position of the
carriage 15. The HP sensor 4 is turned off when the
carriage 15 is located in a positive direction with
respect to the HP sensor 4.

Fig. 2 shows an arrangement of the recording head
15 H. A heater board 1 comprises an electro-thermal
conversion unit (ejection heater) 5 formed on a
silicon substrate and a wiring 6 made of Al or the like
to supply power to the electro-thermal conversion unit
in accordance with film formation techniques. A
20 ceiling plate 30 having partition walls for defining
liquid paths (nozzles) 25 for a recording liquid is
adhered to the heater board 1 to constitute the ink-jet
type recording head H.

A recording liquid (ink) is supplied to a common
25 liquid chamber from a supply port 24 formed in the
ceiling plate 30 and is supplied to each nozzle 25.
When the heater 5 is heated upon its energization, a

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1 bubbling phenomenon occurs in the ink filled in the
nozzles 25. An ink droplet is ejected from each
ejection port 26 upon growth and contraction of the
bubble.

5 As shown in Fig. 3, a pulse motor drive circuit 31
drives the pulse motor 17. A CPU 32 supplies a control
signal to the pulse motor drive circuit 31 to drive the
pulse motor 17, as will be described later. A ROM 33
stores a control sequence (to be described later) of
10 the CPU 32. A RAM 34 has a counter (to be described
later) and temporary data storage areas A and M, and
the like.

A correction value detection operation
(preliminary scanning) of the embodiment having the
15 above arrangement will be described with reference to a
flow chart of Fig. 4 and a recording head movement
diagram shown in Fig. 5.

As shown in Fig. 4, initialization (101) is
performed upon a power-on operation, and then
20 direction-acceleration processing (102) is performed in
which the pulse motor 17 is driven to drive the
carriage 15 (recording head H) in a positive direction
at a speed equal to acceleration in the recording mode
(point A to point B in Fig. 5).

25 The counter A in the RAM 34 is set at "1" (105).
Every time the recording head H is moved by one pulse
at a constant speed (106), the level of the HP sensor 4

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1 is detected (107). When the HP sensor 4 is not ON, the
counter A is incremented by one (108). When the HP
sensor 4 is turned on (point C in Fig. 5), the head H
is moved by an arbitrary number of pulses N (109)
5 (point D in Fig. 5). At this time, the counter A
retains pulses between points B and C. Thereafter,
positive direction-deceleration processing is performed
(110), and movement of the recording head H is stopped
(point E in Fig. 5).

10 Negative direction-acceleration processing (111)
in which the pulse motor 17 is driven in a reverse or
negative direction by the same number of pulses as in
positive direction-acceleration processing is performed
(point E to point F in Fig. 5). The counter M
15 different from the counter A in the RAM 34 is set at
"1" (112). Every time the recording head H is moved by
one pulse (113), the level of the HP sensor 4 is
detected (114). If the HP sensor 4 is not set in the
OFF state, the counter M is incremented by one (115).

20 When the HP sensor 4 is set in the OFF state
(point H in Fig. 5), the counter M has the number of
pulses between points F and H. At this time, the
number of pulses applied to the pulse motor 17 must be
equal to that of pulses in an ideal drive system, i.e.,
25 $M = N$. However, since movement of the recording head H
does not immediately correspond to the number of pulses
applied to the pulse motor, a switching position error

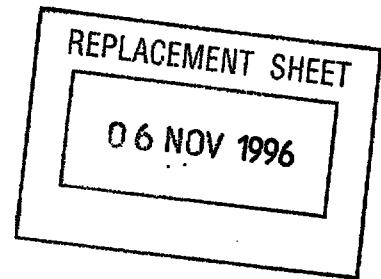
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1 of the HP sensor 4 occurs, and $M > N$ is obtained. In addition, this error varies in accordance with a change in weight of an ink tank of the recording head H, i.e., a change in drive load over time.

5 In practice, the drive system is not an ideal rigid member and has a play, and has error factors such as the hysteresis of the HP sensor 4 and a circuit delay. These error factors are given as a characteristic value B, and an error amount is stored
10 in the RAM 34 as $X = M - N - B$ (116). In order to adjust the positive or negative movement amount of the recording head H, the recording head H is moved by $(A + N - N)$ pulses (117), and deceleration processing (118) is performed by the same number of pulses as that in
15 positive direction-acceleration processing (point A in Fig. 5A). Note that characteristics in consideration of the characteristic value B caused by a play and the like are indicated by a dotted line in Fig. 5. An error amount X with respect to the load upon power-on
20 operation is determined as described above.

An actual recording operation (recording scanning) will be described with reference to a flow chart in Fig. 6 and a movement diagram of the recording head in Fig. 5.

25 Upon reception of a recording or print instruction (301), positive direction-acceleration processing (302) is performed. In order to ensure a correction area,



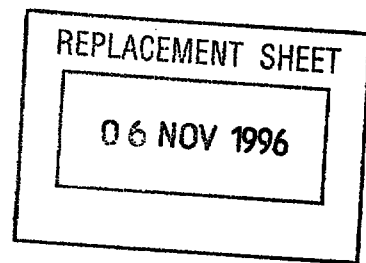
1 the recording head H is driven by K pulses (303) (point
I in Fig. 7). Recording (304) is performed on the
basis of data (point J in Fig. 7). Deceleration
processing (305) is performed, and then the paper is
5 fed (306).

When the print instruction (307) of the next line
is input, negative direction-acceleration processing
(308) is performed (point O in Fig. 7), and the
recording head H is moved by X correction pulses (309)
10 (point P in Fig. 7). Data of the next line is recorded
(310) (point R in Fig. 7). The recording head H is
moved by $(K - X)$ pulses (311), and deceleration
processing (312) is performed.

The above operations are repeated to perform
15 one-page recording.

Fig. 7 illustrates the above operations. The
actual recording head positions are plotted along the
abscissa. The point (i.e., point O) upon completion of
acceleration processing in the negative direction is
20 sifted to the right from the point (i.e., point J) of
the end of printing in the positive direction. By
moving the recording head H by X pulses, the printing
range P-R upon completion of correction almost
coincides with the printing range I-J in the positive
25 direction.

As described above, according to this embodiment,
the recording head H is moved in the positive and



1 negative directions under the same conditions as in the
recording mode upon the power-on operation. The
numbers of pulses until a moment at which the recording
head H crosses the HP sensor 4 are counted, and print
5 error correction in both the directions is performed in
accordance with the calculated difference. Without
increasing cost or performing adjustment, print error
correction with high precision in both the directions
can be performed. In addition, since the above
10 correction operation is always performed upon each
power-on operation, appropriate correction can be
performed against variations in drive load and
particularly changes in ink tank weight over time.

In addition to the difference in numbers of
15 pulses, error correction in consideration of the
characteristic value unique to the head drive system is
performed in this embodiment. Therefore, print error
correction in both the directions can be performed with
high precision.

20 In this embodiment, the positive recording area is
set to be equal to the negative recording area.
However, these areas may be different from each other,
and printing with a minimum distance can be similarly
performed.

25 As shown in Fig. 4, when the state is changed from
an off-line state to an on-line state (102), the same

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1 control as in (104) to (118) can be performed upon
initialization (103) to update correction data.

In this embodiment, correction is performed when
the recording head is moved in the negative direction.

5 However, correction may be performed when the recording
head is moved in the positive direction, as shown in
Fig. 8.

More specifically, after positive
direction-acceleration processing is performed, the
10 recording head is moved by the X pulses corresponding
to the correction value. In this state, recording is
performed, and the recording head is moved by (K - X)
pulses. Thereafter, the recording head is decelerated
and finally stopped. In printing in the negative
15 direction, upon completion of acceleration processing,
the recording head is moved by K pulses to ensure a
correction area. Recording is then performed, and the
recording head is decelerated and finally stopped. In
this manner, even if the recording head is moved by
20 pulses in the positive direction, the same effect as in
the above embodiment can be obtained.

The second embodiment of the present invention
will be described below.

This embodiment has the same mechanical structure
25 as in the embodiment shown in Fig. 1, and the block
diagram of an electrical arrangement of a drive system
for a recording head H is shown in Fig. 9.

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1 Referring to Fig. 9, the drive system includes a
pulse motor drive circuit 31 for driving a pulse motor
17, a CPU 32 for supplying a control signal to the
pulse motor drive circuit 31 to drive the pulse motor
5 17, as will be described later, a ROM 33 for storing a
control sequence (to be described later), and a RAM 94
having counters (to be described later) or temporary
data storage areas P, Q, and X, and the like.

The pulse motor 17 has a resolution per pulse
10 corresponding to a drive amount of $1/60''$ of the
recording head H. A print area corresponds to 480
pulses (8").

A correction value detection operation
(preliminary scanning) of this embodiment will be
15 described with reference to a flow chart in Fig. 10 and
a movement diagram of the recording head shown in
Fig. 11.

As shown in Fig. 10, initialization (401) is
performed upon power-on operation, and positive
20 direction-acceleration processing (402; point A to
point B in Fig. 11) is performed wherein the pulse
motor 17 is driven to drive a carriage 15 (recording
head H) in a positive direction at a speed equal to
that in a recording mode.

25 A movement pulse count V (e.g., $180\frac{1}{3}$ of 480
pulses corresponding to the print area) in the positive
direction is set in a movement pulse counter U in the

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1 RAM 94 (403). In this case, the count V is a value
stored in the ROM 33 and corresponding to a pulse count
representing a distance up to point E sufficiently
spaced apart from point B in Fig. 11, passing through
5 an HP sensor 4. The counter P is set to be "0" (404).
Every time the recording head H is moved by one pulse
at a constant speed (405), the level of the HP sensor 4
is detected (406). If the HP sensor 4 is set in the
OFF state, the counter P is incremented by one (407).
10 This operation is repeated by V pulses (408 and 409).
At this time, the counter P represents a pulse count
from point D to point E in Fig. 11, i.e., a period
during which the sensor level is changed from the ON
state to the OFF state. Upon completion of movement by
15 V pulses, positive direction-deceleration processing
(410) is performed, and movement of the recording head
H is stopped (points E and F in Fig. 11).

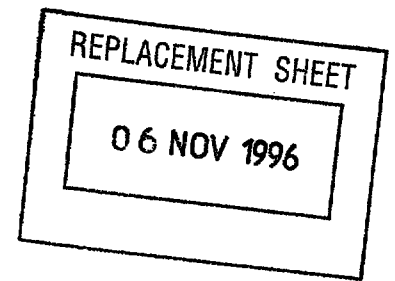
The pulse motor 17 is driven in the negative or
reverse direction, and negative direction-deceleration
20 processing (411; point G to point H in Fig. 11) is
performed by the same pulse count as that in the
positive direction-deceleration processing. The same
value V as in positive movement is set as a movement
pulse count in the negative direction in the movement
25 pulse counter U (412). The counter Q is set to be "0"
(413). Every time the recording head H is moved by one
pulse at a constant speed (414), the level of the HP

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1 sensor is detected (415). When the level of the HP
sensor is set in the OFF state, the counter Q is
incremented by one (461). This processing is repeated
by V pulses (417 and 418). At this time, the counter Q
5 stores a pulse count from point H to point J in Fig. 11
during which the level of the sensor is changed from
the OFF state to the ON state. Upon completion of
movement of the recording head by V pulses, negative
direction-deceleration processing is performed by the
10 same pulse count as in the positive
direction-acceleration processing (419), and movement
of the recording head H is stopped (point K to point L
in Fig. 11).

When the above processing is completed, condition
15 $P = Q$ must be obtained in an ideal drive system. In
practice, however, since the drive system is not an
ideal rigid body, the drive system has a characteristic
value Y (points A to L and points F to G in Fig. 11)
such as a play. In addition, since the recording head
20 H cannot immediately respond to the pulses supplied to
the pulse motor 17, a level inversion position of the
HP sensor 4 is shifted from point C to point D in the
positive direction and from point I to point J in the
negative position, thereby obtaining condition $Q > P$.
25 When this error value is given as X, the value X in the
positive direction is regarded to be equal to that in
the negative direction, so that the error value can be



1 calculated by $X = (Q - P - Q)/Y$. This value is stored
in the RAM 94 as a correction value (420). The error
amount X for the load upon the power-on operation can
thus be obtained.

5 In this embodiment, since $P = 145$, $Q = 150$, and Y
= 1, then $X = 2$. Alternatively, the above operations
are repeated a plurality of times to obtain a plurality
of correction values, an average value of the plurality
of correction values is calculated, and the average
10 value may be stored in the RAM 94 as a correction
value.

 A correction sequence (recording scanning) during
actual recording will be described with reference to a
flow chart in Fig. 12 and a recording head movement
15 chart shown in Fig. 13.

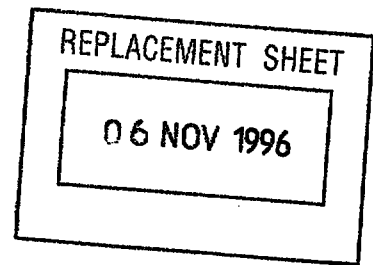
 During actual recording, as shown in Fig. 12, upon
reception of a print instruction (501), positive
direction-acceleration processing is performed (502;
point A to point B in Fig. 13). The recording head is
20 moved by Z pulses to obtain an area for ensuring a
correction area, and the recording head is moved by the
correction value corresponding to X pulses (503; from
point B to points C and D in Fig. 13). At this time,
the area Z is set to have a larger value than a sum of
25 a maximum value of the assumed correction value X and
the characteristic value Y caused by a play.

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1 Recording is then performed in accordance with
recording data (504; point D to point E in Fig. 13),
and the recording head is moved by $(Z - X)$ pulses to
adjust the correction area upon recording (505; point E
5 to point F in Fig. 13). After positive
direction-deceleration processing is performed (506;
point F to point G in Fig. 13), the paper is fed (507).

 When a print instruction of the next line is
received (508), negative direction-acceleration
10 processing is performed by the same pulse count as in
the positive direction-deceleration processing (509;
point H to point I in Fig. 13). The recording head is
moved by Z pulses to obtain an area for assuring the
correction area, and then the recording head is moved
15 by Y pulses as the characteristic value Y caused by a
play and the like. In addition, the recording head is
moved by X pulses as the correction value (510; from
point I to points J, K, and L in Fig. 13).

 Recording is then performed in accordance with
20 recording data (511; point L to point M in Fig. 13).
In order to adjust the correction area upon recording,
the recording head is moved by $(Z - X - Y)$ pulses (505;
point M to point N in Fig. 13). Negative
direction-deceleration processing is performed by the
25 same pulse count as in the positive
direction-acceleration processing (513).



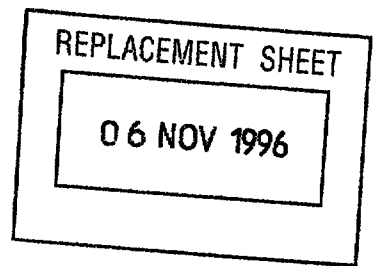
1 The above operations are repeated to perform
one-page recording.

 Fig. 13 illustrates the positions of the recording
heads H in the above operations. This processing is
5 performed so that the printing range in the positive
direction falls between point D and point E, and that
in the negative direction falls between point M and
point L. In practice, however, an error corresponding
to X occurs as in detection of the correction value.
10 The printing range in the positive direction falls
between point C and point E', and that in the negative
direction falls between point M' and point K.

 An actual print start position can be kept to be
point C even if the correction value X upon detection
15 is changed by load variations such as differences
between apparatuses and deteriorations over time. This
is because error correction is performed in both the
positive and negative directions.

 In this embodiment, the positive recording area is
20 set to be equal to that of the negative recording area.
However, the positive recording area may be different
in size from the negative recording area, and printing
with a minimum distance can be performed.

 When the off-line state is changed to the on-line
25 state, as shown in Figs. 10 (421, 402 to 420), the same
control as described above can be performed to update
the correction value. In addition to the case wherein



1 the apparatus is powered on, or is changed from the
off-line state to the on-line state, the correction
value calculation control described above can be
performed prior to recording.

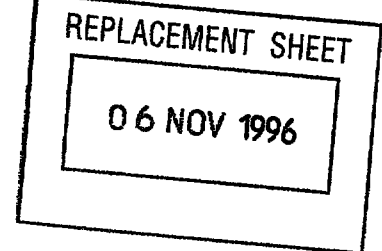
5 In this embodiment, the pulse count (i.e., a
switching count of excitation phases) of the pulse
motor 17 is counted. However, when ink ejection (dot)
is performed at timings each obtained by dividing
(e.g., six divisions) one phase of the pulse, the
10 number of dots may be counted. In this case, error
correction precision can be given as $1/360^\circ$, thereby
further improving error correction precision.

In a recording apparatus having a plurality of
print speeds, correction values $X_1, X_2, \dots$
15 corresponding to the respective speeds are obtained,
thereby performing optimal error correction at the
respective speeds.

The present invention is not limited to a pulse
motor as a drive source for the recording head
20 (carriage), but can employ, e.g., a DC motor.

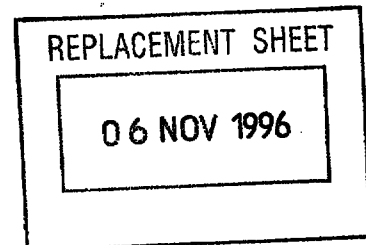
The HP sensor can be arranged outside the
acceleration or deceleration processing area.

A preliminary scanning amount is not limited to a
specific value. However, in consideration of
25 preliminary scanning time and precision, this amount is
preferably set to be $1/2$ to $1/4$, particularly $1/3$, of
the recording width.



1 The present invention can equally applied to,
e.g., a thermal transfer recording system using a
thermal head, a heat-sensitive recording system, and an
impact recording system using a daisy wheel, a wire
5 dot, or the like. When the ink-jet recording system is
employed, an excellent effect can be obtained in the
ink-jet recording apparatus utilizing heat energy, as
described in the above embodiments. According to this
system, high-density, high-precision recording can be
10 performed.

As to its representative constitution and
principle, for example, one practiced by use of the
basic principle disclosed in, for example, U.S. Patents
4,723,129 and 4,740,796 is preferred. This system is
15 applicable to either of the so called on-demand type
and the continuous type. Particularly, the case of the
on-demand type is effective because, by applying at
least one driving signal which gives rapid temperature
elevation exceeding nucleus boiling corresponding to
20 the recording information on an electricity-heat
converters arranged corresponding to the sheets or
liquid channels holding liquid (ink), heat energy is
generated at the electricity-heat converters to effect
film boiling at the heat acting surface of the
25 recording head, and consequently the bubbles within the
liquid (ink) can be formed corresponding one by one to
the driving signals. By discharging the liquid (ink)



1 through an opening for discharging by growth and
shrinkage of the bubble, at least one droplet is
formed. By making the driving signals into pulse
5 effected instantly and adequately to accomplish more
preferably discharging of the liquid (ink) particularly
excellent in response characteristic. As the driving
signals of such pulse shape, those as disclosed in U.S.
Patents 4,463,359 and 4,345,262 are suitable. Further
10 excellent recording can be performed by employment of
the conditions described in U.S. Patent 4,313,124 of
the invention concerning the temperature elevation rate
of the above-mentioned heat acting surface.

As the constitution of the recording head, in
15 addition to the combination constitutions of
discharging orifice, liquid channel, electricity-heat
converter (linear liquid channel or right angle liquid
channel) as disclosed in the above-mentioned respective
specifications, the constitution by use of U.S. Patent
20 4,558,333, 4,459,600 disclosing the constitution having
the heat acting portion arranged in the flexed region
is also included in the present invention. In
addition, the present invention can be also effectively
made the constitution as disclosed in Japanese Patent
25 Laid-Open Application No. 59-123670 which discloses the
constitution using a slit common to a plurality of
electricity-heat converters as the discharging portion

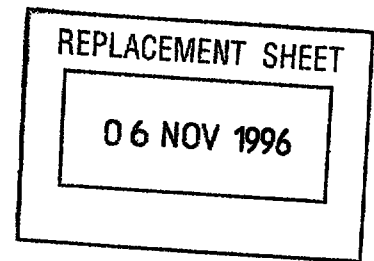
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1 of the electricity-heat converter or Japanese Patent
Laid-Open Application No. 59-138461 which discloses the
constitution having the opening for absorbing pressure
wave of heat energy correspondent to the discharging
5 portion.

Further, as the recording head of the full line
type having a length corresponding to the maximum width
of recording medium which can be recorded by the
recording device, either the constitution which
10 satisfies its length by combination of a plurality of
recording heads as disclosed in the above-mentioned
specifications or the constitution as one recording
head integrally formed may be used, and the present
invention can exhibit the effects as described above
15 further effectively.

In addition, the present invention is effective
for a recording head of the freely exchangeable chip
type which enables electrical connection to the main
device or supply of ink from the main device by being
20 mounted on the main device, or for the case by use of a
recording head of the cartridge type provided
integrally on the recording head itself.

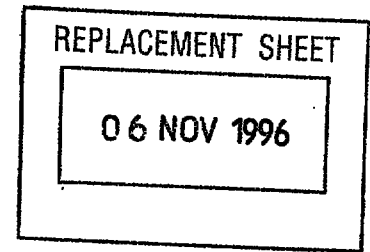
Also, addition of a restoration means for the
recording head, a preliminary auxiliary means, etc.
25 provided as the constitution of the recording device of
the present invention is preferable, because the effect
of the present invention can be further stabilized.



1 Specific examples of these may include, for the
recording head, capping means, cleaning means,
pressurization or aspiration means, electricity-heat
converters or another heating element or preliminary
5 heating means according to a combination of these, and
it is also effective for performing stable recording to
perform preliminary mode which performs discharging
separate from recording.

Further, as the recording mode of the recording
10 device, the present invention is extremely effective
for not only the recording mode only of a primary color
such as black etc., but also a device equipped with at
least one of plural different colors or full color by
color mixing, whether the recording heat may be either
15 integrally constituted or combined in plural number.

In each embodiment described above, the ink is
exemplified as a liquid. However, an ink which is
solidified at room temperature or less is generally
temperature-controlled to be softened or liquefied at
20 room temperature or in a temperature range of 30°C to
70°C, thereby controlling the viscosity of the ink to
fall within a stable ejection range. For this reason,
an ink need only be in a liquid phase when a recording
signal is applied. Alternatively, by using an ink
25 which positively prevents temperature increase by heat
energy by using it as energy for changing a state from
a solid phase to a liquid phase of the ink, or by using



1 an ink which is solidified in an exposed state for the
purpose of evaporation prevention, heat energy is
applied to the ink in accordance with a recording
signal, and the liquefied ink is ejected. An ink
5 which starts solidifying before it reaches the surface
of a recording medium may also be used. That is, an
ink which is liquefied only upon application of heat
energy may be used in the present invention. In
addition, as described in Japanese Patent Laid-Open
10 Application No. 54-56874 or 60-71260, an ink as a
liquid or solid body stored in a recess or through hole
of a porous sheet may be opposed to an electricity-heat
converter. According to the present invention, a most
effective method for each ink is a film boiling method.

15 In addition, the ink-jet recording apparatus
according to the present invention is used in an
application form as an image output terminal of data
processing equipment such as a computer, a copying
apparatus in combination with a reader and the like,
20 and a facsimile apparatus having transmission and
reception functions.

Fig. 14 is a schematic block diagram in which a
recording apparatus of the present invention is applied
to a data processing apparatus having functions as a
25 wordprocessor, a personal computer, a facsimile
apparatus, and a copying apparatus.

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1 A controller 201 controls the overall operation of
the apparatus and includes a CPU (e.g., a
microprocessor) and has various I/O ports. The
controller 201 outputs control and data signals to the
5 respective circuit components or receives control and
data signals from these components. A display 202
displays various menus, document information, and image
data read by an image reader 207 on the display screen.
A transparent pressure-sensitive touch panel 203 is
10 arranged on the display 202. When the surface of the
touch panel 203 is pressed with a finger or the like, a
desired item or a coordinate position can be input on
the display 202.

 An FM (Frequency Modulation) sound source 204
15 stores music information generated by a music editor or
the like in a memory 210 or an external memory device
212 in the form of digital data, reads out stored data
from the memory and the like, and performs FM
modulation of the readout data. An electrical signal
20 from the FM sound source 204 can be produced as sounds
from a speaker 205. A printer 206 is constituted by
the recording apparatus of the present invention as an
output terminal for a wordprocessor, a personal
computer, a facsimile apparatus, and a copying machine.

25 The image reader 207 photoelectrically reads
original data and inputs the read data. The image
reader 207 is arranged in an original convey path and

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1 reads a facsimile original, a copying original, and
various other originals. A FAX transmitter-receiver
208 performs facsimile transmission of original data
read by the image reader 207, receives a transmitted
5 facsimile signal, and decodes the received facsimile
signal. The FAX transmitter-receiver 208 has an
interface function with an external device. A
telephone 209 has various telephone functions such as
normal telephone functions and automatic telephone
10 answering functions.

The memory 210 includes a ROM for storing a system
program, a manager program, other application programs,
character fonts, and a dictionary, and a video RAM, and
further stores application programs loaded from the
15 external memory device 212 and document information.

A keyboard 211 is used to input document
information and various commands.

The external memory device 212 uses a memory
medium such as a floppy or hard disk. Document
20 information, music or voice information, and user
application programs are stored in the external memory
device 212.

Fig. 15 is an external perspective view of the
data processing apparatus shown in Fig. 14.

25 A flag display panel 301 is obtained by using a
liquid crystal or the like and displays various menus,
graphic data, and document data. The touch panel 203

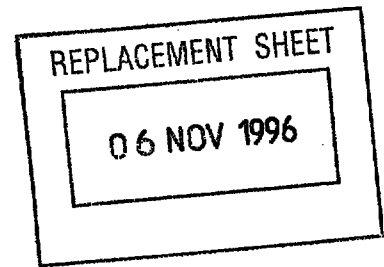
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1 is formed on the display 301. Upon depression of the
surface of the touch panel 203 with a finger or the
like, coordinate data or an item can be input. A
handset 302 is used when the apparatus serves as a
5 telephone. A keyboard 303 is detachably connected to
the main body through a cord and is used to input
various document data and other data. The keyboard 303
has various function keys 304. A floppy disk slot 305
is formed in the main body for accessing data from the
10 external memory device 212.

An original is placed on an original table 306 and
is read by the image reader 207. The read original is
discharged from the rear portion of the apparatus. In
a facsimile reception mode or the like, the received
15 data is recorded at an ink-jet printer 307.

The display 202 may be constituted by a CRT
display. However, a flat panel such as a liquid
crystal display utilizing a ferromagnetic liquid
crystal is preferred to obtain a compact, low-profile,
20 lightweight display.

When the data processing apparatus is used as a
personal computer or a wordprocessor, various data
input from the keyboard 211 is processed by the
controller 201 in accordance with a predetermined
25 program. The processed data is output as an image at
the printer 206.



1 When the apparatus serves as a receiver of the
facsimile apparatus, facsimile data input from the FAX
transmitter-receiver 208 through a communication line
is received and processed by the controller 201 in
5 accordance with a predetermined program. The processed
data is output as a reception image at the printer 206.

 When the apparatus serves as a copying machine, an
original is read by the image reader 207, and the read
original data is output as a copy image at the printer,
10 206 through the controller 201. When the apparatus
serves as a transmitter of the facsimile apparatus,
original data read by the image reader 207 is
transmitted by the controller 201 in accordance with a
predetermined program. The processed data is sent to
15 the transmission line through the FAX
transmitter-receiver 208.

 The data processing apparatus may be an integral
unit including an ink-jet printer, as shown in Fig. 16.
In this case, a more portable apparatus can be
20 obtained. The same reference numerals as in Fig. 15
denote the same parts in Fig. 16.

 As described above, the recording apparatus of the
present invention is applied to the multifunctional
data processing apparatus as described above to obtain
25 a high-quality recorded image with low noise at high
speed, thereby further improving the functions of the
data processing apparatus.

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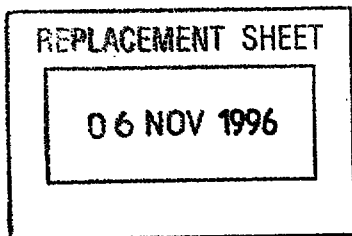
1 As has been described above, according to the
present invention, the positions of the recording head
in the positive and negative directions can be
accurately controlled regardless of drive load
5 variations.

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1 WHAT IS CLAIMED IS:

1. A serial recording apparatus for reciprocating a recording head with respect to a recording medium to perform bidirectional recording, comprising:

5 position detecting means for detecting a reference position of said recording head;

driving means for reciprocating said recording head within a predetermined area including the reference position;

10 means for calculating a difference between reference positions detected by said position detecting means by reciprocal movement when said recording head is reciprocated by said driving means within the predetermined area; and

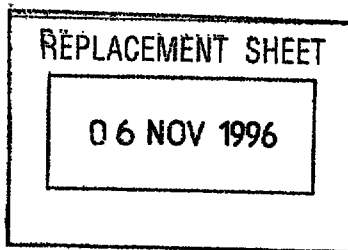
15 means for correcting a positional error in bidirectional recording on the basis of the difference calculated by said calculating means.

20 2. An apparatus according to claim 1, wherein said correcting means corrects a positional error on the basis of a difference calculated by said calculating means and a characteristic value of said driving means.

25 3. An apparatus according to claim 1, wherein said correcting means corrects a positional error while

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1 said recording head is moved for recording in one
direction or the other direction.

4. An apparatus according to claim 1, wherein
5 said correcting means corrects the positional error
during movement of said recording head for recording in
both directions.

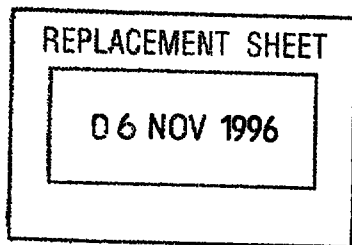
5. An apparatus according to claim 1, wherein
10 said driving means includes a pulse motor, and said
calculating means calculates the difference between the
detected reference positions by the number of pulses
for driving said pulse motor.

15 6. An apparatus according to claim 1, wherein
said driving means includes a pulse motor, and said
calculating means calculates the difference between the
detected reference positions in accordance with a
plurality of phases obtained by dividing the pulse for
20 driving said pulse motor.

7. An apparatus according to claim 1, wherein
said driving means drives to reciprocate said recording
head to cause said calculating means to calculate the
25 difference between the detected reference positions
upon a power-on operation.

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1 8. An apparatus according to claim 1, wherein
said driving means drives to reciprocate said recording
head to cause said calculating means to calculate the
difference between the detected reference positions in
5 an on-line mode.

 9. An apparatus according to claim 1, wherein
said calculating means calculates the differences
between the detected reference positions at a plurality
10 of speeds.

 10. An apparatus according to claim 1, wherein the
predetermined area is about 1/3 the recording area.

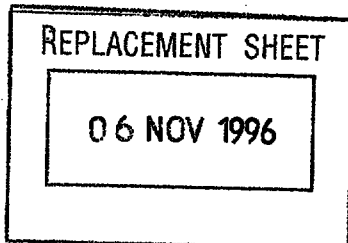
15 11. An apparatus according to claim 1, wherein
said recording head is an ink-jet recording head for
ejecting an ink droplet to perform recording.

 12. An apparatus according to claim 1, wherein
20 said recording head is a bubble-jet recording head for
ejecting an ink droplet to perform recording upon
growth and shrinkage of a bubble.

 13. An apparatus according to claim 1, wherein
25 said recording head comprises a plurality of ejection
ports for ejecting an ink, and heat energy generating
means, respectively arranged in correspondence with

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1 said plurality of ejection ports, ~~for causing a change~~
in state in the ink by heat and ejecting the ink from
said ejection ports to form flying liquid droplets on
the basis of the change in state.

5

14. An apparatus according to claim 1, wherein
said recording head is interchangeable with respect to
said serial recording apparatus.

10

15. An apparatus according to claim 14, wherein
said recording head is an ink-jet recording head for
ejecting an ink droplet to perform recording.

15

16. An apparatus according to claim 15, wherein
said recording head comprises a tank for storing an
ink.

20

17. A serial recording method of reciprocating a
recording head with respect to a recording medium to
perform bidirectional recording, comprising the steps
of:

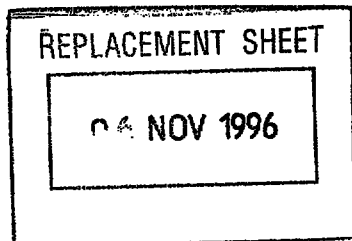
reciprocating said recording head within a
predetermined area including a reference position prior
to recording;

25

detecting the reference positions in both movement
directions during reciprocal movement and calculating a
difference between the detected reference positions; and

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1 correcting a positional error to perform
bidirectional recording on the basis of the calculated
difference.

5 18. A method according to claim 17, wherein the
step of performing bidirectional recording comprises
the step of correcting the positional error while said
recording head performs recording in one direction or
the other direction.

10

19. A method according to claim 17, wherein the
step of performing bidirectional recording comprises
the step of correcting the positional error during
recording of said recording head in both directions.

15

20. An apparatus according to claim 17, wherein
the predetermined area is about 1/3 the recording area.

20 21. An apparatus according to claim 17, wherein
said recording head is an ink-jet recording head for
ejecting an ink droplet to perform recording.

25 22. An apparatus according to claim 17, wherein
said recording head is a bubble-jet recording head for
ejecting an ink droplet to perform recording upon
growth and shrinkage of a bubble.

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1 23. An apparatus according to claim 17, wherein
said recording head comprises a plurality of ejection
ports for ejecting an ink, and heat energy generating
means, respectively arranged in correspondence with
5 said plurality of ejection ports, for causing a change
in state in the ink by heat and ejecting the ink from
said ejection ports to form flying liquid droplets on
the basis of the change in state.

10 24. An apparatus according to claim 17, wherein
said recording head is interchangeable with respect to
said serial recording apparatus.

15 25. An apparatus according to claim 24, wherein
said recording head is an ink-jet recording head for
ejecting an ink droplet to perform recording.

20 26. An apparatus according to claim 25, wherein
said recording head comprises a tank for storing an
ink.

25 27. A serial recording apparatus for
reciprocating a recording head with respect to a
recording medium to perform by directional recording
characterised in that there are means for calibrating
the recording head in response to variations in load
on the recording head and means responsive to the
calibration in order to correct any positional errors
of the bidirectional recording head caused by
variations in the load.

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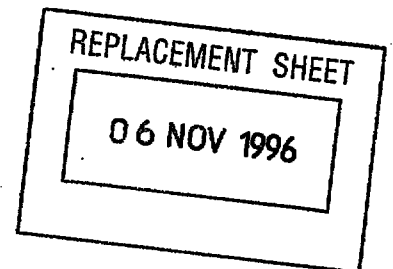
- 37 -

SERIAL RECORDING APPARATUS FOR BIDIRECTIONAL RECORDING

ABSTRACT OF THE DISCLOSURE

A serial recording apparatus for reciprocating a recording head with respect to a recording medium to perform bidirectional recording includes a position detector for detecting a reference position of the recording head, a driving unit for reciprocating the recording head within a predetermined area including the reference position, a calculating unit for calculating a difference between reference positions detected by the position detector by reciprocal movement when the recording head is reciprocated by the driving unit within the predetermined area, and a correcting unit for correcting a positional error in bidirectional recording on the basis of the difference calculated by the calculating unit.

FIGURE 1



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FIG. 1

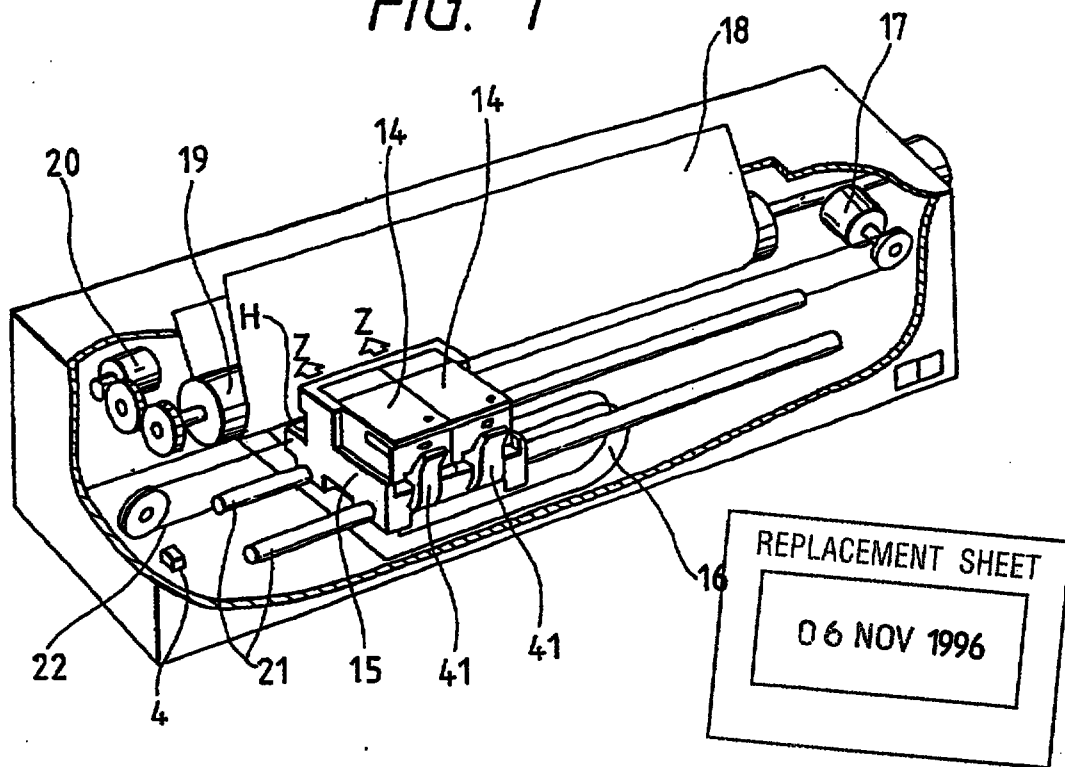
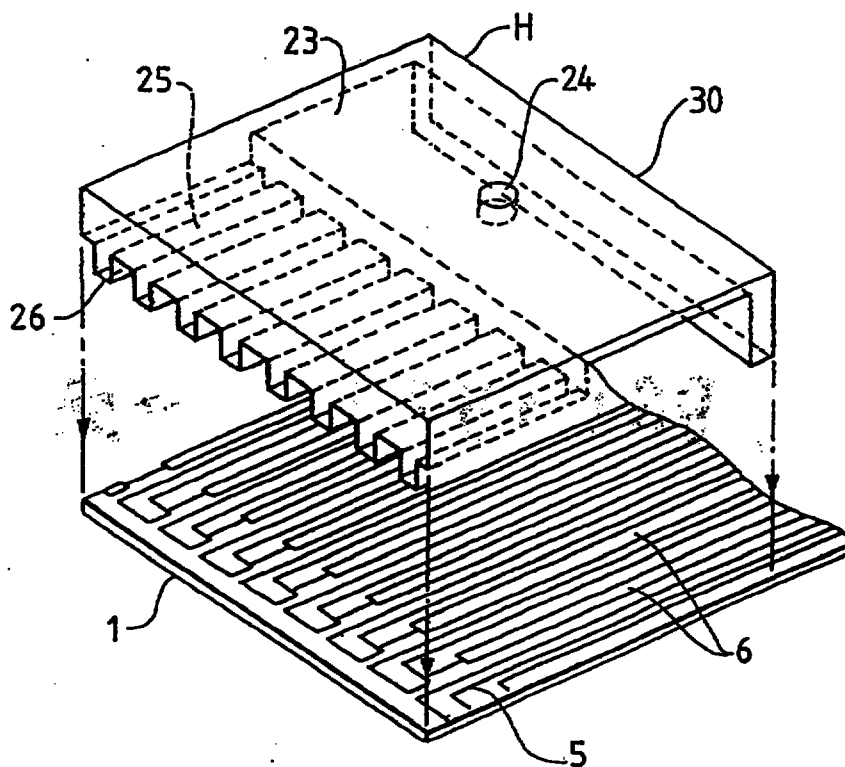


FIG. 2



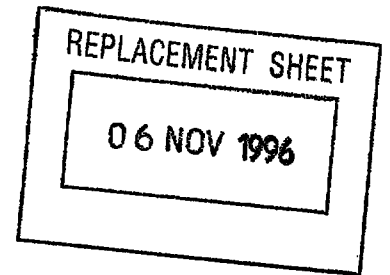
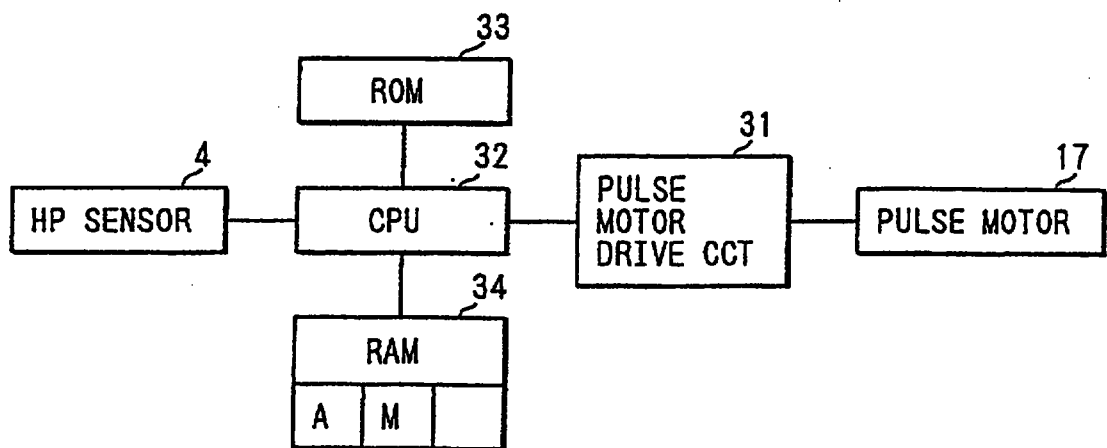


FIG. 3



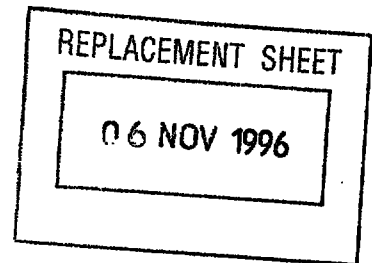
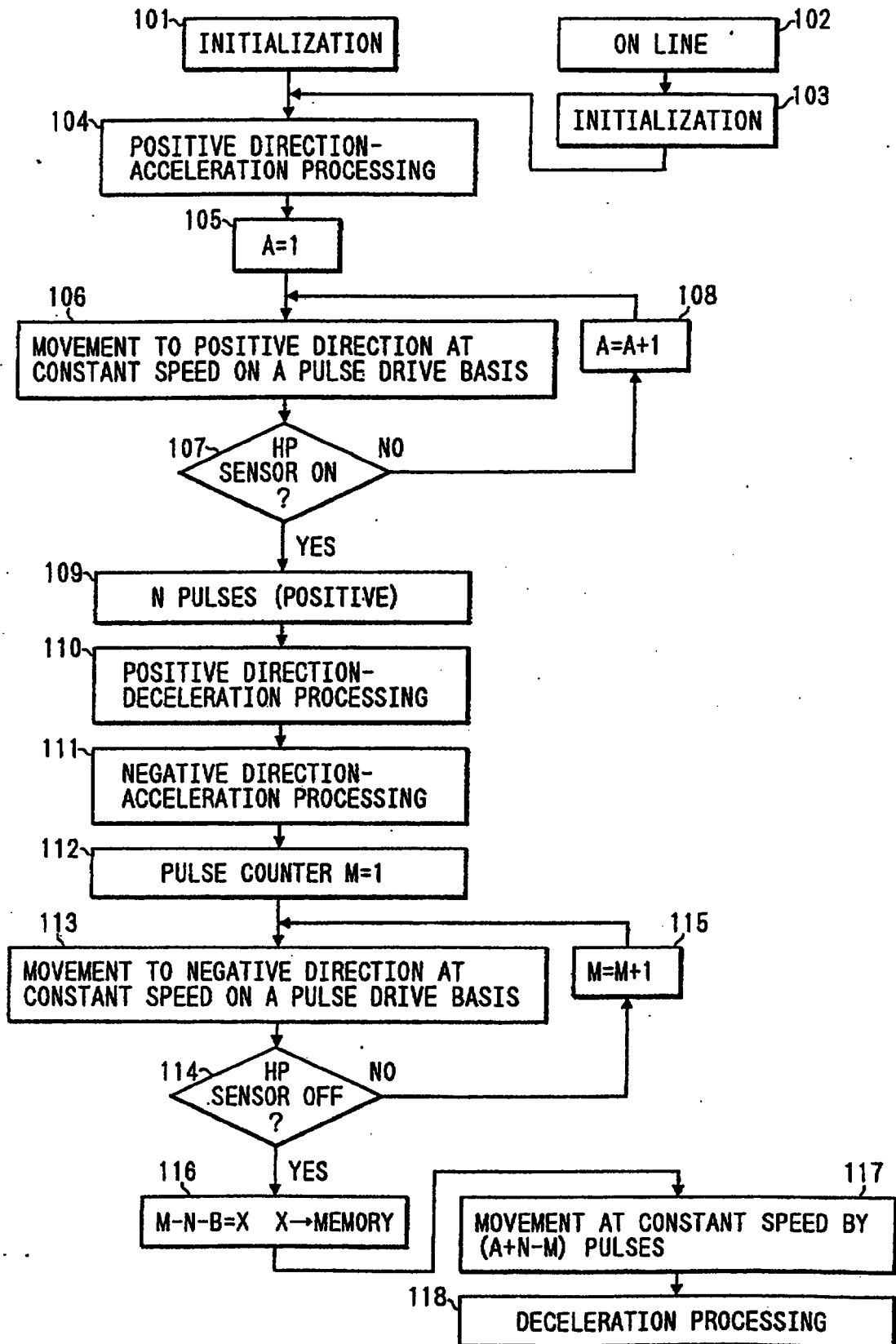


FIG. 4



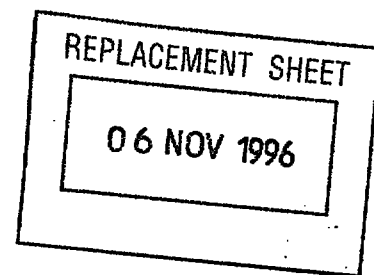
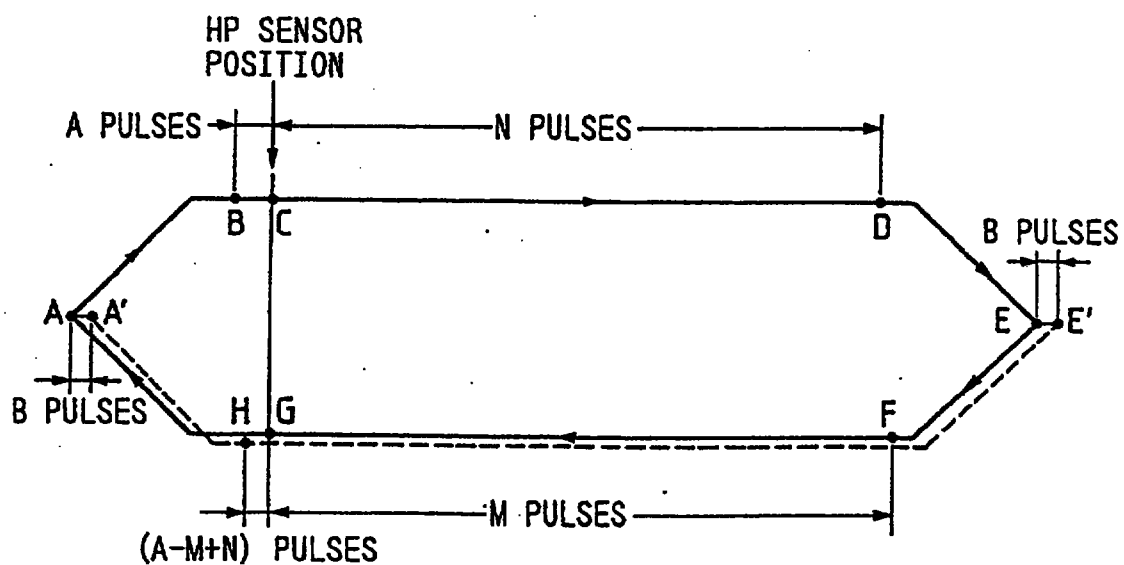


FIG. 5



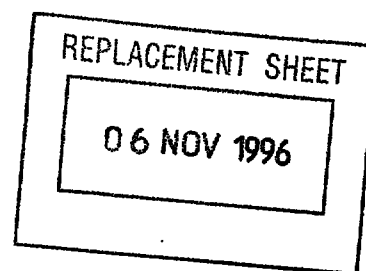
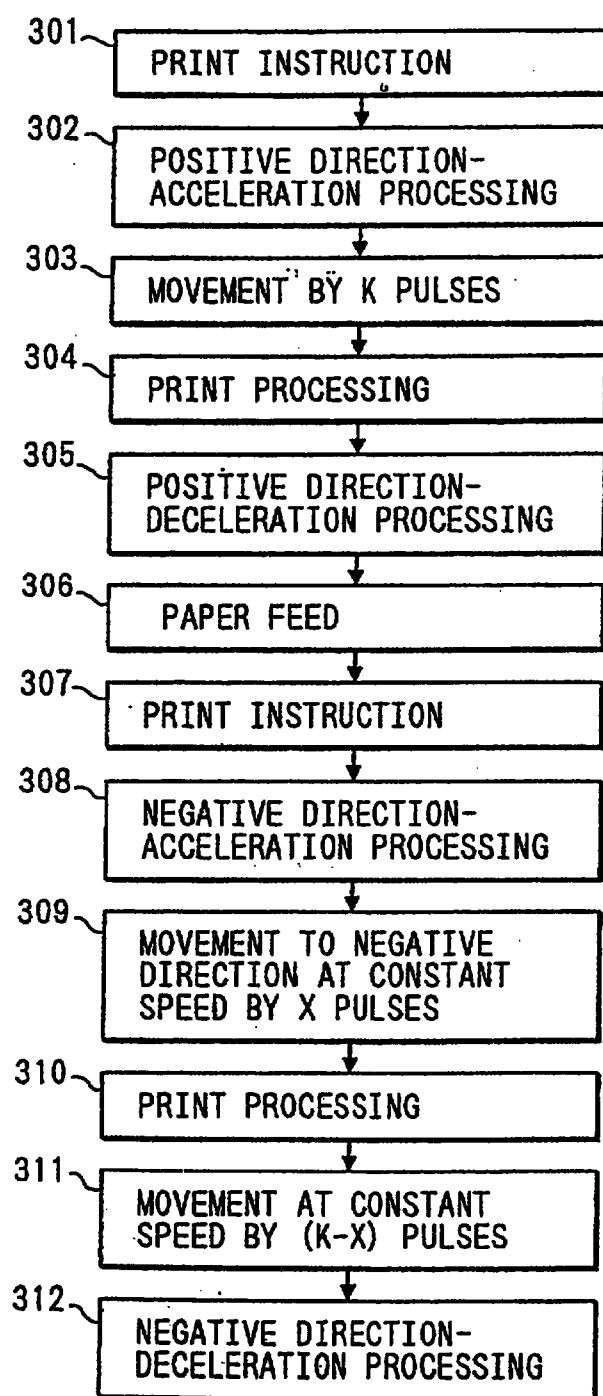


FIG. 6



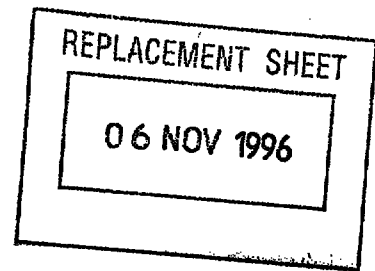


FIG. 7

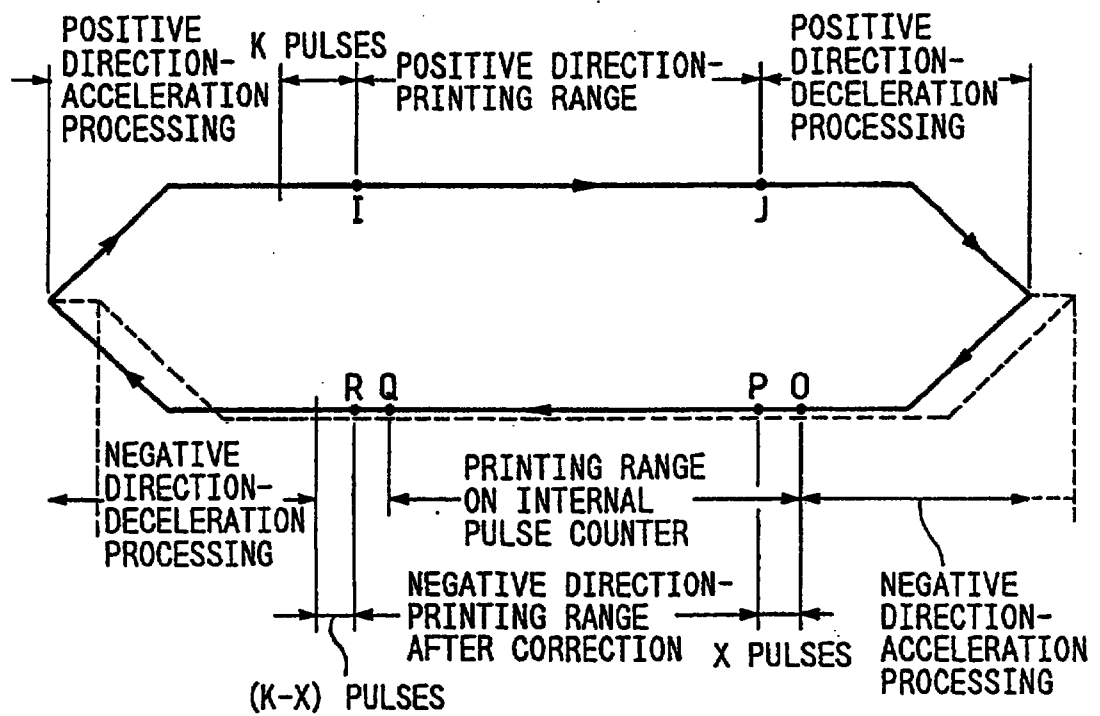


FIG. 8

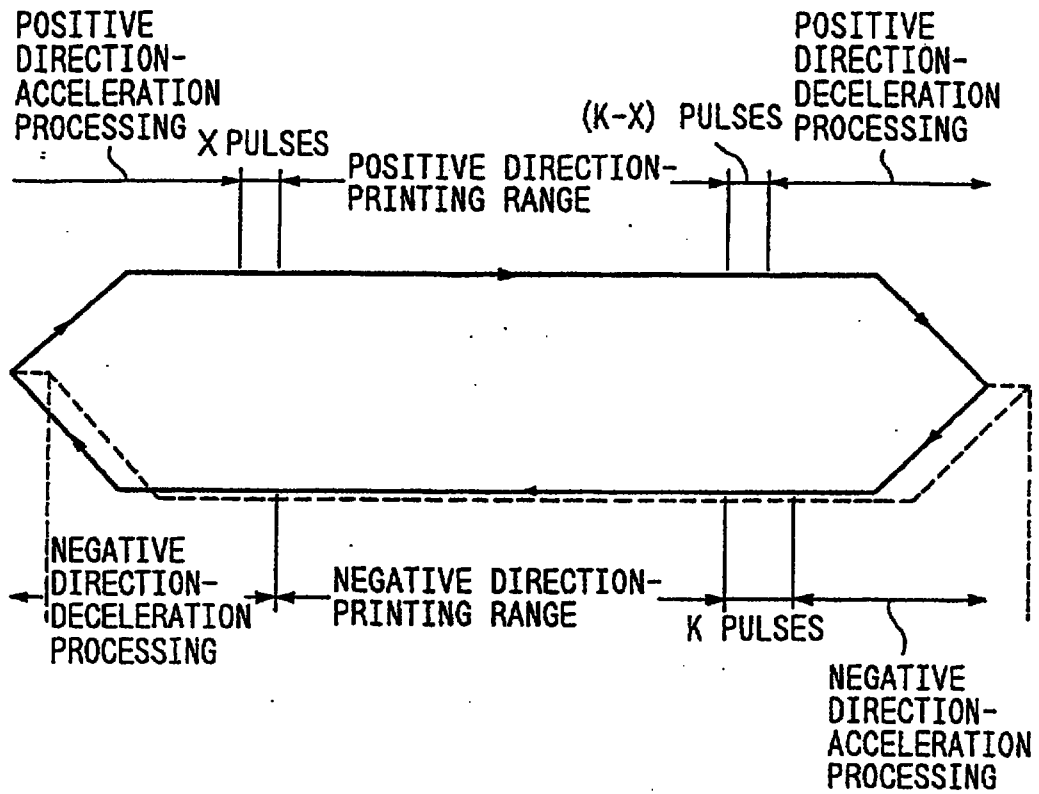
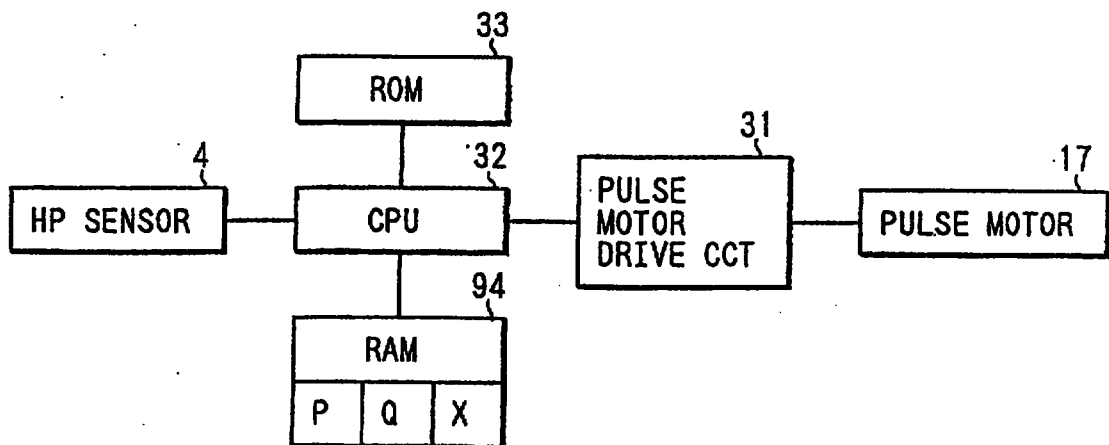


FIG. 9



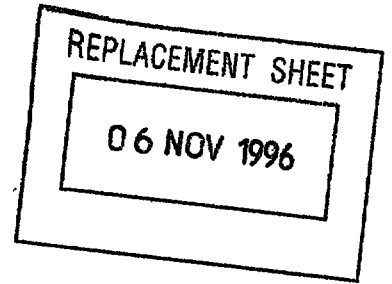
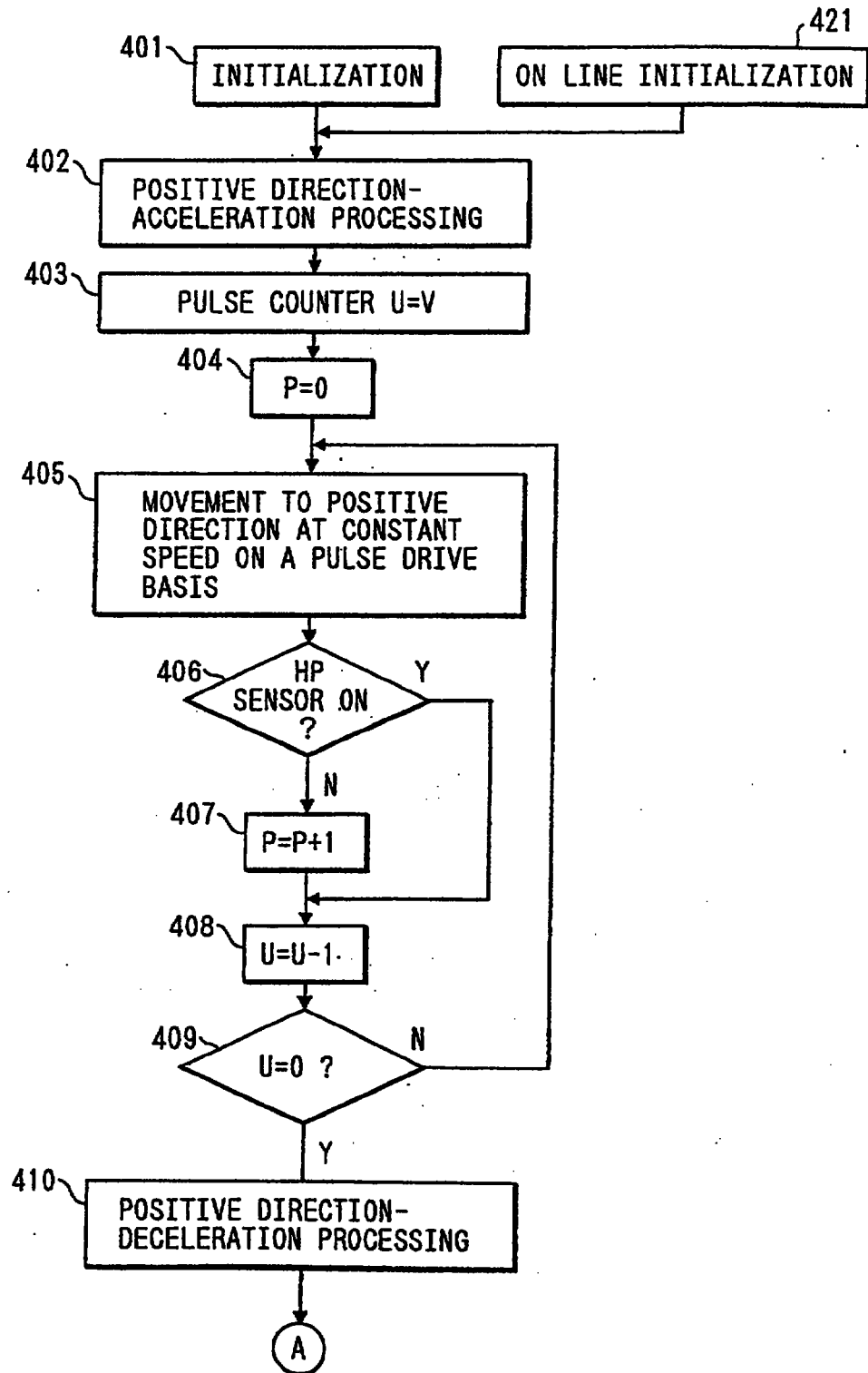


FIG. 10

FIG. 10A
FIG. 10B

FIG. 10A



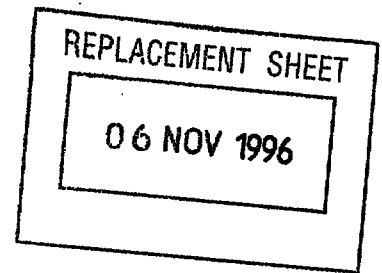
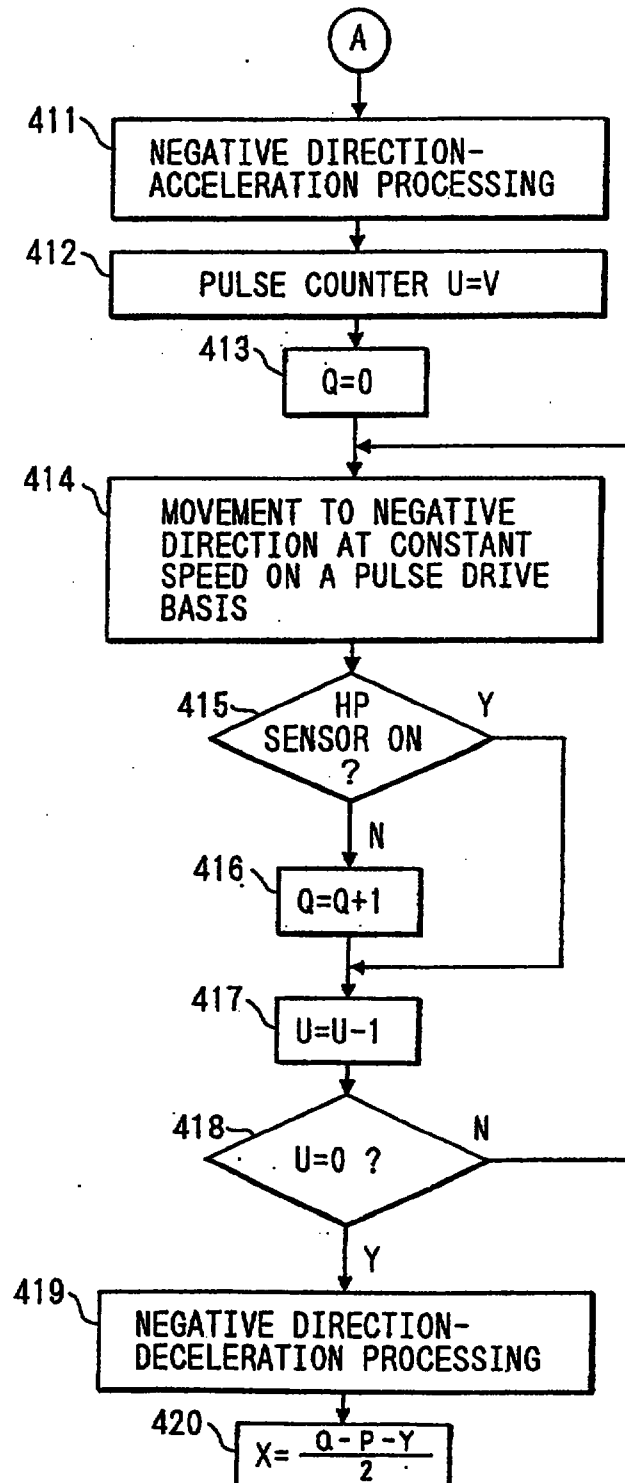


FIG. 10B



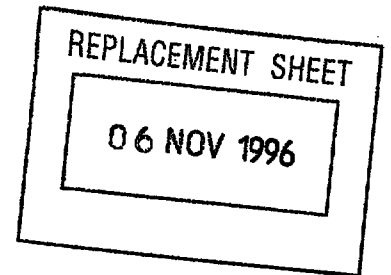
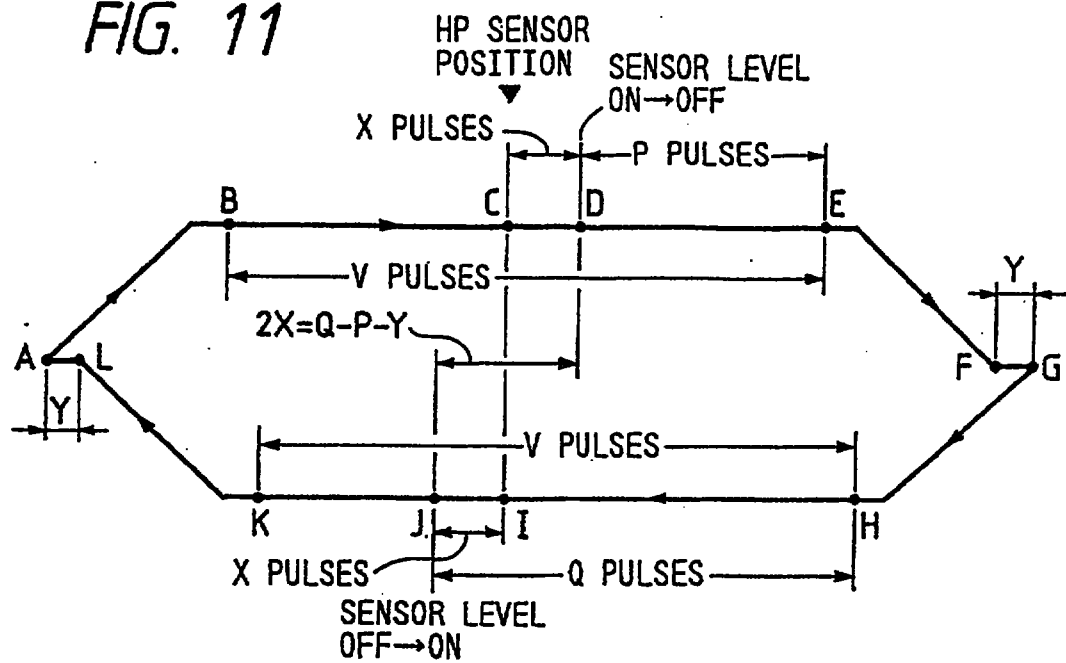


FIG. 11



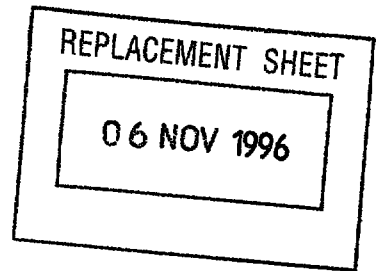
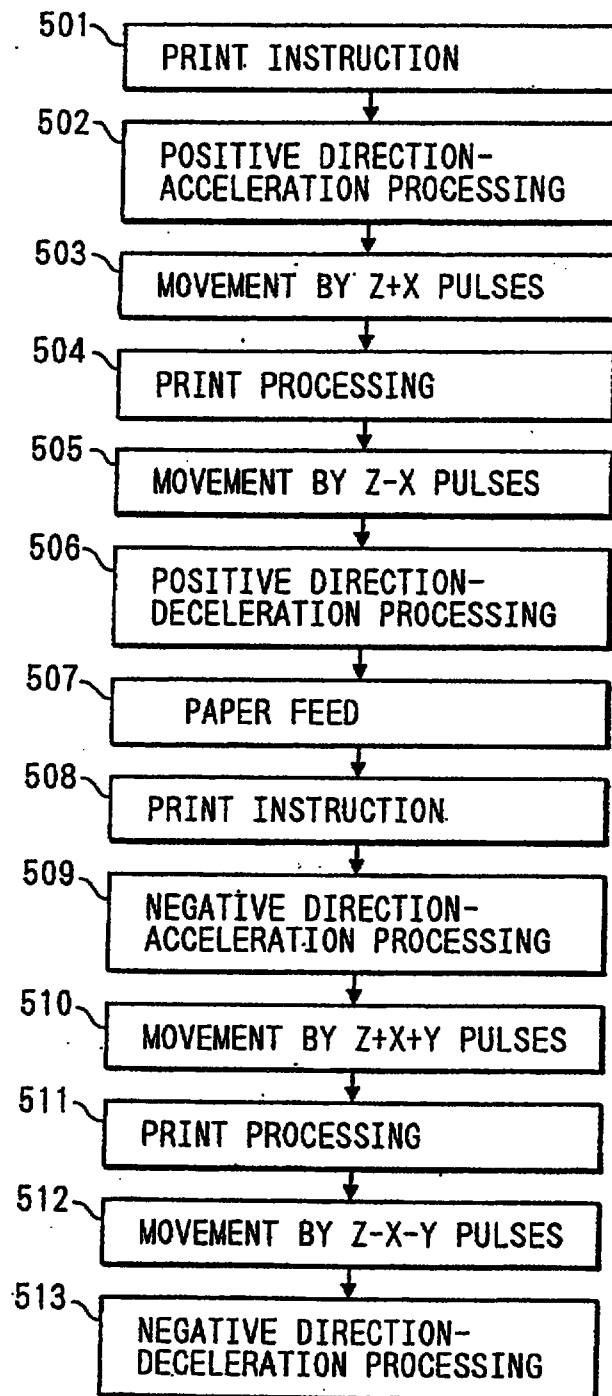


FIG. 12



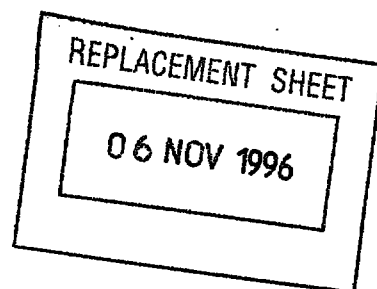
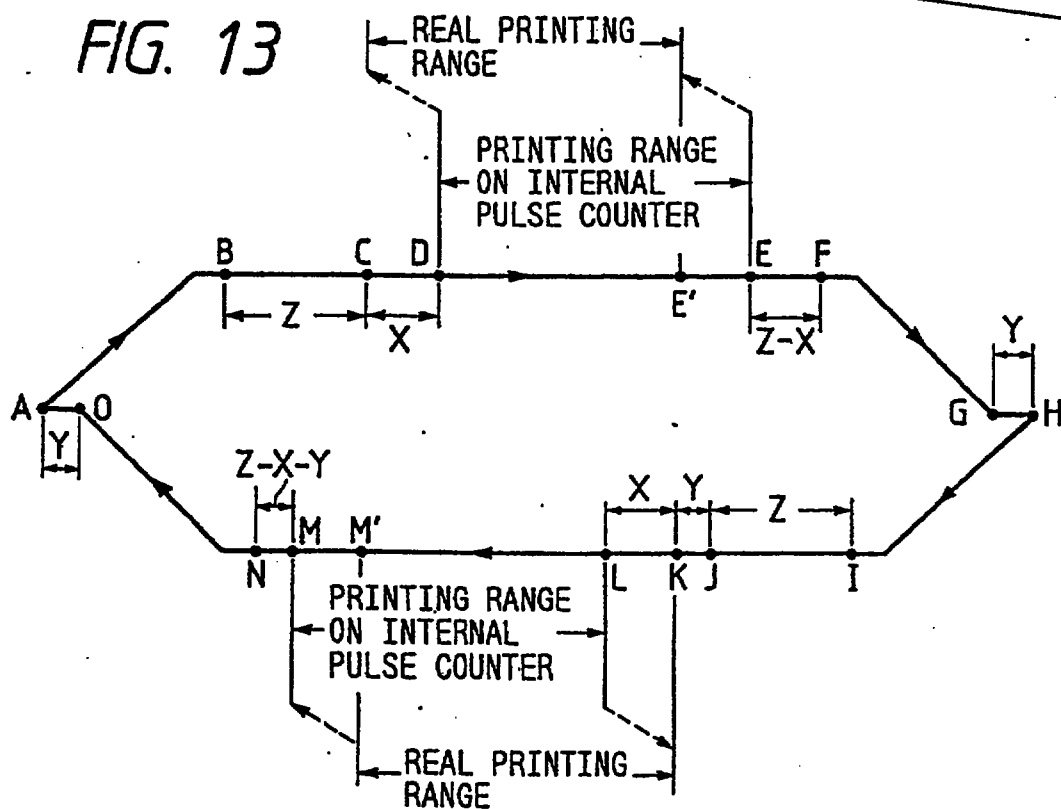


FIG. 13



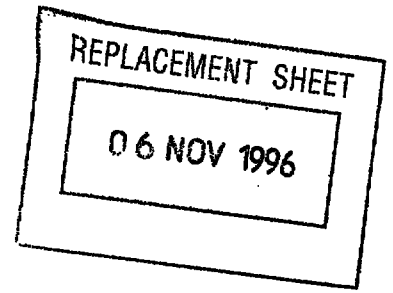


FIG. 14

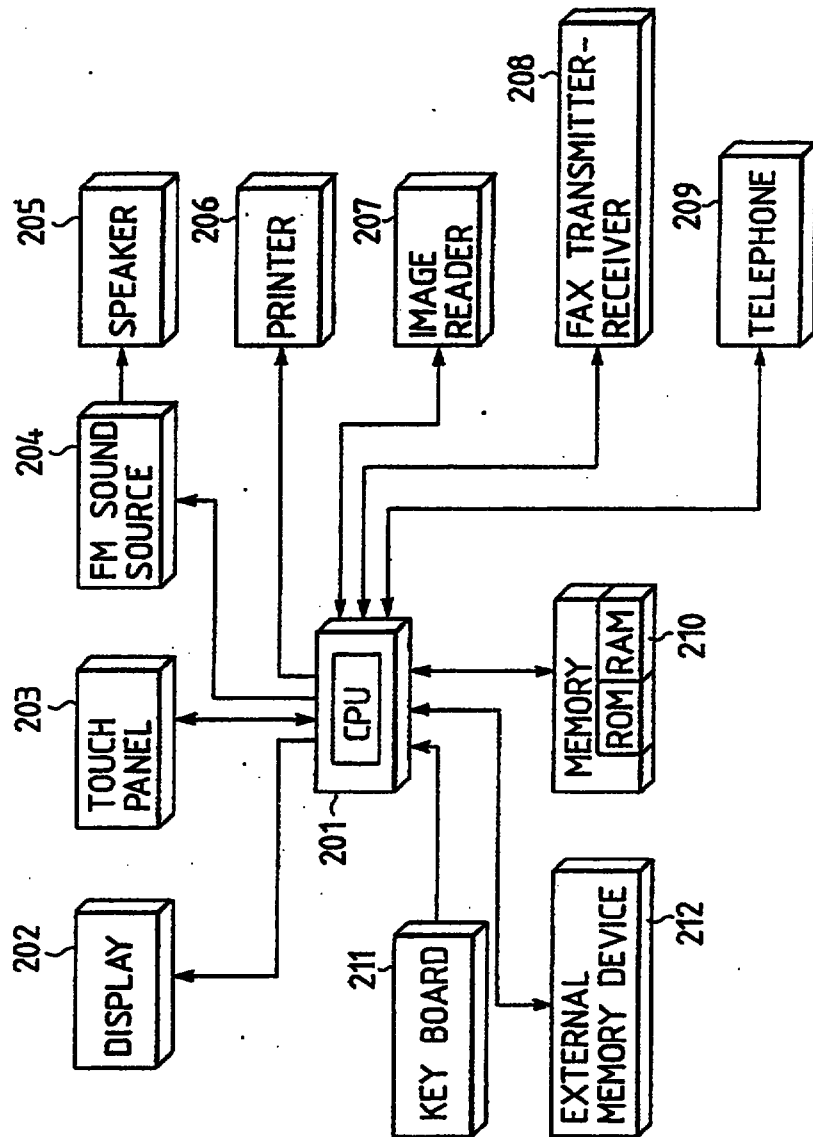
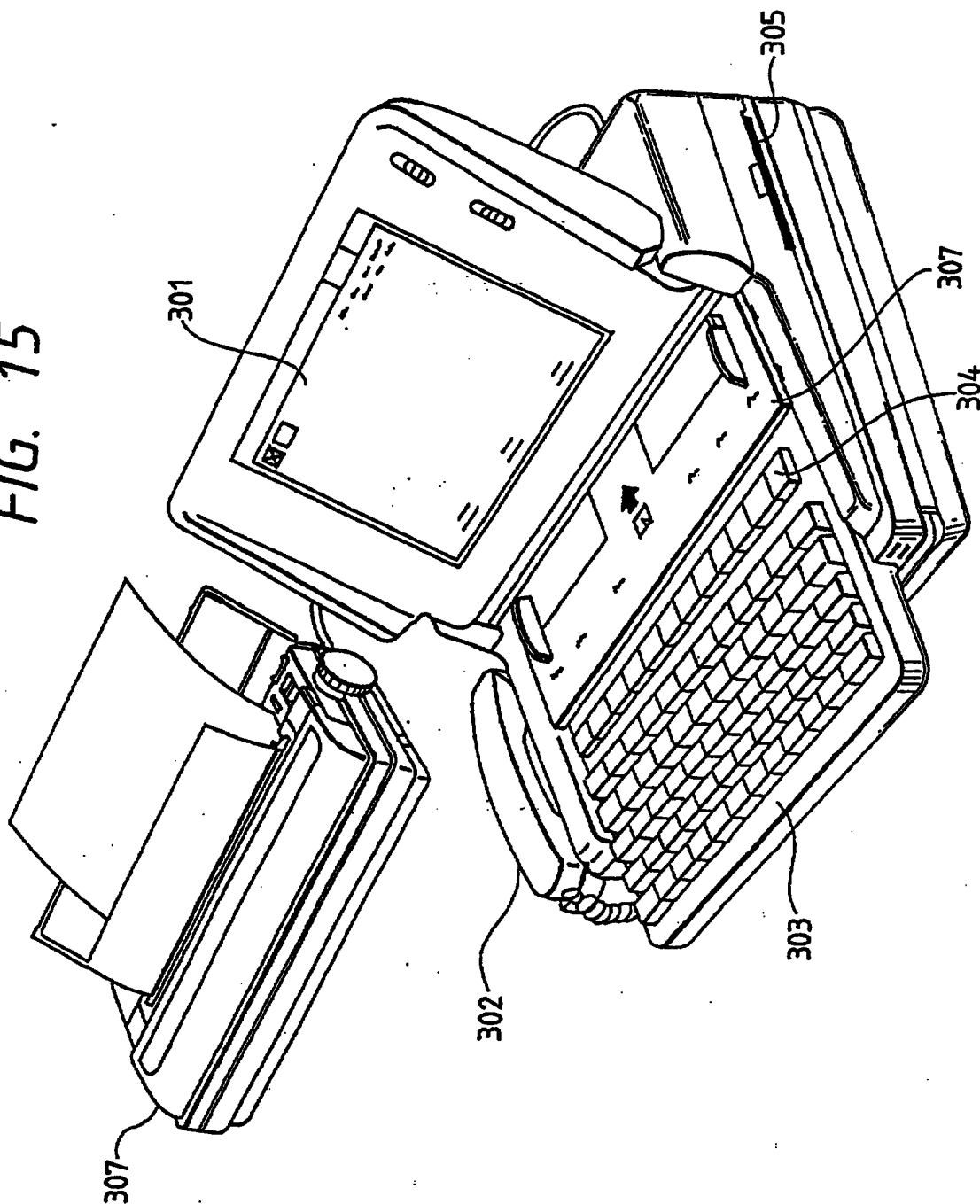


FIG. 15



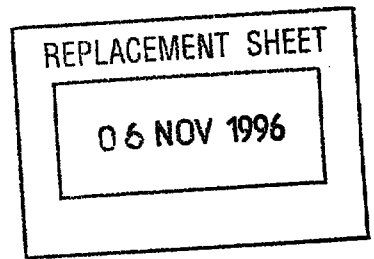
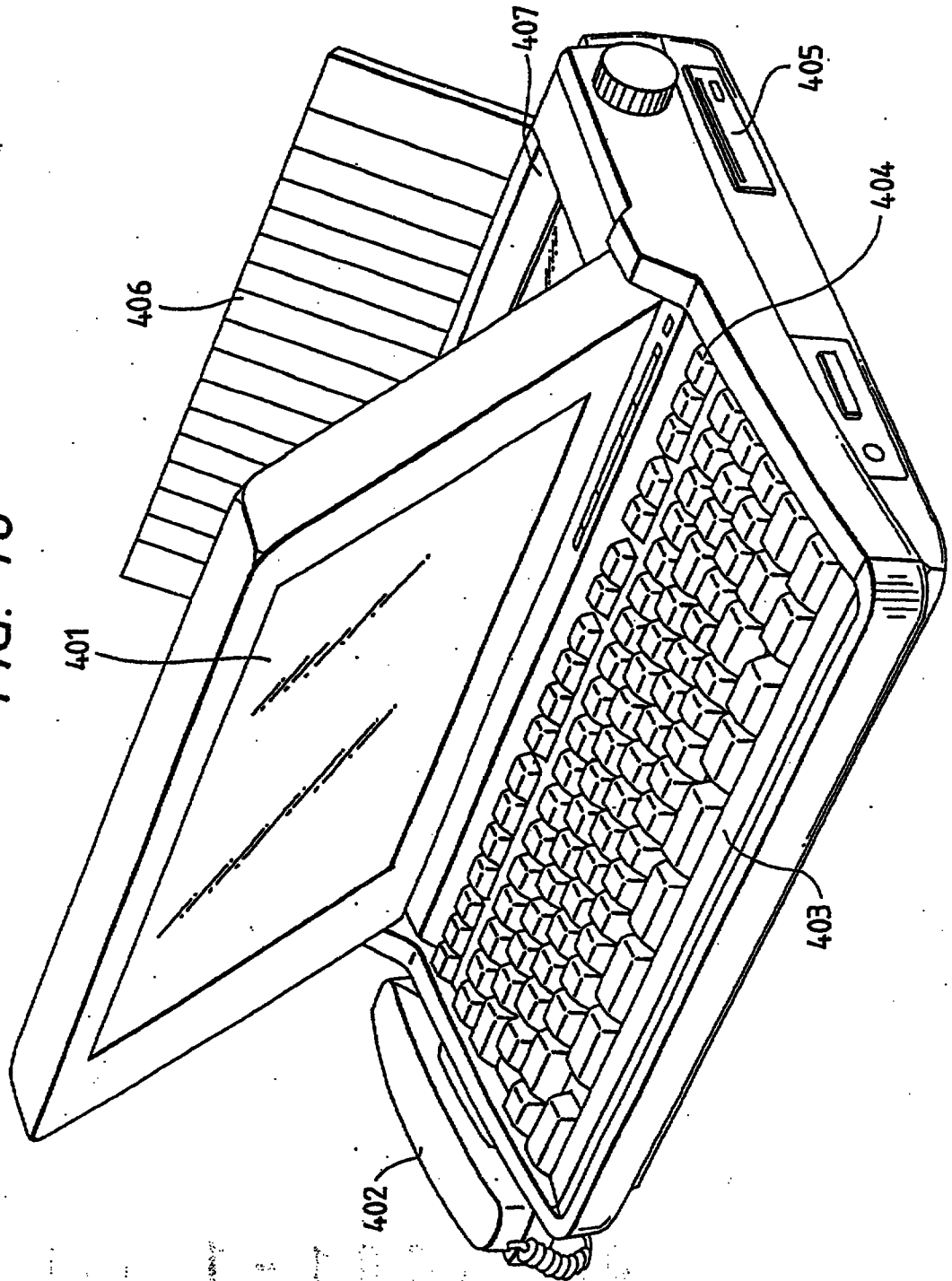


FIG. 16





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REPLACEMENT SHEET

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What is claimed is:

1. A serial recording apparatus for reciprocating a recording head with respect to a recording medium to perform bidirectional recording, said apparatus comprising:

position detecting means for detecting a reference position of said recording head;

driving means for reciprocating said recording head within a predetermined area including the reference position, the predetermined area being within a range from $\frac{1}{4}$ to $\frac{1}{2}$ of a recording area;

means for calculating a difference between reference positions detected by said position detecting means by reciprocal movement when said recording head is reciprocated by said driving means within the predetermined area; and

means for correcting a positional error in bidirectional recording on a basis of the difference calculated by said calculating means.

2. An apparatus according to claim 1, wherein said correcting means corrects the positional error on the basis of the difference calculated by said calculating means and a characteristic value of said driving means.

3. An apparatus according to claim 2, wherein the characteristic value of said driving means is based at least in part on play of said driving means.

4. An apparatus according to claim 2, wherein said driving means comprises circuitry and the characteristic value of said driving means is based at least in part on a delay in said circuitry of said driving means.

5. An apparatus according to claim 1, wherein said correcting means corrects the positional error on the basis of the difference calculated by said calculating means and a characteristic value based at least in part on a hysteresis of said position detecting means.

6. An apparatus according to claim 1, wherein said correcting means corrects the positional error while said recording head is moved for recording in one direction or the other direction.

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7. An apparatus according to claim 1, wherein said correcting means corrects the positional error during movement of said recording head for recording in both directions.

8. An apparatus according to claim 1, wherein said driving means includes a pulse motor, and said calculating means calculates the difference between the detected reference positions by a number of pulses for driving said pulse motor.

9. An apparatus according to claim 1, wherein said driving means includes a pulse motor, and said calculating means calculates the difference between the detected reference positions in accordance with a plurality of phases obtained by dividing a pulse for driving said pulse motor.

10. An apparatus according to claim 1, wherein said driving means drives to reciprocate said recording head to cause said calculating means to calculate the difference between the detected reference positions upon a power-on operation.

11. An apparatus according to claim 1, wherein said driving means drives to reciprocate said recording head to cause said calculating means to calculate the difference between the detected reference positions in an on-line mode.

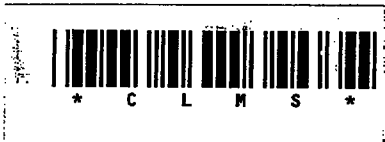
12. An apparatus according to claim 1, wherein said calculating means calculates the differences between the detected reference positions at a plurality of speeds.

13. An apparatus according to claim 1, wherein the predetermined area is about $\frac{1}{3}$ the recording area.

14. An apparatus according to claim 1, wherein said recording head comprises an ink-jet recording head for ejecting ink droplets to perform recording.

15. An apparatus according to claim 1, wherein said recording head comprises an ink jet recording head for ejecting ink droplets to perform recording upon growth and shrinkage of bubbles.

16. An apparatus according to claim 1, wherein said recording head comprises a plurality of ejection ports for ejecting ink, and heat energy generating means, respectively arranged in correspondence with said plurality of ejection ports, for causing a change in state in the ink by heat and ejecting the ink from said ejection ports to form flying liquid droplets on the basis of the



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change in state.

17. An apparatus according to claim 1, wherein said recording head is interchangeable with respect to said serial recording apparatus.

18. An apparatus according to claim 17, wherein said recording head comprises an ink-jet recording head for ejecting ink droplets to perform recording.

19. An apparatus according to claim 18, wherein said recording head comprises a tank for storing ink.

20. An apparatus according to claim 1, further comprising computing means for computing and recording various information inputted through an input device.

21. An apparatus according to claim 1, wherein said serial recording apparatus has a facsimile function which records facsimile information received through a communication line.

22. An apparatus according to claim 1, wherein said serial recording apparatus has a word processing function which records various information inputted through a keyboard.

23. An apparatus according to claim 1, wherein said serial recording apparatus has a copier function which records read original information.

24. A serial recording method of reciprocating a recording head with respect to a recording medium to perform bidirectional recording, said method comprising the steps of:

reciprocating said recording head within a predetermined area including a reference position prior to recording, the predetermined area being within a range from $\frac{1}{4}$ to $\frac{1}{2}$ of a recording area;

detecting reference positions in both directions during reciprocal movement and calculating a difference between the detected reference positions; and

correcting a positional error to perform bidirectional recording on a basis of the calculated difference.

25. A method according to claim 24, wherein said step of performing bidirectional recording comprises the step of correcting the positional error while said recording head performs recording in one direction or the other direction.

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26. A method according to claim 24, wherein said step of performing bidirectional recording comprises the step of correcting the positional error during recording of said recording head in both directions.

27. A method according to claim 24, wherein the predetermined area is about $\frac{1}{3}$ the recording area.

28. A method according to claim 24, wherein said recording head comprises an ink-jet recording head for ejecting ink droplets to perform recording.

29. A method according to claim 24, wherein said recording head comprises an ink jet recording head for ejecting ink droplets to perform recording upon growth and shrinkage of bubbles.

30. A method according to claim 24, wherein said recording head comprises a plurality of ejection ports for ejecting ink, and heat energy generating means, respectively arranged in correspondence with said plurality of ejection ports, for causing a change in state in the ink by heat and ejecting the ink from said ejection pots to form flying liquid droplets on the basis of the change in state.

31. A method according to claim 24, wherein said recording head is interchangeable with respect to a serial recording apparatus.

32. A method according to claim 31, wherein said recording head comprises an ink-jet recording head for ejecting ink droplets to perform recording.

33. A method according to claim 32, wherein said recording head comprises a tank for storing ink.

34. A serial recording apparatus for reciprocating a recording head with respect to a recording medium to perform bidirectional recording, said apparatus comprising:

position detecting means for detecting a passage of a reference position by said recording head;

driving means for reciprocating said recording head within a predetermined area of a recording area including the reference position;

means for calculating a difference in timing between passages of reference positions detected by said position detecting means of movements in both directions, respectively, when said recording head is reciprocated by said driving means within the predetermined area; and

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means for correcting a positional error in ~~bidirectional~~ recording on a basis of a difference calculated by said calculating means and a characteristic value of said driving means.

35. An apparatus according to claim 34, wherein the characteristic value of said driving means is based at least in part on play of said driving means.

36. An apparatus according to claim 34, wherein said driving means comprises circuitry and the characteristic value of said driving means is based at least in part on a delay in said circuitry of said driving means.

37. An apparatus according to claim 34, wherein said correcting means corrects the positional error on a further basis of another characteristic value based on a hysteresis of said position detecting means.

38. An apparatus according to claim 34, wherein said correcting means corrects the positional error while said recording head is moved for recording in one direction or the other direction.

39. An apparatus according to claim 34, wherein said correcting means corrects the positional error during movement of said recording head for recording in both directions.

40. An apparatus according to claim 34, wherein said driving means includes a pulse motor, and said calculating means calculates the difference between the detected reference positions in accordance with a plurality of phases obtained by dividing a pulse for driving said pulse motor.

41. An apparatus according to claim 34, wherein said driving means drives to reciprocate said recording head to cause said calculating means to calculate the difference between the detected reference positions upon a power-on operation.

42. An apparatus according to claim 34, wherein said driving means drives to reciprocate said recording head to cause said calculating means to calculate the difference between the detected reference positions in an on-line mode.

43. An apparatus according to claim 34, wherein the predetermined area is about $\frac{1}{3}$ the recording area.

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44. An apparatus according to claim 34, wherein said recording head comprises a plurality of ejection ports for ejecting ink, and heat energy generating means, respectively arranged in correspondence with said plurality of ejection ports, for causing a change in state in the ink by heat and ejecting the ink from said ejection ports to form flying liquid droplets on the basis of the change in state.

45. An apparatus according to claim 34, wherein said recording head is interchangeable with respect to said serial recording apparatus.

46. An apparatus according to claim 34, wherein said serial recording apparatus has a facsimile function which records facsimile information received through a communication line.

47. An apparatus according to claim 34, wherein said serial recording apparatus has a word processing function which records various information inputted through a keyboard.

48. An apparatus according to claim 34, wherein said serial recording apparatus has a copier function which records read original information.

49. An apparatus according to claim 34, further comprising computing means for computing and recording various information inputted through an input device.

50. A serial recording method of reciprocating a recording head with respect to a recording medium to perform bidirectional recording, said method comprising the steps of:

providing a recording head driving system to reciprocate said recording head;

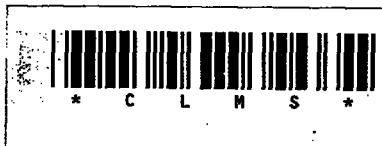
reciprocating said recording head within a predetermined area of a recording area including a reference position prior to recording;

detecting reference positions of movements in both directions, respectively, during reciprocal movement and calculating a difference in timing of the detection of the reference positions; and

correcting a positional error in order to perform bidirectional recording on a basis of the calculated difference and a characteristic value of the driving system.

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51. A method according to claim 51, wherein the characteristic value of the driving system is based at least in part on play of the driving system.

52. A method according to claim 50, wherein the driving system comprises circuitry and the characteristic value of the driving system is based at least in part on a delay in the circuitry of the driving system.

53. A method according to claim 50, wherein said step of correcting a positional error is effected on a further basis of another characteristic value based at least in part on a hysteresis of a detector for detecting the reference position.

54. A method according to claim 50, wherein said step of performing bidirectional recording comprises the step of correcting the positional error while said recording head performs recording in one direction or the other direction.

55. A method according to claim 50, wherein said step of performing bidirectional recording comprises the step of correcting the positional error during recording of said recording head in both directions.

56. A method according to claim 50, wherein the predetermined area is about $\frac{1}{4}$ the recording area.

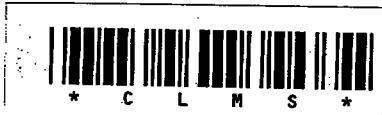
57. A method according to claim 50, wherein said recording head comprises a plurality of ejection ports for ejecting ink, and heat energy generating means, respectively arranged in correspondence with said plurality of ejection ports, for causing a change in state in the ink by heat and ejecting the ink from said ejection ports to form flying liquid droplets on the basis of the change in state.

58. A method according to claim 50, wherein said recording head is interchangeable with respect to a serial recording apparatus.

59. A serial recording apparatus for reciprocating a recording head with respect to a recording medium to perform bidirectional recording, said apparatus comprising:

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driving means for reciprocating said recording head within a predetermined area of a recording area including a reference position, said driving means comprising a pulse motor driven by switching an exciting phase;

position detecting means for detecting a passage of the reference position by said recording head, said position detecting means performing the detection in accordance with a plurality of phases obtained by dividing the exciting phase;

means for calculating a difference in timing between the passages of reference positions detected by said position detecting means of movements in both directions, respectively, when said recording head is reciprocated by said driving means within the predetermined area, said calculating means calculating the difference in accordance with a plurality of phases obtained by dividing the exciting phase; and

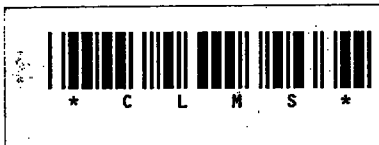
means for correcting a positional error in bidirectional recording on a basis of the difference calculated by said calculating means.

60. An apparatus according to claim 59, wherein said correcting means corrects the positional error on a basis of the difference calculated by said calculating means and a characteristic value of said driving means.

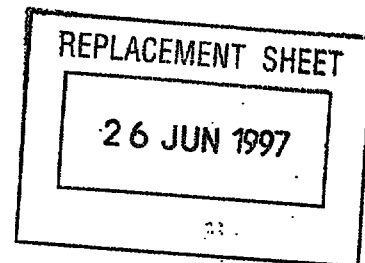
61. An apparatus according to claim 60, wherein the characteristic value of said driving means is based at least in part on play of said driving means.

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62. An apparatus according to claim 60, wherein said driving means comprises circuitry and the characteristic value of said driving means is based at least in part on a delay in said circuitry of said driving means.

63. An apparatus according to claim 59, wherein said correcting means corrects the positional error on a basis of the difference calculated by said calculating means and a characteristic value based at least in part on a hysteresis of said position detecting means.

64. An apparatus according to claim 59, wherein said correcting means corrects the positional error while said recording head is moved for recording in one direction or the other direction.

65. An apparatus according to claim 59, wherein said correcting means corrects the positional error during movement of said recording head for recording in both directions.

66. An apparatus according to claim 59, wherein said driving means drives to reciprocate said recording head to cause said calculating means to calculate the difference between the detected reference positions upon a power-on operation.

67. An apparatus according to claim 59, wherein said driving means drives to reciprocate said recording head to cause said calculating means to calculate the difference between the detected reference positions in an on-line mode.

68. An apparatus according to claim 59, wherein the predetermined area is about $\frac{1}{3}$ the recording area.

69. An apparatus according to claim 59, wherein said recording head comprises a plurality of ejection ports for ejecting ink, and heat energy generating means, respectively arranged in correspondence with said plurality of ejection ports, for causing a change in state in the ink by heat and ejecting the ink from said ejection ports to form flying liquid droplets on the basis of the change in state.

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70. An apparatus according to claim 59, wherein said recording head is interchangeable with respect to said serial recording apparatus.

71. An apparatus according to claim 59, wherein said serial recording apparatus has a facsimile function which records facsimile information received through a communication line.

72. An apparatus according to claim 59, wherein said serial recording apparatus has a word processing function which records various information inputted through a keyboard.

73. An apparatus according to claim 59, wherein said serial recording apparatus has a copier function which records read original information.

74. An apparatus according to claim 59, further comprising computing means for computing and recording various information inputted through an input device.

75. A serial recording method of reciprocating a recording head with respect to a recording medium to perform bidirectional recording, said method comprising the steps of:

- providing a recording head driving system to reciprocate said recording head in accordance with the switching of an exciting phase;

- reciprocating said recording head within a predetermined area of a recording area including a reference position prior to recording;

- detecting reference positions of movements in both directions, respectively, during reciprocal movement in accordance with a plurality of phases obtained by dividing the exciting phase and calculating a difference in timing of the detection of the reference positions; and

- correcting a positional error in order to perform bidirectional recording on a basis of the calculated difference.

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76. A method according to claim 75, wherein said step of performing bidirectional recording comprises the step of correcting the positional error while said recording head performs recording in one direction or the other direction.

77. A method according to claim 75, wherein said step of performing bidirectional recording comprises the step of correcting the positional error during recording of said recording head in both directions.

78. A method according to claim 75, wherein the predetermined area is about $\frac{1}{2}$ the recording area.

79. A method according to claim 75, wherein said recording head comprises a plurality of ejection ports for ejecting ink, and heat energy generating means, respectively arranged in correspondence with said plurality of ejection ports, for causing a change in state in the ink by heat and ejecting the ink from said ejection ports to form flying liquid droplets on the basis of the change in state.

80. A method according to claim 75, wherein said recording head is interchangeable with respect to a serial recording apparatus.

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What is claimed is:

1. A serial recording apparatus for reciprocating a recording head with respect to a recording medium to perform bidirectional recording, said apparatus comprising:

position detecting means for detecting a reference position of said recording head;

driving means for reciprocating said recording head within a predetermined area including the reference position, the predetermined area being within a range from $\frac{1}{4}$ to $\frac{1}{2}$ of a recording area;

means for calculating a difference between reference positions detected by said position detecting means by reciprocal movement when said recording head is reciprocated by said driving means within the predetermined area; and

means for correcting a positional error in bidirectional recording on a basis of the difference calculated by said calculating means.

2. An apparatus according to claim 1, wherein said correcting means corrects the positional error on the basis of the difference calculated by said calculating means and a characteristic value of said driving means.

3. An apparatus according to claim 2, wherein the characteristic value of said driving means is based at least in part on play of said driving means.

4. An apparatus according to claim 2, wherein said driving means comprises circuitry and the characteristic value of said driving means is based at least in part on a delay in said circuitry of said driving means.

5. An apparatus according to claim 1, wherein said correcting means corrects the positional error on the basis of the difference calculated by said calculating means and a characteristic value based at least in part on a hysteresis of said position detecting means.

6. An apparatus according to claim 1, wherein said correcting means corrects the positional error while said recording head is moved for recording in one direction or the other direction.

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7. An apparatus according to claim 1, wherein said correcting means corrects the positional error during movement of said recording head for recording in both directions.

8. An apparatus according to claim 1, wherein said driving means includes a pulse motor, and said calculating means calculates the difference between the detected reference positions by a number of pulses for driving said pulse motor.

9. An apparatus according to claim 1, wherein said driving means includes a pulse motor, and said calculating means calculates the difference between the detected reference positions in accordance with a plurality of phases obtained by dividing a pulse for driving said pulse motor.

10. An apparatus according to claim 1, wherein said driving means drives to reciprocate said recording head to cause said calculating means to calculate the difference between the detected reference positions upon a power-on operation.

11. An apparatus according to claim 1, wherein said driving means drives to reciprocate said recording head to cause said calculating means to calculate the difference between the detected reference positions in an on-line mode.

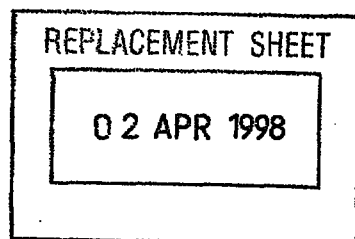
12. An apparatus according to claim 1, wherein said calculating means calculates the differences between the detected reference positions at a plurality of speeds.

13. An apparatus according to claim 1, wherein the predetermined area is about $\frac{1}{3}$ the recording area.

14. An apparatus according to claim 1, wherein said recording head comprises an ink-jet recording head for ejecting ink droplets to perform recording.

15. An apparatus according to claim 1, wherein said recording head comprises an ink jet recording head for ejecting ink droplets to perform recording upon growth and shrinkage of bubbles.

16. An apparatus according to claim 1, wherein said recording head comprises a plurality of ejection ports for ejecting ink, and heat energy generating means, respectively arranged in correspondence with said plurality of ejection ports, for causing a change in state in the ink by heat and ejecting the ink from said ejection ports to form flying liquid droplets on the basis of the



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change in state.

17. An apparatus according to claim 1, wherein said recording head is interchangeable with respect to said serial recording apparatus.

18. An apparatus according to claim 17, wherein said recording head comprises an ink-jet recording head for ejecting ink droplets to perform recording.

19. An apparatus according to claim 18, wherein said recording head comprises a tank for storing ink.

20. An apparatus according to claim 1, further comprising computing means for computing and recording various information inputted through an input device.

21. An apparatus according to claim 1, wherein said serial recording apparatus has a facsimile function which records facsimile information received through a communication line.

22. An apparatus according to claim 1, wherein said serial recording apparatus has a word processing function which records various information inputted through a keyboard.

23. An apparatus according to claim 1, wherein said serial recording apparatus has a copier function which records read original information.

24. A serial recording method of reciprocating a recording head with respect to a recording medium to perform bidirectional recording, said method comprising the steps of:

reciprocating said recording head within a predetermined area including a reference position prior to recording, the predetermined area being within a range from $\frac{1}{4}$ to $\frac{1}{2}$ of a recording area;

detecting reference positions in both directions during reciprocal movement and calculating a difference between the detected reference positions; and

correcting a positional error to perform bidirectional recording on a basis of the calculated difference.

25. A method according to claim 24, wherein said step of performing bidirectional recording comprises the step of correcting the positional error while said recording head performs recording in one direction or the other direction.

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26. A method according to claim 24, wherein said step of performing bidirectional recording comprises the step of correcting the positional error during recording of said recording head in both directions.

27. A method according to claim 24, wherein the predetermined area is about $\frac{1}{3}$ the recording area.

28. A method according to claim 24, wherein said recording head comprises an ink-jet recording head for ejecting ink droplets to perform recording.

29. A method according to claim 24, wherein said recording head comprises an ink jet recording head for ejecting ink droplets to perform recording upon growth and shrinkage of bubbles.

30. A method according to claim 24, wherein said recording head comprises a plurality of ejection ports for ejecting ink, and heat energy generating means, respectively arranged in correspondence with said plurality of ejection ports, for causing a change in state in the ink by heat and ejecting the ink from said ejection ports to form flying liquid droplets on the basis of the change in state.

31. A method according to claim 24, wherein said recording head is interchangeable with respect to a serial recording apparatus.

32. A method according to claim 31, wherein said recording head comprises an ink-jet recording head for ejecting ink droplets to perform recording.

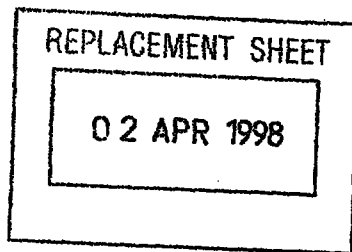
33. A method according to claim 32, wherein said recording head comprises a tank for storing ink.

34. A serial recording apparatus for reciprocating a recording head with respect to a recording medium to perform bidirectional recording, said apparatus comprising:

position detecting means for detecting a passage of a reference position by said recording head;

driving means for reciprocating said recording head within a predetermined area of a recording area including the reference position;

means for calculating a difference in timing between passages of reference positions detected by said position detecting means of movements in both directions, respectively, when said recording head is reciprocated by said driving means within the predetermined area; and



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means for correcting a positional error in bidirectional recording on a basis of a difference calculated by said calculating means and a characteristic value of said driving means.

35. An apparatus according to claim 34, wherein the characteristic value of said driving means is based at least in part on play of said driving means.

36. An apparatus according to claim 34, wherein said driving means comprises circuitry and the characteristic value of said driving means is based at least in part on a delay in said circuitry of said driving means.

37. An apparatus according to claim 34, wherein said correcting means corrects the positional error on a further basis of another characteristic value based on a hysteresis of said position detecting means.

38. An apparatus according to claim 34, wherein said correcting means corrects the positional error while said recording head is moved for recording in one direction or the other direction.

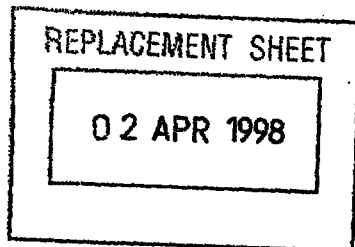
39. An apparatus according to claim 34, wherein said correcting means corrects the positional error during movement of said recording head for recording in both directions.

40. An apparatus according to claim 34, wherein said driving means includes a pulse motor, and said calculating means calculates the difference between the detected reference positions in accordance with a plurality of phases obtained by dividing a pulse for driving said pulse motor.

41. An apparatus according to claim 34, wherein said driving means drives to reciprocate said recording head to cause said calculating means to calculate the difference between the detected reference positions upon a power-on operation.

42. An apparatus according to claim 34, wherein said driving means drives to reciprocate said recording head to cause said calculating means to calculate the difference between the detected reference positions in an on-line mode.

43. An apparatus according to claim 34, wherein the predetermined area is about $\frac{1}{2}$ the recording area.



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44. An apparatus according to claim 34, wherein said recording head comprises a plurality of ejection ports for ejecting ink, and heat energy generating means, respectively arranged in correspondence with said plurality of ejection ports, for causing a change in state in the ink by heat and ejecting the ink from said ejection ports to form flying liquid droplets on the basis of the change in state.

45. An apparatus according to claim 34, wherein said recording head is interchangeable with respect to said serial recording apparatus.

46. An apparatus according to claim 34, wherein said serial recording apparatus has a facsimile function which records facsimile information received through a communication line.

47. An apparatus according to claim 34, wherein said serial recording apparatus has a word processing function which records various information inputted through a keyboard.

48. An apparatus according to claim 34, wherein said serial recording apparatus has a copier function which records read original information.

49. An apparatus according to claim 34, further comprising computing means for computing and recording various information inputted through an input device.

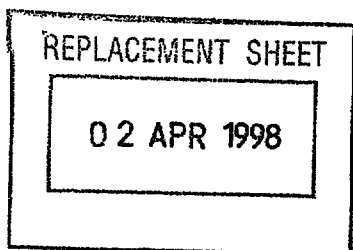
50. A serial recording method of reciprocating a recording head with respect to a recording medium to perform bidirectional recording, said method comprising the steps of:

- providing a recording head driving system to reciprocate said recording head;

- reciprocating said recording head within a predetermined area of a recording area including a reference position prior to recording;

- detecting reference positions of movements in both directions, respectively, during reciprocal movement and calculating a difference in timing of the detection of the reference positions; and

- correcting a positional error in order to perform bidirectional recording on a basis of the calculated difference and a characteristic value of the driving system.



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51. A method according to claim 51, wherein the characteristic value of the driving system is based at least in part on play of the driving system.

52. A method according to claim 50, wherein the driving system comprises circuitry and the characteristic value of the driving system is based at least in part on a delay in the circuitry of the driving system.

53. A method according to claim 50, wherein said step of correcting a positional error is effected on a further basis of another characteristic value based at least in part on a hysteresis of a detector for detecting the reference position.

54. A method according to claim 50, wherein said step of performing bidirectional recording comprises the step of correcting the positional error while said recording head performs recording in one direction or the other direction.

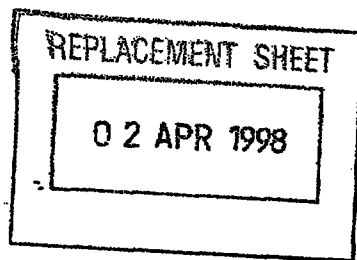
55. A method according to claim 50, wherein said step of performing bidirectional recording comprises the step of correcting the positional error during recording of said recording head in both directions.

56. A method according to claim 50, wherein the predetermined area is about $\frac{1}{2}$ the recording area.

57. A method according to claim 50, wherein said recording head comprises a plurality of ejection ports for ejecting ink, and heat energy generating means, respectively arranged in correspondence with said plurality of ejection ports, for causing a change in state in the ink by heat and ejecting the ink from said ejection ports to form flying liquid droplets on the basis of the change in state.

58. A method according to claim 50, wherein said recording head is interchangeable with respect to a serial recording apparatus.

59. A serial recording apparatus for reciprocating a recording head with respect to a recording medium to perform bidirectional recording, said apparatus comprising:



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driving means for reciprocating said recording head within a predetermined area of a recording area including a reference position, said driving means comprising a pulse motor driven by switching an exciting phase;

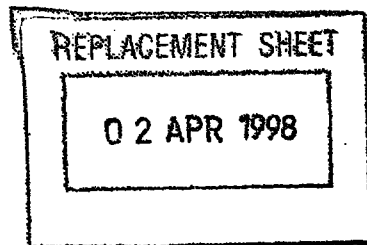
position detecting means for detecting a passage of the reference position by said recording head, said position detecting means performing the detection in accordance with a plurality of phases obtained by dividing the exciting phase;

means for calculating a difference in timing between the passages of reference positions detected by said position detecting means of movements in both directions, respectively, when said recording head is reciprocated by said driving means within the predetermined area, said calculating means calculating the difference in accordance with a plurality of phases obtained by dividing the exciting phase; and

means for correcting a positional error in bidirectional recording on a basis of the difference calculated by said calculating means.

60. An apparatus according to claim 59, wherein said correcting means corrects the positional error on a basis of the difference calculated by said calculating means and a characteristic value of said driving means.

61. An apparatus according to claim 60, wherein the characteristic value of said driving means is based at least in part on play of said driving means.



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62. An apparatus according to claim 60, wherein said driving means comprises circuitry and the characteristic value of said driving means is based at least in part on a delay in said circuitry of said driving means.

63. An apparatus according to claim 59, wherein said correcting means corrects the positional error on a basis of the difference calculated by said calculating means and a characteristic value based at least in part on a hysteresis of said position detecting means.

64. An apparatus according to claim 59, wherein said correcting means corrects the positional error while said recording head is moved for recording in one direction or the other direction.

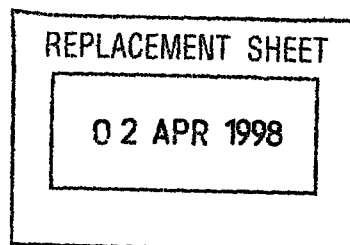
65. An apparatus according to claim 59, wherein said correcting means corrects the positional error during movement of said recording head for recording in both directions.

66. An apparatus according to claim 59, wherein said driving means drives to reciprocate said recording head to cause said calculating means to calculate the difference between the detected reference positions upon a power-on operation.

67. An apparatus according to claim 59, wherein said driving means drives to reciprocate said recording head to cause said calculating means to calculate the difference between the detected reference positions in an on-line mode.

68. An apparatus according to claim 59, wherein the predetermined area is about $\frac{1}{3}$ the recording area.

69. An apparatus according to claim 59, wherein said recording head comprises a plurality of ejection ports for ejecting ink, and heat energy generating means, respectively arranged in correspondence with said plurality of ejection ports, for causing a change in state in the ink by heat and ejecting the ink from said ejection ports to form flying liquid droplets on the basis of the change in state.



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70. An apparatus according to claim 59, wherein said recording head is interchangeable with respect to said serial recording apparatus.

71. An apparatus according to claim 59, wherein said serial recording apparatus has a facsimile function which records facsimile information received through a communication line.

72. An apparatus according to claim 59, wherein said serial recording apparatus has a word processing function which records various information inputted through a keyboard.

73. An apparatus according to claim 59, wherein said serial recording apparatus has a copier function which records read original information.

74. An apparatus according to claim 59, further comprising computing means for computing and recording various information inputted through an input device.

75. A serial recording method of reciprocating a recording head with respect to a recording medium to perform bidirectional recording, said method comprising the steps of:

- providing a recording head driving system to reciprocate said recording head in accordance with the switching of an exciting phase;

- reciprocating said recording head within a predetermined area of a recording area including a reference position prior to recording;

- detecting reference positions of movements in both directions, respectively, during reciprocal movement in accordance with a plurality of phases obtained by dividing the exciting phase and calculating a difference in timing of the detection of the reference positions; and

- correcting a positional error in order to perform bidirectional recording on a basis of the calculated difference.

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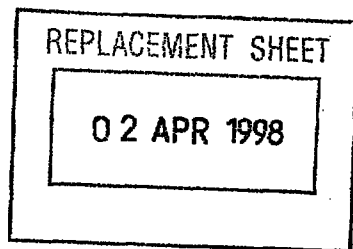
76. A method according to claim 75, wherein said step of performing bidirectional recording comprises the step of correcting the positional error while said recording head performs recording in one direction or the other direction.

77. A method according to claim 75, wherein said step of performing bidirectional recording comprises the step of correcting the positional error during recording of said recording head in both directions.

78. A method according to claim 75, wherein the predetermined area is about $\frac{1}{2}$ the recording area.

79. A method according to claim 75, wherein said recording head comprises a plurality of ejection ports for ejecting ink, and heat energy generating means, respectively arranged in correspondence with said plurality of ejection ports, for causing a change in state in the ink by heat and ejecting the ink from said ejection ports to form flying liquid droplets on the basis of the change in state.

80. A method according to claim 75, wherein said recording head is interchangeable with respect to a serial recording apparatus.



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SERIAL RECORDING APPARATUS FOR BIDIRECTIONAL RECORDING

ABSTRACT OF THE DISCLOSURE

A serial recording apparatus for reciprocating a recording head with respect to a recording medium to perform bidirectional recording includes a position detector for detecting a reference position of the recording head, a driving unit for reciprocating the recording head within a predetermined area including the reference position, a calculating unit for calculating a difference between reference positions detected by the position detector by reciprocal movement when the recording head is reciprocated by the driving unit within the predetermined area, and a correcting unit for correcting a positional error in bidirectional recording on the basis of the difference calculated by the calculating unit.

FIGURE 1