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Dot printer

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I.B.M.; Tech. Disc. Bull.; Vol.27; No.7B; December 1984; Pp 4429-30

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F I G. 1

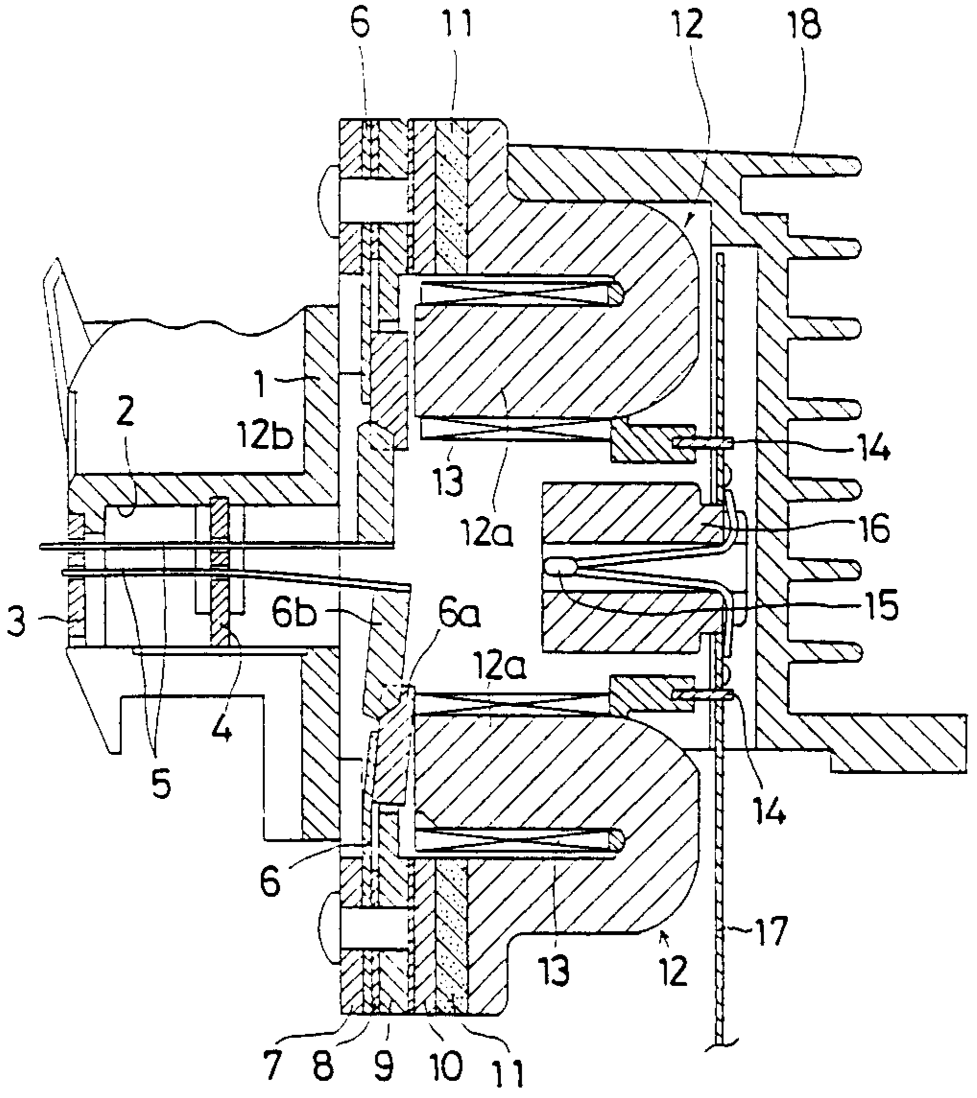
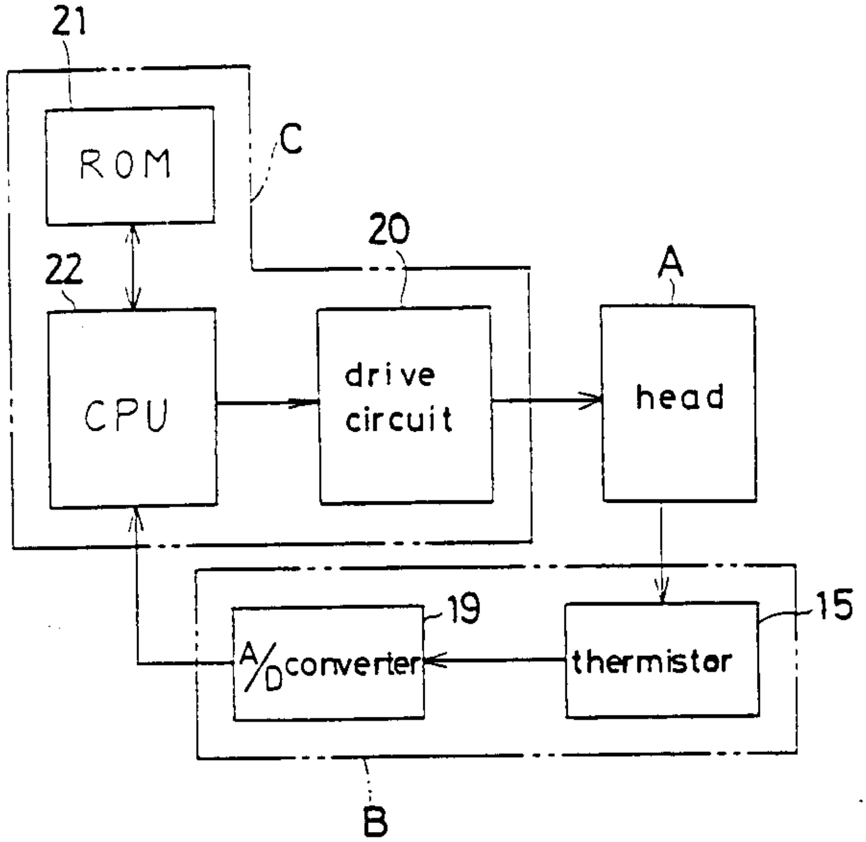


FIG. 2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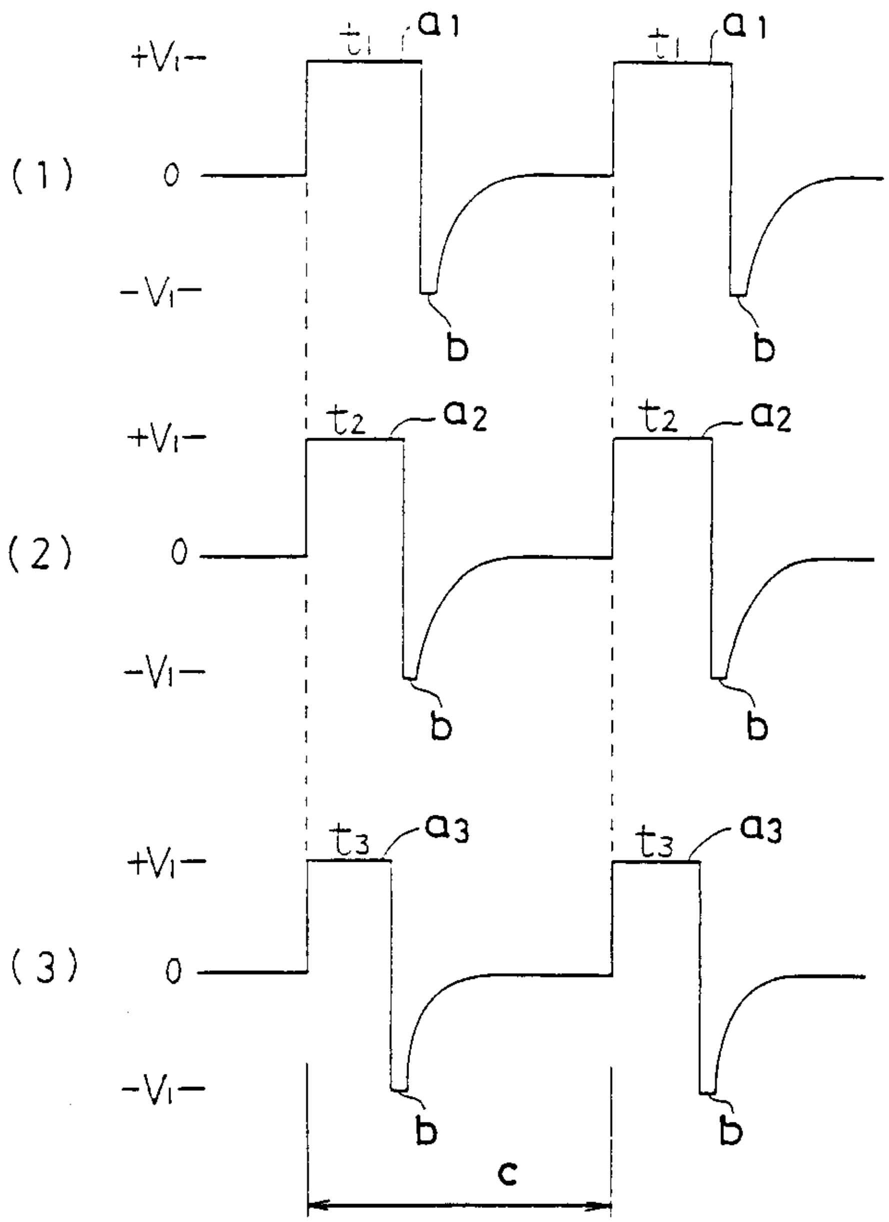
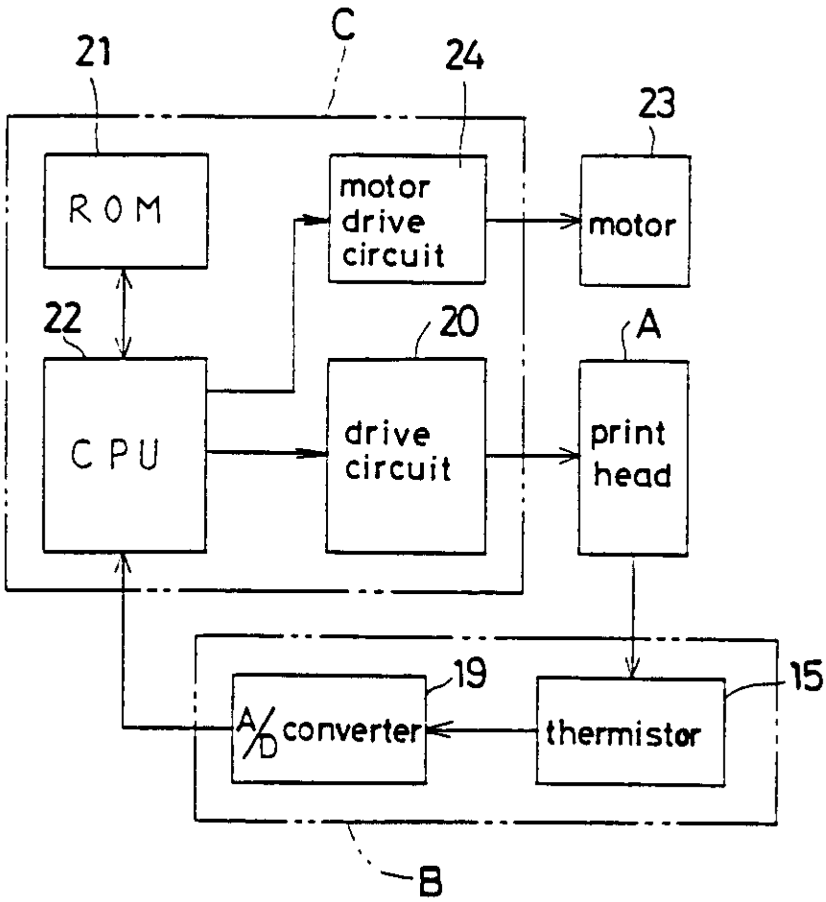
C
22
20
A
CPU
drive circuit
head
19
15
A/D converter
thermistor
B

F I G. 3



t1, t2, t3 ··· pulse width
V1 ---------- voltage
c ---------- period

FIG.4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24
23
ROM
motor
drive
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A
CPU
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print
head
19
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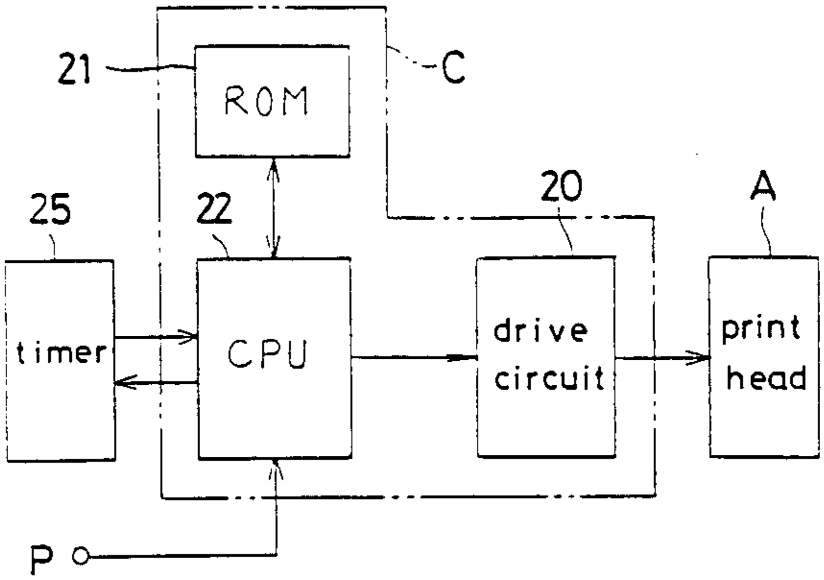
A/D converter
thermistor
B

F I G. 5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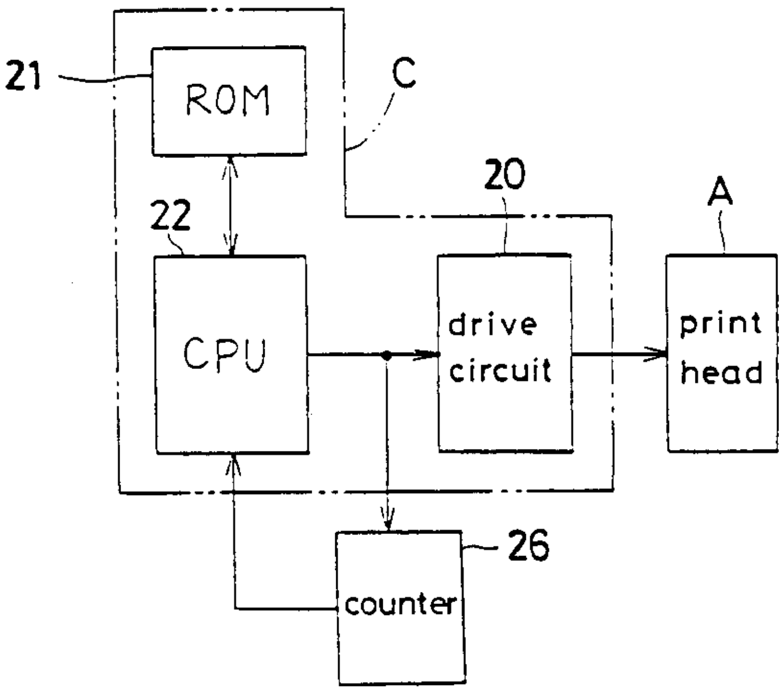
CPU
drive
circuit
print
head
P

F I G. 6


21
ROM
C
22
20
A
CPU
drive
circuit
print
head
26
counter

DOT PRINTER

The present invention relates to a dot printer.

A known dot printer of the spring release type has a plurality of electro-magnetic drive means for controlling respectively a plurality of drive arms for driving associated printing elements. Each drive arm is normally attracted by a permanent magnet of the electro-magnetic drive means, the force of the permanent magnet being overcome by the supply of current to a drive coil of the electro-magnetic drive means in order to release the drive arm for driving the associated printing element. Certain parts forming the electro-magnetic drive means are manufactured to a high degree of accuracy to ensure that each printing element has a uniform printing motion and printing characteristic. However, continuous printing when the dot printer operates at high speed causes the print head to generate heat such that the temperature within the print head rises to 100°C or higher. In consequence, the permanent magnet becomes de-magnetised, resulting in defective response by the drive arms or a deterioration in response rate.

More especially, in the spring release type of dot printer, the magnetic characteristic of the permanent magnet changes depending on temperature, and hence the characteristic of the print head itself also changes. Since the permanent magnet is partially de-magnetised when it is heated, the force with which it attracts a movable yoke of the associated drive arm is reduced. Accordingly, the magnetic field generated by the drive coil becomes relatively greater and as a result the period, when the printing elements advance to form the dots and then return under the attraction of the permanent magnet, becomes longer. During this period, the print head is moving and therefore the following problems may occur, namely, for instance, an ink ribbon of the printer may be caught by the end of a respective printing element or certain dots may not be printed.

One proposed solution to the problem is to set the input to the drive coils to take account of the heat generation by the print head. However, in this case, the magnetic field generated by each coil in the condition that the print head does not yet generate heat, during initial printing for example, is insufficient in comparison with the magnetic field of the permanent magnet, and so the associated printing element does not advance sufficiently because the movable yoke is not released perfectly. Consequently, the print head cannot achieve full print pressure and print speed.

Another proposed solution is to set the intensity of the permanent magnet in order to obtain a sufficient attracting force when the print head generates heat. However, a large drive energy is then required and as a result the power consumption becomes large and heat generation by the print head is further accelerated.

According to the present invention there is provided a dot printer having a print head in which a drive arm for driving a respective printing element is biased to a first position by a permanent magnet and is controlled by electro-magnetic means acting in opposition to the permanent magnet for effecting printing, the printer having control means arranged to vary at least one of pulse width, voltage or pulse spacing of drive pulses supplied to a drive coil of the electro-magnetic means for operating the drive arm in dependence upon the temperature of the print head.

The control means may be responsive to an output from temperature detecting means for varying the selected characteristic of the drive pulses. Alternatively, the control means may be responsive to an output from a timer for measuring the printing time of the print head or from a counter for counting the number of dots printed by the print head.

Since the magnetic field provided by the drive coil is variable in dependence on the temperature of the print head by variably controlling at least one of the pulse width, voltage or pulse spacing of the drive pulses corresponding to such temperature, the magnetic field may be arranged so as just to cancel the magnetic field of the permanent magnet at all times, and thereby high quality printing can be attained.

The present invention thus provides a dot printer which is automatically adjusted in order to give a uniform drive characteristic and good printing quality whether or not the print head generates heat.

The present invention will be described further, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a sectional view through a print head of a dot printer embodying the present invention;

Figure 2 is a block diagram of a control circuit of the dot printer;

Figure 3 is a wave form diagram showing drive pulses generated in the control circuit wherein pulse width is variably controlled; and

Figures 4 to 6 are block diagrams respectively showing further examples of the control circuit.

As shown in Figure 1, a print head (designated A in Figure 2) of a dot printer according to the present invention has wire guides 3, 4 fixed in a hollow part 2 of a head frame 1 formed from plastics material, and a plurality of print wires 5 which serve as printing elements are slidably supported by the wire guides 3, 4.

A base region of a drive arm 6 is held between a stopper plate 7 and a spacer 8 made of non-magnetic material and a yoke plate 9 made of magnetic material. The drive arm 6 is one of a plurality of such drive arms arranged radially at equal angular intervals, each drive arm 6 corresponding to a respective one of the print wires 5. The base regions of the respective arms are integrally connected to one another, and an opposite end region of each drive arm 6 carries a movable yoke 6a formed from magnetic material and joined to the remainder of the arm by any suitable means such as welding. A print lever 6b is connected to the movable yoke 6a, and the associated print wire 5 is fixed to an end of the print lever 6b.

A core assembly is located behind the yoke plate 9. This core assembly constitutes an annular plate 10 made of magnetic material, a permanent magnet 11 and a core body 12, which is composed of a plurality of U-shaped core pieces 12a made of magnetic material, all these parts being integrally connected to one another.

The U-shaped core pieces 12a are arranged radially in correspondence with the arrangement of the drive arm 6, and a leg at the inside of each such core piece 12a has a trapezoidal section to make efficient use of space. A front surface of each core piece 12a opposes a rear surface of a respective one of the movable yokes

6a. A respective drive coil 13 is wound around the internal leg of each core piece 12a, each drive coil 13 being connected to an associated terminal pin 14.

Within a central hollow region 12b of the core body 12, a thermistor 15, providing one example of a sensor for use in temperature detecting means designated B in Figure 2 for detecting the temperature of the print head A, is supported by fitting means 16. At a rear surface of the core body 12, there is disposed a flexible cable 17, both terminals of the thermistor 15 and the terminal pins 14 being connected at specific locations to the flexible cable 17. The external circumference and the rear surface of the core assembly are covered with a heat radiation fin 18.

As shown in Figure 2, a control circuit of the dot printer for operating the print head A comprises the temperature detecting means B and control means C. The temperature detecting means B includes the thermistor described previously and an A/D converter 19 which is arranged to convert an output from the thermistor 15 into a digital signal. The control means C includes a drive circuit 20 for the print head A, a memory circuit 21 in the form of a read only memory (hereinafter called a ROM) and a central processing unit 22 (hereinafter called a CPU). The ROM 21 stores a control program for controlling driving of the print head A, by variably controlling at least one of pulse width, voltage or pulse spacing of drive pulses generated by the drive circuit 20, depending on the temperature condition of the print head A as detected by the temperature detecting means B.

A first example of such control, in which the pulse width of the drive pulses generated by the drive circuit 20 is variably adjusted, will be explained with reference to Figure 3.

At the beginning of a printing operation, the print head A does not yet generate heat. When the heat generated by the print head A and detected by the thermistor 15 yields a temperature of, for example, 90°C or lower, the CPU 22 controls the drive circuit 20, according to the control program stored in the ROM 21, so as to generate drive pulses a_1 having a pulse width t_1 as shown in Figure 3 (1). Since the print head A does not yet generate heat, the magnetic flux of the permanent magnet 11 is quite large but this magnetic flux is overcome by the magnetic flux generated by the core pieces 12a in response to the pulses a_1. The relevant movable yoke 6a are thereby released and the associated print wires 5 are caused to advance quickly. When each drive pulse a_1 decays, the respective movable yoke 6a is attracted to the core piece 12a again under the magnetic force of the permanent magnet 11. Therefore, the print wire 5 withdraws to the initial position. During this return, a reversely induced pulse b is generated in the drive coil 13, but this reversely induced pulse b is quickly attenuated by a reversely induced pulse absorbing circuit (not illustrated) and thereby the print wire 5 returns immediately to its initial position.

When the heat generated by the print head A raises the temperature in excess of 90°C, the CPU 22 controls the drive circuit 20, according to the control program in the ROM 21, so as to generate drive pulses a_2 having a pulse width t_2 ($t_2 < t_1$) as shown in Figure 3 (2). The energy supplied to the respective coil 13 by the drive pulse a_2 is smaller than in the case of the drive pulses a_1, but such a reduction of input energy corresponds with de-magnetisation of the permanent magnet 11 resulting from heat generation within the print head A. Accordingly, the respective movable yoke 6a is still correctly controlled by the application of the drive pulses a_2.

Such operation continues for so long as the temperature within the print head A exceeds 90°C but does not exceed 110°C. When the heat generated by the print head A finally causes the temperature to exceed 110°C, the CPU 22 controls the drive circuit 20, according to the control program in the ROM 21, to generate drive pulses a_3 having a pulse width t_3 ($t_3 < t_2$) as shown in Figure 3 (3). The input energy to the respective coil 13 by the drive pulses a_3 is still smaller than in the case of the drive pulses a_2 but again such reduction in the input energy corresponds approximately with further de-magnetisation of the permanent magnet 11. Accordingly, the respective movable yoke 6a is correctly controlled by the application of the drive pulses a_3 even under the condition that heat generated by the print head A raises the temperature in excess of 110°C.

As shown in Figure 3, the period c of the drive pulses a_1, a_2 and a_3 remains constant.

In the above example, the effect of each coil 13 is adjusted by changing the pulse width. However, the invention is not limited to pulse width variation and a similar effect can also be obtained by changing the voltage V_1 or the pulse spacing of period c of the drive pulses. Moreover, the input to the respective coil 13 is adjusted step by step in the above example, but it is also possible to change the input continuously depending on temperature change.

In the case where the pulse spacing of the drive pulses (print timing) is changed, it is also necessary to control a feed rate for the print head A depending on the temperature. An arrangement for this is shown in Figure 4. In this case, a motor 23 to drive a carriage (not illustrated) for transporting the print head A is also controlled as shown in Figure 4 through the CPU 22 and a motor drive circuit 24. In addition, control may be effected so that the feed rate is increased at the beginning of a printing operation and is then lowered depending on the heat generated.

Figure 5 shows an example of control circuit wherein a timer 25 is provided in place of the temperature detecting means B. By inputting a print instruction P to the CPU 22, printing time can be measured by the timer 25, instead of measuring temperature.

Figure 6 shows an example of control circuit wherein a counter 26 for counting the number of dots printed is provided in place of the temperature detecting means B.

It is possible to replace the temperature detecting means B with the timer 25 and the counter 26 because the heat generated by the print head A may effectively be determined indirectly or experimentally from the time it takes for printing and from the number of dots printed.

As a result of the present invention as explained above, the drive pulses applied to each drive coil are varied in an optimum manner according to whether the print head generates or does not generate heat. Consequently, optimum printing capability and print pressure may be obtained and good printing quality can also be attained.

CLAIMS

1. A dot printer having a print head in which a drive arm for driving a respective printing element is biased to a first position by a permanent magnet and is controlled by electro-magnetic means acting in opposition to the permanent magnet for effecting printing, the printer having control means arranged to vary at least one of pulse width, voltage or pulse spacing of drive pulses supplied to a drive coil of the electro-magnetic means for operating the drive arm in dependence upon the temperature of the print head.

2. A dot printer according to claim 1 in which temperature detecting means are provided for detecting the temperature, the control means being responsive to an output of the temperature detecting means.

3. A dot printer according to claim 1 in which the temperature is estimated in accordance with duration of use and in which a timer is provided for measuring the printing time of the respective printing element, the control means being responsive to an output of the timer.

4. A dot printer according to claim 1 in which the temperature is estimated according to the rate of use and in which a counter is provided for counting the number of dots printed by the print head, the control means being responsive to an output of the counter.

REGISTER ENTRY FOR GB2219768

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Priority claimed:
15.06.1988 in Japan - doc: 63147624

Title DOT PRINTER

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B6F
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Publication No GB2219768 dated 20.12.1989

Examination requested 09.06.1989

Patent Granted with effect from 18.11.1992 (Section 25(1)) with title DOT PRINTER

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J MILLER & CO, Lincoln House, 296-302 High Holborn, LONDON, WC1V 7JH, United Kingdom [ADP No. 00001149001]
to
J MILLER & CO, 34 Bedford Row, Holborn, LONDON, WC1R 4JH, United Kingdom [ADP No. 00001149002]
dated 18.05.1992. Official evidence filed on 9209295.6
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**** END OF REGISTER ENTRY ****

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