Compact and Low Power-consuming Thermal Transfer Printer Unit for Built-in Use in Mobile Devices

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Abstract

We have developed the compact and low power-consuming printer unit PTMTL27. This unit is designed especially for built-in use in mobile devices such as digital still cameras and camcorders. The unit is roughly the size of a business card, is 17.7mm thick and weighs 135g. Printing is done by the thermal transfer variable dot scale method.

As a matter of course, battery-driven operation is indispensable for mobile applications. Therefore the structure around the heat elements of the print head and the drive method were optimized in order to reduce power consumption, and print operation by battery was attained. And the number of printable pages using various kinds of dry batteries is simulated in this paper.

Introduction

Recently, photo-quality printing has become easier, by the popularization of the digital still camera and the performance improvement of color printers. However, as it is necessary to use a personal computer, the process of obtaining photo-quality prints still has some inconvenient aspects. Consequently it is thought that ease of use is improved if the printer can be built into the camera, or it is possible to print by connecting directly.

Moreover, a new use of the camera is created if such a mobile printer can be achieved. For instance, it is assumed that souvenir pictures are taken at a party or when travelling, etc. The photograph can be given to the person of whom it was taken. Then, the inconvenience of mailing the photograph after developed is not needed.

Such operation is possible by the instant cameras that already exist. However, only one print is obtained via the instant camera. On the other hand, mobile printers can produce multiple prints on the spot. Therefore, the prints can be given to a few people. The capability to produce multiple prints on the spot has previously been impossible.

We are developing the compact and low power-consuming printer while assuming the usage as explained above. This paper introduces an outline of printer unit PTMTL27, which is newly developed, and explains the power consumption of this product.

Out-line of Printer Unit

The key specification of PTMTL27 is shown in table 1, and Figure 1 shows appearance and example of installing in a camcorder. The printing is done by the thermal transfer variable dot scale method, and 256 levels of dot size are available for each yellow, magenta, and cyan plane.

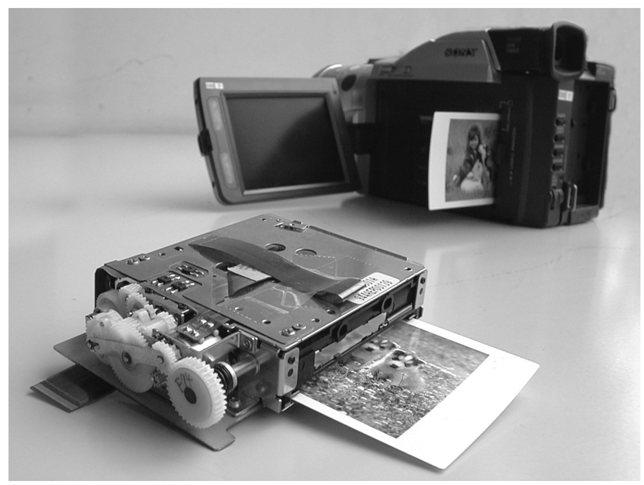

Figure 1. Appearance of PTMTL27 (front) and a camcorder which the unit is built-in (back)

Table 1. Specification of PTMTL27

Print Method	Thermal wax transfer
Print Head	254dpi / 480dots
Number of colors	24bit colors
Ink Cassette	Y,M,C+OP 20 cycles
Paper Size	55 x 91 mm
Print Area	48 x 64 mm
Dimensions	17.7 x 82.5 x 61.1 mm
Weight	135g

Figure 2 shows a cross sectional view of the printer unit. This printer employs the U-turn type ink ribbon route, which means the turn of the ink ribbon around the print head from the ink roll side to take-up spool. By using this layout, the maximum diameter of ink roll overlaps with the maximum roll diameter of take-up spool and, as a result, the printer was downsized.

Using the thermal wax transfer method means that the necessary electric power is 1/3 or less compared with the D2T2 method. Therefore, a heat sink for the print head and heat radiation fin like those used for the D2T2 printer are almost unnecessary. Thus, the surroundings of the print head can be designed compact as shown in figure 2. Consequentially, the depth of the printer unit could be designed thinly.

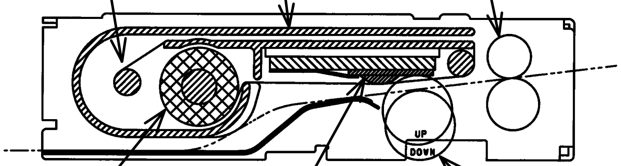

Figure 2. A cross sectional view of MTL27.

Power Consumption

As a matter of course, a mobile printer should be able to be driven by battery. Even if the power consumption is very high printing becomes possible, if a battery with high enough capacity is installed. However, if the battery becomes big and heavy, there is no sense in a downsized printer unit. It was thought that four AA batteries or less were suitable for this printer unit, and aimed at this.

The electric power necessary to drive the printer is the total power of the print head, the motor, and the electric circuit. Here, the print head is the highest in the ratio of those elements, and makes up the majority of total power. Therefore some studies to reduce the electric power of the print head were carried out.

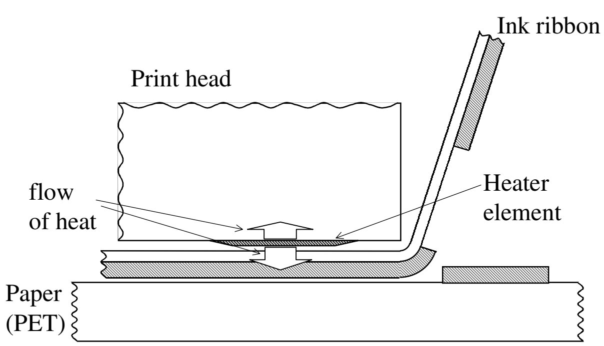

Figure 3. Scheme of ink transfer process.

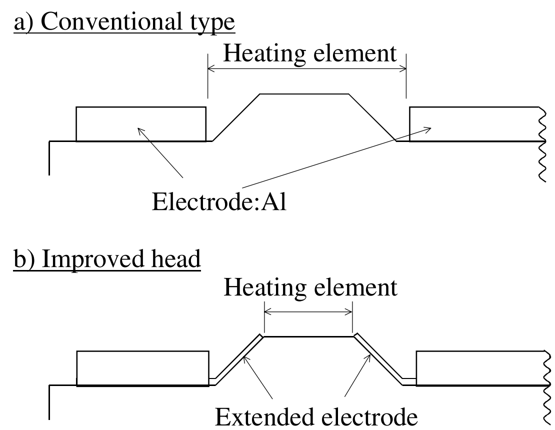

Figure 4. Structure around the heater element.

Structure of Print Head

Figure 3 is a scheme of the ink transfer process. The ink transfer occurs when the heater element of the print head melts the ink. It is necessary to heat the ink efficiently in this part, and keeping back the heat that flows from the heater element to the substrate side is a key factor.

Figure 4 shows the schematic diagram around heater element. To improve contact with the ink ribbon, the heater element has been shaped in a convex structure that sticks out from the thickness of the electrode as shown in figure 4.

As the result of the some studies of a conventional type of print head, it was found that the slope in the convex part generates heat but it has been understood to contribute only a little in the heating of the ink ribbon. Then, the slope was covered with the electrode thin enough to allow good contact of the convex part to the ink ribbon. As a result, the slope part no longer generated heat, and the electric power necessary to transfer the same area of ink could be reduced by 25%.

Head Driving Method

The print head is a parallel resistor circuit and heating resistance aligns a number of dots. Therefore, a large current flows when all dots are turned on at the same time. The wiring pattern of the resistor circuit should be made bold to reduce the voltage drop, which occurs when the current is high. This has the undesired effect that the printing head becomes large.

In order to reduce the current the dots to be energized are divided into groups, which are energized separately. Figure 5 shows it in a schematic. Here, the pulse width of one dot shortens necessarily when the number of division is increased without changing the print speed as show. Because the transferred dots are small as it is, it is necessary to drive using a high voltage. As a result, it would seem that the electric power, a product of the current and the voltage, is unchanged even if the number of dots energized at the same time decreases and the current decreases.

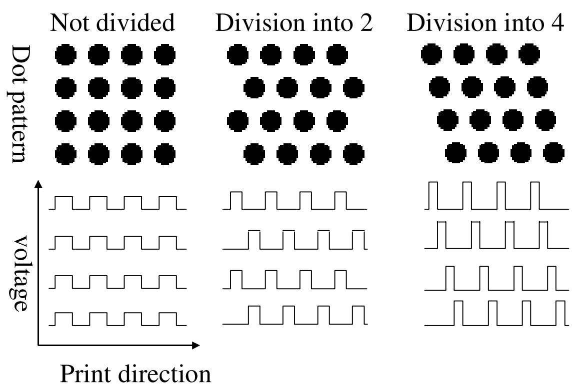

Figure 5. Example of dot pattern and shape of drive pulse when division drive is done.

However, it was found by experimentation that the power for the print head decreases by increasing the number of divisions of energized dots. Sufficient voltage to produce the same print density under each division condition was applied and the total electric power of the print head calculated.

Figure 6 shows the result of the experiment. As shown in the figure, the electric power for each dot increases when the number of division is increased. Nevertheless, if the number of dots turned on at the same time is multiplied, and the total electric power of print head is calculated, the power tends to decrease as the number of divisions increase. It is thought that the diffusion of heat to the substrate became small when the number of divisions is increased and the heat time of each dot shortens. This method improves the thermal efficiency, which is proved by the observed decrease in the temperature rise of the head unit under printing with an increase in divisions.

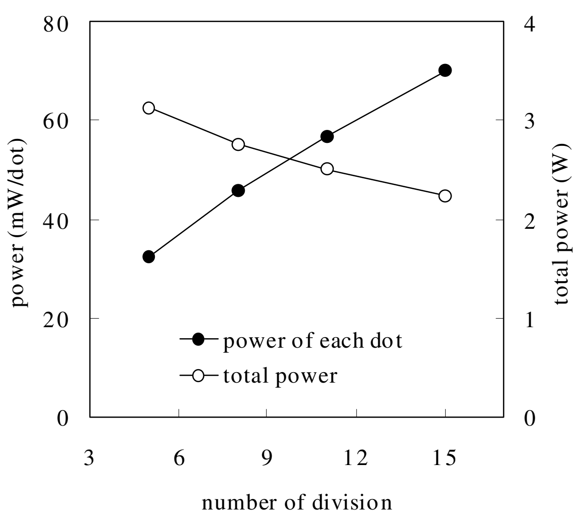

Figure 6. Relationship between division number and head power.

This printer aggressively applies this phenomenon. That is, the number of division is made as high as possible within the range where resolution of controlling tone reproduction does not become a problem. Consequently, a reduction of power consumption is achieved.

Performance when Driven by Battery

Figure 7 is a bar graph of the electric power of the head, the motor and the circuit, which are required for printing. The time needed to print one page was also shown in figure 7. The electric power of the print head shown in the figure is a result of the reduction attained by these methods.

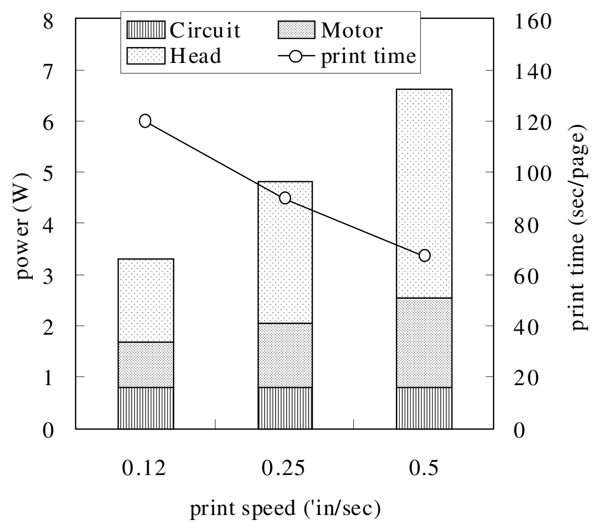

Figure 7. Relationship between print speed and power consumption.

The case that the total electric power is supplied with the AA type dry battery was assumed, and the performance was simulated. The specification of the battery used for the simulation is shown as follows.

Alkaline battery	2100mAh	1.5V
Nickel metal-hydride battery	1300mAh	1.2V
Lithium-ion battery	780mAh	3.7V

The maximum current that can be discharged is different depending on the kind of the battery. The maximum electric power of a battery was calculated as 3 times the denotation capacity about NiMH battery, and 2.5 times for Li-ion battery. For the alkaline battery, the value generally used does not exist, however, from the result of our experiments it was assumed to be 0.6 times.

Figure 8 shows the relationship between print speed and the electric power required for the printing operation. In addition, the maximum electric power of the battery, described above, is shown in the horizontal line. The point where the curve of the electric power crosses each battery horizontal line indicates maximum print speed driven by the battery. It is possible to print at a practical speed by two or more in the alkaline battery and one in NiMH battery and Li-ion battery as shown.

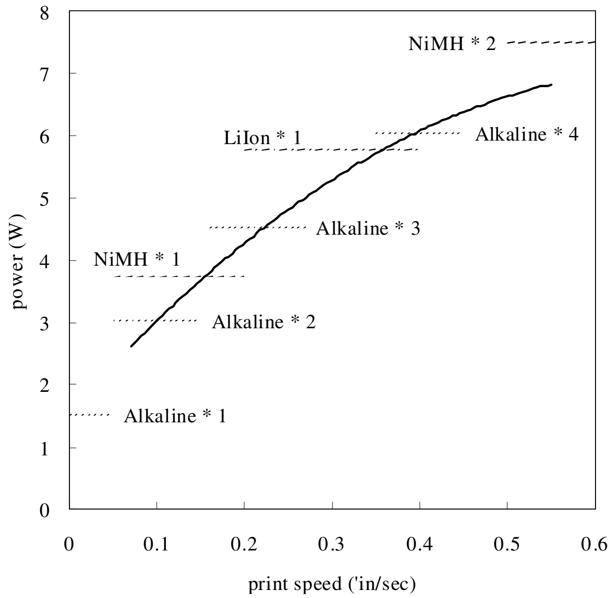

Figure 8. Relationship between print speed and electric power which required for printer unit.

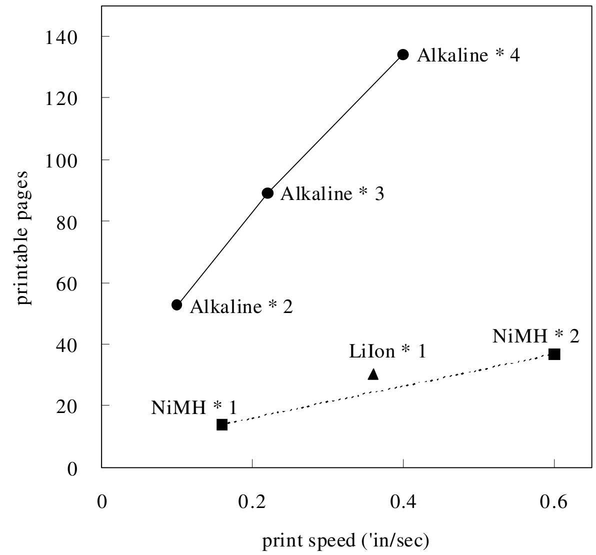

Figure 9. Relationship between print speed and the number of printable pages while operated by different kinds of battery.

The number of printable pages that can be printed with a set of battery is an important consideration for the mobile printer. Then, energy requisite to print one page is calculated by multiplying the print time to the electric power at each print speed. Subsequently, the energy that the battery contained was divided by energy requisite to print one page, and the numbers of printable pages of each kind of battery calculated.

Figure 9 is the results of the calculation. As shown, when a few alkaline batteries are used, a sufficient number of pages can be printed. On the other hand, it might be seem that the number of printable pages when using NiMH and Li-ion batteries is low. However, this is a value calculated when black is printed on the whole area of the page and in a low temperature environment (10 degrees centigrade). Therefore, when a usual picture is printed at the normal temperature, about twice the number of pages can be printed. In addition, because the number of pages that can be printed with one cartridge is 20, it seems to be an acceptable performance.

Conclusion

The compact and low power-consuming printer unit that has been developed for built-in use in mobile devices was introduced. And the methods that reduce the electric power of the print head were described. In addition, the performance when driven by battery was simulated.

A further direction of this study will be to improve the performance when driven by battery. To do that, we plan to search for a method to reduce the power consumption.

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Biography

Shin'ichi Sagawai received his M.Sc. degree in engineering from Nagaoka University of Technology, Japan in 1988. Subsequently he joined Alps Electric Co., Ltd., System Devices Division and has been working on the development of thermal transfer technology. His interests are mainly in the control of the thermal print head and image processing. He received a technical award from The Society of the Electro-photography of Japan in 1996.