A dot-matrix thermographic printing head is disclosed which is particularly adapted to print on the thermosensitive record while that record is in continuous relative motion with respect to said printing head (i.e., “in flight”) comprising a plurality of printing surfaces each adapted to be selectively actuated and each having a printing surface in the form of a long thin rectangle. There is also disclosed spring arrangements which assure that changes in the length of the print heads due to electronic erosion are compensated for automatically. There is also disclosed electronic arrangements to prevent the head from overheating due to successive activations.

4 Claims, 8 Drawing Figures
THERMOGRAPHIC PRINTING ARRANGEMENT

The present invention relates to a non-impact printing unit of the thermographic type which responds to input electric impulses to produce visible markings on a heat sensitive recording member.

The invention utilizes printing electrodes which taper down to a relatively thin printing point; the taper causes the current which is passing through the print electrode to sharply increase in density in the region of the printing surface, thereby causing rapid and isolated heating. When the electric potential is relaxed, the printing surface cools in a relatively short time because of the significant difference in mass between the large unheated tapered portion of the electrode and the small heated tapered portion.

The printing surface is not square or round but rather rectangular or elongated with the short side being parallel to the direction of travel of the thermographic paper and the long side being perpendicular thereto. This feature allows the use of "on the fly" printing (printing in which the paper does not stop for each print operation) wherein the markings produced on the paper will be, practically speaking, square. That is, the visible impression on the paper is not identical in shape to the print surface but is elongated due to the effect caused by the movement of the paper past the print surface during the temperature elevation of the surface.

The print surfaces are held in firm contact with one surface of a thin conducting sheet while the thermographic paper is moved over the other surface of the sheet. The electrodes are kept in proper contact with the sheet by novel spring arrangements. Electronic circuitry is provided for assuming uniform marking of the paper even if the same electrode is successively pulsed.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a perspective view of an embodiment of the printing head according to the invention;

Fig. 2 shows a perspective view of a stack of resistive elements which are insulated from one another and immersed in a block of insulating epoxy plastic;

Fig. 3 shows a perspective view of a hollow parallel-sided support for the printing block;

Fig. 4 shows a simplified transverse view of a tape feeding device;

Fig. 5 shows a block diagram of the system used to drive the print heads in accordance with the invention;

Fig. 6 shows a block diagram of the activating circuit of a printing element according to the invention;

Fig. 7 shows a perspective view of a stack of resistive elements having convergent resistive elements;

Fig. 8 shows a further embodiment of a printing head having convergent resistive elements.

Fig. 1 shows one of the heating elements which is used to generate the heat necessary to discolor the thermographic paper (not shown). These elements are made of resistive material so that they will heat in response to an electric current. The elements have a tapered tip, which causes the current density to increase at the terminal surface, thereby causing the heating to be limited to a relatively small portion of the element and further facilitating the rapid cooling of the terminal surface. The terminal surface is not square in but rather rectangular in shape (e.g., 2 mm by 50 microns). The fact that the terminal surface is longer than wider allows one to utilize "on the fly" printing that will result in square markings (generally called "dots") instead of elongated marking which would result if the terminal surface were square or round. As is seen in Fig. 2, the elements are of different lengths permitting electrical connections to be made to the conductive portion 4; the elements are encased in insulating material (e.g., plastic) and are separated from each other by thin insulative sheets 5.

The terminal surfaces are not covered by the plastic case 7 so that they will be able to make electrical contact with metal band 10 (Fig. 3); the block of electrodes is placed in the cavity 9 of container 8 with the spring 12 urging the electrodes against metal band 10. The paper is passed over the outside surface of band 10 and, as band 10 heats in isolated regions, the paper becomes correspondingly discolored. The plastic block 7 is held in cavity 9 by the rod 13 which holds block 11 in place.

Fig. 4 shows a simplified roller arrangement for driving the thermosensitive paper 36 past the writing electrodes. Driving roller 37 and counter roller 38 pull paper 36 past drum 39; below 39 is the print head and between the print head and drum 39 is the band 10 (Fig. 3), which band is not shown in Fig. 4.

Fig. 5 shows a typical electronic driving arrangement for the printing heads 28. Electrode driving network 27 is connected between a conventional read only memory (ROM) 20 and the print heads 28 which are in contact with the grounded metal bands. The ROM 20 is fed by any one of a number of conventional input means (computer, bookkeeping machine, etc.), which is depicted by the arrows to the left of the ROM 20.

The circuitry for triggering the driving network 27 forms no part of their invention and is included in this description in order to disclose the mode in which the invention is intended to be utilized.

The characters fed to the ROM 20 may consist of a 6-bit parallel code which the ROM 20 converts into the code corresponding to a representation in accordance with a 5 \times 7 dot matrix.

The ROM 20 is fed by another set of channels adapted to control the sequential printing of columns of the character according, via trigger circuit 22, to the 5 \times 7 format. These channels represent the output of scanning network 21, which network is activated by the same device (not shown) which feeds ROM 20. Scanning network 21 forms no part of this invention.

Trigger circuit 22 starts the operation of an oscillator 23 which feeds ring counter 24 which consists of seven bistable elements (the counter 24 is of the type described by R.K. Richards in "Digital Computers" at page 205). Each bit is shifted through ring counter 24 and excites each of the five output channels, which channels are connected to gates 29. The seventh stage of ring counter 24 is connected to stop circuit 30 which is in turn connected to oscillator 23; the stop circuit 30 responds to the output signal of said seventh bistable element by stopping the oscillator 23.

The oscillator 23 is also connected to a regulating circuit 25 (which consists of a monostable multivibrator) which controls the duration of the activation of gates 29.

The output of ROM 20 consists of seven output leads corresponding to the number of resistive elements 1 (Fig. 1) of the printing head.

The output leads terminate at electrode driving network 27 which includes individual energizing circuits.
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26; the energizing circuits 26 amplify the signal power to a level necessary for imprinting the signals onto the paper during the printing operation. Each energizing circuit 26 is connected to a printing device 28 of the head consisting of a resistive element 1 contacting the metal band 10 (FIG. 3).

The details of a single energizing circuit 26 are shown in FIG. 6; all seven energizing circuits 26 share a stabilized voltage generator 41 and long term compensation network 40 (generator 41 and network 40 are not shown in FIG. 5). The output of long term compensation network 40 (which network includes a resistor 42 and a capacitor 43) is connected to transistor 44; transistor 44 is switched by signals from ROM 20 which are connected to the transistor 44 by means of resistor 46.

The output of transistor 44 is connected to phase leading network 47, which network is connected to ground via resistors 51 and 52. The phase leading network 47 includes resistors 48 and 49 and capacitor 50. Power stage 54 is a conventional amplifier which accepts the output of network 47 and, after properly amplifying this output applies it, via resistor 58, to the printing element. Power amplifying stage 54, which includes a n-p-n transistor 55 connected as anode follower, is controlled by a pair of transistors 56 and 57 connected according to the Darlington scheme.

The printing elements undergo a succession of heating and cooling cycles during operation; if the same element is rapidly successively pulsed, it will not have sufficient time to cool. This will result in a gradual overheating of the element which, in turn, results in the printed dot to grow increasing darker. In order to have an uniform printing, the energizing current which is applied to the printing element should decrease as the frequency of energizations increases.

According to the invention, there are two compensation networks which cause the gradual decrease in energizing current as the frequency of activations increases.

FIG. 6 shows long term compensation network 40 and short term compensation network 47. As has been stated, generator 40 and network 40 are common to all the energizing networks 26 (FIG. 5). When the printer (as opposed to any particular printing element) is continuously used the entire printing head (i.e., all of the elements 28 of FIG. 5) becomes overheated. To this end long term network 40 is utilized to decrease the energizing current. If the printer is not being used or the elements are not being rapidly activated, the capacitor 43 of network 40 has time to completely charge. When transistor 44 is switched on by ROM 20, a large pulse will pass through the transistor 44. If the transistor 44 (or any of the other energizing circuits 26, FIG. 5) is shortly thereafter energized, a somewhat weaker pulse will pass through 44 since the capacitor 43 has not yet had time to completely recharge. This compensation network 40 assures that the entire printing unit will not overheat due to rapid printing.

The short term compensation network 47 (or phase leading network) assures that any particular printing element 28 (FIG. 5) will not overheat. The first pulse through transistor 44 passes through capacitor 50 as if that capacitor were a short circuit. The pulse does however charge the capacitor 43. The capacitor immediately begins to discharge through resistors 49 and 48 and in a short time returns to its normal state. If, however, a second pulse is passed through transistor 44 before capacitor 50 has a chance to discharge, the amplitude of that pulse will be decreased by an amount which corresponds to the shortness of the elapsed time between the two pulses. Therefore the amount of energizing current which passes through amplifier 54 depends upon the energization frequency of the entire print head and of any particular print element.

FIG. 7 shows an actual printing unit which includes a housing means 61 and support plane 62 having thereon a printed circuit 63 consisting of seven conductive paths 4 on one side, 4 on the other. The seven elongated flat resistive elements 64 are perpendicular to the plane of the support 62. The end portion of each resistive element is coated with a thin copper layer and is soldered to the corresponding conductive path 63.

The terminal portion 65 of the tapered end of each resistive element 64 is substantially flat and is held in firm contact with band 66 by the action of spring 67. The resistive elements 64 are aligned so as to have coplanar the terminal portions 65 and are immersed in a block of insulating plastic except for the terminal portions 65.

FIG. 8 shows a further embodiment of the thermographic printing head which includes a rigid housing means made of three elements 71, 72, 73.

The element 71 consists of an insulating body, one face thereof has a recess while the opposite face has a flat projection having the same dimensions as the recess. An element 72 consists of an insulating body having the same dimensions as the element 71 and is provided with a corresponding recess and projection so that each element can accommodate the projection of the other. Element 72 has a projection 74 which fits into recess 75 of element 73; element 73, which is a good heat conductor, accommodates metal band 77 in groove 76.

The grooves seen in elements 71, 72 and 74 receive the seven flat resistive elements 78; insulative plate 81 is placed between the exposed edges of elements 78 and the wall of cavity 75 of element 73. Springs 80 insure that each individual element 80 is held in firm contact with metal band 77; the springs rest in clamps 79 which, in turn, rest in the grooves of element 71.

It is important that the elements 78 be held in firm contact with the metal band so that there will be no contact resistance between the elements and the band. It is the electrical resistance of the elements 78 which is to determine the heat generated, not the contact resistance between the elements and the band. This is imperative since the contact resistance is difficult to control.

The dimensions of the printing head (FIG. 2) have a substantial bearing on the performance of the unit. Good results are obtainable by using graphite resistive elements 0.2 mm thick, 1.5 mm wide, 15 mm long and having a V-shaped 90° angled end portion, the edge of the portion should be beveled and the print surface should be flat and with an area of 0.01 mm². For a printing rate of 200 characters per second, the required input thermic power should be 8 Watts for 0.3 mscm which is supplied by a 2.5 Amp current impulse lasting 0.3 mscm. This power is capable of producing good printing on thermosensitive paper through a steel metal band which is 20 µm thick.

What we claim is:

1. In a thermographic printing unit, a plurality of printing elements, each being connected to a source of
electric energy and each having an end in contact with one surface of a heat conductive element, the opposite surface of said heat conductive element being adapted to support moving thermosensitive paper, said end of each of said printing elements having a printing surface, the surface having a longitudinal dimension which is substantially greater than the latitudinal dimension, said longitudinal dimension being perpendicular to the direction of movement of said paper, each of said printing elements having a rectangular body and a tapered portion, the tapered portion being between the printing surface and the body.

2. The unit according to claim 1, wherein each element is held in contact with said heat conductive element by means of a spring.

3. In a thermographic printing unit including a plurality of printing elements, each element having an individual activating unit, the plurality of elements sharing a voltage source and a long term compensation network, said long term network having a capacitor which is charged by said source and which supplies the individual activating units with energy, said activating units having a short term compensation network which includes a resistor in parallel with a capacitor, said long and short term networks being connected by a switch.

4. In a thermographic printing unit, a plurality of printing elements, each being connected to a source of electric energy and each having an end in contact with one surface of a heat conductive element, the opposite surface of said heat conductive element being adapted to support a thermosensitive paper in continuous relative motion with respect to said thermographic printing unit during each printing operation, said end of each of said printing elements having a longitudinal dimension which is substantially greater than the latitudinal dimension, said longitudinal dimension being perpendicular to the direction of movement of said paper, each of said printing elements having a rectangular body and a tapered portion, the tapered portion being between the printing surface and the body.

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