

SPECIFICATION

Non-impact printing device with selective emission of solid ink particles

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The present invention relates to a device for recording graphic symbols on ordinary paper by means of selective emission of ink particles by an ejector.

Devices of the aforesaid type are known wherein drops of liquid ink are emitted selectively through a nozzle by an ejector device actuated through the medium of a piezoelectric crystal and wherein to every electrical stress applied to the crystal there correspond a compression of the volume of the chamber containing the ink and a corresponding emission of drops through the nozzle.

Devices are moreover known wherein the emission of drops is caused by applying a potential difference between the conductive liquid ink and the mouth of the nozzle (U.S. Patent 1,958,406).

One of the problems which arise with the aforesaid devices known in the art is that the liquid ink encrusts the nozzle and ends by blocking it in the course of time. The choice of special water-based inks does not permit the problem of encrustation to be solved completely.

The object of the present invention is therefore to provide a recording device with selective emission of ink particles by an ejector which is free from encrustation problems. The invention is defined in claim 1. The rod can consist of carbon black compressed with 5% to 20% of stearic acid as binder.

The invention will be described in more detail, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal section of a first embodiment of the printing device according to the invention;

Figure 2 is a longitudinal section of a second embodiment of the printing device according to the invention;

Figure 3 is a perspective view of a serial printer using a printing device according to the invention;

Figure 4 is a logic diagram of the control unit of the printer of *Figure 3*;

Figures 5a, b, c, d, are time diagrams of the signals generated by the control unit of *Figure 4*;

Figure 6 is a perspective view of a series-parallel printer using a printing device according to the invention.

Referring to *Figure 1*, the printing device 10 comprises a hollow cylinder 11 of electrically insulating material, such as glass, ceramic or thermosetting resin, which is closed at one end by a wall 12 in the centre of which there is formed a hole 13 flared towards the inside, with a diameter of the order of 1/10 of a millimetre so as to assume a substantially frustoconical longitudinal section.

On its outer surface 14 the wall 12 has a circular projection 15 in correspondence with the hole 13.

A circular electrode 16 having a hole 17 in the centre is mounted on the outer surface 14 and on the circular projection 15 in such manner that the hole 17 is concentric with the hole 13. The circular electrode 16 may be obtained by means of metallization of the

outer wall surface 14.

Inside the hollow cylinder 11 there is mounted a cylindrical rod 19 of electrically conductive ink having a diameter slightly smaller than the inner diameter of the hollow cylinder 11 and obtained by compressing carbon black (80%-95%) with a binder (5% - 20%) of the type: waxes of various kinds, fatty acids, paraffins, cellulose resins and glycols. One end 19a of the rod 19 is pushed against the wall 12 by the action of a spring 20 compressed between the opposite end 19b of the rod 19 and a metallic abutment element 22, which can be fixed removably to the hollow cylinder 11, for example inserted therein as a plug.

The circular electrode 16 is connected to the positive pole of a high voltage generator 23 via a break circuit 24; the solid ink 19 is connected to the negative pole of the high voltage generator 23 via the abutment element 22 and the spring 20.

By applying a potential difference of the order of 4000 V between the two electrodes 16 and 22 by means of activation of the break circuit 24, erosion of ink particles from the surface 19a of the rod occurs and they are emitted through the hole 13 against a recording sheet 25 located at a distance of 0.5 to 5 mm, forming thereon a sufficiently clear and focused black dot.

The physical explanation of the phenomenon is not exactly known; it is probably to be looked for in the formation of an electric arc between the surface 19a of the ink rod 19 and the electrode 16, with a consequent transport of ink towards the electrode 16 and, because of the hole 13, against the recording sheet 25; a concomitant effect is probably that due to breakdown of the air dielectric in the conical hole 13, which causes a pressure wave inside the hole and in the adjacent area inside the hollow cylinder such as to "fire" the eroded particles against the recording sheet 25 and keep the hole 13 constantly clear from encrustations. The conviction that the predominant cause of the phenomenon is due to the electric arc is reinforced by the fact that on inverting the polarities of the foregoing connection (that is, positive pole to the ink rod) the phenomenon does not manifest itself in optimum manner. In fact, for formation of the electric arc, it is necessary that there be heating of the cathode and this does not occur when the cathode is located on the metallic electrode 16 instead of on the solid ink.

Surprisingly the inversion of polarity causes, on the other hand, a phenomenon of sucking back of the particles deposited on the recording sheet towards the hole 13, with at least partial erasure of a previously printed dot.

Starting with a plane surface 19a, the erosion of the rod 19 is not uniform, at least initially, over the entire surface, but is greater in the centre and steadily falls off towards the edges and, for obvious reasons of symmetry, after a prolonged number of discharges, the surface 19a therefore acquires the form of a spherical cup, as shown in *Figure 1*.

For correct functioning of the device, it is necessary that the erosion also take place at the places where the curved surface 19a bears against the wall 12, so as to permit the supply of fresh ink by

means of a sliding action of the rod 19 produced by means of the spring 20.

It has been found that with an average diameter of the hole between 0.1 mm and 0.5 mm and a length of the hole between 0.6 mm and 1.5 mm, with a diameter of the rod 19 between 2 mm and 3 mm and with the spring applying a force of from 200 g to 500 g, the supply of ink takes place regularly and the repeatability of the printed dot is ensured.

Optimum results are obtained with the aforesaid dimensions by applying between the electrodes 16 and 22 a pulsed potential difference of the order of 4000 V, with a duration T_d between 1 and 200 μ s and with a waveform substantially of the type shown in Figure 5d with $V_i \approx 4000$ V and $V_e \approx 2500-3000$ V.

With these values, a printing speed of 5000 dots per second has been achieved, with good visibility of the printed dot.

The position and the shape of the electrode 16 have no effect on the operation of the device and, in fact, good results have also been obtained with the device of Figure 2, in which a potential difference is generated between the recording sheet 25 and the ink block 19 by placing the second electrode 16 behind the recording sheet 25, with the hole to recording sheet distance of the order of 0.5 to 1 mm. On the other hand, in this second embodiment, the phenomenon of erasure of the printed dot is accentuated by inverting the polarity between the two electrodes 16 and 22.

The printing device hereinbefore described constitutes a low-cost printing head 10 which can be employed with advantage in serial, series-parallel and parallel alphanumeric printers for office machines and, moreover, for plotter devices and for facsimile applications. Figure 3 shows an embodiment of a serial printer using the printing device or head 10.

Two printing heads, 10a, 10b are mounted on an endless belt 35 which passes round toothed wheels 38 and 39 so that the runs 35a and 35b of the belt are parallel to the printing line of the recording sheet 25 passed around a platen 40 advanced by elementary line-spacings by means of a stepping motor 41. The endless belt 35 is driven to rotate clockwise (in Figure 3) at constant speed by means of a DC motor 42.

The electrode 16 of each of the heads 10a and 10b is connected to earth through the belt 35. Parallel to the upper strand 35a of the belt 35 there is mounted a metal strip 45 connected in a control logic unit 69 (Figure 4), via an energizing circuit 99 to the negative pole of a high voltage generator 100, the positive pole of which is earthed.

The heads 10a and 10b are spaced equally apart on the endless belt 35 so that when one is located at the left-hand end of the strand 35a the other is located at the right-hand end of the strand 35b.

Each of the heads 10a and 10b transported by the belt 35 moves in the upper run 35a with the rear electrode 22 a few millimetres distant from the metal strip 45 and no metallic connection exists between the strip 45 and the electrode 22. The high voltage pulses are transmitted by the strip 45 to the electrode 22 through the medium of an electric arc via

the air dielectric.

On the belt runs 35a, 35b there are moreover formed pluralities of notches 58a, 59a and 58b, 59b adapted to be detected by photocell sensing devices 60 and 61, respectively (Figure 3).

The notches 59a and 59b follow the printing devices 10a and 10b, respectively, in the direction of movement of the belt 35 and cause the sending of strobe signals TT (Figure 5a) to the control unit 69 (Figure 4) through the medium of the sensing device 60, the strobe signals being adapted to define the printing positions for each dot along the printing line.

The first notch 58a and 58b (Figure 3) of each run is detected by the photocell device 61, which sends to the control unit a signal TI (Figure 5b) which enables the beginning of the printing of a fresh line of dots and which commands the carrying out of an elementary line-spacing operation of the platen 40 by means of the stepping motor 41.

The control logic unit 69 of the printer (Figure 4) comprises a shift register 70 within which there is stored the information relating to a line of print which comes from the channel 71, for example the output channel of the central unit of a processor to which the printer is understood to be connected.

The signals PR and PL coming from the said processor on wires 72 and 73, respectively, are also applied as input to the control logic unit and, when at logical 1 level, select a plotter (PL) operation mode and a printer (PR) operation mode, respectively, for the control logic unit.

In the first case ($PL = 1$), there is a one-to-one correspondence between the storage cells of the register 70 and the dot printing positions of the printing line.

Each storage cell of the register 70 will therefore have stored therein an information bit at logical 0 level if a dot does not have to be printed in the corresponding printing position, or a bit at logical 1 level if, on the other hand, a dot must be printed in the corresponding printing position.

In the second case ($PR = 1$), the register 70 is regarded as divided into groups of eight storage cells (bytes), each of which is adapted to store a binary code of an alphanumeric character and each of which corresponds to a printing position of a character within the printing line. Assuming the characters are printed in matrices of seven rows by five columns of dots, there is a character printing position for every five dot printing positions.

The signals TT coming from the light-sensing device 60 are applied as input count signals to a column counter 80 through an AND circuit 81 enabled by the condition $PR = 1$. The counter 80 counts cyclically from 1 to 5 and, on reaching its maximum counting capacity (5), is adapted to emit a signal T5 on its output 80b.

The signals TI coming from the light-sensing device 61 are applied as input as count signals to a row counter 82 through an AND circuit 83 enabled by the condition $PR = 1$. The counter 82 counts cyclically from 1 to 7 and, on reaching its maximum counting capacity (7), is adapted to emit a signal T7 on its output 84. The signals TT are moreover

applied as input count signals to a counter 140. The counter has a maximum counting capacity equal to the number of storage cells of the register 70 and generates a signal MA at logical 1 level when it reaches its maximum counting capacity.

In the operation of the printer, the counters 80, 82 and 140 therefore define that dot of the 7×5 matrix of which possible printing is enabled in the printing position identified by the counter 140.

The outputs 80a and 82a of the counters 80 and 82 are applied as input, through the medium of the AND circuits 85 and 86 enabled by the condition $PR = 1$, to a ROM (read only memory) 90 which also receives as input, through the medium of the channel 87 and the AND circuit 88, the binary code of the alphanumeric character contained in the byte 89 most to the left of the register 70.

The ROM 90 has stored the printing and non-printing information for each dot of the 7×5 matrix identified by the counters 80 and 82 for each printable alphanumeric character (space included) identified by the byte 89. The ROM 90 supplies a signal at logical 1 level as output on the wire 91 if the identified dot of the matrix is to be printed for formation of the identified character, and at logical 0 level in the opposite case.

With the condition $PR = 1$, the output 91 enables the AND circuit 95 which, with the timing of a signal TR supplied by a timing unit 96 and via the OR circuit 97, activates the energizing circuit 99 interposed between the negative pole of the high voltage generator 100 and the strip 45, and, by energizing the printing head 10, causes the printing of a dot on the recording sheet. The energizing circuit of the high voltage generator can moreover be activated in the plotter operation mode ($PL = 1$) through the medium of the OR circuit 97 and the AND circuit 98, the latter being enabled by the condition $PL = 1$ and by the presence of a bit at logical 1 level in the storage cell 89a on the extreme left of the register 70, with the timing of the signal TR.

The timing circuit 96, which is of known type, receives as input the signals TT, the signals T5 and the signals PR and PL and is adapted to emit, on the output 101 and as input to the register 70, a signal SR for a shift to the left for each signal TT received if $PL = 1$, and eight consecutive signals SR for a shift to the left for each signal T5 received if $pr = 1$, with a predetermined delay with respect to the signals TT and T5 (Figure 5). The timing circuit 96 moreover emits as output a signal TR for each input signal TT.

During the printer operation mode, a channel 107 enabled by the condition $PR = 1$ connects the output of the byte 89 of the register 70 with the byte 105 on the extreme right of the register 70.

Therefore, with $PR = 1$, at each advance of the belt 35 by five notches (at each signal T5), the alphanumeric codes stored in the register 70 are translated to the left by one byte by means of eight signals SR and the code of the byte 89 is stored in the byte 105, so that the code of the alphanumeric character adjacent that previously processed for the printing of a dot matrix row is applied as input to the ROM 90 by way of the channel 87.

With $PL = 1$, on the other hand, at each advance by

one notch 59, the contents of the storage cells of the register 70 are translated to the left by one cell, so that the information bit adjacent that previously processed for the printing of a dot is stored in the cell 89a and that previously processed is lost in the shift. With $PR = 1$, the contents of the register 70 are renewed by the processor, to which the printer is connected, with the rise to 1 of the signal MA following the rise to 1 of the signal T7, with enabling of the channel 71 through the medium of the AND circuit 112 and the OR circuit 113.

With $PL = 1$, on the other hand, the contents of the register 70 are renewed by the processor at each signal $MA = 1$ through the medium of the AND circuit 112 and the OR circuit 114. Each signal T1 moreover activates the driving circuit 110 of the stepping motor 41 for the execution of a corresponding elementary line-spacing, while with $PR = 1$ the signal $MA = 1$ following the rise of the signal T7 to logical 1 level activates the driving circuit 110 through the AND circuit 120 for the execution of three consecutive elementary line-spacings corresponding to the space between one line of characters and the next. Since the printing commands for the heads 10 are applied to the strip 45, and not directly to the electrode 22 of the head by means of a metallic connection, they are effective only for that head 10 which is running adjacent the strip 45 during the application of a command.

The control unit therefore pays no regard to the presence of one, two or more heads, provided that each head is accompanied by reference notches which allow the position thereof to be detected and the command pulses on the strip 45 to be synchronized with the position.

In addition to permitting contactless control of the head 10, it has been found that the electric discharge which develops between the strip 45 and the rear electrode of the head assists the formation of the electric arc between the ink rod 19 and the electrode 16 and, therefore, also the emission of ink particles for the printing of the dot.

In accordance with another embodiment of the present invention, Figure 6 shows a series-parallel printer 200 in which a plurality of heads 10 is mounted on a carriage or slide 201 in such manner that they are aligned and spaced regularly parallel to the printing line of the recording carrier 225 advanced by elementary line-spacings through the medium of the stepping motor 205.

The carriage is made to oscillate parallel to the printing line by means of the eccentric device 210 driven by the DC motor 211. The number of heads 10 mounted on the carriage 201 may be equal to the number of characters which can be written in a line of print and in this case the stroke of the carriage will be at least equal to the width of a character of the line and each head 10 will describe at each oscillation a row of dots of the matrix of an alphanumeric character and, through repeated oscillation, all the matrix dots of a character of the line of print.

Alternatively the number of heads 10 may be equal to one half of the number of characters which can be written in a line of print and the stroke of the carriage will then have to be at least equal to the

width of two characters plus an intercharacter spacing and each head will describe all the matrix dots of two adjacent characters of the line of print through repeated oscillations of the carriage.

- 5 The printing command is given simultaneously to all the printing heads 10 through the medium of a control unit 220 by simultaneously reading from the memory in a known manner the printing information of one line at a time (Figure 6), which, through a cable 222 and the electrodes 22, effect the selective and simultaneous activation of emission means 19 of all printing devices 10 for a number of times equal to the number of columns in the character matrix during a passage of the carriage 201 produced by the eccentric device 10. In addition the line spacing means 205 is conditioned to advance the recording sheet 225 during each reversal of movement of the carriage 201, whereby a line of characters is printed during a number of consecutive passages equal to the number of rows in the character matrix.

- 20 The front electrodes 16 of the heads 10 are replaced in the printer 200 by a single electrode 223 located behind the recording sheet 225 and connected to earth, in accordance with the configuration already described with reference to Figure 2:

- 25 Attention is drawn to an application No. 8027305 (Serial No.) divided out of the present application and having claims directed towards the solid ink cartridge itself.

CLAIMS

1. Non-impact printing device for printing graphic symbols on a recording sheet by means of selective emission of ink particles from a nozzle, characterised by means housing a rod of conductive solid ink adjacent the nozzle and means adapted to be activated selectively for establishing a potential difference along the nozzle sufficient to cause the emission of ink particles by erosion from the rod and ejection of the particles through the nozzle.

2. A printing device according to claim 1, wherein the rod of solid ink comprises a compressed mixture of pigmented particles and binder and is mounted in the housing means with an end adjacent the nozzle, the said means for selectively establishing a potential difference comprises first and second electrodes, spaced from each other with the nozzle therebetween the first electrode being electrically connected to the rod and the second electrode being located (in use) adjacent the recording sheet, and selectively activatable means for applying a predetermined high voltage across the electrodes sufficient to overcome the binding action of the binder on the solid ink particles of the rod adjacent the nozzle to cause erosion thereof from the rod, to eject them through the nozzle and to move them rectilinearly toward the sheet.

3. A printing device according to claim 2, wherein the housing means is movable along a printing line whereas the first electrode is fixedly mounted and comprises a bar extending along the printing line.

4. A printing device according to claim 2 or 3,

wherein the voltage is sufficient to create an electric arc between the rod and the second electrode.

5. A printing device according to any of claims 2 to 4, wherein the said mixture is formed from 80 to 95 per cent of pigmented particles and 20 to 5 per cent of binder.

6. A printing device according to any of claims 1 to 5, wherein the conductive solid ink comprises a compressed mixture of steric acid and carbon black.

7. A printing device according to any of claims 1 to 6, wherein the housing means comprise a chamber adjacent to and in communication with the nozzle, and means for pressing the rod in the chamber towards the nozzle.

8. A printing device according to claim 1, wherein the said means for establishing a potential difference comprise a first electrode in electrical contact with the rod, a circular second electrode mounted coaxially with the nozzle and externally thereof in the zone between the nozzle and the recording sheet, and a selectively activatable high voltage generator having its opposite poles connected to the electrodes.

9. Printing device according to claim 1, wherein the said means for establishing a potential difference comprise a first electrode in electrical contact with the rod, a second electrode located behind the recording sheet, and a selectively activatable high voltage generator having its opposite poles connected to the electrodes.

10. A printing device according to claim 2, 8 or 9, wherein the first and second electrodes are connected to the negative and positive poles, respectively, of the high voltage generator.

11. A printing device according to any of the preceding claims, wherein the distance of the nozzle from the recording sheet is in the range of 0.5 - 1 mm.

12. A printing device according to any of the preceding claims, wherein the diameter of the nozzle is in the range of 0.1 - 0.5 mm and the diameter of the rod is between 2 and 3 mm.

13. A printing device according to any of the preceding claims, wherein the potential difference reaches a peak of the order of 4,000 V.

14. A printing device according to claim 13, wherein, in operation, a pulsed potential difference is applied having a duration between 1 and 200 μ s with a first peak of the order of 4,000 V followed by a drop to a value between 2,500 and 3,000 V which is maintained for a following portion of the duration of the pulse and drops to zero at the end of the pulse.

15. A printing device according to claim 14, including means for so relatively displacing the housing means and the recording sheet as to cause the printing in a series of consecutive locations, the duration of the pulsed voltage being less than the duration of the relative movement of the housing and sheet.

16. A printer employing one or more printing devices according to any of claims 1 to 15, comprising means for moving the or each of the printing devices along a path parallel to the printing line, line-spacing means for incremental advance of the recording sheet transversely of the printing line, and means for detecting the position of the or each



width of two characters plus an intercharacter spacing and each head will describe all the matrix dots of two adjacent characters of the line of print through repeated oscillations of the carriage.

- 5 The printing command is given simultaneously to all the printing heads 10 through the medium of a control unit 220 by simultaneously reading from the memory in a known manner the printing information of one line at a time (Figure 6), which, through a cable 222 and the electrodes 22, effect the selective and simultaneous activation of emission means 19 of all printing devices 10 for a number of times equal to the number of columns in the character matrix during a passage of the carriage 201 produced by the eccentric device 10. In addition the line spacing means 205 is conditioned to advance the recording sheet 225 during each reversal of movement of the carriage 201, whereby a line of characters is printed during a number of consecutive passages equal to the number of rows in the character matrix.

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CLAIMS

1. Non-impact printing device for printing graphic symbols on a recording sheet by means of selective emission of ink particles from a nozzle, characterised by means housing a rod of conductive solid ink adjacent the nozzle and means adapted to be activated selectively for establishing a potential difference along the nozzle sufficient to cause the emission of ink particles by erosion from the rod and ejection of the particles through the nozzle.

2. A printing device according to claim 1, wherein the rod of solid ink comprises a compressed mixture of pigmented particles and binder and is mounted in the housing means with an end adjacent the nozzle, the said means for selectively establishing a potential difference comprises first and second electrodes, spaced from each other with the nozzle therebetween the first electrode being electrically connected to the rod and the second electrode being located (in use) adjacent the recording sheet, and selectively activatable means for applying a predetermined high voltage across the electrodes sufficient to overcome the binding action of the binder on the solid ink particles of the rod adjacent the nozzle to cause erosion thereof from the rod, to eject them through the nozzle and to move them rectilinearly toward the sheet.

3. A printing device according to claim 2, wherein the housing means is movable along a printing line whereas the first electrode is fixedly mounted and comprises a bar extending along the printing line.

4. A printing device according to claim 2 or 3,

wherein the voltage is sufficient to create an electric arc between the rod and the second electrode.

5. A printing device according to any of claims 2 to 4, wherein the said mixture is formed from 80 to 95 per cent of pigmented particles and 20 to 5 per cent of binder.

6. A printing device according to any of claims 1 to 5, wherein the conductive solid ink comprises a compressed mixture of steric acid and carbon black.

7. A printing device according to any of claims 1 to 6, wherein the housing means comprise a chamber adjacent to and in communication with the nozzle, and means for pressing the rod in the chamber towards the nozzle.

8. A printing device according to claim 1, wherein the said means for establishing a potential difference comprise a first electrode in electrical contact with the rod, a circular second electrode mounted coaxially with the nozzle and externally thereof in the zone between the nozzle and the recording sheet, and a selectively activatable high voltage generator having its opposite poles connected to the electrodes.

9. Printing device according to claim 1, wherein the said means for establishing a potential difference comprise a first electrode in electrical contact with the rod, a second electrode located behind the recording sheet, and a selectively activatable high voltage generator having its opposite poles connected to the electrodes.

10. A printing device according to claim 2, 8 or 9, wherein the first and second electrodes are connected to the negative and positive poles, respectively, of the high voltage generator.

11. A printing device according to any of the preceding claims, wherein the distance of the nozzle from the recording sheet is in the range of 0.5 - 1 mm.

12. A printing device according to any of the preceding claims, wherein the diameter of the nozzle is in the range of 0.1 - 0.5 mm and the diameter of the rod is between 2 and 3 mm.

13. A printing device according to any of the preceding claims, wherein the potential difference reaches a peak of the order of 4,000 V.

14. A printing device according to claim 13, wherein, in operation, a pulsed potential difference is applied having a duration between 1 and 200 μ s with a first peak of the order of 4,000 V followed by a drop to a value between 2,500 and 3,000 V which is maintained for a following portion of the duration of the pulse and drops to zero at the end of the pulse.

15. A printing device according to claim 14, including means for so relatively displacing the housing means and the recording sheet as to cause the printing in a series of consecutive locations, the duration of the pulsed voltage being less than the duration of the relative movement of the housing and sheet.

16. A printer employing one or more printing devices according to any of claims 1 to 15, comprising means for moving the or each of the printing devices along a path parallel to the printing line, line-spacing means for incremental advance of the recording sheet transversely of the printing line, and means for detecting the position of the or each



of the devices along the path for selective activation of the means establishing a potential difference in synchronism with the movement.

17. A printer according to claim 16, wherein the moving means comprise an endless belt having a straight run along the said path.

18. A printer according to claim 17, insofar as dependent on claim 8, wherein the second electrode is mounted adjacent the straight run of the belt and fixed with respect to the recording sheet, and the transmission of electric energy between the fixed electrode and the rod movable with the belt, when the generating means are activated, takes place through an electric discharge in air.

19. A printer according to claim 17 or 18, wherein printing devices are mounted on the belt spaced regularly thereon in such manner that a single printing device at a time travels along the said path.

20. A printer according to any of claims 17 to 19, wherein the detecting means comprise a plurality of notches for the or each printing device which are provided on the belt, and sensing devices for the notches.

21. A printer according to claim 16, wherein there is a plurality of selectively activatable dot printing devices according to any of claims 1 to 15 mounted on a carriage, spaced regularly along the printing line of a recording carrier and each selectively activatable for printing a dot, means for the reciprocating rectilinear movement of the carriage along the printing line and control means responsive to the position of the carriage so controlling the printing devices that, during repeated oscillations of the carriage, each of the printing devices prints all the dots of at least one character of the line of print.

22. A printer according to claim 21, wherein the number of printing devices is equal to the number of characters in a line of print, the control means effecting selective and simultaneous activation of all the printing devices for a number of times equal to the number of columns in the matrix during a passage of the carriage.

23. A printer according to claim 22, wherein the line-spacing means advance the recording sheet during each reversal of movement of the carriage, a line of characters being printed during a number of consecutive passages equal to the number of rows in the matrix.

24. A non-impact method of printing on a paper sheet, comprising the steps of locating a conductive solid body of ink close to the paper; generating a potential difference between the body and the paper, to cause the emission of ink particles by erosion from the body and their transfer on to the paper.

25. A method according to claim 24, wherein the said potential difference is obtained by charging the body at predetermined voltage with respect to another electrode adjacent to the paper.

26. A method according to claim 25, wherein the said other electrode is located on the side opposite to the body with respect to the paper.

27. A non-impact printing method for printing matrix dots on a paper sheet, comprising the steps of mounting on a movable base member a plurality

of conductive solid bodies of ink applying high voltage to selected ones among the plurality of ink bodies to cause the emission of particles of ink by erosion from the selected ink bodies and their transfer on the paper, reciprocating the base member along a printing line, advancing the paper in a direction perpendicular to the printing line, and actuating a selectively activatable pulse generator in synchronism with the reciprocation and the advance of the paper so as to apply pulses of the voltage to the selected ink bodies for defining the shape of symbols to be printed.

28. A non-impact printing method according to claim 27, wherein the ink bodies are regularly spaced on the base member along the printing line.

29. A non-impact printing method according to claim 27 or 28, wherein the number of ink bodies is equal to the number of the symbols of a printing line, and the pulses are applied simultaneously to the ink bodies a number of times equal to the number of columns of the matrix during each traverse of the base member.

30. A non-impact printing method according to claim 29, wherein the paper sheet is advanced during each reversal of movement of the base member, a line of character being completely printed after a number of consecutive passages equal to the number of rows in the matrix.

31. Printing device substantially as described with reference to and as illustrated in Figures 1 or 2 of the accompanying drawings.

32. Printer substantially as hereinbefore described with reference to and as illustrated in Figures 3 and 4 or 6 of the accompanying drawings.

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