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(54) **A multi-jet single head ink jet printer.**

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Description

The present invention relates to a multi-ink jet printer comprising:

- an ink chamber and an array of nozzle orifices; generally aligned on an axis,
- deflection plates between which ink droplets emerging from the respective nozzle orifices pass and which deflect said ink droplets substantially perpendicular to the axis of the said orifice array so as to be able to print dotted lines which extend in said direction of deflection,
- charging electrodes adjacent to the breaking point of ink filament associated with the respective nozzle orifices and a source of voltage to apply in a prearranged order selected voltages to the respective charging electrodes, each of which is capable of inducing a charge of predetermined magnitude on each droplet to cause each droplet to be directed to a predetermined position on the receiving medium,
- means of supporting the receiving medium and said array of nozzles for a relative movement thereof.

Besides, the present invention also relates to an ink jet printer in accordance with the preamble of claim 5. In addition, the present invention is related to a method of printing with an ink jet printer, wherein ink drops separated and expelled through a plurality of orifices are charged and then deflected by electrode plates, to be directed to predetermined points on a receiving medium, said receiving medium being moved in a print direction relatively with respect to said orifices and each droplet is given a charge corresponding to its placement substantially perpendicular to said relative print direction so that dotted lines which extend substantially perpendicular to said relative print direction, can be printed in a matrix format representing a printed mark or character.

Such a device and a corresponding method are known from US-A- 3,739,395.

In the known device, several arrays of nozzle orifices are arranged behind each other along the direction of relative movement with respect to the printing medium. Each of said arrays is aligned transverse to said direction. In summary, such a device acts as a kind of line printer, wherein each array of nozzles or several arrays together are covering the width of the printing medium without being moved alone the width thereof. Here, a printed symbol or character represented by a matrix of printed dots is formed by one and the same array of nozzles. Accordingly, for a paper with the ordinary width of a letter, the total number of orifices is rather large and the whole device gets complicated and expensive. DE-A-23 44 453 describes an ink jet matrix printer having an array of nozzle orifices aligned transverse to a relative print direction whereas US 4,272,771 describes a multiple-ink jet printer, wherein bands printed by different nozzles are overlapping with their outermost neighbouring lines in order to prevent black or white lines to occur along the boundary between the bands printed by different nozzles. Also in these known printers, a printed symbol or character is confined in a matrix printed by the same nozzle or nozzle array respectively.

Limited by how closely we can pack nozzles per millimeter and by jet straightness obtained by today's fabrication technology (1 to 1/2 milliradian), the print quality in the prior art printers not exceeded an equivalent of 240 dots/inch (or 10 dots/mm.).

In view of the state of art as discussed above it is the object of the present invention to provide a multi-ink jet printer as defined above, which is capable to print at high quality with increased printing speed without the need of a nozzle orifice array substantially extending along the length or the whole length of the lines to be printed.

This object is achieved by a multi-ink jet printer as defined in claim 1 and 5 respectively.

With respect to the corresponding method of printing, the object of the present invention is also achieved by a method as defined in claim 8.

The present invention as defined in claim 1 has the following structure and interlacing scheme to achieve the said objectives of SPEED with QUALITY:

Structure: An array of N nozzles (or N individual single jets) aligned in an axis substantially parallel to the relative print direction; and means to create a deflection electric field substantially perpendicular to the relative print direction.

Interlacing: Each adjacent dotted line of a letter or mark is printed by a different nozzle of the head structure

Improvements:

(1) At the same resolution, the print speed is N times faster than that of a single jet;

(2) At the same printing speed, the resolution will be $(N)^{1/2}$ times better.

An ink jet printer of the present invention in accordance with claim 1 comprises a print head containing from 2 to n jets. All jets are aligned in a straight line parallel to the printing direction. Each jet deflection is in a direction perpendicular to the print direction. Proper delay is provided to each jet during printing to

maintain a good printing quality. By the use of the multiple jets the printing speed will be increased 2 to n times faster depending upon the number of jets used. At 12 characters per inch printing, a high resolution character needs 640 print droplets at 10 dots/mm (or 240 dots/inch) resolution; and needs 1000 print droplets at 12 dots/mm. (or 300 dots/inch) resolution. While at 5 dots/mm. (or 120 dots/inch) resolution, only 160 print droplets are sufficient to form a character. A typical continuous ink jet operates at about 100,000 droplets a second. Hence, a typical single continuous jet printer prints about 50 characters per second at 12 dots/mm. resolution; about 80 characters per second at 10 dots/mm. resolution; and about 310 characters per second at 5 dots/mm. resolution. The following table lists the printing speeds as a function of process and a number of jets:

Table I Printing Speed Vs Number of Jets per Head at 132,000 droplets/second

Number of Jets/Head		1	2	4	n
12 dots/mm	2-guard-drop scheme	44 cps	88 cps	176cps	44n cps
	1-guard-drop scheme	66 cps	132 cps	264cps	66n cps
10 dots/mm	2-guard-drop scheme	68 cps	136 cps	272cps	68n cps
	1-guard-drop scheme	103 cps	206 cps	412cps	103n cps
5 dots/mm	2-guard-drop scheme	275 cps	550 cps	1100cps	275n cps
	1-guard-drop scheme	412 cps	825 cps	1650 cps	412n cps

At 12 dots/mm., a single continuous jet printer has a quality and speed comparable with that of a daisywheel printer. There is very little price performance advantage over a daisywheel printer. By adding mutli-nozzle to the print head, the present invention offers a printing speed increase by n-times (where n is the number of nozzles in a single print head), while maintaining the same high resolution quality. Furthermore, the additional structure required in accordance with the present invention is relatively nominal. The parts are known and easily fabricated and many parts can be used in common such as the ink system, the deflection plates, the gutter and recirculation system.

An ink-jet printer as is defined in claim 1 has the ink jet nozzles aligned in a straight line which is parallel with the relative print direction. Each nozzle is capable of producing a stream of ink droplets. Each droplet is properly charged to a pre-determined level and is able to be deflected by the deflection electric field to a maximum deflection of at least 1.35 times the character height perpendicular to the print direction. In other word, each nozzle in the ink jet printer prints exactly like the ink jet printer described in the Sweet patent and Lewis and Brown patent. When multi-nozzle print head is used as described, each nozzle will print a portion of the vertical dotted lines The vertical dotted lines printed by different nozzles in the array will interlace to form a high resolution character.

For example, if the array head contains two nozzles, jet "1" will print every even number of vertical

dotted lines, while the jet "2" will print every odd number of vertical dotted lines. There is a time delay for jet "2" with respect to jet "1" by (d ± 1/R)/10V seconds where:
d is the inter jet spacing in mm.,
R is the resolution in dots/mm., and
V is the printer head speed in cm./sec; or a
special delay of (dR ± 1) dotted lines.

It will then be understood that the distance between centers of two nozzles must be a multiple integer of the inter-dot distance between centers for the given resolution. If three nozzles are used, each nozzle prints only every third vertical dotted lines, i.e.,
jet "1" prints (3m ± 1)th dotted line;
jet "2" prints (3m ± 2)th dotted line;
jet "3" prints (3m ± 3)th dotted line; where m is an integer.
The time delays with respect to jet "1" are, (d ± 1/R)/10V seconds for jet "2"; and (2d ± 2/R)10V seconds for jet "3", or there are spacial displacements ("delays") with respect to the nozzle for jet "1" by (dR ± 1) dotted lines the nozzle for the nozzle for jet "2", and (2dR ± 2) dotted lines for the nozzle for jet "3".

In general, if there are n nozzles in a single head separated by a distance d between centers (d is also an integer of 1/R), each nozzle will print every nth dotted line apart. In particular, the Kth jet in the array will print every (mn ± K)th dotted line, while the first jet will print every (mn ± 1)th dotted line, where n is an integer. There exists a time delay for the Kth jet with respect to the first jet by (K-1) [d ± 1/R]/10V second, or a spacial delay (displacement) of (K-1) [dR ± l] dotted lines.

Let us now examine the electrostatic interaction between charged droplets on flight between two adjacent jets which could effect the droplet placement error. Electrostatic Coulomb force between two charged particles of adjacent jets is

$$F = K \frac{q_1 q_2}{r^2}$$

where q is the charge contained in the droplet "i", r is the distance between the droplets of adjacent jets, and K is a constant. Note that the closest distance between charged droplets from 2 adjacents jets is the distance between the jet nozzles which as a practical proposition is taken to be 1 - 3 mm. At 132,000 droplets/sec. and a droplet velocity of 2000 cm./sec., the inter-droplet spacing for a single jet is .152 millimeter, the inter-droplet spacing is 7 to 20 times closer than the inter-jet spacing. Since Coulomb force is inversely proportional to the square of the distance, correction due to adjacent jet is very small. Hence, one can ignore both the electrostatic correction as well as the aerodynamic wake effect for droplets between jets.

More specifically, the ink jet printer apparatus of the present invention employs an ink chamber or reservoir having at least two matched orifice nozzles aligned parallel to one another. Means of constant pressure or of constant flow is employed to apply pressure to the reservoir to force ink out through each of said orifices in a thin filament, including acoustic energy means generating waves of the same phase being preferred, acting on the ink to break the filament into droplets of predetermined size, each droplet being of a size to produce a dot of predetermined size in a raster of dots forming a printed character. Deflection plates are positioned so that all of the droplets pass in droplet paths from the respective nozzles each in planes transverse to the deflection plates. Deflection voltage supply means is connected to the deflection plates to impose an electrostatic field between the deflection plates. Charging electrode means is fixed relative to each orifice nozzle in position adjacent to the respective orifice nozzles along the droplet paths from that nozzle. Electrostatic shielding means may be interposed between adjacent charging electrodes to isolate charge effects imposed on droplets of one stream from droplets of another. A source of voltage is connected to the respective charging electrode means. Each charging electrode, in turn, is capable of inducing electrostatic charge on the individual droplets as they break off from the ink filament emerging from the orifice associated with the charging electrode. The droplets are then deflected into paths determined by their respective charges as they pass through the field imposed by the deflection plates. Voltage switching means is provided for applying in a prearranged order selected voltages (which may include zero voltage) to each charging electrode, as the individual droplets pass through. The selected level of voltage induces charge on each droplet determined by and different for each voltage and causes that droplet to follow a predetermined droplet path. Each droplet having the same charge will follow the same path, different from paths followed by droplets having other charges but all of which droplet paths lie in a

common plane transverse to the deflection plates. Ink collector means is positioned for collection of non-print ink droplets for all nozzles moving along the predictable paths generated by a particular selected level of voltage typically at zero potential. Means is supplied for supporting paper in position such that droplets moving along paths in a plane from an orifice nozzle will impinge the supported paper at points along a line opposite that orifice nozzle and parallel to a line opposite another orifice nozzle upon which droplets from said other nozzle impinge. Carriage is also provided for moving the orifice nozzles and charging electrode means relative to the means supporting the paper transverse to the plane of droplet paths from a particular nozzle.

The method of the present invention involves either manually or automatically, as by computer, delaying the printing of intermediate lines until the second nozzle orifice catches up with the position adjacent to that the first nozzle orifice was in when it printed the line adjacent to which the new line is to be printed by the second nozzle. In accordance with the present invention, the pattern of dots in the (2n ± 1)th dotted line printed by the second jet is delayed from the time of the printing of the 2nth dotted line by the first jet by (d ± 1/R)/10V seconds where "d" is in the inter-jet spacing in millimeters, "V" is the print speed in cm./sec., and "R" is resolution in dots per millimeter. The spacial delay (corresponding spacial displacement of the nozzle) is expressed (dR ± 1) dotted lines.

The present invention will be better understood by reference to the accompanying drawings in which:

Fig. 1 is a side elevational view of a two jet version of the present invention in a partial sectional view or in the section as taken through the charging eletrode ring and deflecting plate along the paths from one orifice;

Fig. 2 is a plan view from above partially in section showing a section through the jet path at orifice level at both orifices and the bottom plate of the deflection plates;

Fig. 3 is an alternative construction shown in a view similar to that of Fig. 1;

Fig. 3A is a sectional view taken along line 3A of Fig. 3 showing one form of deflection electrodes;

Fig. 3B is a similar view to that of Fig. 3A but showing an alternative form of electrode;

Fig. 4 is a detail view taken along line 4-4 of Fig. 3 showing a modified ink collector means;

Fig. 5 is a side sectional view of printer head in Fig. 1;

Fig. 6 is sectional view taken along line 6-6 of Fig. 5;

Fig. 7 is a front view of the ink jet head as seen from line 7-7 of Fig. 6;

Fig. 8 is a sectional view taken along line 8-8 of Fig. 5;

Fig. 9 is a schematic drawing representing a five jet version of the present invention;

Fig. l0 is a side sectional view across any one of the jets in Fig. 9;

Fig. 11 illustrates how a letter "T" is printed by the five jet printer; and

Figs. 12a, b and c are fragmentary perspective views of different configurations of charging electrodes.

Referring now to the drawings, Fig. 1 and 2, 5, 6, 7 and 8 illustrate a preferred embodiment. Much of the system is known to be conventional. Much of it has been shown in schematic form since the actual physical form is well known. Thus, for example, in Figs. 1 and 2 , the ink chamber 10 is shown schematically. The orifice nozzles through which ink filaments are ejected from the reservoir are best seen as nozzles 12a and 12b in an orifice plate 12. The use of two nozzles in this configuration is new. A support structure l8 of insulating material supports ring charging electrodes l6a and l6b, between which is provided a conductive electrostatic shield 14 of conductive material.

Considering Figs. 5 and 6 briefly, it will be seen that the reservoir structure is more representative of an actual form which would be employed. The reservoir provides a cone-shaped cavity in a block 20 provided with a cylindrical extension 20a the outside surface of which is threaded to engage the threads of a cap 22. The cap closes the narrow end of the conical cavity and is provided with the orifices 12a and 12b on an orifice plate 12. Ink is fed into the cavity 10 through a conduit 24, preferably from a sump fed from the return means from the gutter (to be described) through a suitable pump which supplies pressure at a constant rate, typically about l6 to 80 pounds per square inch. The ink is fed into the ink chamber by way of a cavity 26 adjacent to back plate 28 mounted on the reservoir plate 20 using a sealing gasket 30 and suitable fasteners and supporting an ultrasonic transducer 32. A filament of ink on the order of 20 to 30 microns in diameter is ejected under the pressure through the orifice nozzle and is broken into well-defined ink droplets in the charge rings l6 at a rate equal to the rate of the frequency of the ultrasonic source, thus, enabling each individual droplet to be separately and differently charged by the charging means l4.

Specifically the two jets involved here are charged by the charging ring electrodes l6a and l6b which surround the paths of the droplets close to the orifice and before they are deflected by the electrostatic plates 34a and 34b. The amount of deflection of an individual droplet depends upon the charge imposed upon that droplet by its charging ring electrode l6a or l6b. In the usual configuration, uncharged droplets are allowed to proceed undeflected through the electrostatic field between the plates 34a and 34b into the

gutter or catcher 36. They are returned by drain 38 to a sump and by the pump back to the reservoir through the line 24 as described all in conventional manner. If instead of not being charged the droplets are charged, the electrostatic field will act upon the to deflect them. The arrangements shown in the drawings requires an upward deflection much that the greater the charge, the more upward the deflection would be. By varying the amount of charge in steps, a line of dots can be drawn by successive droplets on a piece of paper 40 carried on a platen 42 on a printer. The ink must pass through an elongated slot 44a in a shield 44 and the slot is gauged to permit the full length of the character to be drawn or printed on the paper 40. In practice, although they are shown as elements broken-away, suggesting their extension the length of the platen, the deflection electrodes 34a and 34b may be short and carried on the print head carriage or may be made optionally long and extend the length of the printer platen. The same is true of the catcher or gutter 36. The rest of the structure, the charging electrodes l6a and l6b and their support l4 are effectively mechanically integral with the reservoir and orifices and are part of the laterally moving print head which moves parallel to the length of the platen. The print head therefore is designed to sequentially print as it moves along the structure, parallel to the platen.

Some dimensions actually used in a two jet construction are helpful in visualizing the size of the structure. The two orifice nozzles located along the horizontal diameter (or axis) are spaced on the order of 3 to 4 mm apart. The tip of the cone in the ink chamber l0 is elongated in the horizontal direction, the direction of head traverse to a dimension of 6 mm as opposed to 3 mm in the vertical dimension. The elongated cone tip is recommended to focus the acoustic energy and to assure an efficient non-perturbed acoustic wave reaching at the orifice nozzles with identical energy density and at identical phase. The back of the cone has a diameter of 8 mm and is closed by a stainless steel plate 28 with a circular disc transducer 32 , 8-10 mm in diameter, mounted in the other side of the metal cover for stimulation. For maximum transfer of acoustic energy, the distance between the orifice plate and the back plate for stimulation should be $(2m + 1)\ \lambda/4$ where λ is the acoustic wave length of the ink, and m is an integer. Other than two orifice nozzles at the orifice plate and an elongated cone tip, the head structure remains identical with that of a single jet head structure.

Charging electrodes l6a and l6b consist of two metal rings with 1.0 mm inner diameter. The thickness of the charging electrode or the length of each ring is about 0.9 to 1.0 mm. The distance between centers of the charging rings is identical to the distance between centers of the orifice nozzles.

Both the orifice nozzles 12a and 12b and two charging rings l6a and l6b are located an equal distance above the bottom of the deflection plates 34a.

In operation nozzles 12a and 12b produce jets that are as close to identical twins as possible. As the printer head traverses along its carrier rod (not shown), for example, from left to right, for any given spot on the paper, jet a will reach there first, while jet b is 3 mm. away. The printed dot from a droplet in jet a will be 3mm. away from the one in jet b, plus additional error caused by the jet straightness. Hence jet straightness is a major concern for a high resolution printing ink jet array. For a printing resolution of 300 dots per inch, the droplet placement error should be within 25 microns. The corresponding jet straightness is less than 1 milliradian.

For a given vertical printed dotted line, there are 40 printing positions vertically for each jet. Signal voltage plus the charge compensation control are used to assure that droplet is placed within a 25 micron radius of the predetermined spot position.

In a regular text printing mode with a resolution of 300 dots per inch (or l2 dots/mm.), jet a will print the 2nth dotted line, while jet b will print the $(2n \pm 1)$th dotted line. There is a delay (displacement) of $3 \times 12 \pm 1$ dotted lines between jets, or a time delay of $(3 \pm 1/12)$ /10V seconds before jet b starts printing next to the dotted line printed by jet a, where "V" is the velocity of the carrier in cm. /second. For bi-directional printing, jet a lags behind jet b by $3 \times 12 \pm 1$ dotted lines or lags by a time of $(3 + 1/12)/10V$ seconds.

For a resolution of 240 dots/inch (or l0 dots/mm), each jet prints 32 positions. Jet a prints the even number 2n th dotted lines and jet b prints the odd (2n-1)th dotted lines. Time delay between these two jets is $(3 \pm 1/10)/10V$ seconds or $3 \times l0 + 1$ dotted lines. In general, if "d" is the inter-jet spacing in mm. and resolution is R dots/mm., then the time delay between two jets is

$(d \pm 1/R)/10V$ seconds;

or a spacial delay of

$(dR \pm 1)$ dotted lines.

In a draft printing mode, the electronics takes a slightly different sequence. Jet a will print at the 2(2m)th dotted lines; while jet b prints at the 2(m - 1)th dotted lines. All odd number of dotted lines are omitted. The time delay between two jets is always

$(d \pm 2/R)/l0V$ seconds;

or a spacial delay of

(dR ± 2) dotted lines away.

"d", "R" and "V" have been defined in Section (1).

Since each jet is basically the same as a regular single continuous jet used in regular printing, droplet charging, charge compensation, and guard drop scheme are the same. To minimize the cross talk between jets, electrostatic shielding between charging electrodes is recommended.

Referring now to Fig. 9, a configuration is shown in which a 5-nozzle jet configuration is employed. The structure is very similar as that for the 2-jet array shown in Figs. 1, 2, 5 through 8 and therefore similar numbers with the addition of primes thereto are employed in the structure. The ink reservoir l0' is modified somewhat in shape and elongated within plate 20' in order to accommodate three transducers 32', 32b', 32c'. The back plate 28' supports the transducers distributed longitudinally and the transducers are interconnected in such a way that they will be cumulative or additive in their effect rather than counteracting the effect of other transducers. Specifically, they all act to generate a pulse which is in phase and they are selected to be of such a frequency as to avoid standing waves or other effects counterproductive to the generation of the droplets. The orifice plate l2' in this case has five separate orifices l2a', l2b', l2c', l2d', and l2e'. The orifices are carefully aligned so that they produce jets which are directed in parallel paths. The jets pass through charging rings l6a', l6b', l6c', l6d', and l6e' and they are each supported on an insulating charge plate l8'. Fig. 9 is a sectional view through the structure so that only the lower deflection plate 34b' is seen but it will be understood that an upper deflection plate 34a' is also employed as in the prior structure. Furthermore, an ink collector means 36' is positioned so that if no charge is placed upon the droplets, they will be collected by the collection means. However, as in the prior arrangements, if charges are placed upon the droplets, they will be suitably deflected onto paper 40' on a platen 42'.

Fig. 11 shows a typical pattern printed by the 5-nozzle printer of Fig. 9 to print a character "T". Jet "1" prints the 1st, 6th, 11th, l6th and 21st dotted lines; jet "2" prints the 2nd, 7th, 12th, 17th, and 22nd dotted lines; ...; and jet "5" prints the 5th, l0th, l5th, 20th, and 25th dotted lines. The interlacing of all printed dotted lines forms the character "T". Note that all 5 nozzles must be identical in every practical means. Jet straightness must be within acceptable level. The interlacing scheme blends all 5 jet printing in every portion of the character. Hence, it produces a more homogeneous appearance, and every slight misalignment will be averaged out. The vertical positional accuracy is precisely taken care of by electronic compensation on the amount of charge given to each individual droplet.

Note that the printing sequence by the 5-jet array is shown on the top of Fig. 11 where kth jet prints every (5m + K)th dotted lines, if we choose a time delay for the Kth jet with respect to the 1st jet by (K-1) (d + 1/R)/10V seconds, where d, R, m, and V are as defined above. The corresponding spacial delay is (K-1) (dR + 1) dotted lines for th Kth jet. Another printing sequence is shown in the bottom of Fig. 11 where the Kth jet prints every (5m - K)th dotted lines, if we choose the time delay for the Kth jet with respect to the first jet by (K-1) (d - 1/R)/10V seconds. The corresponding spacial delay is (K-1) (dR - 1) dotted lines.

Character printing is done through a character generator on a ROM chip. The signal from each dotted column will first go through a specific shift register to provide a proper spacial delay (or time delay) before being sent to the driving electronics for the Kth jet charge electrode. In Fig. 9 the printer head assembly starts with a transducer array 32a', 32b', 32c' of rectangular shape mounted on a back plate 28' opposite to the rectangular pads 31a', 31b' and 31c'. A transducer array is necessary when the total length of the ink jet array exceeds $\lambda/2$, the half acoustic wavelength of the ink. The acoustic wave generated by the transducer array must have the same amplitude and phase to avoid generating a longitudinal acoustic standing wave along the direction of the orifices. Transducers are mounted by epoxy on the back plate 28', which may be a flat thin plate, or with a number of corresponding pads. The structure separates the transducer array fro direct contact with ink, while transmitting acoustic energy effectively to the ink chamber.

The ink chamber contains ink inlet 24' and an ink outlet 25', preferably with a controlled valve (not shown). The tapered slot shape ink chamber block has transducer array mounted on the larger crossection end, and the orifice plate at the tapered end. Mechanical clamping, soldering, or gluing by epoxy are methods of mounting. A tapered shaped ink chamber is to focus the acoustic energy toward the orifice plate. The length of the ink chamber should be at least $\lambda/2$ longer than the total length of the orifice array. The width of the slot in the ink chamber should not exceed half wavelength $\lambda/2$ to avoid higher order standing wave generation. For the best stimulation, the depth of ink chamber between the back plate and the orifice plate should be kept at $(2m + 1)\ \lambda/4$, where m is an integer and λ is the acoustic wavelength of the ink at the stimulation frequency.

The fabrication of the orifice plate 12' is one of the most critical parts of the ink jet printer. Although it is possible to drill a series of identical holes on a thin metal plate, (preferably a 5+ to 10 mils stainless or nickel plate) it is better recommended to use photo-fabrication process to control precisely the dimension and the shape. Silicon single crystal wafer can be made as an orifice plate through oxidation then

preferentially etch nozzles at predetermined positions using photo-resist. One can also use electroform process to fabricate a precision orifice plate, where a photoresist image is first made on a conductive substrate before electrodeposition. Care must be exercised to assure perfectly round holes with identical dimensions to minimize the droplet placement error.

The charge plate I8' has equal number of holes lined-up concentrically with the orifices as shown in Fig. 12a. Conductive rings I6a', I6b', I6c', I6d' and I6e' are made on the holes in the charge plate and is individually connected to the driving circuit for charging electrode. Electrostatic shields between nearest charge rings are recommended though not necessary. Another configuration of the charge plate consists of an array of conductive U-shaped channels I8a (see Fig. I2b) or semi-circles I8b (see Fig. I2c) On the charge plate. Each channel is connected to the driving electronic circuit. Although the former configuration has superior shielding against cross-talk between jets, the latter has advantages in operation especially during the start-up and shut down.

The width of the deflection plates and catcher 36' have to be widened to cover beyond the entire jet array in the present invention. Otherwise, they are identical with that of a single jet printer. The ink chamber, deflection plates, catcher and ink system including pump, filtration, ink supply and tubings are common to all jets.

Attention is now directed to Figs. 3 and 4 which shows a modified construction wherein two jets are employed but the jets are provided one above the other instead of in lateral alignment.

Fig. 3 is the side view of another type of 2-jet configuration, where two jets are aligned 3 to 6 mm apart one on each side of printing area. The charge electrodes for jet a and jet b have opposite polarities. Under the deflection electric field given in Fig. 3, charged droplets from jet a will be positively " + " charged, hence deflected downward; while droplets from jet b will be negatively charged "-" and are deflected upward. A dual catcher is shown in Fig. 4 which is a sectional view from line 4-4 in Fig. 3. The upper catcher catches the non-print droplets from jet a and the lower catcher catches the non-print droplets from jet b. The aperture between the catcher fingers is the window for printing. It is at least 0.1 inch in height. One may interlace droplets from jet a to droplets from jet b to form a single line (each jet needs only 1/2 the number of steps per vertical line), or interlace the dotted lines printed by each jet to form a character. In either scheme, the 2-jet head printer will print twice the speed of a single jet printer.

Furthermore, the jet a and jet b in Fig. 3 nay be replaced by two rows of ink jet array, each array is parallel to the print direction. Row a is located above the print area and row b is located below the print area. The polarities of the matched charge electrodes for row a is opposite to that of row b so that the print droplets from each row of ink jet array are deflected in opposite direction into the print area to form the predetermined characters or images. Using the interlacing schemes described previously, high resolution images can be obtained at a printing speed n times faster than a single jet printer, where n is the total number of jets in the print head.

Claims

1. A multi-ink jet printer comprising :

- an ink chamber and an array of nozzle orifices (12a, 12b; 12a', 12b', 12c', 12d', 12e') generally aligned on an axis,
- deflection plates (34a, 34b; 34a', 34b') between which ink droplets emerging from the respective nozzle orifices pass and which deflect said ink droplets substantially perpendicular to the axis of the said orifice array so as to be able to print dotted lines which extend in said direction of deflection,
- charging electrodes (16a, 16b; 16a', 16b', 16c', 16d', 16e') adjacent to the breaking point of ink filament associated with the respective nozzle orifices (12a, 12b; 12a', 12b', 12c', 12d', 12e') and a source of voltage to apply in a prearranged order selected voltages to the respective charging electrodes, each of which is capable of inducing a charge of predetermined magnitude on each droplet to cause each droplet to be directed to a predetermined position on the receiving medium (40, 40'),
- means of supporting the receiving medium and said array of nozzles for a relative movement (51) thereof,

wherein

the axis of the said orifice array is substantially parallel to a relative print direction (51) and the said relative movement takes place in this same direction so that the said dotted lines can be printed in a matrix format representing a printed mark or character, said printer comprises additional means for providing proper sequences for marking such that, in the course of said relative movement between this

array and the receiving medium, each adjacent dotted line of said matrix format on the receiving medium is produced by a different nozzle orifice within said orifice array so that the said matrix format is formed of interlaced dotted lines of which adjacent ones are formed by different nozzle orifices respectively.

2. Ink jet printer according to claim 1 wherein said array of nozzle orifices and said charging electrodes are mounted on a carriage which is movable in said print direction, and the spacing of the nozzle orifice and the movement of the carriage means is such that the said interlacing of said dotted lines within the said matrix format takes place.

3. Ink jet printer according one of claims 1 or 2, wherein an electrostatic means is interposed between adjacent charging electrodes to isolate charge effects imposed on droplets of one stream from droplets of another stream, and a plurality of charge rings are supported by a common support structure and conductive members are placed between the charge electrodes and are grounded electrically to afford electrostatic shielding to isolate charge effects imposed on droplets of one stream by droplets of another stream.

4. Ink jet printer according to one of the claims 1 to 3, wherein the means to apply pressure to an ink chamber (10, 10', 10") to force ink out through the orifice nozzles is a constant pressure or constant flow means, and the means acting on the ink to break the filaments into droplets is at least one acoustic wave generator (32; 32a', 32b', 32c') associated to the ink chamber and the orifice nozzles to generate acoustic waves of the same amptitude and the same phase at the array of nozzle orifices, and the means to apply pressure to the ink chamber includes means for recirculating ink from the ink collector means (36; 36'; 36a", 36b").

5. Ink jet printer comprising:
a) an ink chamber having two orifice nozzles (12a", 12b"),
b) means of supporting the receiving medium and said nozzles for relative movement thereof along a relative print direction (51),
c) deflection plates (34a", 34b") extending substantially parallel to said printing direction (51) between which deflection plates all of the droplets pass in droplet paths from the respective orifice nozzles (12a", 12b"),
d) charging electrodes (16a", 16b") adjacent to the breaking point of the ink filaments associated with the respective nozzle orifices (12a", 12b"), and a source of voltage for applying voltages to the respective charging electrodes,
characterized in that,
e) the nozzle orifices are positioned along a common axis which is substantially orthogonal to said relative print direction so that one orifice (12a") is above a character print area and the other orifice (12b") lies below said area,
f) the said source of voltage connected to the respective charging electrodes (16a", 16b") imposes signals of one polarity upon the stream of droplets emerging from the one orifice, and signals of reverse polarity upon the other stream so that the droplets of the said two streams are deflected in opposite directions into the same print area and produce printed dotted lines which are substantially orthogonal to said print direction and composed of interlaced droplets of both streams, and wherein
g) preferably separate ink collector means (36a", 36b") are employed to collect the non-print ink droplets from the respective orifice nozzlfes.

6. Ink jet printer according to claim 5, characterized in that separate arrays of ink jet nozzle orifices in two rows are located above and below the said print area, each array of nozzle orifices being aligned substantially parallel to the said relative print direction (51), and the said source of voltage imposes signals of one polarity to the charging electrodes adjacent to the breading points of ink filaments emerging from the upper array of nozzle orifices, and signals of a reverse polarity to the charging electrodes of the other array of said nozzle orifices, so that droplets are deflected in opposite directions into the same print area under the deflecting electric field to print said dotted lines which are interlaced to form a predetermined image, character or symbol.

7. Ink jet printer according to one of the claims 1 to 6, characterized in that the charging electrodes are supported in a common insulating structure, and are each ring-shaped, U-shaped, or semicircular-

shaped and precision-formed to be identical to one another.

8. Method of printing with an ink jet printer, wherein ink drops separated and expelled through a plurality of orifices (12a, 12b; 12a', 12b', 12c', 12d', 12e') are charged and then deflected by electrode plates (34a, 34b; 34a', 34b'), to be directed to predetermined points on a receiving medium (40, 40'), said receiving medium being moved in a print direction (51) relatively with respect to said orifices and said orifices being aligned substantially parallel to the direction of said relative movement, and each droplet is given a charge corresponding to its placement substantially perpendicular to said relative print direction so that dotted lines which extend substantially perpendicular to said relative print direction, can be printed in a matrix format representing a printed mark or character, and wherein adjacent dotted lines within said matrix format are printed by different nozzle orifices of the printhead, so that the printed mark or character is composed of interlaced dotted lines of which adjacent ones are formed by different nozzle orifices respectively.

9. Method of printing according to claim 8, comprising charged ink droplets to draw parallel dotted lines needed for a selected characeter or image such that the kth nozzle of an n nozzle array will print every (mn + k)th line where m is an integer, and after a spatial displacement of (DR + 1) dotted lines or (DR - 1) dotted lines for any lagging k'th nozzle assigned to print the adjacent line, that is the [(mn + k) + 1]th dotted line or the [(mn + k) -1]th dotted line respectively, where R is the resolution in dots per millimeter, D is the spacing in millimeter between kth nozzle and the lagging k'th nozzle, and k and k' = 1, 2, 3, ..., or n, so that dotted lines are interlaced properly to complete the selected character, mark, or image.

10. Method according to claim 9, wherein in a constant relative print velocity mode, droplets generated from the lagging k'th nozzle to print the interlaced line adjacent to said (mn + k)th line, that is the [(mn + k) + 1]th dotted line or the [(mn + k) - 1]th dotted line, are subjected to a timing delay of (D + 1/R)/10V seconds or (D - 1/R) / 10V seconds, where "V" is the relative print speed in cm/sec.

11. Method according to claim 8 using a two-jet head, wherein droplets are generated by said jet orifice "a" and deflected onto a receiving medium (40, 40') to print a 2nth dotted line in a character or image and, after a spatial displacement of (RD - 1) or (RD + 1) dotted lines, or in a constant velocity mode after a time delay of either (D - 1/R) / 10V seconds or (D + 1/R) / 10V seconds where the resolution is R dots per millimeter, D represents the spacing between the centers of the two nozzle orifices in millimeters and V is the relative velocity in cm/sec, droplets are generated from a second jet orifice "b" to print a (2n - 1)th dotted line or a (2n + 1)th dotted line of the character or image.

12. Method according to claim 8 using a two jet printhead, wherein droplets are generated and deflected by said jet orifice "a" onto a receiving medium (40, 40') to print the 2(2n)th dotted line, while a second jet orifice "b" prints at the 2(2n ± 1)th dotted line after a spatial displacement of (DR ± 2) dotted lines, or in a constant velocity mode, after a timed delay of (D ± 2/R) / 10V seconds where the resolution is R dots per millimeter, D represents the spacing between the centers of the two nozzles in millimeters, and V is the relative print speed in cm/sec.

Revendications

1. Imprimante à jets d'encre multiples comportant :
   - une chambre à encre et un groupement d'orifices de buses (12a, 12b ; 12a', 12b', 12c', 12d', 12e') alignés de façon générale selon un axe,
   - des plaques déflectrices (34a, 34b ; 34a', 34b') entre lesquelles les gouttelettes d'encre qui sortent des orifices de buses correspondantes passent et qui défléchissent lesdites gouttelettes d'encre sensiblement perpendiculairement par rapport à l'axe dudit groupement d'orifices de façon à permettre l'impression de lignes en pointillés qui s'étendent dans ladite direction de déflexion,
   - des électrodes de charge (l6a, 16b ; 16a', l6b', l6c', 16d', 16e') voisines du point de cassure des filaments d'encre associés aux orifices de buses respectifs (12a, 12b ; 12a', 12b', 12c', 12d', 12e') et une source de tension pour appliquer des tensions choisies dans un ordre pré-défini aux électrodes de charge correspondantes, chacune desquelles est susceptible d'appliquer une charge d'une valeur prédéterminée à chaque gouttelette pour provoquer la direction de chaque

gouttelette vers une position prédéterminée sur le moyen récepteur (40, 40'),

- un moyen pour supporter le moyen récepteur et ledit groupement de buses en vue d'un mouvement relatif (51) entre eux,

dans laquelle

l'axe dudit groupement d'orifices est sensiblement parallèle à une direction relative d'impression (51) et ledit mouvement relatif a lieu dans la même direction de façon á ce que les lignes en pointillés puissent être imprimées selon un un format de matrice représentant un signe ou un caractère imprimé, ladite imprimante comporte des moyens additionnels pour fournir des séquences convenables pour marquer de telle sorte qu'au cours du mouvement relatif entre ce groupement et le moyen récepteur, chaque ligne en pointillés adjacente dudit format de matrice sur le moyen récepteur est produite par un orifice de buse différent à l'intérieur dudit groupement d'orifices de telle sorte que le format de matrice est formé de lignes en pointillés entrelacées dont les lignes adjacentes sont réalisées par des orifices de buses différents respectivement.

2. Imprimante à jets d'encre selon la revendication 1 dans laquelle ledit groupement d'orifices de buses et lesdites électrodes de charge sont montés sur un chariot qui est susceptible de se déplacer dans ladite direction d'impression et l'espacement entre les orifices de buses et le mouvement des moyens formant chariot est tel que ledit entrelacement desdites lignes en pointillés se produit à l'intérieur dudit format de matrice.

3. Imprimante à jets d'encre selon l'une des revendications 1 ou 2 dans laquelle un moyen électrostatique est interposé entre les électrodes de charge adjacentes pour isoler les effets de charge appliqués aux gouttelettes du premier courant des gouttelettes du second courant et un ensemble de bagues de charge est supporté par une structure de support commune et des éléments conducteurs sont placés entre les électrodes de charge et sont mis à la masse électriquement pour assurer une protection électrostatique destinée à isoler les effets de charge appliqués aux gouttelettes d'un courant par les gouttelettes de l'autre courant.

4. Imprimante selon l'une des revendications 1 à 3 dans laquelle les moyens pour appliquer de la pression à la chambre à encre (10, 10', l0") en vue de forcer l'encre vers l'extérieur à travers les orifices de buses est un moyen à pression constante ou à débit constant et le moyen agissant sur l'encre pour rompre les filaments sous la forme de gouttelettes est au moins un générateur d'ondes sonores (32 ; 32a', 32b', 32c') associé à la chambre à encre et aux orifices de buses pour engendrer des ondes sonores de la même amplitude et de la même phase pour le groupement d'orifices de buses et le moyen pour appliquer la pression à la chambre à encre comporte des moyens pour recirculer l'encre à partir de moyens formant collecteur d'encre (36 ; 36'; 36a", 36b").

5. Imprimante à jets d'encre comprenant :

a) une chambre à encre comportant deux orifices de buses (l2a", l2b"),

b) des moyens pour supporter le moyen récepteur et lesdites buses en vue d'un mouvement relatif entre eux selon une direction relative d'impression (51),

c) des plaques déflectrices (34a", 34") s'étendant sensiblement parallèlement par rapport à la direction d'impression (51) entre lesquelles toutes les gouttelettes passent suivant des trajets provenant des orifices de buses correspondants (12a", 12b"),

d) des électrodes de charge (16a", 16b") voisines du point de cassure des filaments d'encre associés aux divers orifices de buses (12a", 12b") et une source de tension pour appliquer des tensions aux diverses électrodes de charge, caractérisée en ce que

e) les orifices de buses sont disposés selon un axe commun qui est sensiblement perpendiculaire à la direction relative d'impression de sorte qu'un premier orifice (l2a") se trouve au-dessus de la zone d'impression d'un caractère et un autre second orifice (l2b") se trouve en dessous de cette zone.

f) ladite source de tension connectée aux diverses électrodes de charge (16a" , l6b") applique des signaux d'une polarité sur le courant de gouttelettes à sa sortie du premier orifice et des signaux de polarité inverse sur le second courant de telle sorte que les gouttelettes desdits deux courants sont défléchies dans des directions opposées dans la même zone d'impression et produisent des pointillés imprimés qui sont sensiblement perpendiculaires par rapport à ladite direction d'impression et composés de gouttelettes entrelacées des deux courants et dans laquelle

g) de préférence, les moyens distincts séparés collecteurs d'encre (36a", 36b") sont utilisés pour collecter les gouttelettes d'encre non utilisée pour l'impression provenant des divers orifices de

buses.

6. Imprimante à jets d'encre selon la revendication 5 caractérisée en ce que des groupes distincts d'orifices de buses de jets d'encre disposés selon deux rangées sont situés au-dessus et en dessous de ladite zone d'impression, chaque groupement d'orifices de buses étant aligné sensiblement parallèlement par rapport à la direction relative d'impression (51), et en ce que ladite source de tension applique des signaux d'une polarité aux électrodes de charge qui sont voisines des points de cassure des filaments d'encre sortant du groupement supérieur des orifices de buses et des signaux de polarité inverse aux électrodes de charge de l'autre groupement desdits orifices de buses de telle sorte que les gouttelettes soient défléchies dans des directions opposées vers la même zone d'impression sous l'action du champ électrique de déflexion pour imprimer lesdites lignes en pointillés qui sont entrelacées pour former une image, un caractère ou un symbole prédéterminé.

7. Imprimante selon l'une quelconque des revendications 1 à 6, caractérisée en ce que les électrodes de charge sont supportées par une structure isolante commune et sont chacune en forme de bague, de U ou semi-circulaires et réalisées avec précision pour être identiques les unes par rapport aux autres.

8. Procédé d'impression au moyen d'une imprimante à jets d'encre dans lequel des gouttes d'encre distinctes et projetées au moyen d'un ensemble d'orifices (l2a, l2b ; l2a', 12b', 12c', l2d', 12e') sont chargées et alors défléchies par des plaques formant électrodes (34a, 34b ; 34a', 34b') de façon à être dirigées vers des points prédéterminés sur un moyen récepteur (40, 40'), ledit moyen récepteur étant déplacé dans une direction d'impression (51) par rapport auxdits orifices et lesdits orifices étant alignés sensiblement parallèlement par rapport à la direction dudit mouvement relatif et chaque gouttalette reçoit une charge correspondant à son positionnement sensiblement perpendiculairement pur rapport à ladite direction relative d'impression de telle sorte que des lignes en pointillés qui s'étendent sensiblement perpendiculairement par rapport à la direction relative d'impression puissent être imprimées sous la forme d'une matrice représentant un signe ou un caractère imprimé et dans lequel des lignes en pointillés adjacentes à l'intérieur du format de matrice sont imprimées par différents orifices de buses de la tête d'impression de telle sorte que le signe ou la caractère imprimé soit composé de lignes en pointillés entrelacées dont les lignes adjacentes sont respectivement formées par différents orifices de buses.

9. Procédé d'impression selon la revendication 8 comportant le fait de réaliser la déflexion de gouttelettes d'encre chargées pour dessiner des lignes en pointillés parallèles nécessaires pour un caractère ou une image choisi de telle sorte que la k ième d'un groupement de n buses imprime chaque (mn + k ième) ligne, m étant un nombre entier, et après un déplacement dans l'espace de (DR + 1) lignes en pointillés ou (DR - 1) lignes en pointillés pour toute buse de rang k' restée en arrière destinée à imprimer la ligne voisine, c'est-à-dire la [(mn + k) + 1] ième ligne en pointillés ou [(mn + k) - 1] ième ligne en pointillés respectivement où R est la résolution en points par millimètre, D est l'espacement en millimètres entre la k ième buse et la k' ième buse en retard et k et k' = 1, 2, 3, ..., ou n, de telle sorte que les lignes en pointillés sont entrelacées convenablement pour réaliser le caractère, le signe ou l'image désiré.

10. Procédé selon la revendication 9 dans un mode d'impression rapide à vitesse relativement constante, les gouttelettes engendrées par la k'ième buse en retard pour imprimer la ligne entrelacée adjacente à ladite (mn + k) ième ligne, c'est-à-dire la [(mn + k) + 1] ième ligne en pointillés ou la [(mn + k) - 1] ième ligne en pointillés sont soumises à un retard de (D + 1/R)/l0V secondes ou (D - 1/R) / 10V secondes, où "V" est la vitesse relative d'impression en cm/sec.

11. Procédé selon la revendication 8 utilisant une tête à deux jets dans lequel les gouttelettes sont engendrées par ledit orifice de jets "a" et défléchies vers un moyen récepteur (40, 40') pour imprimer une 2n ième ligne en pointillés dans un caractère ou une image et, après un déplacement dans l'espace de (RD - 1) ou (RD + 1) des lignes en pointillés ou selon un mode de vitesse constante après un retard de soit (D - 1/R) / 10 V secondes ou (D + 1/R) / 10V secondes où la résolution est de R points par millimètre, D représente l'espacement entre les centres des deux orifices de buses en millimètre et V est la vitesse relative en les centres des deux orifices de buses en millimètre et V est la vitesse relative en cm/sec, les gouttolettes sont engendrées à partir d'un second orifice de jet "b" pour imprimer une (2n - 1) ième ligne en pointillés ou une (2n + 1) ième ligne en pointillés du caractère ou

de l'image.

12. Procédé selon la revendication 8 utilisant une tête d'impression à deux jets dans lequel les gouttelettes sont engendrées et défléchies par ledit orifice de jet "a" vers un moyen récepteur (40, 40') pour imprimer la 2(2n) ième ligne en pointillés alors qu'un second orifice de jet "b" imprime selon la 2(2n + 1) ième ligne an pointillés après un déplacement dans l'espace de (DR ± 2) lignes en pointillés ou selon un mode de vitesse constante, après un retard de (D ± 2/R) / 10V secondes où la résolution est R points par millimètre, D représente un espacement entre les centres des deux buses en millimètres, et V est la vitesse d'impression relative en cm/sec.

Patentansprüche

1. Mehstrahltintendrucker mit:
   - einer Tintenkammer und einem Feld von Düsenöffnungen (12a, 12b; 12a', 12b', 12c', 12d', 12e'), welche in etwa entlang einer Achse angeordnet sind,
   - Ablenkplatten (34a, 34b; 34a', 34b'), zwischen welchen Tintentröpfchen, die aus den jeweiligen Düsenöffnungen austreten, hindurchlaufen und welche die Tintentröpfchen im wesentlichen senkrecht zu der Achse des Düsenöffnungsfeldes ablenken, so daß es möglich ist, aus Punkten zusammengesetzte Linien zu drucken, die sich in der Ablenkrichtung erstrecken,
   - Ladeelektroden (16a, 16b; 16a', 16b', 16c', 16d', 16e'), die neben dem Abbruchpunkt eines Tintenfadens liegen, der zu den jeweiligen Düsenöffnungen (12a, 12b; 12a', 12b', 12c', 12d', 12e') gehört, und einer Spannungsquelle, um in einer voreingestellten Reihenfolge ausgewählte Spannungen den jeweiligen Ladeelektroden zuzuführen, wobei jede in der Lage ist, eine Ladung vorbestimmter Größe an jedem Tröpfchen zu induzieren, um zu bewirken, daß jedes Tröpfchen auf eine vorbestimmte Stelle auf dem Aufzeichnungsmedium (40, 40') gelenkt wird,
   - Einrichtungen zum Haltern des Aufzeichnungsmediums und des Düsenfeldes, so daß sie relativ zueinander bewegbar (51) sind,

   wobei die Achse des Düsenfeldes im wesentlichen parallel zur relativen Druckrichtung (51) liegt und die erwähnte Relativbewegung in eben dieser Richtung stattfindet, so daß aus Punkten zusammengesetzte Linien in Matrixform gedruckt werden können, die ein gedrucktes Zeichen oder einen Buchstaben darstellt, wobei der Drucker zusätzliche Einrichtungen aufweist, um geeignete Markierungsfolgen bereitzustellen, derart, daß während des Ablaufs der Relativbewegung zwischen dem Feld und dem Aufzeichnungsmedium jeweils benachbarte, aus Punkten zusammengesetzte Linien der Matrix auf dem Aufzeichnungsmedium von unterschiedlichen Düsenöffnungen innerhalb des Öffnungsfeldes erzeugt werden, so daß die Matrix aus miteinander vernetzten, aus Punkten zusammengesetzten Linien gebildet wird, wobei benachbarte Linien jeweils von verschiedenen Düsenöffnungen gebildet sind.

2. Tintenstrahldrucker nach Anspruch 1, wobei das Feld von Düsenöffnungen und die Ladeelektroden auf einem Schlitten montiert sind, der in der erwähnten Druckrichtung bewegbar ist und wobei der Abstand der Düsenöffnungen und die Bewegung des Schlittens derart ist, daß eine Vernetzung bzw. Überlappung der aus Punkten zusammengesetzten Linien innerhalb der Matrix stattfindet.

3. Tintenstrahldrucker nach Anspruch 1 oder 2, wobei eine elektrostatische Einrichtung zwischen benachbarten Ladeelektroden angeordnet ist, um Ladewirkungen, die auf Tropfen eines Stromes von den Tropfen eines anderen Stromes ausgeübt werden, zu isolieren, und wobei eine Mehrzahl von Laderingen von einem gemeinsamen Stützaufbau gehaltert wird und leitfähige Teile zwischen den Ladeelektroden angeordnet und elektrisch mit Masse verbunden sind, um ein elektrostatisches Abschirmen zu bewirken, um Ladewirkungen auf Tropfen eines Stromes durch Tropfen von einem anderen Strom zu isolieren bzw. abzuschirmen.

4. Tintenstrahldrucker nach einem der Ansprüche 1 bis 3, wobei die Einrichtungen zum Aufbringen eines Druckes auf eine Tintenkammer (10, 10', 10''), um Tinte durch die Düsenöffnungen herauszudrücken, Einrichtungen mit konstantem Druck und konstanter Strömung sind, und wobei die Einrichtungen, die auf die Tinte einwirken, um die Fäden in Tropfen aufzuteilen, zumindest aus einem Generator für akustische Wellen (32; 32a', 32b', 32c') bestehen, der der Tintenkammer und den Düsenöffnungen zugeordnet ist, um akustische Wellen mit derselben Amplitude und der gleichen Phase an dem Feld von Düsenöffnungen zu erzeugen, und wobei die Einrichtung zum Aufbringen von Druck auf die Tintenkammer eine Einrichtung aufweist, um Tinte aus einer Tintensammeleinrichtung (36; 36'; 36a'',

36b") zu rezirkulieren.

5. Tintenstrahldrucker mit:
a) einer Tintenkammer mit zwei Düsenöffnungen (12a", 12b"),
b) Einrichtungen zum Haltern des Aufzeichnungsmediums und der Düsen, so daß sie entlang einer relativen Druckrichtung (51) relativ zueinander bewegbar sind,
c) Ablenkplatten (34a", 34b"), welche sich im wesentlichen parallel zu der Druckrichtung (51) erstrecken, wobei zwischen den Ablenkplatten alle Tropfen entlang von Tropfenwegen aus den jeweiligen Düsenöffnungen (12a", 12b") hindurchtreten,
d) Ladeelektroden (16a", 16b"), die neben dem Abbrechpunkt der Tintenfäden angeordnet sind, welche mit den entsprechenden Düsenöffnungen (12a", 12b") verknüpft sind, und mit einer Spannungsquelle, um Spannungen an die jeweiligen Ladeelektroden anzulegen,
dadurch gekennzeichnet, daß
e) die Düsenöffnungen entlang einer gemeinsamen Achse angeordnet sind, die im wesentlichen senkrecht zu der relativen Druckrichtung verläuft, so daß eine Öffnung (12a") oberhalb einer Zeichendruckfläche und die andere Öffnung (12b") unterhalb dieser Fläche liegt,
f) die Spannungsquelle, die mit den entsprechenden Ladeelektroden (16a", 16b") verbunden ist, Signale einer Polarität auf den Tropfenstrom, der aus der Öffnung austritt, abgibt und Signale der umgekehrten Polarität auf den anderen Strom, so daß die Tropfen der beiden zwei Ströme in entgegengesetzten Richtungen auf dieselbe Druckfläche abgelenkt werden und gedruckte, aus Punkten zusammengesetzte Linien erzeugen, die im wesentlichen senkrecht zur Druckrichtung verlaufen und aus miteinander vernetzten bzw. sich überlappenden Tropfen beider Ströme zusammengesetzt sind, und wobei
g) vorzugsweise getrennte Tintensammeleinrichtungen (36a", 36b") verwendet werden, um die nicht zum Drucken verwendeten Tintentropfen aus den entsprechenden Düsenöffnungen zu sammeln.

6. Tintenstrahldruck nach Anspruch 5, dadurch gekennzeichnet, daß getrennte Felder von Tintenstrahldüsenöffnungen in zwei Reihen oberhalb und unterhalb des Druckbereiches angeordnet sind, wobei jedes Feld von Düsenöffnungen im wesentlichen parallel zu der relativen Druckrichtung (51) ausgerichtet ist und wobei die Spannungsquelle Signale einer Polarität auf die Ladeelektroden abgibt, die an den Abbrechpunkten der Tintenfäden liegen, welche aus dem oberen Feld von Düsenöffnungen austreten, sowie Signale der umgekehrten Polarität an die Ladeelektroden des anderen Feldes von Düsenöffnungen abgibt, so daß die Tröpfchen in entgegengesetzten Richtungen unter der Wirkung des ablenkenden elektrischen Feldes auf denselben Druckbereich gelenkt werden, um die erwähnten aus Linien zusammengesetzten Punkte zu drucken, die vernetzt sind, so daß sie ein vorbestimmtes Bild, einen Buchstaben oder ein Symbol drucken.

7. Tintenstrahldrucker nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, daß die Ladeelektroden in einem gemeinsamen Isolationsaufbau gelagert sind und jeweils ringförmig, U-förmig oder halbkreisförmig und sehr präzise ausgebildet sind, so daß sie miteinander identisch sind.

8. Verfahren zum Drucken mit einem Tintenstrahldrucker, wobei Tintentröpfchen abgetrennt und durch eine Mehrzahl von Öffnungen (12a, 12b; 12a', 12b', 12c', 12d', 12e') ausgestoßen und geladen und dann durch Elektrodenplatten (34a, 34b; 34a', 34b') abgelenkt werden, so daß sie auf vorbestimmte Punkte auf einem Aufzeichnungsmedium (40, 40') gelenkt werden, wobei das Aufzeichnungsmedium relativ zu den Öffnungen in einer Druckrichtung (51) bewegt wird und wobei die Öffnungen im wesentlichen parallel zu der Richtung dieser Relativbewegung ausgerichtet sind, wobei weiterhin jeder Tropfen eine Ladung erhält, die seiner Anordnung im wesentlichen senkrecht zu der relativen Druckrichtung entspricht, so daß aus Punkten bestehende Linien, die sich im wesentlichen senkrecht zu der relativen Druckrichtung erstrecken, in Form einer Matrix gedruckt werden können, welche ein gedrucktes Zeichen oder einen Buchstaben darstellt, und wobei benachbarte aus Punkten bestehende Linien innerhalb dieser Matrix von verschiedenen Düsenöffnungen des Druckkopfes gedruckt werden, so daß das gedruckte Zeichen oder der Buchstabe aus miteinander vernetzten bzw. überlappenden, aus Punkten bestehenden Linien zusammengesetzt ist, wobei jeweils benachbarte Linien von jeweils verschiedenen Düsenöffnungen gebildet worden sind.

9. Verfahren zum Drucken nach Anspruch 8, unter Ablenken geladener Tintentröpfchen, um parallele, aus Punkten bestehende Linien zu ziehen, welche für einen ausgewählten Buchstaben oder ein Bild

benötigt werden, derart, daß die k'te Düse eines Feldes aus n Düsen jede (mn + k)'te Linie druckt, wobei m eine ganze Zahl ist, und wobei nach einer (örtlichen) Verschiebung von (DR + 1) aus Punkten bestehenden Linien oder (DR - 1) aus Punkten bestehenden Linien für jede zur erstgenannten verschobene (k')'te Düse, welche dafür vorgesehen ist, die benachbarte Linie zu drucken, d.h. die [(mn + k) + 1]'te Punktlinie bzw. die [mn + k) - 1]'te Linie, zu drucken, wobei R die Auflösung in Punkten pro Millimeter, D der Abstand in Millimeter zwischen der k'ten Düse und der relativ verschobenen (k')-'ten Düse ist und wobei k und k' = 1, 2, 3... oder n sind, so daß die Punktlinien in geeigneter Weise miteinander vernetzt sind, um den ausgewählten Buchstaben, das Zeichen oder Bild vollständig zu bilden.

10. Verfahren nach Anspruch 9, wobei bei einer Betriebsart mit konstanter relativer Druckgeschwindigkeit die von der verschobenen (k')'ten Düse erzeugten Tropfen, welche die vernetzte Linie unmittelbar neben der (mn + k)'ten Linie drucken sollen, d.h. die [(mn + k) + 1]'te gepünktete Linie oder die [(mn + k) -1]'te Punktlinie, einer Zeitverzögerung von (D + 1/R)/10V Sekunden oder (D - 1/R)/10V Sekunden ausgesetzt wird, wobei "V" die relative Druckgeschwindigkeit in cm/Sekunde ist.

11. Verfahren nach Anspruch 8 unter Verwendung eines Zweistrahlkopfes, wobei Tröpfchen von der Strahlöffnung "a" erzeugt und auf ein Aufzeichnungsmedium (40, 40') abgelenkt werden, um eine 2n'te Punktlinie in einem Buchstaben oder Zeichen zu drucken und, nach einer räumlichen Verschiebung von (RD - 1) oder (RD + 1) Punktlinien, oder, bei einer Betriebsart mit konstanter Relativgeschwindigkeit, nach einer Zeitverzögerung von entweder (D - 1/R) / 10V Sekunden oder (D + 1/R) / 10V Sekunden, wobei die Auflösung R Punkte pro Millimeter beträgt, D den Abstand zwischen den Zentren der beiden Düsenöffnungen in Millimeter angibt und V die Relativgeschwindigkeit in cm/sec ist, und wobei Tropfen aus einer zweiten Strahlöffnung "b" erzeugt werden, um eine (2n - 1)'te Punktlinie oder eine (2n + 1)-'te Punktlinie des Buchstabens oder Bildes zu drucken.

12. Verfahren nach Anspruch 8 unter Verwendung eines Zweistrahldruckkopfes, wobei Tropfen von der Strahlöffnung "a" erzeugt und auf ein Aufzeichnungsmedium (40, 40') abgelenkt werden, um die 2(2n)-'te Punktlinie zu drucken, während eine zweite Strahlöffnung "b" die 2(2n ± 1)'te Punktlinie druckt nach einer räumlichen Verschiebung von (DR ± 2) Punktlinien oder, bei einer Betriebsart mit konstanter Geschwindigkeit, nach einer Zeitverzögerung von (D ± 2/R) / 10V Sekunden, wobei die Auflösung R Punkte pro Millimeter beträgt, D den Abstand zwischen den Zentren der beiden Düsen in Millimetern angibt und V die relative Druckgeschwindigkeit in cm/sec ist.

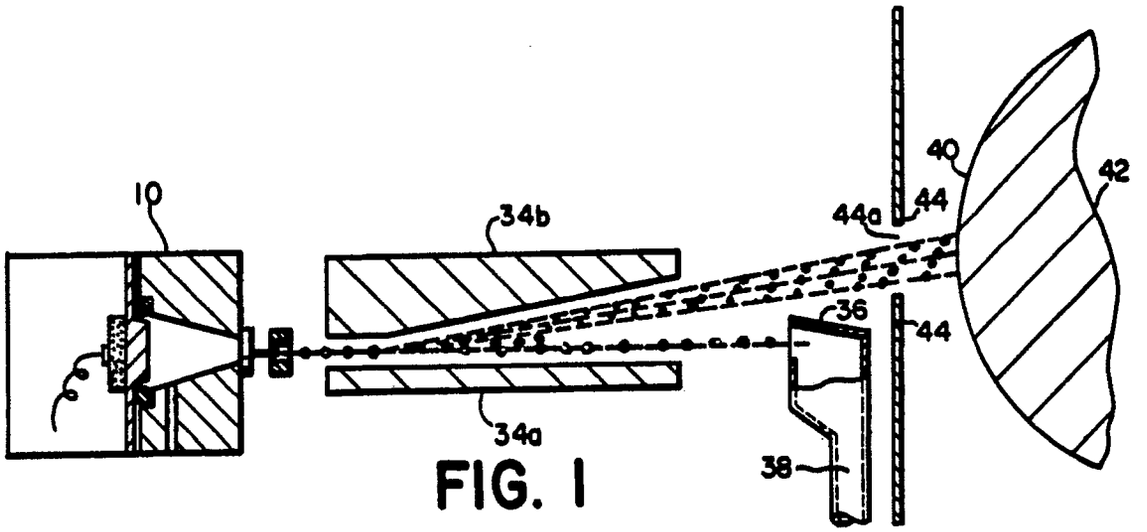

FIG. 1

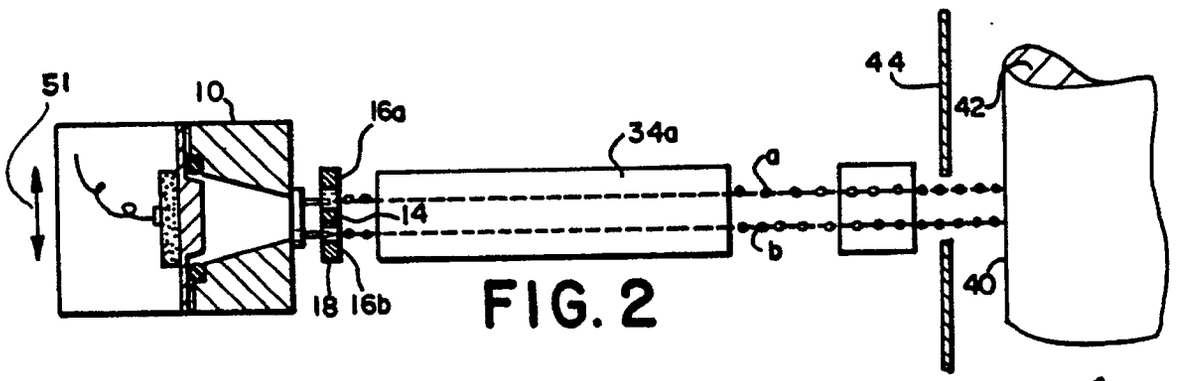

FIG. 2

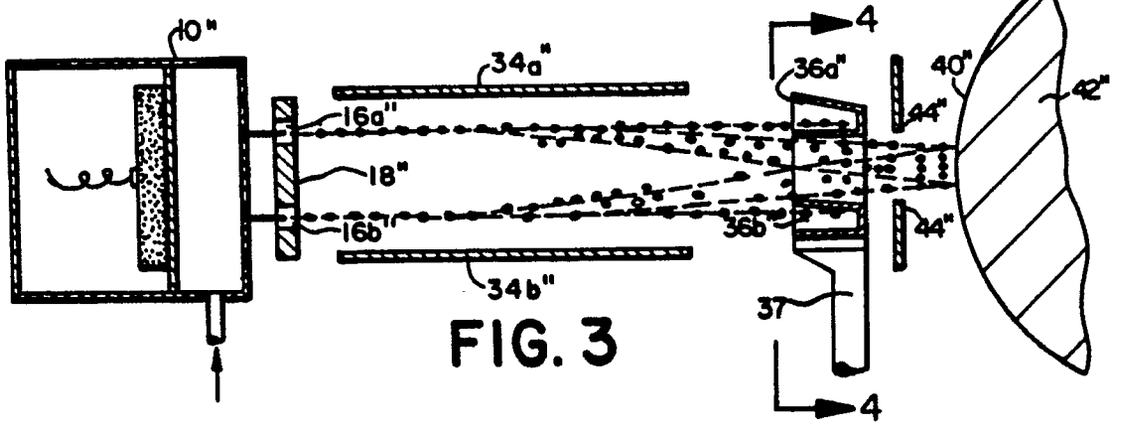

FIG. 3

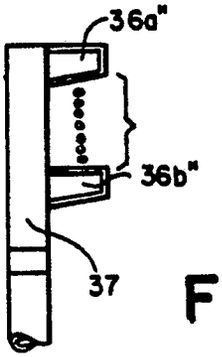

FIG. 4

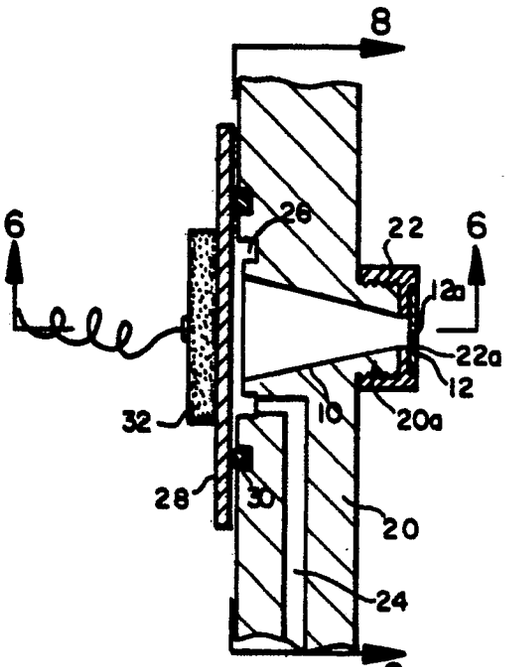

FIG. 5

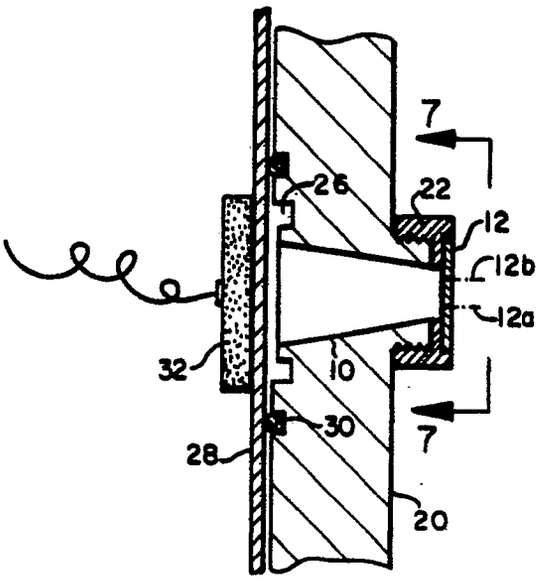

FIG.6

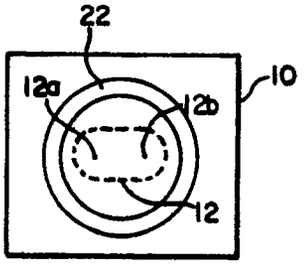

FIG. 7

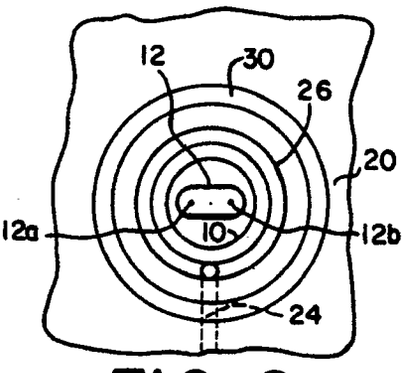

FIG. 8

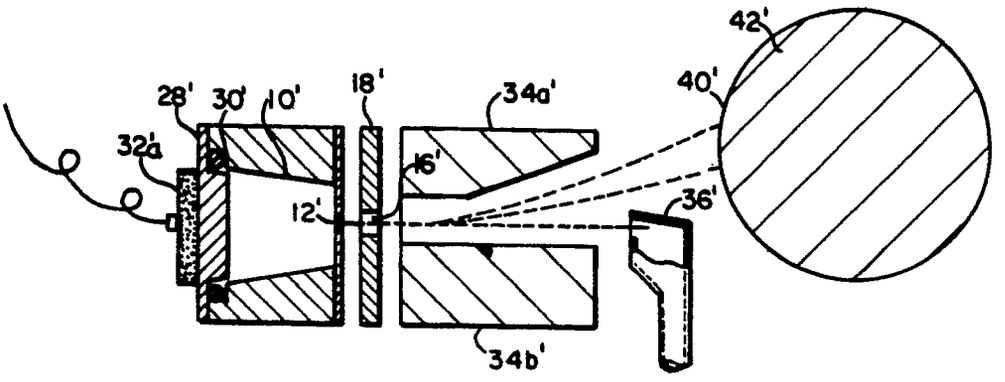

FIG. 10

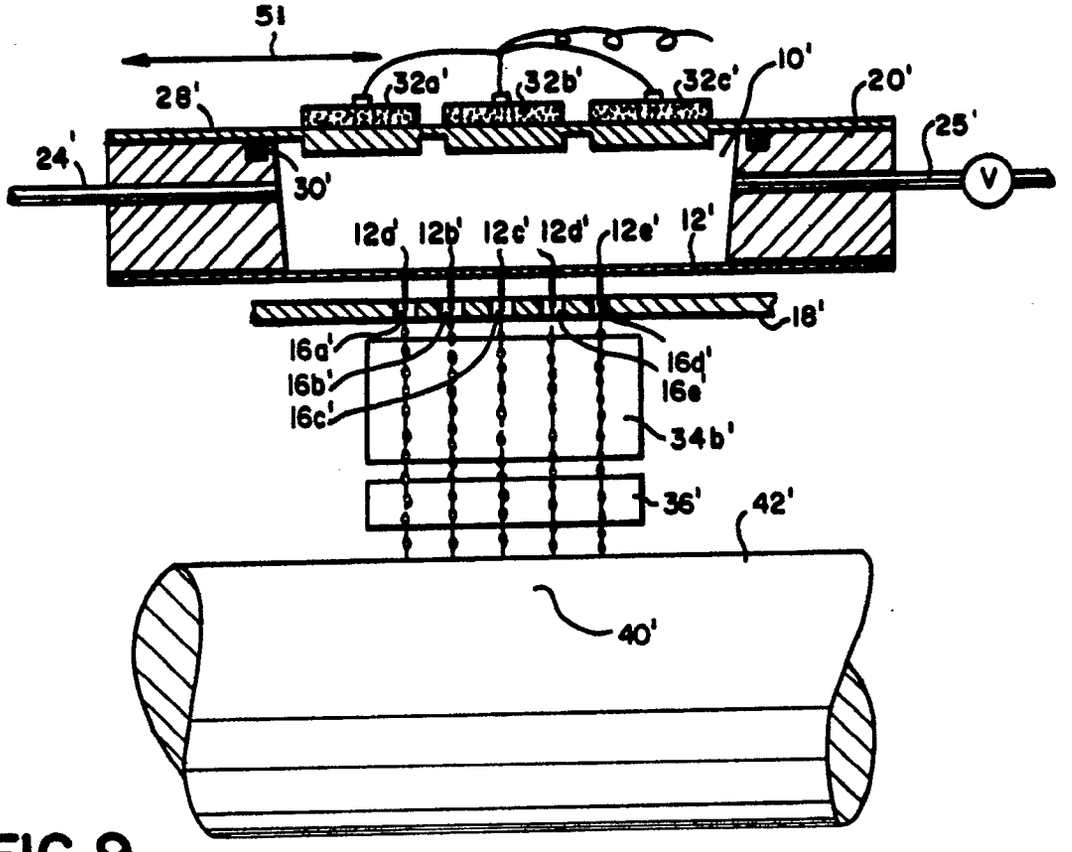

FIG. 9

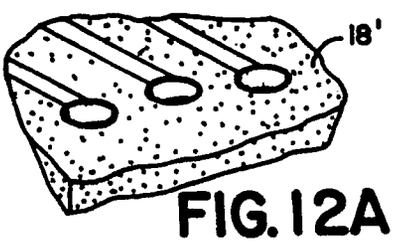

FIG. 12A

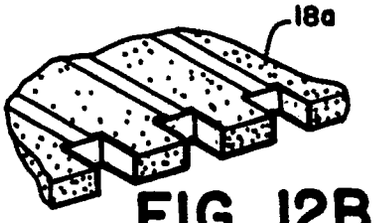

FIG. 12B

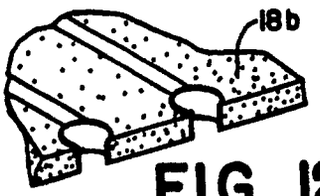

FIG. 12C

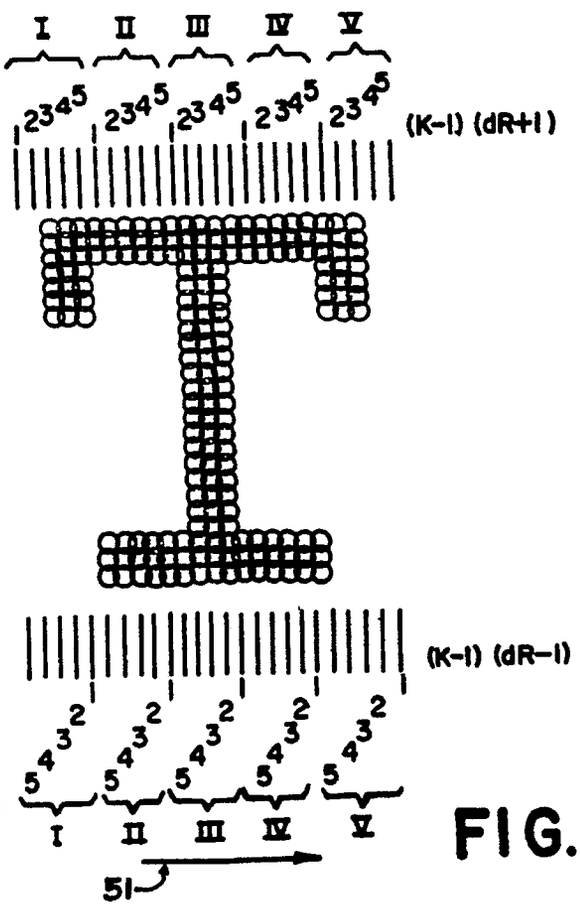

FIG. 11