

[54] **INK DROP WRITING HEAD**
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[51] Int. Cl. **G01d 15/18**
[58] Field of Search **346/75, 140**

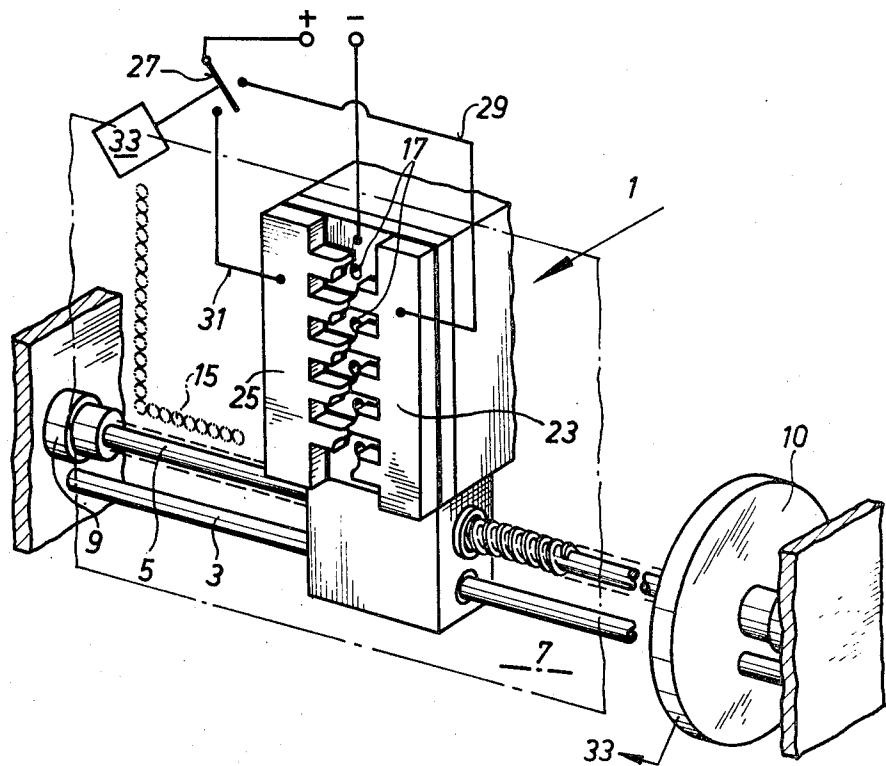
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UNITED STATES PATENTS			
3,656,171	4/1972	Robertson.....	346/75 X
3,747,120	7/1973	Stemme	346/75
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Primary Examiner—Joseph W. Hartary
Attorney, Agent, or Firm—Spencer & Kaye

[57] **ABSTRACT**
In a writing head for producing a high resolution character from drops of a writing fluid on a record carrier, the head including fluid chambers in communication with a common reservoir and ejector nozzles arranged in a row opposite the record carrier for the ejection of fluid drops by means of selectively excitable pressure generators, at least one electrode plate is disposed between the record carrier and a cover plate containing the ejector nozzles, the geometrical dimensions of the electrode plate being selected so that when a voltage is applied between the cover plate and the one electrode plate an inhomogeneous electrical field is produced in the area of every ejector nozzle which is able to deflect the electrically neutral fluid drops ejected from the ejector nozzles in the direction toward the record carrier, due to polarization of charges in the drops in the direction of the field gradients, so that the deflection of the ink droplets occurs in a direction which has a component in the direction of the row along which the ejector nozzles extend.

4 Claims, 5 Drawing Figures



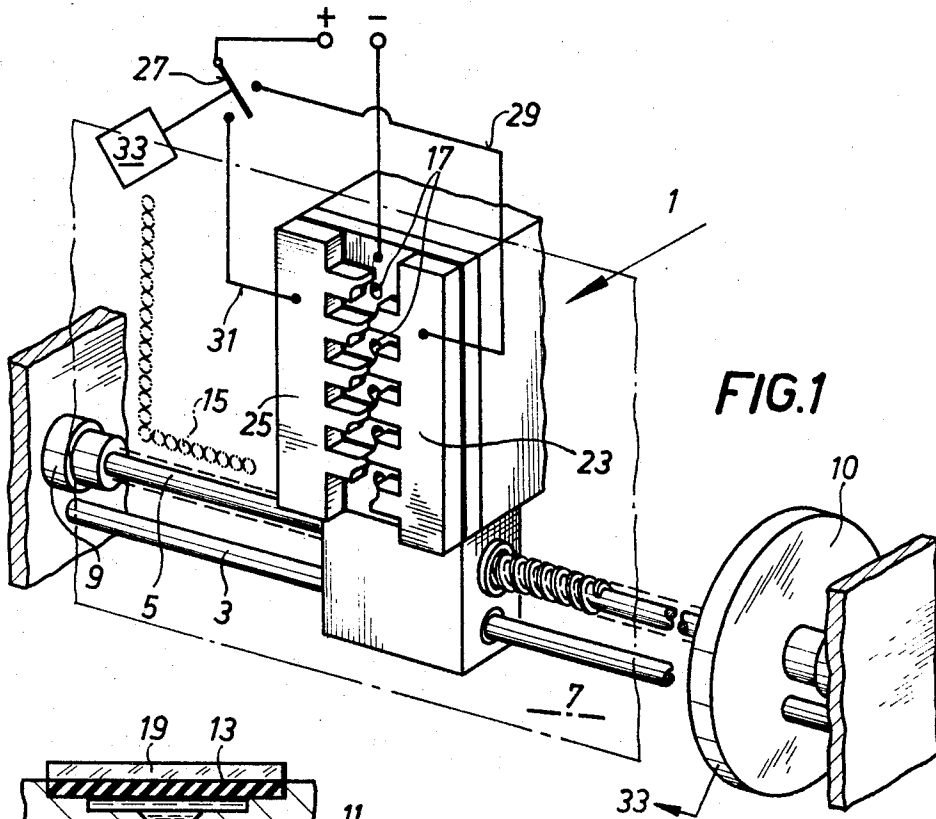


FIG. 1

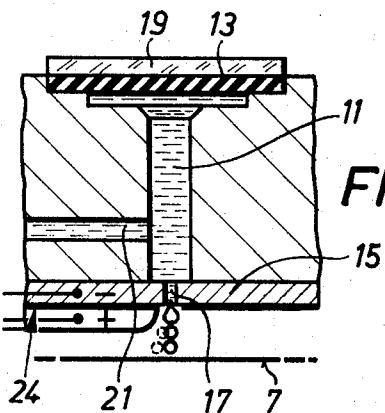


FIG. 2a

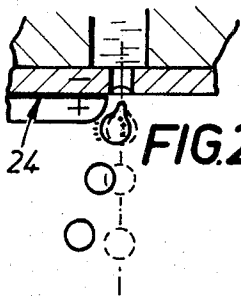


FIG. 2b

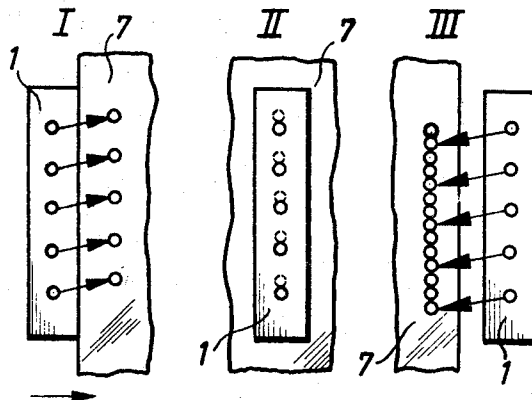


FIG. 3

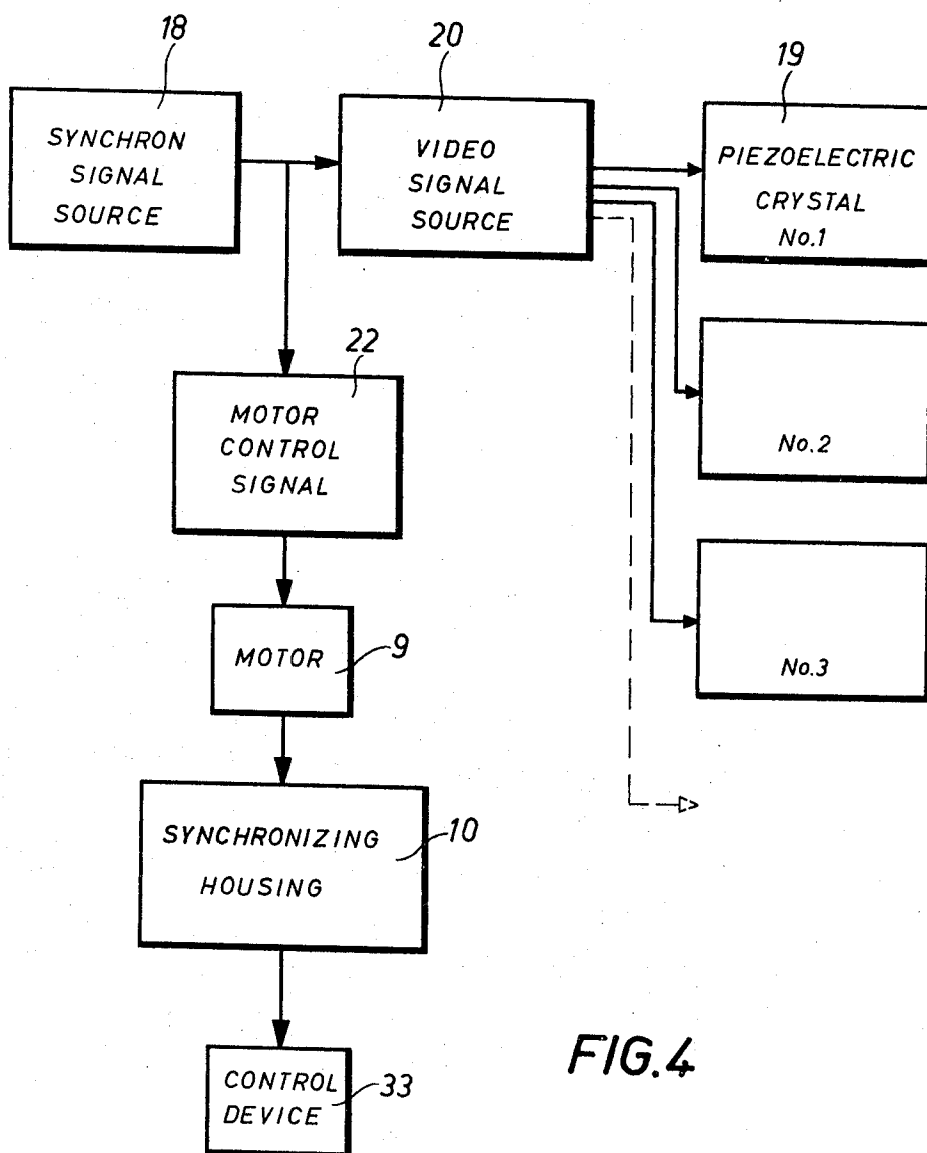


FIG.4

INK DROP WRITING HEAD

BACKGROUND OF THE INVENTION

The present invention relates to a writing head for producing a high resolution character on a record carrier from drops of a writing fluid.

STATE OF THE ART

German Offenlegungsschrift [Laid-Open Patent Application] No. 2,164,614 and corresponding U.S. Pat. No. 3,747,120 disclose a printer in which the volume of a chamber filled with ink can be temporarily varied by an electromechanical transducer device. The temporary increase in pressure in this device ejects individual droplets of ink from an ejector nozzle and sprays them onto the record carrier. However, considerable expense is involved in constructing a device of this type to produce a high resolution character.

If, for example, the character, which consists of a pattern of dots forming elements of a raster, is to be optically scanned it is necessary that the line of script be uninterrupted. In order to avoid malfunctions during optical scanning with an optical reading machine, it is necessary to have about 12 to 15 raster dots, or elements, per column. This in turn requires a corresponding number of pressure generators so that the dimensions of the writing head become rather large and the head becomes too expensive for normal correspondence readers.

On the other hand, German Auslegeschrift [Published Pat. Application] No. 1,960,522 and corresponding U.S. Pat. No. 3,562,761, disclose an ink printer in which a steady jet of ink is ejected by a nozzle and breaks down into droplets of ink after having traveled a short distance from the nozzle tip. These droplets of ink are then charged according to the signal to be recorded by means of a charging ring or tunnel. The drops which are not to be used receive either a certain maximum, or a minimum, or no charge. All droplets then pass through a constant electrical field and are deflected to a greater or lesser extent depending on the charge they carry. Those droplets which are not to be used are generally directed to an aperture so that they do not reach the record carrier.

In this type of recording, however, there is the drawback that the charges carried by the individual droplets vary within substantial limits from one drop to the next so that the alternating effect of the strongly deviating potentials between adjacent droplets leads to interference in the deflection. This produces a print which is not as good as it should be or a print which is inaccurate for purposes of forming a character so that it is less suited for optical scanning. This is particularly the case if the charge on a droplet which has already been charged is relatively high compared to the charge carried by the next succeeding droplet. In order to produce a high resolution character this system also requires expensive controls which makes use of this writing head unacceptable for inexpensive correspondence typewriters for small offices and private gentlemen.

SUMMARY OF THE INVENTION

It is an object of the present invention to improve the written image produced in a jet printer in the form of a pattern of dots forming elements of a grid or raster array, and to make it suitable in particular for automatic reading without increasing the number of jets.

These and other objects are achieved by the provision, in a writing head, for producing a high resolution character from drops of a writing fluid on a record carrier, the head including fluid chambers in communication with a common reservoir and ejector nozzles arranged in a row opposite the record carrier for the ejection of fluid drops by means of selectively excitable pressure generators, of at least one electrode plate disposed between the record carrier and a cover plate containing the ejector nozzles, the geometrical dimensions of the electrode plate being selected so that when a voltage is applied between the cover plate and the electrode plate an inhomogeneous electrical field is produced in the area of every ejector nozzle which is able to deflect the electrically neutral fluid drops ejected from the ejector nozzles in the direction toward the record carrier, due to polarization of charges in the drops, in the direction of the field gradients so that the deflection of the ink droplets occurs in a direction which has a component in the direction of the row along which the ejector nozzles are disposed.

The device according to the invention can thus produce characters with the highest resolution and high quality of the order of that obtainable with present-day mechanical writing and printing mechanisms. Such mosaic-type or grid pattern-type characters are also suitable for automatic reading.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic perspective representation of one preferred embodiment of a movable writing head according to the invention with ejector nozzles arranged in a row.

FIG. 2a is a cross-sectional detail view of one nozzle of the arrangement of FIG. 1.

FIG. 2b is a cross-sectional detail view to an enlarged scale of part of the unit of FIG. 2a.

FIG. 3 is a schematic representation of the individual steps performed by the writing head for printing a column.

FIG. 4 is a block schematic drawing of an control arrangement for synchronizing the movement of a motor 9, control device 33 for a switch 27 and the excitation of pulse generators 19. The control device 33 is connected to a known synchronizing housing 10 as described in U.S. Pat. No. 3,651,915. The synchron signal source is connected to video signal source 20 for the piezoelectric crystal 19 and to motor control signal device 22.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows a writing head 1 for producing a high resolution character on a record carrier 7 from drops of a writing fluid. The writing head has a plurality of writing devices, e.g., five, and is mounted on a shaft 3 to be movable across the surface of the record carrier 7 by means of a threaded spindle 5. The threaded spindle 5 is driven, for example, by means of a stepping motor 9. It is of course also possible to arrange the writ-

ing head to be fixed and to move the record carrier 7 correspondingly.

Each writing unit of the writing head 1 substantially includes, as shown in FIG. 2a, a chamber 11 which is closed, at one end, by a membrane 13 in a known manner and at the other end by a cover plate 15 which is perforated to present an ejector nozzle 17. The membrane 13 can be actuated, i.e., deflected, by an exciter system including, for example, a piezoelectric crystal 19.

The piezoelectric crystal 19 can be excited, via leads which are not shown, by a signal source which is also not shown, such arrangement already being well known in the art. The fluid chamber 11 is also connected in a well known manner with a reservoir, also not shown, via an inlet channel 21.

Returning to FIG. 1, two electrode plates 23 and 25 are firmly connected to the cover plate 15 and are arranged opposite one another along the line of ejector nozzles 17. The electrode plates are designed so that when a voltage is applied to one or the other of them via a switch 27 and one of leads 29 and 31, nonuniform fields are produced in the region of the ejector nozzles 17. The field gradients of these fields cause the impinging uncharged droplets to be respectively oppositely deflected. Such deflection results from the polarization of charge carriers in each drop, as shown most clearly in FIG. 2b, although the drops are electrically neutral. Switch 27 is controlled via a control device 33, which can be of any suitable, known type of electrically controlled switch actuator.

An insulating layer 24 is disposed between cover plate 15 and electrode plates 23, 25. The electrode plates 23, 25 are formed, in the area of the ejector nozzles 17, with extensions which curve away from the surface of the cover plate 15 to the record carrier 7. Furthermore, the electrode plates 23, 25 are laterally spaced from ejector nozzles 17 by such a distance that the deflected drops will not come in contact therewith. Thus the electrode plates 23, 25 will not be soiled.

In the writing head shown in FIG. 1 the dotted characters are generated by producing successive columns of dots. A column of dots may, of course, be composed of one dot or a plurality of dots adjacent one another or spaced apart along the column.

It is, of course, also possible to arrange the row of ejector nozzles 17 parallel to the direction of a line of characters and to generate the characters by producing horizontal lines of dots.

The device of the present invention operates as follows:

In order to produce the characters each one of the pressure generators can be selectively excited by a signal source to eject three droplets to different points along a column. FIG. 3 shows the sequence of this ejection process in three stages for producing a full column of dots.

In stage I, the writing head 1 is disposed at a step *a* transverse to the direction of printing and ahead of the column on record carrier 7 into which the raster dot droplets are to be ejected. When head 1 is in this position, switch 27 is switched so that a voltage is applied to electrode plate 25 so that inhomogeneous electrical fields are produced in the region of all ejector nozzles 17 of cover plate 15. The field gradients of these electrical fields are here directed obliquely to the column to be produced and in the direction of movement of

head 1 relative to carrier 7. If now electrically neutral fluid drops are ejected from ejector nozzles 17 these drops are polarized and directed in the direction of the field gradients.

Then, for stage II, the writing head 1 is moved in the direction of the horizontal arrow by a step *a* by stepping motor 9 to bring the nozzles 17 into line with the column being printed. At the same time switch 27 is moved to position 0, i.e., no voltage is applied to either one of the electrode plates 23 and 25. If now fluid drops are ejected from ejector nozzles 17, these drops impinge vertically on the record carrier since they are not being deflected. The drops ejected in this stage II lie closely below the drops ejected onto the record carrier in the first stage.

Then, for stage III, the writing head 1 is again moved in the writing direction, i.e., in the direction of the arrow, by a step *a*. Now a voltage is applied via switch 27 to electrode plate 23. The droplets ejected from the ejector nozzles 17 in this third stage are again polarized and deflected obliquely to the rear column and in the direction opposite to the direction of movement of head 1 relative to carrier 7. The ejected ink droplets thus come to lie closely underneath the undeflected droplets on the record carrier. This stage III is already the starting position of the head for stage I of printing the next column, it only being necessary to move switch 27 from line 29 to line 31.

The operation of the writing head 1 could also be controlled to cause it to effectuate stage I operation for one raster column while it is in position to effectuate stage II operation for the immediately preceding raster column, and corresponding stage III operation for one column while it is in position to perform stage II operation for the immediately preceding column. This will permit closer spacing between raster dot columns.

By tripling the number of possible dots in each column of the raster, characters are produced which have substantially uninterrupted lines and which can be optically scanned due to their being well defined.

Since the deflections produced by the electric field need be only very slight, approximately, 0.1 mm, voltages which can be easily handled, e.g., less than 300 volts, produce high accuracies in the placing of the dots. On the other hand, a small number of impulse pressure generators produce a large number of raster dots. The arrangement according to the present invention is particularly distinguished by its simple and inexpensive structure and its dependable operation.

It is also possible to move the writing head 1 continuously from column to column or across the entire line of characters. In this case, however, more complicated controls are required. It is also possible to permanently arrange a plurality of writing heads according to the invention in a row along the line, the ejected fluid drops again being deflectable in inhomogeneous fields by means of charge carrier polarization. In this case the number of impulse pressure generators can also be reduced considerably compared to the known arrangements. Furthermore, the drops produced by all pressure generators can again be deflected by two electrode plates which can be connected with a voltage source by simple control means. With such an inexpensive and simple line printer it is also possible to produce essentially solid line characters of good quality.

FIG. 4 is a block schematic drawing of a control device for synchronizing the movement of motor 9, the

5

control device 33 for the switch 27 and the video signal source 20 for the piezo-electric crystal 19. The driving shaft 5 is fixed with a synchronizing housing 10 as described in the U.S. Pat. No. 3,651,915. The control device 33 can consist of two electromagnets of solenoids, which are controlled through the synchronizing arrangement.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

I claim:

1. In a writing head for producing, on a record carrier, a high resolution character formed of drops of a writing fluid the head including a cover member and a plurality of writing fluid drop ejectors each composed of a fluid chamber communicating with a writing fluid reservoir, an ejector nozzle communicating with the chamber and constituted by an opening in the cover member, and an individually excitable pressure pulse generator arranged to apply pressure pulses to the fluid in the chamber for ejecting drops of writing fluid from the nozzle, the plurality of nozzles being aligned in a row and the head being arranged to be positioned with the row of nozzles facing the record carrier so that fluid drops are ejected from the nozzles toward the record carrier the improvement comprising: at least one electrode member disposed adjacent all of said nozzles and mounted between said cover member and the location in which the record carrier writing surface is to be disposed during writing; and means for selectively applying a voltage differential between said cover member and said electrode member for producing an electric field which polarizes charge carriers contained in the electrically neutral writing fluid drops ejected from said nozzles and thus creates an attractive force between each such drop and said electrode member; and wherein said electrode member is configured to constitute means for causing the direction of such field to cause such attractive force to deflect the ejected writing fluid drops in a direction which is transverse to the row in which said nozzles are aligned and which has a component parallel to such row.

2. Writing head as defined in claim 1 wherein there are two said electrode members disposed at respectively opposite sides of said row of ejector nozzles, and said potential applying means are arranged to selec-

6

tively apply a potential between said cover member and either one of said electrode members, said electrode members being configured for causing the voltage between one said electrode member and said cover member to produce an attractive force which is diametrically opposite that produced by the potential between the other said electrode member and said cover member.

3. Writing head as defined in claim 2 wherein said voltage applying means comprises a switch member connected for connecting either one of said electrode members to a source of electric potential.

4. Writing head as defined in claim 3 further comprising means for producing relative movement between said head and the location of the record carrier writing surface, parallel to such surface, in the direction normal to the row along which said nozzles are aligned, and wherein: each said pressure pulse generator is arranged to produce a succession of three pulses for causing three writing fluid drops to be ejected in succession; said switch member is arranged to connect the source of electric potential during ejection of the first of the succession of writing fluid drops to that one of said electrode members which is spaced from said nozzles in the direction of movement of said head relative to the location of the record carrier writing surface, to disconnect both electrodes members from the source of electrode potential during ejection of the second of the succession of writing fluid drops, and to connect the source of electrical potential, during ejection of the third of the succession of writing fluid drops, to the other of said electrode members, which is spaced from said nozzles in the direction opposite to the direction of movement of said head relative to the location of the record carrier writing surface; and said means for producing relative movement are arranged to move said head, between successive writing fluid drop ejections by incremental distances equal to the amount by which a drop reaching the record carrier is deflected normal to the row along which said nozzles are arranged by a voltage between said cover member and one of said electrode members, whereby the succession of ejected writing fluid drops ejected by one said nozzle are deposited on the record carrier as a line of closely adjacent dots parallel to the row along which said nozzles are arranged.

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