April 13, 1965 H. F. WELSH 3,177,800

IMMERSED SPARK GAP PRINTER

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FIG. 1

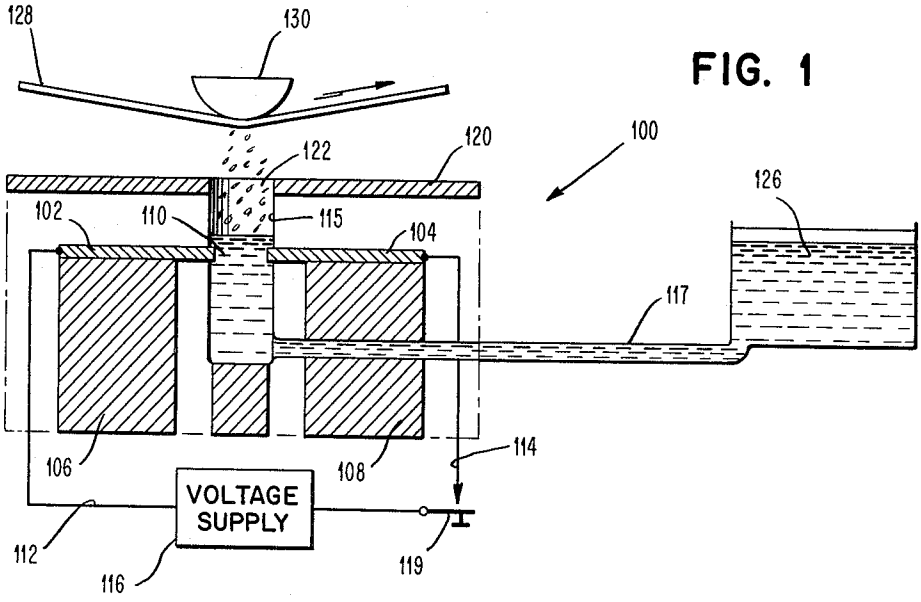


FIG. 2

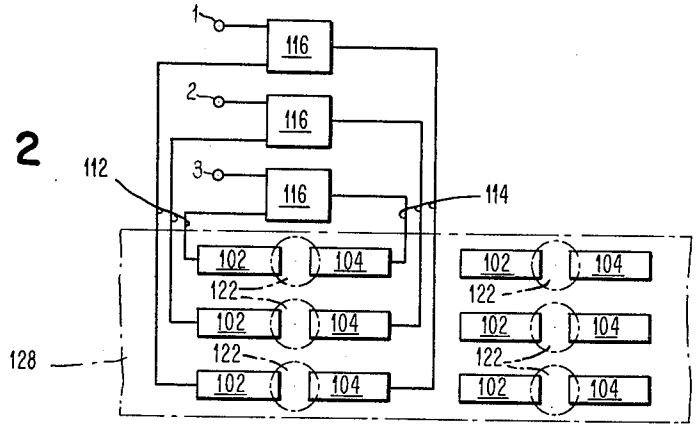
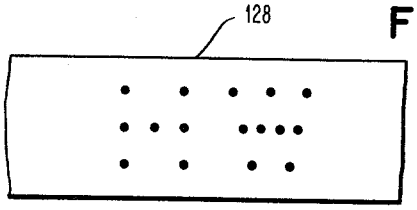


FIG. 3



INVENTOR
HERBERT FRAZER WELSH

BY David Teschner

ATTORNEY

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IMMERSED SPARK GAP PRINTER

Herbert Frazer Welsh, Philadelphia, Pa., assignor to Sperry Rand Corporation, New York, N.Y., a corporation of Delaware

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This invention relates to printing devices and more particularly to that type of printing device wherein there is no direct contact between a moving print means and the surface upon which the printing is placed.

Despite the advances in computer technology, making the arithmetic and other internal organs of the computer faster in operation, the computing systems as a whole have not increased greatly in speed of operation. This lack of overall speed increase is due to a large measure to the relatively low speeds of operation possible with conventional and so-called high-speed types of printing means used to provide a printed record of the computer output information. These printing devices, when compared to the speed of operation of the computer elements themselves, require relatively long periods of time for selection of the character to be printed, movement of the character to contact the surface (or the surface to contact the character) and return to the normal intermediary condition. For example, if the printing device were a band printer, time would be required to move the band to a position wherein the character was in proper alignment for printing. Then more time would be consumed in moving the band to contact the paper (or alternatively move the paper to contact the band) and then allow the moving member to return to its normal intermediary condition, ready for the next print operation. In those types of systems in which the printing member is in constant motion, a period of time is required to allow the print member to move in its cycle sufficiently to permit the desired character to be presented to the surface to be printed upon. The time required for movement to permit contact and the return to a normal condition will be similar to that of the band printer described above. Further, due to the fact that the paper is permitted to move, during the print operation, usually in a direction transverse to the direction of movement, of for example the band of a band or chain printer, special positioning techniques are required to prevent the individual characters from "walking" up or down the surface as a row across the width of the surface is printed.

Also, due to the use of light weight bands to support or carry the desired printing characters, care must be taken to provide proper back-up for the bands regardless of whether they are moved or merely struck by a moving paper, depending upon the type of band printer employed.

Thus it is obvious that if it were possible to reduce or completely eliminate the time required to position a character or allow it to rotate until the proper character was presented, as well as, the time required to move the character or paper the overall speed of operation of the print apparatus and in turn, that of the computational system would be greatly increased.

A solution to this problem of printing speeds would be to use a spark type of printer whereby the characters are formed by a plurality of individual spark positions and which permits the tape to be moved during the entire operation of printing. In well-known devices employing the spark principle, a matrix of electrodes is found on either side of the paper or tape to be printed upon. A plurality of electrode groups, that is an electrode on one side and a corresponding electrode on the other side of the paper or tape are selected, in the form of the particular letter or character to be printed by the device. Although this system is able to overcome the defects in the selection

and movement of print characters and eliminates the requirement for moving either the character or the surface upon which the printing is to be placed, they, however, introduce defects and disadvantages of their own. The most apparent of these defects is the inability to maximize the performance by accurately controlling the air gap or space between the electrodes placed on either side of the paper. This is due to the fact that the electrodes must be placed in such a position, relative to one another, to permit the heaviest to lightest weights of paper to be handled by the same set of electrodes. Otherwise, there would be the requirement for constant i.e. adjustment of the air gap to optimize performance every time the paper weight was changed. A further difficulty is introduced in the fact that the spark created from the discharge between the two groups of electrodes perforates the tape or paper surface. This may cause unwanted signals to be produced in certain types of sensing devices which may be employed to read the surface of the paper or tape. Further, these systems require rather large voltages in order to bridge the air gap between the respective groups of electrodes and cause the spark discharge which will perforate the paper or tape. It is also quite evident that as a result of the procedure used, it is impossible to merely print the material desired upon a single surface of the paper or tape and thus leave the other side free for use.

As briefly stated, this invention makes possible a system of printing similar in operation to electrostatic spark gap printing systems now employed in printing means. However, by a unique placement of the electrodes coupled with a particular characteristic of the ink employed, it is possible to overcome many of the difficulties which are found to exist in presently known systems of spark gap printing. This invention employs a pair of electrodes mounted in the same plane and so arranged that a small gap exists between the electrodes which constitute each pair. In this manner the gap may be fixed to a single value which produces optimum results without concern for the weight of the paper or tape to be printed on. The electrode assembly is completely immersed in an ink supply, which ink is non-conductive and has a high dielectric constant. Further, the electrodes are connected to a voltage source, to selectively apply voltage thereto. Due to the dielectric, non-conducting properties of the ink, the application of voltage to the electrode, causes sparking at the electrode gap but not the flow of current. This spark causes the ink within the gap to be vaporized, ionized and to generally expand with the effect that it forces the ink existing above the gap upward towards the surface of the paper or tape. A sheet of plastic, with an aperture in it and placed above the electrode pair, is used to shape and direct the burst of ink to the surface upon which the printing is to be placed.

A number of these individual electrode pairs, may be arranged in a matrix form, with the individual voltage supplies being controlled by a further electronic matrix. With such an arrangement it is then possible to form any desired character for printing merely by actuating the electrode pairs which conform to the desired shape. The density of the individual dots making up such a character may be varied simply by providing greater or fewer electrode pairs in the print matrix.

It is therefore an object of this invention to provide a novel form of print means wherein no actual contact is made between a moving printing device and the surface upon which the printing is to be placed.

It is another object of this invention to provide a printing device not employing pre-formed characters but rather employing a device wherein the particular form of the character or symbol may be selected at will.

It is another object of this invention to provide a printing device the individual unit of which consists of a pair

of electrodes separated by an electrode gap, which upon proper excitation of a current or voltage source produces a drop or burst of ink which is forced by vaporization of the ink within the gap of said electrode pair, to the print surface.

It is a further object of this invention to provide a vapor operated printing system.

It is yet another object of this invention to provide a vapor operated printing system employing ink which is non-conducting and which possesses a high dielectric constant.

Other objects and features of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose by way of example the principle of the invention, and the best mode which has been contemplated for carrying it out.

In the drawings:

FIGURE 1 illustrates the device constructed in accordance with the basic concept of the invention;

FIGURE 2 shows an arrangement for placing devices constructed in accordance with FIGURE 1 in a matrix for printing composite letters or symbols;

FIGURE 3 shows the manner in which the tape will appear after it has been printed with a device constructed in accordance with this invention.

Similar elements will receive similar reference characters in all of the respective figures.

Referring to FIGURE 1, there is shown an individual print element constructed in accordance with the principles of this invention. The device consists of a small ink tube 115 sealed at its lower end, into which are placed a pair of electrodes 102 and 104. The electrodes are placed along the same plane, perpendicular to the length of the tube 115. The ends of the electrodes 102 and 104 are bonded to the tube 115 in such a manner as to permit a desired gap distance between the electrodes to be set and maintained. This gap may be chosen to give maximum performance, without regard for the weight of the paper or tape to be printed upon. This may be done because the paper or tape is passed above the electrode pair and not between them as in conventional prior art devices. The criteria used for gap selection will be the characteristics of the ink employed and the strength of the voltage supply to be applied to the electrodes. The electrodes 102 and 104 are mounted upon insulating supports 106 and 108 respectively. Further the electrodes are connected by means of conductors 112 and 114 to a voltage supply 116. Said voltage supply being operated by the closing of a switch 119 in response to the selection of the print unit for printing. The application of this voltage will attempt to pass current through the path composed of closed switch 119, conductor 114, the electrode 104, gap 110, the ink, electrode 102, and conductor 112 back to the voltage supply 116.

Ink is supplied to fill the tube 115 to a level above the electrodes 102 and 104 via a duct 117 from an ink reservoir 126. The duct 117 is small in cross section and relatively long, so as to isolate the reservoir from the effects of any activity within the tube 115. Further, the level of the ink in reservoir 126 is kept to a point where the pressure exerted by it will not force the ink out of the tube 115.

The ink employed is an oil based ink which has a high dielectric constant and will not pass current through it. An example of an ink having such properties and commercially available is Carroll Power Press Rotary Black 34P–163 manufactured by the Fredrick H. Levy Co., Inc. of Philadelphia, Pennsylvania. Further, the consistency of the ink is such that it can easily pass from the tube 115, but has sufficient surface tension to prevent it from doing so without some additional external force being applied.

Mounted above the tube 115, but in contact with its upper, open end is a plastic sheet 120, which has an

aperture 122 placed in it. The aperture is so placed as to correspond with the open end of tube 115 and to be of approximately the same size. The aperture may be circular in cross-section, as is the tube 115 or it may be made in any desired shape. This aperture 122 will serve to confine, direct and shape the ink droplets formed as set forth below.

A continuous belt or web of paper, tape or other similar material 128 is passed in the direction of the arrow by means (not shown) under a guide roller 130 which aids in positioning the paper or tape to occupy a desired position with respect to the apertures of the plastic sheet.

The operation of the device can now be set forth. Upon the actuation of the voltage supply 116, by means of the switch 119, a voltage is impressed across the electrodes 102 and 104. No current is permitted to flow in the electrode path due to the gap 110 and the fact that the ink within said gap is non-conductive and has a high dielectric value. However, if the voltage is sufficiently high in value, it will break down the dielectric properties of the ink and force a spark from electrode to electrode. This spark will generate sufficient heat instantaneously to vaporize at least a portion of the ink in the gap, as well as ionize a portion and generally generate a volume of gas. These will result in a rapid expansion of the ink in the gap, which in turn will apply a sudden force to the portion of the ink supply which exists directly above the gap 110 causing it to be propelled through aperture 122 of the plastic sheet 120 to the surface of the paper or tape 128. The droplets of ink so propelled, due to the guiding and confining effects of the aperture 122, land in a concentrated area producing a mark in the form of the aperture 122 of the plastic sheet.

Referring now to FIGURE 2 it can be seen how a plurality of the particular print units shown in FIGURE 1 suitably supported, may be used to produce a composite letter or symbol to be printed. As is evident from the figure a plurality of the electrode pairs are arranged along the length and width of the paper or tape and in turn connected to individual voltage supplies. Each of these voltage supplies in turn are connected to portions of an electrical or electronic matrix which can be used to select desired print groups. Matrices or function table devices of the type required are well known in the art, as shown by the matrix of FIGURE 4–3*b* of the book "High-Speed Computing Devices" by the staff of Engineering Research Associates, Inc., published by McGraw-Hill Book Company, Inc., (1950) at page 43. Thus for example if it was desired to print a character similar in form to the number 1 by selecting each of the terminals 1, 2 and 3 the three electrode pairs shown in FIGURE 2 would be actuated thus producing three dots along the width of the tape in a single line thus giving a character indicative of the 1.

Referring now to FIGURE 3 there is shown a portion of the tape 128 which has been printed by devices arranged in accordance with the invention, the matrix being arranged as shown in the FIGURE 2.

While a relatively small matrix of printing elements has been shown in the respective FIGURES 1 and 2 larger matrixes may be constructed or a plurality of these matrixes may be employed without departing from the invention concepts disclosed herein. It will be understood that various omissions and substitutions and changes of the form and details of the device illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Printing means of the type wherein no force is exerted between a character forming means and the surface to be printed upon comprising:

(*a*) an ink supply, said ink having a high dielectric constant and being non-conductive;

(*b*) a plurality of electrical means inserted into said

ink supply to selectively cause a portion of said ink to be vaporized;

(*c*) means having a plurality of apertures, each aperture being associated with a single of said electrical means, to direct the portion of ink vaporized by its associated electrical means to impinge upon said surface;

(*d*) and means adapted to receive selection signals and selectively operate each of said plurality of electrical means whereby the desired printed characters are produced upon said surface.

2. A device as claimed in claim 1 wherein each of said electrical means is a pair of electrodes.

3. A device as claimed in claim 2, wherein said means to operate, is a voltage supply which causes a short duration spark to be created between said electrodes causing the ink between said electrodes to be vaporized.

4. Printing means of the type wherein no force is exerted between a character forming means and the surface to be printed upon comprising:

(*a*) an ink supply, said ink having a high dielectric constant and being non-conductive;

(*b*) a plurality of pairs of electrodes arranged to have a gap between said pairs mounted along a single plane, completely immersed in said ink supply;

(*c*) means to selectively apply a voltage to one or more of said electrode pairs thus causing a spark to breach said gap and vaporize the ink within said gap propelling a portion of the ink supply upwardly;

(*d*) means having a plurality of apertures, each aperture being associated with a single of said electrode pairs, to direct and shape the portion of ink propelled by its associated electrode pair to impinge upon said surface.

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WILLIAM B. PENN, *Primary Examiner.*