May 14, 1968 P. J. RICE ETAL 3,383,697

NONIMPACT DRUM PRINTER WITH MULTIPLE INTERRELATED PRINTING STATIONS

Filed Dec. 30, 1963 2 Sheets-Sheet 1

Fig. 1

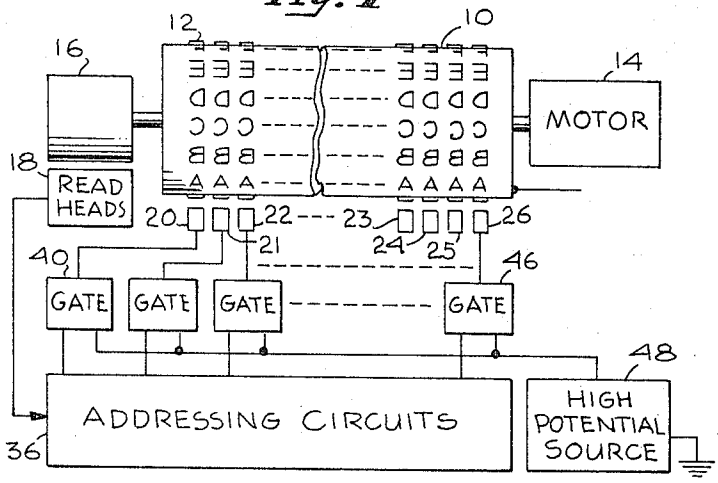


Fig. 2

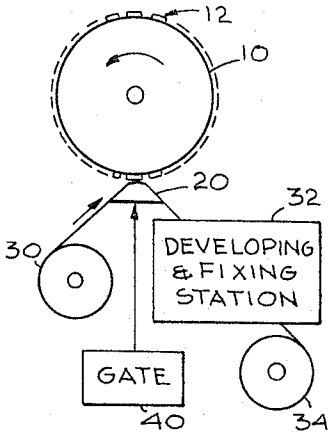


Fig. 3

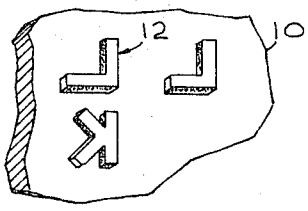


Fig. 4

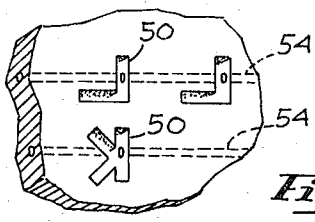
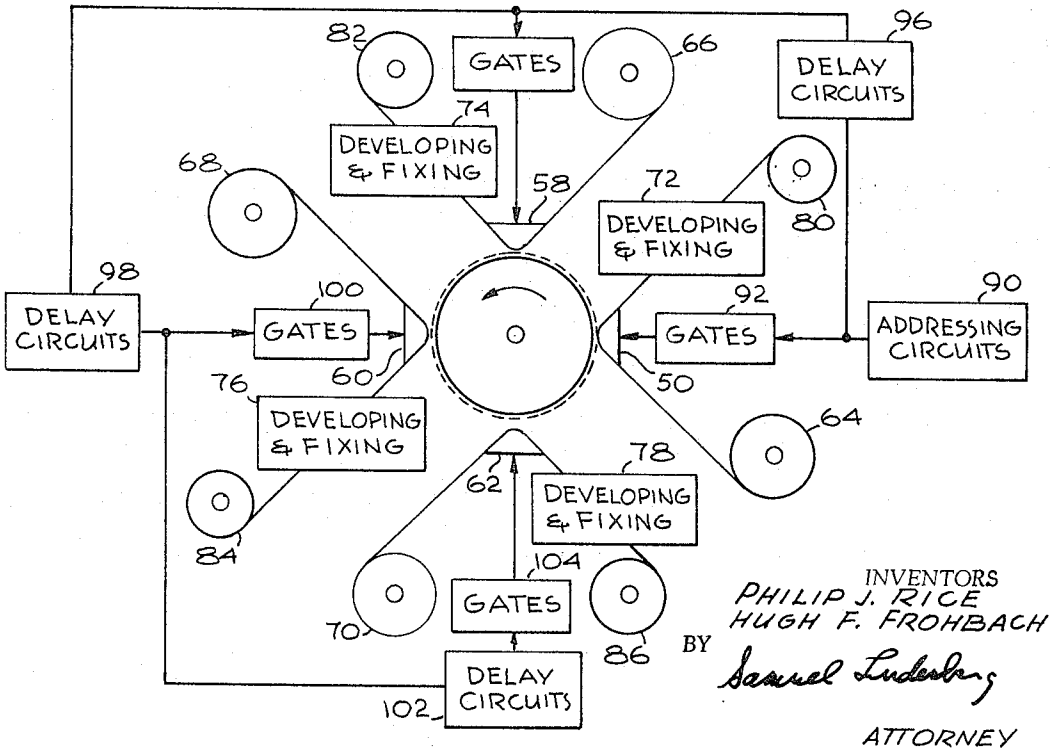


Fig. 5



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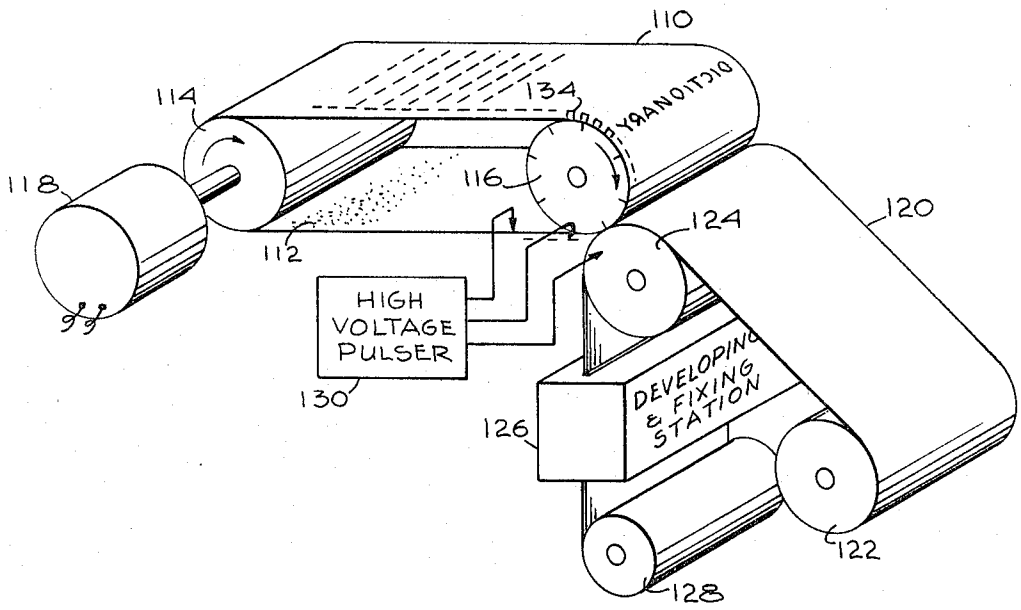
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NONIMPACT DRUM PRINTER WITH MULTIPLE INTERRELATED PRINTING STATIONS

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Fig. 6



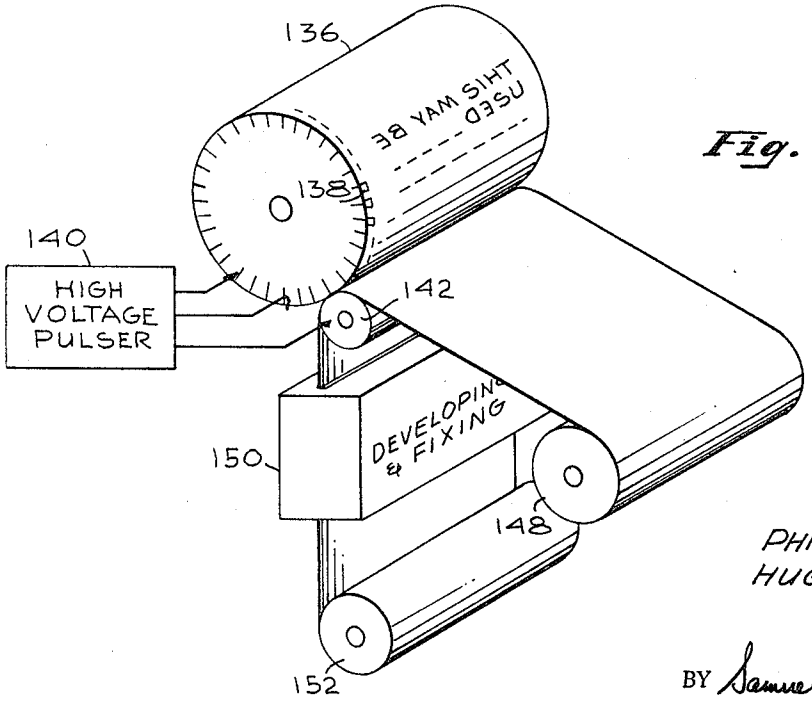


Fig. 7

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United States Patent Office 3,383,697
Patented May 14, 1968

3,383,697

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Filed Dec. 30, 1963, Ser. No. 334,365
2 Claims. (Cl. 346—74)

ABSTRACT OF THE DISCLOSURE

An electrostatic printing system is provided wherein conductive type characters are arranged about the periphery of the drum in spaced rows. Positioned at a printing location is either a conductive bar or a plurality of conductive segments. The writing medium on which printing is to occur is passed between the drum and the bar or segments. By selectively applying a voltage between the segments and a row of type at the printing position or, in the case where the type on the drum surface has already been arranged in the form of desired copy. A potential is applied between the type on the drum surface and the bar in the printing position each time a row of type arrives in the printing position. An electrostatic charge image is formed on paper positioned within the printing position. The electrostatic images or charge images on the surface of the writing medium are then passed through a developing station.

This invention relates to high speed printing systems and more particularly to an improved electrostatic high speed printing system.

One of the presently favored high speed printing systems which is employed to print out the data provided by a data processing machine comprises apparatus which employs a print drum having rows of type thereon together with apparatus for providing an identifying signal for each row of type as it passes beneath a printing station. The characters in each different row of type are identical. The identifying signals are compared with signals from a storage means indicative of the characters desired to be typed. When an identity is sensed by the comparator, it produces an output signal. For each character in a row at the printing station there is provided a separate print hammer. Paper together with carbon paper is interposed between the print hammers in a row and the surface of the printing drum. Upon the occurrence of a signal at the output of the comparator together with another signal indicating which of the characters along a row are to be printed, the print hammer at the specified location is actuated whereby it drives the paper and carbon paper against the drum surface to thereby leave an impression of the character at that location on the paper. By way of example, a system of this general type may be found described in a patent to E. C. Nelson, Patent No. 2,850,566.

Systems of this type are limited in speed due to the fact that the print hammers are normally solenoid actuated devices which must be energized, the mass of the hammer must be moved, and then restored as the solenoid is de-energized in order that the next operation can

be performed. The hammer must have sufficient mass to press the paper against the carbon paper and type on the drum face to leave an imprint on the paper.

An object of this invention is to produce a high speed printer which does not require the use of a moving hammer to effectuate printing.

Another object of the present invention is the provision of an arrangement for a drum type printer which can operate at higher speeds than presently known drum type printers.

Still another operation is the provision of a novel and useful contactless printing system.

These and other objects of the present invention may be achieved in an arrangement wherein instead of moving printing hammers, a stationary segmented conductive bar is provided with a segment for each letter or character in a row on the drum. The letters or characters on the drum face may be either raised above the surface of the drum if the entire drum surface is conductive or, may be flush with the drum surface if the surface of the drum except for the letter shapes is an insulator. Paper is caused to pass between the conductive segments and the surface of the drum and need not touch the drum surface. The region between the conductive segments and the surface of the drum is termed a printing station. Whenever a row of characters is in the printing station and it is desired to print that character at one or more selected locations in the row of the characters in the printing station, then a voltage pulse is applied to the segments at the locations at which printing is desired. A shaped electric charge pattern is deposited on the paper at that time. The shape of the charge pattern is determined by the shape of the character in the printing location at that time. The drum continues rotating in order to bring every single row of characters on its surface within the printing station. Then the paper is advanced to bring a fresh printing surface into the printing station. The paper continues to advance after each line of type has been printed in order to pass through a developing and fixing station, wherein using well known electrostatic developing and fixing techniques, pigment powder having electroscopic properties is dusted on the paper. This powder adheres only to those areas wherein there is an electric charge. The powder is then fixed by heating or otherwise to the paper and thus constitutes a visible image.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIGURE 1 is a schematic drawing of an embodiment of the invention;

FIGURE 2 is a side view of an embodiment of the invention;

FIGURES 3 and 4 show details of the printing surface employed in the embodiment of the invention;

FIGURE 5 is an arrangement in accordance with this invention for securing multiple printed copies;

FIGURE 6 is a schematic view of another arrangement of the embodiment of the invention; and

FIGURE 7 is still another drawing of an embodiment of the invention.

Referring now to FIGURE 1, there may be seen an arrangement for an embodiment of the invention. A printing drum **10**, shown in segmented form, has rows of characters **12** disposed around the periphery thereof. The drum is rotatably driven by a motor **14**. The drum has a smaller disc or drum **16** connected to be rotatably driven therewith. The drum **16** carries indicia which may be read by read heads **18** for indicating which character on the periphery of the drum is at a printing station.

The printing station may be simply defined as the region at which printing occurs. This is determined by the location of a plurality of aligned conductive segments respectively **20** through **26**. These segments are spaced a small distance from the drum to permit paper to pass between them and the drum surface without contacting the drum surface. As may be seen from FIGURES 1 and 2, the area of the surface of each conductive segment which is opposite the surface of the drum is slightly larger than the area encompassed by a character which passes underneath that segment. A pay-out roll of paper **30** feeds the paper over all of the segments, between the segments and the drum surface and thereafter through a developing and fixing station **32** to a takeup roll of the paper **34**.

The characters **12** on the surface of the drum may be embossed thereon as shown in FIGURE 3 so that effectively, what is presented is a raised conductive letter, which is raised above the conductive drum surface **10**. The drum is grounded and therefore should a high voltage pulse be applied between a segment and the drum when paper is between the segment and a character is opposite the segment then charges are deposited on the paper which will have the pattern thereof determined by the letter or character opposite the segment at that time. Should the paper have dielectric properties or a reasonably low value of conduction, then the charge pattern will remain on the paper until it can be subsequently developed and fixed. The development of the charge pattern may be performed in accordance with well known techniques either by dusting the paper with a pigment powder having electroscopic properties whereby the powder will adhere to the charge pattern and not to the remainder of the paper, or by inversion in liquid toner. The powder or liquid segment can then be fused to the paper by heat or other well known means. Some liquid toners are self-fixing.

In accordance with this invention, instead of moving hammers when a row of letters is in the printing position high voltage pulses are selectively applied to the row of segments whereby electric charge patterns are deposited on the paper corresponding to the letters opposite the energized or pulsed conductive segments. This may be carried out by using previous well known circuitry, such as that in the previously referred to patent to Nelson, whereby the signal outputs of the read heads **18** which indicate the row of letters or characters in the printing position are applied to the addressing circuits **36**. These addressing circuits contain circuitry for determining from data which is provided from a computer for example at which one of the locations on the paper in the printing position, it is desired to print. The addressing circuits **36** then energize selectively one of the gates **40** through **46** which have their outputs respectively connected to one of the conductive segments **20** through **26**. As a second input to each one of the gates **40**, **46**, there is provided a high voltage from a high potential source **48**. Thus, the ones of the gates which are pulsed open by the addressing circuit **36**, apply for a short interval a high potential to the ones of the conductive segments connected to the open gates. As previously indicated, this enables a charge pattern deposition to occur on the paper under the conductive segment corresponding to the character or letter under the conductive segment at that time.

It will be appreciated that the technique for handling paper and for addressing the drum segments may be the same as is employed with presently known drum printers. That is, the paper advances after each complete line of printing has occurred. If the drum requires one revolution to place every character on the periphery thereof in the printing station, then the paper will advance after each complete revolution of the drum. However, if the drum has a sufficiently large surface so that the characters thereon are repeated and it takes less than one revolution of the drum to bring a character at least once into the printing station, then the paper will advance more than once for each revolution of the drum.

As previously indicated, FIGURE 3 shows an arrangement whereby the letters on the drum surface extend beyond the surface of the drum. This is required where the surface of the drum is conductive. If the drum surface is not conductive then, as shown in FIGURE 4, the letters **50** need not extend beyond the surface of the drum but may be flush therewith. It is necessary however to provide a ground return for each letter so that a voltage discharge may occur therebetween. This may be done by having a pin extend through the insulating portion of the drum periphery to a central connector ring which is grounded, or to a conductive drum surface. Alternatively, the drum periphery may be made using printed circuit techniques. As shown in FIGURE 4, the letters **50** may be printed on one surface of the insulating substrate **52**. Collector conductors **54** shown by dotted lines are printed on the opposite surface of the insulating substrate **52**. Small holes may then be drilled in each one of the letters and connection may be made between each letter and the collector line **54** by plating through, using known techniques for accomplishing this. The collector lines **54** are then brought to a common junction for connection to ground.

FIGURE 5 shows an arrangement in accordance with this invention for obtaining multiple copies during a single rotation of the drum. This time, instead of having a single printing station, as many printing stations are provided around the drum periphery as the number of copies desired. In FIGURE 5, by way of example, four printing stations are shown. At each printing station there are provided a row of conductive segments respectively **56**, **58**, **60**, **62**. At each printing station a pay-off roll of paper respectively **64**, **66**, **68**, **70**, feeds paper over the row of conductive segments respectively **56**, **58**, **60**, **62**, through the printing station, and then through the respective developing and fixing stations respectively **72**, **74**, **76**, **78**, to a takeup roll of paper, respectively **80**, **82**, **84**, **86**.

Addressing circuits **90** determine which one of the segments **56** is to have voltage pulses applied thereto when a particular row of characters appears at that printing station. In response to this determination, which is made in accordance with the system described in FIGURE 1, for example, gates **92** are enabled selectively to apply voltage pulses to selective ones of the conductive segments **56**. The input to the gates **92** is also applied to delay circuits **94**. A separate delay circuit is provided for each one of the gates **92**. Each one of the separate delay circuits **94** is connected as an input to a separate one of a plurality of gates **96**. The output of each one of these gates connects to a separate one of the conductive segments **58**.

Each one of the delay circuits **94** provides a delay which is required for the row of characters in the position opposite the conductive segments **56** at the time printing occurs, to advance to a location opposite the row of conductive segments **58**, or to the second printing position. Similarly, delay circuits **98**, to which the outputs of delay circuits **94** are applied, delay the application of these output signals to gates **100** for the time required for the row of characters to advance from the printing position delineated by the row of conductive

segments **58** to the printing position delineated by the row of conductive segments **60**. The output of the delay circuit **98** besides being applied to the gates **100** is also applied to corresponding delay circuits **102**. The function of these delay circuits is to delay the application of enabling signals to gates **104** until the row of characters has been moved by the rotation of the drum to the printing position delineated by the conductive segments **62**. Accordingly, the enabling signals applied by addressing circuits **90** to the gates **92** successively enable gates **96**, **100**, and **104**, so that these gates can with their outputs apply voltage pulses to correspondingly positioned conductive segments **58**, **60**, **62**. As a result, when the drum has completed one revolution, an identical line of print has been printed on four separate sheets of paper. The four separate sheets of paper can then be advanced to position the next location at which printing is desired in the respective printing stations. As was described previously, the paper advances through the respective developing and fixing stations **72**, **74**, **76**, **78** after which the paper is rolled up on the respective takeup rolls **80**, **82**, **84**, **86**.

It should be appreciated at this time that since the printing process effectively comprises depositing a predetermined pattern of electrostatic charges on paper, and since the time for this to occur is very much faster than even the time required for the voltage pulse applied to the conductive segment to rise to its full amplitude, and then to die away, the electrostatic drum printing system which is described herein can operate at a much higher speed than previously known drum printer systems which use moving hammers. Indeed the limit to the speed at which this system can operate may only be determined by the speed at which the paper can be handled.

While the foregoing description has been in terms of a high speed printer of the type which may be employed to receive the output of a computer for example, this invention should not be so limited. It was pointed out previously in connection with FIGURE 4 that the periphery of the drum may constitute a printed circuit. The printed circuit art has developed to the point where a substrate may be made of a flexible material such as Teflon for example. Accordingly, referring now to FIGURE 6, a flexible substrate **110** may have printed on the outer surface thereof printed material such as the contents of a paper, a magazine, etc. The inner surface **112** of the web may be left conductive. The web may be made perforate, that is, it may have holes which are much smaller than the letters which extend through the web so that it is possible to plate or print through conductive connections between the letters which are deposited by printed circuit wiring and the conductive inner surface **112** through these holes. The web **110** is stretched over rollers **114**, **116**. The roller **114** is rotatably driven by a motor **118** whereby the web **110** is moved over the rollers **114**, **116**.

Paper **120** on which printing is to occur extends from a payoff roll **122** over a conductive roller **124**, then through a developing and fixing station **126**, to a takeup roll **128**. The paper **120** may either be brought in direct light contact with the surface of the web **110** or may be slightly spaced therefrom. The conductive roll **124** should have sufficient surface area so that the portion of the paper adjacent a line of type on the outer surface of the web **110** is effectively parallel to that line of type. A high voltage pulse source **110** is energized each time a line of type is in the printing position, which is defined by the time when that line of type is directly opposite or directly and fully in contact with the paper **120**. The high voltage pulse source may be synchronously energized either by operating off one of the rollers **114**, **116**, or preferably by having a brush **132** which contacts conductive line marks **134** which are printed on the outer periphery of the web **110** at the time each line is printed. The high voltage pulser is connected between the conductive inner surface **112** of the web **110** and the conductive roller **124**, and applies a high voltage pulse on the order of between 600 and 1100 volts, for example between the two. As a result, there occurs a line of electrostatic charge depositions corresponding to the pattern of the letters at the printing position at the time of the high voltage pulse. This line is advanced through the developing and fixing station **126** and thereafter to the takeup roll **128**.

The electrostatic printing technique which has just been described may also employ a drum instead of a web for printing. In FIGURE 7, there is shown such a drum **136**, and the data desired to be printed is disposed over the surface thereof either as embossed characters, or deposited using a printed circuit technique on shells which are then attached to the periphery of the drum. At the time of the formation of the conductive letters on the surface of the drum, line markers **138** may also be deposited, in the same manner as was described in FIGURE 6. These line markers indicate to the high voltage pulser **140** when a row or line of letters is in the printing position. The high voltage pulser **140** has a brush in contact with the periphery of the drum which senses this and thereupon instructs the high voltage pulser to apply a voltage pulse to a conductive roller **142**. The paper on which printing is to occur extends from a payout roll **148** over the conductive roller **142**, then through a develop and fixing station **150**, and thereafter onto a takeup roller **152**. The paper may either contact or be closely spaced from the periphery of the drum **136**.

There has accordingly been described and shown herein a novel, useful, and improved high speed printing system.

We claim:

1. An electrostatic printing system for printing on a writing medium comprising a printing drum having rows of conductive type spaced around the periphery thereof, said type in said rows of type being aligned around the periphery of said drum to sweep out circular sectors when said drum is rotated, a plurality of printing positions, spaced around the periphery of said drum, at each of said printing positions there being a plurality of conductive segments, there being a segment for each one of said circular sectors, said conductive segments being aligned and each segment being opposite a different one of said sectors, a different writing medium for each printing position, means for passing each writing medium at each writing position between said aligned segments and the surface of said printing drum at each printing position, means at a first of said plurality of printing positions for selectively applying voltage pulses between the conductive segments at said first printing position and a row of type when a row of type is opposite said conductive segments for depositing electrostatic charges on the writing medium at the first printing positions with a pattern determined by the shape of the type in the row of type opposite the conductive segments at the time, and means for applying signals derived from and corresponding to the selectively applied voltage pulses successively to the conductive segments at each of the printing positions successive to said first printing position when the row of type at said first printing position reaches the successive printing station to successively deposit duplicate electrostatic charge patterns on the respective writing mediums to the electrostatic charge pattern deposited on the writing medium at the first printing station, and means for subsequently developing said electrostatic charge patterns on each of the writing mediums at each of the printing stations.

2. Apparatus as recited in claim **1** wherein the means for successively applying the voltage pulses which are applied between the conductive segments and a row of type in the first printing station and successively between the conductive segments and the row of type when it appears that the successive printing positions includes:

a gate circuit at each printing station for each conductive segment;

a delay circuit connecting each gate circuit at a printing station to a corresponding gate circuit at a succeeding printing position;

means for applying the voltage pulses which are applied to the conductive segments at the first printing position to the delay circuits connected between the gate circuits at the second printing position and the first printing position, the time of the delay of each of the successive delay circuits being determined as the time required for a row of type to move between adjacent printing positions.

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