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Merka et al.

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[54] **ELECTROGRAPHIC PRINTER MATRIX CIRCUIT**

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[52] **U.S. Cl.**.....**346/74 ES**, 250/49.5 GC, 346/74 S

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[58] **Field of Search**.....346/74 E, 74 ES, 346/74 S, 74 SB, 74 SC; 250/49.5 GC

[56] **References Cited**

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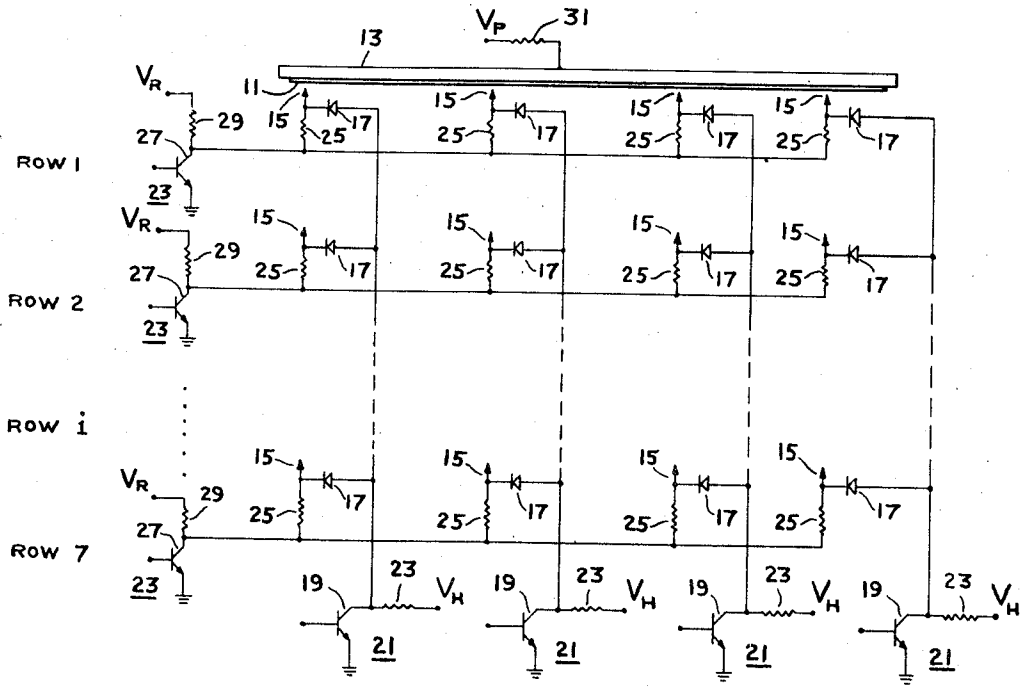
3,564,556	2/1971	Tsukatani et al.	346/74 ES
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[57] **ABSTRACT**

An electrographic printer having a multiplex matrix type driving circuit for the printing styli, thereby reducing the number of high voltage switches needed to drive the styli. The styli are grouped into N groups, each containing M styli. A first set of N selectively actuable driving circuits are connected by unidirectionally conductive means to the styli of the corresponding groups, and a second set of M selectively actuable driving circuits are connected by resistive means to the corresponding styli from each of the groups. Means are also provided for selectively simultaneously activating one of said driving circuits from said first set, and selected ones of said driving circuits from said second set, for depositing charge on the paper in image configuration.

4 Claims, 2 Drawing Figures



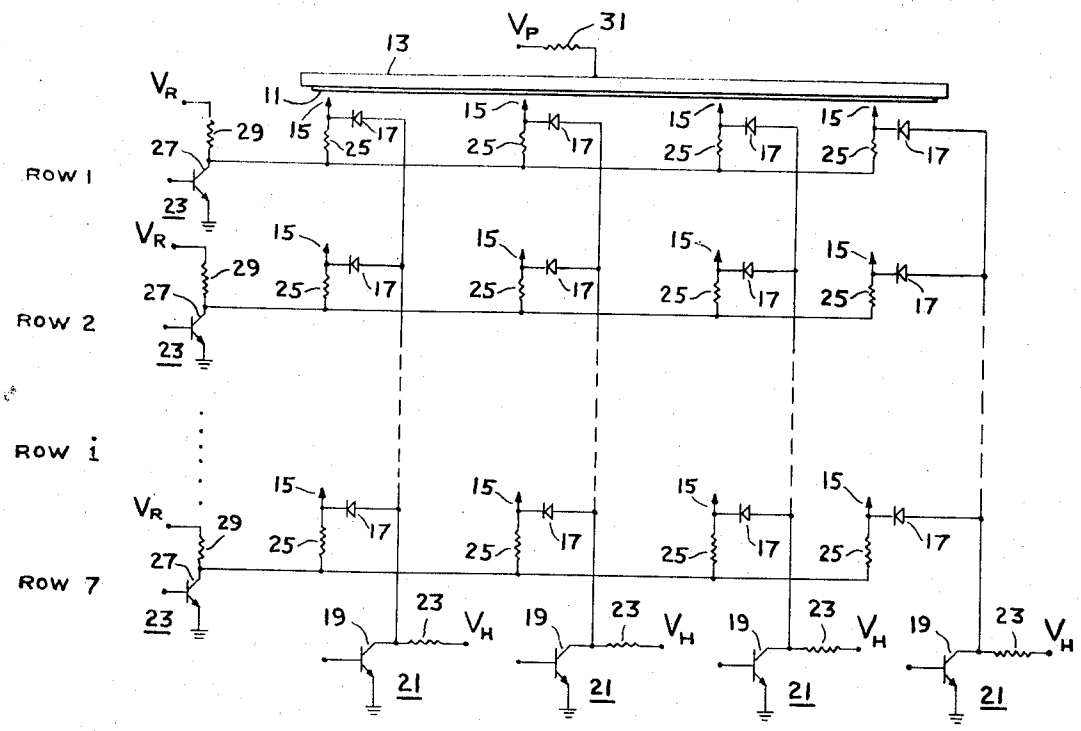


FIG. 1

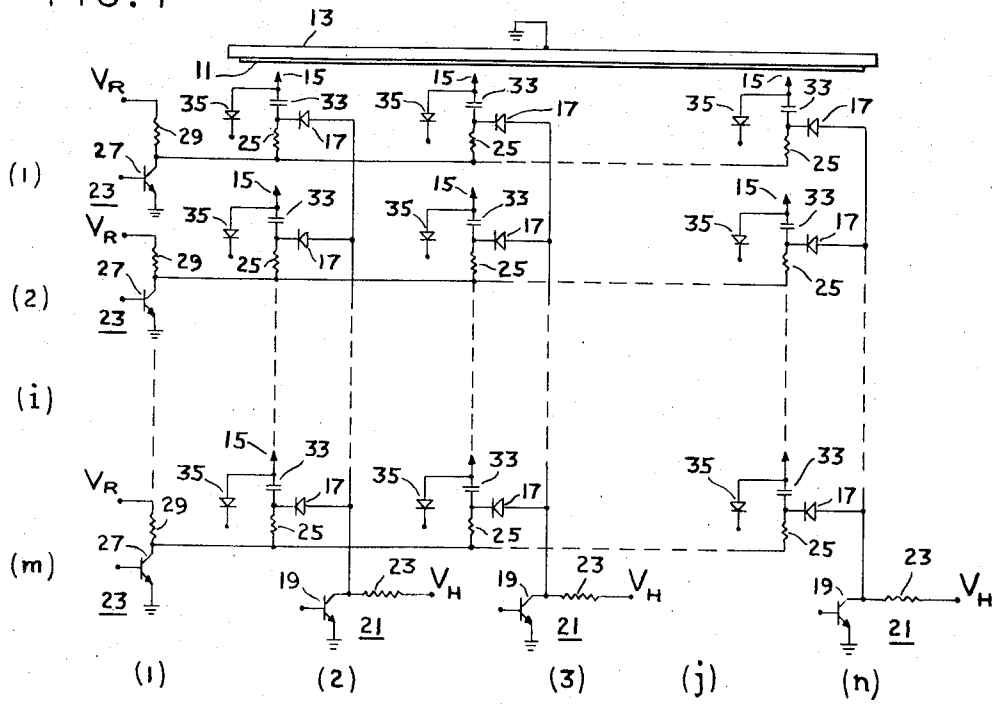


FIG. 2

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ELECTROGRAPHIC PRINTER MATRIX CIRCUIT

BACKGROUND OF THE INVENTION

This invention relates generally to electrographic printers and more particularly to electrographic printers having improved matrix type driving circuits.

Electrographic line printers deposit electrostatic latent images of information to be printed on a web of dielectric coated paper. This latent image is then developed by means of liquid or dry toner developing systems. These machines usually include a stationary printing head assembly having as many as 1000 or more individual styli arranged in contact with the coated side of the web in a line normal to its direction of movement. A common electrode is also provided, usually on the opposite side of the web, and, as the web is moved past the styli, dots of electric charge are deposited on the dielectric coating by selectively pulsing the styli. Printers of this type are often arranged to print a character by depositing charge on selected dots of a 5 × 7 dot matrix, but may also be constructed to print graphics or characters using other formats.

Line printers of this type offer a significant step forward over the earlier impacting type of line printer. They are quiet in operation, print at high speed, and produce quite acceptable print quality.

There are, however, many problems with these machines and, since they require an individual high voltage switch for each of the 1000 or more styli, in addition to the electronics for controlling the activation of all the styli in parallel, they become very expensive.

This problem of electronic complexity and high cost is partially solved at some sacrifice in printing speed by means of the electrographic printer described in patent application Ser. No. 116,361 by Robert H. Detig and Bertrand Boyson, which was filed on February **18, 1971**, and which is assigned to the assignee of the present invention. In that application there is described an electrographic nonimpact printer in which four print-heads, each carrying seven linearly arranged styli therein, is transported in an oscillatory fashion across the coated face of a web. A separate high voltage driving circuit is provided for each of the 28 styli and these driving circuits are selectively energized for depositing dots of electric charge in image configuration on the web as the printhead traverses it in both directions.

Although the printer described in the above application does substantially reduce the complexity of the electronics and is adequately fast for most applications, it still has a disadvantage of requiring a separate high voltage driving circuit for each of the 28 styli.

U. S. Pat. No. 3,564,556, to Kenmi Tsukatani et al. overcomes the requirement for having a high voltage driving circuit for each stylus by grouping the styli into a number of groups and by providing a matrix type driving circuit in which each of the column driving circuits is connected to all of the styli of corresponding groups, and the row driving circuits are connected to corresponding styli in all of the groups. The energization of individual styli is then accomplished by selectively energizing row and column driving circuits. The system described in this patent greatly reduces the number of high voltage driving circuits required to control the activation of the styli, but still has several disadvantages. In order to print with a particular styli, Tsukatani must switch on the row driving circuit for the row corresponding to the pin, and the driving circuits for all the columns other than that for the column in which the stylus is located. This results in a rather large power drain, especially in systems having a large number of rows and columns. Also, according to Tsukatani's teaching, in order to obtain a 500-volt pulse at a stylus, it is necessary for the circuit described to switch to 1000 volts. This results in there being rather stringent requirements for the components of the driving circuits, thereby increasing their cost. Furthermore, the circuit requires both a positive and a negative high voltage power supply which further increases the cost of the system in which it is used.

OBJECTS AND SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide an electrographic printer having an improved matrix type multiplex driving circuit for selectively energizing the styli.

It is a further object of the invention to provide an improved matrix type driving circuit for an electrographic printer having lower power consumption and fewer components.

In accordance with these and other objects of the invention, there is provided according to the present invention an electrographic printer whose printing styli are arranged in N groups of M styli which includes a first set of M selectively actuable driving circuits, each having an output voltage near a reference potential when the driving circuit is actuated, and an output voltage magnitude when the driving circuit is not actuated near that necessary to be impressed across the paper being printed upon to cause printing on said paper, and a second set of N selectively actuable driving circuits, each having an output voltage near a reference potential, when the driving circuit is actuated, and an output voltage magnitude when the driving circuit is not actuated near that necessary to be impressed across said paper to cause printing. Also provided are unidirectionally conductive means connecting the styli of each of said groups to corresponding ones of said set of N driving circuits, resistive means connecting corresponding styli from each of said groups to corresponding ones of said M driving circuits, and means for selectively actuating the first and second sets of driving circuits for depositing charge on said paper in image configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of a preferred embodiment of the matrix type driving circuit according to the invention.

FIG. **2** is a schematic diagram of a second embodiment of a matrix type driving circuit according to the invention.

DETAILED DESCRIPTION

Referring to FIG. **1** of the drawings, there is illustrated a matrix circuit according to the invention for depositing electric charge in image configuration on the coated face of dielectric coated web **11** which passes between platen **13** and the printing styli **15**. The printing styli **15** may be imbedded in writing heads (not shown), such as those described in the aforementioned

patent application Ser. No. 116,361. As described therein, four printing heads, each carrying seven styli, are carried by a slider back and forth across the face of the web **11** with the styli **15** in virtual contact with the web **11**. The styli are selectively energized for depositing dots of electric charge on the surface of the web **11** in image configuration.

The energizing circuit for the styli **15** is in the form of a 7 × 4 matrix with the four columns of the matrix corresponding to the four printing heads and the rows of the matrix corresponding to the seven styli on the printing heads. Each of the styli **15** are connected through a diode **17** to the collector of the NPN transistor **19** of the corresponding head driving circuit **21**. The emitters of the transistors **19** are grounded and the bases are connected to selective actuating circuits. The collector of each of the transistors **19** is also connected to a voltage source V_h through a resistor **23**.

Each of the column driving circuits **21** therefore acts as a high voltage switch controlled by the inputs to the bases of the respective transistors **19**. The output of the driving circuit to the styli is approximately equal to V_h when no input is present and close to the reference potential (in this case ground) when a positive going input is present at the base of the respective transistor **19**.

Each of the styli **15** is also connected to the output of corresponding row driving circuit **23** through resistor **25**. Each driving circuit **23** is made up of grounded emitter connected high voltage transistor **27** whose collector is connected to a voltage source V_r through a resistor **29**. The output from the driving circuit **23** is taken from the collector of the transistor **27** and the input signal is applied to the base of the transistor **27**. When no input signal is applied, the transistor is in its nonconducting state and the output voltage is approximately equal to V_r. When a positive going input signal is present, the transistor conducts and the output is at approximately reference potential (in this case ground).

The platen **13** is made of a conductive material such as copper and is connected to a voltage source V_p through a resistor **31**.

In operation, the column driving circuits **21** for each printhead are energized sequentially and the row driving circuits **23** are energized selectively simultaneously with the energization of the column driving circuit **21** to cause the styli **15** of each of the printheads to deposit the desired charge configuration on the web **11**. A stylus **15** is activated to deposit charge on the web **11** only when both the corresponding row and column driving circuits are energized.

The voltage V_r and V_h may be equal to one another and be on the order of 500 volts. The voltage V_p may also be equal to V_r and V_h or may be somewhat higher. The limitation on the allowable difference between V_p and V_r will be discussed below.

Referring to the stylus **15** connected to row driving circuit **23** for row **2** and column driving circuit **21** for column **2**, if neither column driving circuit **21** for column **2** nor the row driving circuit **23** for row **2** is energized, the collectors of the respective transistors **19** and **29** are at approximately V_h and V_r respectively, since neither of the transistors is conducting. In this case, the aforementioned stylus **15** is at a voltage between V_h and V_r. If V_h and V_r are equal, it is at V_r.

In this case the voltage difference between the stylus **15** and the platen **13** is well below the threshold needed for printing, and no charge is deposited on the dielectric coated face of the web **11**.

If the transistor **19** of column driving circuit **21** for column **2** is energized with a positive going pulse at its base while row driving circuit **23** for row **2** is not energized, the stylus **15**, located at row **2**, column **2**, is not actuated. The transistor **19** of driving circuit **21** is switched on, thereby dropping the voltage at the collector to close to ground, but this merely back-biases diode **17** connected to the stylus **15** of row **2**, column **2**, which is still held at approximately V_r by the voltage at the collector of transistor **27** of driving circuit **23** for row **2**.

If the row driving circuit **23** is actuated while the column driving circuit **21** is not actuated, the stylus **15** connected to these two circuits also does not print. The pulsing of the base of the transistor **27** with the positive going pulse causes the transistor **27** to conduct, thereby dropping its collector voltage to near ground potential. This causes a voltage V_h to divide across resistors **23** and **25**, since diode **17** becomes forward biased. Since normally resistor **23** is on the order of 10K ohms, while resistor **25** is on the order of 500K ohms, almost all of the voltage V_h appears across resistor **25**, and the voltage drop at the stylus **15** is quite small and still well below the threshold necessary to cause the deposition of charge on the face of the web **11**.

If both the column driving circuit **21** and the row driving circuit **23** for the stylus **15** located at row **2**, column **2**, are energized simultaneously, the voltage at the collectors of both transistors **19** and **27** drop to near ground potential for the duration of the energizing pulse, and a negative voltage going pulse, which is approximately equal to V_r appears at the stylus **15**. This results in a voltage difference between the stylus **15** and the platen **13** which is approximately equal to V_p, which causes the deposition of a dot of electric charge on the dielectric coated face of web **11**.

By selectively energizing the row and column driving circuits **23** and **21**, dots of electric charge in image configuration are deposited on the face of web **11**. This latent charge image is then developed in the normal method by either a liquid or a dry toner.

The upper limit on the voltage V_p is determined in part by the maximum permissible voltage difference between stylus **15** and the platen **13**, which still does not result in the deposition of electric charge on the face of web **11**. The worst case occurs when column driving circuit **21** is not energized while all seven of the row driving circuits **23** are energized. In this case, the voltage at the styli of the unenergized column is determined by the voltage division between the resistor **23** of the unenergized column driving circuit **21** and the parallel combination of the resistors **25** of all the styli in the column. For the aforementioned case where resistor **21** is equal to 10K ohms and resistors **25** are equal to 500K ohms, the voltage at the stylus **15** of the unenergized column is equal to 87.7% V_r. The difference between this voltage and the voltage V_p must be less than the printing threshold. This printing threshold is normally on the order of 250 to 300 volts.

The matrix driving circuit illustrated in FIG. **1** is not, of course, limited to an embodiment which controls seven styli on each of four printing heads. Circuits of

this type may also be used for controlling the actuation of styli in machines having other configurations, for instance, one in which the machine has a line of stationary styli. Printers of that type are available having a line of as many as 924 styli. A printer of this type could utilize a matrix driving circuit such as that illustrated in FIG. 1, but with the dimensions of 28 × 33. Some adjustments might also have to be made in component values in order to have acceptable worst case voltage values.

In cases where the circuit, according to the invention, is used to control the energization of a line of fixed styli, the styli are grouped with each column driving circuit **21** being connected through diode **17** to each of the styli in a group and with the row driving circuits **23** being connected through resistors **25** to the corresponding styli of each of the groups. The operation of the circuit may then be exactly as described above with the row and column driving circuits **23** and **21** being energized selectively to deposit electric charge on the face of the web **11** in image configuration.

An alternate embodiment of the invention is illustrated in FIG. **2** of the drawings. A circuit, according to this embodiment, operates in a manner quite similar to that of the circuits shown in FIG. **1** and corresponding circuit components are numbered similarly.

The differences between the circuit of FIG. **2** and that of FIG. **1** are that the platen **13** of the circuit of FIG. **2** is grounded instead of being connected through a resistor **31** to a voltage source P, that in the circuit of FIG. **2**, a capacitor **33** is connected in series between the junction of a resistor **25** and the cathode of diode **17** and the stylus **15**, and that a diode **35** is connected between the junction of capacitor **33** and the stylus **15** and a point of constant potential which may be either ground or a negative offset voltage. The anode of diode **35** is connected to the capacitor **33**, while the cathode of diode **35** is connected to the point of constant potential.

In operation, when neither the row nor the column driving circuits **23** and **21** of a particular stylus **15** is energized, the voltage at the junction of diode **17** and resistor **25** is at a voltage level between V_r and V_h which, as in the case of FIG. **1**, may be equal. This causes the capacitor **33** to charge through the diode **35** which results in the stylus **15** being held at approximately the voltage level of the constant potential to which diode **35** is connected, so that no electric charge is deposited on the face of the web **11**. When either the column driving circuit **21** or the row driving circuit **23** is energized separately, the voltage level at the junction of resistor **25** and diode **17** does not change sufficiently to cause the deposition of charge on the web **11** by the stylus **15**, since the circuit in these cases operates in the same manner as was described in relation to the embodiment of FIG. **1**.

When both the row and column driving circuits **23** and **21** are energized simultaneously by positive going pulses at the bases of resistors **27** and **19** respectively, the potential at the junction of diode **17** and resistor **25** drops to near ground potential since both transistors **27** and **19** are conducting. Since the voltage across the capacitor cannot change instantaneously, a negative going voltage pulse approximately equal to V_r appears at the stylus **15**, which causes the deposition of a dot of electric charge on the face of the web **11**. By the selective energization of row and column driving circuits **23** and **21**, dots of electric charge in image configuration may be deposited on the face of the web **11**.

The negative offset voltage to which the diode **35** may be connected is a reference voltage for the pulse which is capacitively coupled to the stylus **15** when both the row and column driving circuits **23** and **21** are energized simultaneously and increases the net voltage at the stylus **15**, thereby increasing the amount of charge deposited on the web **11**. The magnitude of this negative offset voltage is limited by the maximum permissible non-printing voltage which may exist between the stylus **15** and the platen **13**.

What is claimed is:

1. A matrix circuit for driving the styli of an electrographic printer for selectively depositing electrostatic charge in image configuration on a web having a dielectric surface, said web being passed between said styli and a platen with said styli in contact with said dielectric surface, said styli being arranged in N groups of M styli, comprising:

a first set of M selectively actuable driving circuits each having its output voltage at a first level normally and near a reference potential when the driving circuit is actuated;

a second set of N selectively actuable driving circuits each having an output voltage at a second level normally and near a reference potential when the driving circuit is actuated;

unidirectionally conductive means connecting the styli of each of said N groups to the corresponding driving circuits of said set of N driving circuits; and

resistive means connecting corresponding styli from each of said N groups to corresponding driving circuits of said set of M driving circuits, said platen being held at a voltage level near the normal voltage level of said styli, the actuation of related ones of said first and second sets of driving circuits operating to impose a voltage difference having a magnitude at least equal to the voltage necessary to cause charge deposition in said web between the styli connected to simultaneously actuated driving circuits of said first and second sets of driving circuits and said platen.

2. The matrix circuit of claim **1** wherein said platen is held at a voltage level near said first voltage level of said set of M selectively actuable driving circuits and the difference between said first and second voltage levels and said reference potential being at least equal to the voltage difference across said web necessary to cause charge deposition on said web.

3. The matrix circuit of claim **1** wherein said platen is held at a voltage level near said reference potential and wherein said matrix circuit further includes a capacitor for each of said styli, each of said capacitors being connected between one of said styli and the unidirectionally conductive means and resistive means and diode means connected between the stylus connected side of said capacitor and an offset voltage.

4. The matrix circuit of claim **3** wherein said offset voltage has a polarity opposite to the polarity of said first and second voltage levels.

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