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FIG. 1.

FIG. 2.

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ELECTROSTATIC-WRITING SYSTEM

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5 Claims. (Cl. 178-6.6)

This invention relates to electrostatic-writing systems and, more particularly, to an improvement therein.

Electrostatic-writing systems of the type now known and in use constitute an arrangement for depositing electrical charges on paper in a pattern which represents the intelligence desired to be written. Thereafter, a toner powder is dusted onto the paper. The powder adheres only to those areas of the paper wherein there is an electrostatic charge. Toners dispersed in a suitable liquid may also be used. Thereafter, heat may be applied to permanently fix the powder to the paper. Thus, the intelligence which was initially conveyed to the paper in the form of a charge pattern now appears as a visible pattern.

Various arrangements have been provided for depositing electrostatic charges on paper in accordance with information received from signals. One system is to provide a delay line, from which many taps are taken from different points along the delay line. These taps are terminated as writing styli above an insulating paper, upon which it is desired to deposit an electrostatic charge. A bar of conducting metal is located on the side of the paper opposite to the side to which the writing styli are brought. Thus, the paper is moved between the writing styli and the back bar.

A pulse is applied to one end of the delay line. The amplitude of the pulse is such that, in and of itself, it will not cause an electrostatic discharge from any one of the styli through the paper to the back bar. However, a signal can be applied to the back bar, having an amplitude such that, when it is present simultaneously with a pulse on any one of the styli, an electrostatic discharge will take place. By synchronizing the application of a pulse to the delay line with the time of the application of a signal to the back bar and the motion of the paper, the charge pattern can be laid down on the paper in a manner to convey intelligence information.

One of the problems which arises with a system of this type occurs when it is desired to increase the number of writing styli so that the writing density is increased. If the number of styli are increased, it is necessary to increase the number of taps made to the delay line. However, then it is necessary to insure that a pulse exists on only one tap at any instant, which requires a line which has a delay-to-rise-time ratio equal to the number of taps. At present, the maximum number of taps available on lines having delay-to-rise ratios equal or greater than the number of taps is on the order of 100, and these are expensive. Lines having 30 to 40 taps are readily available at reasonable cost.

An object of this invention is the provision of an electrostatic-writing system of the type employing a tapped delay line, whereby the number of writing styli employed may be increased without an inordinate increase in the cost of the system.

Another object of the present invention is the provision of an electrostatic-writing system of the type employing a tapped delay line, wherein the number of writing styli which are driven may be increased without inordinately increasing the complexity of the writing system.

Yet another object of the present invention is the provision of a novel and unique electrostatic-writing system of the type employing tapped delay lines.

Yet another object of the present invention is the pro-

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vision of a novel, simple, and inexpensive electrostatic-writing system for depositing electrostatic images of alphanumeric characters on dielectric-coated paper in character-sequential fashion.

These and other objects of this invention may be achieved in an arrangement wherein there are provided a first and a second tapped delay line. A separate, elongated conductor is connected to each tap of the first delay line. These separate conductors are positioned to be parallel to one another and to extend in a plane along one surface of a dielectric-coated paper on which it is desired to deposit electrostatic charges. A separate, elongated conductor is connected to each tap of the second delay line. These are also positioned parallel to one another, and substantially in a plane, and extend at substantially right angles to the previously mentioned elongated conductors on the side of the dielectric coated paper opposite to the side which is contacted by the first group of elongated conductors. Thus, effectively, the two sets of conductors define two opposed planes, between which the writing paper is moved, and which two opposed planes define the region at which electrostatic charge deposition occurs.

The arrangement of tapped delay lines and writing conductors may be operated in many ways, but one which is suitable for use with video signals enables the application of a pulse to a conductor attached to a tap in one delay line, while a pulse is applied to each one of the conductors attached to the taps in the other delay line. The polarities and amplitudes of the pulses which are applied are such that no discharge for depositing electrostatic charges occurs between these conductors unless there is also present a third signal, namely, the video signal. Thus, a scanning action is achieved across the region defined by the two opposed planes, and charge deposition may take place in accordance with the information contained in the video signals.

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 circuit, schematic diagram of one embodiment of the invention;

FIGURE 2 is a circuit, schematic diagram of a second embodiment of the invention; and

FIGURE 2A is a detail of a fragment of the elongated conductors of FIGURE 2.

Reference is now made to FIGURE 1, which shows one arrangement in accordance with this invention. There is shown a first multitapped delay line 10 and a second multitapped delay line 12. The delay-line shield 10A is connected to ground. A separate, elongated conductor 14A to 14N is connected to each one of the taps on the multitapped delay line 10. These conductors are arranged to be spaced from one another, to be parallel with one another, and to be substantially in a common plane. As shown in FIGURE 1, these conductors extend in the direction of travel of dielectric-coated paper 16. These conductors are in contact with the surface of the dielectric-coated paper 16.

The delay line 10 is terminated in the characteristic impedance 18 of the delay line 10. The other end, or input end, of the delay line 10 is connected to a negative-pulse generator 20. The second multitapped delay line 12 also has a plurality of elongated conductors, respectively 22A through 22F, associated therewith. A separate one of these elongated conductors is connected to a different tap of the delay line 12A. These conductors 22A through 22F extend parallel to and spaced

from one another and substantially at right angles to the conductors 14A through 14N. These conductors 22A through 22F are substantially in a plane and are in contact with the bottom side, or side of the dielectric-coated paper opposite to the side being contacted by the elongated conductors 12A through 14N. Thus, effectively, the sets of conductors 14A through 14N define one plane and the sets of conductors 22A through 22F define an opposite plane, and the dielectric-coated paper on which electrostatic charges are to be deposited is positioned between these two planes and in contact with both.

The end of the delay line 12 is terminated in its characteristic impedance 24, connected between the end of the delay line 12 and the shield 12A. A positive-pulse generator 26 applies its output to the input end of the delay line 12 with respect to the shield 12A. The amplitude of the output of the negative-pulse generator 20 and positive-pulse generator 26 is established at values such that, even though they are both simultaneously present at opposed elongated conductors, no electrostatic discharge will take place unless there is an additional signal present. This additional signal is derived from the video amplifier 28, which amplifies video signals from a source 30, which are applied thereto. The output of the video amplifier is connected to the delay line 12 in a manner so that the potential of the entire delay line is raised above ground by the amplitude of a video signal. Thus, this video signal and the positive-pulse generator output are combined and, in the presence of a negative pulse on an opposed conductor, a discharge will occur therebetween, during the interval that all signals are simultaneously present.

The delays provided for the delay lines 10 and 12 are such that a scanning action will take place. A pulse applied to the delay line 10 will be delayed long enough so that a pulse applied to the delay line 12 can completely travel therethrough. In this manner, a pulse applied to the delay line 10 will hold the elongated conductor 14A at a negative potential with respect to ground, while a pulse applied to the delay line 12 is applied successively to the elongated conductors 22A through 22F. The pulse on delay line 10 then is applied to elongated conductor 14B.

A second pulse must be applied to delay line 12, so that it may be successively applied to the elongated conductors connected thereto while the pulse applied to the elongated conductor 14B is present. Any signals received from the video amplifier 28 cause an electrostatic discharge to occur between the one of the elongated conductors 14A through 14N and the one or more of the elongated conductors 22A through 22F, as determined by the interval during which a positive and negative pulse and a video signal are simultaneously present on these opposed conductors.

It will thus be seen that the delay of delay line 12 is equal to or less than the delay per tap of delay line 10, and that the output-pulse repetition rate of the positive-pulse generator 26 is equal to or greater than the product of the output repetition rate of the negative-pulse generator 20 times the number of taps on delay line 10, to which elongated conductors are connected. After a complete scanning action has taken place between the two planes of elongated conductors, the dielectric paper is moved to present a fresh field for electrostatic charge deposition between the two planes of conductors. Means may be provided to synchronize the pulses provided by the respective pulse generators 20 and 26.

The system described in FIGURE 1 is operative. However, difficulties arise when it is desired to obtain a resolution, for example, in excess of 100 lines per inch across an 8½" page. This would require at least 850 taps to the delay line 10. Furthermore, in order to insure that the negative pulse exists on only one tap at any instant, it is necessary to obtain a delay line which has a delay-to-rise-time ratio equal to the number of

taps. At present, the maximum number of taps available on lines having delay-to-rise ratios equal or greater than the number of taps is on the order of 100, and these are expensive. Lines having 30 to 40 taps are readily available at reasonable cost. One method for obtaining the equivalent of one line with 850 taps would be to use 22 lines, each having 40 taps with repeating-pulse generators between them.

FIGURE 2 presents a practical solution to the problem postulated, which requires far fewer delay lines and has great flexibility. In FIGURE 2 there is provided a first multitapped delay line 40, a second multitapped delay line 42, and a third multitapped delay line 44. As in FIGURE 1, there is provided a plurality of elongated conductors, but this time the elongated conductors are divided into groups of elongated conductors, respectively 46A through E, 48A through E, 50A through E, and 52A through E. A different one of the elongated conductors in each group is connected to a different tap on the delay line 40. Thus, to the first tap in delay line 40 there are connected elongated conductors 46A, 48A, 50A, and 52A. These groups of conductors are positioned adjacent one another, substantially parallel to one another, and in a common plane.

Delay line 42 is a multiple-tapped delay line, and a different one of a plurality of conductors, respectively 54A through 54E, is connected to a different one of the taps of the multitapped delay line 42. These elongated conductors 54A through 54E extend parallel to one another, in a common plane, and are substantially at right angles to the elongated conductors 46A through 52E. Both sets of conductors define opposite planes through which the paper 56 be moved.

A third set of elongated, spaced, parallel conductors 60A through 60G are provided. These extend substantially parallel with the conductors 46A through 52E. There should be at least as many of the conductors 60A through 60G, and preferably more, than there are groups of conductors 46A through 52E. These conductors 60A through 60G are notched so that they may be interleaved with the elongated conductors 54A through 54E. These conductors are supported therein in a manner to be insulated from the conductors 60A through 60G through the notches of which the conductors 54A through 54E extend. FIGURE 2A shows a section in detail of the elongated conductors 54E and 54D and the notched conductors 60A and 60B. This is presented in order to illustrate the effective interleaving of these sets of conductors. A different one of the conductors 60A through 60G is connected to a different one of the taps along the multitapped delay line 44.

The delay line 40 is terminated at one end in its characteristic impedance 62. A negative-pulse generator 64 has its output applied across the delay line and the characteristic impedance 62. The shield 40A of the delay line 40 is also connected to the end of the characteristic impedance 62 connected to the negative pulse generator output.

A positive-pulse generator 66 has its output applied to one end of the delay line 42. The other end of the delay line 42 is connected to a characteristic impedance 68, which, in turn, is connected to ground. The shield 42A of the delay line 42 is also connected to ground.

Another positive-pulse generator 70 has its output applied to one end of the delay line 44. The other end of the delay line 44 is connected to ground through a characteristic impedance 72. The shield 44A of the delay line 44 is also connected to ground.

The pulse generators, respectively 64, 66, and 70, are connected to be synchronized from a common-sync-input source. Video signals are applied to a video amplifier 74. The output of the video amplifier is applied to the delay line 40 in a manner to alter the potential of the entire delay line with respect to ground by the amplitude of the video signal received from the video amplifier.

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This is achieved by connecting the output of the video amplifier to the return from the characteristic impedance 62, back to the negative-pulse generators 64.

Without the presence of the third set of interleaved conductors 60A through G the system shown in FIGURE 2 would behave in the same manner as that in FIGURE 1, except that when a negative pulse reached the end of delay line 40, the resulting electrostatic-charge pattern on the paper would be repeated across the page a number of times equal to the number of conductor groups connected to the delay line 40. The purpose of the set of interleaved conductors 60A through G is to prevent the printing of all groups of conductors except one. This is accomplished simply by putting a positive pulse on the delay line 44.

The time delays of delay lines 40 and 44 are designed so that the scanning velocities of the pulses applied to the delay line 40 and a pulse supplied to the delay line 44 are equal. That is, while pulses are being applied to the successive conductors in a group of conductors from delay line 40, pulses are also applied to those of the conductors 60A through 60G which are opposite this group of conductors. The time of delay of delay line 42 is selected so that a pulse which is applied to one of the conductors 54A through 54E will be maintained while pulses are successively applied to all of the conductors in all of the groups connected to the delay line 40.

The amplitudes of the pulses received from the pulse generators are established in a manner so that only when a video signal is present simultaneously with pulses on opposed conductors can an electrostatic discharge take place between two opposed conductors. The pulses applied to delay lines 40, 42, and 44 insure that a scanning action take place successively in lines across the paper. The video signal then can initiate a discharge at the proper location, so that the electrostatic-charge pattern on the paper represents an intelligible signal. After a complete scanning action, the paper is moved to present a fresh surface for receiving electrostatic discharges.

The operation of the arrangement may be understood qualitatively by considering the field at the surface of one of the conductors 46A through 52E as resulting from a potential difference between the one of these conductors to which a pulse is applied and the small-area average potential directly opposite to the paper. This average potential is the average of the potentials of the conductors 54A through 54E and two adjacent conductors 60A through 60G. In the absence of a positive pulse on the two adjacent conductors 60A through 60G, the pulses on the conductors 54A through 54E are insufficient to raise the effective potential at the back of the paper high enough to cause sufficient field at the surface of the negatively pulsed one of the conductors 46A through 52E to cause field emission. Similarly, a positive pulse on one or two of the conductors 60A through 60G will not cause a sufficient field without a corresponding pulse on one of the conductors 54A through 54E. If, however, the conductors connected to the delay line 42 and the conductors connected to the delay line 44 are positively pulsed, their average potential becomes equal to the pulse height, and, together with the negative pulse and the video signal, the field at the intersection can become sufficient to cause charge deposition at that point.

The net effect, therefore, is a scanning path which is geometrically identical to the scanning path derived from the system shown in FIGURE 1. An interesting modification may be employed, if desired, to give greater flexibility in the order of positioning of characters on a line. If, instead of using a delay line 44, an electronic selection switch is used, the position of a character on the line may be specified by the signals received from this selection switch. The ability to specify not only which character, but where on the line it is to be printed, may be important in some applications.

There has accordingly been described and shown here-

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in a novel, useful, and unique arrangement of elongated conductors in order to obtain a scanning-raster pattern for electrostatic-charge-image deposition.

I claim:

1. An electrostatic printing system comprising a first and second delay line each having a plurality of taps spaced along the length thereof, a first plane substantially parallel to and spaced from a second plane, said first and second planes defining an electrostatic printing region therebetween, a first plurality of spaced and substantially parallel elongated conductors substantially in said first plane, a second plurality of spaced substantially parallel elongated conductors substantially in said second plane, said first plurality of elongated conductors extending substantially at right angles to said second plurality of elongated conductors, means connecting each of the conductors in said first plurality of conductors to a different one of the plurality of taps of said first delay line, means connecting each of the conductors in said second plurality of conductors to a different one of the plurality of taps of said second delay line, and means for effectuating electrical discharges between predetermined conductors of said first and second pluralities of conductors includes a third delay line having a plurality of taps along the length thereof, a third plurality of elongated, spaced substantially parallel conductors positioned behind said second plurality of elongated conductors and extending parallel to said first plurality of elongated conductors.

2. An electrostatic writing system comprising a first, second, and third delay line each having a plurality of taps spaced therealong, a plurality of groups of spaced, substantially parallel elongated conductors extending substantially in a first plane, means connecting a different one of conductors in a different one of the groups of conductors to a different tap on said first delay line, a first plurality of spaced substantially parallel elongated conductors extending in a second plane which is substantially parallel to and spaced from said first plane, said conductors in said first plurality extending substantially at right angles to the conductors of said groups of conductors, a second plurality of spaced substantially parallel elongated conductors, the number of conductors in said second plurality of conductors corresponding to the number of groups of conductors, said conductors in said second plurality being substantially coextensive and parallel to the conductors in said groups of conductors and being notched to afford interleaving with said first plurality of conductors without contact therewith, means connecting a different one of the conductors of said first plurality to a different one of the taps on said second delay line, means connecting a different one of the conductors of said second plurality to a different one of the taps on said third delay line, and means for effectuating electrical discharges between predetermined ones of the conductors in said groups of conductors and said first plurality of conductors.

3. An electrostatic writing system as recited in claim 2 wherein said first delay line and third delay line have substantially the same delay time and said second delay line has a delay equal to the delay between adjacent taps of said first delay line.

4. An electrostatic writing system as recited in claim 3 wherein said means for effectuating electrical discharges between predetermined ones of the conductors in said groups of conductors and said first plurality of conductors includes a first means for generating pulses having one polarity, second and third means for generating pulses having a polarity opposite to that of the pulses of said first means, the frequency of pulses generated by said first and third means being substantially equal, the frequency of pulses generated by said second means equaling the product of the number of conductors in a group of conductors and the frequency of the pulses generated by said first means, means for applying pulses from said first means to one end of said first delay line, means for

applying pulses from said second means to one end of said second delay line, means for applying pulses from said third means to one end of said third delay line, means for applying intelligence signals to both ends of said first delay line, and means for adjusting the amplitudes of the pulses and signals to require their simultaneous presence on an opposed conductor in a group and a conductor in said first and second plurality of conductors to effectuate an electrical discharge therebetween.

5. In an electrostatic writing system of the type employing a first multiple tapped delay line having a plurality of writing conductors connected thereto and extending to one side of a dielectric medium for effectuating electrical discharges through said dielectric medium to conductive means on the opposite side of said dielectric medium, the improvement comprising said writing conductors comprising a plurality of groups of elongated conductors spaced parallel to each other and to said dielectric medium, means connecting a different one of the conductors in each group to a different one of the taps of said first multiple tapped delay line, said conductive means comprising a plurality of second elongated con-

ductors parallel to each other and to said dielectric medium and oriented substantially at right angles to said first elongated conductors, a plurality of third elongated conductors parallel to each other and to said dielectric medium and being coextensive with said elongated conductors in said plurality of groups of conductors, said third elongated conductors being notched to afford interleaving with said plurality of second conductors without being contacted thereby, a second multiple tapped delay line, means for connecting a different one of said second conductors to a different one of the taps of said second multiple tapped delay line, a third multiple tapped delay line, and means for connecting a different one of the third conductors to a different tap of said third multiple tapped delay line.

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