Nov. 17, 1964 N. D. MANOR ETAL 3,157,330

ELECTROSTATIC DRIVE APPARATUS

Filed March 5, 1962 3 Sheets-Sheet 1

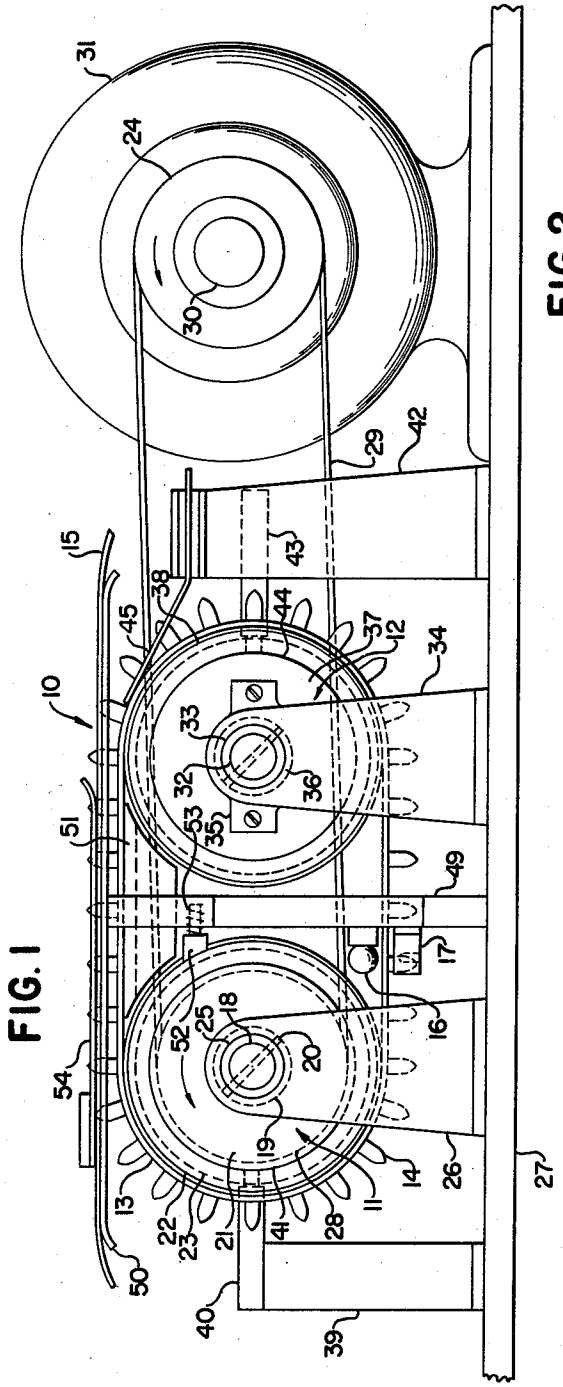


FIG. 1

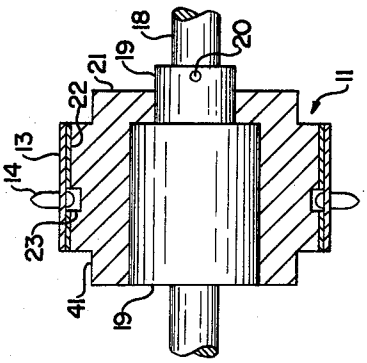


FIG. 2

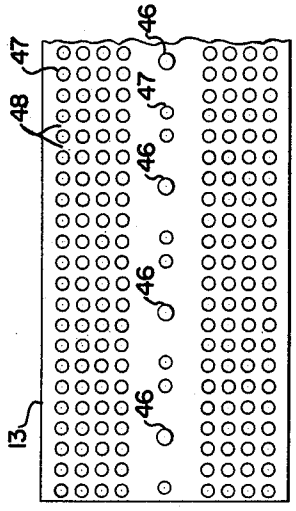


FIG. 3

INVENTORS
NEIL D. MANOR
NIYAZI AYGUN

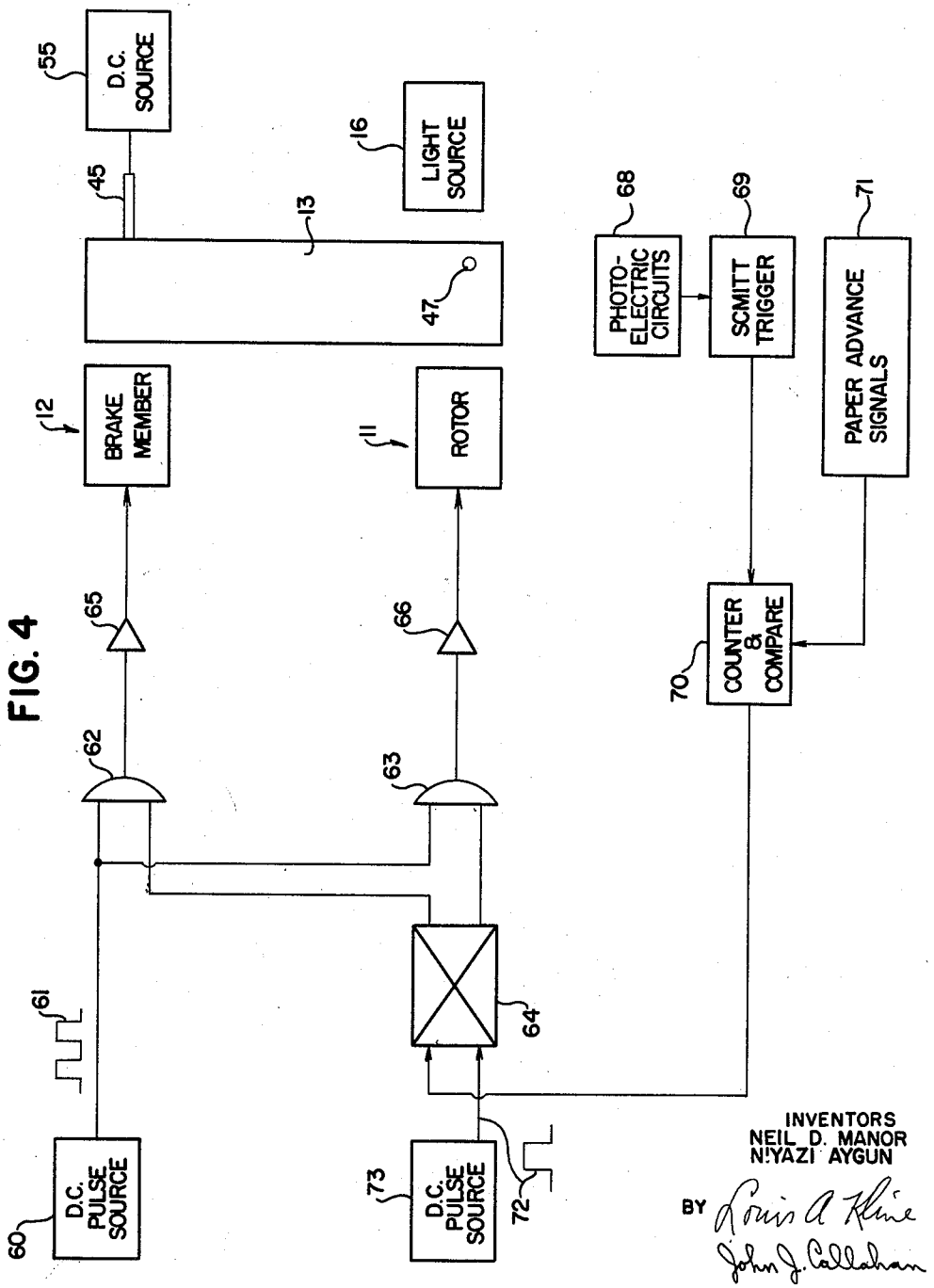
BY Louis A. Kline
John J. Callahan
THEIR ATTORNEYS

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FIG. 4



INVENTORS
NEIL D. MANOR
NIYAZI AYGUN

BY Louis A. Kline
John J. Callahan

THEIR ATTORNEYS

Nov. 17, 1964 N. D. MANOR ETAL 3,157,330

ELECTROSTATIC DRIVE APPARATUS

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FIG.6

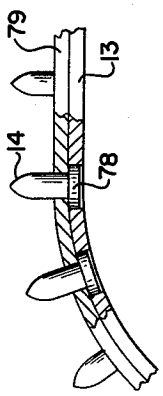


FIG.5

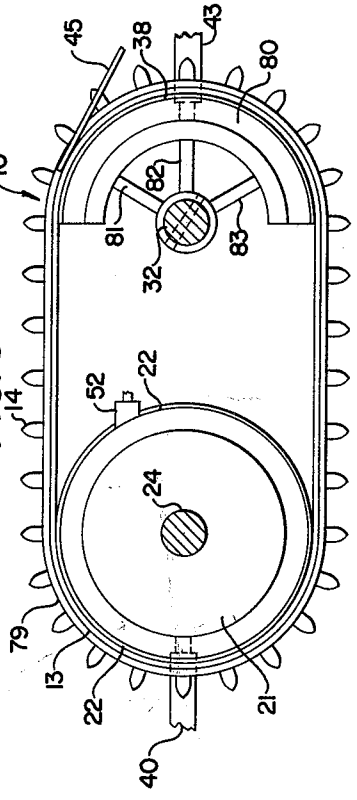
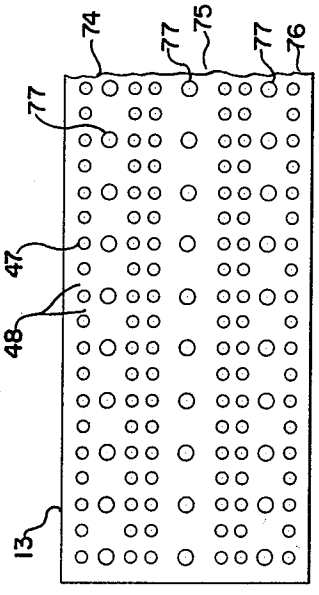


FIG.7



INVENTORS
NEIL D. MANOR
NIYAZI AYGUN

BY Louis A. Klein
John J. Callahan

THEIR ATTORNEYS

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3,157,330

ELECTROSTATIC DRIVE APPARATUS

Neil D. Manor, Xenia, and Niyazi Aygun, Dayton, Ohio, assignors to The National Cash Register Company, Dayton, Ohio, a corporation of Maryland

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2 Claims. (Cl. 226—74)

This invention relates to an electrostatic drive and more particularly to an electrostatic drive for a printer suited for positioning paper selectively on command.

It is an object of the present invention to provide an electrostatic drive for the indexing and the advancing of paper at high operating speeds.

It is another object of the present invention to provide an electrostatic drive for positioning paper which is relatively low in initial cost and is relatively low in operational cost.

It is a further object of the present invention to provide an electrostatic drive whose operational noise is below that of mechanisms now known.

It is a still further object of the present invention to provide an electrostatic drive using the electrostatic principle both as a driver and as a brake.

In accordance with the present invention, there is provided an electrostatic drive suited for paper, magnetic tape, and the like, comprising a rotor adapted for continuous rotation. The rotor is adapted to carry electrostatic resistance material in an encircling relation. Adjacent to the rotor there is disposed a brake member which is also adapted to carry electrostatic resistance material thereon. A paper drive including an endless driven member is provided for effecting advancement of paper, and it is adapted to extend around both the rotor and the brake member and is in engagement with the electrostatic resistance material thereon. The rotor is adapted to be energized to hold the endless driven member thereto while it is rotating, whereby advancement of the paper is effected. The brake member is adapted to be energized simultaneously with deenergization of the rotor, whereby movement of the endless driven member is stopped and advancement of the paper is terminated. The deenergization of the rotor causes the endless driven member to be released from the rotor, while the energization of the brake member causes the endless driven member to be held thereto.

However, the novel features of the present invention, as well as the invention itself, both as to its structural organization and as to its mode of operation, will be more readily and completely understood from the following detailed description when considered in connection with the accompanying drawings, in which like reference numerals refer to like or similar elements, and in which:

FIG. 1 is a side view of an electrostatic drive in accordance with the invention;

FIG. 2 is a fragmentary view, on an increased scale, showing the manner of cooperation between the rotor and the paper drive including the endless driven member;

FIG. 3 is a top plan view of a portion of the endless driven member of the paper drive;

FIG. 4 is a schematic diagram, partly in block diagram form, showing the manner used in controlling and/or energizing the electrostatic drive;

FIG. 5 is a side view of a modification of the invention;

FIG. 6 is a fragmentary view, on an increased scale, of the paper drive including the endless driven member used in the modification shown in FIG. 5; and

FIG. 7 is a top plan view of a portion of one element of the paper drive shown in FIG. 6.

Referring to FIGS. 1, 2, and 3, there is shown an electrostatic drive apparatus 10 including a rotor 11, a brake member 12, and a paper drive including an endless driven member 13 of electrically-conductive material provided with a plurality of pins 14. The pins 14 are projectable into perforations provided in paper 15 to be advanced to cause the paper to be moved in a generally linear direction. The drive apparatus 10 also includes a position-detecting system including a light source 16 and a light-detecting device 17.

The rotor 11 is supported on a shaft 18. The shaft 18 is fixed to an insulating portion 19 of the rotor 11 by a pin 20. The subassembly including the shaft 18 and the insulating portion 19 is press-fitted to an annular electrically-conducting portion 21 of the rotor 11. The portion 21 has bonded to its outer surface, in encircling relation, a coating or face 22 of a suitable electrostatic resistance material. The electrostatic resistance material is semiconductive and is barium titanate or lead zirconate. A groove 23 is cut into the annular portion 21 and the coating 22, to provide clearance for the riveted side of the pins 14.

As shown in FIG. 1, the rotor 11 is supported by means of the shaft 18 in bearings 25, which are fixedly attached to a bracket 26, which is, in turn, attached to the base 27. The rotor 11 is free to rotate in the bearings 25. A pulley 28 is fixedly attached to the shaft 18. A drive belt 29 is wrapped around the pulley 28 and a pulley 24. The pulley 24 is fixedly attached to the shaft 30 of a motor 31. The ratio of the pulley 24 to the pulley 28 is one to one. The motor shaft 30 is rotated at approximately 390 r.p.m., thus causing the rotor 11 to rotate by means of the pulley and belt assembly.

The brake member 12 is supported by a shaft 32 in bearings 33 by means of a bracket 34. The brake member 12 is fixed to the bracket 34 by means of another bracket 35 in such a manner as to prevent it from rotating. The brake member 12, shown in FIG. 1, is otherwise substantially identical to the rotor 11, having an insulating portion 36 similar to the insulating portion 19, an annular portion 37 similar to the annular portion 21, and a coating 38 of electrostatic resistance material similar to the coating 22.

The rotor 11 and the brake member 12 are attached to the base 27 by means of the brackets 26 and 34 a fixed distance apart determined by the length of the endless driven member 13.

A brush holder 39 is mounted on the base 27 adjacent to the rotor 11. The brush holder 39 has attached to it a spring-loaded brush 40, which presses against a surface 41 (FIG. 2) of the electrically-conducting portion 21 of the rotor 11. The brush 40 has a wire (not shown) attached thereto to provide a means for applying a potential to the rotor 11. A brush holder 42 is mounted on the base adjacent to the brake member 12. The brush holder 42 has attached to it a brush 43, which contacts a surface 44 of the electrically-conducting portion 37 of the brake member 12. The brush 43 has a wire (not shown) attached thereto to provide a means for applying a potential to the brake member 12. Also attached to the brush holder 42 is a brush 45, which makes contact with the endless driven member 13. The brush 45 has a wire (not shown) attached thereto to provide a means for applying a potential to the driven member 13. Accordingly, means are provided for applying an electrical potential difference between the endless driven member 13 and the rotor 11 and the endless driven member 13 and the brake member 12.

The driven member 13 is constructed in such a manner that it forms an endless loop. A plurality of holes 46 (FIG. 3) are provided in the driven member 13 for accepting the pins 14, which are of a plastic material. The distance between the holes 46 is fixed by the hole

distance along the paper 15, which may be of the pin-feed form type. A plurality of smaller holes 47 are also provided in the driven member 13 to isolate solid areas 48 from each other. The holes 47 are also located a fixed distance apart so as to provide a means to develop a control or clock signal in conjunction with the light source 16 and the light-detecting device 17. The driven member 13 is so placed that it extends around and is in engagement with portions of the electrostatic resistance material on the rotor 11 and the brake member 12. Also, the rotor 11 and the brake member 12 are located a fixed distance apart, so that a sufficient amount of contact pressure is maintained between the electrostatic resistance material portions 22 and 38 of the rotor 11 and the brake member 12, respectively, and the driven member 13.

A bracket 49, attached to the base 27, is provided to support a table 50. A plastic guide block 51 is also attached to the table 50. The guide block 51 has a groove (not shown) located along its length to provide a guide surface for the underneath side of the paper guide pins 14. The guide block 51 also prevents any downward movement of the driven member 13, thus preventing disengagement of the paper 15 and the drive pins 14. A lubricating block 52 is also attached to the bracket 49 and is spring-urged against the electrostatic resistance material portion 22 of the rotor 11 by a spring 53. The block 52 is of sufficient width to allow the area of the portion 22 contacted by the driven member 13 to be lubricated. Lubrication is then carried to the electrostatic resistance material portion 38 of the brake member 12 by means of the driven member 13.

The table 50 is slotted to allow the paper drive pins 14 to pass without interference. A pressure plate 54 is pivotally mounted on the table 50 and is spring-urged, so that, when it is raised, it tends to remain in that position, and, when it is lowered, it tends to remain in the lowered position, shown in FIG. 1. The pressure plate 54, in its raised position, allows the paper 15 to be placed so that the paper drive pins 14 can be engaged in the pin-feed holes. The pressure plate 54, in its lowered position, allows sufficient clearance for the paper 15 to pass freely between it and the table 50.

If the paper or other medium to be advanced is relatively wide, a pair of laterally-spaced electrostatic drive units, each unit similar to that shown in FIG. 1, is provided. Both of these drive units may be operated synchronously by the motor 31. The pins 14 of each endless driven member 13 of a drive unit would engage the drive holes provided in the appropriate margins of the paper. The driven member 13 would have a width sufficient to accommodate and provide a support for the widest paper or form to be advanced.

The operation of the electrostatic drive shown in FIG. 1 is based upon the well-known Johnson-Rahbek effect as described by them in the Journal of the Institution of Electrical Engineers, 61, page 713 (1923). It depends upon the electroadhesive forces between a conductive member and a cooperating semi-conductive member when a voltage is applied across the members. The endless driven member 13 is maintained at a positive potential by means of the brush 45, which is coupled to a source 55 (FIG. 4) of positive direct current. The rotor 11 and the brake member 12 each have associated therewith electrical means to conditionally maintain them either at a positive potential or at a potential less positive than said positive potential. If either the rotor 11 or the brake member 12 is maintained at the positive potential, no attraction will take place between it and the driven member 13. If either the rotor 11 or the brake member 12 is energized with the less positive potential, a normal force will be exerted between it and the driven member 13, due to electrostatic attraction, which, along with the friction between the two surfaces, will cause the driven member 13 to assume the same condition (moving or stationary) as the element that is energized with the less positive potential.

Referring now to FIG. 4, a source 60 of positive direct current pulses 61 is coupled to one input of an AND circuit 62 and to one input of an AND circuit 63. The other input of the AND circuit 62 is coupled to one output of a conventional flip-flop circuit 64. The other output of the flip-flop circuit 64 is coupled to the other input of the AND circuit 63. The output of the AND circuit 62 is coupled to a stop amplifier 65. The stop amplifier 65 is of the well-known inverter type, providing an amplified output which is approximately 180 degrees out of phase with its input. The output of the stop amplifier 65 is coupled to the portion 37 of the brake member 12 by means of the brush 43 (FIG. 1). The output of the stop amplifier 65 may assume a value approximately equal to the positive supply voltage 55 (the positive potential), or it may assume a value approximately equal to the negative supply voltage of the stop amplifier 65 plus the voltage drop across the stop amplifier 65 (the less positive potential). The output of the AND circuit 63 is coupled to a drive amplifier 66. The drive amplifier is identical to the stop amplifier 65. The output of the drive amplifier 66 is coupled to the portion 21 of the rotor 11 by means of the brush 40 (FIG. 1). The output of the drive amplifier 66 may assume a value approximately equal to the positive supply voltage 55 (the positive potential) or it may assume a value approximately equal to the negative supply voltage of the drive amplifier 66 plus the voltage drop across the drive amplifier 66 (the less positive potential).

The light source is so positioned that its light can shine through the holes 47 in the driven member 13 and illuminate the light-detecting device or photocell 17 included in the photoelectric circuit 68. If a hole 47 is located adjacent to the light source 16, it allows the light to shine on the photocell 17. Each increase in light intensity will be detected, and the photoelectric circuit 68 will develop an output signal. The output of the photoelectric circuit 68 is coupled to a conventional Schmitt trigger circuit 69. The output signal from the photoelectric circuit 68 is shaped by the trigger circuit 69 and applied to the counter and compare circuit 70. The counter and compare circuit 70 is a conventional circuit whose purpose is to compare the actual movement of the driven member 13 to the desired movement as indicated by signals from a source of paper advance signals 71, and to supply a stop signal to the flip-flop circuit 64 so that its condition will change. This change in condition of the flip-flop circuit 64 will cause a stop condition of the driven member 13. The desired paper advance signals from the source of paper advance signals 71 are in the form of a direct current level.

Assume now that the driven member 13 is in its stopped condition. In this case, a positive voltage will be applied to one input of the AND circuit 62 from the flip-flop circuit 64. The direct current pulses 61 from the pulse source 60 will pass through the AND circuit 62 and the stop amplifier 65 and be applied to the brake member 12, causing it to be energized. With the brake member 12 energized, a large potential difference exists between it and the driven member 13, causing a large normal force to be present. This large normal force is such that it prevents the driven member 13 from being moved.

When it is desired to move the driven member 13 to advance the paper 15, a positive direct current movement signal 72 from a source of direct current pulses 73 is supplied to the flip-flop circuit 64. The state of the flip-flop circuit 64 will change so that the pulses 61 will be prevented from passing through the AND circuit 62. As a result, the brake member 12 will be deenergized, and the driven member 13 will be free to move. With the state of the flip-flop circuit 64 changed, a positive voltage will be applied to the AND circuit 63, allowing it to pass the pulses 61 from the pulse source 60 to the rotor 11 by

way of the drive amplifier 66. A large normal force will exist at this time between the rotating rotor 11 and the driven member 13. Accordingly, the driven member 13 will assume the condition of the rotor 11 after a brief period of slippage, and it will continue to rotate at the peripheral velocity of the rotor 11. The movement of the driven member 13 will cause the holes 47 in a desired row thereon to pass between the light source 67 and the photocell in the photoelectric circuit 68 to develop pulses which are supplied to the counter and compare circuit 70 via trigger circuit 69. The pulses from the photoelectric circuit 68 are compared with a predetermined signal from the source of paper advance signals 71, which indicates either a single line or a multiple line advance of the paper 13. Upon the receipt of a compare or stop signal by the flip-flop circuit 64 from the counter and compare circuit 70, the condition of the flip-flop circuit 64 will change, allowing the pulses 61 to pass to the brake member 12 and preventing passage of these pulses 61 to the rotor 11. Accordingly, a large normal force will exist between the brake member 12 and the driven member 13, forcing it to assume the stationary condition of the brake member 12. At the same time, the rotor 11 and the driven member 13 will assume approximately the same voltage, reducing the normal force between them, caused by the previous difference in potential, to some minimum value. The foregoing operation can be repeated with single line and multiple line advance signals intermixed.

Referring now to FIGS. 5, 6, and 7, there is shown a modification of the present invention wherein the driven member 13 has three rows 74, 75, and 76 of spaced holes 77, into which the lower portions 78 of the pins 14 may be secured. In this embodiment, the pins 14 are a part of or are fixedly attached to a belt 79. If the paper 15 to be advanced has a width approximately equal to the width of the driven member 13, then a belt 79 will be positioned over each of the rows 74 and 76 of holes 77, so that the lower portions 78 of their pins 14 are secured in the holes 77. The belts, so positioned, will then move with the driven member 13. If the paper 15 to be advanced has a width approximately equal to one half the width of the driven member 13, then a belt 79 will be positioned over either each of the rows 74 and 75 or each of the rows 75 and 76. Accordingly, in this embodiment, there is provided, by means of the belts 79 and the rows 74, 75, and 76 of holes 77 in the driven member 13, an electrostatic drive which can be quickly and easily changed to accommodate paper or forms of various sizes.

In the embodiment shown in FIG. 5, the brake member 12 comprises an arcuate member or shoe 80, which is insulated from and supported on the shaft 32 by means of the support members 81, 82, and 83, rather than the brake member 12 of FIG. 1, which is in the form of a drum.

While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention. For example, the driven member 13 has been described as being maintained at a positive potential, while the rotor 11 and the brake member 12 have been described as being energized when a less positive potential is applied to them. Nevertheless, it is clear that the driving member 13 may be maintained at ground potential, while the rotor 11 and the brake member 12 may be considered as being energized when a sufficient negative potential is applied to them.

What is claimed is:

1. An electrostatic drive apparatus suited for advancing perforated paper, comprising, in combination:

(*a*) a rotor adapted for continuous rotation,

(*b*) electrostatic resistance material carried by and encircling said rotor,

(*c*) a brake member,

(*d*) electrostatic resistance material carried by said brake member,

(*e*) a paper drive

(*f*) including an endless driven member extending around both said rotor said brake member and being in engagement with said electrostatic resistance material thereon, and

(*g*) including a pair of belts attached to said endless driven member in a laterally-spaced relationship for movement therewith,

(*h*) said pair of belts each carrying a plurality of pins projectable into the perforations to advance said paper in a generally linear direction,

(*i*) means for energizing said rotor to cause said endless driven member to be held thereto and said endless driven member and said belts to be moved thereby whereby advancement of said paper is effected, and

(*j*) means for simultaneously deenergizing said rotor and energizing said brake member to cause said endless driven member to be released from said rotor and to be held by said brake member whereby movement of said endless driven member and said belts is stopped and advancement of said paper is terminated.

2. An electrostatic drive apparatus for advancing perforated paper, comprising, in combniation:

(*a*) a rotor adapted for continuous rotation,

(*b*) electrostatic resistance material carried by and encircling said rotor,

(*c*) a brake member,

(*d*) electrostatic resistance material carried by said brake member,

(*e*) a paper drive

(*f*) including an endless driven member having a plurality of rows of apertures therein, and

(*g*) including a pair of belts each carrying a plurality of pins projectable into the perforations to advance said paper in a generally linear direction,

(*h*) said endless driven member extending around both said rotor and said brake member and being in engagement with said electrostatic resistance material thereon,

(*i*) each of said belts being attached to said endless driven member by means of its pins and one of said rows of apertures,

(*j*) means for energizing said rotor to cause said endless driven member to be held thereto and said endless driven member and said belts to be moved thereby whereby advancement of said paper is effected, and

(*k*) means for simultaneously deenergizing said rotor and energizing said brake member to cause said end less driven member to be released from said rotor and to be held to said brake member whereby movement of said endless driven member and said belts is stopped and advancement of said paper is terminated.

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