Dec. 19, 1967 D. J. NESIN ET AL 3,358,592

ELECTROGRAPHIC PRINTING

Filed March 17, 1966 8 Sheets-Sheet 1

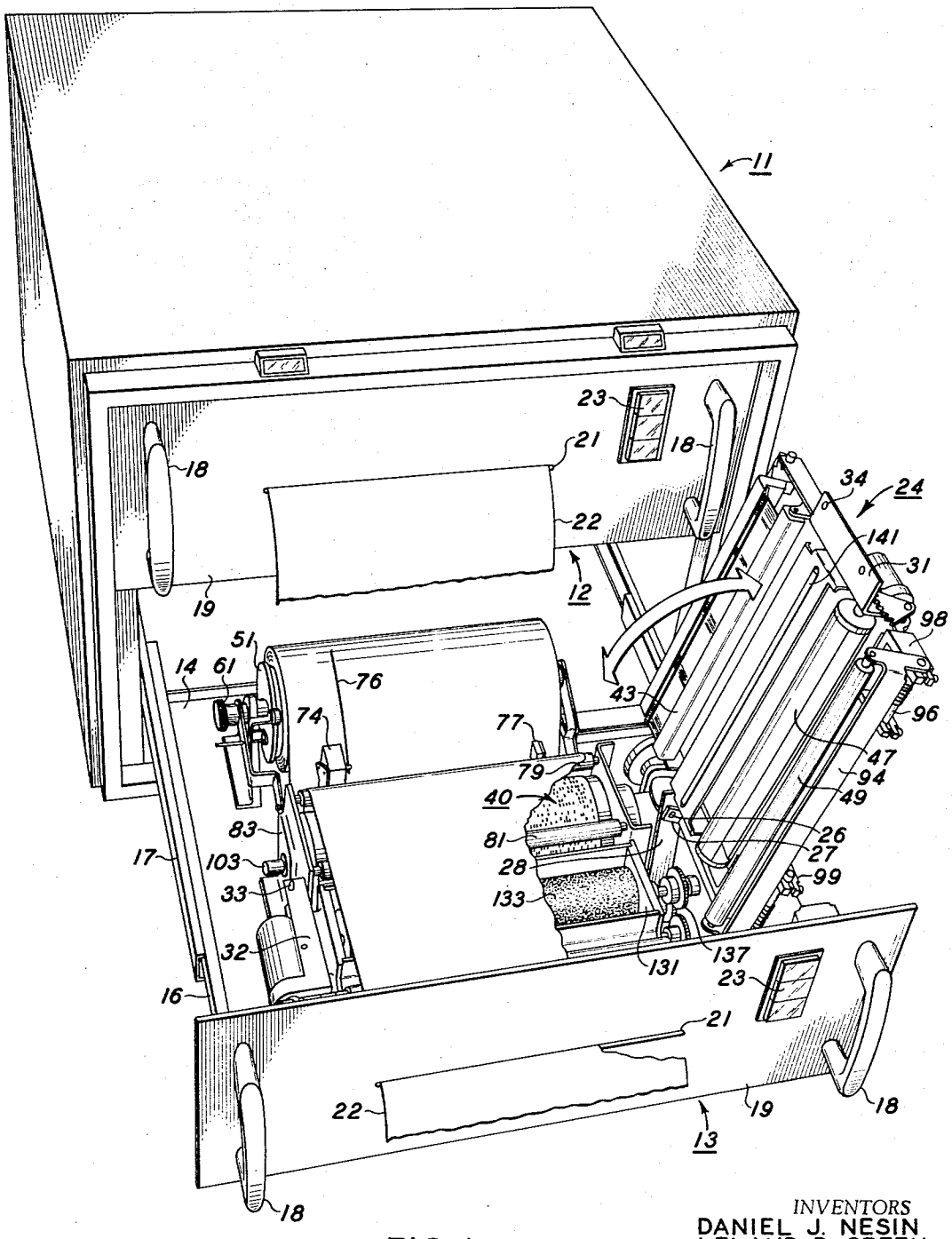


FIG. 1

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ELECTROGRAPHIC PRINTING

Filed March 17, 1966 8 Sheets-Sheet 2

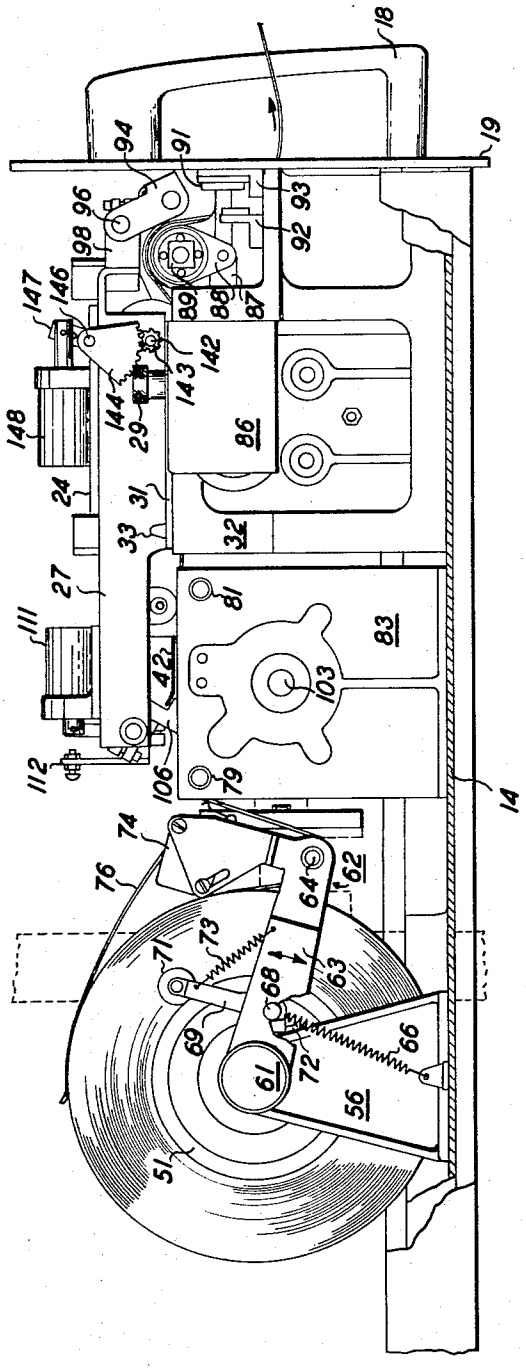


FIG. 2

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ELECTROGRAPHIC PRINTING

Filed March 17, 1966 8 Sheets-Sheet 3

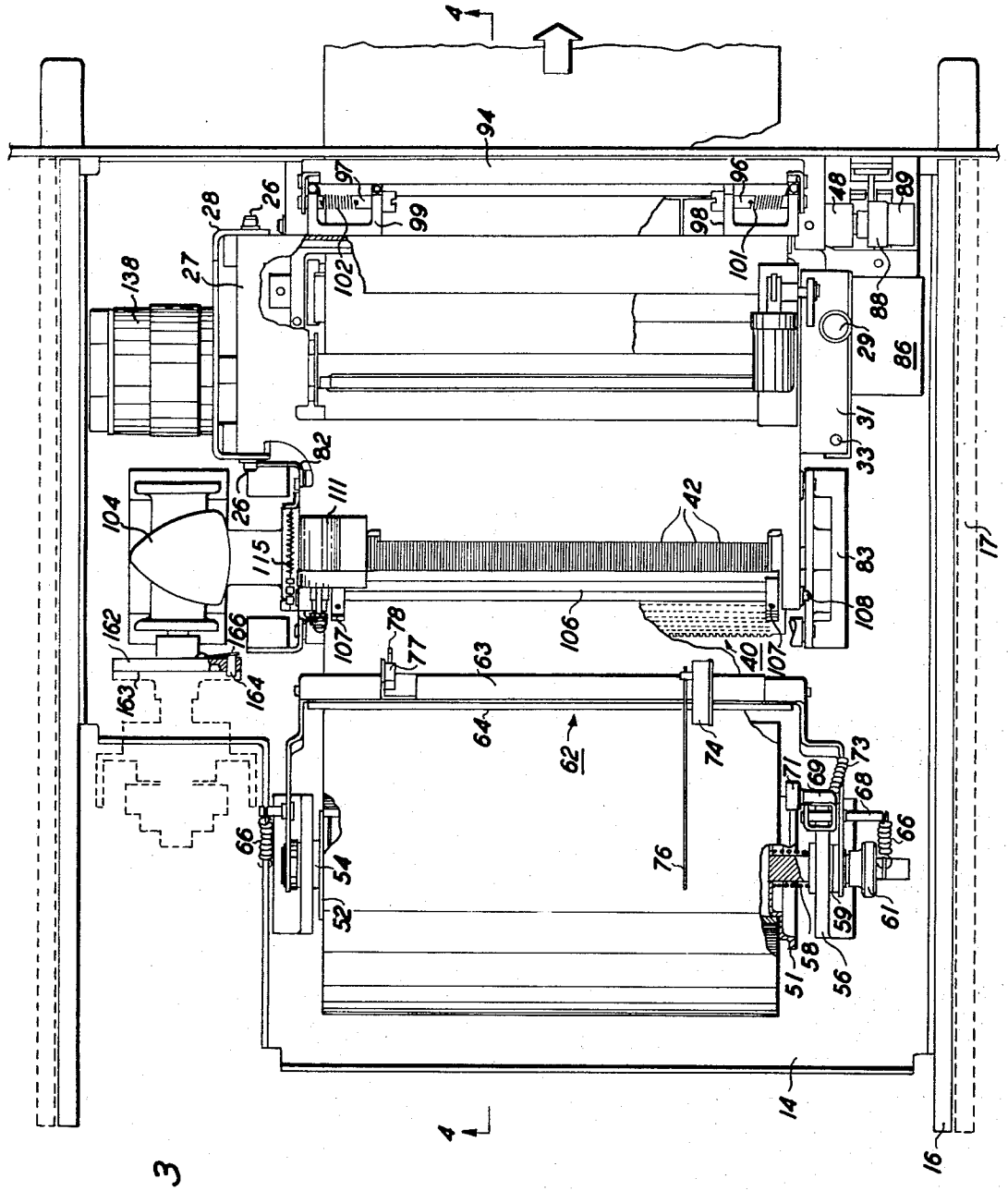


FIG. 3

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ELECTROGRAPHIC PRINTING

Filed March 17, 1966 8 Sheets-Sheet 4

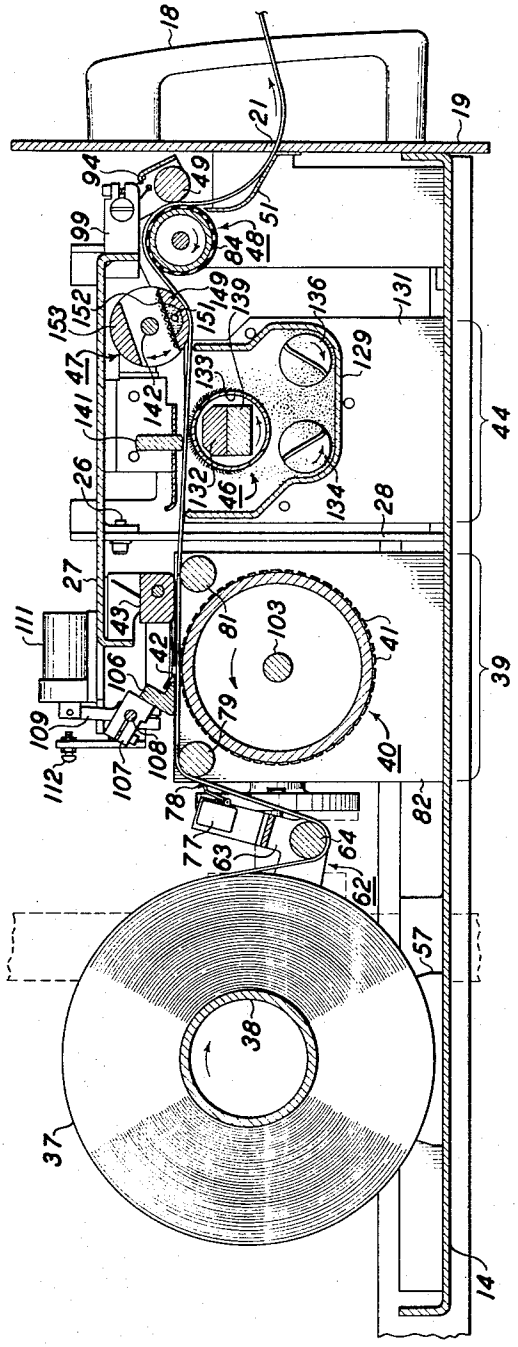


FIG. 4

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ELECTROGRAPHIC PRINTING

Filed March 17, 1966 8 Sheets-Sheet 5

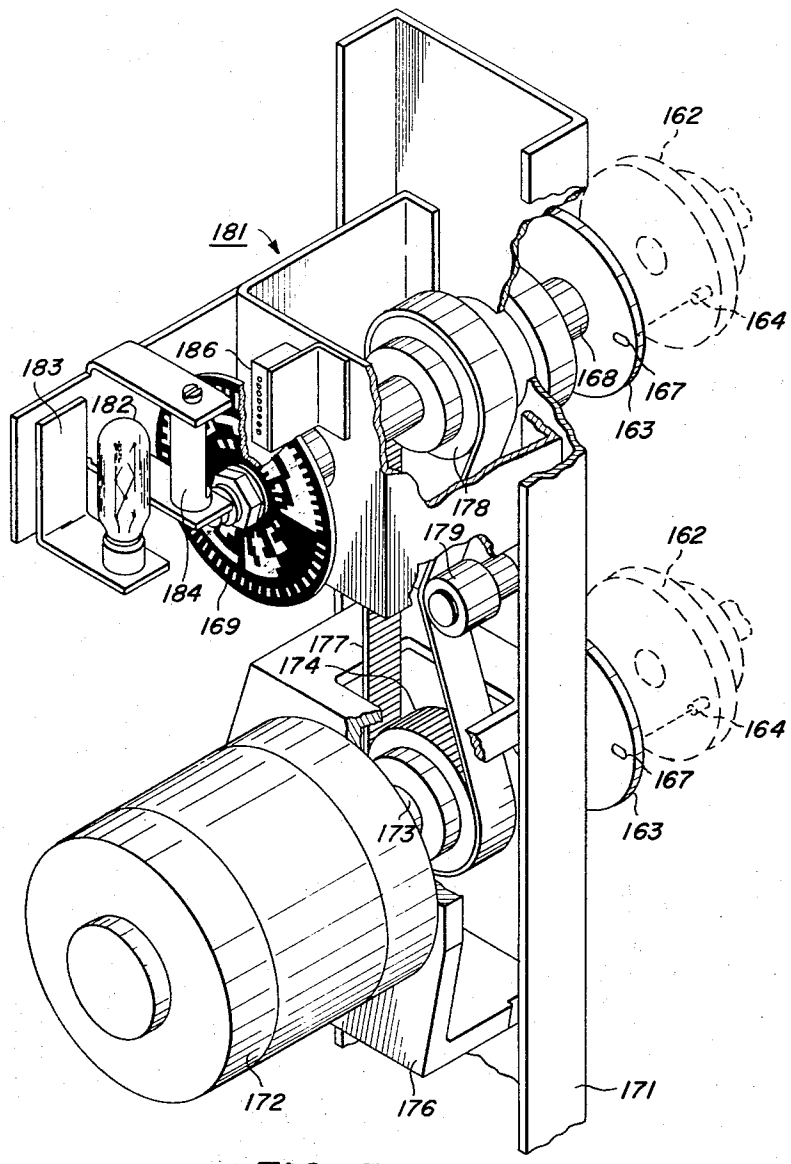


FIG. 5

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ELECTROGRAPHIC PRINTING

Filed March 17, 1966 8 Sheets-Sheet 6

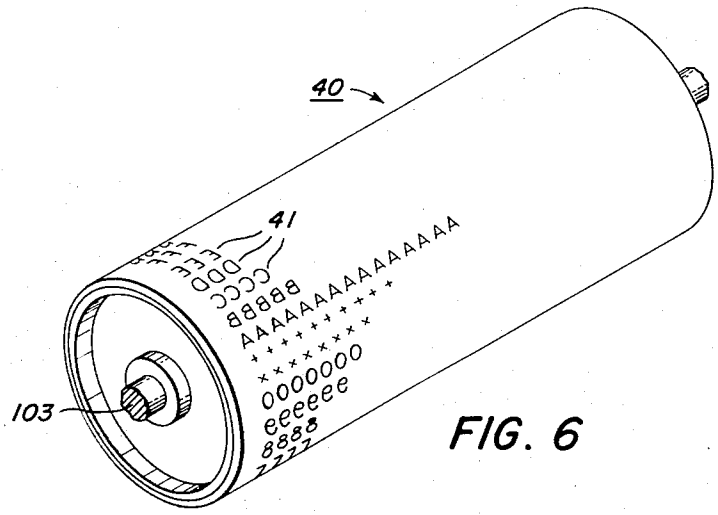


FIG. 6

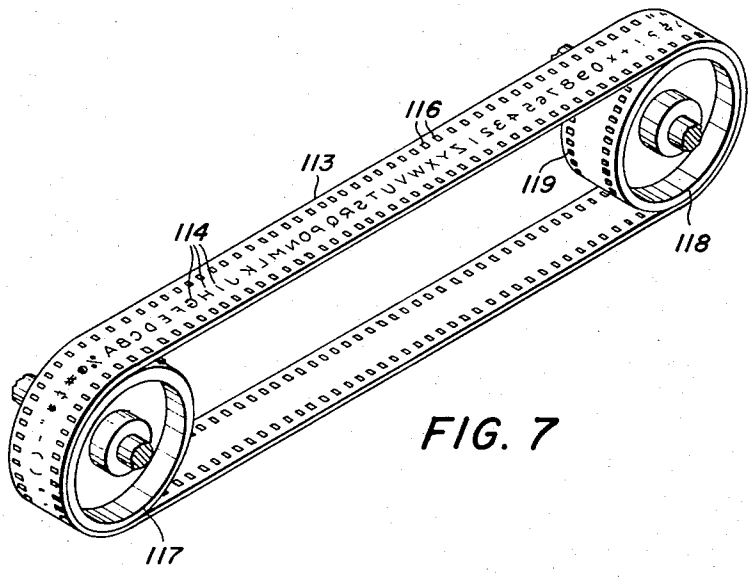


FIG. 7

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ELECTROGRAPHIC PRINTING

Filed March 17, 1966 8 Sheets-Sheet 7

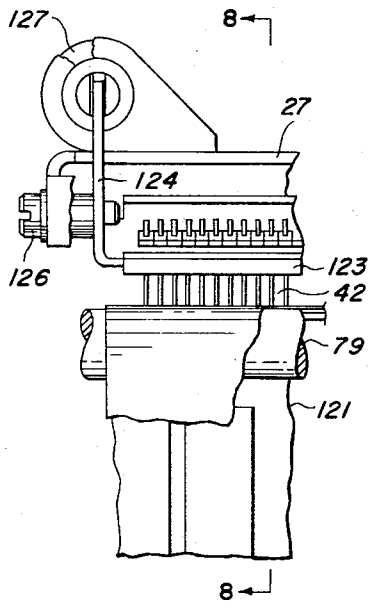


FIG. 9

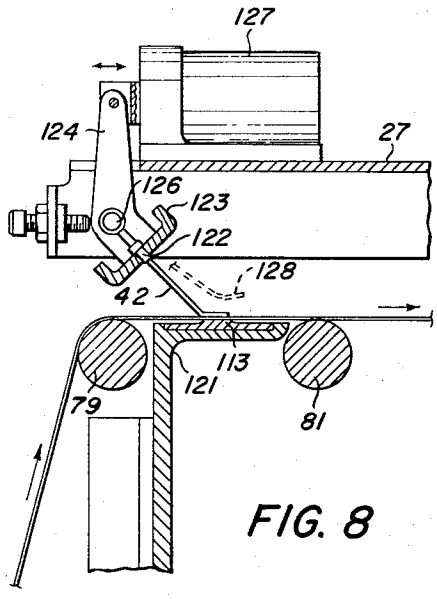


FIG. 8

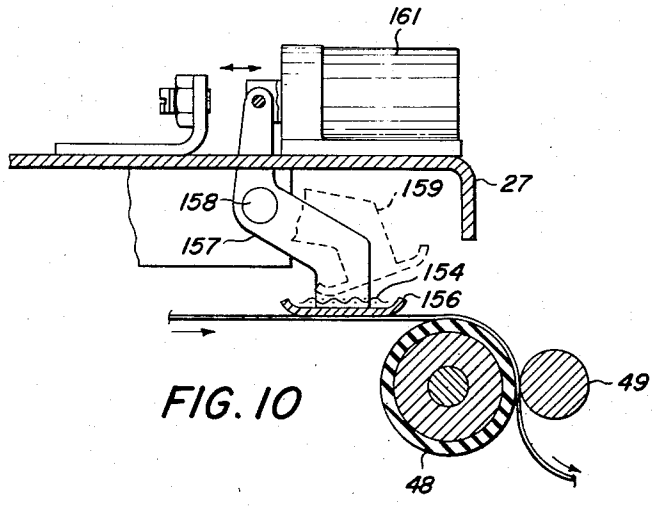


FIG. 10

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ELECTROGRAPHIC PRINTING

Filed March 17, 1966 8 Sheets-Sheet 8

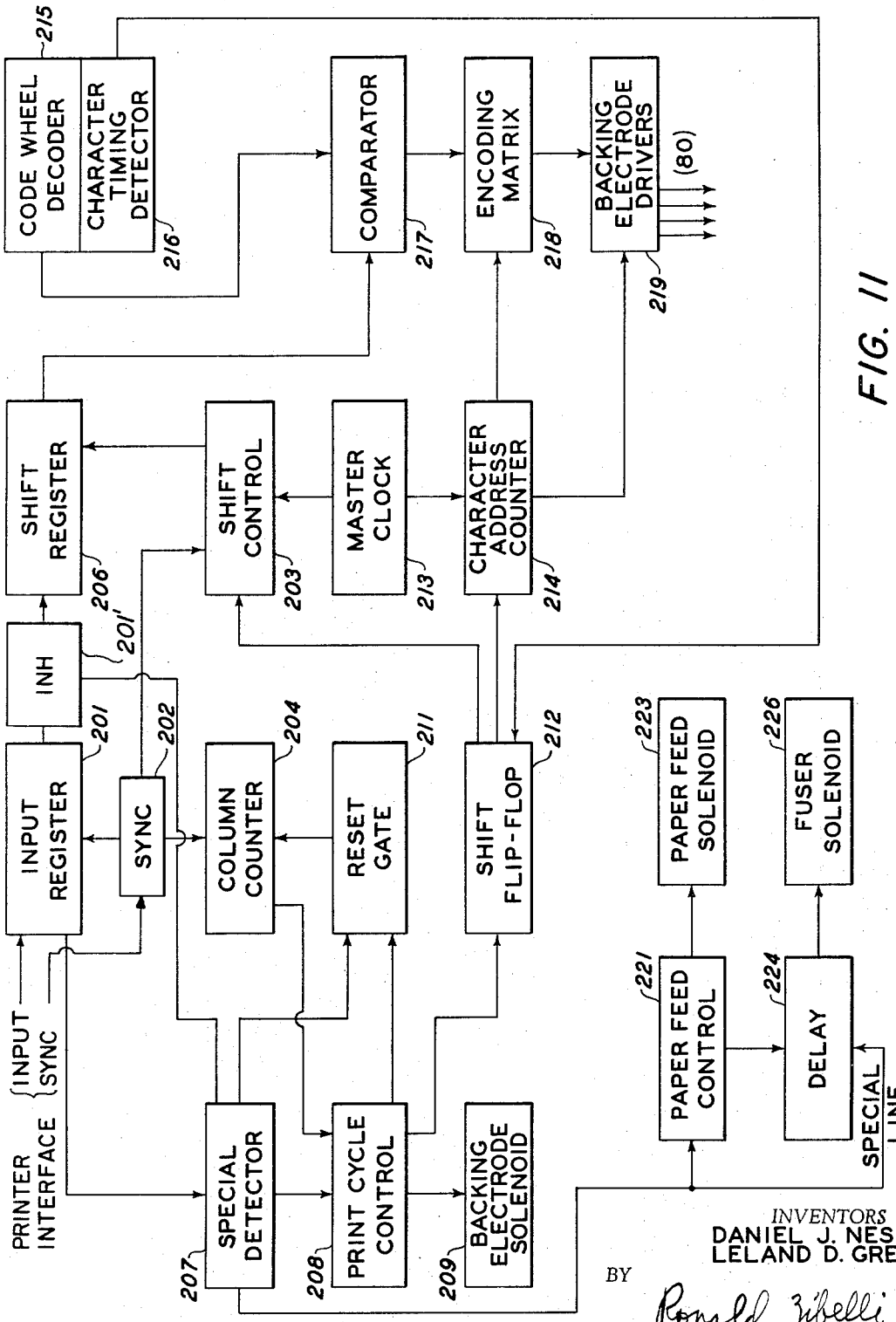


FIG. 11

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United States Patent Office 3,358,592 Patented Dec. 19, 1967

3,358,592

ELECTROGRAPHIC PRINTING

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Filed Mar. 17, 1966, Ser. No. 535,074
11 Claims. (Cl. 101—45)

ABSTRACT OF THE DISCLOSURE

This application relates to an apparatus for forming latent electrostatic images on a movable web consisting of a carrier containing character-shaped electrodes about its outer periphery on one side of the web and a line of spring-biased movable backing electrodes on the opposite side of the web. To record, the backing electrodes press the web against the character-shaped electrodes and the electrodes are pulsed to form a latent image on the web. After pulsing the backing electrodes are moved away from the web and the web is advanced to place a different recording web area between the electrodes. After the web is advanced the backing electrodes are again moved towards the web pressing it against the character-shaped electrodes in preparation for pulsing a new line.

A great number of electrical printing and recording techniques have been developed in the past. Some of these are based on sparking or electrical burning of specially prepared or coated recording papers in a pattern to produce the desired images. Although techniques of this type have been used in limited applications, they suffer from obvious disadvantages inherent in any system in which such a burning process is employed. For example, they produce smoke in the area adjacent the machine, they produce dirt and dust inside the machine which tends to clog it up and cause it to misprint and the specially prepared recording papers frequently employing two, three, or even more coated layers are too expensive for widespread general use. In addition, this type of burning technique has been found to be too slow for use in high speed communications printers or high speed computer output printers where a reliable high speed system might offset the cost and other inconveniences of this technique.

In order to overcome the many difficulties inherent in electrical spark recording, a technique known as "Tesiprinting" was developed. This technique which is more fully described in British Patent 734,909 to Carlson employs at least one shaped electrode and a backing electrode which are spaced apart to form a gap. Any suitable paper, plastic, plastic coated paper, or other recording web capable of holding an electrostatic charge is placed in the recording gap and an electrical field of sufficient intensity to initiate an ionizing field discharge is then applied across the gap forming an electrostatic charge pattern on the recording web which conforms in shape with the face of the shaped electrode. This electrostatic charge pattern is then developed as with finely divided, colored electroscopic marking particles which are fixed to the recording web to form a permanently visible image. While Tesirecording is extremely fast, simple, and quiet in operation, the electrical discharge required for this type of printing is less than 100% reliable under ordinary atmospheric conditions. This lack of reliability occurs because naturally formed, ionized air molecules must be present in the printing gap when the pulse is applied so that the discharge will take place. Although the probability of a discharge occurring in the gap at any one time will generally run to 98% or 99%, the severe reliability requirement of computer printers and high speed communication printers have required the use of special techniques and

mechanisms for improving the reliability of this type of system. Typically, these improved techniques have involved the redirection of continuous discharges in the recording gap, the use of special electronegative gases, and the like. At the same time that these modified techniques have improved the reliability of tesiprinting systems, they have also added significantly to its cost and complexity.

Another problem with prior art electrostatic printing devices is that they must be held in a standby condition ready for printing input which may well come at irregular intervals. This means, for example, that a character drum or other device which presents different alphanumerically character shaped electrodes in quick succession at the printing gap must be kept running and that the heat fixing device which fuses the thermoplastic marking particles employed to develop the electrostatic image formed on the recording sheet must be kept at or very near to the fusing temperature and that the recording web must be threaded in the machine, so that it can go into operation instantaneously. Since the use of a continuous recording web is required for any really high speed system, the aforementioned requirements may well result in brunishing or tearing of the recording web at the printing gap or in charring or tearing of the web at the fusing station.

It is, therefore, an object of this invention to provide a high speed electrostatic printer of novel design.

Another object of the invention is to provide a new method of electrostatic printing.

A still further object of the invention is to provide a new method and apparatus for electrostatic printing of extremely high reliability.

Yet another object of the invention is to provide a novel recording web feeder adapted to advance the web through the printer one line at a time under controlled tension in conjunction with the operation of the print head.

A further object of the invention is to provide a novel method and apparatus for electrostatic printing incorporating extremely high output printing speed in which the system may be held in a continuous standby condition, ready for instantaneous operation.

A still further object of the invention is to provide a novel fusing method and apparatus incorporating the advantages of instantaneous fusing readiness with no damage to the recording web during standby operation.

An additional object of the invention is to provide an electrostatic printing apparatus with a multiple copy output capability.

Generally speaking, the apparatus of the invention incorporates a device for presenting a plurality of differently shaped alphanumeric character electrodes in very rapid succession at a printing station. By providing a plurality of these printing stations arranged in a line, a complete line of type may be recorded on the recording web at one time. A backing electrode is also provided for each printing station on the opposite side of the recording web from the alphanumeric character shaped electrode so that recording may be accomplished by applying a pulsed voltage between the desired character electrode and the backing electrode at one particular station to record a latent electrostatic image of the desired character at the printing station. Character selection is provided by applying only a short duration pulse during the time when the desired shaped electrode is at the printing station. Although the whole group of different character shaped electrodes is cycled through the printing station, continuously at a very rapid rate, the actual printing of a complete line of copy may be accomplished within one of these cycles and the backing electrodes press the recording web into contact with the electrodes only during this cycle so as to avoid burnishing or tear-

ing of the recording web or marked slow-down, or drag on the characters as they move past the printing station. By bringing the electrodes on both sides of the printing gap into contact with the recording web during the application of the pulse, reliability problems inherent in air gap discharges are completely eliminated from the system.

Provision is also made for the inclusion of more than one printer in the system so that multiple copies of the printer output may be produced simultaneously. This result is achieved by mounting multiple printers adjacent each other and locking their mechanical drive systems together so that they operate in tandem. Then by merely connecting the electrical inputs of each of the printers in parallel to the activating circuitry of the system, duplicate prints are produced by each printer. Any number of duplicate copies of the printer output may thus be produced according to the number of printers in the system. Advantageously, the printing head drive mechanism may be left mechanically coupled into the overall drive system of each of the printers, and the number of copies desired may be selected by electrically switching individual printers in and out of operation as required.

There is also provided a recording web feed mechanism including a recording web roll brake, a recording web tensioning arm and tension detector and a web feeding mechanism for advancing the web through the printer one line at a time in conjunction with the printing operation. A special spring-loaded web tensioning arm also carries the web roll drum mounting brake in such a way that it is released when a predetermined amount of tension is applied to the web by the feeding rollers.

A special fusing mechanism is employed in the system and is kept in a heated standby condition even when no printing input is being fed into the system. This continuous heating of the fuser is made possible by the provision of a mechanism for moving the fuser or at least the heated portion of the fuser out of contact with the recording web when the printer stops recording for a predetermined time.

For a clearer understanding of the above and still further objects, features, and advantages of the invention, reference is now made to the following detailed description of the invention and the accompanying drawings in which:

FIGURE 1 is a left-hand top perspective view of a multiple communications printer according to the invention with one printer drawer pulled out and the upper portion of the printer pivoted up off the recording web;

FIGURE 2 is a left-side view of a single printer unit with the supporting slides partially broken away to show the relationship of the parts to the base plate of the printer;

FIGURE 3 is a top plan view of a single printer unit partially broken away to show the configuration of various parts in the unit and showing the cabinet slides and the cabinet drive coupling in ghost outline;

FIGURE 4 is a left-side sectional view of a single printer unit taken along section line 4—4 of FIGURE 3;

FIGURE 5 is a left upper-rear isometric view of the common printer drive mechanism and the binary coded character position wheel;

FIGURE 6 is a partially diagrammatic isometric view of the character cylinder;

FIGURE 7 is an isometric view of a character electrode tape which is an alternate embodiment of the cylinder;

FIGURE 8 is a side sectional view of the character tape and its support along with an alternate backing electrode mechanism;

FIGURE 9 is an end view of the FIGURE 8 apparatus;

FIGURE 10 is a side sectional view of an alternate embodiment of the heat fuser and the mechanism for moving it into and out of contact with the recording web;

FIGURE 11 is an activating circuit.

Referring now to FIGURE 1, there is seen a multiple printer cabinet generally designated **11** in which there

are mounted two duplicate units generally designated **12** and **13** respectively. Each of printer units **12** and **13** is on a base plate **14** with side rails **16** which are mounted in guide tracks **17** connected to cabinet **11** so that the printers can be slid in and out of the cabinet **11** for easy servicing and replacement of supplies. This movement of the printers in and out of the cabinet is readily accomplished by grasping printer handles **18** on face plates **19** of the printer units to either pull the units out of cabinet or push them back inside the cabinet after servicing has been completed. The face plates **19** of the printers are also provided with slots **21** through which the recording webs **22** exit from the printers. Each of the face plates **19** is also provided with a series of indicator lights **23** to indicate when the machine is on, when the recording web supply is low or when a break occurs in the recording web during operation. In each printer, an upper printer sub-assembly **24** is mounted on pivot pins **26** so that it can be opened as shown in FIG. 1, by pivoting it up and away from the recording web feed path. The pivot pins **26** connect the frame **27** of this upper sub-assembly to standards **28** which are mounted on the base **14** of the printer. This mounting arrangement is best seen in FIGURES 1 and 3. As best seen in FIGURES 2 and 3, a set screw **29** is employed to hold the end of the pivoted upper printer sub-assembly down in the operating position through a flange **31** on frame **27** with the flange bearing on a side frame member **32**. A locating pin **33** is also provided on side frame member **32** to mate with a hole **34** in flange **31** so that the upper printer sub-assembly is properly aligned with the remainder of the printer when it is in operating position.

General machine operation

Broadly speaking, the operation of the overall apparatus entails forming a latent electrostatic image on a recording web, developing this image with finely divided electroscopic marking particles and heat fusing these particles to the recording web to permanently fix the image thereon. In carrying out these operations, the recording web is first fed off a spool of recording web material **37** mounted on a reel **38** as best seen in FIGURE 4. The recording web is then guided through an electrostatic recording station generally designated **39** where a latent electrostatic image of the printing to be recorded is applied to the web. In the embodiment of the invention illustrated in FIGURE 4, the recording station employs a rotating alphanumeric character cylinder generally designated **40** which constantly rotates at high speed in the direction indicated by the arrow. This character cylinder which is also seen in FIGURES 1 and 3 and which is shown in detail in FIGURE 6 contains 80 duplicate character discs along its axial length. Each character disc is made up of a number of raised, alphanumeric, character shaped electrodes **41** arranged in a line around the circumference of the cylinder. Although 64 different numbers, letters, and arbitrary symbols including punctuation and the like are employed in each of the character discs shown, any number desired may be used and any number of discs may be arranged along the axial length of the character cylinder so as to print lines of different widths. Above the recording web and opposite the upper most portion of the character cylinder as seen in FIGURE 4 are 80 individual spring wire, conductive metal backing electrodes **42** with one being provided for each character disc on the character cylinder. As best seen in FIGURES 3 and 4, each one of these backing electrodes is aligned with one of the character discs on the character cylinder and each backing electrode is insulated from all of the other backing electrodes by virtue of its mounting in an insulating holder bar **43**. During recording, the backing electrodes **42** press the recording web against the raised characters **41** on character cylinder **40** and then by selectively applying a pulse between individual backing electrodes and the character cylinder at selected times in

the rotation of the cylinder, electrostatic images of the desired characters are recorded along the whole 80 character width of the recording web. Following recording of this line of latent electrostatic character images on the recording web, backing electrodes **42** are raised off the recording web and it is advanced through the system a distance equal to the height of one line to prepare it for the next line of recording. After the web passes through the recording station **39**, it enters a developing station generally designated **44** in which a magnetic brush developing unit generally designated **46** deposits finely divided, thermoplastic, electroscopic marking particles on the recording web in conformity with the pattern of electrostatic charge formed on the web at the recording station. After passing through the developing station **44**, the recording web then passes under a heat fuser generally designated **47** which melts the thermoplastic developer particles causing them to fuse onto the recording web surface. The recording web then passes between the bite of a feed roller **48** and a spring-biased idler roller **49**, which presses the recording web against the feed roller, and proceeds down a guide shoot **51** and then out of the machine through slot **21** in face plate **19** of the printer.

Recording web feed mechanism

As pointed out above, the recording web comes off a roll of recording web material **37** mounted on a reel **38**. The reel **38** is mounted at its ends on the flanged portions **51** and **52** of two shafts **53** and **54**, respectively. Shafts **53** and **54** are journaled for rotation in upright standards **56** and **57**, respectively, each of which is fastened to base **14** of the printer assembly. As best seen in FIGURE 3, a cylindrical spring **58** encircles shaft **53** between standard **56** and the flanged end portion **51**. This spring serves to force flange **51** against the end face of reel **38** so that the opposite end of the reel is pressed against the longitudinally flanged portion **52** of shaft **54**. Shaft **53** is, of course, slidably mounted in its journal **59** and a handle **61** is fixed to the end of shaft **53** most remote from flange **51**. This handle acts as a stop to limit the movement of shaft **53** caused by spring **58** and is also employed to pull the flanged end **51** of the shaft away from reel **38** when the roll of recording web material is replaced.

A U-shaped (as seen in FIG. 3) tensioning arm assembly **62** also has its ends mounted for pivotable movement on shafts **53** and **54**. This tensioning arm assembly pivots about the axis of the two shafts as indicated by the arrow on the assembly as shown in FIGURE 2. The assembly includes a U-shaped sheet metal frame member **63** in which an idle roller **64** is journaled for rotation. As can be seen in FIGURE 3, this idle roll extends well beyond the ends of the recording web which passes beneath it when the web is threaded through the printer. This idle along with the whole tensioning arm assembly is biased in the downward position as seen in FIGURE 2 by a pair of hold-down springs **66** as best seen in FIGURES 2 and 3. These springs connect the base **14** of the printer to a pair of pins **67** and **68** mounted on the arms of the U-shaped frame **63**. A braking arm **69** is also mounted for pivotal movement on pin **68**, the upper end of braking arm **69** carries a rubber brake shoe **71** which engages with the outermost portion of the flange **51** on shaft **53** when abutting stop **72** which is also carried by braking arm **69** is engaged by the front face of standard **56** as best seen in FIGURE 2. A spring **73** is also provided connecting a remote end of the braking arm **69** with the tensioning arm assembly **63**. Spring **66** is significantly stronger than spring **73** so that until the tensioning arm assembly **63** (as seen in FIGURE 2) is raised against the action of spring **66**, the pressure of abutting stop **72** pressing against upright standard **56** causes the rubber brake shoe on braking arm **69** to press up strongly against flange **51** to prevent the complete recording web roll from rotating. As soon as the tensioning arm assembly is raised against the action of spring **66**, abutting stop **72** pivots away from upright standard **56** allowing spring **73** to pivot braking arm **69** down about pin **68** and out of contact with flange **51**. This pivoting action of arm **69** about pin **68** causes the direct line distance between the brake shoe **71** and the center of the flanged shaft to increase so that the face of the brake shoe moves out of contact with the edge of the flange. As soon as the tensioning arm assembly **62** is allowed to return to the lower position in response to the action of springs **66**, engagement of the abutting stop **72** against upright standard **56** again causes the brake shoe **71** to engage flange **51** thereby preventing free wheeling the recording web drum.

Also mounted on the U-shaped frame **63** of the tensioning arm assembly is a microswitch **74** operated by a feeler arm **76**. This microswitch is employed to operate the "paper low" indicator light **23** on the front panel of the printer and is set so that when the feeler arm **76** reaches a predetermined low position where only a few more feet of recording web are left on the reel **38**, the switch is activated and the light goes on. As best seen in FIGURES 3 and 4, a second microswitch **77** is also carried by tensioning arm assembly **62** and is activated by a short feeler arm **78**. This feeler arm **78** bears against the tensioned recording web as it passes through the device and its tension is released as by a break in the recording web. The microswitch is immediately activated to operate one of the indicator lights **23** on the front panel of the device so as to alert the operator to a recording web break. This switch is also employed to turn off the recording pulse input, stop the recording web feed and remove the fuser from contact with the recording web. After passing beneath idle roller **64** on the tensioning arm assembly and feeler arm **78** on the microswitch, the recording web passes over two guide rollers **79** and **81** These guide rollers are journaled for idle rotation in a pair of side frame members **82** and **83**. After the recording web passes over idle rollers **79** and **81** and through the printing station **39**, it passes through the developing station **44** under the fuser **47** and then between feed roller **48** and idle roller **49** which together serve to advance the recording web through the printer. The feed roller **48** is a metal core roller coated with a rubber sheath **84** to provide good frictional contact between this roller and the recording web during feeding. The feed roller **48** is indexed forward periodically enough to advance the recording web a distance equal to the height of one line of characters through a one-way clutch arrangement **89** operated by a feed roller crank **88** which is driven through the shaft **87** of a solenoid **86** mounted on side frame member **32**. A flange **91** is also mounted on the end of solenoid shaft **87** and is large enough so that it will abut up against two stops **92** and **93** mounted on side frame member **32** so as to precisely delimit the length of travel of the solenoid shaft. This, in turn, provides for a precise degree of rotation of feed roller **48** each time solenoid **86** is actuated. Idle roller **49** is mounted at both ends for rotation in a U-shaped sheet metal frame member **94** as best seen in FIGURES 1–4. This frame member, in turn, is mounted for pivotable movement about a pair of shaft pins **96** and **97** which are mounted in two C-shaped brackets **98**, **99**, each of which is fastened to the frame of the upper printer sub-assembly **27**. One end of each of a pair of cylindrically wound springs **101** and **102** is inserted in a hole in fixed shafts **96** and **97**, respectively, while the other end of each of these springs is inserted in a hole in the side of U-shaped frame member **94** as best shown in FIGURES 2–4. This causes roller **49** which is carried by the frame member **94** to bear strongly against the recording web between it and the feed roller **48** when the upper pivoted printer sub-assembly is brought down into the operating position.

Accordingly, when feed roller **48** is rotated, it advances the recording web and tension thus applied on the recording web raises the tensioning arm assembly by apply-

ing an upward component of force on idle roller **64** so that brake **71** is released and the roll of printing web material **37** is allowed to advance.

Electrostatic recording station

As briefly explained above, the recording station includes a character cylinder generally designated **40** carrying a plurality of raised alphanumeric character shaped electrodes **41** thereon. These character shaped electrodes **41** are in the shape of alphabetical letters, numbers, punctuation, or any other arbitrary symbols as desired. In this embodiment of the invention, the raised character shaped electrodes **41** are arranged in **80** identical circumferential discs with each disc carrying the same symbol in the same position around the circumference of the drum as shown most clearly in FIG. 6. In this particular drum, 64 differently shaped electrodes are provided in each disc and 80 discs are provided along the axial length of the drum. However, each of these numbers may be varied as required to fit the circumstances. Preferably, each of the raised character shaped electrodes is made of a conductive material and rests directly on the common electrically conductive drum **40**. The drum has an axial shaft **103** which is journaled for rotation in two upright side frame members **82** and **83**. The shaft **103** is directly driven at a high rate of speed through a gear box **104** as best seen in FIGURE 3.

As explained above, a plurality of springy conductive metal backing electrodes **42** are provided on the side of the recording web opposite character cylinder **40** and are mounted in an insulating holder bar **43** so that all of electrodes **42** are insulated one from the other. A backing is provided for each of the **80** character discs on character cylinder **40**. Each of the backing electrodes **42** is mounted in holder bar **43** at such an angle that they tend to bear down on the recording web, pressing it against the character cylinder. Each of the electrodes **42** is connected to a pulse source (not shown) so that a pulse may be applied to each of these electrodes at a selected time in the rotation of character cylinder **40**. In this way, a complete line of latent electrostatic images corresponding to a line of the information to be printed out can be recorded on the recording web during one rotation of the alphanumeric cylinder **40**. As stated above, the angle of mounting and the springiness of the metal backing electrodes **42** causes these backing electrodes to bear down on the recording web during that cycle of rotation of character cylinder **40** when a line of characters is recorded on the web. Once this line of characters has been completed and the web is ready to be advanced for recording of the next line of information to be recorded, the backing electrodes **42** are cammed up away from the recording web by an insulating cam **106** mounted on a pair of end brackets, **107** as best seen in FIGURES 3 and 4. These end brackets, in turn, are mounted for rotation about a pair of pins **108** which are fixed in the upper printer frame **27**. The end brackets **107** and the cam are caused to rotate about pins **108** by the movement of a lever arm **109** actuated by a solenoid **111**. A stop **112** is also provided to limit the reciprocal movement of the solenoid. A spring **115** has one end connected to the frame **27** of the upper printer sub-assembly and the other end connected to a portion of lever arm **109** below pin **108** so that the spring constantly biases the cam into a position where it will raise the backing electrodes **42** and the solenoid **111** must be actuated to allow the backing electrodes to press down on the recording web. The spring is best seen in FIGURE 3.

It should, of course, be recognized that many alternate embodiments of various portions of the invention may be substituted in the printer while still coming within the scope of the invention. For example, the character cylinder illustrated in FIGURES 1–4 and 6 may be replaced with an endless flexible character tape **113** as illustrated in FIGURE 7. This tape is also preferably made of an electrically conductive material and bears raised electrically conductive alphanumeric characters **114** of the same type employed in connection with the character drum illustrated in FIGURE 6. Instead of moving the various characters past the backing electrode in a direction which is generally parallel to the direction of movement of the recording web through the printer, the endless tape is mounted in the printer so that the characters move past the backing electrodes in a direction perpendicular to the direction of movement of the recording web or, in other words, in a direction parallel to shaft **103** of the original character cylinder as seen in FIG. 4. The belt is provided with a plurality of sprocket holes **116** and is entrained about a pair of pulleys **117** and **118** provided with sprockets **119** which mate with sprocket holes **116** in the endless belt. The shaft of one or both of these pulleys may then be directly driven through a gear box in the same manner employed to drive the alphanumeric character cylinder illustrated in FIGURE 6 with appropriate changes in gear ratios as required. As best shown in FIGURE 8, the tape **113** runs between the pulleys in a grooved guide platen **121** so that the characters are kept in perfect alignment with the backing electrodes.

Alternative mechanisms may also be employed for moving the backing electrodes **42** in and out of pressing contact with the recording web. Thus, for example, as shown in FIGURE 8, the electrodes **42** are mounted in insulating sleeves **122** in a U-shaped channel bar **123**, the end of which is fixed to a lever arm **124** mounted for pivotal movement about a pin **126** which, in turn, is mounted on the upper printer frame **27**. The end of lever arm **124** most remote from the backing electrodes **42** is moved in the directions shown by the arrow in FIGURE 8 by a solenoid **127** which contains an internal spring biasing the backing electrodes toward the raised position **128** until the solenoid is actuated. An end view of this alternative embodiment of the backing electrodes lifting mechanism is shown in FIGURE 9.

Image developing mechanism

Once the latent electrostatic image has been formed on the recording web, it passes into the developing mechanism which deposits finely divided, colored electroscopic marking particles on the web in accordance with the pattern of the latent electrostatic image. The developing mechanism includes an elongated container **129** mounted between upright end frame members **32** and **131** which thus serve as the ends of the container. These features are best seen in FIGURES 1, 2, and 4. Also mounted between the end frame members is a magnetic assembly **132** surrounded by a cylindrical non-magnetic shield **133**. Both this non-magnetic shield **133** and a pair of sheet metal helical screw agitators **134** and **136** are journaled for rotation in upright frame members **32** and **131**. Shafts on each of these elements extending out beyond frame member **131** are geared together as shown at **137** in FIGURE 1. This gearing is arranged so that the gear connected to the shaft of shield **133** meshes with that connected with the shaft of agitator **134** and this gear, in turn, meshes with the gear on the shaft of agitator **136**. Thus, non-magnetic shield **133** and agitator **136** rotate in the same direction while agitator **134** rotates in the opposite direction as shown by the arrows in FIGURE 4. The geared shaft of non-magnetic shield **133** is directly driven by a motor **138** best seen in FIGURE 3. In operation then, the counterrotating agitators feed or kick up a mixture of finely divided, electroscopic, colored marking particles and magnetic material such as iron filing to the rotating non-magnetic shield **133** and a magnetic brush made up of bristles formed through the action of the magnetic field on the developing material mixture is brought in contact with the recording web bearing the latent electrostatic image formed at the printing station **39**. Since the finely divided, electroscopic marking par-

ticles in the developing mixture are triboelectrically charged by rubbing against the iron filings to a polarity which is opposite to the polarity of the latent electrostatic image recorded on the recording web, these marking particles deposit out on the electrostatic image. A steel bar **139** placed beneath magnet **132** shunts the lower portion of the magnetic field as seen in FIGURE 4 so that once the magnetic brush passes the recording web, the field collapses and the developing mixture forming the brush on the outside of the non-magnetic shield falls back into the bottom of container **129** for reuse in developing a later image. In order to improve the quality of the developed image and reduce background, a counter electrode **141** is provided on the opposite side of the recording web from the magnetic brush and a biasing voltage of about 100 to 200 volts DC of the same polarity as the charge applied to the recording web by backing electrodes **42** in forming the image is advantageously applied to this counter electrode to prevent the formation of spurious background deposits of developer in non-image areas on the recording web. Reference is made to many patents and literature sources in the xerographic arts for a detailed teaching of developing material mixtures which are useful in operating this developing mechanism.

Fusing mechanism

Once the recording web passes the developing station **44**, the pattern of finely divided, colored, thermoplastic marking particles is heat fused to the recording web by being brought in contact with fuser **47**. The fuser mechanism is generally cylindrical and is mounted on a pair of end shafts **142** journaled for rotation in downwardly depending side portions of the frame **27** of the upper printer sub-assembly. As seen in FIGURE 2, a pinion **143** is keyed to shaft **142** and meshes with a large gear segment **144**. The gear segment **144** is mounted for rotation upon a small shaft **146** fixed to frame **27** and is rotated by a lever arm **147** connected to a reciprocating solenoid **148**, so that acutation of relatively short throw solenoid **148** can be used to cause 180° rotation of the fuser **47**. The heated side of the fuser itself is made up of a cylinder segment of steel **149**. A hollowed out portion in the back of segment **149** contains a "Thermistor" or any other suitable temperature detector encapsulated in a heat resistant plastic resin and an electrical resistance heater screen **152** is provided behind this assembly. By incorporating the thermistor into the fuser design, the temperature of the fuser is closely controlled through regulation of the current flow to the resistance heater **152** regulated by a feedback signal from the thermistor. Motion of the colder web is thus readily sensed by the thermistor, maintaining constant fusing temperature. An additional unheated cylinder segment **153** is also provided so that when the fuser is rotated 180° from the position shown in FIGURE 4, this unheated segment will contact the recording web. Since heated fuser contact with the recording web can be terminated almost instantaneously when recording web feed stops, the fuser may be maintained at a relatively high temperature without fear of scorching or burning the web.

Here again, it is to be understood that alternative embodiments of the fuser may be incorporated into the printer without departing from the spirit and scope of the invention. One of these embodiments is shown by way of example in FIGURE 10, where an electrical resistance heater grid **154** is positioned closely in back of a heat conductive platen **156** which bears down on the recording web when in operating position. Platen **156** is connected to a lever arm **157** mounted for pivotal movement about shaft **158** so that heater platen **156** can be pivoted out of contact with the recording web into ghost outline position **159** by the actuation of a solenoid **161** which is connected to the end of lever arm **157** most remote from platen **156**.

Multiple printer common drive mechanism

As stated above, each of the character cylinders in each printer is driven through a gear box **104**. The input drive shaft of each of these gear boxes carries a clutch plate **162** which engages a similar clutch plate **163** when the printer is fully slid into the main cabinet where clutch plate **163** and its associated drive mechanism is permanently mounted. Each of clutch plates **162** carries a pin **164** biased towards clutch plate **163** by a leaf spring **166**. These features are best seen in FIGURES 3 and 5. Each of clutch plates **163** contains a hole **167** adapted for mating with pin **166** when the two clutch plates are in exact angular alignment with each other. Until this exact angular alignment between the two plates occurs and the pins mate with holes **167** by virtue of the pressure exerted by leaf springs **166**, the clutch plates are allowed to slip with respect to each other. Generally, however, within a few rotations of clutch plates **163**, pins **164** come into alignment with holes **167** and the plates are positively engaged with each other. This exact angular alignment of clutch **162** and **163** with respect to each other is an important feature of the invention since a binary coded character position disc is also mounted on the shaft **168** which carries the upper clutch plate **163** as seen in FIGURE 5, and the angular position of this shaft with respect to the angular position of the character drum must always be exact so that the position signal generated by the binary coded character disc **169** will correspond with the actual character which is opposite backing electrodes **42** at the time the signal is generated. The whole common drive mechanism for the multiple printers is mounted on an upright channel **171** which is positioned inside the main cabinet **11**. A motor **172** directly drives the shaft **173** upon which lower clutch plate **163** is mounted. In addition, a timing gear **174** is also mounted on shaft **173** for rotation therewith. An additional frame element **176** connected to channel **171** is also included to provide additional journal support for the motor and shaft **172** and **173**. The geared timing belt **177** is entrained about timing gear **174** on shaft **173** and an identical timing gear **178** on shaft **168** so that the two shafts rotate at identical speeds. An idle roller **179** bears against timing belt **177** to keep it under tension so that the teeth on the timing belt engage with each of the timing gears **174** and **178**. A second additional frame element **181** connected to channel **171** is used to provide additional support for shaft **168** and to support a number of additional elements described hereinafter. Binary coded character disc **169** contains 64 differently coded segments, one segment for each alphanumeric character around the periphery of a character disc on the character cylinder **40** with each of these coded segments corresponding to a specific one of the characters. The coding is accomplished by making different portions of each segment either transparent or opaque to light as can best be seen in FIGURE 5. A light source **182** mounted on a bracket **183** connected to frame member **181** provides a light beam which is focused to a line by a cylindrical lens **184** and this line of light then passes through the transparent areas of the various segments of the binary coded character disc **169** as they rotate past the line of light. A series of very small photo-diodes (not shown) are mounted behind holes in a mask **186** so that light passing through the various combinations of transparent areas in each segment of character disc **169** can be used to operate a decoder **215** which generates a coded output corresponding to the character electrode positioned opposite the backing electrodes at that time.

As seen in FIGURE 11, binary coded input data enters an input register **201** on 8 lines (not shown). A sync pulse arrives with the input data, or alternately, a sync pulse generator **202** is also connected to register **201** and to a shift control **203** and a column counter **204**. The input register **201** feeds coded data signals to shift register **206** through an inhibit gate **201'** controlled by the special

detector **207**. Detector **207** is employed to control the operation of the printer when it receives binary coded operational signals indicating the end of the line of printing, etc. By using an 8 line binary coded input, 128 different input signal combinations are provided—more than enough for 60 different alphanumeric characters, punctuation and other printing symbols and a number of operational signals as required. Signals from the column counter **204** and the special detector **207** are employed to activate print cycle control flip flop **208** which, in turn, activates backing electrode solenoid **209** causing the backing electrode fingers to move down into pressure contact with the back of the recording web. The print cycle control and special detector inputs are also employed to activate reset gate **211** to restart column counter **204** at the beginning of each line of recording. Another output line from print cycle control **208** is employed to activate shift flip flop **212** so that pulses from the character timing detector **216** may pass through it to the shift control **203**. Flip flop **212** also starts character address counter **214** in conjunction with character timing detector **216**. This character timing detector **216** produces a pulse for each binary coded segment on the coded disc so that one signal from the print cycle control **208** and the character timing detectors **216** activate the shift control **203** to cause the shift register **206** to recirculate its entire contents to comparator **217** each time another coded portion of the binary coded disc activates detector **216**. At the same time, code wheel decoder **215** signals the comparator according to the particular binary coded segment which happens to be in front of the light source at any particular time, and when circulated signals from the shift register **206** coincide with signals from the decoder **215** in the comparator **217**, a signal is fed from the comparator to an encoding matrix **218**. The comparator input signal is addressed to a particular section of the encoding matrix **218** by a character address counter **214**. Each of these sections of the encoding matrix correspond to one of a number of output lines corresponding to the number of backing electrodes which are to be driven by the system. A character address counter **214** serially addresses comparator output to sections of encoding matrix **218**. Counter **214** also receives an input signal from master clock **213** as does shift control **203**. When counter **214** has received a number of input pulses from the master clock **213** which corresponds with the number of characters in the line width to be printed, it fires a one shot printing pulse directly to the backing electrode drivers **219** causing those which have been activated from the encoding matrix to discharge. Every time, during printing, one line of similar characters on all of the character discs of the character cylinder comes opposite the 80 backing electrodes, then the system contains input data, the entire contents of shift register **206** are circulated at the output of the register and compared with the code wheel readout which is, of course, an analog of the character position on the drum. Thus, for example, when the "*a*'s" on each of the discs of the character electrode drum are opposite the 80 backing electrodes, all the "*a*'s" in the line of type will be "printed" on the recording web, in the proper position on the line according to their serial position in the shift register **206**. Since all of the other characters encoded in the shift register represent other letters which are coded differently, no pulse will pass through comparator **217** when this data is compared with the output signal from the code wheel decoder **215** and the comparator **217**. This same procedure is repeated for the "*b*'s", "*c*'s" and all the other letters, numbers, and punctuations so that after one complete rotation of the alphanumeric character drum, a complete line of type is recorded on the recording web. Thus, it is seen that the shift register is recirculated to the comparator once for each character registered from the code wheel so that all of the information in the shift register for one line of printing is recorded in the proper position in the line when the proper character comes opposite the backing electrode at that position. A coincidence occurs for all information in the shift register after one complete rotation of the character electrode drum at most. Special coded signals detected by special detector **207** are employed to operate the feed paper feed control **221** which, in turn, activates the paper feed solenoid **223** to advance this recording web. This paper feed control **221** will not operate unless a signal is also received from a detector (not shown) indicating that shift register **206** is empty. There is also provided a delay circuit **224** which activates the fuser rotating solenoid **226** within any fixed period of time after the last paper feed signal provided that no input signal of new printing is received on the special line from the special detector **207**.

What is claimed is:

1. An apparatus for forming a latent electrostatic image on a charge-retaining recording web comprising at least one shaped electrode on a first side of said recording web, a flat-surfaced backing electrode on the other side of said recording web opposite said shaped electrode, said electrodes being spaced apart a distance greater than the thickness of said recording web so that said web may freely move in the gap formed by said electrodes, web feeding means to intermittently advance said recording web through said open gap, means to bring said electrodes sufficiently close together to press against opposite sides of said recording web to thereby close said gap after web advance, means for applying an electrical recording pulse across said electrodes while said recording web is stationary to form an electrostatic image of said shaped electrode on said recording web, control means to actuate said pulsing means after said electrodes have been brought together to press against opposite sides of said recording web, means to reopen said gap after duration of said pulse whereby said web feeding means can advance said recording web at least one line through said reopened gap to position said recording web for recording another line of output.

2. An apparatus according to claim **1** including a plurality of differently shaped electrodes, means to cycle successive ones of said shaped electrodes past said backing electrode, said pulsing means supplying a pulse having a duration no longer than the time during which one of said shaped electrodes is opposite said backing electrode.

3. An apparatus according to claim **1** comprising a plurality of said separate backing electrodes arranged in a line, means to cycle a plurality of differently shaped electrodes past each of said backing electrodes and a pulsing means for each of said backing electrodes.

4. Apparatus according to claim **3** in which said shaped electrodes are mounted on a flexible endless belt entrained so that movement of the belt causes them to move past said backing electrodes and further including a grooved guide platen, said belt being positioned within said groove in said platen for maintaining alignment of the shaped electrodes with said backing electrodes.

5. Apparatus according to claim **3** in which said shaped electrodes are mounted circumferentially around the periphery of a cylinder journaled for rotation about its longitudinal axis so that successive electrodes mounted around the circumference of said cylinder pass said backing electrodes and further including means to continuously rotate said cylinder about said longitudinal axis.

6. Apparatus according to claim **3** in which said backing electrodes are normally spring biasted towards said shaped electrodes and said backing electrodes are held away from said shaped electrodes by a holding cam.

7. An apparatus according to claim **1** in which said means to bring said electrodes sufficiently close together to press against opposite sides of said recording web after web advance comprises means to move said backing electrode towards said shaped electrode.

8. An apparatus for forming a latent electrostatic

image on a recording web comprising a plurality of separate electrically conductive backing electrodes arranged in line, a plurality of differently shaped electrodes mounted on a carrier, means to move said carrier so that said shaped electrodes repeatedly cycle past said backing electrodes at a small distance therefrom to form a printing gap, means to intermittently advance a charge-retaining recording web through said gap, means to bring said electrodes sufficiently close together to press against opposite sides of said recording web to thereby close said gap after said web is advanced through said gap, means to apply short duration pulses between selected ones of said shaped electrodes on said carrier and corresponding ones of backing electrodes when the desired shaped electrodes are opposite said backing electrodes during a single one of said cycles while said electrodes are in contact with opposite sides of said recording web, means to reopen said gap after said cycle whereby said web advance means can move said recording web at least one line through said reopened gap to position said recording web for recording another line of output.

9. An apparatus according to claim 8 in which said backing electrodes are biased toward said shaped electrode carrier and said means for reopening said gap comprises a camming means mounted adjacent said backing electrodes so as to raise them away from said carrier when said camming means is actuated.

10. An apparatus according to claim 8 in which said backing electrodes are mounted on a pivot arm and said means to close and reopen said gap comprise means to rotate said pivot arm about its pivot point.

11. An apparatus according to claim 8 in which said backing electrodes are actuated by a control mechanism comprising a bi-directional solenoid whereby said backing electrodes press against said web prior to pulsing and said backing electrodes reopen said gap between said backing electrodes and said shaped electrodes prior to said web advance.

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