The present invention is directed to an electrostatic printing system which finds particular utility as a page printer and more particularly to a highly versatile system capable of accepting an input web in either continuous or fan-fold form, printing the record either in the usual readable form or in a reversed or mirror image arrangement, and providing an output either in continuous form or fan-fold form. In the embodiment illustrated, the printed web is then accumulated at the transfer station and transported to the chase station where it is cut into desired portions to form a chopped sheet. If in chopped sheet form it is desirable to provide a first alternative in which the information is imprinted in conventional form; the printed sheet can then be used alone, or as a master for reproduction in conventional office copying machines. It is also manifestly desirable to be able to produce a reversed or mirror image form on the master sheet, and to produce one or more usable, right-side-up pages from the reversed master in a real time, on-line operation. For certain applications, the chopper and page copying means need not be incorporated in the system. Instead the information is printed in reversed or mirror image form on the master web and the copy can then be made in an off-line transfer unit at a later time.

An electrostatic printing system constructed in accordance with the present invention to satisfy the stringent criteria noted above includes a paper feed station for accepting a continuous web of paper or other dielectric material, which may be supplied either in continuous roll or fan-fold form. A "print" station receives the web from the paper feed station, and the print station includes a "reverse print" control for regulating the deposition of the latent image-defining charge either in conventional (right-side-up) or mirror image form. It is emphasized that "print" is not used in the sense of providing a visible image in this specification and in the claims, but rather in the accepted meaning in the electrostatic printing art, that of electronically charging discrete areas of the web to represent information in character, code, or other form.

An inker station is provided to receive the selectively charged web from the print station. The inker station retains opaque particles which are attracted to the charged web areas to provide a temporarily visible representation of the desired information. A fixer station receives the charged web from the inker station and fixes the particles in place, by the application of heat, pressure, chemicals or other known techniques, to provide a permanent record of the input information. From the output side of the fixer station the printed, inked and fixed web can be accumulated in a roll form, in fan-fold form, or the web can be passed to a chopper station which includes a "chop" control to energize this station for chopping the web into sheets of page or other desired length. If it is desired only to chop the continuous web with no reproduction, the chopped pages are passed from the chopper station to a master sheet stacker which accumulates the individual pages as received. In the alternative a "copy" control can be energized to in turn regulate the operation of a particle softening station and one or more transfer stations or copier units. The particle softening or loosening station and the transfer station(s) are interposed between the chopper station and the master sheet stacker. The specific particle softening apparatus utilized will depend on the fixing station. For example, when heat fixing is employed heat is applied at the softening station to loosen or soften the particles on the master web. In the preferred embodiment pressure fixing is utilized and a solvent is applied at the particle softening station. As energized, the particle loosening station is operative to apply a suitable solvent to the fixed web which in effect softens or loosens the conductive particles previously firmly fixed to the web to permit, by engagement of the copy paper at the transfer station(s), reproduction of a copy from the master sheet received from the chopper station. The copies are accumulated at the transfer sta-
tion(s) and the master sheets are passed to the master sheet stacker.

To enable those skilled in the art to practice the invention, the best form contemplated for making and using the invention will now be described in connection with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIGURE 1 is a perspective illustration, and FIGURE 2 is a top view, taken on a scale reduced with respect to that of FIGURE 1, illustrating the general physical arrangement of the stations which together constitute the inventive system;

FIGURE 3 is a block diagram useful in explaining the flow of the dielectric web and the various operations in the novel system of the invention;

FIGURES 4A and 4B are schematic-type diagrams illustrating in general form the components and control elements utilized at the different stations in the system;

FIGURE 10 is a front view of a control panel for use in regulating the inventive system;

FIGURE 11 is a simplified diagram useful in explaining the operation of the print station of the novel electrostatic printing system; and

FIGURE 12 is a block diagram of another embodiment of the invention.

General physical arrangement

As shown in the perspective illustration of FIGURE 1, the complete printing system includes a first large cabinet 20 on which a control panel 21 is disposed; a second major cabinet 22 behind the first cabinet 20; and four modular cabinets 23-26 disposed to the right of main cabinet 20.

In main cabinet 20, as will be detailed hereinafter, are five separate stations of the inventive system including: a paper feed station; a print station; an inker station; a fixer station; and the last station in main cabinet 20 is a chopper station, for selective energyization only when it is desired to provide an output record in chopped sheet form rather than in continuous or fan-fold form.

In the cabinet 22 behind the main cabinet are the various electronic components including the logic circuitry for regulating and coordinating the system operations, the power supplies, and the basic controls for the system.

In the left portion 23A of cabinet 23 is a solvent applying station selectively energizable to soften the ink on the web for the production of copies of the master sheet printed in main cabinet 20. In general, this unit includes a mechanism for applying suitable solvent to the inked and fixed web to loosen or slurry the printed record, so that subsequently in the transfer station, by effecting a pressure engagement of copy paper with the solvent-wetted master form, an accurate copy of the original can be provided.

In the right hand portion 23B of cabinet 23 is the first of six identical transfer stations. Shelf 27 provides support for the copy paper (not shown) which may be easily provided in fan-fold form on the left side of shelf 27 for passage upwardly over paper tractor 795, over a free-turning transfer roller 28, downwardly along the other side of tractor 795, to the lower shelf. A mounting bracket 30 is affixed at the upper portion of this cabinet, and a hydraulic cylinder 31 is affixed to the mounting bracket for supporting the transfer roller.

Selective energization of the hydraulic system operates cylinder 31, a similarly disposed cylinder at the other end of roller 28, and tractor 795, to displace the copy paper upwardly over roller 28 and into engagement with the solvent-wetted master sheet. Condition and alarm lights 32 and 33 are positioned in the upper left-hand corner of cabinet 23, and similar lights 34 and 35 are shown near the upper right-hand portion of the same cabinet.

In cabinet 24, both the left-hand portion 24A and the right-hand portion 24B are identical, and they respectively house the second and third transfer stations. Likewise, the fourth and fifth transfer stations are disposed within the portions 25A and 25B of the third modular cabinet 25 which is thus identical in all respects with cabinet 24.

The last cabinet 26 includes the sixth and last transfer station in the left hand portion 26A of this cabinet. Additional transfer stations may be added to produce additional copies. More than 50 good copies have been produced from a single master web, and best results are realized with an additional solvent application station for every series of six or eight additional transfer stations. Behind the closed door in section 26B is a master sheet stacker for receiving the master sheet after the copies are printed in the preceding transfer stations, or when no copying or chewing of the master is done, to receive the printed record in either continuous or fan-fold form.

FIGURE 2 depicts the straight-line path of the web from the paper feed station in cabinet 20 to the master sheet stacker in cabinet portion 26B.

General web flow description

FIGURE 3 shows in simplified block arrangement the path of a dielectric web such as paper through the electrostatic printing system of the invention. That is, paper feed station 100 accepts a continuous web either from a supply roll or from a fan-fold supply. The web is fed to a "print" station 200 at which the web is selectively charged in accordance with input information received over conductor 201 from some suitable source of information, such as the output circuit of a computer, a teletype line, or so forth. A "reverse print" control 202 is provided for directing the print station to operate and print the information in a latent pattern which is the mirror image of what would normally be viewed on a record. The selectively charged web is then passed through an inker station 300, in which the opaque particles are attracted to the charged web areas. Subsequently, in connection with FIGURE 12, an alternative embodiment in which the latent image is developed with wet ink will be described. Such embodiment obviates the use of both fixer and solvent application stations. When dry "ink" or powder particles is used (FIGURE 3), the temporarily developed web is passed to the fixer station 400, in which the record is fixed to provide a permanent display of the information.

Three separate outputs from the fixer station 400 are possible. The web with the desired information impressed thereon can be accumulated in a roll or in a fan-fold supply, or the web can be separated into page length sheets or any other desired length sheets in chopper station 500 and return to the master cabinet. From the showing in FIGURE 1 it will be evident that the fixed web is always displaced from the main cabinet 20 through the solvent applying station and adjacent each of the transfer stations to the master stacker station. If the printed record is to be accumulated in a roll or fan-fold form fashion, this is accomplished by not energizing the chopper station, or any of the six successive transfer stations, to permit the continuous record to be accumulated in the master stacker cabinet 26B. It does not matter if solvent is applied to the master web, so long as no transfer station is actuated. The solvent rapidly evaporates from the master web, or from the master sheets if the chopper station is actuated. If it is desired to provide the record in page length form, only the chopper station 500 is actuated; the transfer stations are left deenergized to permit the page length forms to pass down to the master stacker. This operation is represented by the line 502 in FIGURE 3, showing a path from paper ion 500 directly to the master sheet stacker 800.

When it is desired to produce one or more copies from the master copy on which the image has been printed in reverse form, the reverse print control 202 is actuated at the print station and the chop control 501 is actuated to energize chopper station 500. The chopped sheets with the information in mirror image form thereon are dis-
placed along the path represented by line 503 to the input side of solvent applying station 600, which always applies solvent to the master web. At transfer station 700, which may include 1, 2, or more of the six stations depicted in FIGURE 1, any number of these six stations may be energized to effect copying at each of the energized transfer stations. The copies are accumulated as previously described at each transfer station, and the master sheets are received in master sheet stacker 800. If the chopper station is not energized, at station 800 the web is collected in roll or fan-fold form. With this basic consideration of the system, and the alternatives of input, output and copying that are readily available, a more detailed description of each station will now be given out.

**Paper feed station**

It has been noted that the paper feed station 100 can accommodate a continuous web either in roll form or in fan-fold form. FIGURE 4 shows the paper guide roller 101, and a master paper roll 101 is journaled on a support shaft 102. A brake 103 is positioned on one side of shaft 102, and the brake can be energized by application of a suitable voltage over conductors 104, 105. A "low roll" sensing lever and switch arrangement 106 is disposed adjacent the roller 101, and includes a generally L-shaped lever assembly 107 pivoted about a shaft 108. The longer arm 112 of lever 107 is terminated in an arcuate portion 110 which engages the periphery of roller 101 when the urging of a bi-spring 111, shown coupled between lever arm 112 and wall 113. The shorter length arm 114 of lever 107 is effective as the diameter of roller 101 decreases and lever 107 is pivoted in a counterclockwise direction to engage actuator portion 115 of an electrical switch 116, which operates to provide a low roll signal over output conductor 117, 118. In a preferred embodiment of the invention these conductors were coupled to associated circuitry to both turn on a warning light and energize an alarm bell, thus to signal the operator both visually and audibly of the low roll condition.

As the web 120 is pulled off the large roll 101, it is pulled upwardly past a first guide roller 121 and past a splicing table 122, then around a second guide roller 123. The paper passes upwardly to the right, and around the periphery of capstan roller 124 as the paper passes between the roller and the pinch roller 125. As indicated by broken lines, capstan roller 124 is coupled to a clutch 127 which receives drive from a drive motor 129, which motor can be energized over conductors 130, 131. Another conductor 132 passes control signals to clutch 127. A similar arrangement can be employed at station 800 to take up a continuous web in roll form when no chopper is employed.

A web splice sensing assembly 133 is disposed adjacent the location where the web is passed around capstan roller 124. It is preferred to position assembly 133 adjacent guide roller 123 to sense the web thickness at that point, but to simplify the drawing, the assembly 133 is shown adjacent capstan roller 124. This assembly includes a generally V-shaped lever having first and second arms 134, 135 which are pivoted about a shaft 136 and disposed so that arm 134 rides a few thousandths of an inch above the surface of paper web 120. When an unusual thickness is sensed, as for example a splice which is too thick for satisfactory passage through the subsequent stages of the printing system, the lever assembly is rotated in a clockwise direction so that arm 135 engages actuator 137 of switch assembly 138, providing an output signal over conductors 140, 141 denoting excess web thickness or an unsatisfactory splice condition. After leaving the satisfactory engagement between rollers 124, 125 the web passes to the left and then downwardly over a third guide roller 143, to hang down in a first buffer loop 144. From the bottom of the loop the web is returned upwardly and passes upwardly to the right, toward the print station 200.

A first buffer loop sensing unit comprising a lamp 145 and an associated photocell 146 is disposed near the bottom of the loop; a second loop sensing arrangement 147, 148 is disposed at an intermediate portion of the loop; and near the top of the buffer loop there is another loop sensing arrangement including another lamp 150 and a photocell 151. The intermediate and lower sensing arrangements are utilized to pass appropriate signals over conductor 152 to clutch 153. That is, when the extent of the loop diminishes so that the buffer loop 144 is just above the path of light energy between lamp 147 and photocell 148, clutch 153 is then energized, brake 153 is de-energized, and motor 128 drives roller 124 to haul off additional web from the roll 101. Each time clutch 127 is de-energized, brake 103 is again energized. This action continually increases the vertical extent of the buffer loop 144 until the bottom of the loop drops downwardly to block passage of light energy from lamp 145 to photocell 146, at which time photocell 146 provides an "off" or no-light signal to deenergize clutch 127.

Should the web break or the end of the roll appear, the loop will gradually disappear and the trailing end of the web will pass upwardly between lamps 150 and 151 to provide a signal to associated equipment to initiate shutdown of the system.

Splicing table 122 includes a plurality of registration pins 153 for retaining, with the aid of suitable clamps (not shown), the trailing edge of one web and the leading edge of a succeeding web when a full roll 101 is placed on shaft 102. Also provided within splicing table 122 is a knife to assist the splicing operation. Groove 154 provides for suitable knife alignment to insure that the splices are properly made. During the splicing operation, table 122 can be displaced to the position indicated by the dash-dot line to facilitate joining of the two webs.

**Print station**

Referring to FIGURE 5, as the web 120 enters the print station, the web margins pass between a pair of brake assemblies 203 (only one of which is visible), one disposed along either margin of the paper web. Each assembly includes a base portion 204 and a movable portion 205. A magnetic circuit is completed responsive to energization of the brake assembly over conductors 206 and 207 to attract shoe or movable portion 205 of the assembly toward the base 204 and securely grip the paper web and hold it against displacement. A pair of separate charge heads 208 and 210 are disposed on the opposite side of the web from an anvil or ground electrode 211. Each of the charge heads 208, 210 can be selectively energized over conductors 212, 213, in accordance with control signals provided from control unit 214. Form length head 208 can be energized at the appropriate time to print a form length mark on the web to indicate to the subsequent equipment what part of the continuous web should be divided into separate sheets, if a chopped sheet output is required. The other head 210 can be selectively energized over conductor 213 to provide a "print" mark on the web to indicate to subsequent equipment that information is present on this portion of the web. Thus, when copies are to be made at any of the transfer stations, any page or form with such a "print" mark thereon will be reproduced at the transfer stations. The selective charging or printing on the web is accomplished as information signals received over conductor 201 are transmitted in control unit 214 into appropriate signals for application to the one of charge heads 215 which will provide clouds of ions at the appropriate times. These ions pass through apertures 227 in tape mask 216 to impinge on web 120 as it rides over anvil 217, which is apertured in the central portion to provide a channel from which a volume of air can be drawn to hold web 120 securely against anvil 217 at the charge station.

The stencil electrode or character mask 216 is journaled about a pair of pulleys, here represented by centerline 218. Drive to one of the pulleys is provided over belt 220 from motor 221 when this motor is energized.
over conductors 222, 223. A lamp 224 is positioned on one side of tape mask 216 to pass radiation through a series of timing apertures 225, spaced in aligment with the charged areas of the timing disc 227 of the tape mask, and this light energy is received in a photocell 226. Timing signals are thus provided by photocell 226 for use in control circuit 214 to gate on the discharge heads 215 at the appropriate times. Each time a font index aperture 228 in the mask 216 passes between lamp 224 and photocell 230, a reset or font index signal is provided to control unit 214.

An anvil position sensing switch 231 is provided above anvil 217 so that, as the anvil is displaced to the loading position as depicted in broken lines, switch arm 232 passes downwardly and an "anvil open" signal appears on conductors 233, 234. The charged web 120 passes upwardly and around a freely journaled guide shaft 235, which has a plurality of teeth 236 spaced apart by angular distances related to the linear distances between apertures in the edge portions of the paper web. One of these shafts 235 is driven at each side of the paper web to sense the rate of displacement of each web margin. A timing disc 237 is affixed to the shaft 235 for simultaneous rotation therewith as a function of paper speed. A lamp 238 is disposed to pass light through an outer array of apertures near the edge of a pinwheel 239 and an inner array of apertures closer to the center of the timing disc. The light passing through the outer array of apertures strikes photocell 240 to provide a first set of timing signals, and the light passing through the inner array of apertures strikes photocell 241 to provide another set of timing signals at a different frequency than that provided by photocell 240 for the same rate of web displacement. These timing signals are utilized in control unit 214, for providing stop and go signals to the respective brake assemblies 263 at each margin of the paper web, and similar signals to the drive assemblies 242, one of which is disposed adjacent each edge portion of the web. Each drive assembly includes a continuously driven capstan roller 243 on one side of the paper web 120, and a pinch roller 244 on the other side of the web for displacement against the paper and the capstan roller responsive to energization of clutch 245 over conductors 246, 247.

A slack web indicating switch 248 is positioned between the timing discs 237 and the control drive assemblies 242 so that, if the web breaks or becomes unduly slack, switch arm 250 will be rotated in a counterclockwise direction to provide a slack signal over conductors 251, 252. The web then passes around the right and over curved guide members 253 to drop downwardly and from the second buffer loop 254, which is positioned between print station 290 and inker station 300. Just below the second buffer loop is a full-loop sensing unit including a lamp 255 and a photocell 256; at an intermediate position another lamp 257 and an associated photocell 258 are provided, and at the top of the buffer loop a third lamp 260 is disposed opposite a corresponding photocell 261. In the position shown, the paper advance unit including the drive assemblies 242 at either edge margin of the paper in the paper station can be energized to pass paper into this buffer loop. However, as the loop continues to drop downwardly and eventually block the light passing from lamp 255 to photocell 256, this photocell is turned off and the print station paper advance unit is inhibited. When the paper is drawn through the inker station to diminish the amount of paper in buffer loop 254, as the level of the loop decreases light from passes from lamp 260 to provide an "on" signal from photocell 261, which inhibits the drive system at the fixes station 400. The fixer drive provides the force for pulling the web through the inker station. When the loop 254 increases in length so that light from lamp 257 is cut off from photocell 258 the drive at the fixer station is turned off, pulling the web through the inker station.

**Inker station**

As shown in FIGURE 6, the charged web enters inker station 390 and passes upwardly around a guide roller 391. Anvil 396 in the inker is shown in the operating position so that the web 120 must pass downwardly to the right and enter a mass 307 of conductive, opaque particles contained in housing 399, some of which are attracted to the selectively charged portions of the web. The web passes upwardly past a series of chevrons or air deflectors 398 and makes a sharp turn to the left, then passing upwardly to the fixer station 400.

It is noted there are no seals within the inker housing itself but that the paper web passes directly downward under anvil 396, up through the mass of particles 307 in container 399, and adjacent to the air deflectors 398, which serve to create air currents that return any stray particles caught in the air stream to the mass 307. The sharp turn before the web leaves the inker also causes additional stray particles to fall off, and still other background particles to be drawn off by the sniffer 312 through the input port 313.

A Solenoid 303 opens valve 366 when the system is energized, responsive to receipt of an energizing signal over conductors 304, 305. The upper output conduit 317 of cyclone 316 is coupled through a filter 321 to a pump 322 which has an output side exhausting to the atmosphere. The pump can be energized over conductors 323, 324 when the system is energized.

Another pump 325 is connected for energization over its input conductors 326, 327, to displace air from the left as shown in the drawing through conduit 328 and to one input connection 330 of a Venturi fitting 331, which includes another input connection 332 for pulling conductive, opaque particles from the inker reservoir 333 downwardly through the Venturi fitting as air under pressure is supplied by pump 325. Thus, an air stream containing ink particles passes through the output connection 334 of the Venturi fitting and through conduit 335 to the tangential input connection 336 of another cyclone separator 337, which includes an upper discharge port 338 and a lower discharge opening 339. In that a filter 344 is applied to conduit 341, the filter 346, 347 to the back pressure side of pump 327. The desired size ink particles and the larger-than-desired-size particles fall through opening 349 of the separator 337 downwardly into another separator unit 347, which may be of the vibrator type having a mesh screen 348 for letting the desired size particles pass downwardly through the mesh screen, through conduit 350 and entrance channel 351 into the inker housing. The ink particles fall downwardly into mass 307 of the conductive particles. Any excess ink provided through this route is dumped immediately through the overflow channel 352 downwardly into the lower portion 333 of the inker housing. Because of its flow characteristics, the ink mass assumes the position shown, and no ink flows over lip 370 down into housing 333. The mass 307 of ink particles is thus maintained at a constant level.

Energization of motor 353 over conductors 354, 355 is effective to vibrate separator 347 and draw out the larger-than-desired-size particles through the output port 356 for collection in any suitable receptacle (not shown). An interlock switch 357 is provided with an actuator portion 358 that abuts part of the anvil 396. Thus when the anvil is open to load the system, switch 357 provides an "anvil open" signal over conductors 360, 361 indicating that the inker station anvil 396 is open and the system is not.
ready for operation. A "low ink" detector 362 is also provided in the bottom of housing 333 to pass a suitable signal over conductors 363, 364 to an associated indicator light or alarm bell 365, or both, when the ink in housing 333 falls below a safe level. The sensing unit 362 may simply be a pair of spaced-apart electrodes, in that the resistivity of the electrodes changes when the ink or powder drops below the level of these electrodes.

**Fixer station**

Considering FIGURE 7, as the inked web 120 is drawn upwardly from the roller, it passes toward the first fixer roller 401 which is journaled on a shaft 402. A clutch 406 is provided between to pass energy from motor 208 (FIGURE 8) to shaft 402 responsive to receipt of a control signal over conductor 408. The upper fixer roller 410 is journaled on a shaft 411 which extends between a pair of pivotally-mounted shaft support members 412. The support members 412 are in their turn supported from a spring-loaded shaft 413, mounted within a U-shaped recess 414 of the wall, so that under the urging of bias spring 415 roller 410 is displaced downwardly against the first roller 401 to insure good contact across the width of the web. The upper roller 410 and its support plates 412 can be displaced against the urging of spring 415 to the position indicated in broken lines to facilitate insertion of the web 120 when the system is loaded.

Instead of providing two steel or hard metal rollers 401, 410, such as conventionally been utilized in strip printers, the preferred construction for rollers 401, 410 includes an elastomer surface on one of these rolls. The elastomer surface may be of butadene, neoprene, or a similar material. With two hard-surfaced rollers, if only one or two columns of the web are inked before passing through the pressure fixer 406, the entire compressive force between the rollers is transmitted over the relatively minute area on which the ink particles have been deposited. Accordingly, there is a considerable variation in the fixation pressure between the condition when only one or two inked columns are being fixed, and the condition where 160 columns are being fixed. A switch assembly 416 is positioned so that, when the upper roller 410 is displaced to the load position, a suitable signal is provided over output conductors 417, 418 to denote that the pressure-fixing rolls are open.

After the fixed web passes from the pressure fixing rolls it passes to the right and falls downwardly over a guide plate 420 into a third buffer loop 421. The bottom of the loop is shown blocking light from lamp 422 from reaching photocell 423, and another lamp-photocell pair 424, 425 is disposed near the center portion of buffer loop 421. In the position shown, with photocell 423 off the clutch 406 is not energized and there is no additional paper web passed from the pressure fixing rolls into the buffer loop 421. When the loop reaches a minimum condition and light passes from lamp 424 to turn on photocell 425, an inhibit signal is furnished to the next station (chopper station 500) to prevent paper from being pulled from buffer loop 421 into the chopper station until additional slack is provided in the buffer loop.

**Chopper station**

FIGURE 8 depicts the chopper station 500 which receives the inked, fixed web 120 from the pressure fixer station 400, and the web enters the station as it passes over edge roller 502. The paper approaches a first tractor or paper displacement assembly 503 which is shown as two spaced-apart sprocket wheels 504, 505 for driving an endless chain 506 on which a plurality of teeth 507 are carried. The teeth 507 are spaced apart at linear intervals corresponding to the center-to-center distance between apertures along the marginal portions of web 120. Accordingly, two assemblies 503 are provided, one to effect displacement of each marginal web portion. Drive to the paper tractors is provided from a drive system motor 508, shown for selective coupling over clutch 510 to a sprocket wheel 505 of the tractor 503.

A pair of mark sensing assemblies are depicted just to the right of the tractor 503. A first lamp 511 is positioned so that an associated photocell 512 senses the level of light reflected from the web 120, to provide a signal denoting a change in the level of the light reflected from the area in which the "form length" mark is imprinted, to signify where the continuous web should be chopped. The second assembly comprises another lamp 513 for directing radiation toward the web, the reflected level of which is sensed by corresponding photocell 514 to provide a "print" signal when the print mark appears on the web, denoting that information has been placed on the web portion about to pass to the guillotine or chopper assembly 515. The chopper assembly includes a stationary blade 516 and an upper, movable blade 517 disposed for relative displacement in a raking action to precisely and rapidly sever the web when the upper blade 517 is displaced downwardly. Blade 517 is shown coupled to a cam assembly 518, which is driven from a clutch 520, coupled between cam 518 and drive motor 508. "Chop" control 501 is provided on clutch 520 to enable the chopper apparatus including blades 516, 517 wherever the web is to be separated into sheets. Each time clutch 520 is energized in response to a "chop" signal the cam 518 is driven through one complete cycle or 360 degrees of rotation, driving blade 517 downwardly through the first half cycle and this blade is returned under the urging of bias springs (not shown) during the latter half cycle of cam displacement. The outer periphery of cam 518 defines an aperture or wedge-shaped cut 521 which, after the first 180 degrees of cam rotation, allows light from lamp 522 to pass through the aperture and impinge on the associated photocell 523 to provide a signal indicating the blade is in the down position and the chop has been completed. When the complete cycle is finished and blade 517 has returned to its upper position, the aperture 521 is in the position indicated and light will pass from lamp 524 through aperture 521 and strike photocell 525 to provide a "cycle completed" signal for the associated equipment.

Another paper tractor assembly 526 is shown to the right of the knife assembly 515, and assembly 526 includes first and second sprocket wheels 527, 528 on which endless drive belt 530 is supported. A plurality of teeth 531 are provided around belt 530 in a spacing related to the spacing of the apertures in the edge portions of the web 120. Tractor 526 of course comprises two different assemblies, one at each edge portion of the web, and responsive to selective energization of clutch 532, drive is provided from motor 508 to each of these assemblies to effect the displacement of web 120 to the right.

**Solvent applying station**

In FIGURE 9 the solvent applying station 600, one of the transfer stations 700, and the master sheet stacker 800 are depicted. The solvent applying station shown in their left-hand portion of the drawing will be described first.

Web 120 is displaced to the right as drive roller 601 is displaced in a counterclockwise direction to correspondingly displace main roller chain 602. Although not depicted in the drawing, the roller chain includes sprocket pins spaced apart to engage the apertures in the peripheries of the web 120 and thus effect positive displacement of the cut web through the remainder of the system. When the web is not cut, a web rewind unit or fan-fold take-up unit replaces the transfer stations. A disc 603 is provided and attached to drive roller 601. The disc is apertured to provide a series of spaced-apart apertures...
604 near its center and another series of apertures 605 nearer its periphery. The one aperture 605 which is visible is in registration, in an angular sense, with one of inner apertures 604. The spacing of apertures 604 is such that light from lamp 606 passes through these apertures and is sensed by photocell 607 to provide timing or clock pulse signals related in time to each passage of one-half inch when the paper web 120. The spacing of each outer aperture 605 is such that light passes from lamp 608 through aperture 605 for receipt in photocell 610 responsive to each passage of a 15 inch segment of the web 120. It is noted that this timing apparatus is not required for the solvent application but it is physically not positioned in the same location as is the mechanism for applying the solvent. The main drive roller 601 and the solvent-applying roller 611 are in fact driven from the same drive motor 586 utilized to drive the paper tractors and knife in the chopper station and the frizer roller in the fixer station. As the web is displaced to the right it passes under the two small guide rollers 612, 613 and over the main solvent-applying roller 611. Solvent is applied from a container 614, being drawn through conduit 615 as pump 616 is energized over conduits 617 and 618 when the system is energized. The pump places solvent upwardly through conduit 625 to an arcuate doctor blade 626 which is apertured to define a channel and pass the solvent from the conduit 625 to the surface of application roller 611. The curved doctor blade is supported at the upper end of arm 627, the lower end of which is pivotedly mounted to a bracket 628 affixed to the wall of container 614. Bias spring 630 coupled between arm 627 and the wall of container 614, maintains a very slight pressure on the edge of the doctor blade 626, which almost contacts roller 611. Thus only a thin, uniform solvent layer is applied to roller 611 for transfer to the master web, to loosen or soften the previously fixed particles. The excess solvent scraped off by doctor blade 626 falls downwardly, cleaning the surface of roller 611 and thereafter dropping into the reservoir.

In general, the ink or conductive particles contain hydrocarbons which are soluble in a class of solvents such as odorless mineral spirits, a chlorinated hydrocarbon, such as trichlroethylene, or aromatic solvents such as toluol or xylene. All of the above solvents are commercially available and can be utilized in the reservoir 614 for application over the series of rollers 616, 617 and 611 to slurry or muddy the particles affixed to the web 120 for subsequent copying. After the solvent has been applied to soften the particles the wetted web 130 passes to the right over roller 630, downwardly around roller 621 and upwardly over roller 622 and to the right toward the first transfer station. The spacing of rollers 620–622 is such as to insure the heated solvent has sufficient time to loosen the particles on the web when copying is to be effected at the first (and any subsequent) transfer stations. Other components at the solvent-applying station include a guide roller 623 for the main drive chain 602, and an indenting lamp 624.

Transfer station

As shown in the central portion of FIGURE 9, the wetted master 120 passes to the right from roller 622 and is carried by the main drive chain 602 beneath a rubber covered impression roll 701 at transfer station 707. Pressure roller 701 is coupled to a cam 702, which is disposed to actuate hydraulic valve 703 at the appropriate time. In turn the cam 702 is mechanically coupled, as indicated by the broken line, to a clover interlock 704, positioned between copy roll actuator 705 and a hydraulic cylinder clutch actuator 706. The various components are actuated with fluid under pressure received over a high-pressure manifold line 707 and returned over the drain manifold line 708. The "copy" control 747 includes a valve 745 which passes the fluid into the high-pressure line 707. Responsive to operation of hydraulic valve 703 by movement of cam 702, and operation of solenoid operated valve 710 by a control signal received over line 711, the hydraulic cylinder 712 is energized to displace the mounting bracket assembly 713 upwardly against the urging of bias springs 714, 715 and move the free-turning transfer roll 28 to position the copy paper 717 against the solvent-wetted web 120. The copy paper 717 is fed from the supply tank 718 by means of tractor assembly 705. While the copy paper is shown in fan-fold form, and is accumulated after the copying process in a fan-fold pile 720, those skilled in the art will appreciate that a roll or continuous web supply can also be provided. A switch assembly 721 includes a spring-biased arm 722 disposed to pass through an aperture (not shown) in the support plate for paper 718 and provide a signal over conductors 723, 724 when the supply of copy paper 718 is exhausted. Of course if the copy paper were supplied in roll form, switch arrangement 721 would also be replaced by an arrangement similar to that of low roll sensing switch 116, at the paper feed station 106 (FIGURE 4).

A tension brush 725 is provided to ride lightly on the copy paper 717 as it passes over a guide roller 726, and another switch assembly 727 is provided so that when the tension brush 725 is actuated if the tension brush 725 engages arm 728. Thus if the web is broken at this point a suitable signal is provided over conductors 730, 731. Another switch 732 provides a similar signal if the reproduced web is broken, as stated arm 733 is displaced to the right and the appropriate signal is passed over conductors 734, 735.

The paper tractor assembly 735 is similar to those previously described in connection with the chopper stations. The upper disc 736 of this assembly defines a plurality of spaced-apart apertures 737 and a lamp 738 is positioned so that light from the lamp passes through the series of apertures and is received in photocell 740 to provide a series of timing signals related to the extent of movement of the tractor assembly 705, and thus related to the extent of linear displacement of the copy paper 717 at the first transfer station. A pair of signal or alarm lights 741, 742 are positioned in the upper portion of the first transfer station. Those skilled in the art will appreciate that, inasmuch as each of the five additional transfer stations is identical to that shown and described in connection with FIGURE 9, no explanation of the other stations is necessary. Further, by selecting timing signals from the conductors such as 711 in FIGURE 9, the successive transfer stations can be sequentially operated to provide one, two, or more copies of the information on the reversed master sheet 120. If no copies are desired the information is printed in usable form, the "copy" control is not actuated, none of the transfer stations is energized and the web passes to the right for collection in the master sheet stacker 800.

Master sheet stacker

As shown in the right-hand portion of FIGURE 9, when the web is cut into individual sheets the master sheets are passed to the right and deflected by guide plate 801 to fall downwardly onto the stack support 802. A combined edge catcher and level sensing arrangement 803 is provided, and includes a longer arm 804 to which a suitable stop arrangement 805 is affixed to halt the master sheet. The shorter arm 806 of assembly 803 is positioned to engage actuator arm 807. When the stack of master sheets reaches apredetermined height and provide a suitable output signal over conductors 810, 811 for operating drive motor 812. As it is energized motor 812 effects the rotation of shaft 813 and thus the displacement of the drive chain, as shown in FIGURE 10, at its upper end over shaft 815. Chain 814 is affixed to the left-hand portion of stack support 802, and the platform
is driven downwardly; sensing and paper catching assembly 803 is rotated in the clockwise direction until the signal is removed from conductors 810, 811 to deenergize motor 812.

As it is displaced downwardly, the support platform 802 carries a switch actuator arm 816 and initially this arm engages the movable actuator arm 817 of an "almost full" sensing switch 818 to provide such a signal over the output conductors 820, 821. When the platform is displaced further to the bottom position, actuator arm 822 of the "full down" switch 823 is actuated to provide a signal over conductors 824, 825 to light an alarm lamp and ring a bell indicating to the operator that the master stacker is full.

Control panel

The control panel shown generally in FIGURE 1 is indicated in more detail in FIGURE 10. As there shown, a form length switch 900 and a series of illuminated control buttons 901 are visible on the upper portion of the panel. Form length switch 900 can be actuated to regulate the length of the web to be severed at the chopper stations. Of the various control buttons 901, the power button 903 is initially actuated to pass energy to the various electrically energized components and power supplies of the system. The load button 904 is utilized when the paper web is initially threaded through the system and after the paper printer is completely loaded, the ready button 905 is actuated to energize the interlocks and other control components to prepare the complete system for operation. One of the two buttons, off-line button 906 or on-line button 907, is actuated to determine whether the information to be printed will be received from associated equipment such as a computer, teletype circuit, or other information transmitting means (in the on-line condition), or whether the information to be printed on web 120 will be generated internally (in the off-line mode). The clear button 908 can be depressed to energize the various drive actuators of the system and drive an amount of paper web, of a length corresponding to that length of the web which generally extends from the print heads at print station 200 to the master sheet stacker 800, through the system.

The controls just described are the only ones readily visible on control panel 21. The vertical array of trouble indicators at the left-hand side of panel 21 is not visible unless a lamp is lighted behind one of the windows. The diagnostic panel includes an error indicator 910; a low web indicator 911; low ink indicator 912; a low hydraulic pressure indicator 913; a broken web indicator 914; a broken form indicator 915; a web splice indicator 916; an open anvil indicator 917; an open cover indicator 918; a cut feed failure indicator 919; and a full stack indicator 920.

The remainder of control panel 21 is a test panel 921, hidden behind a small door which is not shown in the drawing the better to indicate the various controls. The test panel 921 can be utilized with the system in the off-line condition to effect test printing and confirm the operability and accuracy of the equipment. With switch 906 actuated, the on-off switch 922 on the test print panel is displaced to the "on" position and the mode switch 923 is displaced to one of its five positions. In the first position the test operation is manual and any character can be inserted by operation of the eight character-selection switches 924. That is, by displacing any of these switches to the up position a mark is provided at one of the parallel input connections and by displacing the toggle-actuated switch to the lower position a space is provided. In the manual position, after each character selection by manipulation of the appropriate ones of switches 924, start button 925 is pushed to load the selected character into the printer.

No further explanation will be given as to operation of the test equipment in the other positions of mode switch 923, or the use of the tape format switches. It is sufficient to note that the novel electrostatic printing system of the invention includes its own equipment for testing the system to determine operability and accuracy of the system.

Reverse printing control

FIGURE 11 depicts one arrangement enabling the reverse print control 202 to regulate whether the latent image is disposed in the right-side-up or in a reverse pattern. As there shown the tape mask 216 is modified to include an extra set of character-forming apertures 260, reversed with respect to the regular apertures 227. Anvil 217 has been lengthened to provide for alignment of the paper web not only opposite the first charge head 215 but also opposite the second charge head 261, shown as proposed to receive firing or charge signals over cable 262 from control unit 214 when switch 202 is in the "reverse print" position. With switch 202 in the "normal" position, signals are passed over cable 263 to energize charge head 215 when the appropriate one of apertures 227 is between the discharge head and anvil 217. It is of course possible to eliminate the reverse print control, the additional series of apertures and the extra charge head, to provide a system with only right-side-up printing or only reverse printing on the web, but the illustrated arrangement provides for considerable more flexibility in the electrostatic printing system.

Preparing system for operation

Assuming that the system is to be loaded with paper and energized for the first time, the insertion of the paper can be done with the power switch 903 in the off position, or if the power switch is actuated load button 904 is also pushed to disable certain interlocks during the loading of the dielectric web.

Referring to FIGURE 4, a master roll 101 of paper is inserted on the shaft 102. If fan-fold paper is used, it is simply placed on the bottom of the cabinet and threaded upwardly between the rolls 124, 125. Thus for purposes of the present explanation and the appended claims rollers 124, 125 together comprise a means for accepting a continuous web and passing this web toward the subsequent stations in the system. Had a roll of paper already been printed, the new roll would be inserted on shaft 102 and spliced, utilizing splicing table 122, to the trailing edge of the previous web in a manner explained previously.

Because of the other components shown adjacent the pinch roller 125, the simple latching mechanism which permits this roller to be displaced away from the other roller 124 to the open position has been omitted from the drawing. Such a mechanism is provided, however, to permit the operator to separate the rolls, pull off the end of web 120 from the roll, and pull the end of the web through the open space between capstan roller 124 and pinch roller 125.

The operator next swings the anvil 217 at the print station 200 (FIGURE 5) outwardly to the position depicted in broken lines, and pulls the leading edge of the web up to a position between the mask electrode 216 and the opened anvil 217 (the anvil is left in the open position). Approximately three to four feet of the paper web is pulled off at this time to bring the leading edge of the web up to the mask 216 at print station 200.

The operator then swings inker anvil 306 (FIGURE 6) to the retracted position as indicated by the dash-dot lines, and opens the fixer rollers by displacing roller 410 (FIGURE 7) to its retracted or open position against the urging of bias spring 415. The leading edge of the paper is then pulled upwardly over guide roller 301 and led between the inker anvil 306 and the portion of the inker housing. From there the web is pulled upwardly and inserted between the fixer rollers 401, 410, pulled over guide rollers 502 at the chamber station 500 (FIGURE 8) and the leading edge of the web is placed on paper tractor 503. An alignment mark (not shown) is provided on the tractor assembly to enable the oper-
ator to properly position the leading edge of the web.

Working backwardly, the operator closes upper pressure roll 410; closes inker anvil 308; places the edges of the web between the pinch roller 244 and capstan roller 243 at each side of the paper in the print station; engages the marginal apertures of the web with the teeth 335 on each of the left and right timing discs 237; pulls the paper web taut between the rollers 243, 244 and the timing discs 237; closes anvil 217 at the print station; places the left and right margins of the web between the portions of the left and right brake assemblies 203; and pulls the paper web taut between anvil 217 and the brake assemblies 203, letting the web hang down to begin to form the first buffer loop 144 at the paper feed station. The pinch roller 124 is then returned to its normal operating position at the print station, and the operator closes the access door through which the paper roll 101 is inserted; this door would be the left side of cabinet 20 as viewed in FIGURE 1. When copies are to be made, the operator also places copy paper which may be a stack of fanfold, margin punched paper, on each of the shelves 27 of the respective transfer stations. The leading edge of the copy paper would be threaded upwardly over paper tractor 705 (FIGURE 9), over transfer roller 225, downwardly along the other side of tractor 705, through the slot in shelf 27, and back to the lower shelf in cabinet 23B. With the master paper and copy paper in the machine a visual check is made to be sure that support platform 802 in the master stacker station 800 is not in the full down position, that there is solvent in reservoir 614, and that there is ink in the inker housing 335.

Although the system has been loaded, it may be that not all, or even none, of the three buffer loops 144, 225, and 421 are formed. After the loading operation the various interlocks including the switches which sense the open and close conditions at the print station and inker, as well as the open pressure roller condition in the pressure fixer and open pinch roller condition at the paper feed station, are all in a go condition. The "thread" switch on the side access door of cabinet 20 is pushed, sending a signal from the logic circuitry in cabinet 22 over conductor 132 to energize clutch 127, and motor drives roller 124 to haul off the paper web 120 from the master roll and initiate the threading operation. When the first buffer loop 144 is formed, as signaled by interruption of light from lamp 145 striking photocell 146, this signal is removed from conductor 132. If there already were sufficient slack to completely form loop 144, clutch 132 would not be energized and there would be no hauling off from the master roll at this time.

Responsive to an indication from photocell 146 that buffer loop 144 is full, the circuitry in cabinet 22 provides a slow (drive continuously) signal to the pinch roller solenoids 245 at the print station, which causes paper to be pulled from the paper feed station 100 through the print station 200 until the second buffer loop 225 is formed. Of course, the amount of web in the first buffer loop is diminished and signals are passed over conductor 132 to energize clutch 127 and haul off additional paper from roll 101 to fill both the first and second buffer loops.

After the first two buffer loops are full, the logic circuitry provides a signal over conductor 408 to energize clutch 406 and drive the pressure roller 401 at the fixer station to form the third buffer loop 421. During this time, the inker motor solenoids 245 are actuated, and clutch 127 at the paper feed station is actuated, to maintain the first and second buffer loops full as the third buffer loop is being completed. After the third buffer loop 144, 225, and 421 are full, the logic circuitry passes a signal to the tractor assembly 583 which causes this paper passing the knife assembly, which amount is determined by the setting of form length control 900 on the control panel 21. Chopper assembly 515 operates and cuts the web to provide the first page, tractor 526 being energized to pass the first chopped sheet toward the solvent applying station 600 and transfer station 700. However, the web has not been selectively charged with information, and thus no corresponding print mark was provided by print head 210 for subsequent inking in the inker station. This absence of a print mark is sensed by photocell 514 which passes a signal to the logic circuitry to assure that the transfer rollers at the transfer stations are not displaced upwardly; thus there is no copying process when there is no print mark on the web. This operation continues with the chopped sheets being passed to the output master or master stacker. Circuitry is provided for automatically sensing the position of the form length mark relative to the point at which the page is actually chopped and effecting an automatic correction so that the actual page length conforms precisely with that dictated by the setting of form length control 900. The specific details of this arrangement are not necessary to a full understanding of the present invention and it is sufficient to note that such a correction is effected. After all the buffer loops have been filled and the output side of the system has produced the sheets of the appropriate length, the thread indicator light 352 is illuminated to indicate to the operator that the system is ready for operation.

**System operation**

With the system in the ready state, as soon as information-denoting character signals are received over conductor 201 of the print station 200, the electrostatic printing system operates and the information denoted by the received signals is printed on the web. At the paper feed station 100 paper is hauled off roll 101 by the driving of roller 124. The first buffer loop 144 is filled and the web is fed to the brake assembly 216 at the print station. The received signals regulate the selective discharge of the electrodes in charge head 215 at appropriate times as regulated by the timing signals received by photocells 226, 230 as the timing apertures 225 and the reset aperture 228 pass adjacent these photocells. As explained in connection with FIGURE 11, a reverse print control 202 can be provided to regulate whether the latent images denoted by the charged web areas will be light side up or in mirror image form. Assuming that copying is to be effected either switch 202 must be placed in the reverse print position, or if a tape mask is used (FIGURE 3) with only a single character-forming aperture is used, then the mask apertures must be oriented to deposit the latent image in the reversed form. It is noted that the same print station can be utilized to print right side up and reverse image patterns without any switch such as 202 by removing a tape mask such as 216 shown in FIGURE 5 and replacing it with a mask identical in all respects except for the reversal of apertures 227.

The charged web passes up around shafts 235, so that the energized ones of photocells 240, 241 provide appropriate timing signals for the print station drive system. The charged web passes over slack web indicating switch 248 between rollers 243, 244 and drops down over guide member 253 to form the second buffer loop 254. The charged web is drawn into the inker station 300 over guide roller 301, passing around anvil 306 and through the mass of conductive particles 307 retained in housing 369. Accordingly, particles adhere to the charged web and render the image temporarily visible.

The temporarily inked web is drawn from the sniffer assembly between pressure-fixing rollers 401, 410 which apply appropriate pressure to imbed the particles in the surface of web 120, providing a fixed record of the information input signals but not in a recorded form. The fixed web then passes over guide plate 420 downwardly into the third buffer loop 421, and upwardly around roller 502 into the chopper station 500.

When energized tractor 503 displaces the web to the
right between blades 516, 517 of the knife assembly 515. When a chopped sheet output is indicated by the position of switch 501, the upper blade 517 is energized at the appropriate time to chop the web and tractor 526 is energized to pull the chopped sheet to the right and enter the solvent-applying station in cabinet 23A. The wetted master sheet is transported over rollers 620 downwardly, over roller 621 and back up over roller 522 to the first transfer station 700. Operation of the individual transfer stations is controlled from the timing pulses provided by photodetectors 607, 610 adjacent to the main drive roller 601. These timing signals are utilized to energize the main cylinder 31 of the transfer station and drive the free-turning transfer roller 28 upwardly to place copy paper 717 against master web 120, the other side of which is bearing against impression roller 701. Tractor 705 is also energized in the appropriately timed relation to supply a length of copy paper 717 over roller 28 exactly equal to the length of the chopped master sheet. Accordingly, from the reversed image on the master sheet an accurate and true copy in right-side-up presentation is visible on the copy paper 717.

Similar actions occur at each of the other transfer stations when they are energized, and the master sheet passes to the right onto platform 502. This platform gradually descends as explained previously during the copying operation as the master sheets are accumulated. This is the normal operation of the inventive system, and to complete the system description, operation of the alarm units and shut-down of the equipment will also be described.

Alarm signals

Certain of the monitoring equipment of the novel system provides indications of operating condition rather than an abnormality such as would require shut-down of the equipment. Usually, the various monitoring units are individually connected to illuminate an indicator lamp, such as one of the lamps between units 910-920 on the control panel 21, or one of the lamps such as 32-35 on cabinet 23. Simultaneously with the visible signal, an audible alarm such as a bell is sounded so that the operator's visual attention may be focused elsewhere at the moment, he will be signalled by the audible alarm that some part of the system may soon need attention.

For example, in the inker station 300 (FIGURE 6), when the level of the ink in reservoir 614 falls beneath that of solvent 615, control arrangement 365 operates to illuminate the lamp behind indicator panel 912 and at the same time the audible alarm is sounded. Similarly, if the main supply roll 101 (FIGURE 4) diminishes to a very low level, assembly 107 operates to activate switch 116 and provide over conductors 117, 118 a signal which is effective to illuminate diagnostic light 911 and sound the alarm bell. The error light on the diagnostic panel is lighted if an error is produced on the printed web, by equipment not described herein and not necessary to a complete understanding of the invention.

Means (not shown) is also provided to sense the level of solvent in reservoir 614 (FIGURE 9). This means is analogous to that utilized at the inker station. When the solvent level falls beneath a predetermined operating level, a signal is provided to illuminate lamp 32 on cabinet 23 and also to ring the alarm bell. If the supply of copy paper 710 at any transfer station reaches a low level, a signal may similarly be driven. This is effective to illuminate alarm 34 at the transfer station and at the same time the alarm bell is rung. When the master stacker is nearly full, switch 818 is activated and a signal over conductors 820, 821 is effective to illuminate lamp 826 and ring the alarm bell.

System shut-down

Should an unusual condition develop in the system, such as tearing of the master paper or breakage of the copy paper, it is desirable to shut-down the electrostatic printing system. Some faults are more serious in that some of the equipment could be damaged if the fault were not corrected immediately or if the equipment were not shut down immediately. Thus there are three different types of shut-down; an emergency stop to de-energize and halt the equipment as soon as possible; a quick stop in which the print station finishes printing the complete line before shut-down; and a sequential stop in which the last line is printed and shut-down is delayed to allow the last master sheet to pass through each of the transfer stations to the master stacker.

Considering first the quick stop condition, those skilled in the art will appreciate that in connection with the print station 200 and within the control unit 214 is a one-line buffer storage arrangement for storing a given line of information before printing on the web 120. When the quick stop condition is signalled this line of characters is printed out at the print station 200; the printer is then de-energized and the brakes 203 are energized, as well as brake 103 at the paper feed station; at the chopper station 500 a cut cycle is finished if one has been initiated by actuation of clutch 520, and the equipment goes to the load state automatically. This quick stop can be actuated by pressing one of the emergency stop buttons such as 827 over the master sheet stacker cabinet 268. This quick stop will also be initiated if one of the switches such as 727 at any transfer station senses a broken copy form, to avoid a situation where a master sheet will pass through the transfer stations and to the requisite number of copies will not be provided because one of the copy forms is broken.

The emergency stop is a modified sequential shut-down and is effected whenever a faulty web or copy web is detected by operation of switch 138, or when a broken master web is sensed, as for example by operation of switch 248. A larger-than-desired splice could pass from the paper feed station into the narrow area between the tape mask 216 and the anvil 217 at the print station, and be jammed in this space so that the master paper would bunch up in the print station. Similar bunching may occur if the web is broken elsewhere. Accordingingly, in the event that either of these two conditions is sensed, the system is immediately shut down without even clearing out the remaining information stored in the one-line buffer within unit 214, or completion of a line advance instruction.

The sequential stop is similar to the quick stop as respects finishing the one line of printing which has been stored in the one-line buffer, the deenergization of the printer station and application of the brakes, and the finishing of a cut cycle which has already been initiated. However, in the sequential stop operation the equipment delays for eight seconds before going back to the load state automatically, to provide sufficient time for any printed master record to pass through each of the transfer stations. Thus, all the copies requested would be made in a sequential shut-down. This sequential or delayed shut-down, is initiated responsive to opening of any door of the equipment cabinets; the burning out of any trouble or indicator lamp; the accumulation of excess web in any of the three buffer loops; failure of the knife assembly to operate and cut the web as directed (this condition also requires a manual reset at paper tractor 503); a failure to feed copy paper at any transfer station where copying has been ordered; low hydraulic pressure to the transfer station actuation of switch 823 indicating the master stacker is in full down position; a failure of any power supply; and an opening of the anvil at the print or inker station, opening of pinch roller 125 at the paper feed station, or of pressure roller 410 at the fixer station. All of these conditions will initiate the measured or sequential shut-down of the complete system, returning it to the load condition.

System with wet inker

In FIGURE 12 another embodiment of the inventive system is shown. In the arrangement illustrated a "wet
The electrostatic image is now known. Briefly, the wet ink 6 is contained in a row of conductive electrode members, with pointed end portions just above the web surface.

The embodiment of the invention. Summary

The present invention provides a high-speed, accurate and economical electrostatic printer which can produce accurate copies of the input information. Following the teachings of the invention, more or less copies can be provided by adding or subtracting modular transfer station units such as those within cabinets 24 and 25. The various stations from the input or paper feed station through the output, whether in continuous web from the station or in sheet form from the hopper station, are all housed within a single main cabinet. This versatile system will accept the input web in either roll or fan-fold form and provide an output in either roll, fan-fold, or a chocked-sheet format. This arrangement contributes substantially to the high performance as respects operating speed, character selection, and the start-stop control arrangement either under the regulation of the operator or automatically in response to the detection of some aberration in the system function.

The system prints wholly formed characters at the print station and, with the solvent applying and transfer stations of the invention, provides a non-impact, non-contact printing unit which produces copies in on-line operation. No special paper is required for copying at any of the transfer stations. With the hopper station energized by a simple control switch, the copy control switch can also be actuated to effect copying from the master sheet when the input information signals are printed in reverse. With this system, the rate at which information can be visibly reproduced from a computer, reader, or similar high-speed equipment is substantially enhanced. While only particular embodiments of the invention have been described and illustrated, it is apparent that various modifications and alterations may be made therein. It is therefore the intention in the appended claims to cover all such modifications and alterations as may fall within the true spirit and scope of the invention.

I claim:

1. An electrostatic printing system for providing a visible record of input character-denoting signals, comprising:
   - input means for accepting a master dielectric web;
   - selective charging means, positioned to receive the master web from the input means, including a mask electrode defining a series of character-forming apertures and means for providing a cloud of electrically charged particles for passage through the character-forming apertures to charge the master web in a pattern representing the characters denoted by the input information signals;
   - auxiliary charging means for producing additional charged particles to charge the web in a pattern conforming with a reference mark to signify the desired length of a web segment;
   - means for developing the latent image provided by the selective charging means to provide a permanent record of the characters represented by the input character-denoting signals, and for developing the pattern of the reference mark;
   - output means for collecting the master dielectric web;
   - means for properly positioning the developed print means, including a hopper blade control means for enabling the hopper blade means to drive the hopper blade, and means for sensing a reference mark on the web to produce a mark-indicating signal and utilizing the signal in regulating operation of the hopper means, thus to chop the master web into segments of desired length;
   - copying means, positioned between the hopper means and the output means, for removing at least some of the particles previously applied to the master web and providing a copy of the master pattern on a separate sheet.

2. An electrostatic printing system for providing a visible record of input character-denoting signals, comprising:
   - input means for accepting a master dielectric web;
   - selective charging means, positioned to receive the master web from the input means, including a mask electrode defining a series of character-forming apertures and means for providing a cloud of electrically charged particles for passage through the character-forming apertures to charge the master web in a pattern conforming with a reference mark to signify the desired length of the web segment and a second head for producing additional charged particles to charge the web in a pattern conforming with a second reference mark to signify that information has been represented on the web by the selective charging means;
   - means for developing the latent image provided by the selective charging means to provide a permanent mirror image record of the characters represented by the input character-denoting signals, and for developing the patterns of said first and second reference marks;
   - output means for collecting the master dielectric web with the mirror image record thereon;
   - hopper means, disposed between the developing means and the output means, comprising a hopper blade and control means for selectively energizing the hopper blade, first mark-detecting means for detecting the presence and absence of said first reference mark, and second mark-detecting means for detecting the presence and absence of said second reference mark, thus to regulate operation of the hopper blade only when information has been placed on the web and in accordance with the desired web segment length; and
   - copying means, positioned between the hopper means and the output means, for removing at least some of the particles previously applied to the master web and providing a right-side-up copy of the master pattern on a separate sheet.

3. An electrostatic printing system comprising:
   - input means for accepting a dielectric web;
   - selective charging means, disposed to receive the web from the input means, including a stencil electrode defining character-forming apertures and means for providing a cloud of electrically charged particles for passage through the character-forming apertures to charge the master web in a pattern representing the characters denoted by the input information signals;
   - auxiliary charging means for producing additional charged particles to charge the web in a pattern conforming with a reference mark to signify the desired length of a web segment;
   - means for developing the latent image provided by the selective charging means to provide a permanent record of the characters represented by the input character-denoting signals, and for developing the pattern of the reference mark;
   - output means for collecting the master dielectric web;
   - means for properly positioning the developed print means, including a hopper blade control means for enabling the hopper blade means to drive the hopper blade, and means for sensing a reference mark on the web to produce a mark-indicating signal and utilizing the signal in regulating operation of the hopper means, thus to chop the master web into segments of desired length; and
   - copying means, positioned between the hopper means and the output means, for removing at least some of the particles previously applied to the master web and providing a copy of the master pattern on a separate sheet.
cil electrode through which the particles are displaced; an inker housing for containing a mass of opaque particles; and means, including a hard metal covered roller and an elastomer covered roller, for both drawing the selectively charged web through the inker housing and for fixing the conductive particles in place on the dielectric web to provide a permanent record of the input information.

4. An electrostatic system for printing a record representing character-denoting input signals, comprising: input means for accepting a master dielectric web; means for selectively charging the master web in a pattern conforming with said input signals; auxiliary charging means for additionally charging the web in a pattern conforming with a reference mark to signify the desired length of a web segment; inker means for containing a mass of opaque particles which adhere to the charge pattern on said master web and to the pattern signifying the reference mark as the web is pulled through said inker means; inker means for both pulling the inked web through said inker means and for fixing the opaque particles in place on the master web; output means for receiving the master web from the inker means; chopper means, disposed between the inker means and the output means, including a chopper blade, control means for regulating actuation of the chopper blade and sensing means for detecting the presence and absence of said reference mark to assist in regulating actuation of said chopper blade, operable as energized to chop the master web into segments; and copying means, positioned between the chopper means and the output means, for loosening the particles previously fixed on the master web and providing a copy of the master pattern on a separate sheet.

5. An electrostatic system for printing a record representing character-denoting input signals, comprising: input means for accepting a master dielectric web; means for selectively charging the master web in a pattern conforming with said input signals; auxiliary charging means including a first head for additionally charging the web in a pattern conforming with a first reference mark to signify the desired length of the web segment and a second head for additionally charging the web in a pattern conforming with a second reference mark to signify that information has been represented on the web by the selective charging means; inker means for containing a mass of opaque particles; fixer means for both pulling the charged master web through the inker means and for fixing the opaque particles in place on the master web; output means for receiving the master web from the inker means; chopper means, disposed between the fixer means and the output means, including a first sensing means for determining the presence and absence of said first reference mark to assist in regulating operation of the chopper means and a second sensing means to determine the presence and absence of said second reference mark to assist in regulating operation of the chopper means, operable as energized to chop the master web into sheets; and copying means, positioned between the chopper means and the output means, for loosening the particles previously fixed on the master web and providing a plurality of copies of the master pattern on separate sheets.

6. An electrostatic system for printing a record representing character-denoting input signals, comprising: input means for accepting a master dielectric web; means for selectively charging the master web in a pattern, including control means for determining whether the pattern is an exact reproduction of, or the mirror image of, the character-denoting input signals; auxiliary charging means including a first head for additionally charging the web in a pattern conforming with a first reference mark to signify the desired length of a sheet and a second head for additionally charging the web in a pattern conforming with a second reference mark to signify that information has been represented on the web by the selective charging means; inker means for containing a mass of opaque particles; fixer means for both pulling the web through the inker means and for fixing the opaque particles in place on the dielectric web; output means for receiving the master web from the inker means; chopper means, disposed between the fixer means and the output means, including a first sensing means for determining the presence and absence of said first reference mark and second sensing means for determining the presence and absence of said second reference mark, operable as energized to chop the master web into sheets; and copying means, positioned between the chopper means and the output means, for loosening the particles previously fixed on the master web and providing a copy of the master pattern on a separate sheet.

7. An electrostatic system for printing a record representing character-denoting input signals, comprising: input means for accepting master dielectric web; means for selectively charging the master web in a pattern conforming with said input signals; auxiliary charging means including a first head for additionally charging the web in a pattern conforming with a first reference mark to signify the desired length of a sheet and a second head for additionally charging the web in a pattern conforming with a second reference mark to signify that information has been represented on the web by the selective charging means; inker means for containing a mass of opaque particles; fixer means for both pulling the charged master web through the inker means and for fixing the opaque particles in place on the master web; output means for receiving the master web from the inker means; chopper means, disposed between the fixer means and the output means, including a first sensing means for determining the position of said first reference mark to assist in regulating operation of the chopper means and a second sensing means to determine the presence and absence of said second reference mark to assist in regulating operation of the chopper means, operable as energized to chop the master web into sheets; and copying means, positioned between the chopper means and the output means, including control means for energizing the copying means to loosen the particles previously fixed on the master web and to provide a copy of the master pattern on a separate sheet.

8. An electrostatic system for printing a record representing character-denoting input signals, comprising: input means for accepting a master dielectric web; means for selectively charging the master web in a pattern which is the mirror image of that denoted by said input signals; auxiliary charging means including a first head for additionally charging the web in a pattern conforming with a first reference mark to signify the desired
length of a web sheet segment and a second head for
additionally charging the web in a pattern conforming
with a second reference mark to denote that infor-
mation has been represented on the web by the
selective charging means;
inker means for containing a mass of opaque particles;
fixer means for both pulling the web through said inker
means and for fixing the opaque particles in place
on the master dielectric web;
output means for receiving the master web from the
inker means;
chopper means, disposed between the fixer means and
the output means, including control means for ener-
gizing the chopper means to chop the master web
into sheets comprising a first sensing means for de-
termining the position of said first reference mark to
assist in regulating energization of the chopper means;
and a second sensing means to determine the presence
and absence of said second reference mark to assist
in regulating energization of the chopper means;
and
copying means positioned between the chopper means
and the output means, for loosening the particles
previously fixed on the master web and providing a
right-side-up copy on a separate sheet of the mirror
image pattern previously fixed on the master web.

9. An electrostatic system for printing a record repre-
senting character-denoting input signals, comprising:
input means for accepting a master dielectric web;
means for selectively charging the master web in a
pattern which is the mirror image of that denoted by
said input signals;
auxiliary charging means including a first head for addi-
tionally charging the web in a pattern conforming
with a first reference mark to signify the desired
length of a web sheet segment and a second head for
additionally charging the web in a pattern conforming
with a second reference mark to denote that
information has been represented on the web by the
selective charging means;
inker means for containing a mass of opaque particles;
fixer means for both pulling the charged master web
through said inker means and for fixing the opaque
particles in place on the dielectric web;
output means for receiving the dielectric web from the
inker means;
chopper means, disposed between the fixer means and
the output means, comprising a first sensing means for
determining the position of said first reference mark to
assist in regulating energization of the chopper means;
and a second sensing means to determine the presence
and absence of said second reference mark to assist
in regulating energization of the chopper means, operable as energized to chop
the web into sheets;
means positioned between the chopper means and the
output means, for loosening the particles previously
fixed on the master web; and
transfer means, positioned between the particle loosen-
ing means and the output means, for bringing copy
paper into engagement with the master web to pro-
vide a right-side-up copy of the mirror image pat-
tern on the master dielectric web.

10. An electrostatic system for printing a record repre-
senting character-denoting input signals, comprising:
a paper feed station for accepting a continuous master
dielectric web in roll or fan-fold form;
a print station for selectively charging the continuous
master web in a pattern which is the mirror image
of that denoted by said input signals;
auxiliary charging means including a first head for addi-
tionally charging the web in a pattern conforming
with a first reference mark to signify the desired
length of a web page segment and a second head for
additionally charging the web in a pattern conform-
ing with a second reference mark to denote that
information has been represented on the web by the
selective charging means;
a inker station for containing a mass of conductive,
opaque particles;
a fixer station for both drawing the selectively charged
master web through the inker station and for fixing
the conductive, opaque particles in place on the mas-
ter web;
a chopper station for receiving the continuous master
web from the fixer station, including a first sensing
means for determining the position of said first refer-
ence mark to assist in regulating energization of the
chopper station and a second sensing means for de-
termining the presence and absence of said second
reference mark to assist in regulating energization of
the chopper station, and operable when energized
to cut the continuous master web into successive
pages;
a master page stacker for receiving the master dielec-
tric web from the chopper station in successive pages
when the chopper station is energized and in con-
tinuous roll or fan-fold form when the chopper sta-
tion is de-energized;
and
an application station, positioned between the
changer station and the master sheet stacker for
loosening the particles previously fixed on the master
pages; and a
transfer station positioned between the solvent appli-
cation station and the master page stacker, for bring-
ing copy paper into engagement with a solvent-wetted
master page to provide a right-side-up copy of the
mirror image pattern on the master page.

11. An electrostatic printing system as set forth in claim
10 and further including at least one additional transfer
station positioned between the solvent application station
and the master page stacker, with selective control means
at each of said transfer stations to regulate whether copy
paper will be engaged with the solvent-wetted master page
at that particular station to provide a right-side-up copy
of the mirror image printed on the master page, thus regu-
lating the number of copies made from the master page.

12. The method of producing a printed record with
electrostatic techniques comprising the steps of:
providing a master dielectric web and passing the mas-
ter web adjacent a charging station;
providing a cloud of electrically charged particles at
the charging station;
shaping the cloud into a character-denoting charge
which strikes the master web;
providing additional electrically charged particles
which strike the web at first and second reference locations
to comter the desired length of an individual master
sheet and whether information has been placed on the
web in an area which will later become an in-
dividual master sheet;
developing the charged area by applying opaque parti-
cles to render visible the latent charge image and also
developing said reference locations to provide first
and second reference marks;
chopping the master web into individual master sheets
in accordance with the sensing of said first and sec-
don reference marks to determine the correct length
of the individual master sheets and to determine that
the copying should be effected because information
has been placed on the web; and
making copies of the master sheets on separate copy
sheets.

13. An electrostatic printing system for utilizing an
electroscopic, pressure fixable, solvent transferable, partic-
ulate ink to produce a visible record on a record medium
having a charge retentive surface, which system includes
first means for establishing charge patterns along a
row on the surface of said record medium,
means for intermittently displacing said record medium
past said first means a row at a time at a first average
rate to establish successive rows of charge patterns
along the record medium,
means for retaining the particulate ink for contact with
said charge patterns as the charged record medium
is pulled through the retaining means to develop
said particulate into visible images,
means, positioned intermediate the record medium dis-
placing means and the ink retaining means, for form-
ing a buffer loop of the record medium,
means including a drive means for normally continu-
ously fixing the rows of developed charge patterns
by pressure rolling the applied ink particulates into
the surface of said record medium at a second rate
different from said first rate, and
spaced apart sensing means for controllably interrupting
operation of the fixing means to adjust the difference
between said first rate and said second rate such that
the average rates, both of establishing the charge
patterns and of fixing the developed charge patterns,
are substantially the same, including a first sensing
means operative in response to the amount of slack
in said buffer loop being less than a predetermined
minimum amount to provide a control signal for in-
luding said drive means and thus preventing the
record medium from being pulled out of said buffer
loop, second sensing means operative to sense
an intermediate amount of slack in said buffer loop to
provide a control signal to said drive means which
enables said drive means to pull the record medium
from the buffer loop through the ink retaining means
and fixing means, and third sensing means disposed
to sense when the amount of slack in said buffer loop
reaches a predetermined maximum and provide a
control signal to said displacing means to inhibit
movement of the record medium past said first means
when an excess amount of slack material is in the
buffer loop.
14. A system as claimed in claim 13 in which the
means for fixing the developed charge patterns includes a
hard roller and an elastomer covered roller, arranged for
receiving the developed record medium between the
rollers so that the output from the rollers as the record
medium is received drives the ink particulates into
the pressure fixable surface of the record medium.
15. A system as claimed in claim 13 in which said
charge patterns are produced as mirror image representa-
tions of a desired printed record, and further comprising
means for applying a solvent on the surface of the record
medium to loosen the ink particulates previously pressure
fixed into said surface, and means for passing a copy
medium into engagement with said record medium so that
at least some of the loosened particulates adhere to the
copy medium and provide a permanent, right-side-up
record of the desired information.
16. A system as claimed in claim 15 in which the
solvent is rolled onto the record medium by a roller hav-
ing a peripheral speed approximately that of the speed at
which the inked and fixed record medium is displaced
when the solvent is applied.
17. An electrostatic printing system in which a record
medium having a charge retentive, pressure fixable sur-
fate is received from an input point and segments of
the record medium with a visible record thereon are
passed to an output point, comprising
paper feed means for selectively driving the blank
record medium received from said input point,
a print station including an electrostatic charging
arrangement for depositing electrostatic charge pat-
terns on the record medium and drive means for
displacing the record medium through the print
station,
means for defining a first buffer loop of the record
medium between said paper feed means and the
print station, and first sensing means, positioned
adjacent said first buffer loop, operative to provide
control signals for regulating operation of the paper
feed means in accordance with the amount of record
medium in the first buffer loop,
inker means for retaining particulates of an electro-
scopic, pressure fixable, solvent transferable ink,
a fixer station positioned adjacent the inker means and
having a pair of pressure fixing rollers, operative
both to pull the charged record medium through the
inker means so that the ink particulates adhere to
the charge patterns on the record medium and to fix
the particulates in the surface of the record medium
as the inked record medium passes between said
pressure fixing rollers,
means for defining a second buffer loop of the record
medium between the drive means of the print station
and the inker means, and second sensing means, posi-
tioned adjacent the second buffer loop, for regulating
operation of the fixer station in accordance with the
amount of record medium in said second buffer loop,
a chopper station, including a paper tractor unit for
displacing the record medium received from the fixer
station and a knife unit, for receiving the inked and
fixed record medium and cutting the continuous
record medium into segments, and
means for defining a third buffer loop of the record
medium between the fixer station and the chopper
station, and third sensing means, positioned adjacent
the third buffer loop, for regulating operation of the
paper tractor unit in accordance with the amount of
record medium in said third buffer loop, the buffer
loops accommodating different operating rates of
the paper feed means, the drive means in the print
station, the pressure fixing rollers, and the paper
tractor unit.
18. A printing system as claimed in claim 17 in which
said print station also includes means for establishing
a reference charged area on the record medium which when
inked provides a reference mark to indicate the desired
length of each record medium segment, and the chopper
station includes means for sensing passage of the refer-
ence mark to correlate actual actuation of the knife unit with
the desired length of the record medium segment.
19. A printing system as claimed in claim 17 and fur-
ther comprising a solvent application station for receiving
the printed segments of the record medium and applying
solvent thereto to loosen the ink particulates previously
fixed at said fixer station, and at least one transfer station
for receiving the solvent-wetted segments and bringing
a copy medium into pressure engagement with the solvent-
wetted record medium to provide a mirror image copy
of the information printed on the record medium.
20. The method of producing a printed record with
electrostatic techniques comprising the steps of:
- providing a master dielectric web and passing the master
web adjacent a charging station;
- providing a cloud of electrically charged particles at the
charging station;
- shaping the cloud into a character-denoting charge
which strikes the master web;
- directing additional electrically charged particles to-
ward the web to charge first and second reference
areas which as developed will provide reference
marks to indicate the length of an individual master
sheet and whether information has been placed on
the web at the charging station;
- developing the charged areas by applying dry opaque
particles to render visible the latent charge image;
- pressure-fixing the particles in place to provide a
permanent, printed record on the master web;
- applying solvent to the pressure-fixed master web to
loosen the particles;
- chopping the master web into individual master sheets
in accordance with the sensing of said first and sec-
ond reference marks to determine the correct length
of the individual master sheets and to determine that
the copying should be effected because information
has been placed on the web; and
bringing at least one copy sheet into engagement with the solvent-wetted, chopped master web to provide a copy of the printed record.

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