

[54] **MAGNETICALLY CONTROLLED MACHINE PROGRAMMER**

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[73] Assignee: **Eastman Kodak Company, Rochester, N.Y.**

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Related U.S. Application Data

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[51] Int. Cl. **G03g 15/00**

[58] Field of Search **355/14, 16, 3**

[56] **References Cited**

UNITED STATES PATENTS

3,606,532	9/1971	Shelffo et al.	355/16 X
2,918,853	12/1959	Oldenboom	355/14 X

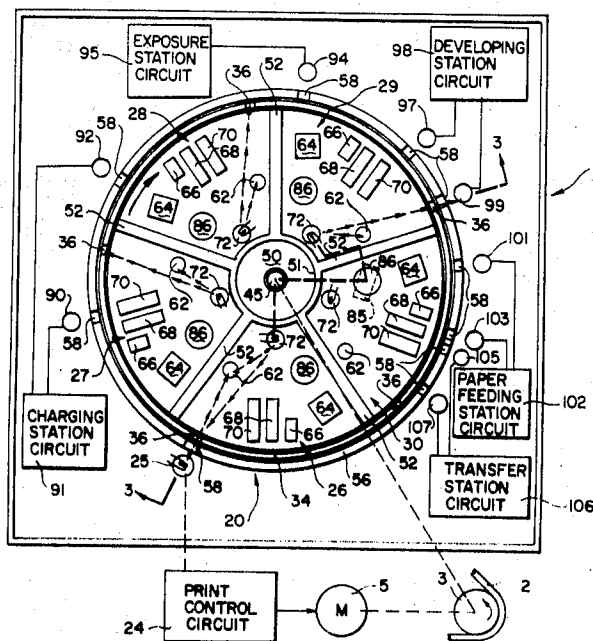
Primary Examiner—Robert P. Greiner

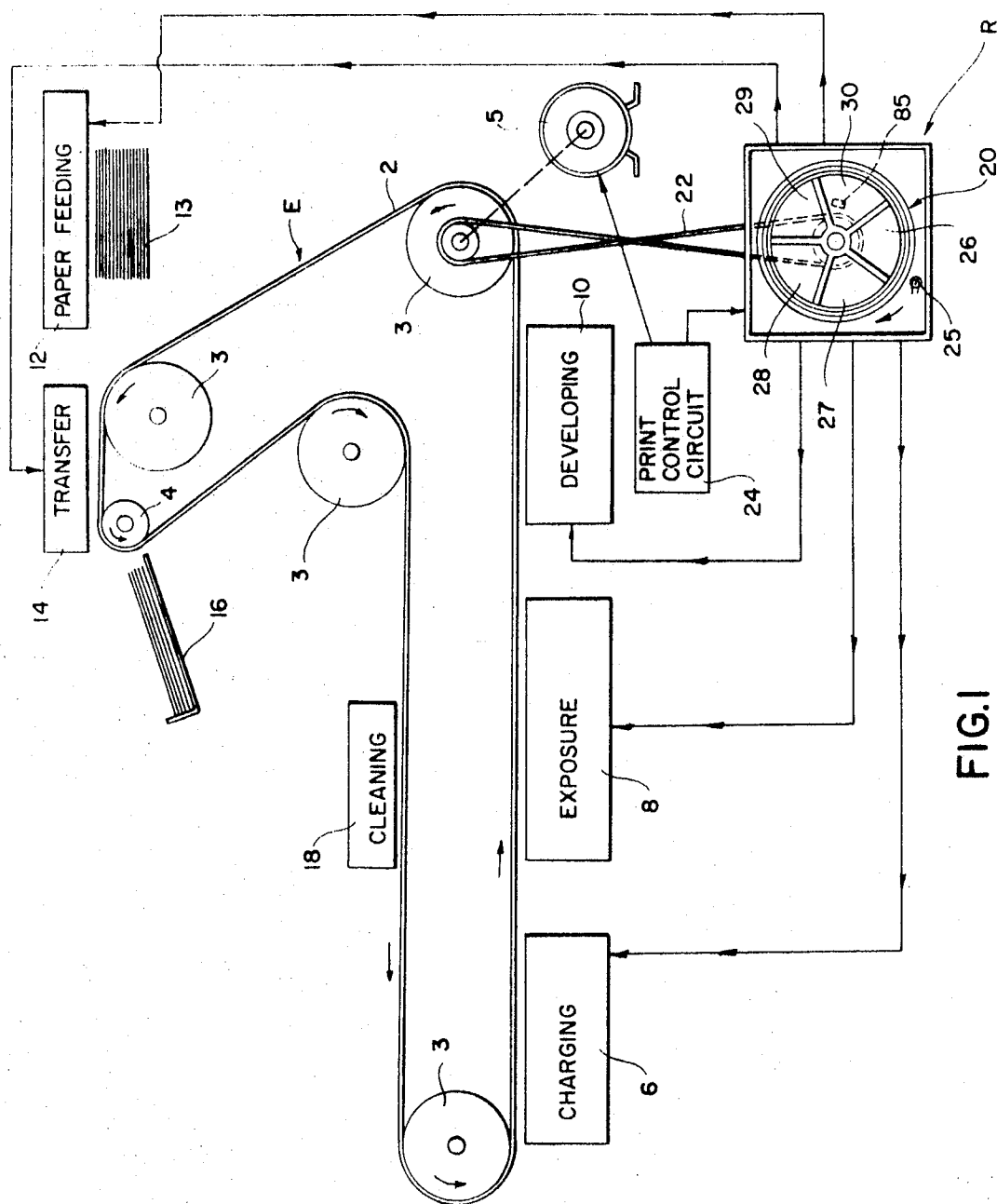
Attorney—R. W. Hampton

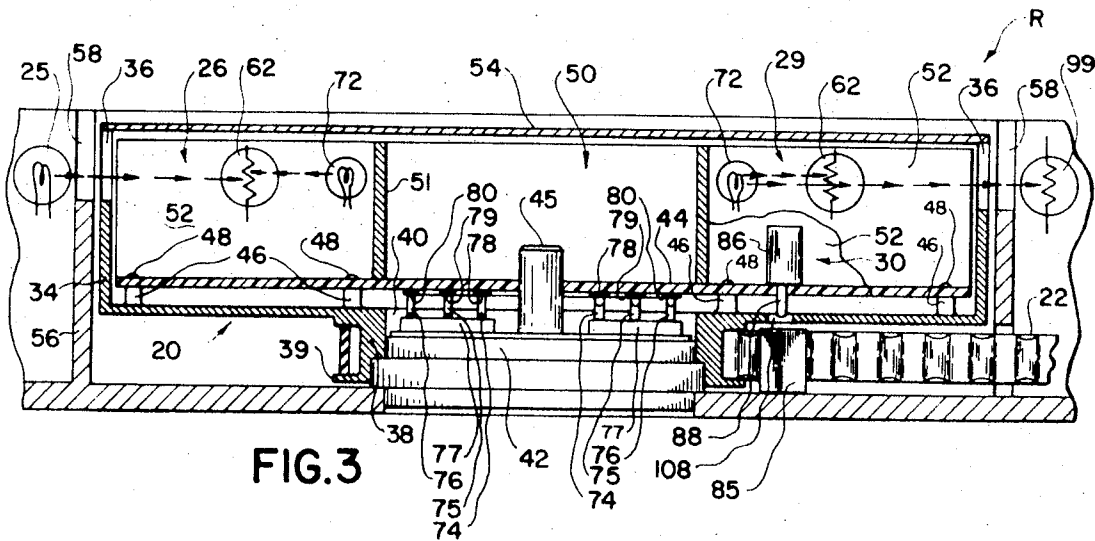
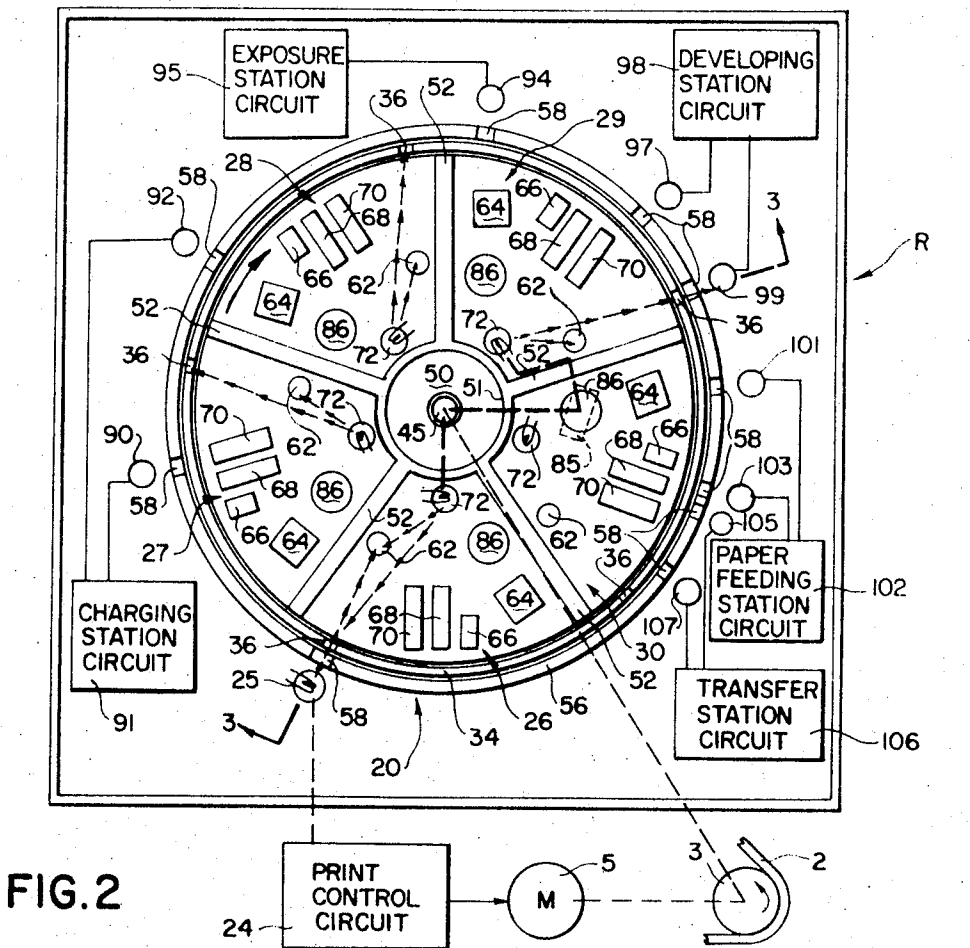
[57] **ABSTRACT**

A machine programmer is provided for controlling work performed on a work piece which moves through separate work stations wherein a shift register selectively energizes and deenergizes the work stations in response to movement of the work. The shift register includes a multisectioned cylinder divided into individual light-tight sectors, each having a slot along the periphery of the cylinder through which light can pass, and is rotatably driven by an endless photoconductive member. Each sector has a switching circuit which includes a lamp and a photosensitive device. When it is desired to make electrophotographic copies of an original, the lamp is turned on by an input signal from an electromagnet adjacent the cylinder which is energized in accordance with the number of copies to be made. As each sector moves along a circular path past the electromagnet, a reed switch is operated to turn on the lamp, whose light by means of a photosensitive device maintains the circuit, and hence the lamp itself, in activated condition. As the cylinder is rotated the light in each lighted sector activates a series of photosensitive devices spaced around the cylinder to energize circuits connected to electrophotographic stations along the path of the photoconductive element in response to movement of the photoconductive element to make copies of the original.

1 Claim, 5 Drawing Figures







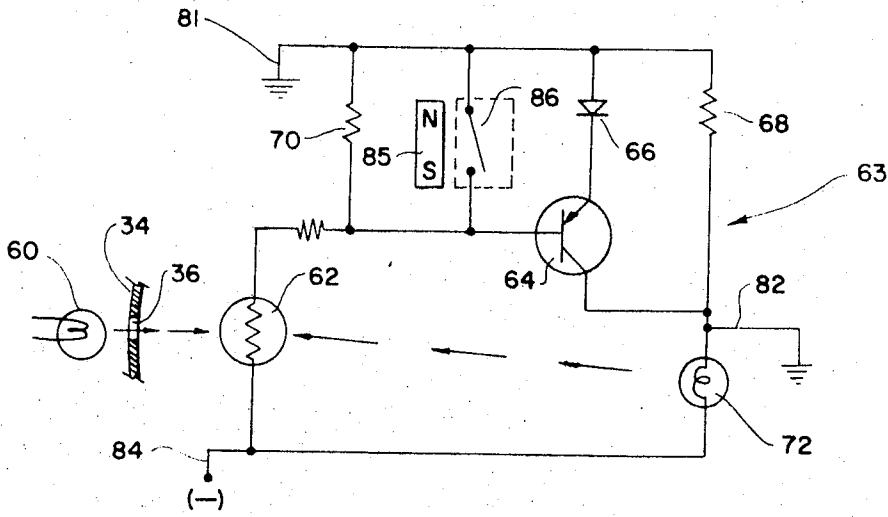


FIG. 4

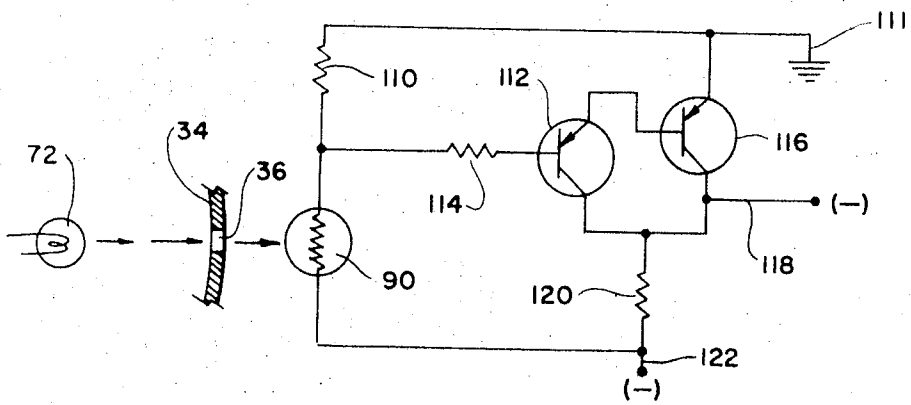


FIG. 5

MAGNETICALLY CONTROLLED MACHINE PROGRAMMER

CROSS-REFERENCE TO RELATED APPLICATION

This application is a divisional of Ser. No. 19,644 entitled, "MAGNETICALLY CONTROLLED MACHINE PROGRAMMER" filed Mar. 16, 1970 in the name of Hickey.

Reference is made to copending U.S. application Ser. No. 19,999, "Machine Programmer" by Lionel R. Hickey and Ellsworth J. McCune, filed on even date herewith.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a machine programmer for controlling operations on a work piece in response to movement of the work piece and more particularly to a machine programmer which includes a shift register for controlling electrophotographic operations on a photoconductive member in response to movement of the photoconductive member through an endless path.

2. Description of the Prior Art

In many machine control applications it is necessary to perform a series of predetermined functions on selective elements as they pass through various work stations along a path. Such machine control problems in general require some type of shift register or control device which permits the insertion of action information at the start of a register cycle for those elements requiring action and provides a shifting of this action information through the register as the work element passes through the separate work stations. It is necessary that multiple sections of the register can receive action information when desired and that each section of the register will shift at the same time as the work element moves from one work station to the next. Thus, it is of utmost importance that the shift register shifts each time the work piece advances from one station to the next station and that this shift occurs simultaneously.

One area in which this type of machine control is necessary is in a continuous electrophotographic process wherein an endless photoconductive member, such as a drum or an endless web moves continuously through a series of electrophotographic stations to form a toner image from an original, which toner image is transferred to a receiver sheet to make a copy of the original. Typically, the photoconductive member first is advanced past a charging station which places a generally uniform electrostatic charge on the photoconductive member, such as by corona discharge. Next it passes an exposure station where it is exposed to a pattern of radiation corresponding to an original to be copied. This discharges a photoconductive member in the exposed areas to form an electrostatic latent image. This image is toned at a developing station to form a toner image. As the photoconductive member continues along its endless path the toner image can be utilized in any one of several ways but is commonly transferred to a receiver sheet at a transfer station to form a copy of the original. At a subsequent station any residual toner particles remaining on the photoconductive member are cleaned therefrom so that the photoconductive member may be recycled through the stations just described.

With such electrophotographic apparatus, it is clear that the operation of each station along the path of the photoconductive member must be perfectly synchronized with the movement of the photoconductive member so that each work function is performed at the proper time in order to make a satisfactory print. It can be seen that if any one function is advanced or retarded slightly with respect to the movement of the photoconductive member the resulting image may be imperfect.

Control of an electrophotographic endless web is disclosed in U.S. Pat. No. 3,134,090 to Blakely which issued May 19, 1964 and is entitled "Proportional Space Recording Devices." This device is directed to the formation and projection of letters having varying dimensions onto a photoconductive member so that they are proportionally spaced. In U.S. Pat. No. 3,294,050 to Corley et al. which issued Dec. 27, 1966 and is entitled "Pattern Mechanism for a Tufting Machine and a Process for Producing a Patterned Tufted Fabric," is disclosed a control device having a plurality of photoelectric cells within a drum wherein light is intermittently interrupted to control a mechanism associated with the drum. U.S. Pat. No. 3,225,207 to Connors et al. which issued Dec. 21, 1965 and is entitled "Radiation Responsive Selectively Programmed Controller," discloses a rotating disc having shutters which are opened or closed to admit or block light from photocells behind the shutters. The disc is rotated to control machine operations and is electrically pulsed from the machine. A light is provided adjacent the photocell to maintain the circuit in activated condition once the photocell has been triggered by light passing through the shutters in the rotating disc. It can be seen that although the prior art provides a number of devices for controlling machine operations no machine programmer is disclosed wherein the control itself is moved in response to movement of the work piece.

SUMMARY OF THE INVENTION

In accordance with this invention a machine programmer is provided which includes a shift register into which is fed information as to the number of times one or more operations are to be performed on a work piece. Output signals are derived from the shift register which is moved in response to movement of the work piece along a path past one or more work stations where the operations are performed. The input signal is derived from a first electromagnetic energy source associated with the shift register. The shift register includes an element having at least one signal circuit for producing an output signal. This circuit includes a first energy sensor for enabling the signal circuit in response to a signal from the first electromagnetic energy source and a second source of electromagnetic energy which retains the signal circuit in enabled condition and provides an output signal. At least one second energy sensor is electrically connected to a work station provides a signal thereto in response to the output signal upon movement of the shift register past the second sensor. Means is provided to disable the signal circuit upon movement of the shift register and work piece through a complete cycle.

More particularly the shift register comprises a rotatable cylinder divided into a plurality of light-tight sectors, each of which has a slit in the periphery thereof through which light can pass and which contains a signal circuit which includes an output signal lamp that is

enabled in response to electromagnetic energy as an input signal from an information center as to the number of operations to be performed on the work piece. Upon rotation of the cylinder in response to movement of the work piece, each sector will move past an electromagnet, which when energized will operate a reed switch in the signal circuit which enables the signal circuit to illuminate the output signal lamp. The light energy from this signal lamp shines on a photocell in the circuit to maintain the circuit in enabled condition after this now lighted sector rotates away from the electromagnet. Other photocells are spaced about the periphery of the cylinder and are sequentially energized by the output signal lamp as the lighted sector moves therepast. Each of these photocells are connected to circuits at the work stations to control operations on the work stations to control operations on the work piece in response to its movement. At the end of a complete revolution of each sector a permanent magnet disables the circuit by operating a second reed switch therein to turn off the signal lamp so that further work operations will not be performed upon the work piece unless the input lamp enables the circuit again. The electromagnet provides a signal to the cylinder sectors until the number of sectors lighted corresponds to the number of times the information center indicates that work is to be done on the work piece.

In one embodiment of the present invention, the work piece comprises an endless photoconductive member, such as an endless belt or drum which moves past a plurality of electrophotographic stations, such as a charging station, an exposure station, a developing station, a transfer station and a cleaning station. The shift register is mechanically connected to the belt whereby the shift register turns one complete revolution for each complete cycle of the photoconductive member so that all electrophotographic operations on the photoconductive web occur in proper timed sequence. Each sector of the shift register corresponds to a print sector of the photoconductive member. As used herein, the term "print sector" is that portion of the photoconductive member required for making a single print.

When it is desired to make a number of electrophotographic prints from an original, the operator places this information into an information center as by means of a keyboard connected to a print control circuit. The print control circuit responds by providing a signal to a drive means for the endless photoconductive member and also by energizing an electromagnet to provide an input signal to the shift register. As the photoconductive member begins to move through a cycle the shift register will move in response thereto so that one of the sectors is brought into a position to be enabled by the electromagnet operating a reed switch to cause the output signal light to be turned on. As the lighted sector rotates the output light therein shines onto the first of several radiation receptors or photosensitive cells spaced about the periphery of the shift register. The first photocell provides a signal to the charging station to begin charging of the corresponding print sector of the photoconductive member. As the photoconductive member continues to move this print sector is charged as it moves through the charging station until the lighted shift register reaches a second photosensitive cell positioned along the periphery of the shift register, which second photosensitive cell provides a second sig-

nal to turn off the charging station. Continued movement of the photoconductive member results in continued rotation of the shift register as the charged print sector is moved into an exposure station which is triggered by another photosensitive cell now receiving light from the lighted shift register sector. This causes an exposure device, such as an electronic flash, to image-wise expose the charged print sector at precisely the time when the print sector is centered in the exposure station.

Similarly, at the developing station a development electrode is turned on and off, respectively, by two spaced photosensitive devices which are responsive to movement of the lighted sector past them in order to develop a toner image. At an appropriate time photocells are energized by the lighted sector to turn on a paper feeding device which causes a receiver sheet to be brought into position at a transfer station. The lighted sector also energizes a second photocell to discontinue paper feeding after one sheet of paper has been fed. When the print sector reaches the transfer station another photocell can be energized as by the shift register to energize a transfer electrode to cause the toner image to be transferred from the photoconductive member to the receiver. The cleaning station normally is not controlled by the shift register since cleaning can be a continuous operation which is not dependent upon the position of the print sector in its cycle.

If more than one print is to be made, additional sectors of the shift registers are sequentially lighted by the electromagnet in response to a signal from the information center. These lighted sectors energize the various stations described in the proper sequence to perform electrophotographic operations on subsequent print sectors of the photoconductive member. As each shift register sector completes a cycle, its circuit is disabled, as by momentarily closing a second reed switch by means of a permanent magnet to turn off the output signal light which once turned off, will remain off, since the photosensitive cell in the circuit is no longer energized. The sector remains off unless a signal from the print control circuit via the electromagnet indicates that additional copies are needed whereupon it is enabled again and becomes lighted to cause another series of electrophotographic operations to be performed on the photoconductive member as a corresponding print sector moves through the various electrophotographic stations.

Additional advantages of this invention will become apparent from the description which follow, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic side elevation of an electrophotographic device incorporating the shift register of this invention;

FIG. 2 is a diagrammatic enlarged view of the shift register of FIG. 1;

FIG. 3 is an offset section taken along lines 3—3 of FIG. 2 showing further details of the shift register;

FIG. 4 is a circuit diagram of the circuit associated with each sector of the shift register; and

FIG. 5 is a circuit diagram of an amplifier circuit which forms part of the circuit for controlling each electro-photographic station.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A typical electrophotographic apparatus E is shown in FIG. 1 which is controlled by a shift register R. The latter controls the sequence and timing of electrophotographic operations on a photoconductive member such as endless photoconductive web 2 which is mounted for movement along a path defined by the rollers 3 and 4 as shown. The web is driven by a drive means, such as motor 5 connected to a roller 3, as shown. Electrophotographic device E includes a charging station 6, an exposure station 8, a developing station 10, a paper feeding station 12 for feeding sheets of paper from a paper supply 13 to a transfer station 14, the finished prints being collected in a receptacle 16. Of course, it will be understood that after transfer the receiver sheets could pass through a fusing station (not shown), before being fed to receptacle 16. After transfer the photoconductive web 2 passes a cleaning station 18. The cycle then is repeated. It will be understood that the sequence of operations described above is by way of example only and that additional operations can be controlled by the shift register as required or that some of the operations described may be performed by other means if desired.

The shift register R includes a rotatable segmented and slotted cylinder 20 which is driven by suitable means, such as belt 22 extending from a pulley around roller 3 so that movement of the shift register is in direct response to movement of photoconductive web 2. When it is desired to make one or more prints a start button on an information center (not shown) is depressed and information as to the number of prints to be made is fed to print control circuit 24. The print control circuit energizes motor 5 so that photoconductive web begins moving through a cycle. Also, it energizes an initiator device such as an electromagnet 25 to enable the sectors of cylinder 20 as they rotate past electromagnet 25. Cylinder 20 may be divided into any number of sectors but is illustrated as being divided into 5 sectors, 26, 27, 28, 29, and 30.

Cylinder 20 includes a bottom wall 32 and a peripheral side wall 34 having a plurality of slots 36, one slot being provided for each sector of the shift register, as best seen in FIGS. 2 and 3. Light can shine through this slit to effect operation of the various electrophotographic stations in a manner to be described. A center hub 38 extends away from the cylinder from bottom wall 32 as shown in FIG. 3 which has a flange 39 and a central opening 40 to provide a bearing surface about which cylinder 20 rotates on bearing 42. Hub 38 and flange 39 form a pulley about which belt 22 extends so that cylinder 20 is rotatably driven in response to movement of photoconductive web 2. A circular or disc-shaped circuit-board 44 is mounted within cylinder 20 and is centered as it is positioned therein by means of a stub shaft 45 which extends from bearing 42 and produces through a hole in the circuitboard when the circuitboard is in place. The circuitboard is spaced from bottom 32 by means of a plurality of spacers 46 and is held in position by fastening means 48 extending into the spacers, as shown. The individual sectors are formed by a divider 50 having a circular center portion 51 which has a plurality of radial flanges 52 extending to sidewall 34, as shown. A circular cover 54 fits over

divider 50 and engages sidewall 34 to complete cylinder 12 and to form the separate light-tight sectors.

Conveniently, cylinder 20 is mounted within a circular sleeve 56 having a plurality of slots 58 spaced therearound. As cylinder 20 is rotated the slots 36 therein are sequentially aligned with slots 58 in sleeve 56. Adjacent each of slots 58 is a photosensitive device which is connected to a circuit associated with one of the electrophotographic stations. When a slot 36 of an enabled sector is aligned with a slot 58 of sleeve 56 the light within the sector shines through the aligned slots onto the photosensitive device adjacent the slots to provide a control signal to an electrophotographic station to control an electrophotographic operation on the corresponding print sector of web 2. Slots 58 and the corresponding photosensitive devices are so spaced about the periphery of cylinder 20 that a signal is provided to an electrophotographic station at precisely the appropriate time with respect to the position of the corresponding print sector so that each step occurs in proper sequence and in proper time relation to the position of each print sector of the web.

In the present embodiment, the input signal from print control circuit 24 is to electromagnet 25 which is energized so that a reed switch 60, which is part of enabling circuit 63 of FIG. 4 and will saturate the base of transistor 64 which is negative with respect to the emitter. This will drive transistor 64 to saturation and light 72 will turn on and illuminate sector 26 and photocell or phototransistor 62. The emitter of transistor 64 is connected to ground through a diode 66 and lamp 72 is connected to ground through resistor 68 as shown. Another resistor 70 is connected between the base of transistor 64 and ground.

Power to enabling circuit 63 of FIG. 4 is provided by means of brushes 74, 75, and 76 (FIG. 3) which are mounted on blocks 77 attached to bearing 42. Conveniently, brushes 74 are connected to ground; brushes 75 are connected to an arming circuit at a potential, such as -12 volts to heat the filament of light 72 so that when reed switch 60 is closed light 72 will immediately be illuminated without requiring a warmup period. Brushes 76 are also connected to a potential source, such as a -12 volts, and provide the power to light lamp 72. Conveniently, the brushes engage slip rings 78, 79 and 80 on the bottom of circuitboard 44 and are connected to the other parts of the enabling circuit of FIG. 4 by means of a printed circuit (not shown) on circuitboard 44. Thus, brushes 74 are connected to ground at input 81; brushes 75 are connected to input 84 and brushes 76 are connected to input 82. The use of input 82 is optional and is used only when it is desirable to have light 72 remain on continuously for more than one cycle for a particular machine operation. In practice, the optional connection between input 82 and brushes 76 can be made through a normally open switch (not shown). Once light 72 has been turned on the circuit effectively locks the light on in that the light level from lamp 72 is sufficient to keep phototransistor 62 saturated.

However, light 72 is turned off at the end of one complete revolution by a permanent magnet 85, shown in FIGS. 2, 3 and 4. This magnet is positioned within sleeve 56 so that a second reed switch 86 connected between ground 81 and the base of transistor 64, is closed as it moves thereacross. Thus, transistor 64 becomes unsaturated and light 72 is turned off. Conveniently,

bottom 32 of cylinder 20 is provided with an opening 108 immediately below the end 88 of reed switch 86 so that the magnetic field from magnet 85 is not blocked at that position.

After electromagnet 25 enables a sector, the sector rotates in a clockwise direction, as viewed in FIG. 2. As it rotates it becomes aligned with a slot 58 adjacent a photocell 90 in charging station circuit 91 at precisely the same time that a print sector of photoconductive web 2 enters charging station 6. This enables circuit 91 which causes a corona discharge device or other charging device to be turned on as photoconductive web 2 moves thereunder. At precisely the time that the end of the print sector of photoconductive web 2 reaches the end of charging station 6 the lighted sector of shift register R has rotated to a position where light 72 shines through the slot 58 adjacent photocell 92 in charging station circuit to disable the circuit to discontinue charging.

As the photoconductive web 2 continues to move the now charged print sector enters exposure station 8. At the point in the cycle where the print sector is centered in the exposure station the lighted sector of shift register R is in a position so that the light shines through a slot 58 adjacent photocell 94 of exposure station circuit 95 to cause exposure of the charged print sector to a pattern of radiation, as by an electronic flash. The charged print sector is discharged in the exposed areas and remains charged in the unexposed areas to provide an electrostatic image.

When the print sector reaches developing station 10, the lighted sector is in a position so that the light shines upon photocell 97 of developing station circuit 98 to activate the developing station. This may consist of agitation and movement developer fluid and of energizing a development electrode to facilitate development of the electrostatic image to form a toner image. Just as the toner image leaves developing station 10, the shift register is rotated to a position so that photocell 99 is energized to disable developing station circuit 98 to turn the developing station off.

As the toner image moves toward transfer station 14, the lighted sector energizes photocell 101 at the appropriate time to cause paper feeding circuit 102 to feed a sheet of receiver paper by means of paper feeding station 12 from paper supply 13 to transfer station 14. The paper feeding operation is discontinued upon energization of photocell 103. As the toned image enters transfer station 14 photocell 105 is energized to enable transfer station circuit 106 to effect operation of transfer station 14, such as to energize a transfer electrode to facilitate transfer of the toner image from photoconductive web 2 to the receiver sheet. After the print sector of web 2 leaves transfer station 14 shift register R has reached a position where photocell 107 is energized to cause transfer station circuit 106 to disable transfer station 14.

As photoconductive web 2 continues to move the print sector passes through cleaning station 18 where any residual toner particles thereon removed. Cleaning station 18 need not be operated in accordance with movement of shift register R since cleaning can be a continuous operation rather than being performed just when a print sector is in the cleaning station.

As the web continues to move cylinder 20 continues to rotate so that a sector reaches a position such as the position of sector 30 where the reed switch 86 passes

over permanent magnet 85 to turn off lamp 72, as described above.

It will be understood that if more than one print is to be made successive sectors are lighted by electromagnet 25 as each sector moves past it so that different electrophotographic operations are performed on different print sectors of photoconductive web 2 at the same time. The number of sectors which are lit correspond in number to the number of prints desired. For example, if three prints are desired, three sectors are lighted. On the other hand, if seven prints are desired, each sector is lighted once and the first two sectors are lighted twice. The print control circuit 24 includes means (not shown) to sense the number of sectors lighted and when the proper number of sectors have been lighted electromagnet 25 is turned off so that no further sectors are lighted.

Each of the circuits for controlling electrophotographic operations include an amplifier circuit which generates a signal in response to energization of the photocell or phototransistor associated with it by lamp 72. FIG. 5 is exemplary of this circuit and shows such a circuit associated with photocell 90. This photocell is connected through a resistor 110 and a lead 111 to ground and is connected to the base of a transistor 112 by means of a second resistor 114. When no light falls upon photocell 90, there is a reverse bias across it and across transistor 112. However, when phototransistor 90 is illuminated by light 72 transistors 112 and 116 become saturated. The amplifier circuit also includes a resistor 120 connected between transistors 112 and 116 and a negative power source through lead 122, as shown. Thus, when no light falls upon photocell 90 the output potential at lead 118 is near the negative input potential at input lead 122, whereas when photocell 90 is illuminated the output potential at lead 118 is near ground.

From the foregoing, the advantages of this invention are readily apparent. A machine programmer has been provided which includes a shift register that operates in response to movement of a work piece wherein the shift register controls different operations to be performed on the work piece as the work piece moves from station to station. In an electrophotographic application the movement of an endless photoconductive member such as endless web causes a circular shift register having a plurality of light-tight sectors to rotate through one complete revolution in response to movement of print sector of the photoconductive member through a complete cycle. The shift register sectors can be energized or lighted by an initiator signal, such as an electromagnet. One sector is lighted for each print which is desired. As the shift register rotates, each lighted sector sequentially energizes photocells to provide signals to respective work stations along the path of the photoconductive member to perform electrophotographic operation on the print sectors in exact time sequence with the passage of the print sectors through each electrophotographic station.

The invention has been described in detail with particular reference to a preferred embodiment thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

We claim:

1. In electrophotographic apparatus having an elongated electrosensitive member defining a plurality of

selectable image areas and movable along an endless first path, the combination comprising:

- a. a plurality of electrophotographic work stations located along said path including an actuable exposure station operative when actuated for exposing a selected image area of said member to a light image to form a latent electrostatic image, a development station for applying toner to such electrostatic images on said member to form toner images, and an actuable transfer station operative when actuated for transferring a toner image on a selected image area of said member to a receiving medium;
- b. means defining a second predetermined path; and
- c. means movable along said second path for sequentially actuating and de-actuating said exposure and transfer stations in accordance with a predetermined sequence in timed relation to movement of said member past said stations to effect sequential operation of said exposure and transfer stations with respect to a selected image area during movement around said endless path, said sequential means being effective to simultaneously produce at least two of such predetermined sequences of work

station actuations to form at least two latent electrostatic images in selected image areas respectively prior to completing the transfer of the toner image corresponding to the first of such two formed latent electrostatic images to a receiving medium, said sequential means includes an element movable along said second predetermined path; an actuable first source of energy positioned along said second path; an actuable second source of energy on said element; means for activating said first energy source; first energy sensor means on said element responsive to said first energy source upon movement of said element along said second path past said first energy source to activate said second energy source; and second energy sensor means disposed along said second path and spaced from said first energy source and coupled to at least one particular work station for causing said particular work station to perform a work operation on said member in response to energy from said second energy source upon movement of said element past said second energy sensor means.

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