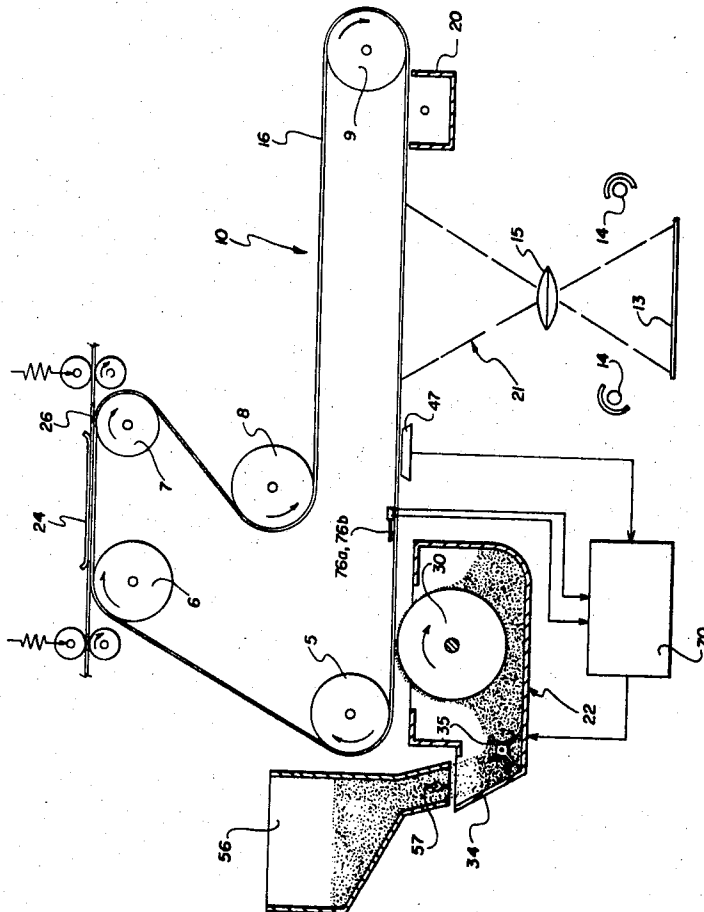


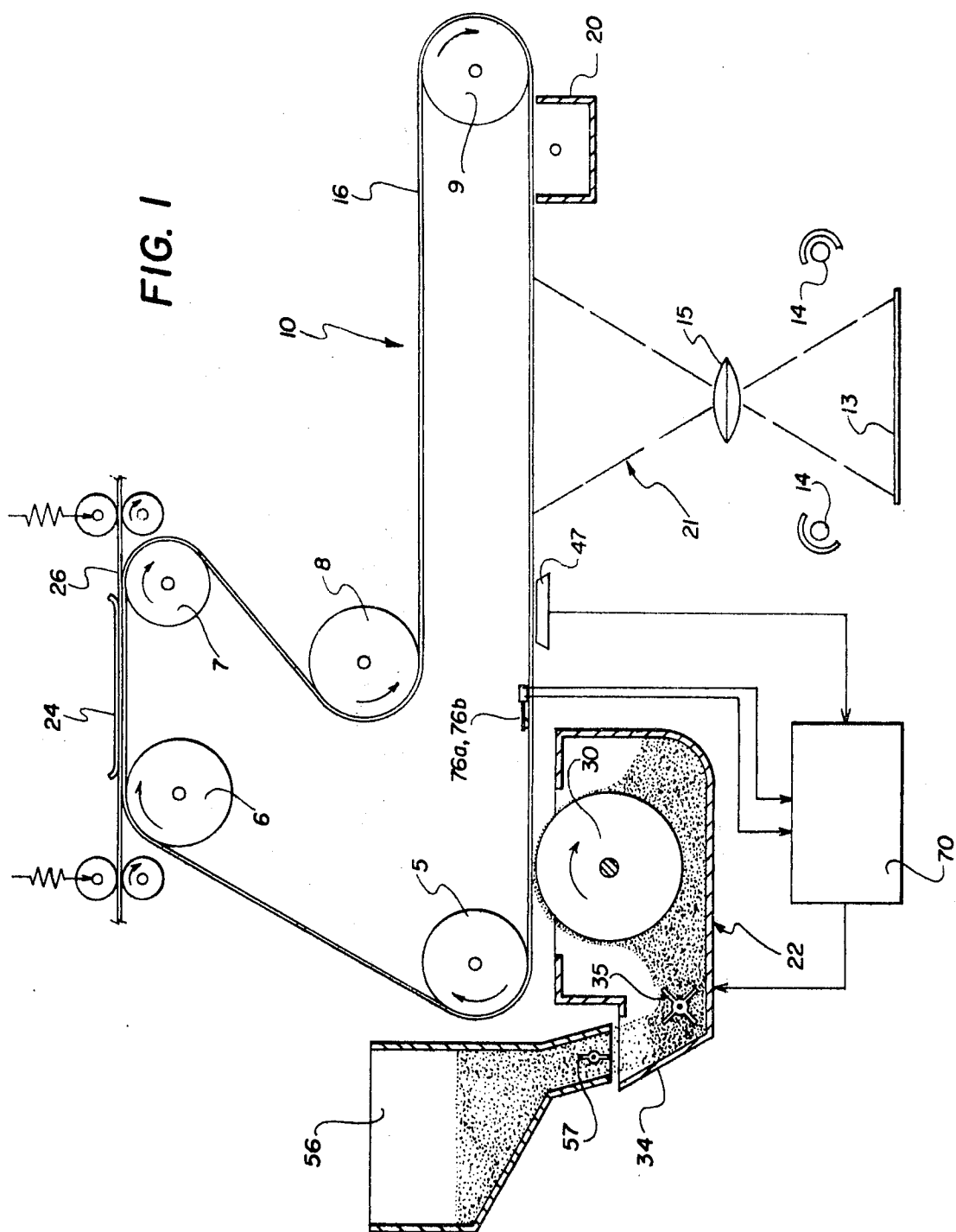
Rowell et al.

[45] Nov. 25, 1975

- | | | | |
|-----------|---------|-------------------|-----------|
| 2,956,487 | 10/1960 | Giaimo | 118/637 X |
| 3,611,982 | 10/1971 | Coriale | 118/637 X |
| 3,654,893 | 4/1972 | Piper et al. | 118/8 X |

1 Claim, 3 Drawing Figures





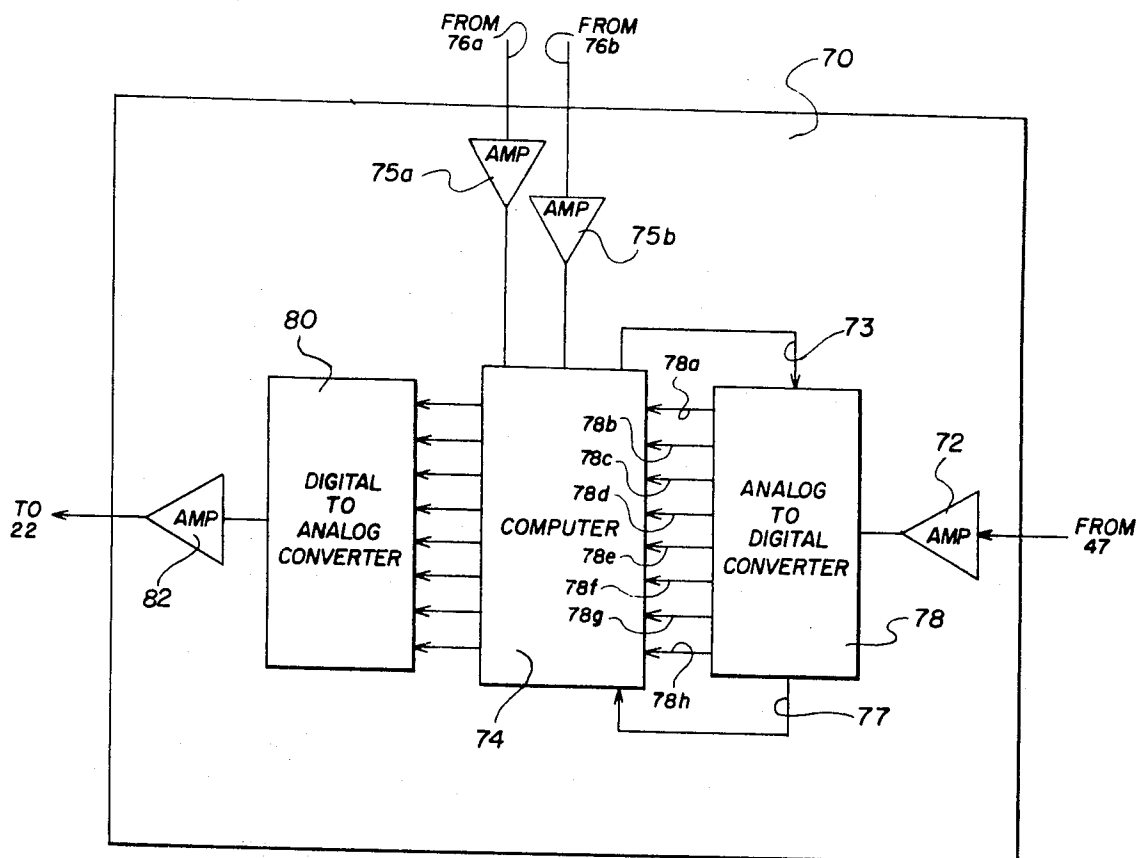


FIG. 2

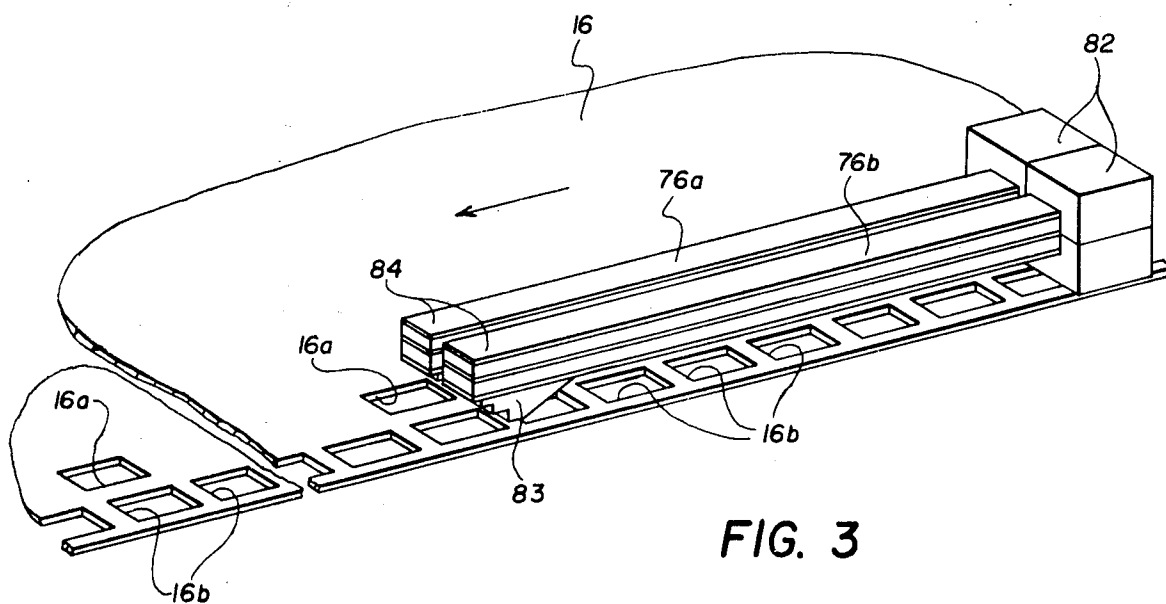


FIG. 3

AUTO BIAS CONTROL METHOD

This application is a division of application Ser. No. 370,997, filed June 18, 1973.

CROSS-REFERENCE TO RELATED APPLICATIONS

Reference is hereby made to commonly-assigned U.S. Pat. No. 280,397 filed Aug. 14, 1972, entitled, **TONER CONCENTRATION AND AUTO BIAS CONTROL APPARATUS**, in the name of Conrad Altmann, now U.S. Pat. No. 3,779,204; and commonly-assigned U.S. Pat. application Ser. No. 217,093 filed Jan. 12, 1972 entitled, **INTEGRATED CIRCUIT SEQUENCER**, in the name of Gareth Lloyd, now U.S. Pat. No. 3,732,005.

BACKGROUND OF THE INVENTION

1. Field Of The Invention

This relates to electrographic development apparatus, and more particularly to auto bias apparatus for adjusting the potential applied to a development electrode as a function of the field strength associated with a charged image area to be toned.

2. Description Of The Prior Art

In electrographic apparatus, an electrostatic image formed on the surface of a drum or web, is developed by application of finely divided toner particles thereon to form a toner image. In certain electrographic apparatus, toner images are formed from electrostatic images by brushing a developer mixture of ferromagnetic carrier particles and much smaller toner particles (typically suitably pigmented or dyed resin-based particles) across the electrostatic images. The contact of the ferromagnetic particles with the toner particles charges the toner particles by triboelectrification to a polarity needed so that the toned particles are attracted to the electrostatic images for toning. In order to insure that the copies produced at the development station are of uniformly good density, an "Auto-Bias" technique is often used. As disclosed in U.S. Pat. Nos. 2,956,487 and 3,611,982, an analog signal is produced upstream of the development station which has a level that is a function of the charge density of the image area to be toned. Such analog signal is then applied to an analog delay circuit and after a time interval, selected to permit the charged image area to come into the development station, the analog signal is applied to the electrode. This time delay may typically be greater than one-half second. A difficulty with such an approach is that there are many problems with circuits for storing and maintaining analog signal levels for relatively long times (viz., say greater than one-half second) such as signal decay or transients being introduced.

SUMMARY OF THE INVENTION

One object of the invention then is to improve the auto bias function to produce high quality toner images.

Another object of the invention is to provide a highly accurate and reliable auto bias apparatus which eliminates the need for long term analog signal delay storage devices.

In the disclosed apparatus, there is provided a digital to analog converter which converts increments of an analog signal representation of the charge density of the image area to digital signals and applies such digital signals to particular storage locations of a digital com-

puter. At the appropriate time, the digital computer applies the stored digital signal corresponding to the increment of the image area just at the development station to a digital to analog converter which in turn applies an analog signal to the development electrode.

It is a feature of the invention that unwanted signal decay or transients found in the analog storage devices of prior auto bias apparatus is obviated by storing digital signals representative of increments of the charged image area. These signals are reconverted back to analog form but there is no need for a long term analog delay apparatus. Further, by taking a large number of incremental samples the accuracy of the auto bias apparatus may be improved.

Other objects of the invention and its various advantages will become apparent from the ensuing description of the embodiment as shown below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic vertical section of an electro-photographic apparatus wherein the invention may be embodied;

FIG. 2 is a circuit diagram partially in schematic and partially in block form of the auto bias apparatus shown as block 70 in the electrographic apparatus of FIG. 1; and

FIG. 3 is a partial perspective view showing in detail a portion of the photoconductive web and bimorph sensors also shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

For a general understanding of an electrographic reproducing or copier apparatus 10 wherein the invention has particular utility, reference is made to FIG. 1 wherein various stations of an electrographic apparatus are schematically illustrated. As in most electrophotographic copiers, an information medium 13 such as a document is illuminated by radiation from flash lamps 14. Such radiation is reflected from the medium and projected by a lens 15 onto a photosensitive member 16 shown as a web, to selectively dissipate charge and form an electrostatic image. The web 16 is trained about drive rollers 5 through 9 and is uniformly charged at a charging station 20. The photosensitive member 16 includes a photoconductive layer with a conductive backing. The photoconductive layer may comprise, for instance, a heterogeneous mixture of a bisphenol A-polycarbonate binder, a triarylmethane organic photoconductor and a pyrylium sensitizing dye. For more specific disclosures see commonly-assigned U.S. Pat. Nos. 3,615,406 and 3,615,414, both issued Oct. 21, 1971.

The apparatus 10 further includes a development station 22 at which the moving electrostatic image is contacted with finely divided charged toner particles that adhere to the photoconductive layer in a configuration defined by the electrostatic image; a transfer station 24 in which toner particles are transferred in the image configuration to a receiving surface of a copy sheet 26 on which it can be subsequently permanently fused; and a cleaning station (not shown) in which residual toner is removed from the photoconductive layer so that it can be reused. In certain known modifications of this same system, one or more of these stations may be eliminated. For a more complete description of the general organization of an electrographic apparatus, reference may be made to commonly assigned copend-

ing U.S. Pat. application Ser. No. 191,304 filed Sept. 21, 1971, entitled, CONTROL APPARATUS FOR ELECTROPHOTOGRAPHIC APPARATUS, to Hickey et al.

The development station 22 is a magnetic brush-type apparatus which includes a cylindrical brush member 30. The member 30 is rotated in a clockwise direction as shown by the arrow, in a magnetic field produced by magnets (not shown). The brush member 30 is effective to transport a portion of a mixture of ferromagnetic carrier particles and toner particles from a developer reservoir 34, which is a conductive member and acts as an electrode, across the surface of the web 16 so that toner particles will contact a portion of and then remain on charged image areas on the surface of the web 16. Since a mixture having a high concentration toner would tend to clog, a continuous control mixing paddle-wheel 35 has been provided to uniformly blend the mixture. An example of an exemplary development station is more fully disclosed in U.S. Pat. No. 3,543,720 to Drexler et al.

As is known, unless the potential applied to the development electrode 34 is adjusted in accordance with the charge on the image entering the development station, the resulting toner image may have an improper density. In order to relieve this condition, an auto bias apparatus 70 is provided. In order to actuate the apparatus 70, a charge sensor or probe 47, such as an electrometer (disposed at a predetermined position along the web path spaced from the development station 22) is provided for sensing the field strength of longitudinal movements of charged image areas. The probe 47 is disposed at the path of the photoconductor a predetermined distance from the reservoir 34. The probe 47 is electrically coupled to the auto bias apparatus 70 which in turn is adapted to control the potential of the development station reservoir 34 (electrode) to provide the well known auto-bias function which is described in some detail in U.S. Pat. No. 2,956,487. An example of an electrometer suitable for use with the invention would be an induction plate or probe fabricated from a highly conductive material such as copper or aluminum, spaced closely to the web to receive an induced charge as longitudinal increments of the electrostatic image pass thereby. The electrometer 47 may extend over the whole width of the image area or a portion thereof and is adapted to scan the electrostatic signal and produce an analog signal which is proportional to the charge density of field strength of that portion of the electrostatic image passing by the probe 47. In placing the probe 47, it is necessary to take into account the factor that some photoconductive members exhibit a delayed photographic response following exposure. Thus, it is desirable to displace the electrometer 47 a sufficient distance from the exposure station 21 so that the effect of such delay will have run its course before the undeveloped image arrives at the meter 47. The probe 47 is directly coupled to the auto-bias apparatus 70 which will now be described in connection with FIG. 2.

Turning now to FIG. 2, the probe 47 continuously samples the charge level of the photoconductor and applies its output to a preamplifier 72. The charge level on the photoconductor may typically be in the order of 500 volts whereas the voltage induced in the probe 47 may be in the order of one-half volt. The preamplifier 72 provides an amplification and isolation function and is adapted to provide an analog input signal to a con-

ventional analog to digital converter 78 which produces a bit output analog word in lines 78a-h including sufficient information content (bits) to facilitate an appropriate level of signal resolution. The preamplifier 72 is adapted to accept the input signal level (say, $\frac{1}{2}$ volt) and scale it upwardly to the applicable voltage, experimentally determined, which should be applied to the development electrode 34 to achieve a satisfactory auto bias function. For a specific example, for the $\frac{1}{2}$ volt induced in the probe voltage applied to the development electrode may be in the order of 5 volts. The analog to digital converter 78 is only effective to convert the analog signal when a start signal in a line 73 is applied to it from a digital computer 74. An example of an analog to digital converter which is especially suitable for use with the invention is Model ADC-ECONVERTER manufactured by Datel System, Inc., of Canton, Mass.

Reference should be made to FIG. 3 which shows in detail a portion of the photoconductor 16 having along its border two rows of indicia or sprocket holes 16a and 16b. Between adjacent holes 16a is defined an image area. By that it is meant an image area is a place across the entire width of the photoconductor 116 wherein a charge pattern corresponding to an image may be placed. The row 16b defines a predetermined number of perforations or sprocket holes disposed between adjacent perforations 16a. As shown, there is provided a bimorph sensor 76a which is adapted to sense the perforations 16a and provide a signal to the digital computer 74 by way of an amplifier 75a each time a perforation 16a is sensed. A second bimorph sensor 76b is adapted to provide a clock pulse to the computer 74 by way of an amplifier 75b each time a perforation 16b is sensed. The computer 74 uses the pulses from both bimorph sensors 76a and b to control and synchronize the various work stations of the electrophotographic operation. In operation, upon receiving a clock pulse from the amplifier 75b, the computer 74 enables the start line 73 which causes a digital word having eight bits to be stored in a storage location which could be provided by magnetic cores. One word for each clock pulse (corresponding to an increment of a charged image area) is stored in a particular core storage location. At the same time as the clock pulse causes a digital word to be stored in such location, the computer is programmed to couple an output digital to analog converter 80 to another core location which has been storing another digital word for a time interval (equal to a predetermined number of clock pulses) selected to cause the appropriate analog voltage to be applied to the development electrode which corresponds to the charge on that increment of the image area just entering the development station. An example of a commercially available digital to analog converter suitable for use with the invention is Model MC 14067 manufactured by Motorola Semi-Conductor Products, Inc. The pulses provided by the amplifier 75a to the computer could be used to control other machine functions such as synchronizing the operation of apparatus (not shown) for feeding sheets 26 and operating the exposure lamps 14 at appropriate times in the machine cycle. The computer 74 may take various other forms known in the art some of which are commercially available as programmable minicomputers. Specific examples are: Model 8008 Micro-Computer manufactured by Intel Corporation of Santa Clara, Calif.; GEPAC 30-manufactured by the General Electric Corporation; In-

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terdata Model 1 or Varian Data Machines Model 520/i. The instructions and method of programming such minicomputers is set forth in the textbook, "Minicomputers for Engineers and Scientists," Gravino Korn (1973).

In addition to its storage function, the computer 74 provides a similar function as the "hard-wired" sequencer disclosed in commonly-assigned U.S. Pat. application Ser. No. 217,093 filed Jan. 12, 1972 in the name of Gareth Lloyd. In the Lloyd sequencer, clock signals are produced by logic 60. In the instant case, this function is provided by the bimorph sensor 76b. Specifically, referring to the Lloyd disclosure, the output of the bimorph 76b could be applied to the counter 70 having a plurality of states, the state at any particular time manifesting the total cumulative member of received clock pulses. The decoding network 80 which responds to particular states of the shift registers and particular states of the shift registers and particular states of the counter 70 could be used to actuate the analog to digital converter 80 (of the instant disclosure) at the appropriate time in the machine cycle when the corresponding increment of the charged image area enters the development station to decode a digital word in a particular storage location. The memory storage would have to be provided by a memory storage device, many of which are commercially available.

Referring now to the instant disclosure, an example of bimorph sensors 76a and 76b which may be suitable for use with the present invention is described in commonly assigned U.S. Pat. No. 3,723,650 in the name of Bradley et al., issued Mar. 27, 1973, entitled, METHOD AND APPARATUS FOR DERIVING THE VELOCITY AND RELATIVE POSITION OF CONTINUOUSLY MOVING INFORMATION BEARING MEDIA. Briefly, such bimorph sensors include a piezoelectric crystal 82 which has attached thereto a single step sensor 83 element, the distal ends 84 of which bear on and slide against the moving medium. When a perforation in medium moves beneath the distal end of the sensor element, the end abruptly drops over the leading edge of the perforation and distorts or otherwise induces mechanical movement of its associated transducer. As the photoconductor 16 continues to move, the distal end 84 of the sensor element 83 is forced out of the perforation by engagement with the trailing edge of the perforation, and once again the sensor element distorts its associated piezoelectric transducer. By means of electrodes or other suitable current collecting means attached to the sensors, voltage signals generated by the distortion of the transducer are transmitted to the computer 74. Other types of perforation sensors which produce output signals such as optical perforation sensors or other types of ceramic transducers responsive to compression, bending or other forms of physical distortion may be substituted for the bimorph sensors shown.

Reviewing the operation of the apparatus 70, clock pulse signals produced by the bimorph sensor 76b on engaging the perforations 16b are coupled into the computer 74. For each such signal, the computer 74

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produces a pulse on start line 73 the leading edge of which resets the converter which permits the analog to digital converter 78 to receive an analog signal from the amplifier 72 and the trailing edge of the pulse initiates digital conversion. Upon completion of conversion, the converter 78 applies a pulse on lead 77 to the computer 74. The computer now accepts a word comprised of an appropriate number of parallel bits and applies such word into a core location of the computer 74 wherein it is stored. At the same time, the computer 74 couples the digital to analog converter 80 to another core location containing a previously stored word. One purpose of the computer is to store a digital word for that time interval needed for the corresponding increment of an image area to advance from the electrometer to the development station. This may be accomplished a number of different ways by taking advantage of different computer storage capabilities and/or utilizing differing programming techniques. The digital to analog converter 80 is adapted to continuously accept the digital signal stored in the particular core location to which it is coupled and reconvert it to an analog signal. This analog signal is applied by means of a high voltage amplifier 82 to the development station electrode 34.

It is a feature of the invention that by being responsive to clock pulse signals it automatically compensates for time delay errors created by any random variation in the photoconductor velocity. This insures that the correct value of bias is always applied to the developer station notwithstanding variations in the photoconductive velocity.

It will be appreciated by those skilled in the art that the subject invention has utility in a number of electrographic reproduction systems, including xerotyping, thermoxerography, and xerothermography, and in no way is dependent upon the physical form of the developer (viz, liquid or particulate) or the manner in which it is applied to the electrostatic image to render it visible.

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. A method for controlling the potential applied to a development electrode of a development station comprising the steps of:

- a. sensing downstream of the development station the charge level of longitudinal increments of a charged image area moving along a predetermined path at substantially a constant speed, and producing first analog signals representative thereof;
- b. converting said first analog signals to digital signals and storing same at particular storage locations; and
- c. reconvert after selected time delay each of said digital signals to a second analog signal and applying a corresponding potential to said second analog signal to said electrode.

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