

[54] **CONTINUOUS TONE PHOTOCOPIER**

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[58] Field of Search **355/10, 14, 27, 100, 355/106; 95/13, 14; 118/637; 117/37 LE**

[56] **References Cited**

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Primary Examiner—Samuel S. Matthews

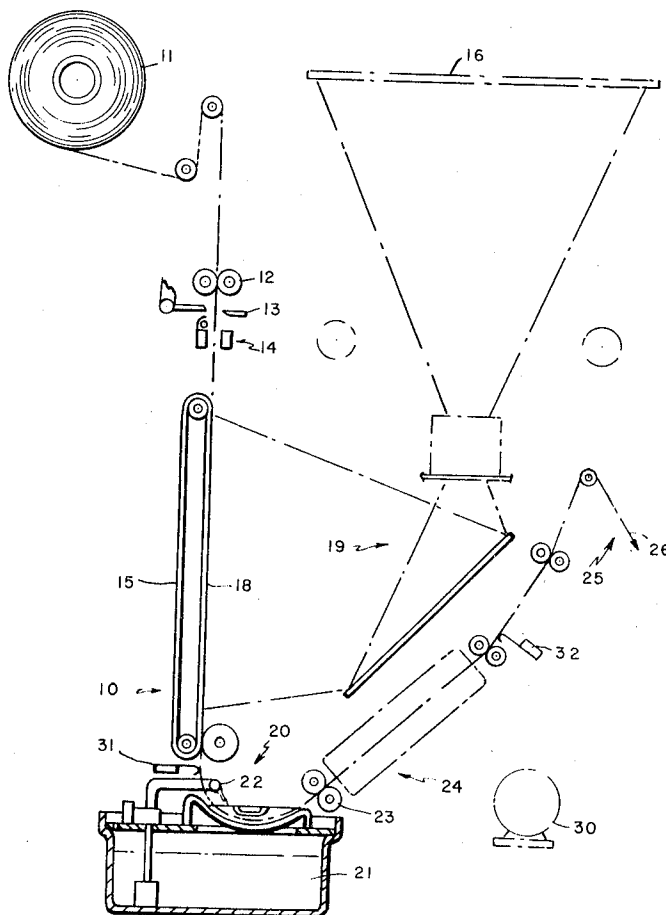
Assistant Examiner—Alan Mathews

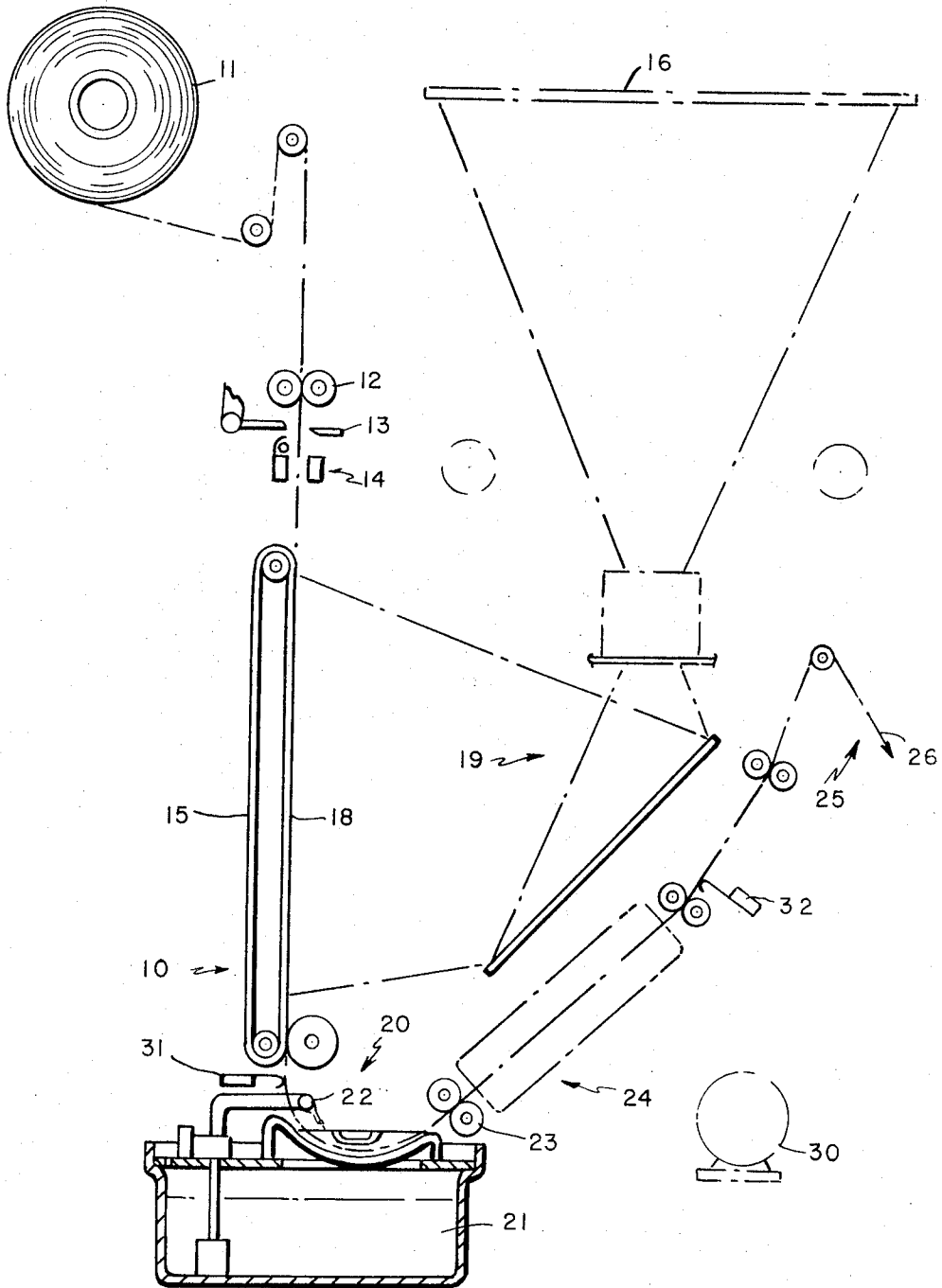
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[57] **ABSTRACT**

An electrostatic copier apparatus for reproducing continuous tone images which utilizes the effect of saturation, or near saturation, development of the latent electrostatic image by using in a preferred embodiment a two-speed motor which feeds the paper to the developer station at a first relatively fast rate of travel, feeds the paper through the developer station at a second relatively slow rate of travel to achieve such saturation, or near saturation, development, and thereupon feeds the paper from the developer station to the apparatus outlet at the first relatively high rate of travel to minimize the overall time spent in the reproduction process.

4 Claims, 1 Drawing Figure





CONTINUOUS TONE PHOTOCOPIER

This invention relates generally to photocopier apparatus of the type which utilizes paper adapted to produce electrostatic images and, more particularly, to an improved system for permitting the copying of continuous tone images through the use of a selected rate of travel of the exposed paper through the developing station in such apparatus.

Such apparatus and processes as used therein are described in the following texts, both of which serve as excellent background prior art material for the understanding of the invention: "Xerography and Related Processes", J. H. Dessauer and H. E. Clark, Focal Press Limited, London and New York, 1965 and "Electrophotography", R. M. Schaffert, Focal Press Limited, London and New York, 1965.

Moreover, although not limited thereto, one general form of a photocopier apparatus which can be broadly adapted to use the invention is illustrated by the type of apparatus generally shown in U.S. Pat. No. 3,425,777 previously issued on Feb. 4, 1969 to K.J. White. As can be seen therein, the apparatus includes a supply of paper adapted to produce electrostatic images which is fed through a charging station, such as one using a conventional corona discharge device, which places a uniform electrostatic charge on the paper coating. The electrostatically charged paper is then fed to an exposure station where it is exposed to an image of a record which is appropriately optically conveyed thereto via a suitable mirror and lens system. The exposed paper is then fed to a developer station which in a preferred embodiment utilizes a developer liquid which is appropriately applied to the image side of the paper to fix the image thereon. The developed image is then fed to appropriate drying and output delivery stations where the image is fixed and the paper is suitably dried and delivered to the user.

In such conventional photocopier apparatus it has been difficult to reproduce continuous tone images and such apparatus normally finds its best use in so-called line image reproduction systems where the image exhibits at best only a few steps on a standard 21-step photographic gray scale having increments of 0.15 optical density units. For example, where a standard silver halide developed photographic image may include up to a full 21 steps, a conventional electrostatic photocopier apparatus inherently produces a high contrast image which may include at most 4-7 steps on the gray tone scale. With the use of this invention, an electrostatic image having from 15-20 discernible steps on the gray scale has been achieved with the use of continuous tone paper for such purpose. Such continuous tone gradations in the gray scale permit excellent reproduction of continuous tone images, such as photographs, far more faithfully than with standard electrostatic photocopier apparatus.

In the invention it has been found that such results are achieved by utilizing a developer station in which saturation, or near saturation, development of the image occurs. That is, the image is permitted to remain in the developer liquid until full, or nearly full, development takes place. In order to achieve such saturation development, the exposed electrosensitive paper is fed through the developer station at a much slower speed than is normal with standard photocopier apparatus. However, in order to avoid the use of an excessive amount of time in the overall operation of the appara-

tus, in a preferred embodiment of the invention, a two speed motor is utilized to feed the electrostatic paper through the charging, exposure, and delivery stations at a relatively rapid rate of travel and to feed the exposed image through the developer station at a relatively slower rate of travel which latter rate is sufficiently low to permit saturation, or near saturation, development to occur. It is found that such an apparatus produces exceptionally fine copies of photographs or other continuous tone record images, with improved image density and a smooth transition between adjacent tones on the gray scale therein.

The invention is described in more detail with the assistance of the accompanying drawing wherein the sole FIGURE shows a diagrammatic view, partially in phantom, of an apparatus utilizing the invention.

Portions of the apparatus which are well known to those in the art are not depicted in detail therein. Thus, the FIGURE depicts a photocopier apparatus 10 which includes a supply roll 11 of paper having an electrostatically sensitizable coating on which an image is to be recorded. The paper may be in the form of a continuous roll, for example, which may have suitably spaced lateral perforations, which paper is appropriately conveyed by rollers 12, one of which is a drive roller driven by a motor 30 through suitable mechanical connections, such as a chain drive (not shown), to well-known cutting means 13 used to cut the paper to an appropriate length or to a device for tearing successive portions thereof at said perforations, if such perforations are used, into separate sheets of appropriate size. The separated sheets are then fed through a high voltage corona discharge device 14 which places a uniform electrostatic charge on the paper coating. The severed sheets are fed onto one or more endless perforated belts 15 through the perforations of which air is drawn in a well-known manner to a plate by a suitable suction pump (not shown). The belts, also driven by motor 30, carry the separated sheets along an image plane 18 to a pre-selected position at which the travel of such sheets is appropriately stopped and the sensitized paper is exposed to an image 16 to be recorded via mirror and lens system 19 shown diagrammatically in the FIGURE and the operation of which is well-known to those in the art.

Thence the exposed paper is fed to a developer station 20 which utilizes a suitable reservoir 21 of developer liquid and appropriate means for applying such developer liquid to one side of the paper as it enters the developer station. Such developer station is of a well-known configuration and is not further described in detail. Beyond the developer station the sheet is fed by rolls 23, also driven by motor 30, to drying and output delivery stations 24 and 25, respectively, where the developed image is fixed and the paper dried and thereupon delivered to a user at an outlet point 26. In conventional apparatus of this type, the driver rolls of the roll sets which drive the paper at each stage of its passage thereof through the machine are activated via appropriate belt or chain drives (not shown) by motor 30 which drives them at a constant speed through each of the stations (except for the time at which the paper stops for exposure at exposure image plane 18). Such speed is conventionally set to provide a rate of travel for the paper of approximately 4 to 6 inches per second and in a typical embodiment of a conventional photocopier apparatus of this type may be set at about 4.5 inches per second. In such an apparatus, however, it is

found that the reproduction of continuous tone images, even with the use of a suitable continuous tone paper which has been developed specifically for such purpose, is not very satisfactory, such images normally being not readily recognizable because the gray tone steps are not sufficiently discernible to permit a good image of the original record to be made.

In accordance with this invention, however, good reproductions of continuous tone images can be obtained by utilizing a slower rate of travel of the paper through the developer station so that saturation development, or near saturation development, occurs. The effect is further enhanced if the electrostatically sensitized paper which is supplied by supply roll 11 is of a continuous tone type. As discussed more fully later, the effect can be even further enhanced if a relatively high concentration of toner particles is used in the developer.

In a preferred embodiment of the invention wherein it is desired to obtain full advantage of the concept of saturation, or near saturation, development for continuous tone images while at the same time avoiding the undesirable long travel time of the paper from the supply roll to the outlet of the machine, motor 30 is selected to be a two-speed motor. Additionally, with the single speed motor as used in conventional copier apparatus of this type replaced by such a two-speed motor, an appropriate switching mechanism 31 is placed at or near the entrance to the developer station 20. As the leading edge of the paper contacts switch 31 in passing from the exposure station into the developer zone, the motor is switched from a first speed to a second speed such that the rate of travel of the paper, which up to the developer station has been maintained at a relatively fast value as determined by such first speed, is changed to a new relatively slow rate of travel through the developer station as determined by the second speed.

For example, the rate of travel from the supply roll through the charging and exposure stations up to the developer station may be set at a relatively high speed, such as in a range from about 2.0 to about 7.0 inches per second depending on the charging characteristics of the coated paper which is used, while the rate of travel through the developer station may be reduced to a relatively low speed in a range from about 0.1 to about 1.5 inches per second, depending on the concentration of toner concentrate which is used. For example, for a concentration of 15-20 cc. of toner concentrate per quart of carrier liquid, a range from 0.3 to 0.5 inches per second, and preferably 0.4 inches per second has been used successfully. For concentrations up to 40 cc. per quart of liquid rates of travel as high as 1.5 inches per second can be used.

These relatively high concentrations of toner concentrate can be contrasted to the concentrations currently in use. For example, concentrations of approximately 1-4 cc. of toner concentrate per quart of carrier liquid are conventionally used. Appropriate relationships between toner concentration and paper rate of travel can be determined by those in the art to optimize operation for particular applications; the higher the concentration the less time required for development, and vice versa.

A second switching device 32 may be located at a position beyond the developer station 20 which switch thereupon changes the motor speed back to its first higher speed value. Thus, switch 32 may be located at

a position such that when the trailing edge of the paper has just left the developer station 20, switch 32 is activated by the leading edge thereof. For example, in one embodiment such location may be at some point beyond the drying station 24 so that the rate of travel of the paper after it has completely left the delivery station resumes at its previous rate of 3 inches per second until it is delivered to outlet point 26.

Thus, in the particular embodiment of the invention described, the relatively slow rate of travel through the developer permits effectively full saturation development of the image, while the use of the higher speed through the remainder of the apparatus permits the overall time of travel of the paper from supply roll to outlet to be set at a reasonable value.

A further variation in the apparatus of the invention may be used by permitting the paper to travel at a relatively high rate up to its entrance into the developer station, as above, and then to make the rate of travel through the developer station effectively zero by stopping the paper while substantially completely immersed in the developer solution for a selected time period sufficient to provide appropriate saturation, or near saturation development, and then to resume the paper travel at the same relatively high rate from the developer station to the outlet point. In such an embodiment the developer station must be sufficiently large in dimension to accommodate a substantial portion of the entire image bearing surface of the paper at the same time. Thus, the time for any portion of the image to travel the length of the developer station and the time that such portion remains in a stopped position in the developer must be sufficient to produce the desired results.

What is claimed is:

1. A copier apparatus for providing continuous tone copies of a record image comprising:

means for supplying paper having a coating on which an electrostatic image is to be developed, said paper being a continuous tone paper;

means for charging said coating on said paper;

means for exposing said charged paper to a record image to be copied so as to form a latent electrostatic image corresponding to said record image thereon;

means for developing said latent electrostatic image to form a fixed image on said paper;

means for drying said developed paper and for delivering said developed paper to the outlet of said apparatus;

two-speed motor means for feeding said paper at a first rate of travel from said supplying means through said charging means and said exposing means to said developing means and at a second rate of travel through said developing means, said second rate of travel always being relatively smaller than said first rate of travel for providing substantial saturation development of said image; and

means for switching said motor speed from a first value which produces said first rate of travel to a second value which produces said second rate of travel substantially when said paper enters said developing means.

2. A copier apparatus for providing continuous tone copies of a record comprising:

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means for supplying paper having a coating on which an electrostatic image is to be developed, said paper being a continuous tone paper;

means for exposing said charged paper to a record image to be copied so as to form a latent electrostatic image corresponding to said record image thereon;

means for developing said latent electrostatic image to form a fixed image on said paper;

means for drying said developed paper and for delivering said developed paper to the outlet of said apparatus;

means for feeding said paper at a first rate of travel from said supplying means through said charging means and said exposing means to said developing means and at a second rate of travel through said developing means, said second rate of travel always being relatively smaller than said first rate of travel for providing substantial saturation development of said image; and

means for feeding said developed paper from said developing means to said outlet at said first rate of travel.

3. A copier apparatus for providing continuous tone copies of a record image comprising:

means for supplying paper having a coating on which an electrostatic image is to be developed;

means for charging said coating on said paper;

means for exposing said charged paper to a record image to be copied so as to form a latent electro-

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static image corresponding to said record image thereon;

means for developing said latent electrostatic image to form a fixed image on said paper, said developing means including means for applying a liquid developing solution to said latent electrostatic image, said solution comprising toner concentrate in a carrier liquid, the concentration of said toner concentrate being within a range from about 15 to 20 cc per quart of carrier liquid;

means for drying said developed paper and for delivering said developed paper to the outlet of said apparatus; and.

means for feeding said paper at a first rate of travel from said supplying means through said charging means and said exposing means to said developing means and at a second rate of travel through said developing means, said first rate of travel being in a range from about 1.0 to about 7.0 inches per second and said second rate of travel being in a range from about 0.1 to about 1.5 inches per second, thereby providing substantial saturation development of said image.

4. An apparatus in accordance with claim 1 and further including means for switching said motor speed from said second value to said first value substantially when said paper substantially entirely leaves said developing means.

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