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van der Sterren

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[54] **PHOTOCONDUCTIVE BELT DEVICE AND ELECTROPHOTOGRAPHIC PROCESS AND APPARATUS UTILIZING THE SAME**

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[21] Appl. No.: **370,680**

Related U.S. Application Data

[63] Continuation of Ser. No. 226,413, Feb. 15, 1972, abandoned.

[30] **Foreign Application Priority Data**

Apr. 29, 1971 Netherlands 7105941

[52] **U.S. Cl.** ..... **96/1 R;** 96/1.5; 355/16

[51] **Int. Cl.²** **G03G 13/22;** G03G 15/22

[58] **Field of Search** ..... 96/1 R; 226/118; 270/61 F; 355/64, 15, 16, 3, 11, 13, 14, 17

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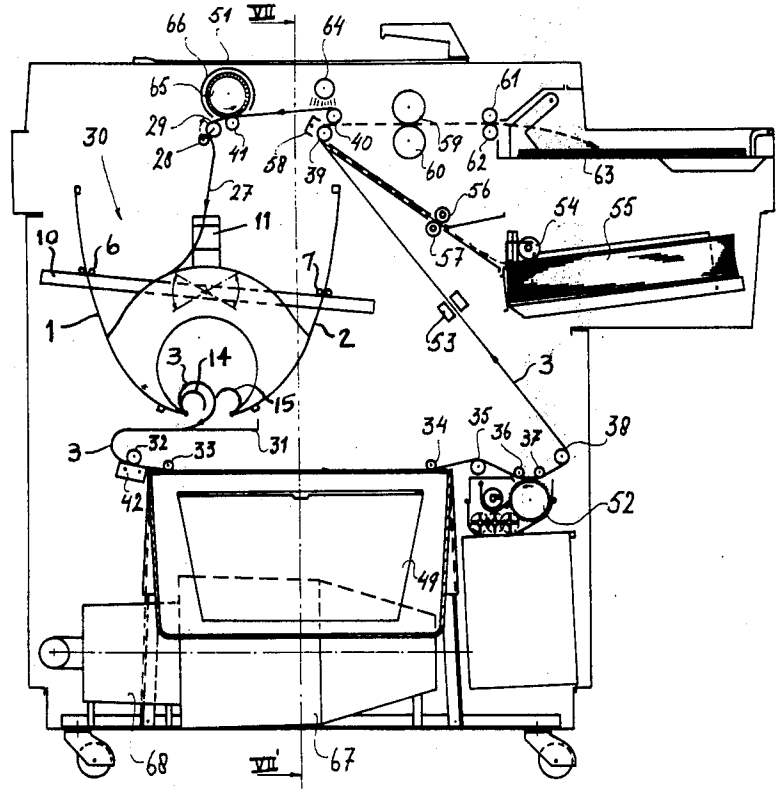
Primary Examiner—Fred L. Braun

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[57] **ABSTRACT**

A very long endless belt of flexible photoconductive sheet material pre-folded in zigzag manner so that the belt sections between the fold lines are disposable one upon another in a stack is utilized for indirect electrophotographic copying in a process and apparatus whereby the belt is moved progressively from one end of a stack composed of a large number of zigzag-folded sections thereof through a processing path and then back onto the other end of the stack for a period of storage in the stack. Meanwhile, the individual belt sections are subjected successively in said path to processing steps, including imagewise exposure and image transfer steps, for the production of zerographic copies on receiving material which may be ordinary paper. The invention enables the use of inexpensive photoconductive sheet material for repeatedly making developable latent images of originals, even though the photoconductive substance employed in the belt material shows memory effect. It also enables use of highly efficient flash exposure instead of slit exposure.

18 Claims, 5 Drawing Figures



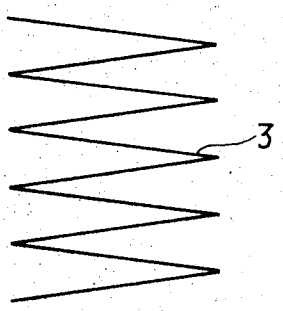


Fig.1a

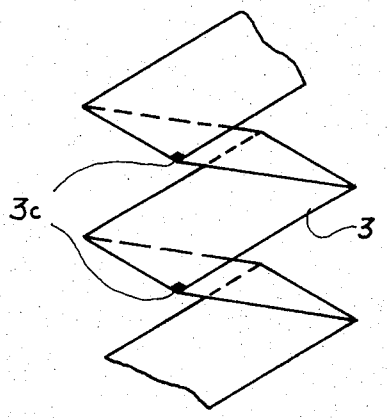


Fig.1c

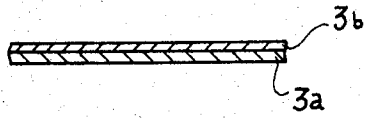


Fig.1b

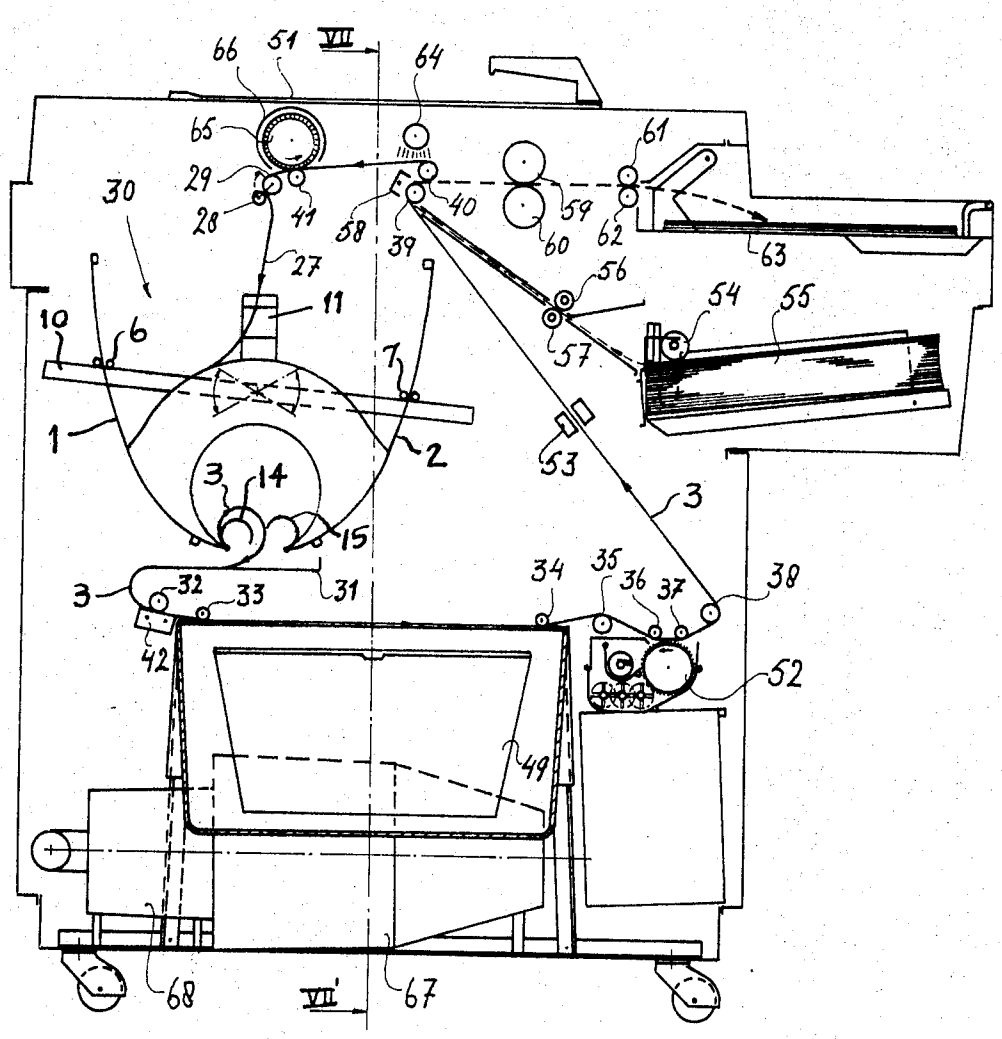

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VII
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VIII'
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Fig. 2

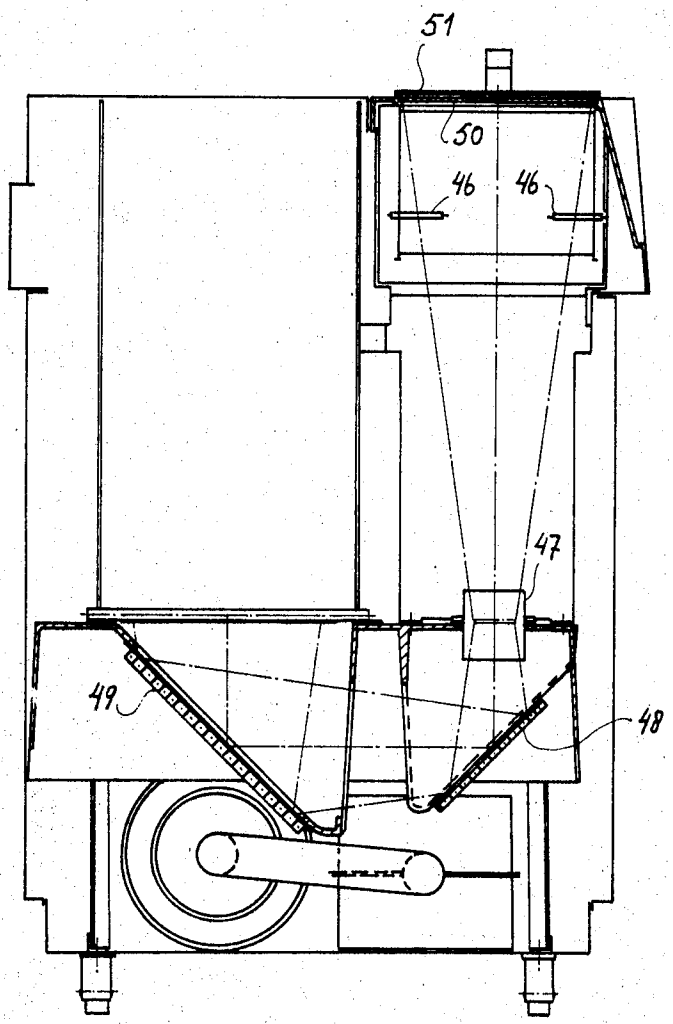


Fig. 3

PHOTOCONDUCTIVE BELT DEVICE AND ELECTROPHOTOGRAPHIC PROCESS AND APPARATUS UTILIZING THE SAME

This is a continuation of application Ser. No. 226,413, filed Feb. 15, 1972, now abandoned.

This invention relates to a photoconductive element in the form of a zigzag-folded belt and to a process and apparatus making use of such belt for the production of copies of originals by indirect electrophotography, or zerography.

In electrophotographic copying processes, use is made of a photoconductive element the electrical resistance of which is varied by exposure to light. As a rule, imagewise exposure causes the formation of a conductivity image, in that the areas struck by light have greater conductivity for an electric current than the unexposed image areas. If the photoconductive surface is charged before imagewise exposure, a charge pattern constituting a latent image results. Such a latent image may be transferred to another element or may be developed by various methods to produce a copy having visually contrasting image areas corresponding to those of the original that was projected onto the photoconductive element.

Direct electrophotgraphy refers to those processes in which a developed image is affixed to the photoconductive surface to give the required copy. For direct electrophotography, use is commonly made of a photoconductive element obtained by coating paper with a photoconductive element obtained by coating paper with a photoconductive insulating layer of zinc oxide dispersed in an organic film-forming binder. By means of powder or a developing suspension a charge pattern formed by charging and imagewise exposing the photoconductive layer is converted into a visible image which is affixed to the zinc oxide layer.

When a copy is made by transferring a latent image, such as a charge pattern, or a powder image to a receiving paper, the process is referred to as indirect electrophotography. The most important advantage of indirect electrophotography is that it will produce copies on ordinary paper.

In indirect electrophotography as it is practised on a large scale in xerography, the photoconductive element generally consists of a metal drum coated with a layer of amorphous selenium. Around the drum are arranged a number of processing units. The first unit builds up a uniform electrostatic charge on the photoconductive layer and, subsequently, an image is projected onto that layer. The latent image, or charge pattern, thus obtained is developed by causing a toner, usually mixed with carrier beads, to flow thereonto. Under the influence of an electric field the powder image thus formed on the drum is transferred to a sheet of paper and is affixed thereto by heating. The photoconductive layer is then passed through a unit which removes toner that was not transferred, whereupon the layer may be reused for making a next copy.

The abovementioned xerographic process is disadvantageous in that the copying apparatus required is expensive and often unsatisfactory in use, due, inter alia, to the selenium drum being susceptible to marring and wear. In addition, slit exposure must be used for projecting the original to the rotating drum. Such exposure requires a complex optical system with moving

mirrors and/or lenses, especially if it is to serve for copying pages of books.

The necessity of using slit exposure can be avoided by employing an endless belt as the photoconductive element and effecting exposure on a flat portion of the moving belt, as disclosed in U.S. Pat. No. 2,551,582. The guidance of such a belt, however, presents problems because the belt tends to shift laterally, due to differences in web tension occurring unavoidably over its width. In addition, the short belt to be used would be continuously bent and re-straightened, causing rapid damage to the photoconductive coating and thus a considerable limitation to the number of copies obtainable. Added to these problems of guiding the belt and of mechanical deterioration of the photoconductive layer, there is still a severe limitation upon the choice of the photoconductor, for in such a system it must not show memory effect.

It is the object of the present invention to provide a photoconductive belt element for indirect electrophotography and an electrophotographic copying process and apparatus making use of this belt, which enable inexpensive photoconductive sheet material to be used for the production of developable latent images even though the photoconductor of the material exhibits memory effect, and by which the use of slit exposure can be avoided.

This object is achieved according to the invention by providing and utilizing as a photoconductive element for indirect electrophotographic copying a continuous belt of flexible photoconductive sheet material prefolded in zigzag manner so that the successive sections thereof between the folds thereof are disposable one upon another in a stack. The invention makes use of such a zigzag-folded photoconductive belt in endless form in an indirect electrophotographic process, and in apparatus for carrying out the process, by which the individual sections of the belt are exposed imagewise in order to change the electric properties in the exposed areas of each exposed section so that a developable latent image is formed thereon.

The zig-zag-folded belt so provided and utilized may be of great length, so that a very great number of copies can be produced before the belt has to be replaced. The guidance of such a belt presents few problems because a definite tension needs be exerted on only a small portion of its length, viz. on a portion of it disposed in a processing path away from the stack. Each of the sections between successive fold lines, when being moved in said path for the copying process, is subject to bending stresses for a short time only. The imagewise exposing of each section of the belt may be effected by unitary, i.e. full frame, exposure which can be a flash exposure effected while the belt is in motion, thus avoiding the delay and the complexity of slit exposure. Furthermore, each section of the belt may be used for making one copy at a time, a following section being used for making the next copy; and before a section once so used is used again it may be stored for a very considerable period of time as part of a stack composed of a large number of successive sections of the belt disposed one upon another between their zigzag folds.

By virtue of this storage period, the photoconductive material, even though it makes use of a photoconductor showing memory effect, is given time enough to recuperate, i.e. to adapt itself to the dark, before it is reused; so all copies are of a consistent good quality. This

feature of the invention is highly beneficial, for most of the photoconductors commonly used — layers of amorphous selenium obtained by evaporation being an exception — show memory effect, which means that, after exposure, their conductivity still remains rather high for a considerable length of time, and if they are exposed again in that condition the photoconductive layer is charged less highly than before and the charge flows off more quickly, as a result of which less contrasty copies are obtained.

For carrying out the invention, the photoconductive belt is assembled with its successive sections between the zigzag folds disposed one upon another in a stack thereof containing, for instance, from 500 to 1500 of said sections. Each section of the belt is formed to a size enabling it by imagewise exposure to form a latent image of an original of any size up to that of the largest copies to be produced in the copying operations. For instance, where copies of A4 size are the largest required, the belt width may be greater than 210 mm., e.g., of approximately 250 mm., and the length of each section may be greater than 297 mm., e.g., of approximately 350 mm.

The stack of superimposed belt sections is stored in a magazine, and a length of the belt is disposed in a path extending from one end of the stack through a series of processing stations and thence back into the magazine where the incoming belt portion joins with a section of the belt on the other end of the stack. Means are provided for propelling the belt through the said path, including means acting upon the belt as it is fed back into the magazine for depositing it upon said other end of the stack in successive sections disposed one upon another between their zigzag folds. At the several processing stations traversed by the belt as it is moved through said path, the apparatus is provided with means for subjecting the belt to processing steps of kinds known to be useful for making copies electrophotographically.

The particular steps and means to be provided at the processing stations of a given apparatus depend upon the particular copying method desired to be employed. In general, one of the processing stations is provided with means for imagewise exposing, such as to light projected in an integral pattern from an original to be copied, any of the sections of the belt brought into that location; while another of the processing stations is provided with means for transferring to a receiving material either the latent image, or charge pattern, formed on each such exposed section or a visible image developed from such latent image.

When the copies are to be made by powder transfer, the apparatus is preferably provided with means for electrostatically charging the belt at a station preceding the exposing station and with means at a station following the exposing station for applying toner to the belt so as to form a powder image on each exposed section thereof. In such case, the image transferring means serve to transfer each such powder image to a receiving paper, to which the powder image may be affixed as by a heating device. Then at further stations of the belt path, by suitable means of known nature, remnant electrostatic charges and remnant toner are removed from the belt before it passes into the magazine for a period of storage as part of the stack held therein.

When zinc oxide is used as a photoconductor in the belt material, the electrostatic charge applied before exposure is a negative charge.

The imagewise exposure preferably is effected episcopically and integrally, i.e., as full frame exposure, by means of a flash exposure of at most 0.01 second in duration — ordinarily of the order of 100 to 1,000 microseconds. The use of flash exposure avoids the necessity of stopping the belt during exposure. Of course, slit exposure can be used if desired.

Each exposure should be effected so as to produce the latent image on a flat section of the belt between two successive folds thereof. To that end, use may be made of scanning means which, for determination of the proper moment of exposure, will generate a signal by detecting the location of markings existing on or applied to the photoconductive belt. In a practical embodiment, the folds may function as detectable markings. The location of the folds may be detected, e.g., by a photoelectric cell. Further to ensure proper functioning, a marking, e.g., a dark colored or black mark on a white or light colored belt, may be applied to the belt on or near to each fold, or alternate folds. When passing a photoelectric cell this mark causes a signal to be created which determines the moment of exposure, e.g., via an electric circuit. The deposition of the belt back into the magazine as well as the feeding and delivery of the receiving paper may be similarly controlled.

The latent image is developed in a usual way. For example, a latent electrostatic image may be developed by a cascade of toning power, by using a magnetic brush, or by a liquid developer. Preferably, development is effected by a magnetic brush system. This allows the photoconductive layer, after image transfer, to be freed more easily from remnant developer, or toner particles, than when using a liquid developer. Also, a power image can be easily transferred onto a receiving material without spreading of the image, and the edge effect is small with this developing method. The toner in the developer preferably has a charge opposite to that of the latent image, as a consequence of which positive-to-positive copying is obtained.

The powder image is transferred to a receiving material, preferably a sheet of ordinary paper, in a manner known per se. The transfer may take place, e.g., under the influence of an electric field obtained from a corona discharging onto the back of the belt sandwiched with the paper, or simply by pressing the paper against the belt, in which case the paper surface may be coated with an adhesive layer. If the toner used in the developer has magnetic properties, the transfer can take place under the influence of a magnetic field. Finally, the powder image transferred to the sheet of receiving paper is fixed thereon. Generally the toner contains a fusible resin and fixing is effected by heat. The copy then is ready to be delivered from the apparatus.

The toner remaining on the belt after transfer of the powder image is removed by a brushing operation using a magnetic brush free from toner, or by an air knife, preferably after the remnant toner particles have been discharged by a corona discharge. This corona discharge is employed in order to remove remnant electrostatic charges from the used section of the belt so that it will be able to accept a uniform charge before being again imagewise exposed in a later operating cycle.

The belt section which has just been used is then moved into the magazine where it can fully adapt itself to the dark before being reused. Meanwhile, another copy is produced in the way described above, by use of a following section of the belt.

The copying process to be employed may differ in various respects from that just described.

For example, when the belt according to the invention is made by use of a photoconductor which shows memory effect, such as from paper coated with a photoconductive layer containing ZnO, the photoconductive layer need not be charged before exposure, but may be exposed directly upon being delivered from the magazine. This results in a conductivity image that may either be charged to build up a latent electrostatic image or be developed directly. Development of latent conductivity images is commonly known and has been exhaustively described in literature. For such development, the photoconductive material prior to being exposed should be perfectly adapted to the dark. This is easily achieved according to the invention by the storage in the magazine of a used section of the endless belt as a part of a stack of many sections thereof.

In another modification, the latent electrostatic image may be transferred to a dielectric material and subsequently developed thereon. This is advantageous in that the photoconductive layer is subject to hardly any further mechanical loads in connection with development and, consequently, it can produce many more copies than otherwise before needing to be replaced. The transfer of charge patterns is commonly known, too; see, e.g., *Dessauer and Clark*, "Xerography and Related Process" (The Focal Press, London and New York, 1965).

The fixing of the powder image may be effected otherwise than by heat. For example, this may be effected by means of a solvent for the resin of the toner, or by exposing the powder image to the vapor of such solvent.

While magazines of various forms may be used for receiving, storing and delivering the sections of the belt stored in a stack according to the invention, a magazine especially suitable for the purpose is disclosed in a copending application of Hubertus J. van Megen and Willem P. H. A. Janssen, Ser. No. 226,870 filed Feb. 16, 1972, now U.S. Pat. No. 3,756,488.

The foregoing and other objects, features and advantages of the invention will be further apparent from the following detailed description and the accompanying drawings of an illustrative embodiment thereof. In the drawings:

FIGS. 1*a*, 1*b* and 1*c* are schematic views in side elevation, cross-section and perspective, of portions of a zigzag folded belt according to the invention;

FIG. 2 is a schematic vertical cross section through a copying process according to the invention wherein use is made of a zigzag-folded endless belt; and

FIG. 3 is a sectional view of the same apparatus as viewed approximately along the line VII—VII' of FIG. 2.

The zigzag-folded belt according to the invention is composed of a photoconductive sheet material which, as shown in FIG. 1*b*, comprises a support 3*a* and a photoconductive layer 3*b*. As indicated in FIG. 1*c*, further markings 3*c* are applied to the belt adjacent to folds thereof to facilitate detection of the location of its fold lines by optical scanning means.

The support 3*a* of the belt may be a band of any material that can be folded, retain the fold and withstand frequent unfolding and refolding. Paper, synthetic paper and plastics may be used as the support material, but paper is preferable.

The photoconductive layer 3*b* is coated on the support and preferably is a layer of a finely divided photoconductor dispersed in a binder. Any known photoconductor substance, inorganic or organic, may be used as the photoconductor. Selenium, zinc oxide, cadmium sulphide and poly-N-vinylcarbazole are examples of effective photoconductors. For a detailed specification of suitable photoconductors reference is made to pages 165 and 170 of *Dessauer and Clark*, supra. The photoconductor is dispersed in an insulating, film-forming binder which is selected so that the layer formed will be flexible. Organic or inorganic binders (e.g. glass binders, silicones or thermoplastics) may be used. Suitable binders are specified on page 165 of *Dessauer and Clark*. In order to extend the light-sensitivity of the layer to a greater part of the spectrum, dye sensitizers may be added to the layer. Examples of such sensitizers are: Acridine Orange, fluorescein, eosine, Rose Bengal, methylene blue, Rhodamine B, and others noted on page 136 of *Dessauer and Clark*.

While in the direct electrophotographic process, due to the requirement that the photoconductive layer look almost white, the amount of a sensitizer to be added to the photoconductive layer should be very small and useful combinations of dye sensitizers are limited, these limitations do not apply to the photoconductive layer useable according to the invention. They do not, because the final copies are obtained on ordinary paper and not on the photoconductive belt material. Hence a considerably greater latitude is available in selecting the kind and amount of sensitizers. Furthermore, activators for increasing the light-sensitivity may be added; for instance, the Lewis-acids, which can form charge-transfer complexes with the photoconductor, excel for that purpose.

According to a preferred embodiment of the invention the photoconductive layer of the belt material is made of zinc oxide dispersed in a binder which is a mixture of polyvinyl acetate and an acrylic resin to which an activator and a sensitizer have been added.

The photoconductive belt, made for example as a long continuous band of a paper or a plastic composition coated with a photoconductive layer, is pre-folded in zigzag manner, as indicated schematically in FIG. 1*a*, so that the successive sections thereof between the fold lines are disposable one upon another in a stack. The length and width of each section between two successive folds are made slightly greater than the size of the largest copies required to be produced in the use of the belt. If such copies are of A4 size (210 mm × 297 mm), the sections are given a size of approximately 250 mm by 350 mm.

While the belt can be given any length desired, a practical length is one of between 200 and 500 meters. If destined for making copies of A4 size, a belt of that length contains approximately 500 to 1,500 sections. Therefore, assuming that the photoconductive layer can be used for only about 300 times before the belt should be replaced, about 150,000 to 450,000 copies may be made by use of the one belt.

In a folded up form, with its many sections between the zigzag folds disposed one upon another, the belt forms a compact stack, or package, which is easy to handle. The belt in this form is mounted in the magazine of the copying apparatus, and a free end portion of the belt is threaded through the apparatus so as to dispose a length of the belt in a path extending from one end of the stack through the processing stations of the

apparatus and thence back into the magazine to the other end of the stack. When the belt has been so threaded for use, its free ends are joined together, e.g., by means of an adhesive tape having sufficient mechanical properties and folding endurance, thus making it into an endless belt.

The electrophotographic apparatus of FIGS. 2 and 3 makes use of a magazine 30 which corresponds substantially to the form of magazine shown in FIG. 3 of and described more particularly in the above-mentioned copending application.

This magazine holds a stack of superimposed sections of the zigzag folded belt, e.g., an endless belt of zinc oxide-binder coated paper, in upwardly bowed postures therein, with a length of the belt extending from the lowermost section of the stack through a delivery opening at the bottom of the magazine, thence through a path traversing the several processing stations, and thence back into the magazine as indicated at 27 for redeposition on the top of the stack.

The belt may be drawn continuously through the processing path, and redeposited in the magazine, by the driving action of rollers 28 and 29 and the transporting and guiding actions of a guide plate 31 located beneath the magazine and rollers 32, 33, 34, 35, 36, 37, 38, 39, 40 and 41 which define the path of travel of the belt.

As the belt travels away from the magazine an electrostatic charge is first deposited on it at a charging station, e.g., by means of a corona discharge unit 42 opposite roller 32.

Then the belt is drawn over a flat exposing table, upon which a portion of the belt at least as large as a section of it between two fold lines is stretched out flat between rollers 33 and 34 at opposite ends of the table. By means of flash lamps 46, lens 47, and mirrors 48 and 49 the image of an original which is placed between a glass plate 50 and a cover 51 is projected on the charged portion of the belt extending over the exposing table. That portion of the belt is thus exposed so that the charge on its surface disappears imagewise and a charge pattern of the original is formed as a latent image thereon.

Upon further movement of the belt the portion carrying the latent image passes through a developing station where toner is applied to it by means 52 of the well-known magnetic brush type. The charge pattern of the latent image is thus converted into a powder image.

Then the portion carrying the powder image is passed onward to a transfer station at roller 39, meanwhile being moved past the beam of a photocell unit 53 which responds to the presence of a marking 3*c* (FIG. 1*c*) on the belt by emitting a signal. Upon that signal, a roller 54 is caused to push a sheet of copy paper from a stack 55 in the direction of feed rollers 56 and 57. These feed rollers grip the paper sheet and propel it forward with such a velocity that it reaches roller 39 at the same moment as the leading edge of the powder image on the belt. Thus the powder image and the copy paper run together around the roller 39, and during this movement the powder image is transferred to the copy paper under the influence of an electric field generated by a corona discharge unit 58.

After traversing the transfer station the belt and the copy paper are separated from each other, the belt being turned around roller 40 while the copy sheet, which now carries the powder image, run straight onward into the nip between heated rollers 59 and 60. These rollers constitute a heat fixing station of a well known type. After they have fixed the powder image to the copy paper, the resulting copy is gripped by rollers 61 and 62 and delivered onto a table 63.

Beyond roller 40 the belt is moved under a lamp 64 which irradiates the belt in order to remove any residual charge from the photoconductive layer, and thereafter it is passed through a cleaning station where a rotating brush 65 working against guide roller 41 cleans the belt by wiping away any remaining powder. Brush 65 is surrounded by a shield 66 which by piping (not shown) is connected through an air pump 67 with a filter bag 68. The removed powder is thus sucked away from brush 65 and collected in bag 68.

From the cleaning station the used portion of the belt, now freed of remnant electrostatic charges and remnant toner particles, is drawn between the rollers 28 and 29; and from them it is fed into the top of magazine 30 so as to be deposited upon the upper end of the stack therein as a section of the belt extending between two successive folds thereof which are disposed on opposite portions of guide structures that define the storage space of the magazine.

The photocell 53 or an equivalent optical scanning means for detecting the presence of a fold the the belt is so located in relation to the location of the exposing table that a signal from such scanning means will cause the flash lamps 46 to act only when the whole of a section of the belt between two successive folds thereof is disposed on the exposing table. Thus each latent image is always formed on a flat section of the belt between its fold lines. This is important because the photoconductive layer of the belt may be damaged at or immediately adjacent to the locations of the zigzag folds.

Referring now to particulars of a preferred form of the magazine, FIG. 2 shows a magazine formed principally by two oppositely disposed upright guide structures, or walls, 1 and 2 which define therebetween a space for storing a stack composed of a large number of zigzag folded sections of the belt 3 disposed one upon another. These guide structures are spaced apart at an upper level of said space by a distance less than the length of each section of the belt, and they converge each toward the other in downward direction to the level of a delivery opening defined between their lower ends. They have smooth inner surfaces which in the vicinity of said upper level may be almost straight but which, as they progress downward, are smoothly curved inward the center line of said space and are provided with greater inward curvature, or a smaller radius thereof, at their lower ends than at any higher level.

The folds pre-formed in the belt 3 tend when the belt is slack to bring it into a zigzag-folded condition but are sufficiently elastic that they will flatten out in the path of the belt between conveyor rollers. At the opposite side edges of the stack formed in the magazine there are upright guides 11 which confine the belt material laterally to the desired location but normally need not come into contact with the material.

At each side of the magazine there is also a rockable arm 10 which is pivoted on a frame member near to one of the guides 11. The ends of the arms 10 extend beneath protruding ends of substantially horizontal rail members 6 and 7 which are disposed at the inner surfaces of the guide walls 1 and 2 and are movable up and down along the upper regions of these surfaces in limited paths. The rail members may have the form of round rods, or of rollers.

As the belt 3 is deposited from the feed rollers 28, 29 into the magazine, the arms 10 are rocked synchronously by any suitable motor device so that their ends oscillate between upper and lower positions thereof. When the left-hand ends of the arms are raised to the upper position, their right-hand ends are in a lowered position in which they let the rail member 7 rest upon and press down along the inside of wall 2 a fold of the belt previously deposited against that guide structure. The second following fold of the belt is then being deposited to the same side of the magazine.

The rocking of the arms now moves their left-hand ends downward, thus placing the rail member 6 upon the fold last previously deposited against the inside of wall 1 so as to press that fold downward, while the right-hand ends of the arms are moved upward so as to lift member 7 to and past the location of the incoming fold. The rising rail member 7 easily traverses the fold then being deposited, thus reaching an elevated position above it so that, in the next half-cycle of the arm movements, member 7 will move down onto that fold and press it down upon the folds of the belt sections already stacked in the magazine.

It results that each incoming belt section between two successive folds of the belt has its folds positioned downwardly along opposite portions of the guide structures 1 and 2 so that it is layed in upwardly curved posture upon a stack of sections of the belt previously bowed upwardly in the belt storage space of the magazine.

The guide structures 1 and 2 as shown in FIG. 2 are provided with means on their lower ends for arresting downward movement, at the level of the delivery opening, of the folds of the lowermost belt section in the stack. These means comprise threshold members 14 and 15, formed as curved extensions of said lower ends, which present upwardly extending surfaces to arrest those folds, until they are drawn out of the magazine, at a location thereof in which the belt section between them is bowed upwardly in a highly arched posture. The threshold members merge into the walls 1 and 2 via relatively sharply curved valleys.

The upwardly bowed postures given to the belt sections stacked in the magazine are such that these belt sections in effect appear to stand on their respective folds disposed on opposite portions of the guide structures 1 and 2. The guide structures themselves converge in downward direction along inwardly curved planes that roughly follow the contours to which the folds of the stacked belt sections tend to adapt themselves, while the folds of the lowest sections of the stack are pressed somewhat farther inwards than accords with their natural posture.

Consequently, only a very small part of the weight of the stack is borne by the belt section located at the bottom of the stack in position to be drawn through the delivery opening, and there is little frictional resistance to the delivery of the stored sections of the belt from the magazine for movement again through the processing stations of the copying apparatus. When the fold-engaging surfaces of the magazine are made very smooth, for example, by chromium-plating them or lining them with Teflon, plush, or the like, the total frictional resistance to sliding of the belt sections down along the guide structures and over the threshold members is very slight indeed.

What is claimed is:

1. Means for indirect electrophotographic copying comprising a long belt of continuously uniform flexible photoconductive sheet material which has been prefolded transversely at regular intervals in a zigzag manner so as to be subdivided by the successive fold lines into a great number of belt sections each slightly larger than the largest copy to be produced, each of said sections having a size and photoconductive properties enabling it by imagewise exposure to light from an original to form a latent image of the original that is transferable from it to a receiving material or is developable into a visible image so transferable, said sheet material being one that exhibits memory effect, said belt being folded zigzag on said fold lines to constitute a stack containing and keeping in the dark a great number of said belt sections disposed one upon another, so that any of said belt sections which has been exposed to light before being folded onto said stack will become substantially rid of memory effect during storage in said stack, the ends of said material being joined together to render said belt endless, said belt having a minor portion of its length extending lengthwise away from one end of said stack into and through a path passing a series of electrophotographic processing stations and thence onto the other end of said stack.

2. Means according to claim 1, said sheet material comprising a paper band coated with a photoconductive surface layer that exhibits substantially the memory effect of photoconductive zinc oxide and said stack being composed of from 500 to 1500 of said belt sections disposed one upon another between their respective zigzag fold lines.

3. Means according to claim 1, each of said belt sections having a length of substantially 350 mm. and a width of substantially 250 mm.

4. Means according to claim 1, said belt having preformed thereon at intervals corresponding to those of said fold lines permanent markings which are detectable by an optical scanning means.

5. Means according to claim 1, said material comprising a band of paper coated over one side thereof with a photoconductive layer containing a photoconductor that exhibits substantially the memory effect of photoconductive zinc oxide, said stack being composed of from 500 to 1500 of said belt sections disposed zigzag one upon another between their respective pre-formed fold lines, each of said belt sections having a length of substantially 350 mm. and a width of substantially 250 mm., said belt having pre-formed on a side thereof at intervals corresponding to those of said fold lines permanent markings which are detectable by an optical scanning means.

6. A process of indirect electrophotographic copying which comprises:

storing in the dark most of the length of a long endless belt of flexible photoconductive sheet material that exhibits memory effect and that has been prefolded zigzag on transverse fold lines at regular intervals throughout its length so as to be subdivided by the successive fold lines into individual belt sections each slightly larger than the largest copy to be produced, said stored belt length being in a stack composed of a great number of said belt sections folded zigzag one upon another on the respective fold lines bordering them and the remaining, minor portion of the length of said belt being extended lengthwise from one end of said stack through a processing path passing a series of electrophoto-

graphic processing stations and thence onto the other end of said stack;

for each copying operation: imagewise exposing one of said belt sections at one of said stations to light from an original so as to form on the exposed belt section a latent image of the original, transporting said extended belt portion lengthwise through said path so as to move said exposed belt section past further of said stations, thus correspondingly drawing from said one stack end into said path aforesaid belt sections trailing said exposed section and depositing onto said other stack end aforesaid belt sections leading said exposed section, and at another of said stations transferring from said exposed section to a receiving material said latent image or a toner image developed on said latent image; said depositing being effected by folding the belt zigzag on the respective pre-formed fold lines bordering said leading belt sections;

continuing copying operations by subjecting to respective exposing, transporting and transferring steps as aforesaid individual belt sections aforesaid drawn from said stack into said path, thus in the course of continued copying operations transporting the entire length of said belt repeatedly through said path and said stack;

and maintaining in the dark in said stack such a great number of said belt sections that any one of them which has been exposed in said path will become substantially rid of memory effect during storage in said stack, before being again drawn from said stack for another exposure.

7. A process according to claim **6,** including for each copying operation electrostatically charging said belt as it passes a one of said stations ahead of said exposing station, at a one of said stations beyond said exposing station applying a developing toner to each exposed belt section to form a powder image thereon, at said another station transferring each such powder image to a receiving paper, and as said belt section passes further of said stations removing remnant electrostatic charges and remnant toner from said belt section.

8. A process according to claim **6,** said imagewise exposing being effected by subjecting an aforesaid belt section at said one section to full frame exposure while holding it flat in a substantially horizontal exposure plane.

9. A process according to claim **6,** said imagewise exposing being effected by subjecting an aforesaid belt section at said one station to a full frame flash exposure of at most 0.01 second in duration while keeping it in motion and holding it flat in a substantially horizontal exposure plane.

10. A process according to claim **6,** said sheet material comprising a paper band coated with a photoconductive surface layer containing a photoconductor that exhibits substantially the memory effect of photoconductive zinc oxide, said stack being composed of from 500 to 1500 of said belt sections and each of said belt sections having a length of substantially 350 mm. and a width of substantially 250 mm.

11. A process according to claim **6,** said belt sections being drawn from said stack to said exposing station in substantially uncharged condition, whereby the latent image formed by said imagewise exposing is a conductivity image.

12. A process of indirect electrophotographic copying which comprises:

storing in the dark a major portion of the length of a long endless belt composed of a flexible photoconductive sheet material comprising throughout its length a photoconductive surface layer that exhibits its memory effect, said belt being prefolded zigzag at regular intervals on transverse fold lines and thus subdivided into a great number of successive unbroken sections thereof each lying between two successive fold lines and slightly larger than the largest copy to be produced, said major portion of the belt length being folded zigzag on said fold lines thereof into a stack composed of the said sections thereof disposed one upon another;

guiding the remaining, minor length of said belt lengthwise from one end of said stack into and through a path passing a series of electrophotographic processing stations including an exposing station and a transfer station, and from said path onto the other end of said stack;

making copies repeatedly by, in each copying operation, imagewise exposing to light said surface layer of a section aforesaid of said minor belt length at said exposure station, drawing the exposed belt section along said path, and at said transfer station transferring from said exposed section to a receiving material a latent image formed on said exposed section by the exposure or a visible image developed from such latent image;

as each such exposed section is drawn along said path withdrawing correspondingly a fresh portion of said belt from said one stack end into said path and depositing correspondingly a leading portion of said belt from said path onto said other stack end by folding the said sections of said leading portion zigzag one upon another on their respective fold lines aforesaid, thus in the course of continued copying operations transporting the entire length of said belt repeatedly through said path and said stack;

and maintaining in said stack such a great number of said belt sections that any one of said sections which has been exposed in said path will be stored in the dark in said stack long enough to become substantially rid of memory effect before being again drawn from said stack into said path.

13. Apparatus for indirect electrographic copying, comprising a long endless belt of photoconductive sheet material pre-folded transversely at regular intervals in a zigzag manner so as to be subdivided by the successive fold lines into successive belt sections each slightly larger than the largest copy to be produced, a magazine storing a stack composed of and keeping in the dark a great number of said belt sections disposed zigzag one upon another between the successive folds, said belt having a minor portion of its length extending lengthwise away from said magazine at one end of said stack into and through a path passing a series of electrophotographic processing stations and thence back into said magazine to the other end of said stack, means for drawing said belt lengthwise from said one end of said stack and through said path while feeding it from said path onto said other end of the stack, including means for depositing said belt sections successively one upon another in said magazine at said other end by folding the belt zigzag on the respective pre-formed fold lines, means for imagewise exposing to light from an original any of said belt sections at one of said stations, and means at another of said stations for transfer-

ring an image from each such exposed belt section to a receiving material, said sheet material being one that exhibits memory effect and said stack containing so many of said belt sections that any one of said sections which has been exposed in said path will be stored in the dark in said stack long enough to become substantially rid of memory effect before being again drawn from said stack into said path.

14. Apparatus according to claim **13,** including means for electrostatically charging said belt at a one of said stations ahead of said exposing station, means at a one of said stations beyond said exposing station for applying a developing toner to each exposed belt station to form a powder image thereon, said means at said another station being means for transferring each such powder image to a receiving paper, and means at further of said stations respectively for removing remnant electrostatic charges and remnant toner from said belt.

15. Apparatus according to claim **13,** further including means along said path for holding flat and in a substantially horizontal plane at said exposing station a length of said belt at least equal to the length of each said belt section, said exposing means comprising means for subjecting the belt in said exposing plane to a full frame exposure from the original.

16. Apparatus according to claim **13,** further including means along said path for holding flat and in a substantially horizontal plane at said exposing station a length of said belt at least equal to the length of each said belt section, said exposing means comprising means for subjecting the belt in said exposing plane to a full frame flash exposure from the original of at most 0.01 second in duration.

17. Apparatus according to claim **16,** said belt having pre-formed thereon at intervals corresponding to those of said fold lines permanent markings which are detectable by an optical scanning means.

18. Apparatus according to claim **16,** said material comprising a band of paper coated over one side thereof with a photoconductive layer containing a photoconductor that exhibits substantially the memory effect of zinc oxide, said stack being composed of from 500 to 1500 of said belt sections disposed zigzag one upon another between their respective pre-formed fold lines, each of said belt sections having a length of substantially 350 mm. and a width of substantially 250 mm., said belt having pre-formed on a side thereof at intervals corresponding to those of said fold lines permanent markings which are detectable by an optical scanning means.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,926,625 Dated December 16, 1975

Inventor(s) Martin Leonard Van Der Sterren

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 33, delete "element obtained by coating paper".
line 34, delete "with a photoconductive".
Column 4, line 34, "power" should read -- powder --.
Column 5, line 28, "Process" should read -- Processes --.
line 52, "process" should read -- apparatus --.
Column 8, line 24, after "fold" the first "the" should read -- of --.
line 49, after "inward" insert -- toward --.
Column 11, line 45, second occurrence "section" should read -- station --.
Column 12, line 46, "electrographic" should read -- electrophotographic --.
Column 13, line 13, "belt station" should read -- belt section --.

Signed and Sealed this

twenty-fifth Day of *May 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

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