May 27, 1969 L. W. JOHNSON 3,446,184

APPARATUS FOR POWDER DEVELOPMENT OF LIQUID LATENT IMAGES

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FIG. 2

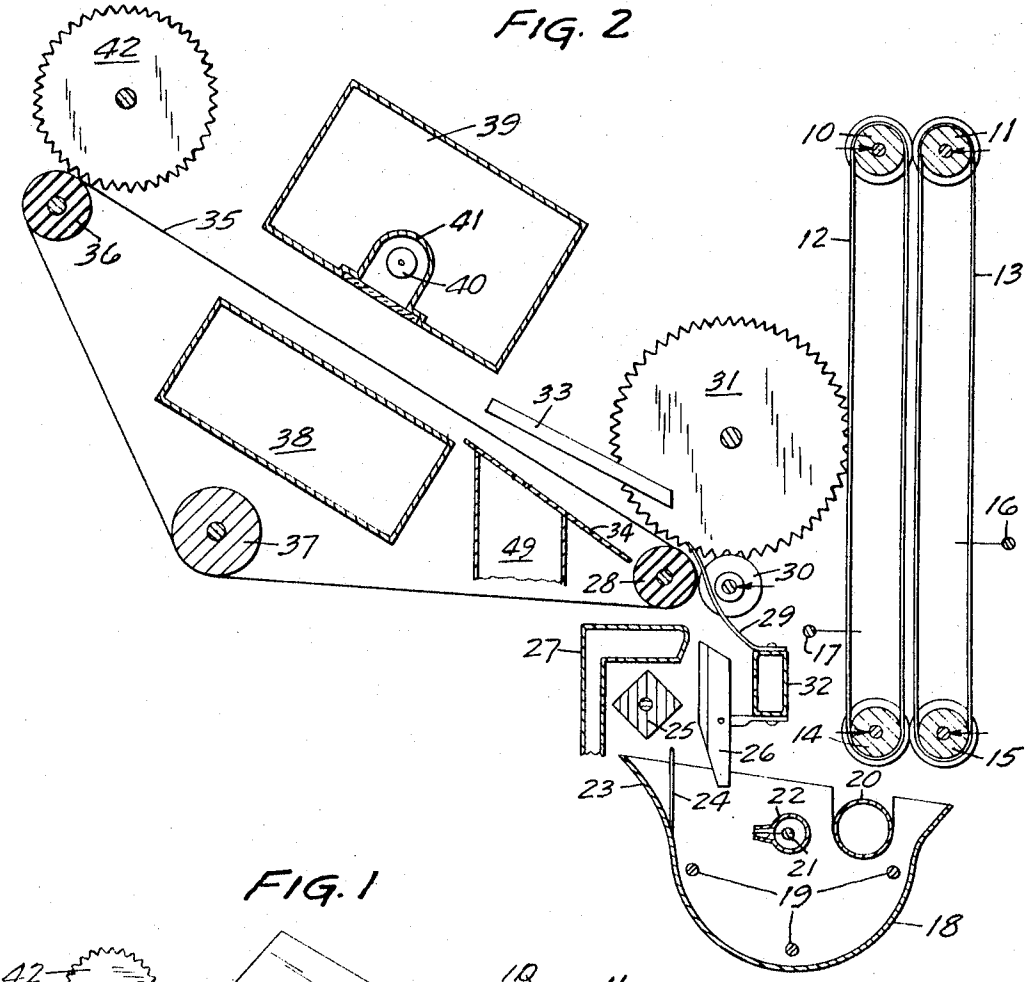
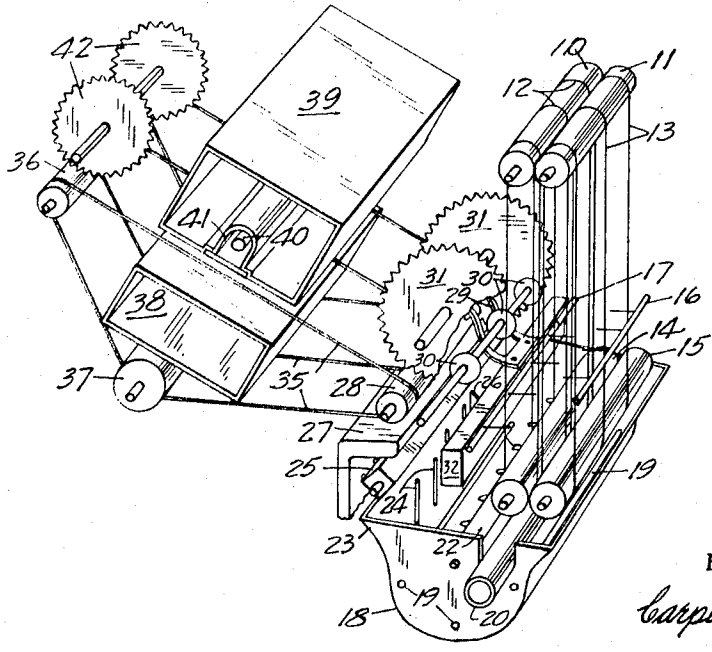


FIG. 1



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FIG. 3

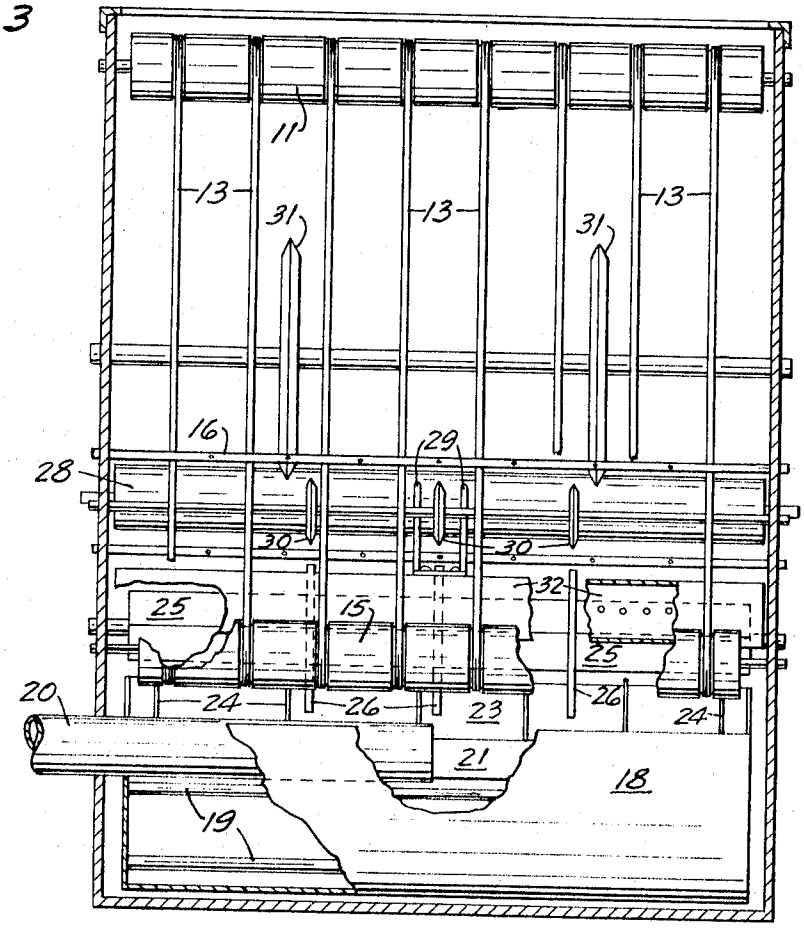
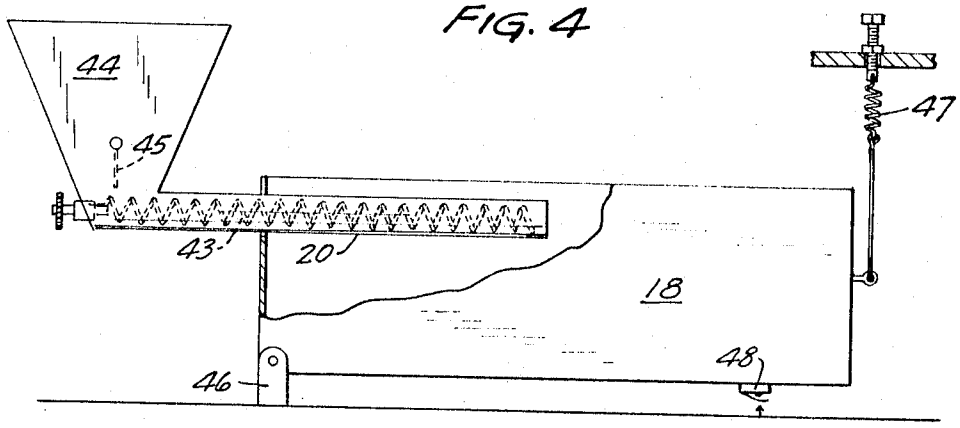


FIG. 4



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United States Patent Office 3,446,184
Patented May 27, 1969

3,446,184

APPARATUS FOR POWDER DEVELOPMENT OF LIQUID LATENT IMAGES

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Filed Oct. 26, 1964, Ser. No. 406,417
Int. Cl. B44c 1/094
U.S. Cl. 118—637
3 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for developing a sticky latent image copy by pushing the sheet into a trough containing a constantly regulated weight of developer powder, the excess powder being returned to the trough and the sheet then heated to fix the image.

This invention relates to the copying art, and has particular reference to apparatus useful in the powder development of liquid latent images.

The invention has particular utility in making single or multiple copies of business correspondence. A heat pattern corresponding to the differentially radiation-absorptive image areas of the printed or typed original is produced by brief exposure of the original to intense radiant energy, for example in a thermographic copying machine as described in Kuhrmeyer et al. U.S. Patent No. 2,891,165. The heat pattern causes fusion of suitable solid materials which are supported on, or transferred to, a receptor sheet in the form of a metastable or supercooled liquid latent image. Application of a colored toner or developer powder which is selectively retained by the liquid then develops the visible image. Subsequent heating to fuse the retained powder may be employed where necessary to render the image smudge-resistant and permanent.

Powder development of latent electrostatic images on a suitably charged and exposed photoconductive plate or sheet has previously been described. The extremely fine-grained and light-weight powder is commonly applied from a triboelectric carrier, for example glass beads or iron filings, which impart to the powder particles a charge of opposite polarity to that of the image areas. The carrier particles are recovered and re-used.

The present process requires no carrier materials. A dense toner powder is applied directly to the sheet carrying the latent image, where it is retained only at the image areas. The process makes possible the preparation of full-image copies at surprisingly high speeds and with greatly simplified apparatus.

The operation of the apparatus depends in large part on the inherent moderate stiffness of the copy-sheet carrying the metastable liquid latent image. In the specific form illustrated, the apparatus will successfully handle those grades of writing paper commonly used in office procedures, such for example as 13–16 lb. basis weight typewriter second sheets. The paper may be coated or uncoated, but as it reaches the developing apparatus will in any case include powder-receptive latent image areas of metastable or supercooled liquid.

In forming the latent image, the liquid latent imaging material may be deposited at the desired image areas on the untreated paper receptor sheet from a coated graphic original or intermediate source sheet by a modified thermographic copying process in which the differentially radiation- absorptive original is briefly exposed to intense radiant energy. The resulting heat pattern at the image areas causes volatilization and transfer of corresponding portions of the normally solid coating to the

surface of the receptor where the material condenses as a metastable liquid and remains in liquid form for a time sufficient to permit powder development. Prior to heating, the coating material is a hard non-tacky solid.

In another procedure the receptor sheet is supplied over its entire surface with a thin coating of the fusible solid material and is then heated at image areas, again by the thermographic copying process, leaving the heated areas of the coating in metastably liquid form adapted to receive and retain the toner powder.

Other techniques, such for example as direct heating of the coated receptor sheet with heated stylus or raised type, or application of the liquefied material by direct printing or scribing, may also be used in imparting to the paper receptor sheet a latent image suitable for powder development by means of the process and apparatus of the invention.

Directly following the formation on the copy-paper of the liquid latent image, the sheet is pushed into and through a bank of toner or image developer powder. The powder is contained within a trough-like receptacle having a smoothly rounded bottom surface which directs the free leading edge of the sheet through or beneath the mass of powder. A portion of the powder is retained by the liquid coating, forming a visible image; any loose powder clinging to the sheet is removed, the bulk of it being returned directly to the trough-like receptacle. The sheet preferably then passes to a heating unit where the retained powder is fused to form a permanent image.

The method, and illustrative apparatus for performing the same, will be further described in connection with the appended drawing, in which:

FIGURE 1 is a view in perspective, with portions cut away or omitted for clarity, of a presently preferred form of the apparatus;

FIGURE 2 is a side elevation, and FIGURE 3 is a partial front elevation, of the apparatus of FIGURE 1; and

FIGURE 4 is a schematic illustration of portions of the powder feed and control apparatus.

The operation of the form of apparatus illustrated will now be described.

The receptor or image sheet, carrying a liquid latent image produced in accordance with any of the methods hereinbefore described, enters the apparatus of FIGURE 1 between steel-surfaced or cotton-flocked rollers **10** and **11** and is conveyed by silicone rubber bands **12** and **13** to metal feed rolls **14** and **15**. The bands **12** and **13** operate within grooves in the corresponding rolls and guide rather than drive the paper. The grooves and bands are typically about one inch apart on the rolls. The materials of construction are selected to reduce to a minimum any triboelectric generation of electrostatic charges on the sheet material. First and second static probes **16** and **17** are provided with needles extending between adjacent pairs of bands into close proximity with the inner paper feed channel and are maintained at a high voltage of about 5000 volts to ionize the surrounding air and further prevent buildup of electrostatic charges on the paper.

Rolls **14** and **15** urge the sheet into the trough **18** and into sliding contact with the smoothly rounded inner or bottom surface thereof. The sheet passes beneath rods **19** which serve to prevent any upward buckling and to hold the sheet near the trough bottom. An externally supported powder feed tube **20** extends to approximately the mid-point of the trough. A third static probe **21**, in this instance enclosed within a protective envelope **22**, is disposed centrally along the trough with its needles extending slightly from open-ended bulges in the envelope in the direction of the paper exit area. A very slight positive air pressure is maintained within the housing **22**, by blower means not shown, so as to prevent entry of

toner powder. The probe **21** is maintained at a high voltage for the same purpose described in connection with probes **16** and **17**.

A powder-catching exit lip **23** on the trough **18** extends outwardly beyond a series of narrow guides **24** which direct the image sheet upwardly and out of the trough. The sheet contacts a rotating beater bar **25** and passes between knife-edged insulating face guides **26** and back guide **27**, being thereby directed slightly back over itself and between rubber roll **28** at the back surface and curved strip guides **29**, small guide discs **30**, and large guide discs **31** at the printed surface of the sheet.

The discs **30** contact the roll **28** at a plane of mutual tangency which extends well into or somewhat beyond the beater bar **25**, so that as the trailing edge portion of the copy-sheet is released from contact with the guides **24** it is urged against the beater bar by its own rigidity.

The thin metal strip forming the guides **29** is supported in position on a duct **32** which is perforated along the surface facing the guides **26** and is connected to suction and filter apparatus, not shown. The guides **26** may also be supported from the duct **32** as shown. The back guide **27** is likewise in the form of a hollow duct, perforated adjacent the beater bar and connected to the suction and filter apparatus. A gentle flow of air into these ducts is sufficient to remove substantially all of the small amount of powder remaining suspended in the air within the apparatus during image development.

Small discs **30** and large discs **31** contact the imaged surface of the copy as it advances from the machine. These discs are provided with narrow toothed edges to insure minimal contact with the copy surface. Likewise the curved guides **29** are of narrow width and direct the leading edge of the sheet into contact with the roll **28** and discs **31** without noticeable smudging of the powdered image areas.

With some liquid latent images and some toner powders no further treatment is required. The copy in such cases may be directed from the development area by sharp-edged metal guides **33** and flat metal guide plate **34** to a suitable tray or other receptor. In other cases a further image fusion or fixing step is found desirable. For this purpose there is provided a series of heat-resistant coiled wire carrier belts **35** supported on roller **28** and on rollers **36** and **37**. These belts transport the copy past guide **34** which serves as a preforated closure for duct **49** connected to the suction and filter apparatus, air flowing into duct **49** from perforated plate **34** removes any final loose dust and also assists in holding the sheet against the belts **35**. The sheet then passes between the adjacent flat faces of ducts **38** and **39**. These latter ducts are connected to a source of cooling air and serve as a screen for preventing excessive heating of adjacent components of the machine by the radiant energy employed. A source of intense radiant energy comprising a tubular lamp **40** within a focusing reflector **41** is located in the upper duct **39**. Radiation from the lamp is focused at the copy-paper-advancing plane of the belts for preferential absorption by the radiation-absorptive powdered image areas of the copy, the powder being thereby heated and fused. The copy is held against the belts **35** and advanced out of the image fixing area by guide discs **42** working in conjunction with roll **36**. As with discs **30** and roll **28**, the plane of tangency of discs **42** and roll **36**, as also of discs **31** and roll **28**, lies somewhat beyond, or in this instance beneath, the upper plane of the carrier belts **35** so that the copy-paper is urged into continuous contact with the carrier belts throughout its entire length. A suitable tray disposed beyond the roll **36** receives the completed copy.

The toner powder is introduced into the trough **18** from the feed tube **20** by means of an open wire coil screw feed **43** operating from a hopper **44** as shown schematically in FIGURE 4. An agitator **45** within the hopper further insures that the powder remains uniformly mixed. It is found that the amount of powder within the trough is critical, since too little powder fails to provide complete toning or developing of the latent image, particularly at the high speeds employed, while excessive amounts of powder impede the entry of the sheets into the mass, the latter effect again being particularly noticeable because of the high density of the preferred forms of toner powder. In a typical example the powder may comprise a metallic pigment in a fusible resinous binder and may have a specific gravity of about 1.5 to about 2.3. About 75–100 grams of such powder serves as an effective load for the trough of a developer machine designed to handle 8½ x 11 inch copy-paper sheets. About 200 copies of originals such as office correspondence are produced in such a machine without addition of further amounts of powder; thereafter some skipping or inadequate toning may occur unless additional powder is supplied.

The addition of powder is accomplished automatically by balancing the trough **18** on a fulcrum **46** near one end and from an adjustable spring suspension **47** near the other. A sensitive switch **48** is arranged to activate the drive for feed **43** and agitator **45** as the amount of developer powder falls below a desired minimum, and to de-activate the drive after sufficient additional powder has been introduced. The same switch also activates a circuit which prevents entry of additional latent image copies during periods of powder addition.

The apparatus as thus described has been found capable of developing liquid latent image copies at rates in excess of 50 to 60 per minute, as compared with rates of six to ten sheets per minute for typical commercial machines used to develop electrostatic latent image copies.

What is claimed is as follows:

1. Apparatus for converting to a visible image a liquid latent image on a copy-paper, said apparatus comprising an internally smoothly rounded open powder-carrying trough having a plurality of guide bars parallel and adjacent to the rounded inner surface for preventing buckling of a copy-paper forced between said bars and said surface, a pair of drive rolls for forcing a copy-paper from said rolls and into said trough, a beater for mechanically separating any loose powder from a copy-paper exiting from said trough, guides for directing the copy-paper into contact with said beater as the copy-paper is pushed from said trough, a drive roll and a plurality of drive discs for drawing the copy-paper from said trough, the plane of mutual tangency at the points of contact of said discs and roll being displaced toward the beater from the plane of said copy-paper as it is drawn past said beater by said drive roll and drive discs.

2. Apparatus for converting to a visible image a liquid latent image on a copy-paper, said apparatus comprising, in combination: trough means for containing a controlled amount of developer powder; guide means for directing a free leading edge of a copy-paper sheet into and through said powder in said trough means; drive means for advancing the free leading edge of a copy-paper sheet into said trough between said guide means and through said powder; further guide means for directing said advancing edge out of and above said trough; vibratory means for removing from said copy-paper any surplus of said powder not retained by said liquid image; withdrawal means for removing said copy-paper from said trough and for maintaining contact between said vibratory means and said copy-paper as the latter is drawn past the former; means for maintaining said controlled amount of powder in said trough, said means comprising a hopper, a powder feed channel, feed means for advancing powder from said hopper through said channel to said trough, balancing means associated with said trough for permitting movement of said trough between a "full" position and a "fill" position, switch means operable by said trough in undergoing movement between said positions, and power input means controlled by said switch means for actuating said feed means to advance powder from said hopper

to said trough when in said "fill" position, said switch means simultaneously preventing passage of copy-paper through said trough.

3. Apparatus for powder developing a liquid latent image on a copy-paper and comprising, in combination: a paper entry and drive mechanism for advancing a copy-paper in essentially uncharged state into said apparatus and including two parallel pairs of drive rolls interconnected with a plurality of narrow electrically insulating belts forming a central channel leading from the nip of the first pair of rolls to the nip of the second pair of rolls, and high-voltage static probes across and in close proximity with each side of said channel; a powder applying device including an internally smoothly rounded open trough containing a series of longitudinal guide bars defining a narrow channel adjacent the rounded inner surface, an outwardly extending exit lip, and a series of exit guides extending from the base of said lip essentially tangent to said channel, said trough being suspended near one end on a pivot and near the other end from an adjustable spring for permitting pivotal movement between predetermined "full" and "fill" positions, the entry edge of said channel being positioned directly in line and closely adjacent with the outlet pair of said two pairs of drive rolls for receiving a sheet of copy-paper from said outlet pair of rolls with its free leading edge making sliding contact with the smoothly rounded inner surface of said trough; a sheet cleaning mechanism directly adjacent said exit guides and including a beater bar, fixed sharp-edged guide members facing said beater bar and a fixed elongate guide member above said beater bar for defining a narrow channel past said bar and guiding a copy-paper

with its back surface in contact with said bar, a high-voltage static probe adjacent said fixed guide members, a drive roll for drawing a copy-paper from said channel, a guide member for directing a leading edge of an advancing copy-paper over said drive roll, and drive discs biased toward said drive roll at a plane of common tangency extending beyond the line of contact of said beater bar with a copy-paper; and a heater station for fusing a powder image on a copy-paper and including a plurality of narrow heat-resistant carrier belts passing around said drive roll of said sheet cleaning mechanism and a delivery roll parallel thereto and providing an upper copy-paper-advancing surface, a set of guide discs biased toward said drive roll at a plane of common tangency passing beneath said copy-paper-advancing surface, and a source of intense radiation focused across said surface for irradiation of a copy-paper advanced thereon to cause heating of radiation-absorptive image areas of said copy-paper.

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PETER FELDMAN, *Primary Examiner.*

U.S. Cl. X.R.

117—17.5; 118—7, 419; 219—216