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U. BRENNEISEN ETAL

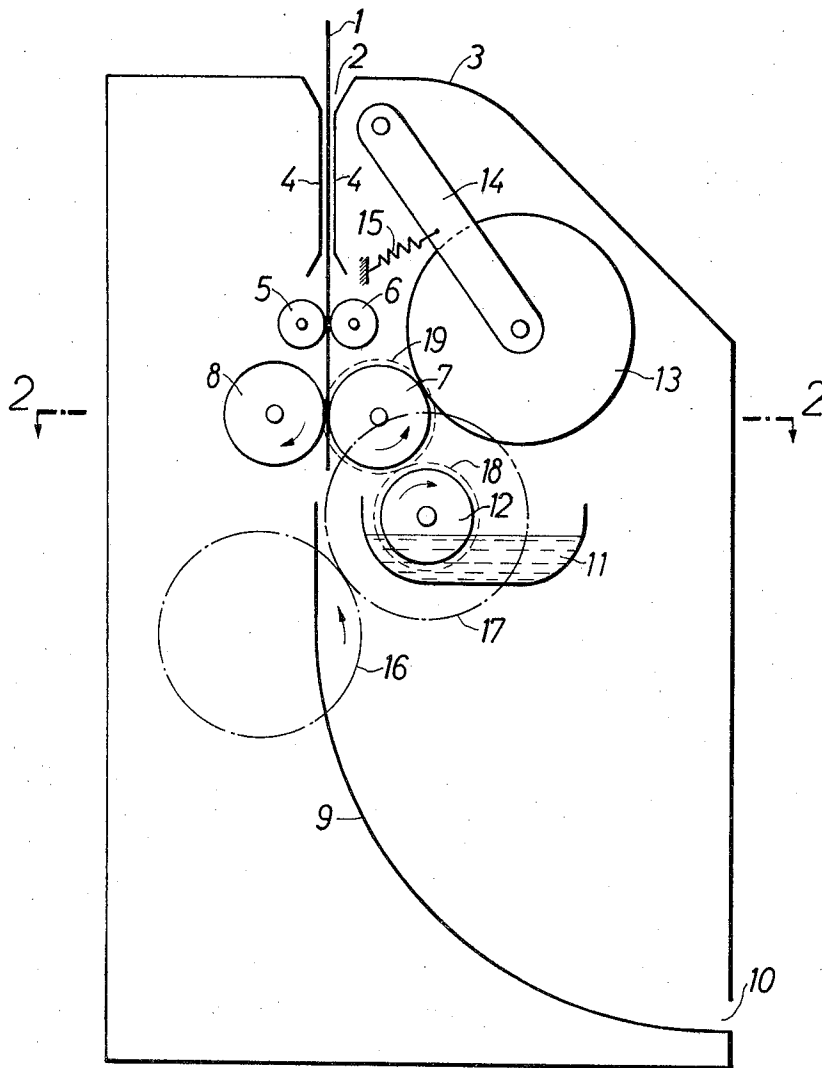
3,245,381

DEVELOPING APPARATUS

Filed March 26, 1963

2 Sheets-Sheet 1

FIG. 1



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2 Sheets-Sheet 2

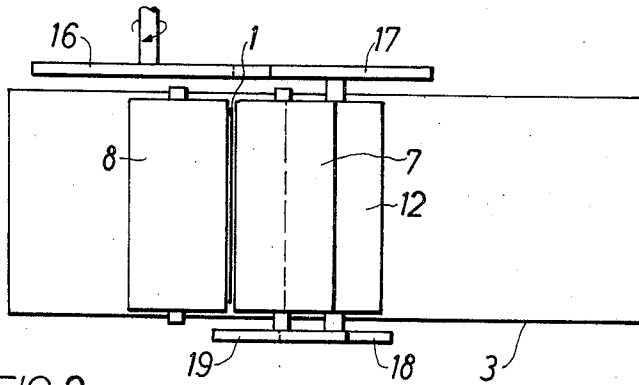


FIG. 2

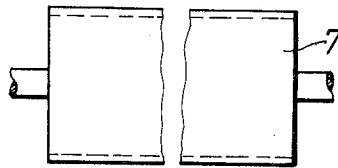


FIG. 3

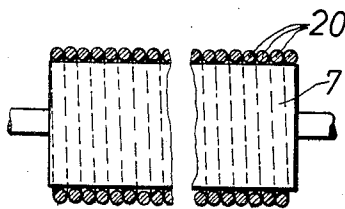


FIG. 4

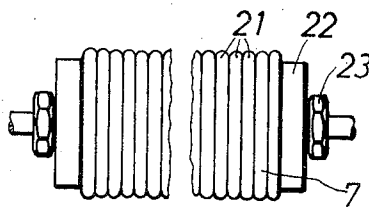


FIG. 5

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## DEVELOPING APPARATUS

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A 37,219, A 42,355

6 Claims. (Cl. 118—637)

This invention relates to an apparatus for developing photoconductive layers carrying latent electric images by a development method which is known as the so-called wetting development.

Under wetting development is to be understood an electrophotographic developing method which is principally distinct from electrolytic or electrophoretic developing methods. The wetting development makes use of the finding that a photoconductive layer which carries a latent electric image is wetted by certain developing liquids in accordance with the said latent electric image.

This method is based on the phenomenon that the surface tension of a liquid can be influenced by an electric field. Thus the interfacial tension between the hydrophilic drop of the developer liquid and the hydrophobic surface of the photoconductive layer is decreased at the areas where the said layer is charged. Due to this effect the developer, e.g., an aqueous solution of dye wets the photoconductive member in a pattern corresponding to the latent electric image, while the developer is repelled by the noncharged areas of the photoconductive layer.

The wetting development is described in detail in the Belgian patent specification 616,644 and the German patent application A 39,779 IXa/57b. The process described in the Belgian patent includes the steps of charging the photoconductive member, exposing the said member to the original to be reproduced and finally developing the resulting latent electrostatic image with a wetting developer.

The method which is described in the German patent application identified above includes the steps of producing a latent image of the original to be reproduced as a differentially conductive pattern in a substantially electrostatically neutral photoconductive layer exposure to the original to be reproduced, and treating the said image bearing layer with the wetting developer, while simultaneously applying a voltage between the conductive support of the said photoconductive layer and the developer liquid. If the developer is an aqueous solution or dispersion of a coloring compound, the resulting colored image can be left to dry or can be transferred to a second support, e.g., by contacting the photoconductive layer carrying the image body of colored liquid while still moist with the said second support.

As wetting developers are preferably used aqueous compositions. Generally, the wetting and electrical properties of the developer liquids which can be used for the present process must satisfy the following conditions:

The difference of the wetting angle under the influence of the voltage between the light-struck and the nonlight-struck areas of the exposed electrophotographic layer should be as great as possible whereby the wetting angle at those areas of the latent conductive image not to be wetted should be greater than approximately 90° and at those areas to be wetted smaller than 90°. The wetting angle can be measured according to known methods or can be estimated in usual manner from the interfacial energies according to the Young equation.

Suitable substances which have a sufficiently large angle of contact and a sufficiently large interfacial tension with respect to the electrophotographic layer are, in most cases,

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the liquids which have also a relatively high surface tension. The wetting properties of the developer liquid can be influenced, in the required manner, by suitable additives.

As regards the electrical properties, it is particularly the "relaxation time" which determines efficacy of the developer liquid. By relaxation time, is to be understood that time which is necessary for the displacement of charges within the drop or film of developer under the influence of an electric field. In the case of the wetting development, this time should be small in comparison with the time taken for the developing operation. If so, the developer liquid can, in the present connection, be considered as conductive and the decay in interfacial energy in the electrical field becomes a maximum.

The relaxation time can be determined from the following equation:

$$\tau(\text{relaxation time}) = \epsilon \cdot \epsilon_0 \cdot \rho [\text{sec.}]$$

In this equation,  $\epsilon$ , is the absolute dielectric constant,  $\epsilon_0$ , the dielectric constant of the developer liquid and  $\rho$  the specific resistivity.

It is apparent from this that the relaxation time can be influenced within wide limits, primarily by varying the conductivity of the developer liquid. Developer liquids with a specific resistivity smaller than  $10^6$  ohm. cm. have relaxation times which are suitable for the instant process.

Since the dielectric constant of the developer liquid can only be varied within a narrow range, this property is of secondary importance.

The properties of the liquid developers which are used in wetting development are thus quite different from those of developers used for electrophoretic or electrolytic image development.

Advantageously aqueous developer liquids are suitable, more especially solutions or dispersions of colored substances.

Wetting development according to the present invention can, in practice, be carried out with all known photoconductive layers, for example, layers of selenium, sulphur and organic photoconductors or with those electrophotographic layers which contain the photoconductive substances dispersed in an insulating binding agent. Preferred electrophotographic materials are those with zinc oxide as photoconductive substance, embedded for example, in silicone resin.

We have found that is particularly advantageous to apply the developer liquid by means of a developing roller consisting of cylindrical member being provided with superficial parallel or thread-like grooves whereby the said grooves are arranged perpendicular to the axis of rotation of the development roller. The development roller is the essential element of a development station which further comprises means to supply developer liquid to the said developing roller, means for driving the said developing roller and guiding elements for guiding the photoconductive layer.

It will be realized of course that such an apparatus could be widely varied in its constructional features, but to enable it to be fully understood, some embodiments will next be described with reference to the accompanying drawings in which:

FIGURE 1 is a schematic view of an embodiment of a developing station; FIGURE 2 is a top view of the developing station of FIGURE 1 in the sectional plane (2—2) and FIGURES 3, 4 and 5 show embodiments of the developing roller.

We first refer to the embodiment shown in FIGURES 1 and 2. The electrophotographic material 1, the photoconductive layer of which carries the latent electric image, for

example, a latent electrostatic image is fed into the apparatus through the inlet slot 2 in the housing 3, the guiding elements 4 guide the electrophotographic material by the aid of conveyor rollers 5 and 6 to the developing roller 7. The photoconductive layer carrying the latent image is brought into an intimate contact with the developing roller by the aid of the presser roller 8. The developed electrophotographic material passes along the curved guiding elements 9 to the outlet slot 10.

The trough 11 contains the developer liquid which is applied to the developing roller 7 by the aid of the applying roller 12. An excess of developer liquid is removed by the squeegee roller 13 which is swingable mounted 14. The roller 13 can be pressed to the developing roller 7 by the aid of a spring 15. The motor 16 drives the applying roller 12 via cogwheel transmission (cogwheel 17). The developing roller is driven by the applying roller via the cogwheels 19 and 18 on the shafts of the rollers 7 and 12 the transmission ratio is 1:1. The various shafts of the rollers can be rotatably mounted in the usual manner in the housing of the apparatus.

The developing roller is produced of a material which is wettable by the developer liquid. The diameter of the developing roller is 20–150 mm. preferably 20–500 mm. The length of the developing roller is adapted to the size of the electrophotographic material which is to be processed whereby the developing roller should be a little longer and the presser roller a little smaller than the breadth of the electrophotographic sheet. The grooves of the surface of the developing roller can have a depth of 0.1–1 mm.

Some embodiments of developing roller according to the invention are shown in FIGURES 3–5.

FIGURE 3 represents a developing roller in the form of a screw thread. Common screw threads of the size  $M_2$  to  $M_8$  (compare "Hütte Engineers Taschenbuch" 27th edition, Berlin 1949, volume II, pages 28–46), can, for example, be used.

Preferred are threads having a thread pitch of 0.1–0.5 mm., a depth of 0.1–1 mm. and an angle of the flank of 20–50°.

FIGURE 4 shows another embodiment of a developing roller whereby the said roller has a cylindrical member onto which is wound a wire 20 of a corrosion resistant metal, for example, stainless steel or tungsten, having a diameter of between 0.1–0.5 mm. The single windings of the wire should be arranged side by side without interspace. The wire can be substituted by a monofilament, for example, of fibre forming material such as polyamide. The monofilament can have a diameter of between 0.01 to approximately 1.5 mm.

FIGURE 5 is another schematic view of a developing roller. This roller consists of circular disks 21 having a thickness of between 0.5–1.5 mm. the edgings of which are rounded off. The disks which have a central boring are concentrically stuck onto a shaft provided with a thread at each end are pressed together by means of a screw. It is advantageous to arrange a thicker disk 22 having a thickness of between 1–3 mm. between the screw 23 and the circular disks described above.

The rounded edges of the ridges, as shown for example in FIGS. 4–5, or the pointed edges of the screw thread of FIG. 3 insures that wire 20, disks 21 on the screw thread will make only line contact of photographic layer 1.

Suitable electrophotographic materials and developer liquids which can be processed in the developer station

according to the invention are described in the Belgian patent specification 616,644 and the German patent application A 39,778 IXa/57b.

We claim;

1. A developer station for developing an exposed electrophotographic material consisting of a photoconductive layer carrying a latent electrical image coated on an electrical conductive support by means of the wetting development which comprises a developing roller of corrosion-resistant material which is wettable by the developer liquid for applying the liquid developer to the surface of the said photoconductive layer, the said developing roller is rotatably mounted and has a diameter of between 20–150 mm. the surface of the said developing roller is provided with means for effecting line contact with said photographic layer, said line contact means including superficial grooves in said surface having a depth of between 0.01–1 mm. and being arranged perpendicular to the revolution axis of the said developing roller, means to supply developer liquid to the said developing roller, means for driving the said developing roller and guiding elements for guiding the photoconductive layer along said developing roller.

2. A developer station according to claim 1 characterized by a developing roller with superficial threadlike grooves, whereby the said thread has a thread pitch of 0.1–0.5 mm. a depth of 0.1–1 mm. and an angle of the flank of 20–50°.

3. A developer station according to claim 1 characterized by a developing roller consisting of a cylindrical member onto which is wound a wire of a corrosion-resistant metal having a diameter of between 0.1–1.5 mm. whereby the windings of the said wire are arranged side by side without interspace.

4. A developer station according to claim 1 characterized by a developing roller consisting of a cylindrical member onto which is wound a monofilament of a fibre-forming material having a diameter of between 0.01–1.5 mm. whereby the windings of the said monofilament are arranged side by side without interspace.

5. A developer station according to claim 1 characterized by a developing roller consisting of circular disks having a thickness of between 0.2–1.5 mm., the edging of which are round off, the said disks having a central hole, are concentrically stuck onto a shaft provided with a thread at each end and pressed together by means of a screw.

6. A developer station according to claim 5 characterized in that all of said disks are the same diameter.

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