Sept. 24, 1968 MOTOKI KOJIMA ET AL 3,402,698

MAGNET ASSEMBLY FOR MAGNETIC DEVELOPING BRUSH AND DEVELOPING APPARATUS FOR ELECTROSTATIC PROCESS

Filed May 26, 1967

FIG. 1

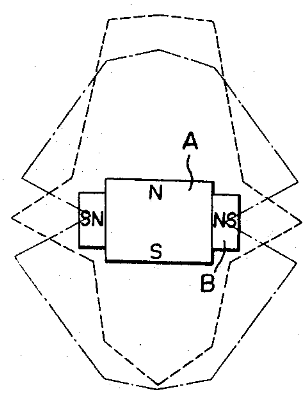


FIG. 2

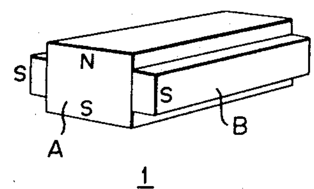


FIG. 3

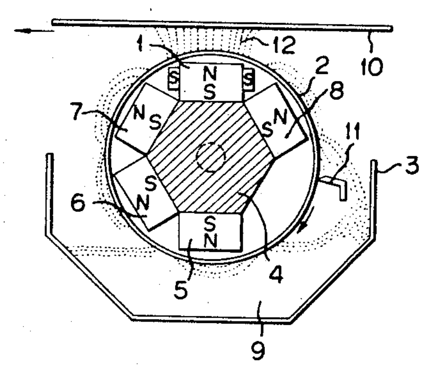


FIG. 4

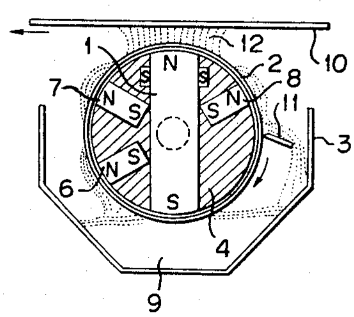
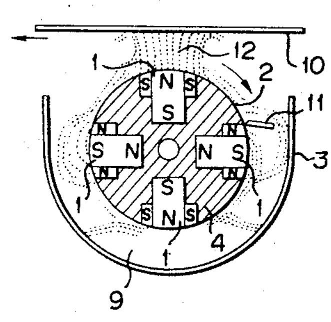


FIG. 5



United States Patent Office

3,402,698
Patented Sept. 24, 1968

3,402,698

MAGNET ASSEMBLY FOR MAGNETIC DEVELOPING BRUSH AND DEVELOPING APPARATUS FOR ELECTROSTATIC PROCESS

Motoki Kojima, Haruo Fujii, and Noboru Kutsuwada, Tokyo, Japan, assignors to Konishiroku Photo Industry Co., Ltd., Tokyo, Japan

Filed May 26, 1967, Ser. No. 641,516
Claims priority, application Japan, June 6, 1966, 41/36,215
6 Claims. (Cl. 118—637)

ABSTRACT OF THE DISCLOSURE

A magnet assembly for forming a magnetic developing brush which can be supplied with and carry developer powders for use in electrophotographic or electrostatic processes, comprises a main magnet and a pair of submagnets coupled to both sides of the main magnet and arranged so that their direction of magnetization lies substantially at right angles to that of the main magnet; each of the submagnets is disposed so that its inner pole has the same polarity as the active pole of the main magnet. This magnet assembly creates an intensified, uniform magnetic field of rectangular cross-section in front of and commensurate in width with the active or brush-forming pole.

The invention relates to a magnet assembly for forming a magnetic developing brush used in an electrophotographic process or electrostatic printing process.

A magnetic brush is conventionally employed in such processes to develop an electrostatic latent image formed on a layer of light-sensitive or photoconductive insulating material as by charging and subsequent imagewise exposure to radiation of the layer in a known manner. Specifically, a mixture of toner and carrier, e.g. iron particles, is retained in the form of a brush under the influence of magnetic force and is brought into sliding contact with a light-sensitive layer which carries the latent image. The toner is transferred onto those parts of the layer of which the charge has not been neutralized during the exposure step.

Although the brush comprising the toner and iron particles should desirably be formed with an elongated, upright tuft so that it may rub the surface of the light-sensitive layer softly and uniformly with a substantial area of contact to produce a visible image of high quality, it has been difficult to maintain a magnetic brush in such condition.

Thus the tuft of the brush is apt to become cut short or uneven, or it may lie down to agglomerate, thereby causing insufficient or excessive pressure of contact with the light-sensitive layer. All these conditions of the tuft fail to achieve uniform reproduction of image density in the resulting image, and cause spots in the background, deposition of iron powders to the layer or other deficiencies of development. In order to overcome these disadvantages, it has been proposed to provide another magnet pole on the opposite side of the light-sensitive layer for forming the toner-iron particle-brush vertically in depending form so that its tuft may be elongated perpendicularly to the layer. However, the former proposal involves difficulty in construction when it is applied, for example, in a copying machine using a drum, while in the arrangement of the latter, it is likely that fall of iron particles onto the light-sensitive surface causes undesirable spots on the developed surface.

It is an object of the invention to provide an improved magnet assembly which enables one to produce and maintain a toner-iron particle-brush having an elongated, upright tuft and having a sufficient rubbing area, thereby allowing to obtain an image of high quality.

Another object of the invention is to provide a developing unit which avoids the above disadvantages.

According to the invention, the magnet assembly creates an intensified, uniform magnetic field in front of an active pole or brush-forming pole and the field distribution has a substantially rectangular cross-section commensurate in width with the active pole. The resulting brush has therefore a rectangular cross-section, thereby achieving a sufficient rubbing area with the surface of the light-sensitive layer that is passed over the active pole. Thus sufficient and uniform toner deposition is assured. The magnetic field created on the active pole is intensified so as to prevent deposition of iron powders on to the layer and at the same time to produce and maintain an elongated brush. The invention thus overcomes the above disadvantages of the prior art with a simple and inexpensive arrangement.

Above and other objects, features and advantages of the invention will become apparent from the following description of embodiments thereof with reference to the drawing, wherein:

FIG. 1 is a vertical section of a magnet assembly incorporating the principle of the invention, illustrating distribution of magnetic flux density in a plane perpendicular to the length of a main magnet;

FIG. 2 is a perspective view of the magnet assembly shown in FIG. 1;

FIG. 3 schematically shows a developer unit, in vertical section, which uses the magnet assembly shown in FIGS. 1 and 2;

FIG. 4 is a vertical section similar to FIG. 3 of a developer unit which incorporates a magnet assembly in accordance with another embodiment of the invention; and

FIG. 5 is a vertical section of a developer unit which uses a magnet assembly in accordance with further embodiment of the invention.

Referring to the drawing, and particularly to FIGS. 1 and 2, a magnet assembly according to the invention is generally shown at **1** and comprises a single piece of magnet A and a pair of submagnets B coupled to both sides of the magnet A. The magnet A may be similar in its material and size to that heretofore used to form a magnetic developer brush. The arrangement of the submagnets B is such that their direction of magnetization lies substantially at right angles to that of the main magnet A, as is best seen in FIG. 1. In addition, each of the submagnets B is disposed so that its inner pole has same polarity as that pole of the main magnet A which serves to form and retain a toner-iron particle-brush thereon. Thus in the example shown in FIGS. 1 and 2, the submagnets B have their N-poles disposed inside abutting against the sides of the main magnet A which has its N-pole as the brush-forming pole. For convenience of illustration, these submagnets are indicated in FIGS. 2 to 5 only by notation of their outer poles, it being hence understood that such outer poles of the submagnets have opposite polarity to that of the brush-forming pole of the main magnet A. The pair of submagnets B may be replaced by a single annular magnet which fits around the sides of the main magnet A.

In FIG. 1, there is shown a comparison of flux density distributions obtained with the magnet assembly **1** of the invention (in broken lines) and with a single piece magnet A as in the prior art (in chain line). The curves were obtained by plotting points, at which the flux density was 400 gauss, in plane perpendicular to the length of the main magnet A. In one example in which the distribution shown was obtained, magnets were made from anisotropic ferrite. The strength of magnetization was 680 gauss at the center and 580 gauss at the edges of one pole piece of the magnet A when a probe was applied to the pole face. When a pair of submagnets having strength of magnetization of 300 gauss were applied to the lateral sides of this main magnet, a uniform flux density of 800 gauss was obtained over the whole region of the N-pole of the main magnet. When each of such submagnets has strength of magnetization of 680 gauss originally, the resulting flux density immediately in front of the N-pole of the main magnet was nearly 1000 gauss. It will be noted that with the magnet assembly according to the invention, the flux density in front of N-pole (brush-forming pole) is much more increased and more uniformly flattened over the entire region of the pole face than the flux density in the prior art. On the other hand, the flux density in front of S-pole and in the fringing areas of the pole is considerably attenuated. Numerically, the flux density decreased to 500 gauss at the center and to 380 gauss at the edge of S-pole. This implies that while the flux density distribution is symmetrical with respect to each pole of the single main magnet, this distribution can be biased to one side of the magnet and modified in shape by combining the pair of submagnets with the main magnet in accordance with the teaching of the invention. It is believed that the action of the combined submagnets is to press inward the laterally flaring portions of the flux emanating from the N-pole of the main magnet A. The modified distribution (broken lines) has an increased flux density in front of the active or brush-forming pole (N-pole) and the flux density is of uniform magnitude in front of the N-pole so that a brush having an elongated, upright tuft can be readily produced and maintained. It will be also appreciated that the resulting brush will have a substantial cross-sectional area, thereby ensuring a uniform and sufficient image density. Control over softness of touch of the brush with the light-sensitive layer can be made by variation of the magnitude of the flux density, which in turn may be achieved by displacing the submagnets B vertically, as viewed in FIG. 1, along the lateral sides of the main magnet A. The length of the brush formed varies with operation factors, but in one example in which the brush is formed to stand upright, the length was 7 mm.

FIG. 3 shows a developer unit using the magnet assembly in accordance with the invention. The developer unit comprises a cylinder **2** of non-magnetic material and below the cylinder there is provided a container **3** which is also made from non-magnetic material and which contains the toner-iron particle mixture. As is well known, the toner particles are selected from materials which are easily charged by triboelectricity by agitation. The cylinder **2** is adapted to be rotatably supported by the end plates (not shown) of the container. In the space within the cylinder **2**, an arbor **4** of non-magnetic material carries a series of magnets **5**, **6**, **7**, **1**, and **8**. The magnets are fixedly arranged radially of the arbor and are homopolar at their outer ends adjacent to the cylinder **2**. The magnet **1** is constructed similarly as mentioned in connection with FIGS. 1 and 2 and its N-pole faces a light-sensitive sheet **10** as the latter passes over the magnet **1** in close proximity to the cylinder. A scraper **11** is arranged in contact with the cylinder between the angular positions of the magnets **8** and **5**.

In operation, the cylinder **2** is rotated in the direction indicated by an arrow by any suitable drive. The mixture of toner and iron particles **9** is supplied into the container **3** in an amount such that the mixture powders cover the bottom part of the cylinder **2**. Thus by force of attaction between the outer pole of the magnet **5** and magnetized iron particles and also by electrostatic force of attraction between toner and iron particles, the developing powders adjacent to this magnet is held on the cylinder and carried thereon over successive magnets **6** and **7** to reach the top position where they are subject to the influence of the composite magnet **1**, thereby forming a magnetic brush **12** which, owing to the effect of the above mentioned flux density distribution, has a favorable tuft shape. The brush thus formed faithfully develops the electrostatic latent image on the sheet **10**. It will be appreciated that because the developing powders are of particle size, e.g. 10 to 20 microns for iron particles and several microns for toner, they are free to move on the cylinder in conformity to the flux distribution. After development, the powders on the cylinder **2** are carried over the magnet **8** and then released from action of the magnetic field to be subsequently freed from the cylinder by the scraper **11** to return to the container **3**. The above cycle repeats until development of the sheet **10** is completed.

FIG. 4 shows another developer unit which is similar in construction to that shown in FIG. 3 except that the main magnet A of the magnet assembly **1** is elongated to extend through the arbor **4** diametrically, thereby achieving an intensified brush-forming pole. The operation of the unit is similar as described in connection with FIG. 3.

In FIG. 5, there is shown further example of the developer unit which incorporates the magnet assembly of the invention. In the example shown, there is not provided a cylinder **2** shown in FIGS. 3 and 4, but the cylindrical arbor **4** itself is adapted to rotate. The arbor can be driven in any suitable manner as by connecting its center shaft (not shown) to an electric motor. All magnets provided in the arbor **4** are of same construction as the magnet assembly **1** shown in FIGS. 1 and 2 and they are embedded in the arbor along the periphery thereof at 90° apart. This achieves an improved brush, of which tuft can be maintained in an operative condition that excellently distinguishes itself over the prior art. Though in FIG. 5 each magnet assembly **1** has a separate brush associated therewith so that during rotation of the arbor **4**, the brushes come in contact with the light-sensitive sheet in turn only intermittently, the latent image on the sheet can be developed continuously, that is, without leaving any undeveloped portion. To this end, the sheet **10** may be moved at a relatively low speed and the arbor rotated at a higher speed so that the brushes repeatedly scan the sheet. Alternatively, the number or arrangement of the magnet assemblies provided in the arbor may be modified so that tuft portions of adjacent brushes continuously cover the sheet. The softness with which the brush tuft formed on the magnet assembly touches the sheet can be controlled by suitable choice of magnetization intensity of the magnets used in the magnet assembly, or by displacing the small magnets B along the lateral sides of the main magnet A.

What is claimed is:

1. A magnet assembly for a magnetic developing brush comprising a main magnet having magnetization in a first direction and also having an active pole, and at least one magnet attached to lateral sides of the main magnet and having magnetization in a second direction substantially perpendicular to said first direction, the pole of the said magnet adjacent to said main magnet being of same polarity as the active pole of the main magnet, whereby said active pole is adapted to produce a uniform magnetic field in front of it.

2. A magnet assembly for forming a magnetic developing brush, comprising a pair of first magnets having magnetization in a substantially common direction and arranged at a distance with their poles of selected like polarity opposing each other, and a second magnet interposed between said pair of magnets in close proximity thereto and having magnetization in a direction substantially at right angles to the first said direction, whereby that pole of the second magnet which has the same polarity as that of the opposing poles is adaped to form a magnetic developer brush thereon.

3. A developer unit including the magnet assembly according to claim **1**, wherein said magnet assembly is stationarily arranged within a cylindrical rotating body of non-magnetic material with said active pole facing outward, said cylinder being adapted to be supplied with and carry developer powders, whereby said magnet assembly acts to form a magnetic brush of developer powders on the body.

4. A developer unit according to claim **3**, wherein a plurality of magnets is arranged adjacent to the inner periphery of the cylindrical body said magnets having poles which cooperate with the cylindrical body to carry developer powders on the body.

5. A developer unit including a plurality of the magnet assemblies according to the claim **1**, wherein the assemblies are fixedly arranged on a cylindrical rotating body with their active poles facing outward, said assemblies being arranged spaced apart along the periphery of the cylindrical body, said body being adapted to be supplied with developer powders to thereby form a magnetic brush of developer powders on the active pole of the respective magnet assembly.

6. A developer unit including at least one magnet as-

sembly according to claim **1**, and including a developing brush which comprises toner and magnetic carrier, said brush being formed and maintained under the magnetic influence of the active pole of the magnet assembly, said brush being laid under relative movement to a surface having an electrostatic latent image.

References Cited

UNITED STATES PATENTS

3,098,765	7/1963	Keller et al.	118—637
3,145,122	8/1964	Streich	118—637
3,152,924	10/1964	Wanielista et al.	118—637
3,318,284	5/1967	Hojo et al.	118—637

FOREIGN PATENTS

1,218,287	6/1966	Germany.

PETER FELDMAN, *Primary Examiner.*