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(54) An electrostatographic apparatus.

(57) An electrostatographic apparatus comprising a developing device or a plurality of developing devices, intended for being used in a development system with a dry powder developer comprising at least toner- and carrier particles, that comprise(s) a container (11) for the developer wherein fresh toner can be mixed with said developer, as well as a container for fresh toner (16), characterised thereby that

(i) the container for the developer does not comprise moving parts,

(ii) said developing device comprises, or said plurality of developing devices comprise, means for changing the position of said container for the developer such as to mix the components of the developer,

(iii) said container for developer has an output that directly connects to a magnetic brush (15) for applying toner to an electrostatic charge image on a dielectric material and an input through which fresh toner can be added.

In a preferred embodiment in the container for developer a body has been provided whose outside wall runs substantially parallel with the inside wall of said container for developer so that an annular space is being defined for containing the developer and said inner body is said container for fresh toner.

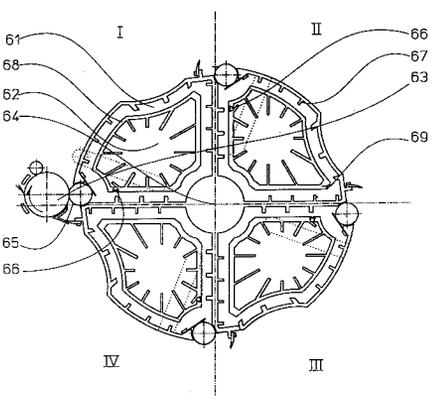

FIG.6

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1. Field of the invention.

This invention is applied in the field of electrostatography, more specifically upon mixing an electrostatographic developer containing toner particles and carrier particles.

2. Background of the invention

In electrostatography a latent image is formed by (i) applying an imagewise charge distribution to a dielectric, (ii) developing the latent image, i.e. converting it in a visible image by depositing thereon selectively light-absorbing particles, called toner particles. The toner particles are mostly electrically charged. The image, made visible by the deposition of toner particles on the latent image that was present on the dielectric, is then transferred to a substratum and fixed thereon to yield the final copy. In electrophotography, which is a special embodiment of electrostatography, the dielectric is a photoconductor and an image is formed by (i) uniformly charging a photoconductor, (ii) imagewise discharging it so as to obtain a latent image, (iii) developing the latent image, i.e. converting it in a visible image by depositing toner particles on the latent image. The image, made visible by the deposition of toner particles on the latent image that was present on the photoconductor, is then transferred to a substratum and fixed thereon so as to yield the final copy.

For the application of toner development two methods are known : "dry-powder" and "liquid-dispersion" development. At present the dry-powder method is the most commonly used. More details on the dry-powder development can be found a.o. in IEEE Transactions on Electronic Devices, Vol. ED-19, no. 4, April 1972, pp. 495-511.

In the dry-powder process the toner particles are charged triboelectrically by mixing them, viz. shaking them together with the carrier particles (toner- and carrier particles have an opposite charge). The mixture of carrier particles and toner particles, that are attracted electrostatically by the carrier particles, is the developer.

During development the toner particles are released by the carrier particles and deposited on the latent image that has been applied to a dielectric. The toner particles are thus the consumable in the developer. This implies that the developer gets exhausted upon being used, i.e. very few toner particles are left in the mixture with the carrier particles. For being able to continue developing latent image, toner has to be added. This fresh toner particles are still uncharged and have to be mixed (shaken) again in the apparatus with the carrier particles for charging them triboelectrically.

In an electrostatographic process it is very important that the charging of all toner particles be so uniform as possible, i.e. that the charge distribution of the toner particles be narrow. Care is taken via the toner composition that the toner particles, when they are treated in the same way, also possess a narrow charge distribution (see e.g. EP-A 0 488 741, EP-A 0 488 742). In order to give all toner particles approximately the same charge it is important that they be subjected to the same treatment, viz. come into contact with the carrier particles in the same way, i.e. as intensively as frequently, during the mixing process of fresh toner particles with the exhausted developer.

From the point of view of today's quality demands put to the copy or print it is desirable not to use developing techniques such as powder-cloud development or cascade development. In order to meet today's quality demands put to the the final image it is desirable to apply magnetic-brush development. For using such a development system it is necessary to realise an optimised system for mixing carrier particles and toner particles, and to couple this mixing system to a magnetic-brush system. Various mixing systems are known for charging the toner particles, most of which, however, exert a mechanical force on the toner particles and carrier particles. So, in US-P 4,456,364 mixing the developer (toner particles and carrier particles) is recommended by allowing a thread provided with loops to rotate in the container of the developer. In EP-A 161 795 a special shaft equipped with mixing ribs rotates in the developer, and in US-P 4,583,842 worm wheels mix the developer. Although it is possible according to the cited embodiments to charge the replenished toner particles in the desired, homogeneous way and to the desired height of charge, there is still the problem of the mechanical pressure being exerted on the toner- and carrier particles, which makes them agglomerate and thus form large particles that are unsuited for a qualitatively acceptable development of the electrostatic latent image. In GB 1,372,731 a stationary cross-mixer has been described for mixing toner and developer, wherein both fall through a series of chambres by gravity. Improvements of that principle have been proposed in GB 2,141,351. The mixing method disclosed in the latter two documents avoids the mechanical pressure on toner- and carrier particles and thus does not give rise to problems of agglomerating particles. Although this system evades several problems it is not suited for being used in an apparatus for forming four-colour images by means of electrostatography. In an apparatus of that type at least four developing units have to be built in. So, there is still a demand for a simpler, inexpensive, small and reliable embodiment of a mixing system

wherein no mechanical pressure is being exerted on the carrier- and toner particles, and said mixing system is compatible with the magnetic-brush setting.

3. Object and summary of the invention

It is an object of this invention to realise a reliable, inexpensive, small and simple system for mixing fresh toner particles with the exhausted developer.

Another object of the present invention is to realise a system that enables one to mix the fresh toner and the exhausted developer in such a way that the toner- and carrier particles do not agglomerate and that all toner particles are treated identically in their contact with de carrier particles so that all toner particles obtain practically the same charge.

Still another object of the invention is to provide an installation with which it is possible to spread the mixed developer over the entire working width of the magnetic brush so that in every point of it enough developer is present for making possible a faultless development of the electrostatic image.

Further objects and benefits of the present invention will appear from the detailed description below.

The objects of the present invention are achieved by providing an electrostatographic apparatus comprising a developing device or a plurality of developing devices, intended for being used in a development system with a dry powder developer comprising at least toner- and carrier particles, that comprise(s) a container for the developer wherein fresh toner can be mixed with said developer, as well as a container for fresh toner, characterised thereby that

(i) the container for the developer does not comprise moving parts,

(ii) said developinh device comprises, or said plurality of developing devices comprise, means for changing the position of said container for the developer such as to mix the components of the developer,

(iii) said container for developer has an output that directly connects to a magnetic brush for applying toner to an electrostatic charge image on a dielectric material and an input through which fresh toner can be added.

In a preferred embodiment the container for developer is arranged so as to rotate round a shaft, and at least one wall of said container is provided inside with ribs.

In a preferred embodiment from said ribs, at least two adjacent ribs converge, viewed in the direction of rotation of said developing device, such as to form a substantially funnel-shaped channel with a relatively large entry opening and a relatively narrow exit opening, each of said converging ribs forming an angle of 70 to 30° with the normal through said entry- and exit openings.

In the most preferred embodiment in said container for developer

(i) a body (futher called internal body) has been provided whose outside wall runs substantially parallel with the inside wall of said container for developer so that an annular space is being defined for containing the developer and

(ii) said internal body is said container for fresh toner and

(iii) at least one outside wall of said inner body carries ribs that converge in pairs when viewed according to the rotation of the container, so that they form a substantially funnel-shaped channel with a relatively large entry opening and a relatively narrow exit opening.

The present invention will be described detailedly below by means of concrete embodiments relating to electrophotography without the described embodiments limiting the present invention thereto. Maybe those skilled in the art propose other embodiments and applications for the entire field of electrostatography that, however, are based completely on the principle of the present invention.

4. Short description of the figures

Figure 1 is a cross-section of a possible embodiment of a developing device according to the present invention.

Figure 2 is a cross-section of another possible embodiment of a developing device according to the present invention.

Figure 3 is a front view of a developing device according to the present invention, wherein the container for the developer incorporates a body that functions as a container for the toner and wherein the outer wall of said body carries a funnel-shaped channel. For clarity's sake it is assumed that the wall of said container is transparent.

Figure 4 is a same view as represented in figure 3, with the difference that the outer wall of said body carries several funnel-shaped channels.

Figure 5 is a cross-section through a possible arrangement of 4 developing devices according to the present invention besides the photoconductor.

Figure 6 is a cross-section through another possible arrangement of 4 developing devices according to the present invention besides the photoconductor.

Figure 7 is a cross-section through a set-up of developing devices according to the present invention arranged around the photoconductor and rotat-

ing eccentrically around it.

Figure 8 is a cross-section through a set-up of developing devices according to the present invention arranged besides the photoconductor and wherein the mixing process of the developer is assisted by a magnetic field excited by a magnet that has been mounted concentrically with respect to the developing devices.

Figure 9 is a cross-section through another possible set-up of developing devices according to the present invention arranged besides the photoconductor and wherein the mixing process of the developer is assisted by a magnetic field excited by a magnet that has been mounted concentrically with respect to the developing devices.

Figure 10 is een cross-section through a possible set-up of developing devices according to the present invention arranged besides the photoconductor and wherein the mixing process of the developer is assisted by a magnetic field excited by a magnet that has been mounted besides the developing devices.

5. Detailed description

According to the present invention, the container for fresh toner can be fixed separately from the container for developer in the electrostatographic apparatus and said container for developer is arranged so as to connect with the container for fresh toner in only one determined angular position.

Although it is possible according to this invention to set up the container(s) for developer separately from the container(s) for fresh toner, the container(s) for the developer according to the present invention is (are) preferably directly connected to a container for fresh toner. In figures 1 and 2 possible embodiments are represented.

In figure 1, 11 is the container for the developer (mixture of toner and carrier), 12 is the wall of said container, 13 are the ribs mounted on the inner side of the wall of said container, 14 is an optional partition placed in said container, 15 is the magnetic brush with which the toner is applied to the latent image, 16 is the container for fresh toner, and 17 is the opening in the wall of the latter container through which fresh toner can come in the container for developer. In a preferred embodiment, from said ribs 13, at least two adjacent ribs converge, viewed in the direction of rotation of said developing device, such as to form a substantially funnel-shaped channel with a relatively large entry opening and a relatively narrow exit opening, each of said converging ribs forming an angle of 70 to 30° with the normal through said entry- and exit openings.

In a further embodiment, in said container for developer one or more partitions 14 have been built in that are provided with ribs, analogous to the ribs 13 on the wall(s) of said container. From said ribs on said partition, at least two adjacent ribs converge, viewed in the direction of rotation of said developing device, such as to form a substantially funnel-shaped channel with a relatively large entry opening and a relatively narrow exit opening, each of said converging ribs forming an angle of 70 to 30° with the normal through said entry- and exit openings.

In figure 2, 21 is the container for developer, 22 is the wall of this container, 23 are the ribs mounted on the inner side of the wall of said container, 24 is an optional partition placed in said container and forming a quadrilateral in this specific embodiment, 25 is the magnetic brush with which the toner is applied to the latent image, 26 is the container for fresh toner, 27 is a partition placed in the latter container, 28 are ribs mounted on the inner side of the wall of said container, and 29 is a common wall between the container for the developer and the container for fresh toner. Also in this embodiment it is preferred that from said ribs 23, at least two adjacent ribs converge, viewed in the direction of rotation of said developing device, such as to form a substantially funnel-shaped channel with a relatively large entry opening and a relatively narrow exit opening, each of said converging ribs forming an angle of 70 to 30° with the normal through said entry- and exit openings.

Also partition 24 that has been built in, can be provided with ribs, analogous to the ribs 23 on the wall(s) of said container 21. From said ribs on said partition, at least two adjacent ribs converge, viewed in the direction of rotation of said developing device, such as to form a substantially funnel-shaped channel with a relatively large entry opening and a relatively narrow exit opening, each of said converging ribs forming an angle of 70 to 30° with the normal through said entry- and exit openings.

In the most preferred embodiment the container for fresh toner and the container for developer are composed as follows: in said container for developer

(i) a body (further called internal body) has been provided whose outside wall runs substantially parallel with the inside wall of said container for developer so that an annular space is being defined for containing the developer and

(ii) said internal body is said container for fresh toner and

(iii) at least one outside wall of said inner body carries ribs that converge in pairs when viewed according to the rotation of the container, so that they form a substantially funnel-shaped channel with a relatively large entry opening and a relatively narrow exit opening. The outer wall of the

internal body may carry several of such funnel-shaped channels, which have been placed in such a way that upon rotation of the developing device around the above-mentioned shaft the developer must fall through at least one of the funnel-shaped channels.

The ribs converging in pairs when viewed according to the rotation of the container so that they form a generally funnel-shaped channel, may be arranged as shown in figure 3. For simplicity's sake a rectangular internal body is represented in this figure and the outer walls of the container of the developer are transparent, so that one looks frontally on the ribs converging in pairs. The ribs 31 mounted on a plane 35 form with the normal through the top-and bottom opening an angle α - (32) that is smaller than $\alpha°$ (whose value is described below). The entry opening 33 is as large as the width of the outside wall of the internal body and smaller than the working width of the magnetic brush, said working width depending on the size of the paper on which the electrostatic image will be fixed. The exit opening 34 is at least 25 times smaller than the entry opening and at most 40 times smaller. In another preferred embodiment (figure 4) the developer is led through successive funnel-shaped channels that mest the above-mentioned demands with respect to the angle between the normal through the entry opening and the exit opening and to the ratio between the sizes of the feed-and exit openings. Instead of half of the height of one or more walls 45 of the internal body being occupied at its outer side by one funnel-shaped channel, a first funnel-shaped channel 41 occupies one fourth part of the height of said wall(s), whereas said funnel-shaped channel 41 has a entry opening 43 which is as large as the width of the outside wall of the internal body and smaller than the working width of the magnetic brush. Under the exit opening 44 of said funnel-shaped channel 41 there are two funnel-shaped channels 42 which have a entry opening 46 equal to half the width of the outside wall of the internal body and that connect to each other in such a way that the point of connection 47 is placed exactly in the centre of the exit opening 44 of the above-mentioned funnel-shaped channel 41.

In order to combine in a developing device according to this invention a proper mixture with suitable developing properties, the developer has to meet powder-rheological as well as magnetic and triboelectrical demands. In a developing device according to the disclosed invention it is very important that the powder-rheological properties of the developer be adjusted to the embodiment of said developing device. Especially the angle α - (figure 3, 32) has to be chosen with respect to the rheological properties of the developer.

Various developers with diverging compositions can be used in a developing device according to the present invention. Preferably a developer is used consisting of at least two components, viz. electroscopic toner particles and carrier particles against which the above-mentioned toner particles are charged triboelectrically and which as magnetic particles on the magnetic brush realise the magnetic pulse.

Suchlike developer has to achieve a real flow and possesses an angle of repose β as small as possible. This angle of repose β can be measured as follows: 300 g of developer (i.e. a mixture of carrier- and toner particles, and optionally other particles) are allowed to flow through a funnel on a sheet of paper. The extreme limits of the flow cone of the developer are marked and the height h of this flow cone is measured with a slide caliper. After the developer has been eliminated from the paper sheet, the diameter of the base of the flow cone is measured in 4 places. The average of these 4 values is the diameter d of the base of the flow cone. The angle of repose β is calculated from:

$$\beta = \tan^{-1} \frac{2h}{d}$$

The developer for being used in a developing device according to the present invention will have an angle of repose β smaller than 40°, preferably smaller than 30°. In the best embodiment the angle of repose is smaller than 20°.

The angle α (see figure 3, 32) formed by the ribs 31 mounted on a plane 35 with the normal through the top- and bottom opening should be smaller than $90° - \beta$. For a developer with an angle of repose $\beta = 20°$, α will be $\leqq 70°$, and for a developer with angle of repose $\beta = 40°$, α will be $\leqq 50°$. In addition to these demands to the angle of repose, the developer for being used in a developing device according to the present invention has to possess a spontaneous flow. This flow is measured by placing 300 g of developer on the basis of a ferrite carrier in a cylindrical funnel of 140 mm height and 50 mm inside diameter, at 80.2 mm from the top that has been provided with sloping faces that form an angle of 30° with the normal between the top opening and the exit opening, and a exit opening with 20.8 mm length and 4 mm diameter, and to measure how rapidly all developer has flown away. In the case of a developer on the basis of a composite carrier only 200 g of developer are placed in the funnel. The speed of delivery is expressed in s/500 g. The spontaneous flow

of a developer for being used in a developing device according to the present invention should be smaller than 200 s/500 g, preferably smaller than 100 s/500 g.

The angle of repose β and the flow of the developer can be adjusted by adding other components to the mixture of carrier particles and toner particles. Interesting materials are, e.g., additives known as flow-improving or fluidising agents such as silica, alumina or TiO_2, as has been described, e.g. in US-P 3,720,617, EP 0 460 665 and WO 91/00548. Also small organic particles, such as described, e.g., in US-P 5,041,351, can be mixed separately or together with inorganic flow-improving agents with the carrier- and toner particles in order to achieve the desired angle of repose. When small particles are added to the developer for being used in a developing device according to this invention, they should have an average diameter d_a that is smaller than the mean diameter d_t of the toner particles. Also the addition of large particles to the developer, as described in WO 92/18908, can be advantageous. Suchlike large particles, admixed as an additive, should have an average diameter d_a that is larger than the mean diameter of the toner particles and smaller than 100 times the average diameter of the carrier particles d_c. Preferably $d_a < d_t$, wherein d_t is the volume-average diameter of the toner particles.

Various carrier particles can be used for composing a developer to be applied in a developing device as meant in the present invention. The carrier particles can be made of metal (e.g. Fe, Ni), metal oxides (e.g. ferrites or magnetites) or can be composite particles consisting of small ($\leqq$ 1 μm) particles of the above-mentioned materials (metals and/or metal oxides) in a binder (e.g. a polymer, glass, etc.). It is possible in the developer to be applied in a developing device according to this invention to use carrier particles that contain a mixture of magnetic pigments having different magnetic properties as described in the not yet published European Patent Application 93200285, filed 4th February 1993. Also a mixture of carrier particles possessing different magnetic properties can be applied successfully in a developer to be used in a developing device according to the present invention. The dimensions of the carrier particles have to be adapted to those of the toner particles to be used and lie between twice those of the toner particles as far as the flow properties are concerned, and 20 times the size of the toner particles as far as the requirements of quality are concerned. Preferably the dimensions of the carrier particles (volume-average diameter d_c) lie between 2 times and 20 times those (volume average diameter) d_t of the toner particles, most preferred are carrier particles with volume-average diameter between 3 and 10 times those of the toner particles. The most preferred carrier particles are those described in the not yet published European Patent Application 93201795, filed 22nd June 1993.

The toner particles that together with the carrier particles and optional other additives constitute the developer to be used in a developing device according to the present invention should have an average (volumetric) diameter smaller than 15 μm, preferably still smaller than 12 μm, and most preferably smaller than 10 μm. The toner particles may contain a.o. a binder, dyes, charge-controlling agents, inorganic fillers, as is known to those skilled in the art of toner preparation. Compositions of the toner particles to be used in the present invention have been described, e.g., in the unpublished European Patent Applications 93201351 filed 11th May 1993, 93201647 filed 9th June 1993, and 93201815 filed 22nd June 1993.

In addition to the carrier- and toner particles the developer according to this invention may incorporate still other additional components, e.g., the above-mentioned flow-improving agent, beads with special magnetic properties, large beads as spacing agents, such as described in WO 92/18908, so that a three- or multi-component developer forms. The admixtures can take place with substances or particles that are not intended to come in the magnetic brush, as well as with substances and/or particles that are intended to do so.

The developing devices according to the present invention can be used for negative/positively working developers as well as for positive/positively working developers.

In a copier, developing units as described above can be provided for each of the four colours yellow, magenta, cyan and black. It is also possible to built in more than four developing units, e.g. a developing device according to the present invention for applying a colourless toner, an additional extra large developing device for using the apparatus as black-and-white copier, etc. The developing devices according to the present invention can be arranged in a (colour) copier in different ways around the photoconductor. When a plurality of development devices are present in an electrostatographic apparatus, according to the present invention, invention, it is preferred that said developing devices are arranged so as to be removable and exchangeable as a whole.

An example of a possible arrangement is represented in figure 5. Around a shaft 51 four developing units as shown in figure 1 are arranged. In this figure 58 is the photoconductor, 55 the magnetic brush, 56 the opening through which fresh toner from the container for fresh toner enters the container for developer. The container for toner 53 has been placed besides the container for devel-

oper 54. In the latter container there is a partition 52, and the inside walls of said container have ribs 57, according to the present invention. For the description of the working principle the circle over which the four developing units are moving has been divided in four quadrants, in the first of which the magnetic brush faces the photoconductor. Each of the four different developing devices represented in figure 5 moves clockwise during copying around a shaft and comes in all four positions in the respective quadrants.

When the developing device is in quadrant I, transfer of toner on the photoconductor takes place (first colour is being applied). For applying the following colour, the four developing units rotate around shaft 51. The developing unit from quadrant IV comes in quadrant I, and the toner furnishing the second colour is being applied. The developing unit from quadrant I comes in quadrant II, and fresh toner while still being in quadrant I, under the influence of gravity is brought in the container for developer (for the first colour) through opening 56 on the horizontal wall of partition 52. At the transition from quadrant I to quadrant II, developer is being shovelled by the ribs mounted in quadrant I on the horizontal wall of the container for developer, and in quadrant II part of the developer falls down and is divided by partition 52 over the container. For applying the third colour the whole rotates again around shaft 51, and the developing device for the first colour comes in quadrant III. During this rotation the ribs on the inside of the container for theveloper at one side shovel developer with fresh toner, and on the opposite side used developer falls down. Partition 52 divides the developer falling down. For the application of the fourth colour the whole rotates another time, and the developing device for the first colour comes in quadrant IV. In the meantime the developer with fresh toner falls on top of the other, non-replenished developer, and is divided by partition 52. The ribs shovel another part of the developer. Before the first colour is applied again to a new copy, the whole is rotated again around shaft 51, and again a portion of developer falls down and is divided by the partition 52. In this way fresh developer is available on the magnetic brush.

In figure 6 an example of a possible practical set-up of a developing device in a four-colour copier is represented, the container for the developer of which contains a body whose outside wall runs substantially parallel to the inside wall of said container for developer (called "internal body" further on) so that an annular space is determined for containing the developer and said inside body is the container for fresh toner, and the outside wall of said internal body carries ribs that converge in pairs when viewed according to the rotation of the container, so that they form a substantially funnel-shaped channel with a relatively large entry opening and a relatively narrow exit opening.

In figure 6, 63 is the photoconductor, 65 the magnetic brush, 64 the shaft around which the four developing devices rotate, 61 the annular space created by building in in the container for developer the inside body 62 being the container for fresh toner, 66 is the dosing opening for fresh toner, and 67 are the ribs on the inside wall of the container for developer. The ribs converging in pairs when viewed according to the rotation of the container so that they form a substantially funnel-shaped channel, have been mounted on the outside walls 68 and 69 of the inside body.

It is not only possible to mount the developing units according to the present invention besides the photoconductor, it is as well possible to mount the developing units eccentrically in a circle around the photoconductor, as represented in figure 7. Only in one position the magnetic brush is in the neighbourhood of (or in contact with) the photoconductor. In this figure, four developing units (I to IV) according to this invention are represented that can rotate around a shaft 73 that is eccentric with respect to shaft 76 of photoconductor 71. In the developing devices, 72 is the container for toner, 74 is the container for developer, and 75 is the magnetic brush. The mixture of toner and developer occurs essentially in the same way as described above. The developing devices according to the present invention need not have the same dimensions; it is possible to shape the container for this toner that is being consumed in larger quantities larger than the container for toner that is being consumed in smaller quantities. The benefit of setting up the developing units in an eccentric ring around the photoconductor is that in this way the developing device shields the rather vulnerable photoconductor against the neighbourhood.

Mixing in the above-described developing devices occurs by gravity only and has the benefit that upon mixing no great forces are being exerted on the developer. Hereby the toner particles and the carrier particles remain free with respect to each other, and they do not adhere to each other.

When it is tried to amplify the action of mixing on the basis of gravity, this can be done without contact by admixing through a magnetic field the developer, that is magnetic via the carrier particles. In this case it is preferred for the carrier particles to have a saturation magnetisation (M_{sat}) so that $M_{sat} \geq 0.3$ T (Tesla).

This external magnetic field can be excited by any means known to those skilled in the art. The magnetic field can be stationary or oscillating. In figure 8 a possible embodiment of mixing on the basis of gravity and magnetism is represented (for

simplicity's sake the ribs on the inside of the container for developer as described above have not been drawn). Quadrant I where the toner is being applied to the photoconductor is the quadrant at the left below. Around two concentric shafts 82 and 83 a magnet 81 and four or more developing units can rotate independently of one another. The magnet rotates counterclockwise and the four developing units rotate clockwise. The developing units consist of a body, wherein an inside body 88 has been built in so that an annular space forms that contains the developer. The annular space can be subdivided in three compartments: 85a and 85b around the magnetic brush 84, and 85c. The outside of said inside body 88 carries ribs that converge in pairs, when viewed according to the rotation of the container, so that they form a substantially funnel-shaped channel with a relatively large entry opening and a relatively narrow exit opening (86).

When the developing unit is in quadrant I, at left below, all developer is in space 85a. The magnetic roller (magnetic brush) is provided with the necessary developer, toner is being transferred to the photoconductor 89, and the finished developer lands in space 85b. After the image has been developed with the first colour, the developing units rotate and the developing unit leaves quadrant I and enters quadrant II. The finished developer remains in space 85a and the fresh developer in space 85b.

When the second colour has been developed, the developing units continue rotating and the developing unit that has applied the first colour comes in quadrant III. The finished developer falls from space 85b in space 85c and the fresh developer falls through the funnel-shaped opening 86 from space 85a in space 85c. Magnet 81 rotates then counterclockwise at 1 to 4 Herz and carries along developer as high as the turning point 85d. Then the developer falls down again, the magnet carries the developer back to turning point 85d, the developer falls down, etc. During the rotation from quadrant II to quadrant III the partition 87 retains an amount of fresh toner that is being brought in quadrant III through an opening in the annular space, which contains the developer.

When the third colour has been finished, the developing units continue rotating and the developing unit that contains the first colour is in quadrant IV. In this quadrant already part of the developer falls from space 85c through the funnel-shaped openings 86 in space 85a. Upon passing from quadrant IV to quadrant I, all the developer in space 85c falls through the funnel-shaped opening 86 in space 85a and is ready for use.

Also when the mixture of the developer takes place by the combined action of gravity and magnetism, embodiments different from those represented in figure 8 are possible. Figure 9 represents a possible other embodiment (for simplicity's sake the ribs on the inside of the container for developer as described above have not been drawn) : 91 is a cross-shaped magnet rotating counterclockwise around a shaft 93 that is concentric with shaft 92, around which are rotating clockwise developing devices according to the present invention. The container for toner 95 is large with respect to the container for developer 94. In the latter two spaces 94a and 94b have been provided separated from each other by a partition 96, that carries ribs that converge in pairs when viewed according to the rotation of the container, so that they form a substantially funnel-shaped channel 97 with a relatively large entry opening and a relatively narrow exit opening.

When the developing device is in quadrant I at the left below, all developer is collected in space 94a and toner is being applied to photoconductor 99. The finished developer lands in space 94b. In the meantime the magnet 91 rotates at 1 to 4 Hz and brings the finished developer up to turning point 98. Part of the finished developer falls through space 94c and the funnel-shaped channels 97 back into space 94a. After the first colour has been applied, the developing device rotates to quadrant II and stops between quadrants II and III, all developer moves to spaces 94b and 94c; upon the further rotation and the stop at the boundary between quadrants III and IV all developer lands in space 94c and remains there during the rotation to the position on the boundary of quadrants IV and I. When the developing device again has to apply toner to the photoconductor 99 (at the stop on the boundary of quadrants I and II) some developer falls through the funnel-shaped channels 97 from space 94c into space 94a, and is again ready for use.

In figure 10 a possible set-up of the developing devices is shown, wherein mixing occurs under the influence of both gravity and magnetism, but wherein the mixing magnet 101 has been mounted besides the set-ups of the developing devices on a separate shaft 102 (for simplicity's sake the ribs on the inside of the container for developer as described above have not been drawn). The developing devices have been arranged around shaft 103. In quadrant I, magnetic brush 108 and photoconductor 109 are in one another's neighbourhood. The container for toner 105 has been mounted besides the container for developer 104. In the container for developer three spaces 104a, 104b, and 104c are to be distinguished. In said container a partition 106 has been placed that carries ribs that converge in pairs when viewed according to the rotation of the container, so that they form a

substantially funnel-shaped channel 107 with a relatively large entry opening and a relatively narrow exit opening.

Essentially, the operation of the set-up of the developing devices according to the present invention as represented in figure 10 does not differ from the above-described operation of the set-ups described in figures 8 and 9.

Claims

1. An electrostatographic apparatus comprising a developing device or a plurality of developing devices, intended for being used in a development system with a dry powder developer comprising at least toner- and carrier particles, that comprise(s) a container for the developer wherein fresh toner can be mixed with said developer, as well as a container for fresh toner, characterised thereby that
   (i) said container for the developer does not comprise moving parts,
   (ii) said developing device comprises, or said plurality of developing devices comprise, means for changing the position of said container for the developer such as to mix the components of the developer,
   (iii) said container for developer has an output that directly connects to a magnetic brush for applying toner to an electrostatic charge image on a dielectric material and an input through which fresh toner can be added.

2. An electrostatographic apparatus according to claim 1, wherein in said container for developer
   (i) a body has been provided whose outside wall runs substantially parallel with the inside wall of said container for developer so that an annular space is being defined for containing the developer and
   (ii) said inner body is said container for fresh toner and
   (iii) at least one outside wall of said inner body carries ribs that converge in pairs when viewed according to the rotation of the container, so that they form a substantially funnel-shaped channel with a relatively large entry opening and a relatively narrow exit opening.

3. An electrostatographic apparatus according to claim 2, wherein the width of the exit opening of said funnel-shaped channel is from 25 to 40 times smaller than the width of the entry opening and the walls of said funnel-shaped channels form each an angle of at most 70° with the normal through the feed- and exit openings.

4. An electrostatographic apparatus according to claim 2, wherein a first funnel-shaped channel has been provided over the entire width of the wall of said inner body and at least a second and a third funnel-shaped channel, that have an entry opening smaller than the entry opening of said first funnel-shaped channel, have been provided after said first funnel-shaped channel when viewed according to the direction of rotation of the device, and wherein the sum of the widths of the entry openings of said at least second and third funnel-shaped channels equals the entire width of the wall of said inner body.

5. An electrostatographic apparatus according to any of the preceding claims, wherein said dielectric material is a photoconductive material applied to a drum in such a way that a photoconductive drum is formed and said container for developer has been arranged so as to rotate around a shaft parallel with the longitudinal axis of said photoconductive drum.

6. An electrostatographic apparatus according to any of the preceding claims, wherein said container for developer has been arranged so as to rotate around an own shaft.

7. An electrostatographic apparatus according to any of the preceding claims, wherein ther is a plurality of developing devices that have been placed besides said photoconductive drum and together can rotate around a shaft parallel with the longitudinal axis of said photoconductive drum.

8. An electrostatographic apparatus according to any of the preceding claims, wherein there is a plurality of developing devices that are arranged around said photoconductive drum and together can rotate eccentrically around a shaft parallel with the longitudinal axis of said photoconductive drum.

9. An electrostatographic apparatus according to any one of the preceding claims, wherein a stationary or oscillating magnetic field is applied in the neighbourhood of said developing device or plurality of devices.

10. An electrostatographic apparatus according to claim 9, wherein said developing device or said plurality of developing devices can together with a magnet rotate around a concen-

tric shaft and that said magnet rotates in a direction opposite to that of said developing device or said plurality of developing devices.

11. An electrostatographic apparatus according to claim 9, wherein said developing device or said plurality of developing devices has been mounted besides the photoconductive drum and rotate around a shaft parallel with said photoconductive drum and a magnet rotates around another shaft parallel with said photoconductor in a direction of rotation opposite to that of said developing devices or said plurality of developing devices.

12. An electrostatographic apparatus according to any of the preceding claims, wherein said developing devices or said plurality of developing devices has been arranged so as to be removable and exchangeable as a whole.

13. Use of a dry powder developer comprising carrier particles with a saturation magnetisation $M_{sat} \geq 0.3$ T in an electrostatographic apparatus according to anyone of the claims 1 to 12.

14. Use of a dry powder developer having an angle of repose smaller than 40° in an electrostatographic apparatus according to anyone of the claims 1 to 12.

15. Use of a dry powder developer having a spontaneous flow ≦ 200 s/500 g in an electrostatographic apparatus according to anyone of the claims 1 to 12.

16. Use of a dry powder developer comprising toner particles with a volume-average diameter $d_t \leqq 15$ µm and carrier particles with a diameter d_c so that $3d_t \leqq d_c \leqq 10d_t$ in an electrostatographic apparatus according to anyone of the claims 1 to 12 .

17. Use of a dry powder developer comprising toner particles with a volume-average diameter $d_t \leqq 10$ µm and carrier particles with a diameter d_c so that $3d_t \leqq d_c \leqq 10d_t$ in an electrostatographic apparatus according to anyone of the claims 1 to 12.

18. Use of a dry powder developer comprising additives with an average diameter d_a so that $d_a < 100d_c$ in an electrostatographic apparatus according to anyone of the claims 1 to 12 .

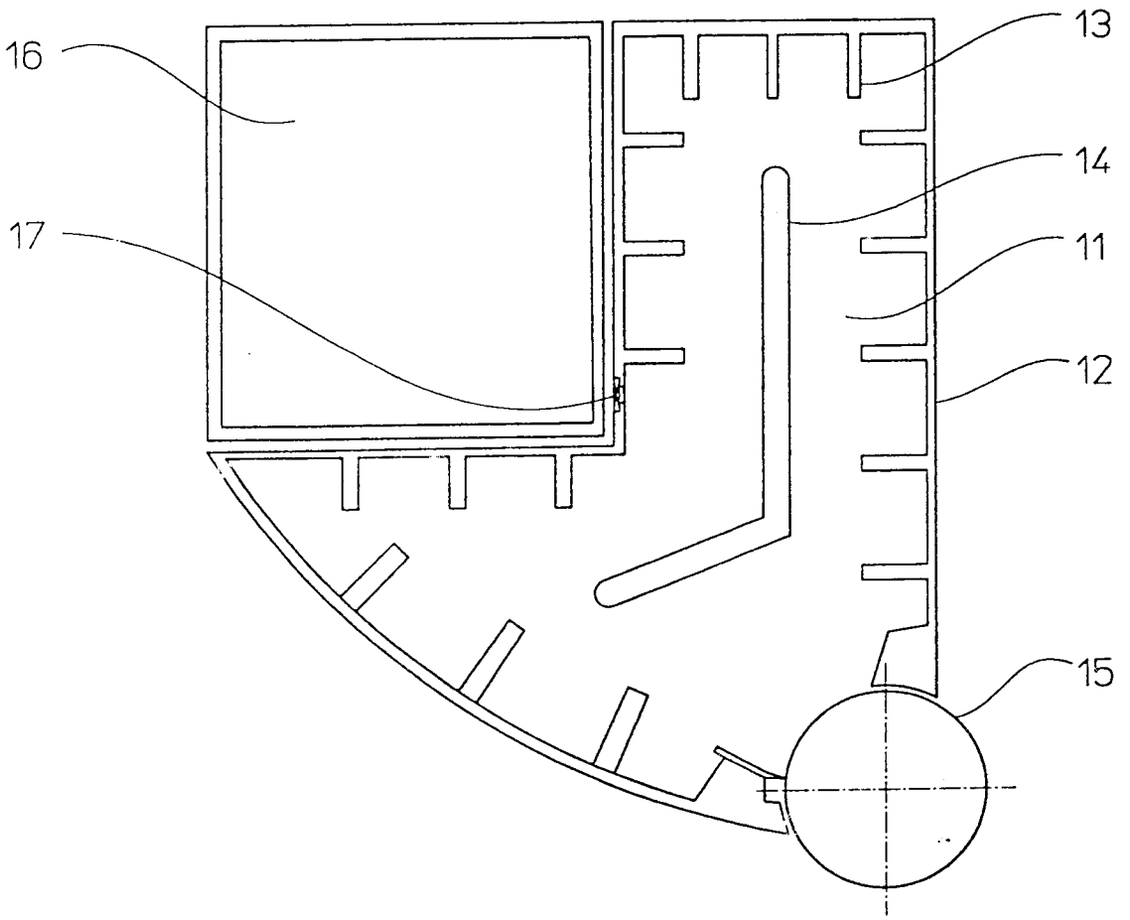

FIG.1

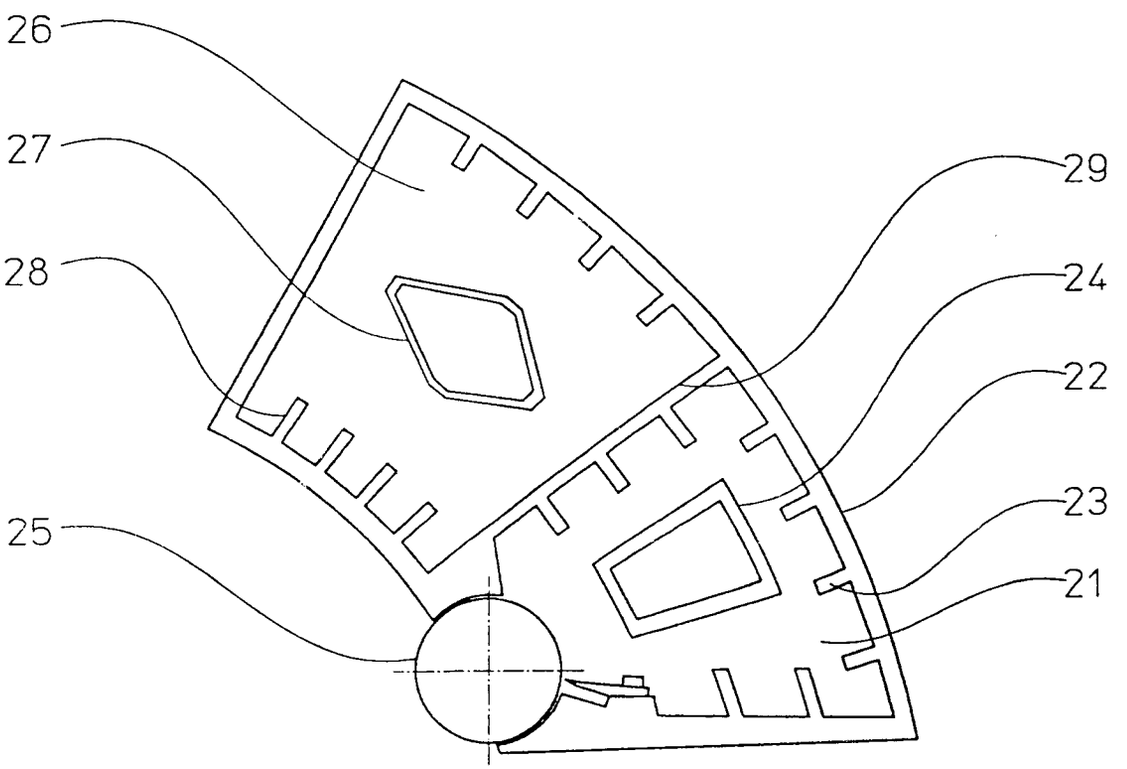

FIG.2

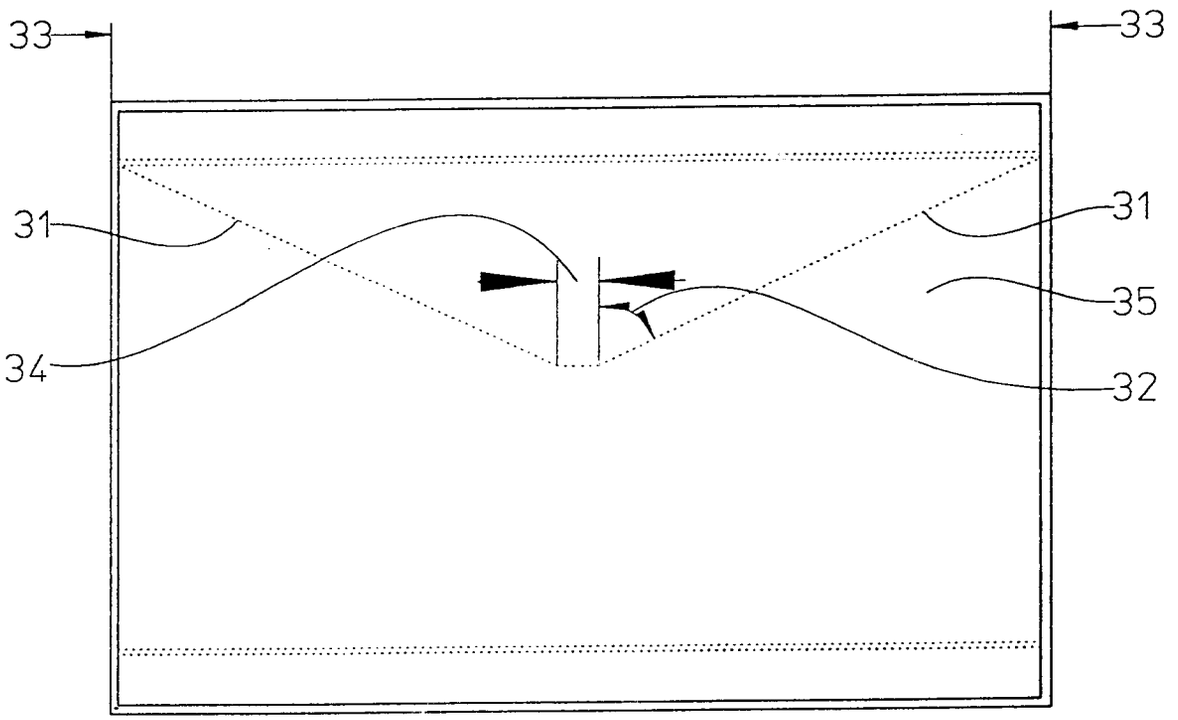

FIG.3

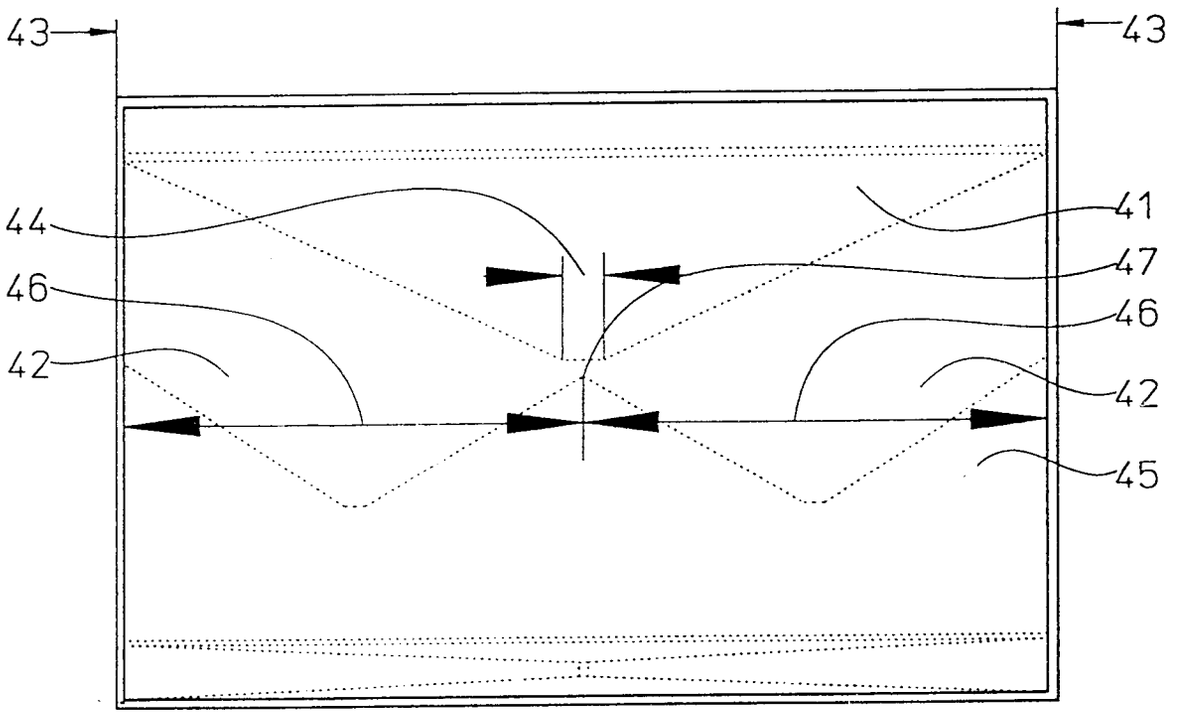

FIG.4

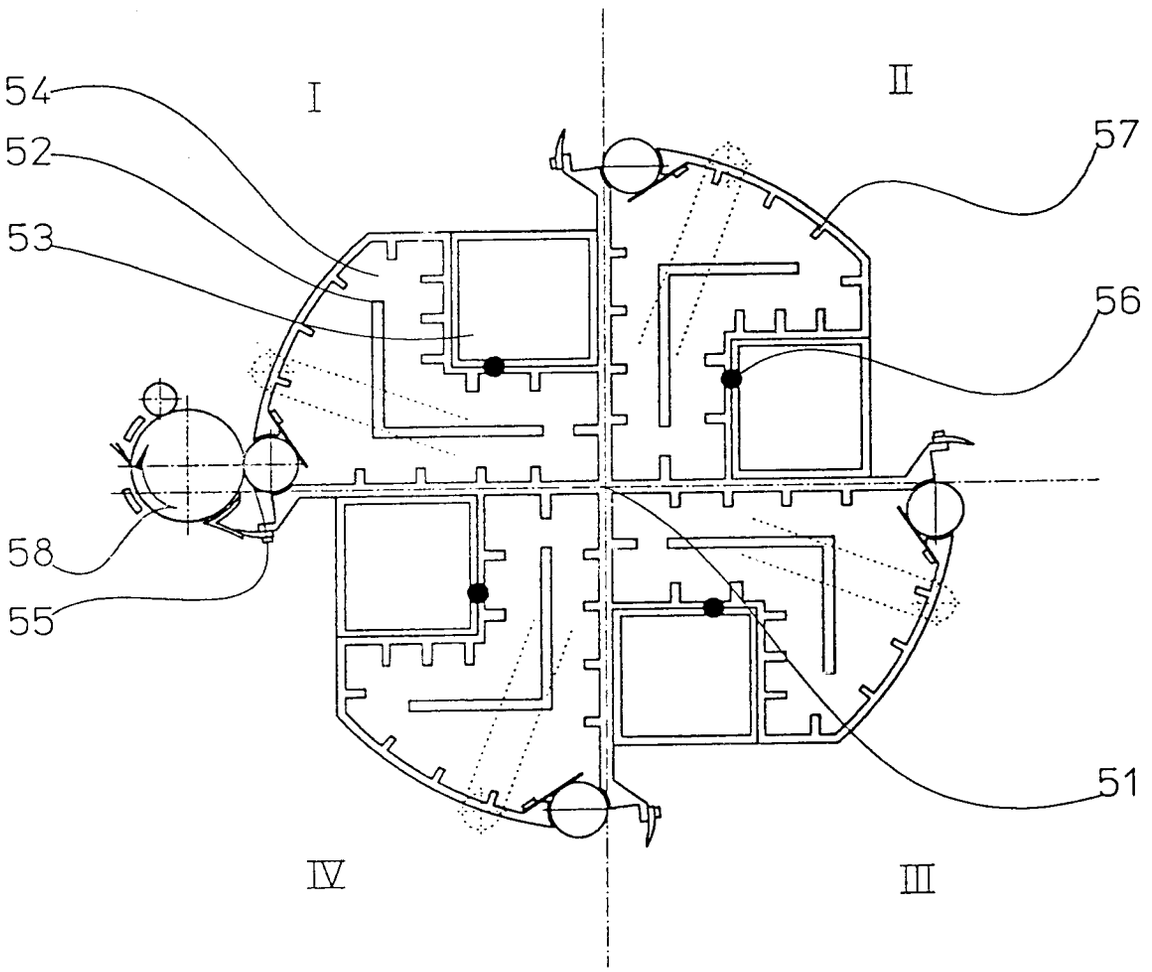

FIG.5

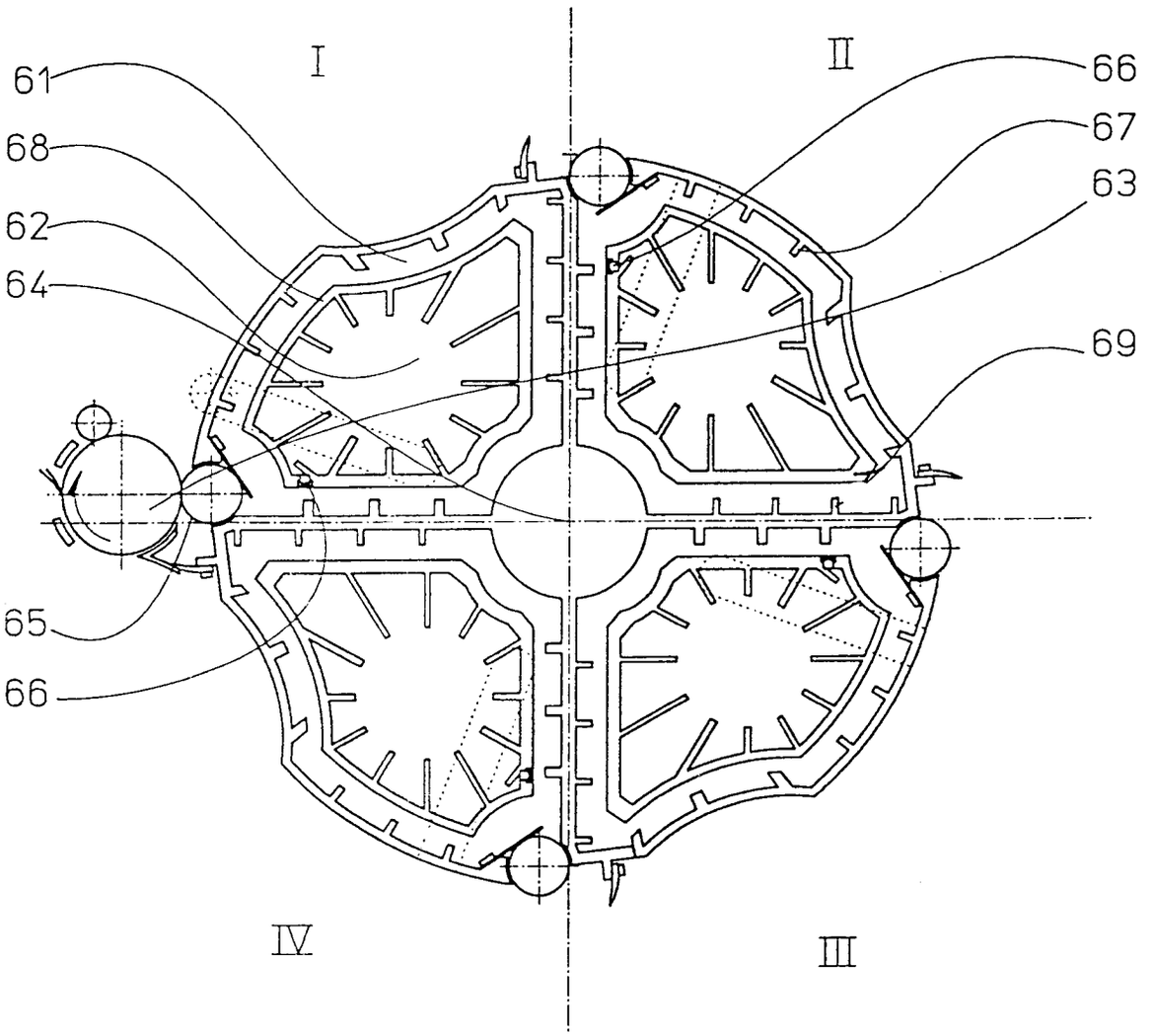

FIG.6

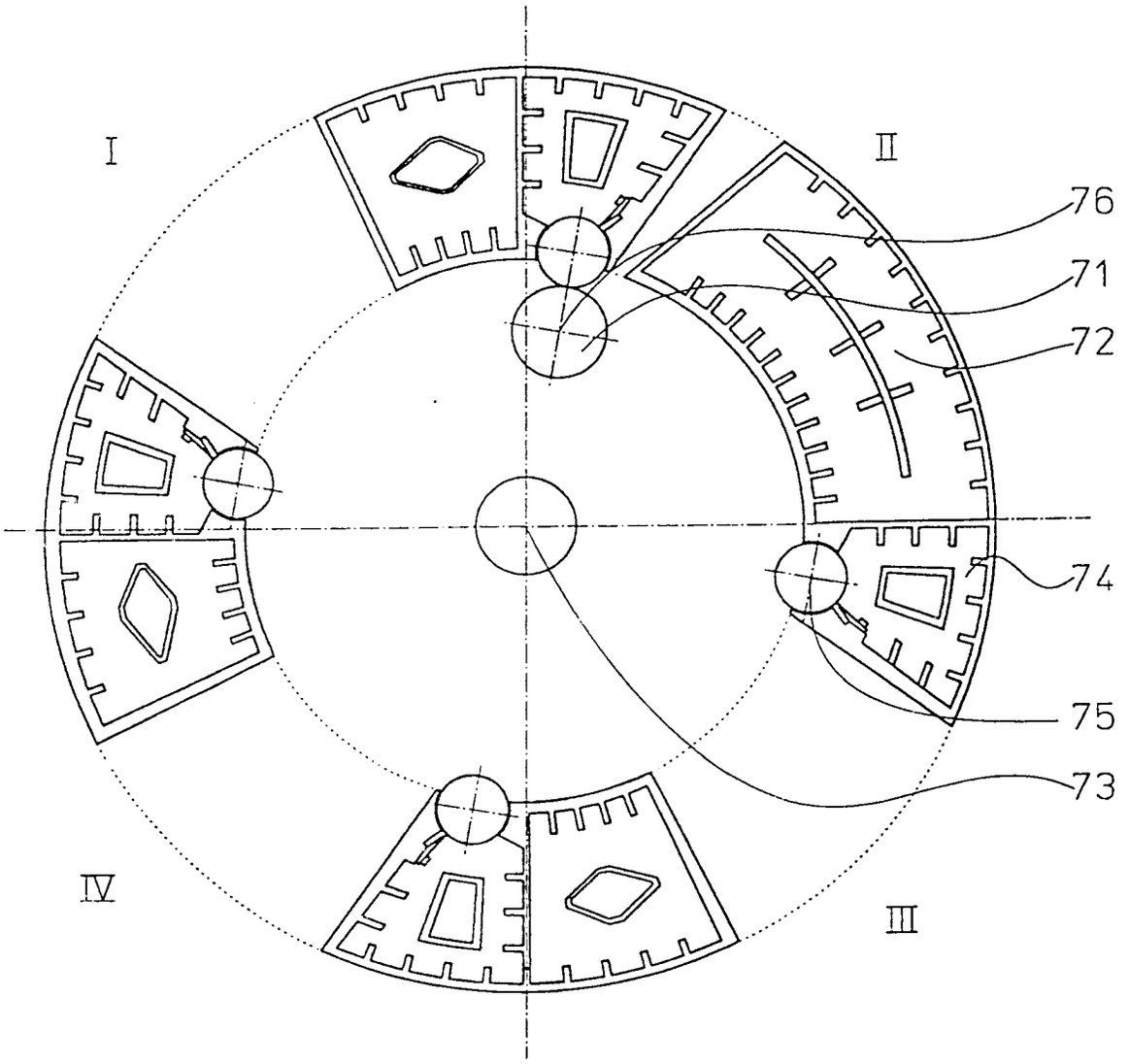

FIG.7

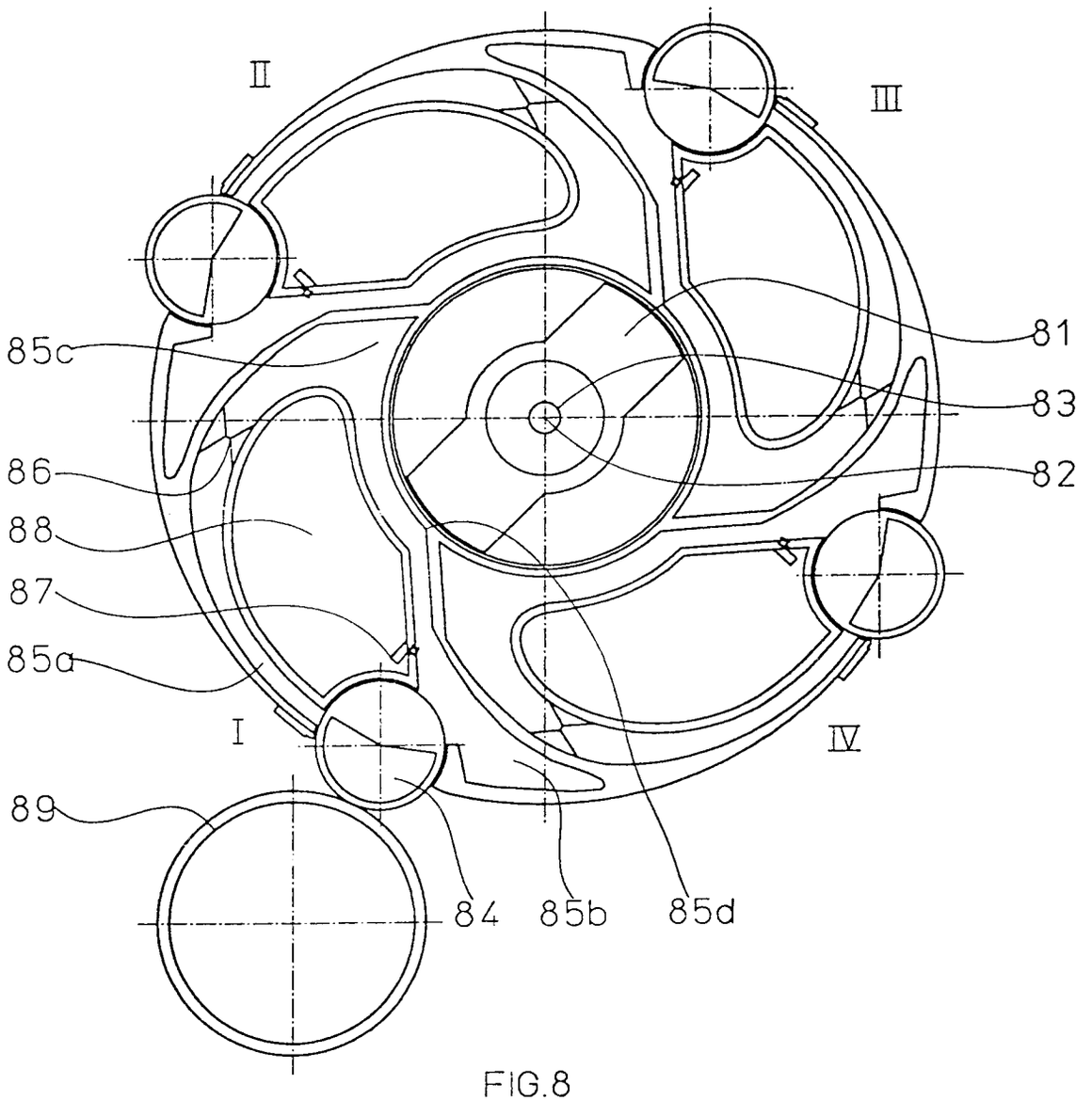

FIG.8

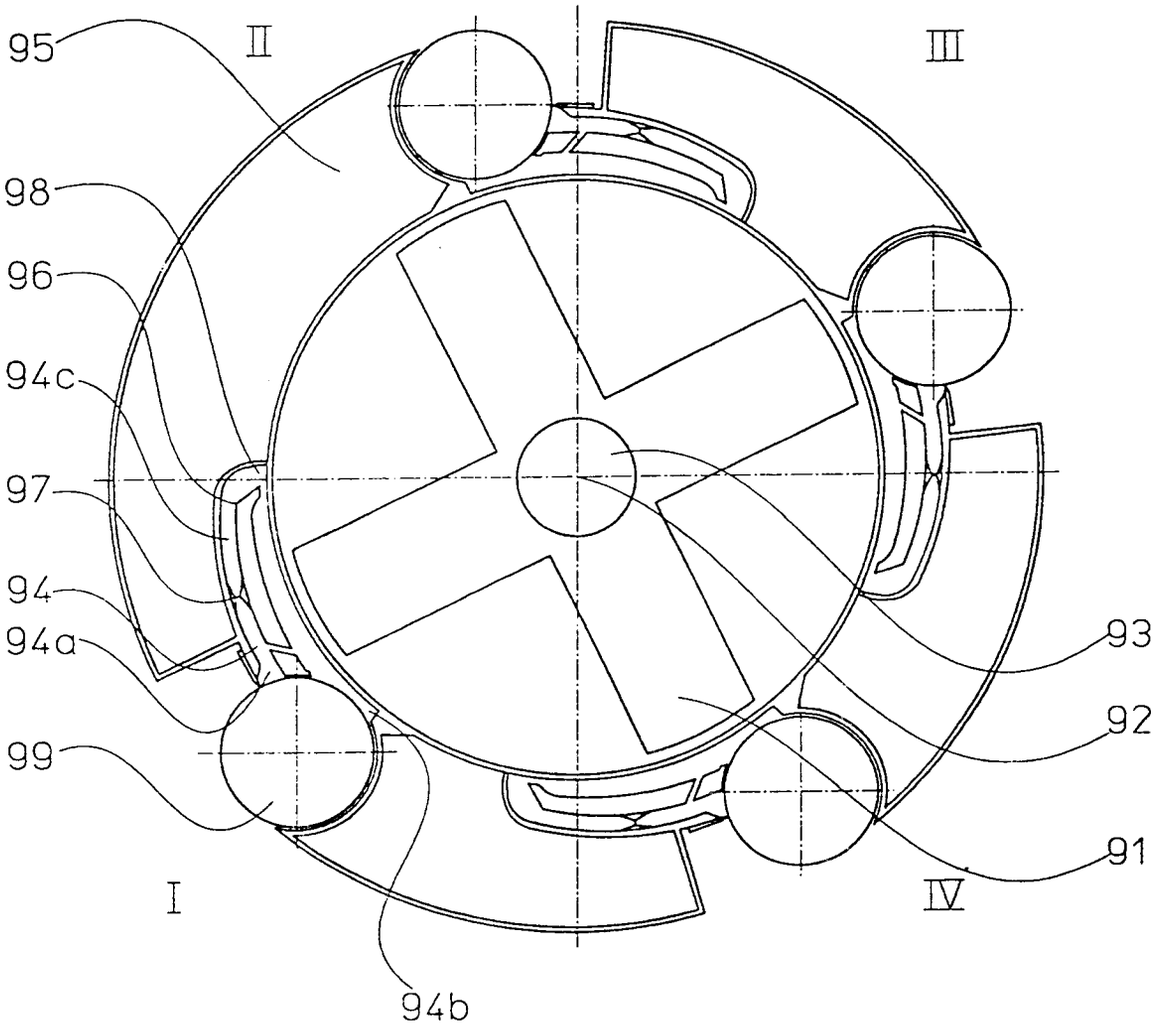

FIG.9

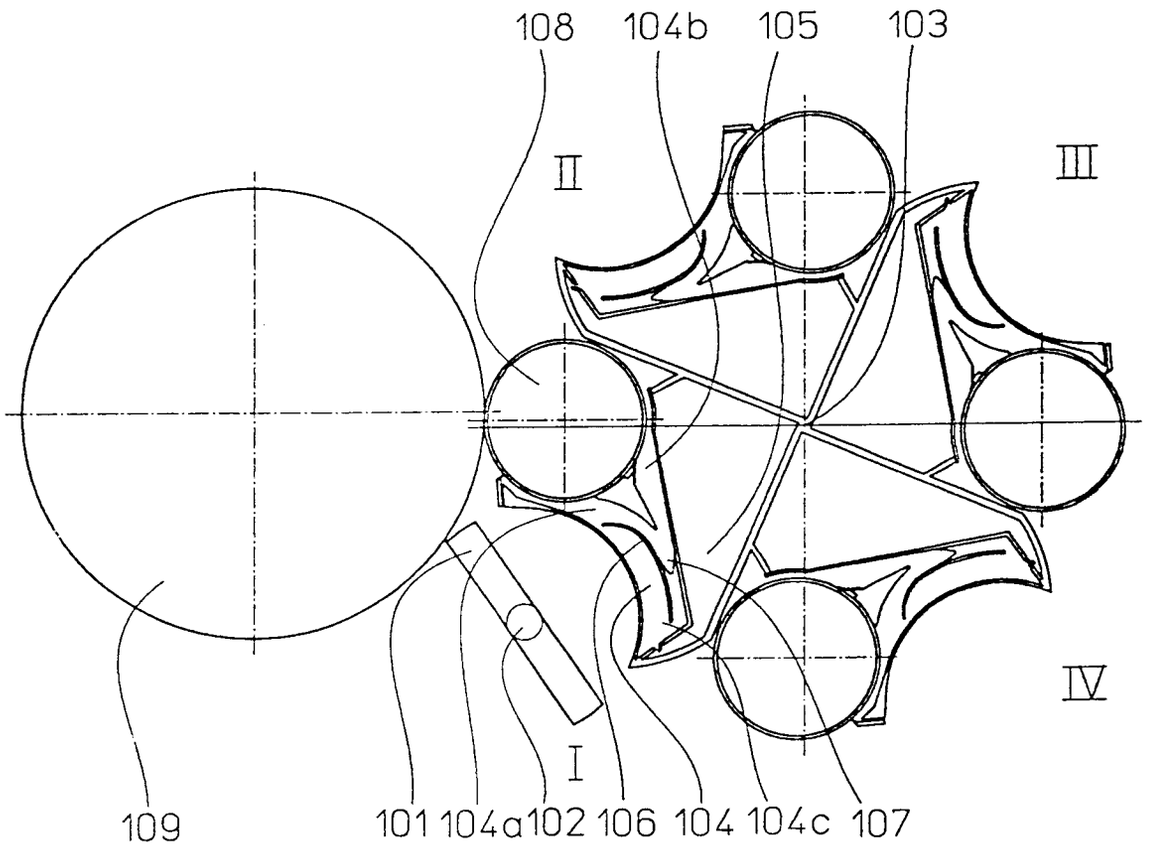

FIG.10

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 20 1776

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	DE-A-41 39 428 (RICOH C., LTD.) * column 6, line 39 - column 7, line 1 * * figures *	1	G03G15/08 G03G15/01
A	WO-A-91 14210 (UNIVERSAL DEVELOPER AND MANUFACTURING CO.) * abstract; figures *	1	
A	PATENT ABSTRACTS OF JAPAN vol. 11, no. 112 (P-565) (2559) 9 April 1987 & JP-A-61 259 282 (CANON INC) 17 November 1986 * abstract *	6,7	
A	DE-A-40 17 457 (MINOLTA CAMERA K.K.) * abstract; figures *	1	
A	PATENT ABSTRACTS OF JAPAN vol. 15, no. 406 (P-1263) 16 October 1991 & JP-A-03 164 766 (HITACHI KOKI CO LTD) 16 July 1991 * abstract *	1	
A	EP-A-0 452 897 (MATSUSHITA ELECTRIC IND.) * claim 9; figures 1A,2,3 * * column 9, line 22 - column 10, line 7 *	1	
A	US-A-4 598 991 (HOPSOYA ET AL.) * abstract; figure 1 *	9	
A	DE-A-32 08 996 (AGFA GEVAERT AG) * the whole document *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

G03G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	8 August 1994	Leisner, C

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