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[11] **3,887,927**

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[54] **APPARATUS AND PROCESS FOR PRODUCING LATENT ELECTROSTATIC IMAGES**

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May 23, 1972 Switzerland 007588/72

[52] **U.S. Cl.** ..... **346/74 ES**; 355/3

[51] **Int. Cl.** **G03g 13/22**; G01d 6/11

[58] **Field of Search** ..... 346/74 ES, 74 E; 355/3; 101/DIG. 13

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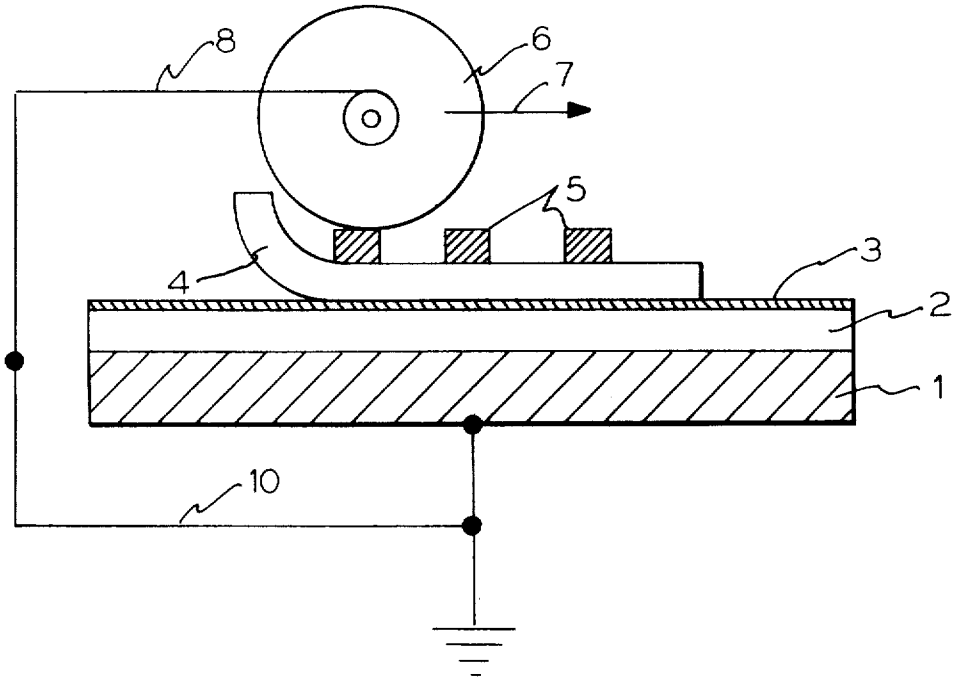
[57] **ABSTRACT**

Process and apparatus is disclosed for producing a latent electrostatic image on a dielectric surface which corresponds to areas on a surface of a master (original) which are more electrically conductive than other areas on the said surface. The process includes the steps of positioning a dielectric carrier member in contact with a surface of the master (original), providing an electrically conductive element on the free surface of the carrier member, applying an electric field potential between the free surface of the master (original) and the conductive element, and thereafter removing the field potential and separating the master (original) and the carrier. An electrostatic latent image which corresponds to the selected areas on the master (original) is retained on the carrier. Apparatus is disclosed for performing the described process.

35 Claims, 12 Drawing Figures



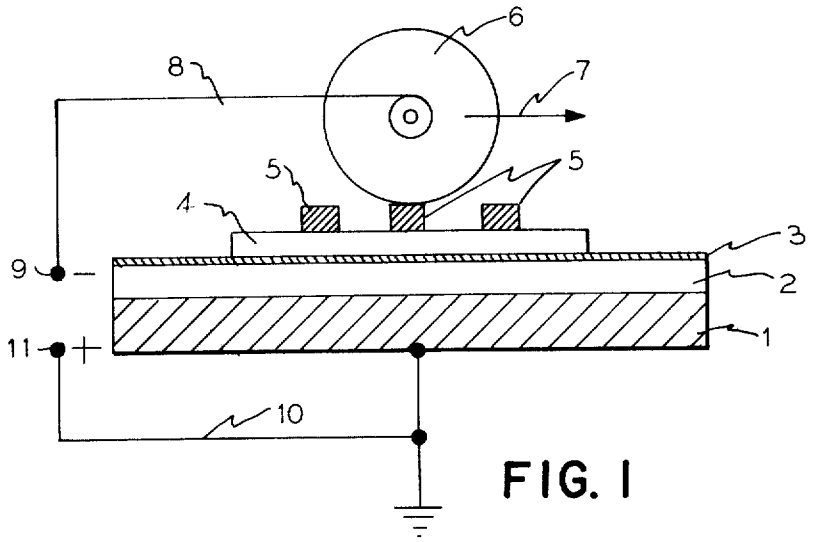


FIG. 1

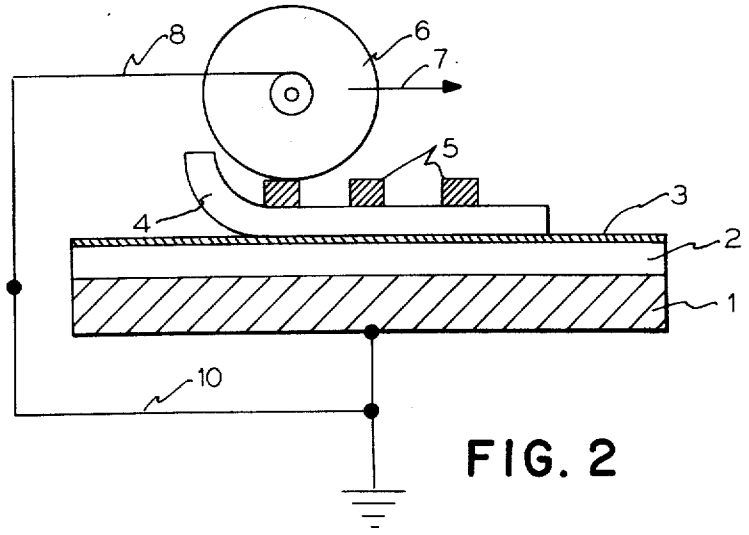


FIG. 2

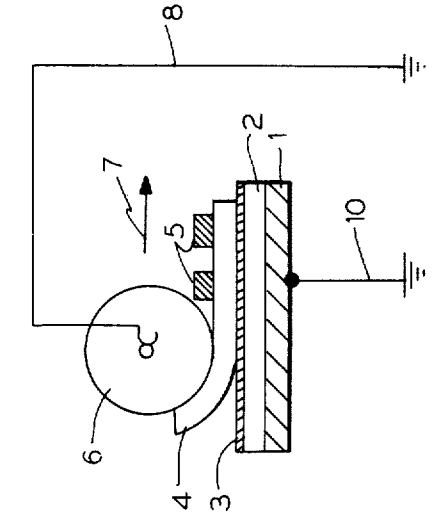


FIG. 5

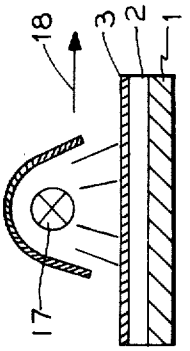


FIG. 7

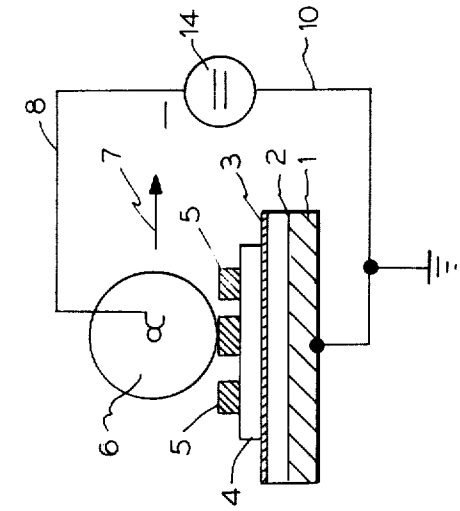


FIG. 4

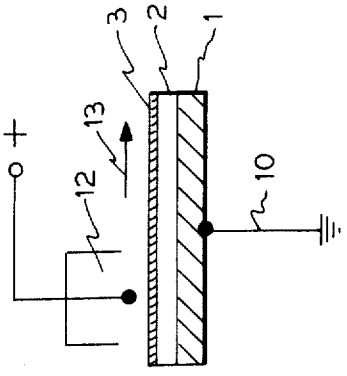


FIG. 3

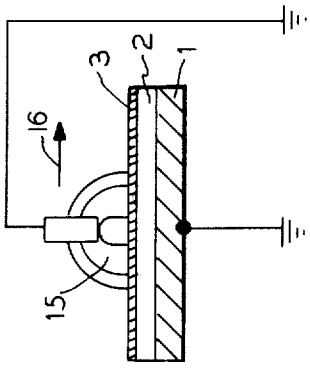


FIG. 6

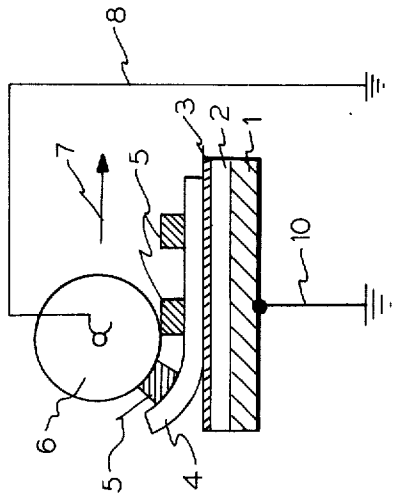


FIG. 10

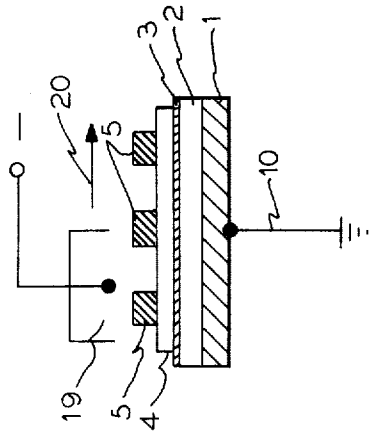


FIG. 9

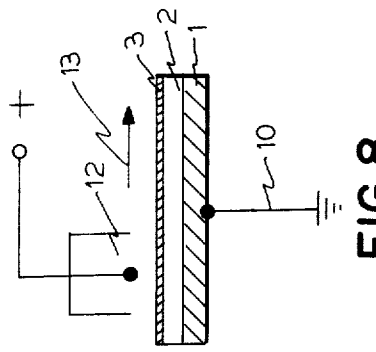


FIG. 8

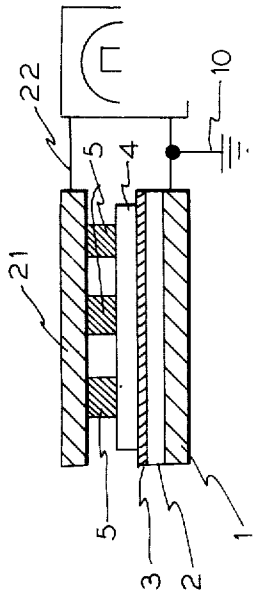


FIG. 12

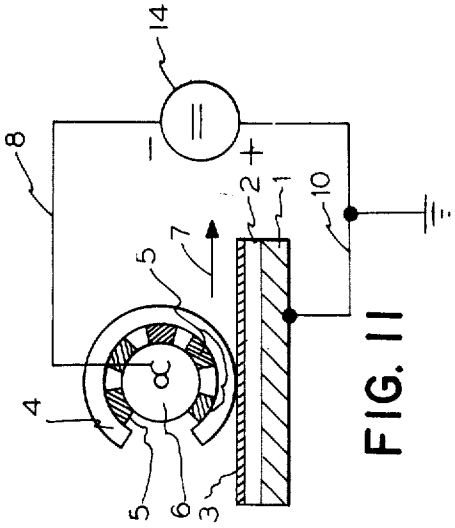


FIG. 11

APPARATUS AND PROCESS FOR PRODUCING LATENT ELECTROSTATIC IMAGES

This invention relates to a process and an apparatus for producing latent images and to the application of this process. More particularly, the invention relates to an electrographic process for producing latent electrostatic charge images and to an apparatus for carrying out this process. The invention also relates in particular to a process for reproducing one-sided originals. The duplicates produced from these originals can also be used as intermediate originals for other reproduction processes. The print obtained can reproduce writing, drawings, printing, etc. Master copies (originals) can be reproduced by a number of different processes, for example by the hectography process using alcohol-soluble dyes, the helio process, electrophotographic processes, conventional photocopying processes, transfer copying processes using carbon paper and similar films and also specially prepared papers which are sensitive to pressure.

Conventional processes are attended by various disadvantages. For example, the hectography process is only suitable for relatively small formats. The helio process is relatively complicated, especially in the case of large formats. It also has the disadvantage of an unpleasant smell. Electrophotographic processes are also difficult to apply in the case of large formats. Conventional photographic processes are expensive and require complicated apparatus. Copying with papers resembling carbon paper is only suitable for small numbers of copies of small formats in connection with typewriters.

The object of the present invention is to provide a process for producing images which, with the simplest of means, enables any number of copies to be produced from a master (original) without any serious restrictions as to format. Another object of the invention is to provide an apparatus for carrying out this process which is simple in structure and easy to handle.

The present invention relates to a process for producing latent electrostatic charge images which is distinguished by the fact that a charge image corresponding to a master (original) is produced on the basis of the differences in conductivity between the printed, written or drawn areas of the master (original) and its blank areas.

The invention also relates to an apparatus for carrying out this process which is characterised by a master (original) in contact with a dielectric carrier, an electrical field being associated with at least part of the master (original) and carrier in contact with one another.

The invention is described by way of example in the following with reference to the accompanying drawings, wherein:

FIG. 1 shows the production of a latent charge image in accordance with a first embodiment.

FIG. 2 shows the removal of the master (original) from the carrier.

FIG. 3 shows the charging of the carrier according to a second embodiment.

FIG. 4 shows the production of the charge image according to the second embodiment.

FIG. 5 shows the removal of the master (original).

FIG. 6 shows the development of the latent charge image.

FIG. 7 shows the fixing of the toner image.

FIG. 8 shows the charging of the carrier according to a third embodiment.

FIG. 9 shows the production of the charge image according to the third embodiment.

FIG. 10 shows the removal of the master (original).

FIG. 11 shows the production of the charge image according to a fourth embodiment.

FIG. 12 shows the production of a charge image according to a fifth embodiment.

In all the Figures, identical elements have been provided with the same reference numerals. The Figures have not been drawn to scale.

The principle on which the invention is based will be discussed briefly in the following before embodiments of the invention are described. In one known electrographic duplication process, an electrostatic charge image is initially produced on a carrier with a photoconductive layer, being rendered visible by a subsequent developing process. To produce this electrostatic charge image, a photoconductive layer arranged on the carrier is electrically charged in the dark and selectively discharged by exposure according to a pictorial or manuscript original. Exposed areas of the photoconductive layer become low in resistance so that a previously applied electrical charge is discharged, leaving an electrostatic charge image corresponding to the master (original). This electrostatic charge image is subsequently developed by known methods, for example by dry development using a magnetic brush known per se and toner particles. In these known reproduction processes, production of the charge image corresponding to the structure of the master (original) necessitates both a photoconductive layer and a high-voltage source for electrically charging this photoconductive layer, and also a lighting arrangement for reproducing the master (original) on the photoconductive layer.

In contrast to these known processes, the electrostatic charge image corresponding to the master (original) is produced, according to the invention, by the direct effect of voltage upon the master (original) which rests on a dielectric carrier. Accordingly, there is no need for any lighting arrangement or for a photoconductive layer for producing the charge image used for reproduction.

A dielectric carrier, for example a piece of writing paper with relatively good insulating properties, lies on a conductive base plate. In order to obtain adequate insulation resistance, the paper can be additionally dried under heat, for example before it is used. A master (original) printed on one side only for example is placed with its blank side on this piece of writing paper. The image to be reproduced, either in the form of typescript or printing, is thus situated on that side of the master (original) remote from the dielectric carrier. It can be in the form of, for example, a sheet of paper that has been typed on one side. An electrode, for example in the form of a knife edge or roller, is guided over the typed side of the master (original). This electrode is connected to one pole of a high-voltage source whose other pole is connected to the base plate. It has been found that the conductivity of the master (original) is higher where it has been printed or typed than where it is blank. By transporting a charge through the master (original) to the dielectric carrier, i.e. for example to the writing paper underneath the master (original), or by polarisation produced by the field applied, an electrostatic charge image corresponding to the master

(original) is formed on the dielectric carrier. After the electrode and the master (original) have been lifted off the carrier, the dielectric carrier supporting the latent charge image can be delivered to a conventional developing unit. For example, it can be swept by a magnetic brush containing toner particles, of the type used in electrography, as a result of which the latent charge image immediately becomes visible. The charge image thus developed can then be fixed in a subsequent fixing process. For example, it is possible for this purpose by applying heat to fix an image consisting of resin-containing toner particles on the carrier. The papers coated with a so-called "dielectric film," of the kind commonly used in electrography, such as for example Kanzaki K-21 M and Varian Statos paper, represent particularly suitable carrier materials.

In conventional electrographic reproduction processes, therefore, the charge image is produced by the varying exposure to light of the photoconductive layer corresponding to the exposed master (original). By contrast, in the process according to the invention, the charge image is produced in the absence of exposure, or without optical reproduction of the master (original) on the charge carrier, for example the sheet of paper referred to above. Instead the difference in conductivity between written or printed areas and blank areas of the master (original) is used to produce the charge image.

The process according to the invention is thus particularly suitable for one-sided masters (originals) in whose case the printing ink should show adequate conductivity whilst the carrier material of the master (original) should not show excessively high conductivity. The master (original) and the carrier on which the reproduction is formed are in contact with one another during production of the electrostatic charge image. Accordingly, this reproduction process eliminates the need to use optical systems, illuminating systems and photoconductive layers. Accordingly, it represents an extremely economical reproduction process.

The use of conductive printing inks for the master (original) presumably leads to the penetration of conductive ink particles into the carrier material of the master (original) and, hence, increases its conductivity in the printed areas. Passage of the charge would thus appear to be made easier in these areas.

On the other hand, it has been found that a latent charge image is also formed on the dielectric carrier in cases where a sheet of paper coated with a film of metal is used instead of the printed master (original) and the electrode passed over this film of metal. The charge image obtained in this case corresponds to the form of the film.

In this case, aluminium particles can hardly be expected to penetrate through the layer of paper. The precise mechanism by which the electrostatic charge image is formed on the sheet of paper underneath the master (original) has not yet been fully clarified. However, the effect of reproducing the master (original) on the underlying dielectric carrier by means of the electrostatic charge image produced and its development has been proved and tested with many different kinds of masters (originals).

The masters (originals) can consist, for example, of extracts from newspapers, sheets of typescript, sheets of manuscript written in pencil, ink, with ballpoint or felt pens, drawings in Indian ink, etc.

An insulating layer on a metal, preferably earthed substrate, can be used as the carrier for the latent electrostatic charge image. The insulating layer can be in the form of for example a thin plastics film, although it is preferably in the form of a dielectrically coated paper with a resistivity of the order of 10^8 to 10^{13} ohms/cm. Coated papers of this kind are commonly used in electrostatic reproduction apparatus. One of their sides is weakly conductive whilst the other carries a known dielectric layer. It is also possible to arrange a dielectric layer on both sides, so that it is possible to obtain an image on both sides of this carrier material by the process according to the invention. It is also possible to use thin Mylar films, for example 12 to 17 μ thick, as carriers for the copy. The master (original) should preferably have a resistivity of less than 10^{15} ohms/cm in its printed areas. The ratio between the resistivity of the blank areas and the resistivity of the printed areas of the master (original) should be substantially of the order of 10 : 1. The printing ink should show adequate specific conductivity, for example of the order of 10^{+5} $ohms^{-1}$ cm^{-1}. Suitable printing inks also include pencil graphite, ink for felt pens, newsprint etc.

An electrostatic d.c. voltage field is applied between the surface of the master (original) and the base plate under the carrier for the electrostatic charge image. This can be done in different ways, for example by means of a high-voltage corona discharge which charges the upper side of the master (original) or by using an electrode in the form of a sliding roller which is connected to a d.c. voltage source and which is rolled over the top of the master (original) under light pressure. However, a blade-like electrode can also be passed over the surface of the master (original). The voltage required for producing the charge image is of the order of about 300 to 400 volts down to the breakdown voltage of the dielectric layer used. Accordingly, the upper limit is substantially in the range from 1000 to 2000 volts. The electrical field is best only briefly applied, for example for no longer than about 1 to 2 seconds. However, useful electrostatic charge images can also be obtained with a much shorter application of the electrical field.

In a following process stage, the original is lifted off its support; this can be done with or without the assistance of a conductive roller connected to a suitable potential, for example the earth potential.

The latent electrostatic charge image formed on the dielectric layer can be developed by any of the developing processes known from electrography. Accordingly, it is possible to use either liquid developers or dry developers with subsequent fixing. It is also possible, however, to transfer the electrostatic charge image to a second carrier film by a so-called charge-transfer process. For development of the toner, the charged toner particles must have a suitable polarity. This should be opposite to the polarity of the charge applied. To improve contrast, the dielectric layer can be charged with opposite polarity either immediately before production of the electrostatic charge image or immediately thereafter, thus preventing the undesirable deposition of toner particles on those areas that are to remain white. After development, the image can be fixed by any of the known processes, for example by applying heat, by means of radiation or by passing a stream of hot air over it, etc. The image produced can also be transferred to papers, textiles, metals or any other suitable

substrates. In cases where the so-called toner transfer process is used, the master (original) has to be directed with its printed side towards the substrate in order not to obtain a mirror-inverted reproduction in the copy.

The process described above can be repeated with the same dielectric layer so that it is also possible to obtain overprints with the same colour or in several process stages with different colours of the copy.

A first embodiment is described in the following with reference to FIGS. **1** and **2** of the accompanying drawings.

A dielectric carrier **2**, for example in the form of a paper provided with a dielectric film **3**, of the kind commonly used in electrography, lies on a conductive base plate **1**. The master (original) **4** with its "image" **5** to be reproduced lies on the dielectric carrier **2**. FIGS. **1** and **2** have not been drawn to scale, instead the structure of the image has been greatly exaggerated in the interests of clarity.

A roller **6** is designed to be guided over the image side of the master (original) **4** in the direction of the arrow **7**. The roller **6** either consists wholly of conductive material or at least its cylindrical surface is conductive. An electrical voltage of for example 900 volts is applied through a line **8** to the roller **6** or to its conductive surface, the roller **6** being connected for example to the negative pole **9** of a voltage source (not shown in FIG. **1**) whilst the base plate **1** is connected through a line **10** to the positive pole **11** of the voltage source. The base plate **1** is preferably connected to earth as well through the line **10**. The arrangement illustrated in FIG. **1** produces a negative latent charge image corresponding to the image **5** after the roller has travelled over the master (original) **4** on the dielectric carrier **2**. If a positive charge image is required, the polarity of the lines **8** and **10** has to be changed. In this way, it is possible to obtain the correct polarity of the charge image, depending upon the polarity of the toner used for development.

FIG. **2** diagrammatically illustrates removal of the master (original) **4** from the dielectric carrier **2**, for which purpose the two lines **8** and **10** are separated from the voltage source, but connected to one another. The latent charge image corresponding to the "image" **5** is situated on the dielectric layer **3**.

A second embodiment will now be described with reference to FIGS. **3** to **7**. According to this second embodiment, the surface of the dielectric carrier **2** (cf. FIG. **3**) is positively charged by means of a conventional corona unit **12**. This is done for example by moving the corona unit **12** in the direction of the arrow **13**. It would of course also be possible to use a stationary corona unit **12**, in which case the base plate **1** together with the dielectric carrier **2** would be moved relative to the corona unit, i.e. against the direction of the arrow **13**.

According to FIG. **4**, the master (original) **4** with its "image" **5** facing upwards is placed on the dielectric carrier **2** and rolled over by the roller **6** in the manner already described with reference to FIG. **1**. The roller **6** is connected through the line **8** to the negative pole of a high-voltage source **14** whose positive pole is connected through the line **10** to the base plate **1** and to earth.

According to FIG. **5**, the master (original) **4** is removed similarly to FIG. **2**, the roller **6** being conductively connected to earth through the line **8**.

FIG. **6** diagrammatically illustrates the development of the charge image produced on the dielectric carrier by means of a magnetic brush **15** which is moved over the dielectric carrier **2** in the direction of the arrow **16**.

FIG. **7** diagrammatically illustrates the fixing of the toner image by means of a heat-radiation source **17** which is moved over the dielectric carrier **2** in the direction of the arrow **18**.

It would of course also be possible in FIGS. **6** and **7** for the magnetic brush **15** and heat-radiation source **17** to be stationary and, instead, to move the base plate **1** together with the dielectric carrier **2** past them.

A third embodiment will now be described with reference to FIGS. **8** to **10** and **6** and **7**.

As in FIG. **3**, the surface of the dielectric carrier **2** is initially positively charged by means of the corona unit **12**.

In the following process stage, cf. FIG. **9**, the master (original) **4** is initially placed with its image **5** facing upwards on the dielectric carrier **2**. A negative corona unit **19** is then moved over the master (original) **4** in the direction of the arrow **20**. Due to the electrical field produced in this case by the corona unit **19** rather than by a roller **6**, a latent charge image corresponding to the image **5** is again produced on the surface of the dielectric carrier **2**.

In FIG. **10**, the master (original) **4** is removed in the manner already described with a roller **6** connected to earth.

Following process stages include development by means of the magnetic brush shown in FIG. **6** and fixing in accordance with FIG. **7**.

A fourth embodiment will now be described with reference to FIG. **11**.

A master (original) **4** wrapped around a roller **6** is rolled over a dielectric carrier **2** charged in accordance with FIG. **3**. The roller **6** is connected through the line **8** to one pole of the voltage source **14** whose other pole is connected to the base plate **1** and, preferably, to earth as well.

During rolling of the dielectric carrier, the electrical field between the roller **6** and the base plate **1** is used to produce a latent charge image from that part of the master (original) **4** in contact with the dielectric carrier **2**.

Development and fixing are again carried out for example as already described with reference to FIGS. **6** and **7**.

In a fifth embodiment (cf. FIG. **12**), the master (original) **4** is placed on a dielectric carrier **2** charged in accordance with FIG. **3** and covered on its image side by a counter-electrode **21**. The counterelectrode **21** is connected through a line **22** to an output terminal of a d.c. voltage impulse source **23** whose other terminal is connected to the base plate **1** and, preferably to earth.

One or several short impulses of, for example, 0.1 to 1 second in duration are sufficient to produce a latent charge image corresponding to the image **5** of the master (original) **4** on the dielectric carrier **2**.

Development and fixing can be carried out as already described.

It is further pointed out that the process and apparatus according to the invention, as described above, can be varied. Thus, it is also possible for example to obtain a latent charge image of a master (original) by placing the image side **5** of the master (original) on the dielectric carrier **2** or **3** in contrast to FIG. **1**. In this case,

however, the charge image is mirror-inverted in relation to the master. This can be desirable for example in cases where an "intermediate original" is to be produced from the charge image for further copying processes.

It is also possible, however, to apply the master (original) **4** with its image **5** to the base plate **1**, cf. FIG. **1**, and the carrier **2** with its dielectric layer **3** to the back of the master (original) **4**. The roller **6** then rolls over the back of the carrier **2** while voltage is applied to the base plate **1** and roller **6**.

A similar procedure can of course also be adopted in the second, third, fourth and fifth embodiments.

The charge image produced in accordance with any of the embodiments described above or modifications thereof can either be developed on the carrier **2** itself by a known method, for example dry by means of a magnetic brush containing toner material or wet by a process known from electrography and optionally fixed, or alternatively it can be transferred in a charge-image transfer process to another carrier and then developed and fixed. However, providing the carrier **2** is of a suitable form, the toner image developed on the carrier **2** can also be transferred to another carrier in known manner by an image-transfer process and then fixed.

The electrical field required to carry the charge through the master (original) or to produce polarisation can be produced by a flat, arcuate, cylindrical, prismatic, stationary or moved electrode connected to different potentials.

The carrier and master (original) can also pass on top of one another for example between two conductive rollers which represent the two electrodes, in such a way that that part of the master (original) and carrier momentarily situated between the two rollers is always exposed to the electrical field.

However, the aforementioned electrical field can also by produced by charging the surfaces of the dielectric carrier or by corona effect on the master (original).

The varying conductivity of the master (original) referred to above can relate both to differences in surface conductivity and also to differences in volume conductivity or to both.

I claim:

1. A one-step process for producing in the absence of intermediate masters a latent electrostatic charge image corresponding to selected areas on one of two surfaces of an uncoated original document having non-electrostatically produced indicia on said one surface thereof, said selected areas on said document being more conductive than other areas, comprising the steps of positioning a dielectric carrier member in contact with the other of the two surfaces of said original document, providing an electrically conductive element on the free surface of said carrier member, applying an electric field potential above at least 200 volts between the free surface of said original document and said conductive element, thereafter removing said field potential and separating said original document and said carrier member whereby a latent electrostatic image is retained on said carrier member.

2. The process according to claim **1** further including the step of placing the original document about a cylindrical electrode prior to positioning the original document in contact with the dielectric carrier member, and rotating said cylindrical electrode and said original document placed thereabout relative to said dielectric carrier member with said dielectric carrier member being in at least rolling contact with said original document while electric field potential is applied between said cylindrical electrode and said electrically conductive element.

3. The process according to claim **1** wherein said electrically conductive element is a first plate electrode, and including the step of positioning a second plate electrode in contact with the surface of the original document opposite its surface in contact with said dielectric carrier member, and wherein said electric field potential comprises at least one pulse and is applied between said first and second plate electrodes.

4. The process according to claim **1** wherein said separating step includes withdrawing the original document from the carrier member by maintaining at least a portion of the original document in contact with a conductive cylindrical electrode and moving said conductive cylindrical electrode relative to said dielectric carrier member while said conductive cylindrical electrode is maintained at at least substantially the same potential as said electrically conductive element.

5. The process according to claim **1** including the additional step of transferring the latent electrostatic image retained on said dielectric carrier member to another carrier member.

6. The process according to claim **5** including the further step of developing the transferred latent electrostatic image on the other carrier member.

7. The process according to claim **1** wherein said dielectric carrier member comprises paper having a dielectric coating on at least one surface thereof.

8. The process according to claim **7** wherein said paper includes a dielectric coating on both surfaces thereof.

9. The process according to claim **1** further including the step of charging the dielectric carrier member with a corona discharge of a first polarity prior to positioning said dielectric carrier member in contact with said original document and applying said electric field potential between the free surface of said original document and conductive element by applying to said free surface of the original document a corona discharge of a polarity opposite to said first polarity to produce a latent electrostatic image on said carrier member.

10. The process according to claim **1** wherein said potential is in the range of 200 to 3000 volts.

11. The process according to claim **1** wherein said field potential is applied intermittently in the form of pulses.

12. The process according to claim **11** wherein the applied potential is in the range of 200 to 3000 volts and said pulses are less than 10 seconds in duration.

13. The process according to claim **1** further including the step of: charging said carrier member prior to positioning said carrier member in contact with said original document.

14. The process according to claim **13** wherein said charging step comprises placing a charge on said carrier member of the opposite polarity of the potential applied to the free surface of said original document.

15. The process according to claim **1** further including the step of charging said carrier member after separating said original document and said carrier member and after a latent electrostatic image is retained on said carrier member.

16. The process according to claim 15 wherein said charging step comprises placing a charge on said carrier member of the opposite polarity to the polarity of the latent electrostatic image retained on said carrier member.

17. The process according to claim 1 further including the step of developing the latent electrostatic image retained on said dielectric carrier member.

18. The process according to claim 17 further including the additional step of transferring the developed image on the dielectric carrier member to another carrier member.

19. The process according to claim 18 further including the step of fixing the transferred image on the other carrier member.

20. The process according to claim 1 further including the additional step of improving the dielectricity of said dielectric carrier member by removing moisture therefrom.

21. The process according to claim 20 wherein said additional step comprises drying said dielectric carrier member prior to positioning said member in contact with said original document.

22. The process according to claim 21 wherein said drying comprises contacting said member with a drying agent to remove moisture therefrom.

23. The process according to claim 21 wherein said drying comprises applying heat to said member to remove moisture therefrom.

24. The process according to claim 1 further including providing an electrode in contact with at least a portion of said free side of said original document and applying said field potential between said electrode and said conductive element.

25. The process according to claim 24 further including the step of electrically contacting said electrode and said conductive element during said separation of said original document and said carrier member.

26. The process according to claim 24 wherein said electrode progressively and linearly contacts said original document.

27. The process according to claim 26 wherein said electrode is a cylinder and progressively contacts said original document across its entire surface.

28. Apparatus for producing a latent electrostatic image corresponding to selected areas on one of two surfaces of an original document having non-electrostatically produced indicia being more electrically conductive than other areas thereon comprising means for contacting a dielectric carrier member with the other of the two surfaces of said original document, an electrically conductive element in contact with the free surface of said carrier member, means for applying an electric field potential between the free surface of said original document and said conductive element to produce a latent electrostatic image on said carrier member corresponding to the differences in conductivity between said selected and other areas on said one surface of the original document and means for separating said original document and carrier member whereby said latent electrostatic image is retained on said carrier member.

29. Apparatus according to claim 28, further comprising corona discharge means for charging at least one surface of said carrier member by conona discharge.

30. Apparatus according to claim 29, further comprising second corona discharge means for applying charges of a polarity opposite to the polarity of the charges produced by said first corona discharge means to the free surface of said original document while said original document is in contact with said dielectric carrier member.

31. Apparatus according to claim 28 wherein a second electrically conductive element is disposed in contact with said free surface of said carrier member, and said means for applying an electric field potential is arranged to apply said potential between said conductive elements.

32. Apparatus according to claim 31, wherein at least one of said electrically conductive elements is movable with respect to the other element.

33. Apparatus according to claim 32, wherein said second conductive element is a cylindrical, rotatable electrode being movable in contact with the free surface of said original document with respect to said original document.

34. Apparatus according to claim 31, wherein said electrodes are at least temporarily connectable to said means for applying an electric field potential whereby different potentials are applicable thereto.

35. Apparatus according to claim 31, wherein said electrodes are connectable to said means for applying an electric field potential for transmitting direct current potential impulses therebetween.

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