

1 IMAGING APPARATUS AND METHOD AND LIQUID TONER THEREFOR

2 FIELD OF THE INVENTION

3 The present invention relates to a liquid toner and
4 imaging method and apparatus using the liquid
5 toner.

6 BACKGROUND OF THE INVENTION

7 Liquid toners have been in use for a great many years.
8 In U.S. Patent 4,794,651, and in a number of other patents
9 and publications based on this patent, liquid toner having
10 fibrous or tentacular toner particles made of various
11 material was described.

12 There has been a need to provide a liquid toner, which
13 when used to form an image on a substrate, forms a more
14 abrasion resistant image than those formed by prior art
15 liquid toners.

16 It is known in the printing art to add particles, for
17 example polyethylene particles, to ink or to the surface of
18 the substrate, in order to improve the abrasion resistance of
19 the ink. Such particles project from the surface of the
20 printed image and the image is more resistant to abrasion
21 from paper. However, abrasion resistance to a conforming
22 eraser is increased by a much smaller amount, if at all.

23 It is also known in the art to coat an already printed
24 image with an abrasion resistant coating.

25 SUMMARY OF THE INVENTION

26 The present invention seeks to provide, in one aspect
27 thereof, an improved toner having greater abrasion
28 resistance than prior art toners.

29 The present invention seeks to provide in a related
30 aspect a method for producing images using the new liquid
31 toner.

32 It has been found that the scuff resistance, abrasion
33 resistance and peel resistance of a wide class of liquid
34 toners may be improved by the addition of a minor amount of
35 an additional material which, at the fusing temperature used
36 for the toner, has a much lower viscosity, preferably

1 several orders of magnitude lower, than the viscosity of the
2 toner particles at the fusing temperature and which forms a
3 separate phase from the toner particles when solidified.

4 It is believed that such material, during the fusing
5 process, migrates to the outer surface of the image. During
6 cooling of the image after it is fused, the additional
7 material forms a substantially separate phase resulting in a
8 hard slippery coating of the additional material which
9 protects the image from abrasion.

10 It has been found that the additional material may be
11 added at almost any point during the toner manufacturing
12 process, but that the effect of the material is most
13 pronounced when the material is added during the final stage
14 of the grinding of the toner or when it is separately ground
15 and added as finely ground material to the toner.

16 There is thus provided, in accordance with a preferred
17 embodiment of the invention an image forming method
18 comprising:

19 providing an image on a substrate, the image comprising
20 toner particles including a polymer material, preferably
21 comprising one or more of an ethylene copolymer, an ethylene
22 terpolymer or an ionomer; an additional material, preferably
23 comprising one or more of polyethylene, a polyethylene wax,
24 a homopolymer and a low molecular weight ionomer, which
25 additional material is solid at room temperature; and
26 carrier liquid;

27 fusing the image to the substrate by heating the image
28 to a fusing temperature at which the toner particles soften
29 to a first viscosity,

30 wherein the additional material has a second viscosity
31 at the fusing temperature which is at least ten times lower
32 and preferably at least two or three orders of magnitude
33 lower than the first viscosity.

34 Preferably the toner particles are solvated by the
35 carrier liquid at the fusing temperature whereby their
36 viscosity is reduced to the first viscosity. Preferably the

1 additional material is solvated by the carrier liquid at the
2 fusing temperature whereby its viscosity is reduced to the
3 second viscosity.

4 Preferably, during fusing or subsequent cooling, the
5 additional material migrates to the surface of the image
6 away from the substrate. In a preferred embodiment of the
7 invention, during cooling, at least a portion of the
8 additional material forms a separate phase from the toner
9 material at said surface, whereby the additional material
10 forms a abrasion resistant layer covering the toner
11 material.

12 In a preferred embodiment of the invention, the
13 additional material is comprised in the toner particles.
14 Alternatively or additionally the additional material is in
15 a finely divided form and is dispersed in the carrier liquid
16 separate from the toner particles.

17 In a preferred embodiment of the invention, the
18 additional material is at least partially incompatible with
19 the toner particles.

20 There is further provided in accordance with a
21 preferred embodiment of the invention, a liquid toner
22 adapted for fusing at a fusing temperature comprising:

23 toner particles comprising a polymer material,
24 preferably incorporating one or more of an ethylene
25 copolymer, an ethylene terpolymer or an ionomer, which has a
26 first viscosity at the fusing temperature;

27 an additional material, preferably comprising one or
28 more of polyethylene, a polyethylene wax, a homopolymer and
29 a low molecular weight ionomer, which additional material is
30 solid at room temperature and has a second viscosity at the
31 fusing temperature; and

32 carrier liquid,

33 the first viscosity being at least ten times,
34 preferably more than 100 or 1000 times, the second
35 viscosity.

36 In a preferred embodiment of the toner, the polymer

1 material is solvated by the carrier liquid at the fusing
2 temperature whereby its viscosity is reduced to the first
3 viscosity. Preferably, the additional material is solvated
4 by the carrier liquid at the fusing temperature whereby its
5 viscosity is reduced to the second viscosity.

6 In a preferred embodiment of the liquid toner, the
7 additional material is comprised in the toner particles.
8 Alternatively or additionally, the additional material is in
9 a finely divided form and is dispersed in the carrier liquid
10 separate from the toner particles.

11 Preferably, the additional material is at least
12 partially incompatible with the toner particles.

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1 BRIEF DESCRIPTION OF THE DRAWINGS

2 The present invention will be understood and
3 appreciated more fully from the following detailed
4 description, taken in conjunction with the drawings in
5 which:

6 Fig. 1 is a simplified sectional illustration of
7 electrostatic imaging apparatus constructed and operative in
8 accordance with a preferred embodiment of the present
9 invention;

10 Fig. 2 is a simplified enlarged sectional illustration
11 of the apparatus of Fig. 1;

12 Fig. 3A is a simplified, cross-sectional side view of
13 an intermediate transfer member, including a removable
14 intermediate transfer blanket mounted on a drum, in
15 accordance with a preferred embodiment of the invention;

16 Fig. 3B is a partially cut-away top view of the
17 intermediate transfer member of Fig. 3A;

18 Figs. 4A and 4B are respective top and side views of an
19 intermediate transfer blanket in accordance with a preferred
20 embodiment of the invention;

21 Fig. 4C shows details of the layered construction of
22 the intermediate transfer blanket in accordance with a
23 preferred embodiment of the invention;

24 Fig. 4D is a cut-away expanded view of a securing
25 mechanism on the intermediate transfer blanket of Figs 4A
26 and 4B; and

27 Fig. 5 is a simplified cross-sectional illustration of
28 a portion of an intermediate transfer member, including a
29 removable intermediate transfer blanket mounted on a drum in
30 accordance with another preferred embodiment of the
31 invention.

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1 DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

2 Reference is now made to Figs. 1 and 2 which illustrate
3 a multicolor electrostatic imaging system constructed and
4 operative in accordance with a preferred embodiment of the
5 present invention. As seen in Figs. 1 and 2 there is
6 provided an imaging sheet, preferably an organic
7 photoreceptor 12, typically mounted on a rotating drum 10.
8 Drum 10 is rotated about its axis by a motor or the like
9 (not shown), in the direction of arrow 18, past charging
10 apparatus 14, preferably a corotron, scorotron or roller
11 charger or other suitable charging apparatus known in the
12 art and which is adapted to charge the surface of sheet
13 photoreceptor 12. The image to be reproduced is focused by
14 an imager 16 upon the charged surface 12 at least partially
15 discharging the photoconductor in the areas struck by light,
16 thereby forming the electrostatic latent image. Thus, the
17 latent image normally includes image areas at a first
18 electrical potential and background areas at another
19 electrical potential.

20 Photoreceptor sheet 12 may use any suitable
21 arrangement of layers of materials as is known in the art,
22 however, in the preferred embodiment of the photoreceptor
23 sheet, certain of the layers are removed from the ends of
24 the sheet to facilitate its mounting on drum 10.

25 This preferred photoreceptor sheet and preferred
26 methods of mounting it on drum 10 are described in a co-
27 pending U. S. Patent application of Belinkov et al., IMAGING
28 APPARATUS AND PHOTORECEPTOR THEREFOR, filed September 7,
29 1994, assigned serial number 08/301,775, the disclosure of
30 which is incorporated herein by reference. Alternatively,
31 photoreceptor 12 may be deposited on the drum 10 and may
32 form a continuous surface. Furthermore, photoreceptor 12 may
33 be a non-organic type photoconductor based, for example, on
34 a compound of Selenium.

35 Imaging apparatus 16 may be a modulated laser beam
36 scanning apparatus, an optical focusing device for imaging a

1 copy on a drum or other imaging apparatus such as is known
2 in the art.

3 Also associated with drum 10 and photoreceptor sheet
4 12, in the preferred embodiment of the invention, are a
5 multicolor liquid developer spray assembly 20, a developing
6 assembly 22, color specific cleaning blade assemblies 34, a
7 background cleaning station 24, an electrified squeegee 26,
8 a background discharge device 28, an intermediate transfer
9 member 30, cleaning apparatus 32, and, optionally, a
10 neutralizing lamp assembly 36.

11 Developing assembly 22 preferably includes a
12 development roller 38. Development roller 38 is preferably
13 spaced from photoreceptor 12 thereby forming a gap
14 therebetween of typically 40 to 150 micrometers and is
15 charged to an electrical potential intermediate that of the
16 image and background areas of the image. Development roller
17 38 is thus operative, when maintained at a suitable voltage,
18 to apply an electric field to aid development of the latent
19 electrostatic image.

20 Development roller 38 typically rotates in the same
21 sense as drum 10 as indicated by arrow 40. This rotation
22 provides for the surface of sheet 12 and development roller
23 38 to have opposite velocities at the gap between them.

24 Multicolor liquid developer spray assembly 20, whose
25 operation and structure is described in detail in U.S.
26 Patent 5,117,263, the disclosure of which is incorporated
27 herein by reference, may be mounted on axis 42 to allow
28 assembly 20 to be pivoted in such a manner that a spray of
29 liquid toner containing electrically charged pigmented toner
30 particles can be directed either onto a portion of the
31 development roller 38, a portion of the photoreceptor 12
32 or directly into a development region 44 between
33 photoreceptor 12 and development roller 38. Alternatively,
34 assembly 20 may be fixed. Preferably, the spray is directed
35 onto a portion of the development roller 38.

36 Color specific cleaning blade assemblies 34 are

1 operatively associated with developer roller 38 for separate
2 removal of residual amounts of each colored toner remaining
3 thereon after development. Each of blade assemblies 34 is
4 selectably brought into operative association with developer
5 roller 38 only when toner of a color corresponding thereto
6 is supplied to development region 44 by spray assembly 20.
7 The construction and operation of cleaning blade assemblies
8 is described in PCT Publication WO 90/14619 and in US patent
9 5,289,238, the disclosures of which are incorporated herein
10 by reference.

11 Each cleaning blade assembly 34 includes a toner
12 directing member 52 which serves to direct the toner
13 removed by the cleaning blade assemblies 34 from the
14 developer roller 38 to separate collection containers 54,
15 56, 58, and 60, for each color to prevent contamination of
16 the various developers by mixing of the colors. The toner
17 collected by the collection containers is recycled to a
18 corresponding toner reservoir (55, 57, 59 and 61). A final
19 toner directing member 62 always engages the developer
20 roller 38 and the toner collected thereat is supplied into
21 collection container 64 and thereafter to reservoir 65 via
22 separator 66 which is operative to separate relatively clean
23 carrier liquid from the various colored toner particles. The
24 separator 66 may be typically of the type described in U.S.
25 Patent 4,985,732, the disclosure of which is incorporated
26 herein by reference.

27 In a preferred embodiment of the invention, as
28 described in U.S. Patent 5,255,058, the disclosure of which
29 is incorporated herein by reference, where the imaging speed
30 is very high, a background cleaning station 24 typically
31 including a reverse roller 46 and a fluid spray apparatus 48
32 is provided. Reverse roller 46 which rotates in a direction
33 indicated by arrow 50 is electrically biased to a potential
34 intermediate that of the image and background areas of
35 photoconductive drum 10, but different from that of the
36 development roller. Reverse roller 46 is preferably spaced

1 apart from photoreceptor sheet 12 thereby forming a gap
2 therebetween which is typically 40 to 150 micrometers.

3 Fluid spray apparatus 48 receives liquid toner from
4 reservoir 65 via conduit 88 and operates to provide a supply
5 of preferably non-pigmented carrier liquid to the gap
6 between sheet 12 and reverse roller 46. The liquid supplied
7 by fluid spray apparatus 48 replaces the liquid removed from
8 drum 10 by development assembly 22 thus allowing the
9 reverse roller 46 to remove charged pigmented toner
10 particles by electrophoresis from the background areas of
11 the latent image. Excess fluid is removed from reverse
12 roller 46 by a liquid directing member 70 which continuously
13 engages reverse roller 46 to collect excess liquid
14 containing toner particles of various colors which is in
15 turn supplied to reservoir 65 via a collection container 64
16 and separator 66.

17 The apparatus embodied in reference numerals 46, 48, 50
18 and 70 is not required for low speed systems, but is
19 preferably included in high speed systems.

20 Preferably, an electrically biased squeegee roller 26
21 is urged against the surface of sheet 12 and is operative to
22 remove liquid carrier from the background regions and to
23 compact the image and remove liquid carrier therefrom in the
24 image regions. Squeegee roller 26 is preferably formed of
25 resilient slightly conductive polymeric material as is well
26 known in the art, and is preferably charged to a potential
27 of several hundred to a few thousand volts with the same
28 polarity as the polarity of the charge on the toner
29 particles.

30 Discharge device 28 is operative to flood the sheet 12
31 with light which discharges the voltage remaining on sheet
32 12, mainly to reduce electrical breakdown and improve
33 transfer of the image to intermediate transfer member 30.
34 Operation of such a device in a write black system is
35 described in U.S. Patent 5,280,326, the disclosure of which
36 is incorporated herein by reference.

1 Figs. 1 and 2 further show that multicolor toner spray
2 assembly 20 receives separate supplies of colored toner
3 typically from four different reservoirs 55, 57, 59 and 61.
4 Figure 1 shows four different colored toner reservoirs 55,
5 57, 59 and 61 typically containing the colors Yellow,
6 Magenta, Cyan and, optionally, Black respectively. Pumps 90,
7 92, 94 and 96 may be provided along respective supply
8 conduits 98, 101, 103 and 105 for providing a desired amount
9 of pressure to feed the colored toner to multicolor spray
10 assembly 20. Alternatively, multicolor toner spray assembly
11 20, which is preferably a three level spray assembly,
12 receives supplies of colored toner from up to six different
13 reservoirs (not shown) which allows for custom colored tones
14 in addition to the standard process colors.

15 It has been found that the scuff resistance, abrasion
16 resistance and peel resistance of a wide class of liquid
17 toners may be improved by the addition of a minor amount,
18 between 2% and 20%, preferably between 4% to 15%, most
19 preferably about 10% (with respect to the solids content of
20 the toner) of an additional material which, at the fusing
21 temperature used for the toner, has a much lower viscosity,
22 preferably several orders of magnitude lower, than the
23 viscosity of the toner particles and which forms a separate
24 phase from the toner particles when solidified. It is
25 believed that such material, during the fusing process,
26 migrates to the outer surface of the image. During cooling
27 of the image after it is fused, the additional material
28 forms a substantially separate phase resulting in a hard
29 slippery outer coating of the additional material which
30 protects the image from abrasion. While not believed to be
31 absolutely necessary for the invention, the additional
32 materials which have been found useful are at least
33 partially incompatible with the toner particles.

34 It has been found that the additional material may be
35 added at almost any point during the toner manufacturing
36 process, but that the salutary effect of the additional

1 material is most pronounced when it is added during the
2 final stage of the grinding of the toner or when it is
3 separately ground and added as finely ground material to the
4 finished toner and dispersed in the carrier liquid. Somewhat
5 less than optimum results are achieved when the additional
6 material is added at the beginning of the grinding process
7 or during the plasticization of the toner.

8 The preferred additional material is Micronised
9 Polyethylene Wax, for example ACumist A-12, ACumist B-12 and
10 ACumist C-9 (Allied Signal, Inc.). Other useful materials
11 are A-C 9A and A-C 1702 Homopolymers (Allied Signal), and
12 AC-290, AC-293A and similar ionomers which are low molecular
13 weight ethylene-based copolymers neutralized with metal
14 salts forming ionic clusters, manufactured by Allied Signal
15 and sold under the trade mark "AClyn."

16 One preferred method of forming a toner having improved
17 abrasion resistance is the following:

18 1) Solubilizing 1400 grams of Nucrel 925 (ethylene
19 copolymer by Dupont) and 1400 g of Isopar L (Exxon) are
20 thoroughly mixed in an oil heated Ross Double Planetary
21 Mixer at least 24 RPM for 1.5 hours, with the oil
22 temperature at 130°C. 1200 g of preheated Isopar L is added
23 and mixing is continued for an additional hour. The mixture
24 is cooled to 45°C, while stirring is continued over a period
25 of several hours, to form a viscous material.

26 2) Milling and Grinding 762 grams of the result of the
27 Solubilizing step are ground in a 18 attritor (Union Process
28 Inc. Akron Ohio), charged with 3/16" carbon steel balls at
29 250 RPM, together with 66.7 grams of Mogul L carbon black
30 (Cabot), 6.7 grams of BT 583D (blue pigment produced by
31 Cookson), 5 grams of aluminum tri stearate and an additional
32 1459.6 grams of Isopar L for eight hours at 30°C.

33 3) Continuation of Grinding 34.5 grams of ACumist A-12
34 is added and grinding is continued for an additional 4
35 hours. While 4 hours is believed to be the optimal grinding
36 time for the added material, much shorter grinding periods

1 and adding the ACumist A-12 at the start of step 2 (or even
2 at the start of step 1) also give substantially improved
3 abrasion resistance. The resulting particles are fibrous
4 particles having a measured diameter in the range of 1-3
5 micrometers.

6 The resulting material is diluted with additional
7 Isopar L and Marcol 82 to give a working developer in which
8 the dry solids portion is about 1.7% and in which the
9 overall ratio of Isopar L to Marcol is between about 50:1
10 and 500:1, more preferably between about 100:1 and 200:1.
11 Charge director as described in US patent application
12 07/915,291 (utilizing lecithin, BBP and ICIG3300B) and in WO
13 94/02887, in an amount equal to 40 mg/gm of solids, is added
14 to charge the toner particles. Other charge directors and
15 additional additives as are known in the art may also be
16 used.

17 Alternatively, ACumist A-12 or one of the other
18 materials listed can be pre-ground to a particle size of 1
19 to 2 microns and added to toner produced according to the
20 above method, to which the ACumist A-12 was not added during
21 grinding.

22 Another additional material which has been found
23 useful is the precipitate formed when the B-12 or the A-12
24 material (60 grams) is heated and solubilized together with
25 30 grams of zinc stearate in 556 grams Isopar L and then
26 stirred while cooling to room temperature. This material may
27 be added during the grinding step or separately.

28 The above described process produces a black toner.
29 Cyan, magenta and yellow toners can be produced by using a
30 different mix of materials for step 2). For Cyan toner 822g
31 of the solubilized material, 21.33 grams each of BT 583D and
32 BT 788D pigments (Cookson), 1.73 grams of D1355DD pigment
33 (BASF), 7.59 grams of aluminum tri stearate and 1426 grams
34 of Isopar L are used in step 2. For Magenta toner, 810 grams
35 of solubilized material, 48.3 grams of Finess Red F2B, 6.81
36 grams of aluminum tri-stearate and 1434.2 grams of Isopar L

1 are used in step 2. For yellow toner, 810 grams of
2 solubilized material, 49.1 grams of D1355DD pigment, 6.9
3 grams of aluminum tri-stearate and 1423 grams of Isopar L
4 are used in step 2.

5 The additional materials described above also give
6 improved abrasion resistance for liquid toner based on
7 Bynell 2002 (ethylene terpolymer by Dupont), Surllyn 8940 or
8 8920 (ionomers by Dupont) and Iotek 8030 (ionomer by Iotek)
9 and blends of these materials. The use of additional
10 materials having the characteristics described above is
11 believed to have applicability to a wide range of toners
12 which comprise polymer particles and hydrocarbon carrier
13 liquids.

14 Intermediate transfer member 30, an especially
15 preferred embodiment of which is described in detail below
16 (in conjunction with Figs. 3 and 4), may be any suitable
17 intermediate transfer member having a multilayered transfer
18 portion such as those described below or in US Patents
19 5,089,856 or 5,047,808 the disclosures of which are
20 incorporated herein by reference. Member 30 is maintained at
21 a suitable voltage and temperature for electrostatic
22 transfer of the image thereto from the image bearing
23 surface. Intermediate transfer member 30 is preferably
24 associated with a pressure roller 71 for transfer and fusing
25 of the image onto a final substrate 72, such as paper,
26 preferably by heat and pressure. For the especially
27 preferred toner described above, an image temperature of
28 about 95°C at the inception of fusing is preferred.

29 Cleaning apparatus 32 is operative to scrub clean the
30 surface of photoreceptor 12 and preferably includes a
31 cleaning roller 74, a sprayer 76 to spray a non-polar
32 cleaning liquid to assist in the scrubbing process and a
33 wiper blade 78 to complete the cleaning of the
34 photoconductive surface. Cleaning roller 74 which may be
35 formed of any synthetic resin known in the art for this
36 purpose is driven in the same sense as drum 10 as indicated

1 by arrow 80, such that the surface of the roller scrubs the
2 surface of the photoreceptor. Any residual charge left on
3 the surface of photoreceptor sheet 12 may be removed by
4 flooding the photoconductive surface with light from
5 optional neutralizing lamp assembly 36, which may not be
6 required in practice.

7 In accordance with a preferred embodiment of the
8 invention, after developing each image in a given color, the
9 single color image is transferred to intermediate transfer
10 member 30. Subsequent images in different colors are
11 sequentially transferred in alignment with the previous
12 image onto intermediate transfer member 30. When all of the
13 desired images have been transferred thereto, the complete
14 multi-color image is transferred from transfer member 30 to
15 substrate 72. Impression roller 71 only produces operative
16 engagement between intermediate transfer member 30 and
17 substrate 72 when transfer of the composite image to
18 substrate 72 takes place. Alternatively, each single color
19 image is separately transferred to the substrate via the
20 intermediate transfer member. In this case, the substrate is
21 fed through the machine once for each color or is held on a
22 platen and contacted with intermediate transfer member 30
23 for composite image transfer. Alternatively, the
24 intermediate transfer member is omitted and the developed
25 single color images are transferred sequentially directly
26 from drum 10 to substrate 72.

27 Figs. 3A, 3B and 4A-4D illustrate a preferred
28 embodiment of intermediate transfer member 30 in accordance
29 with a preferred embodiment of the invention. Fig 3A shows
30 an intermediate transfer blanket 100 mounted on a drum 102.
31 Transfer blanket 100 (whose details are shown in Figs. 4C
32 and 4D) comprises a preferably layered transfer portion 104
33 and a mounting fitting 106.

34 As shown most clearly in Fig. 4C, transfer portion 104
35 comprises a release layer 109 which is outermost on the
36 blanket when it is mounted on drum 102. Underlying layer 109

1 is a conforming layer 111 preferably of a soft elastomer, 2 preferably of polyurethane and preferably having a Shore A 3 hardness of less than about 65, more preferably, less than 4 about 55, but preferably more than about 35. A suitable 5 hardness value is between 45-55, preferably about 50. 6 Underlying layer 111 is a conductive layer 114 which 7 overlays a thin barrier layer 115. Barrier layer 115 8 overlays a blanket body 116 comprising a top layer 118, a 9 compressible layer 120 and a fabric layer 122. Underlying 10 the fabric layer is an adhesive layer 126 which is in 11 contact with drum 102.

12 Drum 102 is preferably heated by an internal halogen 13 lamp heater or other heater to aid transfer of the image to 14 and from the release layer 109 to a final substrate as is 15 well known in the art. For the preferred liquid toner, the 16 temperature at the surface of the intermediate transfer 17 member is preferably about 95°C. The degree of heating will 18 depend on the characteristics of the toner used in 19 conjunction with the invention.

20 As shown in Figs. 4A, 4B and 4D, mounting fitting 106 21 comprises an elongate electrically conducting bar 108, for 22 example, of a metal such as aluminum formed with a series of 23 L-shaped mounting legs 110 (in the form of finger-like 24 extensions) which are also conducting, preferably of the 25 same material as bar 108, and preferably formed integrally 26 therewith. In particular, bar 108 is formed with a slot into 27 which the end of layered transfer portion 104 is inserted. 28 Preferably, the end of the layered portion which is inserted 29 into the mounting bar does not have a release layer 109 or 30 conforming layer 111, whereby conducting layer 114 is 31 exposed and is therefore in electrical contact with bar 108. 32 Alternatively, the bar 108 can be formed with sharp internal 33 projections which pierce the outer layers of the blanket and 34 contact the conducting layer.

35 Optionally, each of the layers beneath the conducting 36 layer 114 may be partially conducting (for example, by the

1 addition of conductive carbon black or metal fibers) and the
2 adhesive layer may be conductive, such that current also
3 flows directly from the drum surface to the conducting
4 layer.

5 In one preferred embodiment of the invention, fitting
6 106 is formed of a single sheet of metal, wherein the legs
7 are partially cut from the metal which is bent into a U
8 shape to form the slot into which the layered portion is
9 inserted. After insertion, the outer walls of the slot are
10 forced against the layered portion to secure the layered
11 portion in the slot. The partially cut out portion is bent
12 to form the mounting legs.

13 In the preferred embodiment of the invention shown in
14 Figs. 1-3, drum 102 is maintained at a potential suitable
15 for transferring images to the intermediate transfer member,
16 for example at 500 volts, which voltage is applied, via
17 mounting fitting 106 to conductive layer 114. Thus, the
18 source of transfer voltage is very near the outer surface of
19 portion 104 which allows for a lower transfer potential on
20 the drum.

21 In a preferred embodiment of the invention, transfer
22 portion 104 is fabricated by the following procedure:

23 1- The starting structure for blanket construction is a
24 blanket body 116 generally similar to that generally used
25 for printing blankets. One suitable body is MCC-1129-02
26 manufactured and sold by Reeves SpA, Lodovicio (Milano),
27 Italy. In a preferred embodiment of the invention, body 116
28 comprises a fabric layer 122, preferably of woven NOMEX
29 material and having a thickness of about 200 micrometers, a
30 compressible layer 120, preferably comprising about 400
31 micrometers of saturated nitrile rubber loaded with carbon
32 black to increase its thermal conductivity. Layer 120
33 preferably contains small voids (about 40 - 60 % by volume)
34 and a top layer 118 preferably comprised of the same
35 material as the compressible layer, but without voids. Layer
36 109 is preferably about 100 micrometers thick. The blanket

1 body is produced by manufacturing methods as are generally
2 used for the production of offset printing blankets for ink
3 offset printing.

4 Blanket body 116 is preferably sized to a relatively
5 exact thickness by abrading portions of the surface of top
6 layer 118. A preferred thickness for the finished body 116
7 is about 700 micrometers, although other thicknesses are
8 useful, depending on the geometry of the printing system in
9 which it is used and the exact materials used in the blanket
10 body.

11 2- The fabric side of blanket body 116 is preferably
12 coated with a 30 micrometer thick coating of silicone based
13 adhesive (preferably, Type D 66 manufactured by Dow
14 Corning). The adhesive is covered with a sheet of mylar
15 coated with a fluorosilicone material, such as DP 5648
16 Release Paper (one side coat) distributed by H.P. Smith
17 Inc., Bedford Park, IL. This adhesive is characterized by
18 its good bond to the surface of drum 102 and is resistant to
19 the carrier liquid used in the liquid toner. The blanket may
20 be removed from the drum, when its replacement is desired,
21 by cutting the blanket along the edge of fitting 106 and
22 removing the blanket and fitting.

23 An adhesive is used to assure good thermal contact
24 between the back of the blanket and the drum on which it is
25 mounted. A silicone adhesive is used since adhesives
26 normally used in attachment of blankets deteriorate under
27 the heat which is generated in the underlying drum in the
28 preferred apparatus. While the temperature of the drum
29 varies, depending on the thermal resistance of the blanket
30 and the desired surface temperature of the blanket (which in
31 turn depends on the toner used in the process and the
32 details of transfer of the toner to the final substrate),
33 the drum temperature may reach 80°C, 100°C, 120°C or 150°C
34 or more.

35 3- Top layer 118 is preferably coated with a sub-micron
36 layer of primer before being coated with additional layers.

1 A preferred primer is Dow Corning 1205 Prime Coat. The type
2 of primer depends on the properties of the top layer and of
3 the conductive layer. Preferably, 0.3 micron of primer is
4 coated onto a clean top layer with a No. 0 bar in a wire
5 coating apparatus and is allowed to dry before applying the
6 conductive layer.

7 4- Since blanket body 116 may contain materials such as
8 anti-oxidants, anti-ozonants or other additives which may
9 migrate through the upper layers of the blanket, for example
10 as a gas, when the blanket is heated during the imaging
11 process and/or in the presence of carrier liquid such as
12 Isopar L, barrier layer 115 is preferably coated onto top
13 layer 116. This barrier layer should be substantially
14 impervious to such materials in the blanket body which may
15 migrate and/or to the carrier liquid which is used.

16 If this layer is omitted, under certain circumstances
17 the additive materials can cause deterioration of the
18 photoreceptor. In particular, it was found that the imaging
19 process may become humidity dependent.

20 In a preferred embodiment of the invention, a 4-11
21 micrometer layer of polyvinyl alcohol (88% hydrolyzed) is
22 coated onto the primer layer covering top layer 118.

23 Polyvinyl alcohol, 88% hydrolyzed, having an average
24 molecular weight preferably between 85,000 and 145,000
25 (Aldrich Chemical Co. Inc., Milwaukee, WI) is dissolved in
26 water at 90°C by continuously stirring the mixture in a
27 reflux system for 30 minutes. After 30 minutes, a quantity
28 of ethanol equal to twice the quantity of water is added to
29 the solution, the resulting polyvinyl alcohol concentration
30 being preferably less than 10%. Higher concentration
31 solutions can be used; however, they give a more viscous
32 solution which is hard to spread evenly.

33 The solution is deposited on layer 118 of body 116
34 using a fine wire rod or knife inclined at 30-45° to the
35 direction of movement of the knife or body. The solvent is
36 evaporated either by drying at room temperature or by

1 blowing hot air on the layer.

2 One or more coating passes are employed to give the
3 required thickness.

4 Too thin a layer will result in some transfer of
5 material from body 116, which has been correlated with
6 "clumping" or agglomeration of the toner particles in the
7 liquid toner. This is believed to be caused by photoreceptor
8 deterioration. While four micrometers of material appears to
9 be sufficient to avoid leaching, a somewhat larger
10 thickness, for example, 6 micrometers, is preferably used.

11 Other barrier materials and other thicknesses may be
12 used depending on the carrier liquid used for the toner or
13 the gasses released by body 116. Other materials may require
14 lesser or greater toner thickness depending on their
15 resistance to the carrier liquid or the gasses released by
16 body 116. Alternatively, if body 116 is resistant to
17 leaching by the carrier liquid or does not contain materials
18 which are released (especially when body 116 is heated),
19 layer 115 may be omitted.

20 Polyvinyl alcohol is a thermoplastic crystalline
21 material having a melting point which is higher than the
22 temperature of the blanket during operation. Polyvinyl
23 alcohol is also believed to form a layer which is impervious
24 to gasses and to the hydrocarbon carrier liquid used in the
25 liquid toner.

26 5- Conductive layer 114 is preferably formed of acrylic
27 rubber loaded with conductive carbon black. In a preferred
28 embodiment of the invention, only 2-3 micrometers of
29 conductive coating are required. The conductive layer is
30 formed by first compounding 300 grams of Hytemp 4051EP (B.F.
31 Goodrich) with 6 grams of Hytemp NPC 50 and 9 grams of
32 sodium stearate in a two-roll mill for 20 minutes; and then
33 dissolving 150 grams of the compounded material in 2000
34 grams of methyl ethyl ketone (MEK) by stirring for 12 hours
35 at room temperature.

36 40 grams of conductive carbon black, such as, for

1 example, Printex XE2 (Degussa) are added to the solution and
2 the mixture is ground in a 01 attritor (Union Process)
3 loaded with 3/16" steel balls. Grinding proceeds at 10°C for
4 4 hours after which time the material is diluted by the
5 addition of MEK to a concentration of 7.5-8% solids and
6 discharged from the grinder in the form of a conductive
7 lacquer.

8 The blanket (after step 3 or step 4) is overcoated with
9 about 3 micrometers of the conductive lacquer (three passes
10 using a No. 0 rod) and allowed to dry for 5 minutes at room
11 temperature.

12 An additional coating of primer is added over the
13 conductive lacquer (except for the portion which is to be
14 inserted into bar 108) before the soft elastomeric
15 conforming layer is applied.

16 The resistance of the conductive layer should
17 preferably be more than about 20 kohms/square and preferably
18 less than about 50 kohm/square. This value will depend on
19 the resistivity of the layers above the conducting layer and
20 on the aspect ratio of the blanket. In general, the
21 resistance should be low enough so that the current flowing
22 on the conducting layer (to supply leakage current through
23 the overlying layers) should not cause a substantial
24 variation of voltage along the surface of the blanket. The
25 resistance of the conducting layer and, more importantly,
26 the resistance of the overlying layers control the current
27 flowing through the overlying layers. Generally speaking,
28 the conductive layer has a relatively low resistance and
29 resistivity, the conforming layer (layer 111) has a higher
30 resistivity and the overlying release layer (layer 109) has
31 a still higher resistivity.

32 6- One kg of pre-filtered Fomrez-50 Polyester resin
33 (Hagalil Company, Ashdod, Israel) is dehydrated and degassed
34 under vacuum at 60°C. 600 grams of the degassed material is
35 mixed with 1.4 grams of di-butyl-tin-diluarate (Aldrich) and
36 degassed at room temperature for 2 hours. 30 grams of the

1 resulting material, 3.15 grams of RTV Silicone 118 (General
2 Electric), 4.5 grams of Polyurethane cross-linker, DESMODUR
3 44V20 (Bayer) and are stirred together. A 100 micrometer
4 layer of the material is coated over the primed conductive
5 layer using a No. 3 wire rod with several passes under clean
6 conditions, preferably, class 100 conditions. The coating is
7 cured for two hours at room temperature under a clean hood
8 to form a polyurethane layer.

9 Layer 111 which is thus formed should have a resistance
10 of the order of about 10^9 ohm-cm, good thermal stability at
11 the working temperature of the blanket, which is preferably
12 about 100°C or less.

13 The function of the conforming layer is to provide good
14 conformation of the blanket to the image forming surface
15 (and the image on the image forming surface) at the low
16 pressures used in transfer of the image from the image
17 forming surface to the blanket. The layer should have a
18 Shore A hardness preferably of between 25 or 30 and 65, more
19 preferably about 50. While a thickness of 100 micrometers is
20 preferred, other thicknesses, between 50 micrometers and 300
21 micrometers can be used, with 75 to 125 micrometers being
22 preferred.

23 7- 12 grams of RTV silicone 236 (Dow Corning) release
24 material diluted with 2 grams of Isopar L (Exxon) and 0.72
25 grams of Syl-off 297 (Dow Corning) are mixed together. A
26 wire rod (bar No. 1) coating system is used, with five or
27 six passes, under clean conditions to achieve an 8
28 micrometer release layer thickness. The material is cured at
29 140°C for two hours. The cured release material has a
30 resistivity of approximately 10^{14} to 10^{15} ohm-cm.

31 In order to mount blanket 100 on drum 102, mounting
32 legs 110 are inserted into a plurality of mounting holes 130
33 formed in drum 102, preferably without removing the mylar
34 sheet from the adhesive layer (the back of the blanket). As
35 can be seen most clearly in Figs. 3A, 3B and 4D, mounting
36 legs 110 each have a tip portion 132 and a back portion 134.

1 Tips 132 are inserted into slots formed in the far sidewalls
2 of mounting holes 130 and the back portion 134 rests against
3 the opposite sidewall of the hole. In this way the end of
4 the blanket is accurately positioned. The edge of the mylar
5 sheet closest to the legs is removed and the remainder of
6 the mylar sheet is progressively removed while making sure
7 that the successive portions of the blanket which are thus
8 attached to the drum by the adhesive lie flat against the
9 drum.

10 Fig. 5 shows an alternative, preferred embodiment of
11 the invention in which somewhat different shaped holes 130'
12 are used. In this embodiment the back portion 134 rests
13 against a protrusion 150 formed on one side of the hole
14 while a surface 154 of leg 110 rests against the bottom 156
15 of a protrusion formed on the other side of the hole.

16 While the preferred electrical connection between the
17 conductive layer and the mounting bar is preferably achieved
18 by removing (or not forming) the layers which overlay an end
19 portion of the conductive layer and piercing the overlying
20 layers, for example, by crimping and/or piercing the
21 mounting bar, for example, at points marked 160 in Fig. 4D.
22 Crimping can also be used to hold the blanket in the
23 mounting bar.

24 While the adhesive layer preferably covers the back of
25 the blanket, alternatively the adhesive layer may cover only
26 a portion of the back such as the edge farthest away from
27 the bracket (the trailing edge of the blanket); or may, for
28 some embodiments of the invention and under certain
29 circumstances, be omitted.

30 It should be understood that the invention is not
31 limited to the specific type of image forming system or
32 transfer system used. The invention is also useful in
33 systems, such as those using other types of intermediate
34 transfer members such as belt or continuous coated drum type
35 transfer members and also for imaging systems which use
36 direct transfer of the image (for example from an imaging

1 surface) to the final substrate and which include a fuser
2 for fusing the image to the substrate. Such systems are very
3 well known in the art.

4 The specific details given above for the image forming
5 system are included as part of a best mode of carrying out
6 the invention. However, many aspects of the invention are
7 applicable to a wide range of systems as known in the art
8 for electrophotographic printing and copying.

9 It will be appreciated by persons skilled in the art
10 that the present invention is not limited by the description
11 and example provided hereinabove. Rather, the scope of this
12 invention is defined only by the claims which follow:

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CLAIMS

- 1
2 1. An image forming method comprising:
3 providing an image on a substrate, the image comprising
4 toner particles including a polymer material, an additional
5 material which is solid at room temperature and carrier
6 liquid;
7 fusing the image to the substrate by heating the image
8 to a fusing temperature at which the toner particles soften
9 to a first viscosity,
10 wherein the additional material has a second viscosity
11 at the fusing temperature which is at least ten times lower
12 than the first viscosity.
13
14 2. A method according to claim 1 wherein the toner
15 particles are solvated by the carrier liquid at the fusing
16 temperature whereby their viscosity is reduced to the first
17 viscosity.
18
19 3. A method according to claim 1 or claim 2 wherein the
20 additional material is solvated by the carrier liquid at the
21 fusing temperature whereby its viscosity is reduced to the
22 second viscosity.
23
24 4. A method according to any of the preceding claims and
25 including cooling the image after fusing.
26
27 5. A method according to claim 4 wherein, during fusing or
28 subsequent cooling, at least a portion of the additional
29 material migrates to the surface of the image away from the
30 substrate.
31
32 6. A method according to claim 5 wherein, during cooling,
33 at least a portion of the additional material forms a
34 separate phase from the toner material at said surface.
35
36 7. A method according to any of claims 3-6 wherein, after



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1 cooling, the additional material forms an abrasion resistant
2 layer covering the toner material.

3

4 8. A method according to any of the preceding claims
5 wherein the first viscosity is at least two orders of
6 magnitude greater than the second viscosity.

7

8 9. A method according to any of the preceding claims
9 wherein the first viscosity is at least three orders of
10 magnitude greater than the second viscosity.

11

12 10. A method according to any of the preceding claims
13 wherein the additional material comprises a polyethylene.

14

15 11. A method according to any of the preceding claims
16 wherein the additional material comprises a polyethylene
17 wax.

18

19 12. A method according to any of claims 1-9 wherein the
20 additional material comprises a homopolymer.

21

22 13. A method according to any of claims 1-9 wherein the
23 additional material comprises a low molecular weight
24 ionomer.

25

26 14. A method according to any of claims 10-12 wherein the
27 additional material further comprises zinc stearate.

28

29 15. A method according to any of the preceding claims
30 wherein the additional material is comprised in the toner
31 particles.

32

33 16. A method according to any of the preceding claims
34 wherein the additional material is in a finely divided form
35 and is dispersed in the carrier liquid separate from the
36 toner particles.



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1

2 17. A method according to any of the preceding claims
3 wherein the polymer material comprises an ethylene
4 terpolymer.

5

6 18. A method according to any of the preceding claims
7 wherein the polymer material comprises an ionomer.

8

9 19. A method according to any of the preceding claims
10 wherein the polymer material comprises an ethylene
11 copolymer.

12

13 20. A method according to any of the preceding claims
14 wherein the additional material is at least partially
15 incompatible with the toner particles.

16

17 21. A liquid toner adapted for fusing at a fusing
18 temperature comprising:

19 toner particles comprising a polymer material which
20 has a first viscosity at the fusing temperature;

21 an additional material which is solid at room
22 temperature and has a second viscosity at the fusing
23 temperature; and

24 carrier liquid,

25 the first viscosity being at least ten times the second
26 viscosity.

27

28 22. A liquid toner according to claim 21 wherein the
29 polymer material is solvated by the carrier liquid at the
30 fusing temperature whereby its viscosity is reduced to the
31 first viscosity.

32

33 23. A liquid toner according to claim 21 or claim 22
34 wherein the additional material is solvated by the carrier
35 liquid at the fusing temperature whereby its viscosity is
36 reduced to the second viscosity.



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2 24. A liquid toner according to any of claims 21-23 wherein
3 the first viscosity is at least two orders of magnitude
4 greater than the second viscosity.
5
6 25. A liquid toner according to claim 24 wherein the first
7 viscosity is at least three orders of magnitude greater than
8 the second viscosity.
9
10 26. A liquid toner according to any of claims 21-23 wherein
11 the additional material comprises a polyethylene.
12
13 27. A liquid toner according to any of claims 21-23 wherein
14 the additional material comprises a polyethylene wax.
15
16 28. A liquid toner according to any of claims 21-23 wherein
17 the additional material comprises a homopolymer.
18
19 29. A liquid toner according to any of claims 21-23 wherein
20 the additional material comprises a low molecular weight
21 ionomer.
22
23 30. A liquid toner according to any of claims 26-28 wherein
24 the additional material further comprises zinc stearate.
25
26 31. A liquid toner according to any of claims 21-30 wherein
27 the additional material is comprised in the toner particles.
28
29 32. A liquid toner according to any of claims 21-31 wherein
30 the additional material is in a finely divided form and is
31 dispersed in the carrier liquid separate from the toner
32 particles.
33
34 33. A liquid toner according to any of claims 21-32 wherein
35 the polymer material comprises an ethylene terpolymer.
36



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1 34. A liquid toner according to any of claims 21-33 wherein
2 the polymer material comprises an ionomers.

3

4 35. A liquid toner according to any of claims 21-34 wherein
5 the polymer material comprises an ethylene copolymer.

6

7 36. A method according to any of claims 21-35 wherein the
8 additional material is at least partially incompatible with
9 the toner particles.

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