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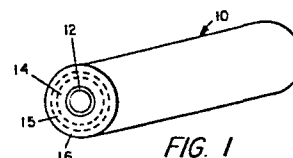
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54 Multilayer fuser member and method of making.

57 Disclosed herein is a multilayer fuser member (10) which includes a first layer (14) of an elastomeric material; an oil-impervious second layer (16), preferably a fluoroelastomer; and (3) a bonding layer (15) intermediate the first and second layers in which the proportion of the elastomeric material to the oil-impervious material gradually varies from substantially only the elastomeric material to substantially only the oil-impervious material.

A method of making the fuser member by a spraying technique is also disclosed.



MULTILAYER FUSER MEMBER AND METHOD OF MAKING

This invention relates generally to the field of electrography and, more particularly, this invention relates to the fusing of toner images to
5 receivers by means of heat and pressure.

In the field of electrography, as practiced, for example, in commercial copiers, a radiation image of an original to be reproduced is projected upon a uniformly charged photoconductive member to produce a latent electrostatic image corresponding to the original image. A visible toner image is produced by developing the electrostatic image with charged toner particles. If the photoconductive member is reusable in the form of a belt
10 or drum, the toner image is then transferred to a receiver such as a web or sheet of plain paper and fused to the receiver. If the photoconductive member itself is the receiver, then the toner image is fused directly to the member.

20 One technique which may be used to fuse a toner image to a receiver is through the application of heat and pressure by contacting the toner image with a heated fuser member such as a roller or belt. Commonly, a pair of rollers held together
25 under pressure form a nip through which a toner image-carrying receiver is passed. One or both of the rollers are heated to melt the heat-softenable toner particles to fuse the toner image to the receiver.

30 In such fusers, one or both rollers preferably includes an elastomeric layer to lengthen the nip through which the receiver passes in order to increase fusing time and to lower fusing energy requirements. To prevent offset of toner particles
35 onto the surface of the fuser roller and to minimize any tendency of the copy sheet to wrap around one of

the rollers causing copier malfunction, the elastomeric material must have good release characteristics. Although silicone elastomers and fluoroelastomers exhibit good release characteristics, it has
5 been found highly desirable to apply a coating of an oil, such as fluorocarbon oils, silicone oils, and fluorosilicone oils, to the elastomeric layer to improve its toner offset-preventing characteristics. Over a period of time, however, it has been
10 observed that such oils tend to be absorbed into the silicone elastomer causing it to swell. This swell causes the growth of a step pattern in the roller when copy sheets of a variety of lengths are processed by the copier. These steps are formed by
15 greater swelling due to fuser oil absorption beyond the areas of the roller used to process the shorter length copies. When longer length copies are passed through the nip of the roller fuser, uneven fusing causes image deterioration in the processed copy
20 sheet and damage to the sheet. Step growth pattern in elastomeric fuser rollers has been found to be especially troublesome when both fuser roller members are provided with elastomeric layers as when processing copy sheets with unfused toner images on
25 both sides of the sheet.

Swelling of a silicone elastomeric layer by absorption of silicone fuser oil may be minimized by providing a multi-layer fuser member wherein the silicone elastomeric layer is overcoated with a
30 layer of material which is resistant to absorption of silicone fuser oil. See, for example, the disclosure of U.S. Patent No. 3,883,293 and Japanese Patent Publication No. 41330/79. Such silicone oil resistant materials include the fluoroelastomers
35 (e.g. fluorosilicone elastomer) and fluoropolymer-based elastomers (e.g. various vinylidene fluoride-

based elastomers which contain hexafluoropropylene as a comonomer). Examples of such fluoropolymer-based elastomers are Viton® A (vinylidene fluoride-hexafluoropropylene) and Viton® B (vinylidene fluoride-hexafluoropropylene-tetrafluoroethylene) which are trademarked compounds available from the DuPont Company, Wilmington, Delaware, USA. Such materials, though substantially more costly than silicone elastomer, are more resistant to silicone fuser oil absorption than silicone elastomer and substantially decrease the forming of steps in the silicone elastomeric underlayer.

Although the aforementioned multilayer fuser rollers have been found to minimize the formation of steps and consequent image degradation in processed copy sheets, thereby substantially increasing the life of the fuser roller, it has been found difficult to form the multi-layered fuser members due to the difficulty in adhering fluoroelastomers to silicone elastomers. Thus, a fuser roller having a silicone elastomer base layer to which is adhered a fluoroelastomer layer has been found to exhibit separation between the layers with prolonged use. This separation may be accounted for by the lack of affinity of the fluoroelastomers for other materials and by the constant flexing of the fuser roller during use.

To overcome the above-mentioned problems of the prior art there are provided first and second related inventions; i.e. a product invention and a method invention.

According to the product invention, a multilayer fuser member comprises an inner elastomeric layer which is bonded to an outer oil-impervious layer (i.e. a layer which resists oil

absorption) by an intermediate bonding layer. Such intermediate layer is characterized by a gradually varying blend of the different materials comprising the elastomeric and oil-impervious layers. In the
5 blended intermediate layer, the proportion of the elastomeric material to the oil-impervious material gradually varies, in a direction from the inner layer toward the outer layer, from substantially only the elastomeric material to substantially only
10 the oil-impervious material. Preferably the oil-impervious layer also comprises an elastomeric material, a particularly preferred material being an elastomeric cross-linked fluoropolymer having tetra-fluoroethylene repeating units and perfluoroalkyl
15 perfluorovinylether repeating units.

According to the method invention, a fuser member of the above construction is manufactured by a method characterized by the steps of (a) spraying a support with an elastomeric material to form an
20 inner elastomeric layer; (b) while performing step (a), spraying the support with an oil-impervious material and gradually increasing the relative proportion of the oil-impervious material to the elastomeric material until only the oil-impervious
25 material is sprayed, thereby forming an intermediate bonding layer comprising a variable blend of the elastomeric and oil-impervious materials; and (c) spraying only the oil-impervious material to form an outer oil-impervious layer atop the intermediate
30 bonding layer.

The invention and its various advantages will become more apparent in the ensuing detailed description of preferred embodiments, reference being made to the accompanying drawings wherein:

35 Fig. 1 illustrates one embodiment of a fuser member structured according to the product invention;

Fig. 2 illustrates another embodiment of a fuser member according to the product invention;

Fig. 3 shows the fuser member of Fig. 2 as used in a roller fusing apparatus for fixing toner
5 images to a receiver; and

Fig. 4 illustrates an apparatus which may be used in effecting the method invention disclosed herein.

Multilayered fuser members may have
10 different configurations. For example, a fuser member may comprise a flat plate, a belt or a roller. However, in commercial electrophotographic copiers, the most common configuration is a roller. Accordingly, the embodiment shown in Fig. 1 includes
15 a fuser roller 10 which may be heated internally. Roller 10 includes a core 12 of heat conductive material (e.g. aluminum, brass or stainless steel) or heat transmissive material (e.g. glass) which supports an inner elastomeric layer 14 and an outer
20 oil-impervious layer 16, both layers being made of materials which are resistant to degradation at high temperatures, e.g. in the range of 100°C to 200°C. According to one embodiment of the product invention herein disclosed, the elastomeric material of layer
25 14 comprises a polysiloxane elastomer such as silicone elastomer. The material of layer 16 preferably comprises a fluoroelastomer which resists absorption of silicone fuser oil, i.e., is substantially impervious to such fuser oil. Layer 16 may, for ex-
30 ample, comprise a fluorosilicone or fluoropolymeric elastomer such as the vinylidene fluoride based fluoropolymers. Particularly preferred fluoropolymers are those cross-linked fluoropolymers having tetrafluoroethylene and perfluoroalkyl perfluoro-
35 vinyl ether repeating units, e.g. disclosed in U.S. Patent No. 4,199,626. Positioned intermediate

layers 14 and 16 is a bonding layer 15 which comprises a gradually varying mixture from only the material of layer 14 to only the material of layer 16. The intermediate layer can best be described by
5 the method in which it is formed.

According to the method invention herein, layer 15 and at least the respective contiguous portions of layers 14 and 16 are formed by a spraying technique. Where a thickness of layer 14 has already been formed on core 12 (e.g. by a conventional
10 molding process) it is preferred that a thin coating of the same elastomer as layer 14 be initially sprayed onto layer 14 to form a continuous layer therewith. While the material of layer 14 is continued to be sprayed, the material which is to form
15 layer 16 is simultaneously sprayed in gradually increasing proportion with the layer 14 material. As spraying continues, the proportion of the layer 14 material is decreased while the proportion of layer 16 material increases (or remains constant)
20 until only the layer 16 material is being sprayed. Only this material is then sprayed to the desired thickness of layer 16. Alternatively, the layer 14 material may be sprayed directly upon core 12 and a desirable thickness thereof built up before the
25 formation of layer 15 is initiated.

In the formation of the intermediate bonding layer 15 between layers 14 and 16 by the above-described process, it is preferred that the
30 proportion of the two materials continuously vary during the spraying process so that the proportion of the layer 16 material to layer 14 material gradually increases. Alternatively, the proportions can be changed in fixed steps so that, for example,
35 initially only layer 14 elastomer is sprayed; then a mixture of 75% of layer 14 elastomer and 25% of

layer 16 elastomer is sprayed; then a mixture of 50% of each elastomer is sprayed; then a mixture of 25% of layer 14 elastomer and 75% of layer 16 elastomer is sprayed; and then only layer 16 elastomer is
5 sprayed. Other variations in the proportions of materials and number of layers may be effected within the scope of the present invention.

The layer 14 elastomer and layer 16 elastomer are preferably dissolved in the same solvents
10 prior to spraying in order to maximize compatibility of the materials once sprayed on the roller. The solvents used are preferably a suitable mixture of low boiling point and high boiling point solvents, the ratio of one solvent to another being selected
15 to obtain proper drying time to insure acceptable roller properties such as the ability to resist delamination between layers.

In the embodiment of Fig. 2, a very thin layer 18 of toner offset preventing elastomer is
20 bonded to the oil-impervious layer 16 by a bonding layer 17. The bonding layer is applied by the spraying technique described above and comprises a gradually varying proportion of the layer 16 elastomer and the layer 18 elastomer from substantially
25 only the layer 16 elastomer to substantially only the layer 18 elastomer. The elastomer of layer 18 is preferably the same as the elastomer of layer 14 and may, for example, comprise silicone elastomer. Layer 16, being made of a fuser oil-resistant elastomer such as fluoroelastomer, substantially pre-
30 vents any oil absorbed by layer 18 from penetrating to layer 14 and thereby swelling it. Though not depicted as such, layer 18 is substantially thinner than layer 14; thus, any swelling of layer 18 due to
35 absorption of fuser oil will be minimal compared to the swelling of layer 14 were it allowed to absorb oil.

Referring now to Fig. 3, there is shown a fuser roller according to the embodiment of Fig. 2 incorporated into a roller fusing apparatus used in an electrographic copier for fusing toner images 60 carried by one side of a receiver 58. As shown, roller 30 includes a metallic core 32 which is internally heated by a quartz lamp 62; a first layer 34 of high-temperature resistant silicone elastomer bonded thereto; a second layer 36 of fluoroelastomer which is impervious to silicone fuser oil and resistant to degradation at high temperatures such as the aforementioned fluoroelastomers; and a bonding layer 35 intermediate to and continuous with layers 34 and 36 in which the proportion of the silicone elastomer to the fluoroelastomer gradually varies from substantially only the silicone elastomer to substantially only the fluoroelastomer. A third layer 38 is provided which may be any high temperature resistant material which has good toner offset preventing characteristics. Preferably layer 38 is of the same material as layer 34 and therefore may comprise silicone elastomer. However, this material may be any other high temperature resistant elastomer which shows good toner offset preventing characteristics or may be a flexible polymer which is not elastomeric but which has good toner offset preventing characteristics and which is heat resistant, such as the fluoropolymer which comprises a copolymer of tetrafluoroethylene and polypropylene.

Layer 37 is intermediate to and continuous with layers 36 and 38 in which the proportion of the layer 36 material to the layer 38 material gradually varies from substantially only the layer 36 material to substantially only the layer 38 material.

In order to enhance the toner offset preventing characteristics of the surface of layer 38,

fuser oil is applied by means of a wick 40 held against roller 30 by member 42. Wick 40 is saturated with fuser oil contained in sump 44. A large number of known fuser oils are commercially available and suitable for such use.

A pressure roller 50 is held in pressure engagement with fuser roller 30 by suitable force-applying means such as that disclosed in Research Disclosure No. 13,703, Sept. 1975, published by Industrial Opportunities, Ltd., Homewell, Havant, Hampshire, UK. Pressure roller 50 includes a core 52 of metallic material mounted on shaft 54 and an outer layer 56 of material having good toner offset preventing characteristics such as polytetrafluoroethylene, silicone elastomer or fluoroelastomers such as the vinylidene-fluoride based fluoropolymeric elastomers. Rollers 50 and 30 form a nip through which is passed receiver 58 carrying an unfixed toner image 60 on its underside. Through heat and pressure, toner image 60 is fixed permanently to receiver 58 as it passes this nip.

Referring now to Fig. 4, there is shown apparatus which is useful for carrying out the above-described method invention. As shown, an aluminum core 70 is rotatably mounted in bearings 72 and 74 by gudgeons 71 and 73, respectively. A motor 76 is connected to core 70 to rotate it at a predetermined rotational speed. Spray assembly 78 is provided and includes a carriage 80 upon which are mounted spray heads 82 and 84. Carriage 80 is driven for movement in directions 86 by means of a threaded rod 88 rotatably mounted in bearings 90 and 92 and driven by motor 93. The spray area of spray heads 82 and 84 are contiguous. Spray head 84 is supplied with first material to be sprayed from reservoir 95 by means of flexible conduit 94. In

like manner, spray head 82 is supplied with second material to be sprayed from reservoir 96 by means of flexible conduit 98. Valves 114 and 116 in conduits 94 and 98 respectively control the amount of material supplied to spray heads 84 and 82. A source of pressurized fluid such as air provides pressure to drive fluid motors 76 and 93, provides a pneumatic source for spraying materials from spray heads 84 and 82 and provides pressure to reservoirs 95 and 96. Conduits 100 and 101 having regulators 102 and 103 supply pressurized air to reservoirs 95 and 96, respectively. Conduits 106 and 108 supply pressurized air to spray heads 84 and 82 respectively. Valves 110 and 112 control the amount of air supplied over conduits 106 and 108 respectively, while valves 114 and 116 control the actuation of spray heads 84 and 82.

The following is a description of the formation of a fuser roller according to the method invention using the apparatus of Fig. 4. The spraying operation is carried out at ambient temperature and humidity but both temperature and humidity are preferably controlled to avoid extremes of either or both. The ultimate fuser roller will be assumed to have a final structure in accordance with the multi-layer roller shown in Fig. 2. In such case, the fuser roller may comprise inner and outer layers of silicone elastomer and a middle layer of a fluoroelastomer. Thus, the inner layer is the thickest layer (e.g. 0.1 to 0.2 centimeter) of the multilayer fuser roller. The outer layer which contacts a toner image is relatively thin (e.g. between 0.005 and 0.012 centimeters), and the middle layer of fluoroelastomer is about 0.025 to 0.050 centimeters thick. The bonding layers (i.e. layers 15 and 17) are of the order of several microns thick.

A fuser roller is formed by the apparatus of Fig. 4 as follows:

5 The aluminum core 70 which may be pre-treated to promote adhesion of the silicone elastomer is rotatably driven at a predetermined velocity. Simultaneously, motor 94 causes spray heads 84 and 82 carried by carriage 80 to move back and forth across cylinder 70 as it is rotated by motor 76. The rotational velocity of roller 70 and
10 velocity of carriage 80 are synchronized to effect the desired buildup of layers on roller 70. Layer buildup is also a function of the rate of spraying by spray heads 84 and 82 and of the characteristics of materials being sprayed.

15 As roller core 70 is rotated and carriage 80 is caused to move back and forth across the width of roller 70, silicone elastomer is sprayed upon core 70 to build up the inner layer to the desired thickness. Since spraying techniques might require
20 an unnecessarily long time for building up such a thickness, it may be desirable as mentioned above, to provide a core 70 upon which a layer of silicone elastomer has already been formed by other techniques such as molding. Then, only an initial thin
25 layer of silicone elastomer need be applied over this layer so that the time required for spraying is substantially reduced or a mixture of silicone elastomer and fluoroelastomer may be sprayed immediately on the silicone layer.

30 After the desired thickness of silicone elastomer has been sprayed onto core 70, silicone elastomer is continued to be sprayed upon roller 70, and valve 116 is gradually opened to actuate spray head 82. Valve 114 which has been fully opened during
35 spraying of silicone elastomer only by head 84 is now gradually closed as valve 116 is gradually

opened so that the mixture of the silicone elastomer and fluoroelastomer sprayed by heads 84 and 82 will gradually vary from only silicone elastomer being sprayed to only fluoroelastomer being sprayed. When
5 only fluoroelastomer is being sprayed, valve 114 will have been closed, valve 116 will be fully opened, and fluoroelastomer will continue to be sprayed until the desired thickness of the fluoro-elastomer layer is built up.

10 To build up an outer layer of silicone elastomer, the reverse process is now effected. As fluoroelastomer is continued to be sprayed upon roller 70 silicone elastomer is progressively added to the spray mixture until only silicone elastomer is
15 being sprayed to a desired thickness. The multi-layer fuser roller is then removed from the spraying apparatus and cured by known curing techniques.

Fusing rolls structured and manufactured in accordance with the aforescribed product and
20 method inventions were used to fuse toner images to 600,000 receiver sheets. After such use the rolls were thoroughly examined and it was found that step growth in the multilayer roller was only one-half of that expected to be found in a fuser roller having a
25 single silicone elastomer layer of comparable thickness. Adhesion between the fluoroelastomer layer and silicone base layer was found to be comparable both before and after processing, indicating no deterioration in the adhesion between these layers
30 after the 600,000 sheets were processed.

WHAT IS CLAIMED IS:

1. A multilayer member (10; 30) for fusing toner images to a receiver comprising a first layer (14; 34) of an elastomeric material, a second layer (16; 36) of a material which is resistant to absorption of fuser oil, and a bonding layer (15; 35) intermediate said first and second layers for bonding said first and second layers, characterized in that said bonding layer (15; 35) comprises a blend of said elastomeric and oil-resistant materials in which the proportion of the elastomeric material to the oil-resistant material gradually varies, in a direction from the first layer (14; 34) toward the second layer (16; 36), from substantially only the elastomeric material to substantially only the oil-resistant material.

2. The member as defined by Claim 1, characterized in that said oil-resistant material comprises an elastomer.

3. The member as defined by Claims 1 or 2, characterized in that said first and second layers (14; 34; 16; 36) comprise high temperature-resistant elastomers.

4. The member as defined by Claims 1 to 3, characterized in that said oil-resistant material comprises a crosslinked fluoropolymer having repeating units of tetrafluoroethylene and perfluoroalkyl perfluorovinylether.

5. The member as defined by Claims 1 to 3, characterized in that said elastomeric material comprises a silicone material and said oil-resistant material comprises a fluoropolymer.

6. The member as defined by Claim 5, characterized in that said elastomeric material comprises a silicone elastomer and said oil-resistant material comprises a fluoroelastomer selected from

the group consisting of fluorosilicone elastomer and vinylidene fluoride-based fluoropolymeric elastomers.

7. The member as defined by Claim 1, characterized in that the thickness of said first layer (14; 34) is substantially greater than the thickness of said second layer (16; 36).

8. A method for forming a resilient, oil-impervious member for fusing toner images to a receiver, characterized by the steps of:

10 spraying a base member (12; 32; 70) with a first material comprising an elastomer;

while spraying such base member with said first material, spraying such base member with a second material which is substantially impervious to oil;

15 gradually increasing the relative proportion of said second material to said first material until only said second material is sprayed; and continuing to spray said second material only to form an oil-impervious layer (16; 36) of said second material atop said first material.

9. The method of Claim 8, characterized in that said second material comprises an elastomer.

10. The method of Claim 8 or 9, characterized in that said first material comprises a silicone material and said second material comprises a fluoropolymer.

11. The method of Claim 8, characterized in that said first material comprises a silicone elastomer and said second material comprises a fluoroelastomer selected from the group consisting of fluorosilicone elastomers and vinylidene fluoride-based fluoropolymeric elastomers.

12. The method of Claim 8, characterized in that said second material comprises a crosslinked elastomeric fluoropolymer having repeating units of tetrafluoroethylene and perfluoroalkyl perfluorovinylether.

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