

- [54] **PRESSURE-FIXABLE DEVELOPING POWDER CONTAINING A THERMOPLASTIC RESIN AND WAX**
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- [51] Int. Cl.<sup>2</sup> .... **G03G 9/00**
- [58] Field of Search .... **252/62.1 P**

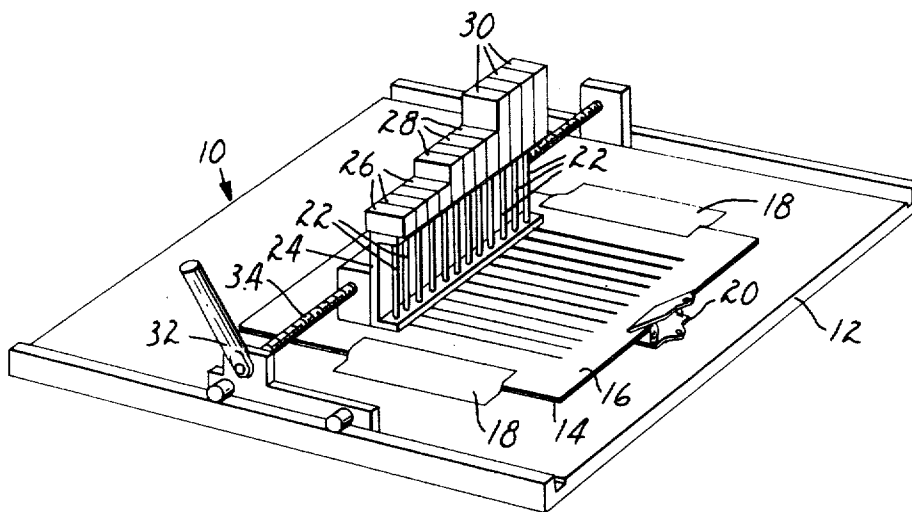
[56] **References Cited**  
**UNITED STATES PATENTS**

3,236,776	2/1966	Kunitzer .....	252/62.1 P
3,639,245	2/1972	Nelson .....	252/62.1 P
3,715,219	2/1973	Kurz et al. ....	252/62.1 P
3,775,326	11/1973	Westdale .....	252/62.1 P
3,829,314	8/1974	Shelffo .....	252/62.1 P

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[57] **ABSTRACT**  
 A pressure-fixable developing powder comprising a wax component and a thermoplastic resin, the powder having defined physical characteristics.

**9 Claims, 2 Drawing Figures**



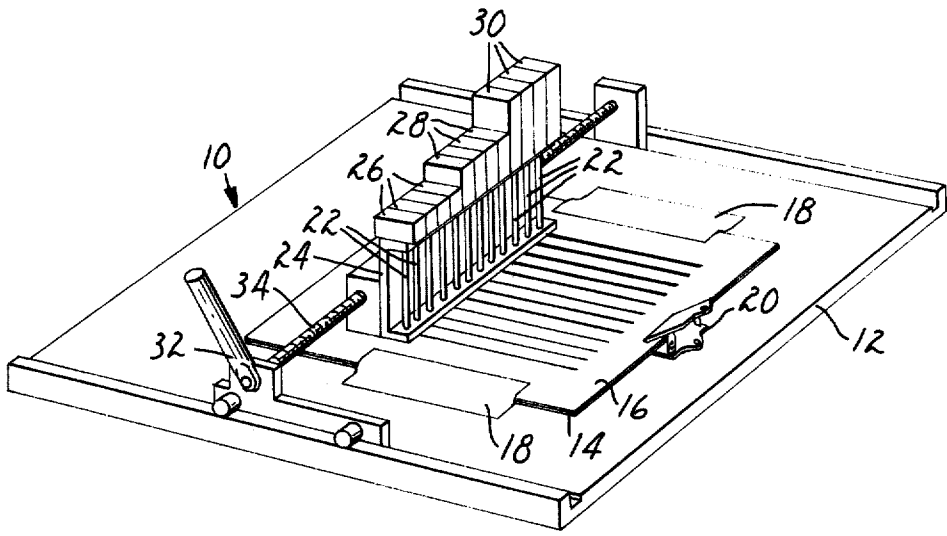


FIG. 1

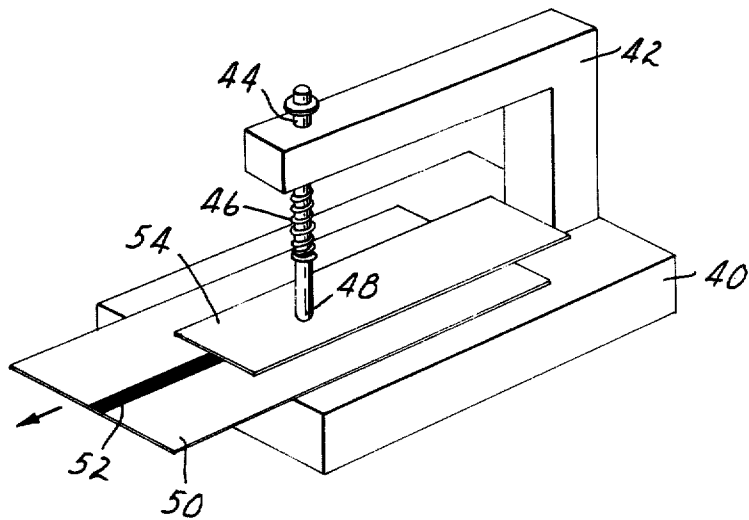


FIG. 2

## PRESSURE-FIXABLE DEVELOPING POWDER CONTAINING A THERMOPLASTIC RESIN AND WAX

This invention relates to a dry ink powder suitable for use in electrographic recording. More particularly, the invention relates to a developing powder which is pressure responsive so that it can be fixed as an imaging material to an image-bearing surface by the application of pressure.

Known developing powder (i.e., toner) formulations used in electrographic recording processes are generally permanently affixed to the substrate by heat. See, e.g., the developing powder described in Nelson, U.S. Pat. No. 3,639,245 wherein the powder is described as being thermoplastic and heat-fusible in the range of 80° to 115°C. Such heat-fusible powders are fixed after image formation by raising the temperature of the powder to its melting or softening point, causing the particles to coalesce, flow together, and adhere permanently to the substrate.

Although such heat-fusing developing powders have been widely used and have met with commercial success, there are certain disadvantages which are inherent in the use of such powders. Such disadvantages relate to the speed and efficiency of the fixing process.

For example, the speed of the fixing process, and hence the speed of the copying or recording process, is limited by the time required to effect fusion of the developer powder. Although the use of more heat to fuse the powder may shorten the fixing time required, this approach is limited by the flammability of the substrate on which the image is fixed. Since paper is widely used as the image-bearing support, care must be taken to avoid charring of the paper during the fixing process. Although the speed of the fixing process may also be increased by using lower melting point thermoplastic resins, the resulting image may be smeary and may exhibit poor character definition.

Another disadvantage associated with the use of heat-fusible powders is the significant power consumption of the equipment used for fixing. A further disadvantage is the significant loss of heat energy to the environment.

Yet another disadvantage associated with the use of heat-fusible powders is that the fixing rolls or other equipment used for fixing must first be heated to the requisite temperature before the copying or recording process can begin.

These disadvantages are overcome with the use of the developing powder of this invention.

### SUMMARY OF THE INVENTION

In accordance with the invention there is provided a flowable, pressure-fixable, dry powder comprising thermoplastic, essentially spherical particles, the binder material of which has a conductivity of at most  $10^{-12}$  mho/cm and which comprises (a) about 50 to 100 parts by weight of a wax component having a melting point between about 45° C. and 150° C., and (b) about 2 to 50 parts by weight of thermoplastic resin having a softening point above about 60° C.; wherein electrically conductive particles are firmly anchored in said binder material, said electrically conductive particles having a conductivity of at least  $10^{-2}$  mho/cm and an average diameter below about 100 millimicrons forming a radially disposed zone; and wherein said essentially spherical particles exhibit:

a. an electronic conductivity ranging monotonically without decreasing from between about  $10^{-11}$  and  $10^{-4}$  mho/cm in a 100 v./cm. DC electrical field to between about  $10^{-8}$  and  $10^{-13}$  mho/cm in a 10,000 v./cm. DC electrical field,

b. a number average particle diameter below about 20 microns, and

c. a volume ratio of said electrically conductive particles to said total particle volume of between 0.01/100 and 4/100;

wherein the dry powder exhibits a "transfer density" of less than about 0.15 and a "paper abrasion density" of less than about 0.15, as hereinafter defined.

The developing powder of this invention exhibits the very desirable electrical properties exhibited by the powder described in U.S. Pat. No. 3,639,245 and is pressure-fixable. Consequently, the disadvantages associated with the use of heat-fusible developing powders are avoided. Furthermore, because of the significant power consumption reduction in processes using these powders, recording and copying processes become more versatile and economical.

Another advantage derived from the use of such powders is that there is no wait for the machine to warm up to operating temperature. Also, the equipment necessary for fixing the powders of this invention is less expensive and less complicated than conventional heat-fusing equipment. Consequently, the fixing equipment is more reliable and more easily serviced than conventional heat fusing equipment.

The developing powders of this invention can be fixed directly to a photoconductive surface, in an imagewise fashion, or they can be transferred to a receiving sheet (e.g., untreated bond paper) to which pressure is subsequently applied (e.g., with a steel roll) to fix the image. The powders are useful with known photoconductive materials, e.g., amorphous or vitreous selenium, selenium alloys with tellurium and arsenic, cadmium sulfide, zinc oxide in a resin binder, and organic photoconductive materials.

Although pressure-fixable developing powders have been suggested generally in British Patent No. 1,210,665, the developing powder of the present invention represents an improvement thereover. This British patent generally suggests that an aliphatic wax can be used, either by itself or in admixture with a thermoplastic resin, as the developing powder. However, it has been found that all waxes and many blends of wax and resin produce developing powders which, although easily pressurefixable, are commercially unacceptable due to their ease of smearing and "carbon paper" transfer. The developing powders of the present invention alleviate these disadvantages.

The developing powders of this invention also differ from those described in British Patent 1,210,665 in another material respect, viz., in terms of electrical properties. The novel developing powders exhibit the highly desirable electrical properties described in U.S. Patent No. 3,639,245, whereas the developing powders described in the aforementioned British patent are not electrically conductive. Consequently, the developing powders described in the British patent are useful only in conventional electrostatic copying processes wherein electroscopic toner powders are used.

### DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows apparatus for determining the "transfer density" value for a particular developing powder.

FIG. 2 shows apparatus for measuring the paper abrasion density for a particular developer powder.

The developer powders of this invention have the electrical conductivity properties of the heat-fusible powders described in Nelson, U.S. Pat. No. 3,639,245, incorporated herein by reference. The novel powders have a number average diameter below about 20 microns, and preferably in the range of about 10–15 microns. Preferably, the average particle size range is such that at least about 95 number percent of the particles have a diameter greater than about 5 microns, while no more than about 5 number percent have a diameter greater than about 25 microns.

The developing powders are pressure-fixable in the sense that the application of pressure thereto causes them to flow and coalesce and also to adhere to the desired support surface (i.e., the image-bearing surface). The binder material in which the electrically conductive particles are anchored comprises a blend of a wax component and a thermoplastic resin, wherein the weight ratio of thermoplastic resin to wax component is about 0.02/1 to 1/1 (preferably about 0.1/1 to 0.5/1). The binder material has a conductivity of at most  $10^{-12}$  mho/cm.

The wax component has a melting or softening point in the range of about 45° C. to about 150° C. (preferably between about 65° C. and 125° C.) and is normally selected from the group consisting of aliphatic compounds such as waxes (natural or synthetic), fatty acids, metal salts of fatty acids, hydroxylated fatty acids or amides, ethylene homopolymers, or a mixture of two or more of these materials. Aromatic or polymeric wax-like materials can also be used, e.g., dicyclohexylphthalate and diphenylphthalate. All of these materials are well known in the art.

Representative useful aliphatic waxes include paraffin wax, microcrystalline wax, carnauba wax, montan wax, ouricury wax, ceresin wax, candellila wax, and sugar cane wax.

Representative useful fatty acids include stearic acid, palmitic acid, and behenic acid. Representative useful metal salts of fatty acids include aluminum stearate, lead stearate, barium stearate, magnesium stearate, zinc stearate, lithium stearate, and zinc palmitate. Representative amide hydroxy waxes include N(beta-hydroxyethyl)ricinoleamide (commercially available under the trade name "Flexricin 115"), N,N'-ethylene-bis-ricinoleamide (commercially available under the trade name "Flexricin 185"), N(2-hydroxyethyl)-12-hydroxystearamide (commercially available under the trade name "Paracin 220"), and N,N'-ethylene-bis-12-hydroxystearamide (commercially available under the trade name "Paracin 285").

Representative fatty acid derivatives include castor was (glyceryl tris-12-hydroxy stearate), methyl hydroxy stearate (commercially available under the trade name "Paracin 1"), ethylene glycol monohydroxy stearate (commercially available under the trade name "Paracin 15") and hydroxy stearic acid.

The thermoplastic resin has a ring and ball softening point above about 60° C. (and preferably between 120° C. and 200° C.) and is normally selected from the group consisting of polyamides (e.g., "Versamid 950"), commercially available from General Mills); polystyrenes (e.g., 2000 mol. wt.); bisphenol A epoxy resins (e.g., "Epon 1004", commercially available from Shell Chemical Corp); acrylic resins (e.g., "Elvacite 2044", an N-butyl methacrylate commercially avail-

able from DuPont); vinyl resins such as polyvinyl butyral (e.g., "Butvar B72-A," commercially available from Monsanto Company), polyvinyl acetate (e.g., "Gelva V-100", commercially available from Monsanto Company); vinyl copolymers such as vinyl chloride/vinyl acetate (e.g., "VYHH", commercially available from Union Carbide Corp.), ethylene/vinyl acetate copolymers; cellulose esters such as cellulose acetate butyrate (e.g., "EAB-171-25", commercially available from Eastman Chemical Products, Inc.), cellulose acetate propionate (e.g., "CAPPLFS 70", commercially available from celanese Corp.); and cellulose ethers. The ring and ball softening point is measured according to ASTM:E28.

Various other materials may be usefully incorporated in or on the developer particles on this invention, e.g., plasticizers, dyestuffs, pigments, magnetically permeable particles, etc. Magnetically permeable particles having an average major dimension of 1 micron or less are particularly preferred, including magnetite, barium ferrite, nickel zinc ferrite, chromium oxide, nickel oxide, etc. A magnetically permeable core may also be used. Powdered flow agents may also be added to the dry particles to improve their flow characteristics.

The developing powder is prepared by first obtaining a blend of appropriate composition by any of several conventional techniques. For example, the wax component and thermoplastic resin may be heated to obtain a melt to which solid filler (e.g., magnetite) may be added and dispersed. The melt may then be atomized so as to obtain particles which, upon solidifying, are ready for further processing. Alternatively, the melt may be allowed to cool and solidify in mass after which it is ground into particles and classified according to the appropriate number average particle size range of about 5 to 20 microns.

The solid particles obtained in accordance with either of the foregoing procedures is then "spheroidized" by the following method. The powder is aspirated into a moving gas stream, preferably air, to create an aerosol. This aerosol is directed perpendicular to and through a stream of hot air, which has been heated to about 900°–1,100° F., in a cooling chamber where the powder is then allowed to settle by gravity while it cools. The resulting powder now comprises substantially spherical particles. It is then dry blended with conductive powder (e.g., conductive carbon black) and the mixture is directed perpendicular and through a stream of gas, preferably air, heated to a temperature (e.g., 700°–800° F.) which can at least soften and desirably melt the thermoplastic binder in the particles and maintain that softened or melted condition for a period of time sufficient to permit the conductive powder to become firmly anchored to the surface of the particle. The particles are then collected, such as by cyclone separation, and are preferably blended with a flow agent (e.g., "CAB-O-SIL", finely divided silica, commercially available from the Cabot Corporation) to insure that it will be free flowing.

In order to be commercially acceptable, the resulting developing powder must exhibit a "transfer density" of less than about 0.15 and a "paper abrasion density" of less than about 0.15. The "transfer density" value for a particular developing powder is determined by first using the apparatus depicted in FIG. 1. Referring to the drawing, there is shown apparatus 10 comprising base 12 on which there is fastened an imaged copy sheet 14 (wherein the image comprises a solid black line or

stripe about 1 inch wide) covered by an unimaged copy sheet 16. The image on sheet 14 has been made using the pressure-fixable developing powder to be tested, and sheet 16 is laid over and in direct contact with the image. Tape strips 18 and clip 20 hold sheets 14 and 16 in position.

Sheets 14 and 16 are "Type 350" copy paper commercially available from 3M Company, and comprise 45 pound Weyerhaeuser "GRS" paper coated on one side with zinc oxide in a binder. The binder comprises a blend of acrylic resin and alkyd resin, and the ratio of zinc oxide to total binder is 6:1. The weight of dried coating on the paper is 2.2-2.4 grams per square foot.

Twelve conventional medium point ball-point pen cartridges 22 are positioned (in free moving vertical position) within holding device 24. Four of the cartridges 22 are each vertically loaded with a weight 26 of 4.25 ounces (121 grams); four of the cartridges are loaded with a weight 28 of 8.8 ounces (250 grams); and 4 of the cartridges are loaded with a weight 30 of 17.3 ounces (492 grams), as shown in FIG. 1. These particular weight loadings encompass the range of writing pressures normally encountered.

Holding device 24 is then rolled across the unimaged copy sheet so that each of the cartridges 22 makes an inked line on sheet 16. The holding device 24 is then indexed 1/64 inch (0.397 millimeters) laterally via indexing device 32 and threaded shaft 34 before the holding device 24 is again passed over sheet 16. This procedure is repeated until about 20-25 passes have been made over sheet 16 with the loaded cartridges 22. The number of passes should be sufficient to obtain an area large enough to permit measuring of the diffuse reflection optical density of the developing powder transferred from the solid image area of sheet 14 to the back side of sheet 16. The optical density are proportional to the amount of image material transferred, and the optical density reading (e.g., 0.1) is taken as the "transfer density" value for the particular powder being tested. Conventional diffuse reflection densitometers (e.g., MacBeth Quanta-Log Diffuse Reflection Densitometer, Model RD-100) can be used to measure the optical density. For the purposes of this invention useful developing powders exhibit a "transfer density" of less than about 0.15 when testing image samples in the foregoing test using a pen cartridge loading of 17.3 ounces.

The "paper abrasion density" is measured by first using the apparatus of FIG. 2 wherein there is depicted a base 40 having mounted thereon arm 42. Rod 44 is 1/2 inch (12.7 millimeters) in diameter and 6 1/2 inches (16.5 centimeters) long. Rod 44 is loaded with 8 pounds of force pushing it against base 40 via spring 46. Pad 48, firmly attached to the bottom of rod 44, is formed of a silicone elastomer (hardness of 35 Shore A).

A copy sheet 50 bearing a solid image stripe 52 formed by pressure fixing the developing powder to be tested is positioned on base 40, with image side up, and 4 inches (10 centimeters) into the throat of the apparatus. Sheet 54 is then placed over and in direct contact with image 52 on sheet 50 after which rod 44 (loaded with 8 pounds force) is placed in contact with sheet 54. Then, while holding sheet 54 in its stationary position, sheet 52 is pulled in the direction of the arrow at the rate of about 2-10 inches per second for a distance of 4 inches (10 centimeters). The diffuse reflection optical density of the material transferred to the back side

of sheet 54 is then measured using a conventional diffuse reflection densitometer (e.g., MacBeth Quanta-Log Diffuse Reflection Densitometer, Model RD-100). The optical density reading is taken as the "paper abrasion density" value for the particular powder being tested.

Copy sheet 50 is "Type 350" copy paper commercially available from 3M Company. Sheet 54 is a conventional 20 pound mimeo paper ("Nekoosa Ardor" Mimeo, Sub-20) which is placed with the wire side against the image stripe in the paper abrasion density test.

The invention is illustrated by means of the following examples wherein the term "parts" refers to parts by weight unless otherwise indicated.

#### EXAMPLE 1

A developing powder is prepared using the following ingredients in the amounts shown:

	Parts
Paraffin wax ("Shellwax 300", melting point 71° C., commercially available from Shell Chemical Company)	32
Ethylene/vinyl acetate copolymer ("Elvax 250", commercially available from DuPont), ball and ring softening point of 138° C.	8
Magnetite	60

The wax is first heated to melting after which the ethylene/vinyl acetate copolymer is added with stirring and continued heating until a hot melt solution or dispersion is obtained. The magnetite (0.2-0.4 micron particles) is then added with continued stirring and heating until a homogeneous dispersion is obtained, after which the dispersion is spread in a thin layer on polyester film to cool and solidify.

The solidified composition is then broken into flakes, chilled with dry ice, and reduced to fine powder particles using a hammer mill (e.g., a "Mikro-Pulverizer", commercially available from MikroPul). A fraction having a diameter less than 45 microns is then collected and blended with 0.1% by weight of a flow agent (e.g., "Aerosil"; an amorphous colloidal silica commercially available from Degussa, Inc.).

The resulting dry developing powder is then used in a copying process wherein an image is formed electrographically on zinc oxide coated paper and developed using a magnetic roller of the type disclosed in U.S. Pat. No. 3,455,276 (Anderson). The developed image on the zinc oxide coated paper is then pressure fixed, for example by passing the imaged and developed paper between two smooth, polished steel rolls (approximately 2 inches in diameter) at a pressure of 200 pounds per lineal inch.

The resulting finished copy has sharp black image areas of high quality with no backgrounding. The transfer density of the finished copy is measured and found to be 0.031 at a pen cartridge loading of 17.3 ounces (492 grams). The paper abrasion density of the finished copy is measured and found to be 0.04.

#### EXAMPLE 2

A pressure-fixable developing powder is prepared using the following ingredients in the amounts stated:

	Parts
Ethylene glycol mono-hydroxy stearate ("Paracin 15", melting point 66° C., commercially available from Baker Castor Oil Company)	34
Cellulose ether ("Ethocel N-200", commercially available from Hercules, Inc., ball and ring softening point of 193° C.)	6
Magnetite	60

A hot melt dispersion is prepared with the stated ingredients using the procedure of Example 1. The dispersion is then solidified and reduced to a powder, after which a small amount of conventional flow agent is added.

The resulting dry developing powder is then used in a copying process wherein an image is formed electrographically on zinc oxide coated paper and developed using a magnetic roller of the type disclosed in U.S. Pat. No. 3,455,276 (Anderson). The developed image on the zinc oxide coated paper is then pressure fixed, for example, by passing the imaged and developed paper between two smooth steel rolls at a pressure of 200 pounds per lineal inch.

The resulting finished copy has sharp black image areas of high quality with no backgrounding. The transfer density of the finished copy is measured and found to be 0.09 at a pen cartridge loading of 17.3 ounces (492 grams). The paper abrasion density of the finished copy is measured and found to be 0.075.

#### EXAMPLE 3

A dry, pressure-fixable developing powder is prepared with the following ingredients using the procedures of Example 1:

	Parts
Castor wax (melting point 87° C., commercially available from Baker Castor Oil Company)	35
Cellulose ether ("Ethocel N-200", commercially available from Hercules, Inc., ball and ring softening point of 193° C.)	5
Magnetite	60

The resulting dry developing powder is used to make finished copies as described in Example 1. The transfer density of such copies is measured and found to be 0.09 at a pen cartridge loading of 17.3 ounces (492 grams). The paper abrasion density is measured and found to be 0.075.

#### EXAMPLE 4

A dry pressure-fixable developing powder is prepared with the following ingredients using the procedures of Example 1:

	Parts
12-hydroxy stearic acid (75° C. melting point, commercially available from Baker Castor Oil Company)	32
Ethylene/vinyl acetate copolymer ("Elvax 250", commercially available from DuPont, ball and ring softening point of 138° C.)	8
Magnetite	60

The resulting dry developing powder is used to make finished copies as described in Example 1. The transfer density of such copies is measured and found to be 0.03 at a pen cartridge loading of 17.3 ounces (492 grams). The paper abrasion density is measured and found to be 0.06.

#### EXAMPLE 5

A dry pressure-fixable developing powder is prepared with the following ingredients using the procedures of Example 1:

	Parts
Ethylene homopolymer (1,000 mol. wt., 113° C. melting point)	32
Ethylene/vinyl acetate copolymer ("Elvax 250", commercially available from DuPont, ball and ring softening point of 138° C.)	8
Magnetite	60

The resulting dry developing powder is used to make finished copies as described in Example 1. The transfer density of such copies is measured and found to be 0.07 at a pen cartridge loading of 17.3 ounces (492 grams). The paper abrasion density is measured and found to be 0.06.

#### EXAMPLE 6

A dry pressure-fixable developing powder is prepared with the following ingredients using the procedures of Example 1:

	Parts
12-hydroxy stearic acid (75° C. melting point)	32
Cellulose ether ("Ethocel N-200", commercially available from Hercules, Inc., ball and ring softening point of 193° C.)	8
Magnetite	60

The resulting dry developing powder is used to make finished copies as described in Example 1. The transfer density of such copies is measured and found to be 0.09 at a pen cartridge loading of 17.3 ounces (492 grams). The paper abrasion density is measured and found to be 0.07).

#### EXAMPLE 7

A dry pressure-fixable developing powder is prepared with the following ingredients using the procedures of Example 1:

	Parts
Castor wax (melting point 87° C.)	32
Polyvinyl butyral (ball and ring softening point of 188° C., "Butvar B72-A", commercially available from Monsanto)	8
Magnetite	60

The resulting dry developing powder is used to make finished copies as described in Example 1. The transfer density of such copies is measured and found to be 0.10 at a pen cartridge loading of 17.3 ounces (492 grams). The paper abrasion density is measured and found to be 0.09.

EXAMPLE 8

A dry pressure-fixable developing powder is prepared with the following ingredients using the procedures of Example 1:

	Parts
Ethylene glycol mono-hydroxy stearate ("Paracin 15", melting point 66°C., commercially available from Baker Castor Oil Co.)	32
N-butyl methacrylate (ball and ring softening point of 132° C., "Elvacite 2044", commercially available from DuPont)	8
Magnetite	60

The resulting dry developing powder is used to make finished copies as described in Example 1. The transfer density of such copies is measured and found to be 0.09 at a pen cartridge loading of 17.3 ounces (492 grams). The paper abrasion density is measured and found to be 0.10.

EXAMPLE 9

A dry pressure-fixable developing powder is prepared with the following ingredients using the procedures of Example 1:

	Parts
N(2-hydroxyethyl)-12-hydroxy stearamide (melting point 104° C., "Paracin 220", commercially available from Baker Castor Oil Co.)	32
Polyvinyl butyral (ball and ring softening point of 188° C., "Butvar B72-A", commercially available from Monsanto)	8
Magnetite	60

The resulting dry developing powder is used to make finished copies as described in Example 1. The transfer density of such copies is measured and found to be 0.10 at a pen cartridge loading of 17.3 ounces (492 grams). The paper abrasion density is measured and found to be 0.09.

What is claimed is:

1. A flowable, pressure-fixable, dry powder comprising thermoplastic, essentially spherical particles, the binder material of which has a conductivity of at most  $10^{-12}$  mho/cm and which comprises (a) about 50 to 100 parts by weight of a wax component having a melting point between about 45° C. and 150° C., and (b) about 2 to 50 parts by weight of thermo-plastic resin having a softening point above about 60° C.; wherein electrically conductive particles are firmly anchored in

said binder material, said electrically conductive particles having a conductivity of at least  $10^{-2}$  mho/cm and an average diameter below about 100 millimicrons forming a radially disposed zone; and wherein said essentially spherical particles exhibit:

- a. an electronic conductivity ranging monotonically without decreasing from between about  $10^{-11}$  and  $10^{-4}$  mho/cm in a 100 v./cm. DC electrical field to between about  $10^{-8}$  and  $10^{-3}$  mho/cm in a 10,000 v./cm. DC electrical field,
- b. a number average particle diameter below about 20 microns, and
- c. a volume ratio of said electrically conductive particles to said total particle volume of between 0.01/100 and 4/100;

wherein the dry powder exhibits a transfer density of less than about 0.15 and a paper abrasion density of less than about 0.15.

2. A flowable, pressure-fixable, dry powder in accordance with claim 1 wherein said wax component is selected from the group consisting of polyethylene, aliphatic waxes, and hydroxylated fatty acids.

3. A flowable, pressure-fixable, dry powder in accordance with claim 1 wherein said thermoplastic resin is selected from the group consisting of cellulose esters, vinyl resins, vinyl copolymers, polyamides and polystyrene.

4. A flowable, pressure-fixable, dry powder in accordance with claim 1 wherein said wax component comprises about 80 parts by weight of polyethylene and said thermoplastic resin comprises about 20 parts by weight of ethylene/vinyl acetate copolymer.

5. The dry powder of claim 1 in which said electrically conductive particles are particles of highly conductive carbon having a conductivity of at least  $10^{-2}$  mho/cm.

6. The dry powder of claim 1 in which the particle size range of said spherical particles is such that at least about 95 number percent of the particles have a diameter greater than about 5 microns and no more than 5 number percent have a diameter greater than 25 microns.

7. The dry powder of claim 1 in which said spherical particles have an electronic conductivity ranging monotonically without decreasing from between  $10^{-6}$  and  $10^{-5}$  mho/cm in a 100 v./cm. DC electrical field to between  $10^{-7}$  and  $10^{-4}$  mho/cm in a 10,000 v./cm. DC electrical field.

8. The dry powder of claim 1 in which said essentially spherical particles contain therein magnetizable particles.

9. The dry powder of claim 8 wherein said magnetizable particles comprise magnetite.

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