

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) PRESSURE FIXING OF TONERS

(71) We, ADDRESSOGRAPH MULTI-
 GRAPH CORPORATION, a corporation organised
 and existing under the Laws of the State of
 Ohio, United States of America, of 1200
 Babbitt Road, Cleveland, Ohio 44117, United
 States of America, do hereby declare the in-
 vention for which we pray that a patent may
 be granted to us and the method by which
 it is to be performed, to be particularly des-
 cribed in and by the following statement:—

This invention relates to fixing toners to a
 surface without the use of heat.

The process of copying indicia by the tech-
 nique of forming an electrostatic image on
 a surface of a substrate material is well de-
 veloped. Typically, this is accomplished in
 either of two ways. In either of these methods,
 a photoconductive surface is electrically
 charged and then exposed to a light and
 shadow pattern of the image. The electro-
 static charge which was deposited upon the
 photoconductive surface is removed from those
 places exposed to light, leaving a latent
 electrostatic image which can be developed.
 Development is accomplished by exposing the
 electrostatic image to a colored powder,
 usually referred to as a "toner" in this context,
 having the property of being attracted to the
 electrostatic image areas. According to the
 first method the toner is then fixed (perma-
 nently adhered) to the photoconductive sur-
 face. According to the other method the toner
 image formed on the photoconductive layer
 is first transferred to another substrate, e.g.
 a sheet of ordinary paper, and is then fixed
 on that other substrate.

The toner is normally a blend of thermo-
 plastic resin, carbon black or other pigment,
 and a small amount of dye. The exact compo-
 sition depends upon the specific purpose for
 which it is to be used.

The fixing or adhering of the toner is nor-
 mally accomplished by heat fusing the thermo-
 plastic resin component thereof. This is usually
 performed by exposing the image to heat
 for a time sufficient to melt somewhat the

toner particles so that they adhere, one to the
 other, and to the paper or substrate. Some
 fixing techniques have also employed the pres-
 sure developed by two hard surfaced rolls to
 fix the particles. Another proposed process
 passes the substrate between hard surfaced
 rolls in combination with the application of
 heat.

Heat fusing, while producing effective re-
 sults in many cases, is undesirable in that it
 requires that a supply of heat be available,
 usually entailing a supply of electric power in
 large quantities, and presents the possibility of
 overheating the substrate as well as the toner,
 with some danger of fire as a result. Pressure
 fusing as applied to the prior art has con-
 sisted of passing the toned substrate between
 two hard surfaced rolls, formed of metal, one
 roll being movable and connected with springs
 to provide a controlled pressure. (See for
 example U.S. Patent No. 3,269,626). Ex-
 perience has shown that this type of pressure
 fusing proves very unreliable due for ex-
 ample to poor contact because of non-uni-
 formity of the substrate thickness, a varia-
 tion in the toner deposit, even though use is
 made of extremely high loadings in an effort
 to obtain an image adequately adhered in all
 of its portions. This is particularly true if
 wider sheets are used rather than tapes. Under
 high loadings the character of the paper sub-
 strate itself may be materially altered, for to
 apply enough pressure to the low points or
 areas in the paper to properly fix the toner,
 it is necessary to apply excessive pressures to
 the high points. This, in turn, can materially
 alter the substrate and bring about unwanted
 surface characteristics in the unprinted areas,
 i.e. make certain areas shiny or glassy rather
 than permitting them to remain dull, and in
 any event almost certainly fails to provide
 degrees of fusing in various portions of the
 sheet which are sufficiently uniform to be
 practical in most applications.

It is perhaps theoretically possible, if the
 destructive effect upon the sheet could be

neglected, to urge the rollers together with sufficient force to provide general and fairly uniform fixing of the toner on a sheet of ordinary size, for example 8-1/2 inches by 11 inches. The difficulty, however, is that the loading required in such a situation may well transcend the normal range by such a large amount that the mechanical element of the system (such as the rollers themselves and their load-applying bearings) would either fail directly under the applied load or would deteriorate so rapidly that no practical device could be constructed.

It is therefore, a primary object of this invention to provide an improved method and apparatus for pressure fusing toners to a substrate without the use of external heat.

With this object in view, the invention provides for a workpiece which comprises a substrate having a toner powder image thereon and having a detectable thickness variation, the method of treating such workpiece to fix the image thereon which comprises passing the same under normal ambient temperature conditions between a pair of unheated pressure members progressively contacting each other along a band, the pressure members being of elastic material having values for the modulus of elasticity such that when loaded sufficiently to provide a calculated peak nip pressure in excess of the threshold pressure of the toner on the workpiece the combined deformation of the material of the members under load will be a substantial multiple of the thickness variation of the workpiece, and applying to the pressure members a loading sufficient to provide said calculated peak nip pressure in excess of the toner threshold pressure for as long as the toner bearing portions of the workpiece are in contact with a pressure member during the passage. The threshold pressure of the toner is the minimum pressure applied to it which will cause it to fuse, without externally applied heat.

The invention provides also apparatus for pressure fixing a powder toner image to a substrate comprising a pair of elastic pressure members arranged for progressively contacting each other along a narrow band with rolling pressure contact, at least one of said members having a calculated modulus of elasticity in compression of between about 100,000 p.s.i. and 2,000,000 p.s.i.; and means for loading said surfaces during passage of the substrate therebetween sufficiently to provide a calculated average pressure on the imaged substrate at the peak pressure point on its passage through the machine of between about 5,000 and 10,000 p.s.i.

The invention will now be further described with reference to the accompanying drawings in which:

Figure 1 is a perspective representation of the apparatus for carrying out the method of this invention;

Figure 2 is an enlarged side elevation of the apparatus shown in Figure 1 with the loading and driving means omitted; and

Figure 3 is a diagrammatic side elevation to a larger scale showing cylinders in pressure-relaxed engagement and in pressure engagement, and illustrating the means of certain symbols used in the description.

The process of forming the powder image is carried out in the usual manner wherein a support sheet carrying a photoconductive layer is charged, exposed to a light and shadow pattern corresponding to the desired image, and then developed with a toner powder according to known procedures. In the alternative, a latent electrostatic image similarly formed on a photo-conductive layer may be developed with toner, and the toner image thus formed transferred therefrom to another sheet or substrate. In any event, the resulting product is a flexible sheet or substrate 11 with a loosely held image 13 defined by toner powder on its surface.

The substrate carrying the toner image is then passed between pressure members which progressively contact each other along a narrow band, and emerges with the image consolidated and firmly adhered i.e. fused to the substrate as at 13'. As here illustrated these pressure members consist of a pair of rolls 15, 17 in rolling pressure contact.

The rolls 15 and 17 form a nip into which the toner bearing sheet 11 is passed. In accordance with prior practice these rolls would be hard metal rolls, but in accordance with the present invention it has been discovered that at least one of these rolls or members should be of softer, more compliant material. Simply to effect fusing, both rolls could be equally compliant. However, from the standpoint of effective practical operation, it is found that it is usually easier to provide a toner rejecting surface on a hard, relatively non-compliant member. Accordingly, the upper upper roll 15 in contact with the toner image is preferably a hard surfaced metal roll, and the lower roll 17 is of a softer and more compliant material.

The compliant roll may, for example, be formed of a hard rubber; it may be a cloth filled or a paper filled roll. (By a filled roll is meant one in which the body is made up of rings of paper or cloth stacked face to face on a mandrel. They are end-clamped between a flange and a threaded collar to form a mass of the desired degree of density, and then the surface is ground smoothly cylindrical. Various fibers can be used in the make-up of the cloth or paper sheets, and these can be derived from a variety of sources such as cotton, wool, nylon, asbestos, corncobs). The roll may comprise a block of nylon with a porosity appropriate to the degree of deformability required. Various types of compliant rolls are known in the papermaking art for purposes

unrelated to the present problem. The form of resilient roll presently preferred is one which is made up of stacked sheets of textile embodying cotton fibers and woolfibers in approximately equal amounts.

As the toned substrate 11, 13 passes between the rolls 15 and 17, the surface of the compliant roll 17 apparently become slightly distorted, as seen in exaggerated representation at 19 in Figure 2, so that pressure is distributed over a wider part of the substrate. Moreover, the compliant characteristic of the roll 17 seems to make it possible for the roll to adjust to variations in the thickness of the paper substrate or the toner deposit, and thereby distributes the pressure more evenly. If this is the case it probably means that it is possible to effect application of a substantially uniform pressure to areas containing the toner image which is to be fused. It is possible that in passing between the rolls, some shear is developed which contributes to the fusing of the toner to the paper. However, it is believed that the application of a uniform pressure to the toner is probably the primary factor in the achievement of good toner fixing.

In passing the toner bearing substrate into the nip of rolls 15 and 17, it is desirable that the toned side be brought into contact with the nonresilient roll 15. This results in better pressure fusing to the substrate surface and in the prevention of toner build-up on the compliant roll surface. This latter factor is particularly important where the surface of the compliant roll possesses any degree of porosity, for the finely divided toner could gradually build up in the surface pores. The relatively hard roll is preferably of a material whose surface is smooth and non-porous, and which has the property of resisting adhesive attachment for the resins employed in the toner particles. Chrome plated steel is generally quite effective for this purpose.

In the drawing, the compliant roll 17 is shown as having a larger diameter than the relatively rigid roll. This is normally desirable, but not necessary. Whether the two rolls are of the same or different size, they are rotated so as to have essentially the same surface speed. This means that the shear developed, if any, will be due almost solely to the surface characteristics of the more compliant roll.

The loading to be applied to the rolls or pressure members 15 and 17 may be effected by joint loading and driving means of conventional character indicated diagrammatically at 21 in Fig. 1, and varies with a number of factors such as the resilience of the members and the threshold pressure of the toner. The initial tests conducted in con-

nection with this discovery were performed using a cotton filled roller of a hardness on the Shore-D scale of about 80 and having a calculated modulus of elasticity in compression of about 200,000 p.s.i. It was found that many conventional toners were effectively fused to the substrate when the loading was in the range of about 200 pounds to 400 pounds per lineal inch. A calculation of the peak pressure which the rolls could be said to apply, on an average, at the area of their contact gives about 5000 to 10,000 p.s.i. The toners used in these tests were conventional dry toners embodying as the binding agent the resins customarily used heretofore for this purpose. These figures represent a particular example of a rather usual situation in which the invention can be applied, but it will be understood that the loading of the pressure members can be adjusted to give the desired pressure, depending upon the materials used, and that the pressure may be varied substantially to meet the fusing requirements of the particular toner. While the particular compliant roll was one in which the calculated modulus of elasticity was about 200,000 p.s.i., it will be understood that other resilient materials can be used in applying the invention and having a modulus much higher than 200,000 p.s.i., based on principles to be explained hereinafter. As to the minimum modulus, it should be such that the material does not deform excessively under the pressures used. Usually a calculated modulus of at least 100,000 p.s.i. is considered preferable in the best interests of overall efficiency.

As a basis for comparison it may be noted that the modulus of elasticity for steels is close to 30,000,000 p.s.i.

The immediately foregoing statements will perhaps be more readily understood in the light of the following comments.

The mechanical interaction of two parallel cylinders urged against one another has been extensively investigated and mathematical relationships developed which will permit the calculation of quantities such as (a) an apparent value for the modulus of elasticity for the cylinder material (where, for example, the material is of a type not having a commonly recognized or recorded modulus value, and (b) the maximum compressive stress or peak effective pressure in p.s.i. exerted by the cylinders at the nip. An example of these relationships can be found in Formulas for Stress and Strain (Fourth Edition) by Raymond J. Roark, published by McGraw-Hill Book Company.

On page 320 of the Roark text, Table XIV, section 5, is found the expression:

where E is the modulus of elasticity of the material of the cylinder, d is the diameter of the cylinder, r is the radius of curvature of the cylinder at the nip, P is the load per unit length of the cylinder, δ is the deflection of the cylinder at the nip, σ is the maximum compressive stress in the cylinder at the nip, and ϵ is the maximum strain in the cylinder at the nip.

$$b = 1.6 \sqrt{p = \frac{D_1 D_2}{D_1 + D_2} \left[\frac{1 - \nu_1^2}{E_1} + \frac{1 - \nu_2^2}{E_2} \right]}$$

where:

b represents the transaxial width in inches of the contact area under load. (See Fig. 3);

5 p represents the cylinder loading in pounds per linear inch;

D₁ and D₂ represent the diameters of the cylinders in inches;

10 ν_1 and ν_2 represent Poisson's ratio in compression for the materials of the cylinders; and

E₁ and E₂ represent the modulus of elasticity in compression for the materials of the cylinders, stated in pounds per square inch.

15 From this it will be seen that when a measurement is taken of the quantity b (as by loading the rolls with a pressure transfer material and a copy sheet therebetween and measuring the breadth of the print) and if
20 one of the rolls has an E of known value (such as steel), the E (calculated modulus of elasticity) for the other roll can be readily obtained. (The effective value of Poisson's
25 ratio for materials in the usable range may be assumed to be closely in the neighborhood of 0.3 in case there is not value reported in the literature, especially since this quantity has little effect on the calculated result).

30 At the same point in the text identified above, there is also found the expression:

$$\text{Max. } s_c = 0.798 \sqrt{\frac{\frac{D_1 + D_2}{p} \frac{p}{D_1 D_2}}{\frac{1 - \nu_1^2}{E_1} + \frac{1 - \nu_2^2}{E_2}}}$$

Where Max. s_c represents the maximum compressive stress or peak unit pressure effect at the nip, expressed in p.s.i., and the other
35 symbols have the same significance as above. As will be readily seen, this formula gives the calculated peak nip pressure directly by merely substituting the appropriate values of p, D₁, D₂, E₁, E₂ and the reported or assumed
40 values for Poisson's ratio.

The significance of certain of the foregoing symbols will perhaps be more clearly understood by reference to Fig. 3 which shows two cylinders which may be considered as corresponding to rolls 15 and 17 of Figs. 1 and 2.
45 In the full line position the cylinders are unloaded, and the axis of cylinder 15 is at A. In the dotted line position the cylinders are under an applied load p which causes the axes
50 to move closer together as represented by the shift of the axis of cylinder 15 to B. The distance AB or y can be measured and is referred to as the deformation. The loaded

cylinders demonstrate a narrow band of contact under load having a width b which can
55 be measured as heretofore described. Similar calculations can be made if either member becomes a plane by letting the value for the diameter of that member approach infinity in the

above expressions, in which case $\frac{D_1 + D_2}{D_1 D_2}$ 60

approaches D.

The tests conducted in connection with this invention have indicated that a certain calculated peak pressure at the nip is needed to secure proper fusing of a given toner, and that this is related primarily to the character of the toner material. As previously stated, for conventional toners currently in use a calculated peak pressure of at least 5000 p.s.i. is
65 needed to secure fixing. The fixing here contemplated involves essentially altering the state of the toner resin sufficiently to make it flow and adhere to itself and to the substrate. This is, presumptively, primarily due to a pressure-induced temperature rise within the toner
70 material although mechanical action may play a minor role in the fixing action also. It is expected that, with experiment, toners requiring a lesser pressure can be developed. It is also conceivable that in compounding
75 toners to secure other beneficial properties, the threshold pressure might have to be increased. In any event, there will be a readily determinable minimum effective value of pressure for the particular toner under consideration, and that value will be referred to hereinafter as the threshold pressure for the toner. 80 85

Having in mind the foregoing requisite, the parameters involved in securing adequate uniform fixing appear, from the tests so far
90 conducted, to be substantially as described hereinafter.

The materials for the pressure members or rolls are (or where, as in the preferred example, one roll has significantly more "give" or compliance than the other, the material for the compliant member or roll is) selected to have values (or a value) of the modulus of elasticity such that, when a loading p is applied which generates a calculated peak nip pressure (Max. s_c) equal to or slightly greater than the threshold pressure for the toner under consideration, there is generated a measured deformation (y) which is still within the elastic limit for the material and whose value is a substantial multiple of the average variation in the workpiece properties. By this variation is meant variation in anything which offers resistance to squeezing, such as thickness or density. For practical purposes, a standardized pressure is usually applied in taking such thickness measurements, so that the overall
100 105 110

effect may normally be regarded as a thickness variation even though a density or compressibility factor may contribute somewhat thereto. Ordinary paper sheets, to take a convenient example, exhibit variations in the order of .0004 inches between the maximum and minimum thickness readings. While the thickness of the toner deposit can, under some circumstances, contribute to this variation and then might need to be taken into account, for most current toner materials and their usual depositing characteristics, this component of the variation may, as a practical matter, be neglected in computing the thickness variation. It is contemplated, however, that situations involving very uniform substrates and toners exhibiting variations in particle size would respond equally to the methods and apparatus proposed herein, so that when a workpiece thickness variation is referred to hereinafter, this form will be understood as included as well as forms of workpiece variation arising primarily from substrate nonuniformity.

For purposes of convenience, variations of this sort which appear as a result of thickness measurement tests may be referred to as "thickness variations".

The term "substantial multiple", used in the immediately foregoing paragraph, means at least several times, and in practical effort, it has been found that, when the calculated peak pressure at the nip is at or slightly above the threshold pressure of the toner, a multiplier of about five, as a minimum, should be applied to the average variation to determine the appropriate deformation in order to secure reasonably uniform fusing on the surface of the substrate. A more generally preferred value would be a multiplier of 10.

This multiplier does not have a firmly fixed value or range, however, but probably depends to some extent on the amount by which the calculated peak nip pressure used is permitted to exceed that required for the toner in question.

Thus, for a toner whose threshold pressure is 5000 p.s.i., and having in mind an ordinary paper sheet with an average thickness variation of about .0004 inches, the material of the roll 17 would be so selected as to its modulus of elasticity (E) that, when loaded to a value p which will give the calculated peak nip pressure of 5000 p.s.i. required, or a little more, the measured deformation y should be at least $5 \times .0004$ or .002 inches. As pointed out above, this might prove somewhat marginal, and the E would preferably be so selected that a deformation y of about $10 \times .0004$ or .004 inches can be achieved to ensure absolute fusing uniformity. However, if we should use a loading p which would produce a calculated peak nip pressure rather greater than is needed for the toner in question, say 15,000 to 20,000 p.s.i., and if this

could be used without damaging the substrate, then it is expected that the deformation generating multiple applied to the average variation could be permitted to have a lesser value, perhaps in the range of 3 to 4 as a minimum.

From the foregoing discussion it will be apparent that having the threshold pressure of the toner in mind, and the average variation in workpiece properties (represented as a thickness variation) it is possible to determine readily whether any particular solid material of a coherent elastic nature will have the properties needed to form an effective pressure fixing member. For convenience it may be stated that the pressure member or rolls will be of a material having a modulus of elasticity in compression such that, when subjected to a loading which develops a calculated peak nip pressure of at least the threshold pressure of the toner in question, they will exhibit a deformation which is a substantial multiple of the workpiece thickness variation.

It will be understood that, while the two roll form has been shown and described, either pressure member may be formed as a platen with the other having a roll or segment configuration and being in rolling pressure contact therewith.

Most of the powdered toners now commonly known and used may be used in forming copies by the process of this invention. However, since the method of this invention achieves uniform toner adherence to the substrate surface by application of pressure alone, it presents an opportunity to use other finely divided powders for toners which are not necessarily the same as those usable in heat fusing. Thus, a greater flexibility in toner choice and final copy characteristics is available.

The method of pressure fixing of this invention makes it possible to work with wider substrate sheets than is possible with the use of two hard surface rolls. Past experience in using two hard surface rolls has indicated that problems of achieving satisfactory characteristics in the untuned surface areas are materially increased as the width of the substrate is increased. This intensification of the fixing problem with increase in width is not experienced when fixing is effected in accordance with the procedure set out in the foregoing description.

WHAT WE CLAIM IS:—

1. For a workpiece which comprises a substrate having a toner powder image thereon and having a detectable thickness variation, the method of treating such workpiece to fix the image thereon which comprises passing the same under normal ambient temperature conditions between a pair of unheated pressure members progressively contacting each other

effect may normally be regarded as a thickness variation even though a density or compressibility factor may contribute somewhat thereto. Ordinary paper sheets, to take a convenient example, exhibit variations in the order of .0004 inches between the maximum and minimum thickness readings. While the thickness of the toner deposit can, under some circumstances, contribute to this variation and then might need to be taken into account, for most current toner materials and their usual depositing characteristics, this component of the variation may, as a practical matter, be neglected in computing the thickness variation. It is contemplated, however, that situations involving very uniform substrates and toners exhibiting variations in particle size would respond equally to the methods and apparatus proposed herein, so that when a workpiece thickness variation is referred to hereinafter, this form will be understood as included as well as forms of workpiece variation arising primarily from substrate nonuniformity.

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The term "substantial multiple", used in the immediately foregoing paragraph, means at least several times, and in practical effort, it has been found that, when the calculated peak pressure at the nip is at or slightly above the threshold pressure of the toner, a multiplier of about five, as a minimum, should be applied to the average variation to determine the appropriate deformation in order to secure reasonably uniform fusing on the surface of the substrate. A more generally preferred value would be a multiplier of 10.

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It will be understood that, while the two roll form has been shown and described, either pressure member may be formed as a platen with the other having a roll or segment configuration and being in rolling pressure contact therewith.

Most of the powdered toners now commonly known and used may be used in forming copies by the process of this invention. However, since the method of this invention achieves uniform toner adherence to the substrate surface by application of pressure alone, it presents an opportunity to use other finely divided powders for toners which are not necessarily the same as those usable in heat fusing. Thus, a greater flexibility in toner choice and final copy characteristics is available.

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WHAT WE CLAIM IS:—

1. For a workpiece which comprises a substrate having a toner powder image thereon and having a detectable thickness variation, the method of treating such workpiece to fix the image thereon which comprises passing the same under normal ambient temperature conditions between a pair of unheated pressure members progressively contacting each other



along a band, the pressure members being of elastic material having values for the modulus of elasticity such that when loaded sufficiently to provide a calculated peak nip pressure in excess of the threshold pressure of the toner on the workpiece the combined deformation of the material of the members under load will be a substantial multiple of the thickness variation of the workpiece, and applying to the pressure members a loading sufficient to provide said calculated peak nip pressure in excess of the toner threshold pressure for as long as the toner bearing portions of the workpiece are in contact with a pressure member during the passage.

2. A method as set forth in Claim 1 in which a first one of the members between which the workpiece is passed is of a material with a smooth, nonabsorbent surface which substantially resists adhesive connection with the toner under pressure, in which the second member is compliant relatively to said first member and has a modulus of elasticity substantially lower than that of said first member such that it accounts for substantially all of the deformation of said members, the workpiece during its passage between the members having its image bearing surface in contact with the first member.

3. A method as set forth in Claim 2 in which the members are rolls and the second member is a textile filled roll of approximately equal parts of cotton fiber and wool fiber.

4. A method as set forth in Claim 2 or Claim 3 in which the members are rolls and the first member is of chrome plated steel.

5. The method of fixing a toner image to a substrate which comprises passing the substrate with the powdered toner image thereon under normal ambient temperature conditions between a pair of unheated elastic pressure members progressively contacting each other along a band, at least one of said members being of a material having a calculated modulus of elasticity in compression of not over about 2,000,000 p.s.i.

6. A method as set forth in Claim 5, in which the said one pressure member is made of material, the modulus of elasticity of which is between about 100,000 p.s.i. and about 2,000,000 p.s.i.

7. A method as set forth in Claim 5 or Claim 6 in which the other pressure member has a smooth, non-absorbent surface and which substantially resists adhesive connection with the toner under pressure, and in which the

toner bearing surface of the substrate is faced towards said one member.

8. A method as set forth in any one of Claims 5 to 7 which further includes so loading the surfaces that the calculated peak pressure at the pressure nip therebetween averages between 5000 and 10,000 p.s.i.

9. A method as set forth in any one of Claims 5 to 8 in which the imaged substrate is passed between members at least one of which is a textile filled roll of approximately equal parts of cotton fiber and wool fiber.

10. A method as set forth in any one of Claims 5 to 9 in which the pressure members are both rolls.

11. Apparatus for pressure fixing a powder toner image to a substrate comprising a pair of elastic pressure members arranged for progressively contacting each other along a band with rolling pressure contact, at least one of said members having a calculated modulus of elasticity in compression of between about 100,000 p.s.i. and 2,000,000 p.s.i.; and means for loading said surfaces during passage of the substrate therebetween sufficiently to provide a calculated average pressure on the imaged substrate at the peak pressure point on its passage through the machine of between about 5,000 and 10,000 p.s.i.

12. Apparatus as set forth in Claim 11 in which both of the pressure members are rolls.

13. Apparatus as set forth in Claim 12 in which one of the rolls is a textile filled roll of approximately equal parts of cotton fiber and wool fiber.

14. Apparatus as set forth in Claim 13 in which the other roll is a metal roll with a smooth non-absorbent surface.

15. Apparatus as set forth in Claim 14 in which the metal roll has a chromium surface.

16. A method of fixing toner to a surface without the use of external heat, substantially as herein described with reference to the accompanying drawings.

17. Apparatus for fixing toner to a surface without the use of external heat, substantially as herein described with reference to the accompanying drawings.

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