

[54] **CONTACT FUSING APPARATUS FOR FIXING TONER IMAGES TO A SUPPORT MEMBER**

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[51] **Int. Cl.²** **G03G 15/20**

[58] **Field of Search** **118/60, 261, 271, 409, 118/416; 432/60, 228**

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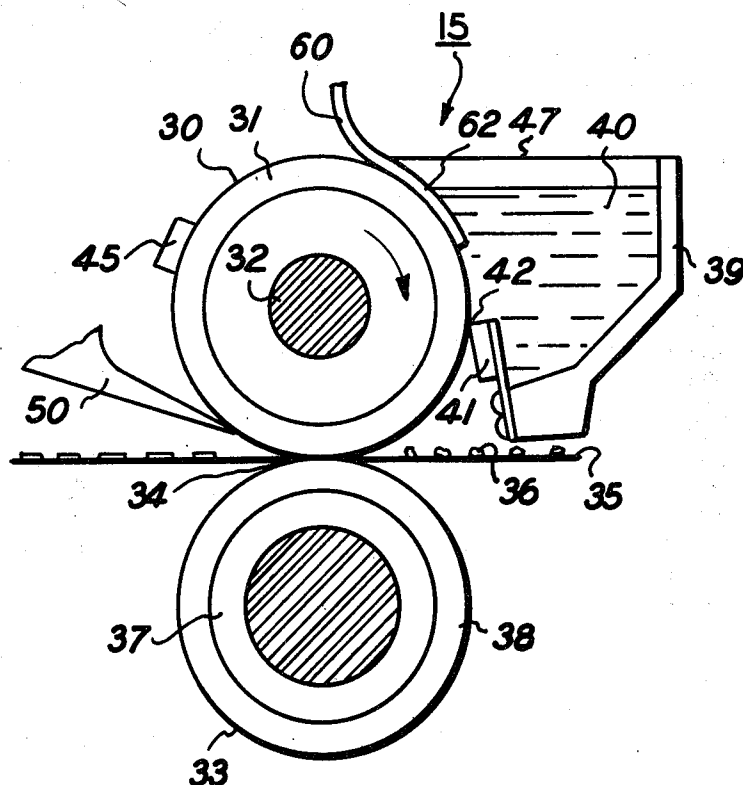
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Assistant Examiner—Douglas Salser

[57] ABSTRACT

A contact fuser assembly for use in an electrostatic reproducing apparatus including an internally heated fuser roll structure comprising a rigid or non-deformable, thermally conductive core capable of interacting with a material applied thereto in such a manner as to form a thermally-stable interfacial coating intermediate the surface of the core and a release coating also formed thereon. The interfacial coating strongly adheres to the core surface and prevents toner material from contacting the outer surface of the core. The combined coatings have a sub-micron thickness and therefore present a minimal thermal barrier to the energy being conducted outwardly by the core. The fuser assembly is characterized by the provision of means for controlling the interaction between the core and the material.

14 Claims, 4 Drawing Figures



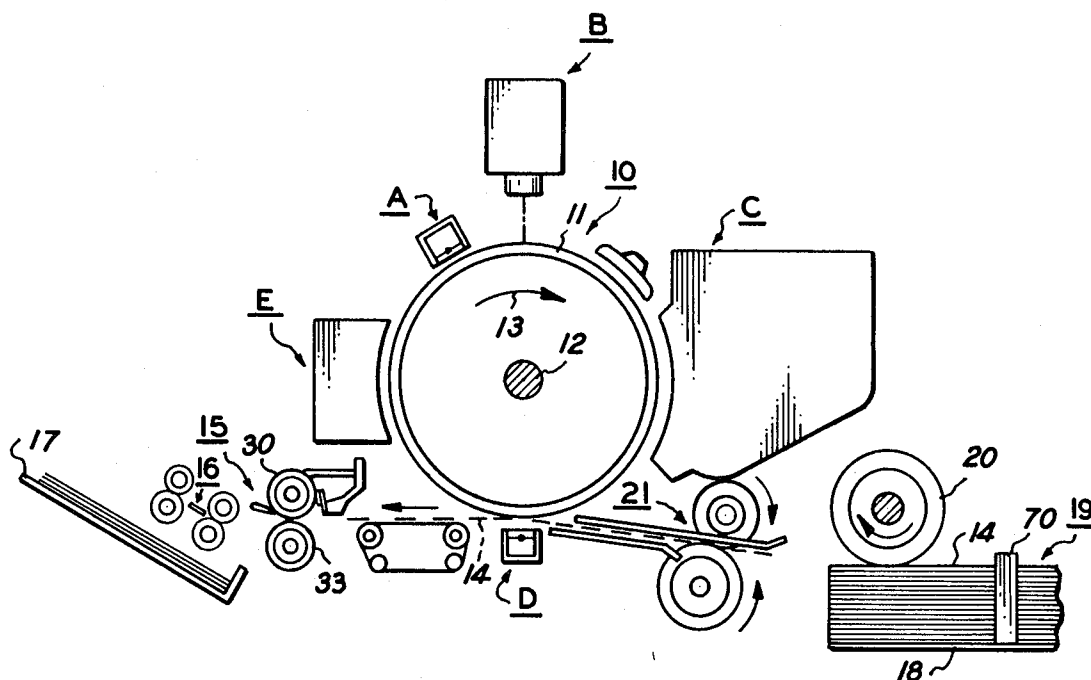


FIG. 1

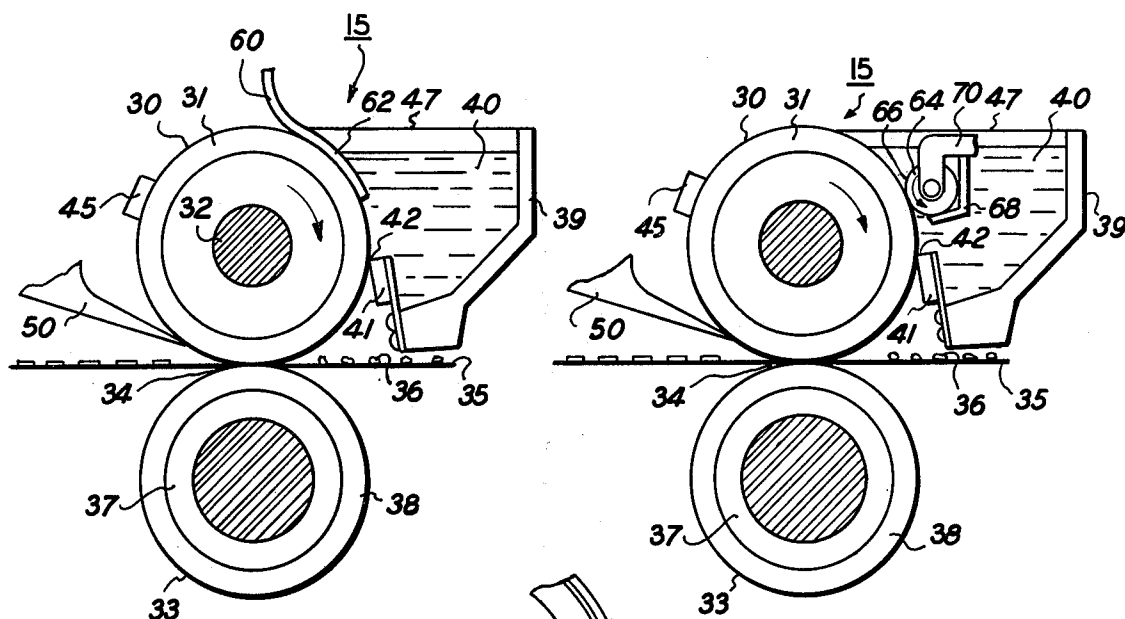


FIG. 2

FIG. 4

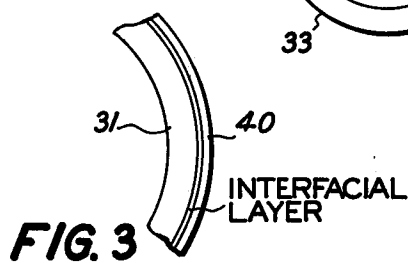


FIG. 3

CONTACT FUSING APPARATUS FOR FIXING TONER IMAGES TO A SUPPORT MEMBER

BACKGROUND OF THE INVENTION

This invention relates generally to xerographic copying apparatus and, more particularly, to a contact fusing system for fixing electrosopic toner material to a support member.

In the process of xerography, a light image of an original to be copied is typically recorded in the form of a latent electrostatic image upon a photosensitive member with subsequent rendering of the latent image visible by the application of electrosopic marking particles, commonly referred to as toner. The visual image can be either fixed directly upon the photosensitive member or transferred from the member to a sheet of plain paper with subsequent affixing of the image thereto.

In order to permanently affix or fuse electrosopic toner material onto a support member by heat, it is necessary to elevate the temperature of the toner material to a point at which the constituents of the toner material coalesce and become tacky. This action causes the toner to be absorbed to some extent into the fibers of the support member which, in many instances, constitutes plain paper. Thereafter, as the toner material cools, solidification of the toner material occurs causing the toner material to be firmly bonded to the support member. In both the xerographic as well as the electrographic recording arts, the use of thermal energy for fixing toner images onto a support member is old and well known.

One approach to thermal fusing of electrosopic toner images onto a support has been to pass the support with the toner images thereon between a pair of opposed roller members, at least one of which is internally heated. During operation of a fusing system of this type, the support member to which the toner images are electrostatically adhered is moved through the nip formed between the rolls with the toner image contacting the fuser roll to thereby effect heating of the toner images within the nip. By controlling the heat transferred to the toner, virtually no offset of the toner particles from the copy sheet to the fuser roll is experienced under normal conditions. This is because the heat applied to the surface of the roller is insufficient to raise the temperature of the surface of the roller above the "hot offset" temperature of the toner whereat the toner particles in the image areas of the toner would liquify and cause a splitting action in the molten toner to thereby result in "hot offset". Splitting occurs when the cohesive forces holding the viscous toner mass together is less than the adhesive forces tending to offset it to a contacting surface such as a fuser roll.

However, toner particles will be offset to the fuser roll by an insufficient application of heat to the surface thereof (i.e. "cold" offsetting); by imperfections in the properties of the surface of the roll; or by the toner particles insufficiently adhering to the copy sheet by the electrostatic forces which normally hold them there. In such a case, toner particles may be transferred to the surface of the fuser roll with subsequent transfer to the back-up roll during periods of time when no copy paper is in the nip.

Moreover, toner particles can be picked up by the fuser and/or back-up roll during fusing of duplex copies

or simply from the surroundings of the reproducing apparatus.

One arrangement for minimizing the problems attendant the foregoing, particularly that which is commonly referred to as "offsetting" has been to provide a fuser roll with an outer surface or covering of polytetrafluoroethylene, commonly known as Teflon, to which a release agent such as silicone oil is applied, the thickness of the Teflon being on the order of several mils and the thickness of the oil being less than 1 micron. Silicone based oils, which possess a relatively low surface energy, have been found to be materials that are suitable for use in the heated fuser roll environment where Teflon constitutes the outer surface of the fuser roll. In practice, a thin layer of silicone oil is applied to the surface of the heated roll to thereby form an interface between the roll surface and the toner images carried on the support material. Thus a low surface energy layer is presented to the toner as it passes through the fuser nip and thereby prevents toner from offsetting to the fuser roll surface.

A fuser roll construction of the type described above is fabricated by applying in any suitable manner a solid layer of adhesive material to a rigid core or substrate, such as the solid Teflon outer surface or covering of the aforementioned arrangement. The resulting roll structure is subject to degradation due to continued operation at elevated temperatures and also to damage from accidental gouging by stripper fingers conventionally employed in such systems. The foregoing in many instances necessitates replacement of the fuser roll which is quite costly when a large number of machines are involved. Moreover, the initial investment for fabricating such constructions is undesirably high and the manufacturing process is quite cumbersome.

Furthermore, since a several mil thickness of polytetrafluoroethylene along with the coating of silicone oil constitutes a poor thermal conductor, longer nip dwell and higher fuser roll temperatures are required to deliver the fusing energy required. Also, control of the surface temperature of the roll presents a problem due to large temperature variations occurring before and after contacting of the substrate carrying the images.

In view of the foregoing, it would appear that the high thermal conductivity and wear resistance of bare metals or similar materials would be desirable for utilization in fuser roll structures, however, such materials have, heretofore, not been found satisfactory for such application. The latter is attributable to the very high surface energy of metals and similar materials which renders them readily wettable by hot toner materials. Once wetted by hot toner, it has been very difficult if not impossible to remove the toner from such materials while they remain hot. Commonly used release agents such as pure silicone oils have been tried in combination with various metals and other high surface energy materials but with relatively little or no success.

One approach to utilizing bare metal or other high surface energy materials has been to use low molecular weight polyethylene in conjunction with a heated fuser roll structure having a rigid core of copper. It is believed that the polyethylene thermally degrades or oxidizes to form carboxylic acid which chemically reacts with the surface of the copper core to form a copper-carboxylate layer which forms a barrier preventing toner from contacting the copper core. Unoxidized polyethylene forms a release coating on the copper-carboxylate layer. The cohesive forces of the release

layer are less than the adhesive forces between the release layer and the toner or paper. Accordingly, the paper with the toner thereon is readily stripped from the fuser roll structure.

It has been found desirable to control the degree of reactivity between the copper core and the carboxylic acids, particularly, during long periods of copier standby at which times it has been observed that a bead forms on the copper surface along a boundary formed by the copper, the polyethylene and the ambient air.

Accordingly, an object of this invention is to provide a new and improved copier apparatus wherein toner images are formed on a support member.

Another object of this invention is to provide in a copier apparatus, a new and improved contact fuser for fixing toner images to a support member.

Still another object of this invention is to provide a new and improved contact fuser incorporating a thermally conductive core capable of reacting with a material applied thereto for forming a toner impenetrable layer thereon and a release coating on the layer.

Yet another object of this invention is to provide, in a contact fuser incorporating a thermally conductive core capable of interacting with a material applied thereto to form a toner impenetrable layer on the core and a release coating on the layer, means for controlling the interaction between the core and the material applied thereto.

BRIEF SUMMARY OF THE INVENTION

Briefly, the above-cited objects are accomplished by the provision of a contact fuser apparatus including a fuser roll structure having a copper core to which polyethylene is applied with simultaneous heating of the core. In the presence of ambient air the polyethylene oxidizes or degrades to form carboxylic acid which chemically reacts with the surface of the core to form a layer thereon which prevents toner from contacting the core. Unoxidized polyethylene is coated on the aforementioned layer to form a release coating which facilitates stripping of copy sheets from the fuser roll structure.

The polyethylene which is a solid at room temperature is contained in a sump in the fuser roll structure which sump is supported such that the core rotates in contact with the polyethylene. It will be appreciated that with the foregoing arrangement there is formed a copper/polyethylene/air boundary which has been found to be undesirable since the rate at which the carboxylic acid is formed thereat is sufficient, when the copier apparatus is in a standby condition, to form a hard bead on the copper core, which bead lies along the aforementioned boundary. In order to prevent such a bead formation, a wiper blade in one embodiment of the invention is provided which contacts the copper core such that it prevents the formation of the aforementioned boundary and in lieu thereof forms a wiper blade/polyethylene/air boundary which does not result in bead formation on the copper core.

In another embodiment of the invention, a roller structure and cleaning blade therefor replaces the wiper blade. Preferably the wiper blade and the roller are fabricated from a material which is compatible with the polyethylene (i.e. does not chemically react therewith and to a lesser degree is dimensionally stable in the presence thereof). To this end, the wiper blade and at least the surface layer of the roller structure comprise an elastomeric material such as silicone rubber.

Other objects and advantages of the present invention will become apparent when read in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic representation of a xerographic reproducing apparatus incorporating the novel contact fuser of this invention;

FIG. 2 is a side elevational view of a fuser system incorporated in the apparatus of FIG. 1;

FIG. 3 is a fragmentary view of a fuser roll during operation; and

FIG. 4 is a side-elevational view of a modified form of the fuser system illustrated in FIG. 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The reproducing machine illustrated in FIG. 1 employs an image recording drum-like member 10 the outer periphery of which is coated with a suitable photoconductive material 11. One type of photoconductive material is disclosed in U.S. Pat. No. 2,970,906 issued to Bixby in 1961. The drum 10 is suitably journaled for rotation within a machine frame (not shown) by means of a shaft 12 and rotates in the direction indicated by arrow 13, to bring the image retaining surface thereon past a plurality of xerographic processing stations. Suitable drive means (not shown) are provided to power and coordinate the motion of the various cooperating machine components whereby a faithful reproduction of the original input scene information is recorded upon a sheet of final support material such as paper or the like.

Since the practice of xerography is well known in the art, the various processing stations for producing a copy of an original are herein represented in FIG. 1 as blocks A to E. Initially, the drum moves photoconductive surface 11 through a charging station A. At charging station A an electrostatic charge is placed uniformly over the photoconductive surface 11 of the drum 10 preparatory to imaging. The charging may be provided by a corona generating device of a type described in U.S. Pat. No. 2,836,725 issued to Vyverberg in 1958.

Thereafter, the drum 10 is rotated to exposure station B where the charged photoconductive surface 11 is exposed to a light image of the original input scene information, whereby the charge is selectively dissipated in the light exposed regions to record the original input scene in the form of a latent electrostatic image. A suitable exposure system may be of the type described in U.S. patent application Ser. No. 259,181 filed June 2, 1972.

After exposure, drum 10 rotates the electrostatic latent image recorded on the photoconductive surface 11 to development station C, wherein a conventional developer mix is applied to the photoconductive surface 11 of the drum 10 rendering the latent image visible. A suitable development station is disclosed in U.S. patent application Ser. No. 199,481 filed Nov. 17, 1971. This application describes a magnetic brush development system utilizing a magnetizable developer mix having carrier granules and toner comprising electrophotographic resin plus colorant from dyes or pigments. A developer mix is continually brought through a directional flux field to form a brush thereof. The electrostatic latent image recorded on photoconductive surface 11 is developed by bringing the brush of developer mix into contact therewith. The developed image on the photoconductive surface 11 is then brought into

contact with a sheet of final support material 14 within a transfer station D and the toner image is transferred from the photoconductive surface 11 to the contacting side of the final support sheet 14. The final support material may be plain paper, gummed labels, transparencies such as Polycarbonate, Polysulfane and Mylar, etc., as desired.

After the toner image has been transferred to the sheet of final support material 14, the sheet with the image thereon is advanced to a suitable fuser assembly 15 which fuses the transfer powder image thereto. After the fusing process, the final support material 14 is advanced by a series of rolls 16 to a copy paper tray 17 for subsequent removal therefrom by a machine operator.

Although a preponderance of the toner powder is transferred to the final support material 14, invariably some residual toner remains on the photoconductive surface 11 after the transfer of the toner powder image to the final support material 14. The residual toner particles remaining on the photoconductive surface 11 after the transfer operation are removed from the drum 10 as it moves through cleaning station E. Here the residual toner particles are first brought under the influence of a cleaning corona generating device (not shown) adapted to neutralize the electrostatic charge remaining on the toner particles. The neutralized toner particles are then mechanically cleaned from the photoconductive surface 11 by conventional means as for example, the use of a resiliently biased knife blade as set forth in U.S. Pat. No. 3,660,863 issued to Gerbasi in 1972.

The sheets of final support material 14 processed in the automatic xerographic reproducing device may be stored in the machine within a removable paper cassette 18. A suitable paper cassette is set forth in U.S. Patent Application Ser. No. 208,138 filed Dec. 15, 1971.

The copier can also have the capability of accepting and processing copying sheets of varying lengths. The length of the copy sheet, of course, being dictated by the size of the original input scene information recorded on the photoconductive surface 11. To this end, the paper cassette 18 is preferably provided with an adjustable feature whereby sheets of varying length and width can be conveniently accommodated therein.

In operation, the cassette 18 is filled with the stack of final support material 19 of pre-selected size and the cassette 18 is inserted into the machine by sliding along a baseplate (not shown) which guides the cassette 18 into operable relationship with a pair of feed rollers 20. When properly positioned in communication with the feed rollers 20 the top sheet of the stack 19 is separated and forwarded from the stack 19 into the transfer station D by means of registration rollers 21.

It is believed that the foregoing description is sufficient for purposes of present application to illustrate the general operation of an automatic xerographic copier which can embody the teachings of the present invention.

The fuser assembly 15 comprises heated roll structure 30 including a hollow cylinder or core 31 having a suitable heating element 32 disposed in the hollow portion thereof which is coextensive with the cylinder. The heating element 32 may comprise any suitable type heater for elevating the surface temperature of the cylinder to operational temperatures, therefore, 250°-400°F. For example, it may be a quartz lamp. The

cylinder 31 is fabricated from any suitable material capable of accomplishing the objects of the present invention. Typical materials are anodized aluminum and alloys thereof, steel, stainless steel, nickel and alloys thereof, nickel plated copper, chrome plated copper, and glass. The resulting structure has an outside diameter on the order of 1.5 to 3.0 inches and has a length on the order of 10 to 15 inches. Power requirements for the foregoing are 500-2500 watts peak power with an average power of 300-2000 watts and 75-250 watts for standby.

The surface temperature of the fuser roll structure is controlled by contacting the surface thereof with a thermistor probe 45 as described in U.S. Pat. No. 3,327,096, issued in 1967 to Bernous and incorporated herein by reference.

The fuser assembly 15 further comprises a backup roll structure 33 which cooperates with the fuser roll structure 30 to form a nip 34 through which a copy paper or substrate 35 passes such that toner images 36 thereon contact the fuser roll structure. The backup roll structure may comprise any suitable construction, for example, a steel cylinder, but preferably comprises a rigid steel core 37 having a Viton elastomer surface or layer 38 thereon. A suitable backup roll has a core approximately 1.8 inches in diameter with a 0.1 inch cover or layer structure of Viton elastomer or other suitable high temperature elastomeric layer structure, for example, silicone rubber and a combination of Viton or silicone rubber with Teflon thereon. Viton is the trademark of Dupont Co. The specific dimensions of the members making up the backup roll will be dictated by the requirements of the particular copying apparatus wherein the fuser assembly 15 is employed, the dimensions being greater or less depending upon the process speed of the machine. The heated roll and backup roll structures are mounted on fixed axes and, therefore, are not moved in and out of engagement as fuser rolls of prior art devices.

Means (not shown) for applying a loading force in a conventional manner to the fuser assembly 15 serves to create nip pressures on the order of 15 to 150 psi average. The durometer of the backup roll is chosen such that "dwell times" of 5 to 100 milliseconds can be obtained with loading forces within the aforementioned range of pressures. "Dwell time" is proportional to the ratio of the nip length to the surface speed of the rolls. For a given angular velocity the surface speeds will vary depending upon the diameter of the rolls. For example, with a 2" fuser roll, speeds of 0 to 30 inches per second are attainable and for a 3 inch fuser roll, speeds of 0 to 45 inches per second have been attained. Accordingly, it can be seen that the aforementioned "dwell times" can be obtained by varying one or the other or both of the "dwell time" relationships. Durometers of 20-90 Shore A have been found to provide satisfactory results.

The aforementioned materials from which the fuser roll structure 30 may be fabricated are relatively high surface energy materials, consequently, hot toner material contacting such surfaces would readily wet the surface of the fuser roll. Accordingly, there is provided a sump 39 for containing a release material 40 capable of interacting with the fuser roll in accordance with objects of the present invention. The release material is preferably a low molecular weight material which is solid at room temperature and which has a relatively low viscosity at the operating temperatures of the fuser

roll structure. An example of such a material is polyethylene homopolymer manufactured by Allied Chemical Company and having the designation AC-8 homopolymer.

A metering blade 41 preferably of silicone rubber is mounted to the sump 39 by conventional means such that an edge 42 thereof contacts the fuser roll structure serves to meter the release agent 40 in its liquid state onto the fuser roll. In the preferred embodiment, a blade 0.060 inch thick and having a width of 1.05 inch and length of 15 inches has been employed. By means of such a construction a 0.1–0.5 μ thickness of release agent is applied to the surface of the fuser roll. The blade 41 also aids in cleaning the fuser roll of toner.

A pair of end seals 47, preferably of sponge rubber are provided to contain the release agent in the sump 39. One or more stripper fingers 50 are provided for ensuring removal of the substrate from the fuser roll.

A wiper blade 60 is attached to the sump 39 in any suitable manner such that it contacts the core 31 to form a wiper blade/polyethylene/air boundary 62 and thereby prevents the formation of a core/polyethylene/air boundary which would result in the formation of a bead on the core which would print out on the copy sheets 14 and also disrupt proper operation of the combination seal and metering blade 41. The wiper blade 60 is preferably fabricated from a material which is compatible with the polyethylene (i.e. does not chemically react therewith and to a lesser degree is dimensionally stable in the presence thereof). To this end, the wiper blade comprises an elastomeric material, for example, silicone rubber.

In a modified form of the invention as illustrated in FIG. 4, the wiper blade 60 and its function are replaced by a roller 64 which is preferably fabricated from a rigid core having an outer deformable cover 66 of, for example, silicone rubber. A wiper blade 68 also made of silicone rubber or fluorocarbon material, preferably fluorinated ethylene propylene or perfluoroalkoxy or polytetrafluoroethylene is supported in a cantilever fashion by a bracket 70 which also supports the roller 64 which bracket is, in turn, supported by the sump 39 in any suitable manner. The roller is driven in a counterclockwise direction by the fuser roll structure 30 and engages the fuser roll structure with sufficient pressure so that the drive torque is greater than the drag force offered by the blade 68.

The toner that forms the toner images 36 is comprised of an electrophotographic resin plus colorant from dyes and pigments such as carbon black and furnace black. The developer material of which the toner forms a portion may contain cleaning materials and plasticisers in accordance with the desired formulation. Typical toners comprise a copolymerized mixture of styrene or a blend of styrene homologs with 10 to 40% of one or more methacrylate esters selected from the group consisting of ethyl, propyl and butyl methacrylates, as described in U.S. Pat. No. 3,079,342 and incorporated herein by reference.

While the invention has been described with respect to a preferred embodiment it will be apparent that certain modifications and changes can be made without departing from the spirit and scope of the invention, for example, the novel contact fuser apparatus disclosed can be employed with other than xerographic copier apparatus, and it is therefore intended that the forego-

ing disclosure be limited only by the claims appended hereto.

What is claimed is:

1. Contact fuser apparatus for fixing toner images to support sheets, said apparatus comprising:
 - a fuser roll structure having a rigid, thermally conductive outer surface;
 - a resilient backup roll forming a nip with said fuser roll structure through which said support sheets move with said toner images contacting said fuser roll structure;
 - means adapted to chemically react with said surface to form a thin toner impenetrable layer thereon;
 - a sump containing a quantity of said chemically reacting material;
 - means supporting said sump adjacent said fuser roll structure such that said surface contacts said chemically reacting material; and
 - means for preventing direct contact of said chemically reacting material with said surface and simultaneous exposure to ambient air.
2. Apparatus according to claim 1, wherein said contact preventing means comprises means supported in contact with said fuser roll structure adjacent the top of said sump.
3. Apparatus according to claim 2, wherein said contact preventing means comprises a wiper blade fabricated from material which is compatible with said chemically reacting material.
4. Apparatus according to claim 3, wherein said chemically reacting material comprises a by-product of a thermally degradable material.
5. Apparatus according to claim 4, wherein said degradable material comprises polyethylene.
6. Apparatus according to claim 1, wherein said sump further comprises material for forming a thin release coating on said impenetrable layer which facilitates stripping of said support sheets with said toner images thereon.
7. Apparatus according to claim 6, wherein said material for forming said release coating comprises polyethylene.
8. Apparatus according to claim 7, wherein some of said polyethylene thermally degrades to form said chemically reacting material.
9. Apparatus according to claim 2, wherein said contact preventing means comprises a roll member.
10. Apparatus according to claim 9, wherein said roll member is rotated by said fuser roll structure and further including a wiper blade contacting said roll member.
11. Apparatus according to claim 10, wherein said sump further comprises material for forming a thin release coating on said impenetrable layer which facilitates dripping of said support sheets with said toner images thereon.
12. Apparatus according to claim 11, wherein said material for forming said release coating comprises polyethylene.
13. Apparatus according to claim 12, wherein some of said polyethylene thermally degrades to form said chemically reacting material.
14. Apparatus according to claim 13, wherein said wiper blade is positioned so as to return toner and polyethylene removed from said fuser roll to sump.

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