(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 018 140**
A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **80301076.8**

(22) Date of filing: **03.04.80**

(51) Int. Cl.³: **G 03 G 15/20**

(30) Priority: **04.04.79 US 26989**
04.04.79 US 26870
04.04.79 US 26869

(43) Date of publication of application: **29.10.80**
Bulletin 80/22

(84) Designated Contracting States: **BE DE FR GB**

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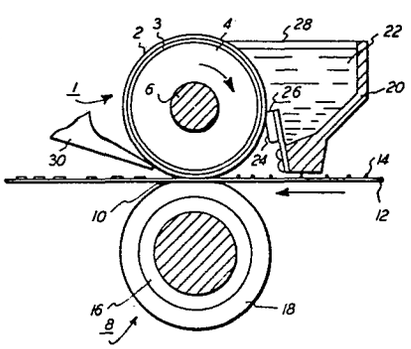
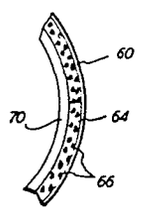
(54) A member for, a method of, and a system for fusing toner images to a substrate.

(57) A fuser member (1) and method of fusing or fixing thermoplastic resin powder images (14) to a substrate (12) in a fuser assembly of the type wherein a polymeric release agent (22) having functional groups is applied to the surface (2) of the fuser member (1) is disclosed. The fuser member (1) comprises a base member (4, 70) having an elastomer (2, 64) surface with metal-containing filler (66) therein. Metal-containing fillers include metals, metal alloys, metal oxides and metal salts. Exemplary of such a fuser member (1) is an aluminium base member (4, 70) coated with poly(vinylidene fluoride-hexafluoropropylene) copolymer (2, 64) having lead oxide filler (66) dispersed therein and utilizing mercapto-functional polyorganosiloxane as a release agent (22, 60).





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A MEMBER FOR, A METHOD OF, AND A SYSTEM FOR FUSING TONER IMAGES TO A SUBSTRATE

This invention relates generally to heat fusing members, assemblies and methods, and more particularly, to an improved fusing surface and method to prevent offsetting of a resin-based powder fused upon a substrate during the fusing operation in electrostatographic copiers. As used herein, the fusing surface may be a roll, a belt, a flat surface or any other shape suitable for fixing toner or resin-based powder images. The invention is particularly useful in the field of xerography where images are electrostatically formed and developed with resinous powders known as toners or thermoplastic resin powders, and thereafter fused or fixed onto sheets of paper or other substrates to which the powder images have been transferred. The resin-based powders or toners of this invention are heat softenable, such as those provided by toners which contain thermoplastic resins and used conventionally in a variety of commercially known methods.

In order to fuse images formed of the resinous powders or toners, it is necessary to heat the powder and the substrate to which it is to be fused, to a relatively high temperature, generally in excess of about 90°C. This will vary depending upon the softening range of the particular resin used in the toner. Generally, even higher temperatures are contemplated such as approximately 160°C or higher. It is undesirable, however, to raise the temperature of the substrate substantially higher than about 200°C because of the tendency of the substrate to discolor at such elevated temperatures, particularly when the substrate is paper.

It has long been recognized that one of the fastest and most positive methods of applying heat for fusing the powder image is direct contact of the resin-based powder with a hot surface, such as a heated roll. But, in most instances, as the powder image is tackified by heat, part of the image carried by the support material will stick to the surface of the plate or roll so that as the next sheet is advanced on the heated roll, the tackified image, partially removed from the first sheet, will partly transfer to the next sheet and at the same time part of the tackified image from said next sheet adheres to the heated roll. This process is commonly referred to in the art as "offset" or "hot offset", terms now well-known in the art.

The offset of toner onto the heated surface led to the development of improved methods and apparatus for fusing the toner image. These

improvements comprise fusing toner images by forwarding the sheet or web or substrate material bearing the image between two rolls at least one of which was heated, the rolls contacting the image being provided with an abhesive surface such as a thin coating of tetrafluoroethylene resin and a silicone oil film to prevent toner offset. The outer surfaces of such rolls have also been fabricated of fluorinated ethylene/propylene polymers, elastomers which contain hexafluoropropylene as a comonomer such as poly(vinylidene fluoride/hexafluoropropylene) or silicone elastomers coated with silicone oil as well as silicone elastomers containing low surface energy fillers such as fluorinated organic polymers, and the like. The tendency of these rolls to pick up the toner generally requires some type of release fluid continuously applied to the surface of the roll to prevent hot offset, and commonly known silicone oils are generally well adapted for this purpose. Bare metal fuser members having functionalized polymeric release agents upon their surfaces are also well-known in the art. The functionalized polymeric release agents, such as mercapto-functional polyorganosiloxanes, are generally well adapted for release of thermoplastic resin toner from the heated surfaces of bare metal fuser members.

Although the foregoing fuser members used in conjunction with various fuser release agents have been successfully used to fuse thermoplastic resin toners to various substrates, each of the prior art combinations has various disadvantages. For example, many of the prior art systems are incapable of fusing toner images to substrates at high speeds. Others consume large amounts of expensive fuser oil or fuser release agent. Still other prior art fusing systems compromise copy quality even though they are capable of fusing large numbers of copies. Many of the fuser member structures are subject to wear and degradation due to continued operation at elevated temperatures. This necessitates replacement of the fuser member which is quite costly when a large number of machines are involved. Moreover, many of the fuser members having elastomeric and resinous layers of material along with a coating of silicone oil to prevent toner offset are of sufficient thickness to constitute a poor thermal conductor, and longer nip dwell and higher fuser roll temperatures are required to deliver the fusing energy required to fix toner. 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 bearing the

images.

The invention is practised by applying a polymeric release agent having functional groups upon the surface of a fuser member comprising a base member and an elastomer surface, the elastomer having metal-containing filler dispersed therein. The metal-containing filler dispersed in the elastomer must be present in an amount sufficient to interact with the polymeric release agent having functional groups on the surface of the fuser member. The fuser member which may be a roll, a belt, a flat surface or other substrate having a suitable shape for fixing thermoplastic resin powder images to a substrate comprises a base member having an elastomer surface, said elastomer having a metal-containing filler, such as a metal, metal alloy, metal salt or metal oxide, dispersed therein in an amount sufficient to interact with a polymeric release agent having functional groups, said polymeric release agent being applied to the elastomer surface to provide a surface abhesive (anti-adhesive) to the thermoplastic resin toner or powder. Thus, there is provided a fuser member for fixing thermoplastic resin powder images to a substrate in a fuser assembly of the type wherein a polymeric release agent having functional groups is applied to the surface of the fuser member, and the fuser member comprises a base member having an elastomer working surface characterized in that the elastomer contains metal-containing filler dispersed therein in an amount sufficient to interact with a polymeric release agent having functional groups.

There is also provided a method of fusing thermoplastic resin toner images to a substrate characterized by the steps of: (a) forming a film of polymeric release agent having functional groups on the elastomer surface of a fuser member at elevated temperatures, said elastomer surface having metal-containing filler dispersed therein in an amount sufficient to interact with the polymeric release agent having functional groups; (b) contacting the toner images on the substrate with the coated, heated elastomer surface for a period of time sufficient to soften the toner; and (c) allowing the toner to cool. The thermoplastic resin powder is fixed to the substrate by contacting the substrate bearing the thermoplastic resin powder image with the heated surface of the described elastomer containing metal oxide, metal salt, metal or metal alloy filler and covered with a polymeric release agent having functional groups for a time and at a temperature

sufficient to permit the fusion of the thermoplastic resin powder to the substrate. The elastomer surface having metal oxide, metal salt, metal, metal alloy or other suitable metal compound filler dispersed therein is abhesive (anti-adhesive) to tackified or molten thermoplastic resin powder undergoing fusion on the substrate because the elastomer having metal oxide, metal salt, metal, metal alloy or other suitable metal compound filler dispersed therein bears a film of polymeric release agent having functional groups which have interacted with the metal, metal alloy, metal salt, metal oxide or other suitable metal compound filler of the elastomer. Because of the synergism between the elastomer having metal oxide, metal salt, metal, metal alloy or other suitable metal compound filler dispersed therein and the polymeric release agent having functional groups, excellent release and the production of high quality copies are obtained even at high rates of speed of electrostatic reproducing machines.

In another improvement of this invention, it has been discovered that when elastomers are cured by a special curing or crosslinking agent or process, and the elastomer has incorporated therein a metal-containing filler in accordance with the present invention, there is not only the realization of the fusing or fixing of a large number of copies, that is the improved release, but there is also a substantial improvement in wear rate over the elastomers cured by conventional curing or crosslinking agents, for example free radical initiator agents such as peroxides. Thus, when elastomers such as fluoroelastomers are cured by a nucleophilic addition curing or crosslinking system, and the fluoroelastomer contains a metal-containing filler in accordance with the present invention, a superior fuser member and method of fusing are obtained. Thus, there is provided a fuser member for fixing thermoplastic resin powder images to a substrate in a fuser assembly of the type wherein a polymeric release agent having functional groups is applied to the surface of the fuser member, wherein the fuser comprises a base member having an elastomer working surface with metal-containing filler dispersed therein in an amount sufficient to interact with the polymeric release agent having functional groups, characterized in that said elastomer is cured with a nucleophilic addition curing agent. In this embodiment the preferred range of metal-containing filler, for example lead oxide, is used at a concentration of about 0.5 parts to 100 parts of the metal-containing filler by weight per 100 parts by weight of the elastomer. The most preferred

concentration of metal-containing filler is about 5 parts to 45 parts by weight per 100 parts of the elastomer. In the broadest embodiment the metal-containing filler must be present in the elastomer in a concentration greater than about 0.05 volume percent based upon the volume of the elastomer.

There is also provided in a heated pressure fusing system for fusing toner images in an electrostatic reproducing apparatus in which a fuser roll and a backup roll define a contact arc to fuse toner images onto a substrate and a release agent is applied to the surface of the fuser roll to prevent toner offset upon the fuser roll, said fuser roll having an elastomer surface, with metal-containing filler dispersed therein, and the release agent applied upon the surface of the elastomer is a polymeric release agent having functional groups which interact with the metal in the filler characterized in that the elastomer is cured with a nucleophilic curing agent. The preferred elastomers in this embodiment are the fluoro-elastomers.

While the mechanism is not completely understood, it has been observed that when certain polymeric fluids having functional groups are applied to the surface of a fuser member having an elastomer surface with metal oxide, metal salt, metal, metal alloy or other suitable metal compound filler dispersed therein, there is an interaction (a chemical reaction, coordination complex, hydrogen bonding or other mechanism) between the metal of the filler in the elastomer and the polymeric fluids having functional groups, so that the polymeric release agent having functional groups in the form of a liquid or fluid provides an excellent surface for release while having an excellent propensity to remain upon the surface of the fuser member. Regardless of the mechanism, there appears to be the formation of a film upon the elastomer surface which differs from the composition of the elastomer and the composition of the polymeric release agent having functional groups. This film, however formed, has a greater affinity for the elastomer having metal oxide, metal salts, metal, metal alloy or other suitable metal compound filler dispersed therein than the toner and thereby provides an excellent release coating upon the elastomer surface. The release coating has a cohesive force which is less than the adhesive forces between heated toner and the substrate to which it is applied and the cohesive forces of the toner. Even though metal oxide,

metal salts, metal and metal alloy particles on the surface of the elastomer normally cause release failure, i.e. offset of toner, the use of the polymeric release agents having functional groups upon the surface of the elastomer containing metal oxide, metal salt, metal or metal alloy filler has substantially reduced offset problems which are common to fusing devices and processes of the prior art having fuser members with an outer surface of an elastomer or resinous material. The functional group (of the polymeric release agent) metal (of the metal-containing filler) interaction leads to an overall diminution of the critical or high surface energy of the metal in the metal-containing filler.

Polymeric release agents having functional groups are well known in the prior art. They are described in U.S. Patent Nos. 4,029,827, 4,078,285, 4,011,362, 4,101,686 and 4,046,795. The polymeric release agents having functional groups as used in this invention may be a solid or a liquid at ambient temperature and a fluid at operating temperatures. By using the term "polymeric" is meant two or more monomer units as a backbone having chemically reactive functional groups attached thereto or attached to side chains and branches of the backbone of the polymer. The reactive functional groups attached to the polymer must be capable of interacting with the metal of the filler dispersed in the elastomer surface of the fuser member. Furthermore, the polymeric release agent having functional groups must form a film or barrier upon the surface of the fuser member, which barrier or film has a surface energy less than the surface energy of the toner at operating temperatures. As used herein metal-containing filler means any metal, metal alloy, metal oxide, metal salt or other metal compound which can be incorporated in the elastomer, and which can interact with the polymeric release agent having functional groups. Since the metal of the metal-containing filler must interact with the functional groups of the polymeric release agent, it may be designated as a reactive metal-containing filler. Metal-containing fillers include metals, metal alloys, metal oxides and metal salts.

In the process and devices of the present invention, it is critical that the polymeric release agent have functional groups (also designated as chemically reactive functional groups) which interact with the metal-containing filler dispersed in the elastomer or resinous material of the fuser member surface to form a thermally stable film which releases thermo-

plastic resin toner and which prevents the thermoplastic resin toner from contacting the elastomer material itself. It is also critical that the metal oxide, metal salt, metal, metal alloy or other suitable metal compound filler dispersed in the elastomer or resin upon the fuser member surface, be a metal oxide, metal salt, metal, metal alloy or other suitable metal compound capable of interacting with the functional groups of the polymeric release agent. Such metal-containing filler materials preferably do not cause gellation of or have any adverse effect upon the polymeric release agent having functional groups.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a typical side elevational view of a fuser system for a xerographic reproducing apparatus;

Figure 2 is a fragmentary view of a fuser member of the present invention;

Figure 3 is a similar view of another embodiment of a fuser member of the present invention, and

Figure 4 is a view of a third form of fuser member.

The fuser embodiments of the present invention may be used in any xerographic reproducing or duplicating machine using heated roll fusers. Exemplary of an automatic xerographic reproducing machine is the machine described in U.S. Patent No. 3,937,637. Therein is illustrated a reproducing machine which employs an image recording drum-like member, the outer periphery of which is coated with a suitable photoconductive material. One type of photoconductive material is disclosed in U.S. Patent No. 2,970,906. The photoconductive drum is suitably journalled for rotation within a machine frame by means of a shaft which rotates to bring the image retaining surface thereon past a plurality of xerographic processing stations. Suitable drive means 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 represented as stations A to E. Initially the drum moves the photoconductive surface through a charging station A. At charging station A an electrostatic charge is placed uniformly over the photoconductive surface of the drum

preparatory to imaging. The charging may be provided by a suitable corona generating device. Thereafter, the drum is rotated to exposure station B where the charged photoconductive surface 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 provided by one skilled in the art.

After exposure, the photoconductive drum rotates the electrostatic latent image recorded on the photoconductive surface to development station C, where a conventional developer mix is applied to the photoconductor surface rendering the latent image visible. A suitable development station may include 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 continuously brought through a direction flux field to form a brush thereof. The electrostatic latent image recorded on the photoconductive surface is developed by bringing the brush of developer mix into contact therewith. The developed image on the photoconductive surface is then brought into contact with a sheet of final support material within a transfer station D, and the toner image is transferred from the photoconductive surface to the contacting side of a final support sheet. The final support material may be plain paper, gummed labels, transparencies such as polycarbonate, polysulfone, Mylar, and the like. Mylar is a trademark of E. I. duPont Company.

After the toner image has been transferred to the sheet of final support material, also described herein as a substrate, the sheet or substrate with the image thereon is advanced to a suitable fuser assembly which fuses the transfer powder image thereto. After the fusing process, the final support material is advanced by a series of rolls to a copy paper tray for subsequent removal therefrom by a machine operator. Although most of the toner powder is transferred to the final support material or substrate, some residual toner remains on the photoconductive surface after the transfer of the toner powder image to the substrate. The residual toner particles remaining on the photoconductive surface after the transfer operation are removed from the drum by any one of several well known cleaning means including cleaning corona generating devices used in conjunction with biased resilient knife blades. It is believed that the foregoing description is sufficient for the purposes of the present application to illustrate the

general operation of a preferred automatic xerographic copier which can embody the fuser members and methods of the present invention.

In accordance with the present invention, the surface for fixing or fusing a thermoplastic resin powder image to a substrate at elevated temperatures may be either a roll, a flat surface, a belt or any other suitable configuration. However, in accordance with the present invention, the surface of the fuser member must comprise an elastomer having a metal oxide, metal salt, metal, metal alloy or other suitable metal compound filler dispersed therein. The metal-containing filler must be one which can interact with the polymeric release agent having functional groups applied to the fuser member surface to provide a surface abhesive (anti-adhesive) to tackified toner and to release molten thermoplastic resin powder therefrom during the fusing operation, and the metal-containing filler dispersed in the elastomer must be present in an amount sufficient to interact with the polymeric release agent having functional groups. Although the invention is applicable to almost any type of surface which may be used in fixing or fusing a thermoplastic resin powder image to a substrate, for convenience, descriptions set forth herein are directed to fuser roll members which are substantially cylindrical in shape.

The fuser members may be constructed entirely of the elastomer having the metal containing filler dispersed therein, however, in the preferred embodiments, the roll structure comprises a base member made of a hollow cylindrical metal core such as copper, aluminum, steel and the like or coated layers of copper, steel, and aluminum and the like, overcoated with the layer of elastomer having metal-containing filler, such as metal oxide, metal salt, metal or metal alloy, dispersed therein. The base member may be any suitable material, and the design is not limited to any particular metal, non-metal or composite.

The elastomers which may be used in accordance with the present invention must be heat stable elastomer or resin materials which can withstand elevated temperatures generally from about 90°C up to about 200°C or higher depending upon the temperature desired for fusing or fixing the thermoplastic resin powder to the substrate. The elastomers used in the present invention must resist degradation or attack by the particular polymeric release agent having functional groups which is used to promote release of the molten or tackified thermoplastic resin powder or toner from

the fuser member surface. Exemplary of the elastomers which may be used in accordance with the present invention are the fluoro-silicone elastomers, the silicone carborane elastomers, various other silicone rubbers, fluoroelastomers, vinylidene fluoride-based elastomers, various organic rubbers such as ethylene/propylene diene, fortified organic rubbers which resist degradation at fusing temperatures, various copolymers, block copolymers, copolymer and elastomer blends, and the like. Any elastomer or resin used in accordance with the present invention must have thermal oxidative stability, i.e., resist thermal degradation at the operating temperature of the fuser member. Thus the organic rubbers which resist degradation at the operating temperature of the fuser member may be used. These include chloroprene rubber, nitrile rubber, chlorobutyl rubber, ethylene propylene terpolymer rubber (EPDM), butadiene rubber, ethylene propylene rubber, butyl rubber, butadiene/acrylonitrile rubber, ethylene acrylic rubber, sytrene/butadiene rubber, and the like or the foregoing rubbers fortified with additives which thermally stabilize the rubber at least at the operating temperature of the fuser member. Most fuser members are operated at temperatures from about 90°C to about 200°C but higher or lower temperatures are also contemplated depending upon the softening or melting point of the toner. Resins having the foregoing properties may also be used in accordance with the present invention. For example, polytetrafluoroethylene (PTFE), fluorinated ethylene-propylene copolymer (FEP) and polyfluoroalkoxypolytetrafluoroethylene (PFA Teflon) may also be used in accordance with the present invention.

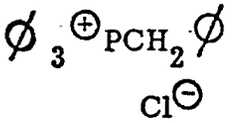
The preferred elastomers useful in the present invention are the fluoroelastomers and the most preferred fluoroelastomers are the vinylidene fluoride-based fluoroelastomers which contain hexafluoropropylene as a comonomer. Two of the most preferred fluoroelastomers are (1) a class of copolymers of vinylidene fluoride and hexafluoropropylene known commercially as Viton A, and (2) a class of terpolymers of vinylidene fluoride, hexafluoropropylene and tetrafluoroethylene known commercially as Viton B. Viton A and Viton B and other Viton designations are trademarks of E. I. duPont de Nemours and Company. Other commercially available materials include Fluorel 2170, Fluorel 2174, Fluorel 2176, Fluorel 2177, Fluorel LVS76, Viton GH, Viton E60C, Viton B910, Viton E430. Fluorel is a trademark of 3M

Company. Mixtures of the foregoing vinylidene fluoride-based fluoroelastomers with tetrafluoroethylene, with silicone rubber, with fluorosilicone rubber and the like may also be compounded. Any suitable heat resistant elastomer or resin may be used in accordance with the present invention as long as it is resistant to physical and chemical degradation from the particular polymeric release agent having functional groups used as the release agent and as long as the particular metal oxide, metal salt, metal, metal alloy or other metal compound filler or fillers which interact with the polymeric release agent having functional groups can be dispersed therein in a sufficient amount to produce the chemical interaction between the metal oxide, metal salt, metal, metal alloy or other metal compound and the polymeric release agent having functional groups. As used herein the term elastomer is used interchangeably with resin. Although it is not critical in the practice of the invention the molecular weight range may vary from a low of about 1,000 to a high of about 200,000. The most preferred embodiments, the vinylidene fluoride-based fluoroelastomers have a molecular weight range of about 50,000 to about 100,000, the molecular weight of commercially available Viton E430 being about 75,000.

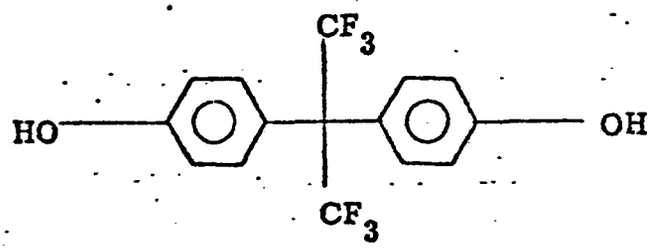
The most preferred elastomers especially fluoroelastomers having metal, metal alloy, metal salt, metal oxide or other metal compound in accordance with the present invention are those elastomers which can be cured by a nucleophilic addition cure of crosslinking agent or agents. Crosslinking with basic nucleophiles (nucleophilic addition) is well known in the art, but the elastomers having metal, metal alloy, metal salt, metal oxide or other metal compound fillers therein and cured with basic nucleophiles result in improved fuser members. Fuser members having these preferred elastomers with metal, metal alloy, metal salt or metal oxide fillers therein have about a ten fold reduction in wear rate and demonstrate the improved release of the present invention when the metal, metal alloy, metal salt or metal oxide filled elastomers are used upon the surface of the fuser member. At the same time the elastomer layer containing metal, metal alloy, metal salt or metal oxide filler or mixtures thereof provides a conformable surface which improves copy quality even at high rates such as 7,000 copies per hour.

The basic nucleophile cure system is disclosed and discussed in various journals and articles including a paper entitled "VITON FLUORO-

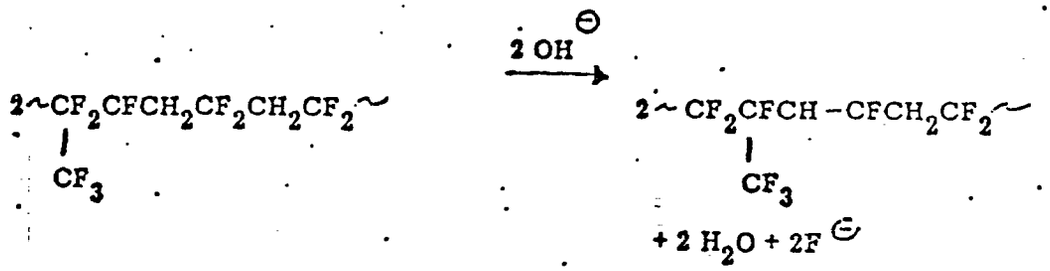
ELASTOMER CROSSLINKING BY BISPHENOLS" written by W. W. Schmiegel and presented at the South German Meeting of the Deutsche Kautschuk Und Gummi Gesellschaft, April 28-29, 1977. One example of the nucleophilic addition cure system is the bisphenol crosslinking agent with organophosphonium salt accelerator. The phosphonium salt may be exemplified as:



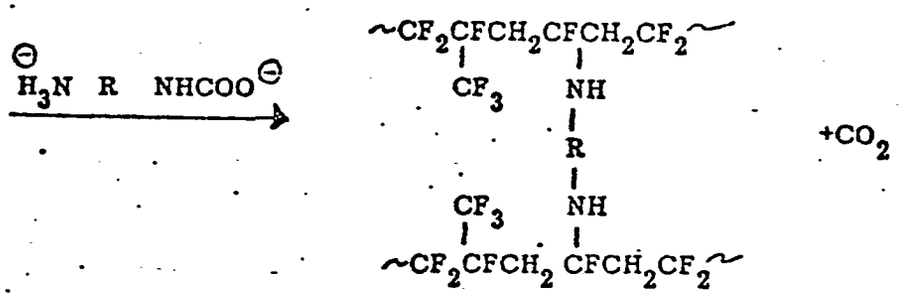
where ϕ represents phenyl groups, and the bisphenol is exemplified as:



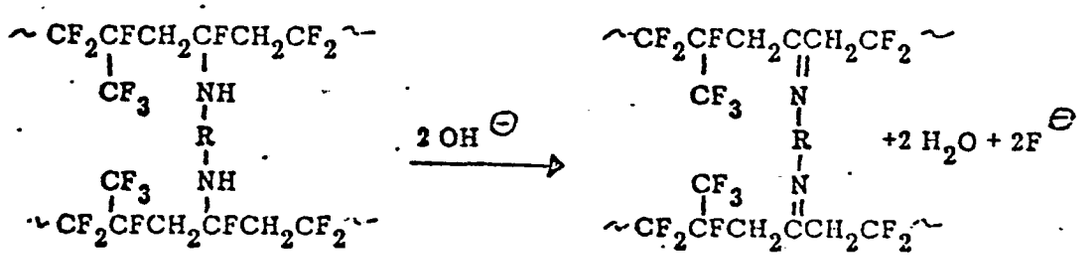
Another example of the nucleophilic addition cure system is crosslinking with a diamine carbamate type curing agent commonly known as DIAK 1. The following scheme showing three separate reactions represents the curing of poly(vinylidene fluoride-hexafluoropropylene) with diamine carbamate as the curing or crosslinking agent:



2)



3)



where step 1 shows the loss of HF in the presence of a base; step 2 shows the insertion of the diamine carbamate agent; and step 3 shows post cure in the presence of heat. This mechanism is well known in the art as a crosslinking or curing system. Examples of diamine carbamate cure systems are hexamethylenediamine carbamate known commercially as DIAK No. 1 and N,N'-dicinnamylidene-1,6-hexanediamine known commercially as DIAK No. 3 (DIAK is a trademark of E. I. duPont de Nemours & Co.).

Although other conventional cure or crosslinking systems may be used to cure the elastomers and resins useful in the present invention, for example, free radical initiators such as the peroxide cure system, the nucleophilic addition system is the preferred curing system, especially for fluoroelastomers, in the present invention. By nucleophilic addition curing

system is generally meant the use of a bifunctional agent such as a bisphenol or a diamine carbamate to generate a covalently crosslinked network polymer formed by the application of heat following basic dehydrofluorination of the copolymer. Some of the commercially available fluoroelastomer polymers which can be cured by the nucleophilic addition system are Viton E60C, Viton B910, Viton E430, Viton A, Viton B, Fluorel 2170, Fluorel 2174, Fluorel 2176 and the like. Viton is a trademark of E. I. duPont de Nemours & Company, and FLUOREL is a trademark of 3M Company.

The metal oxide, metal salt, metal, metal alloy or other metal compound fillers which may be used in accordance with the present invention, will vary depending upon the particular polymeric release agent having functional groups used as a release agent in the fusing assembly. The metal-containing fillers may be dispersed in the elastomer in any suitable manner, but in the preferred embodiments the metal-containing filler is uniformly dispersed throughout the elastomer layer, coating or body. In certain cases, especially where the fuser member is externally heated and the thickness of the elastomer may be a millimeter or greater in thickness, the metal-containing filler may be dispersed or disposed only proximal the working surface of the fuser member as desired to provide metal at or near the surface for interaction with the polymeric release agent having functional groups. The metal of the metal-containing filler dipsersed in the elastomer may be easily selected by one skilled in the art without undue experimentation by testing the metal-containing filler, such as a metal, metal alloy, metal oxide, metal salt or other metal compound, in an elastomer. The general classes of metals which are applicable to the present invention include those metals of Groups Ib, 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b, 6b, 7b, 8 and the rare earth elements of the Periodic Table. The metal-containing fillers include the oxides, the salts and the alloys of the metals in foregoing groups of the Periodic Table. In certain instances, especially insalts and alloys, certain metals of group Ia of the Periodic Table are also included as metal-containing fillers in accordance with the present invention.

The metal oxide filler dispersed in the elastomer may be any metal oxide which can be incorporated in the elastomer without adverse effect upon the elastomer or upon the polymeric release agent having functional groups. Obviously, the release characteristics of the polymeric

release agent having functional groups will vary depending upon the particular metal oxide filler dispersed in the elastomer surface because of the kinetics of the interaction between the particular metal oxide and the particular functional group or groups, and it will also depend upon the elastomer material itself. This invention will also produce superior release when certain preferred metal oxide fillers are used. For example, the advantages of this invention can be obtained when the metal oxide filler dispersed in the elastomer is an oxide of aluminum, copper, tin, zinc, lead, iron, platinum, gold, silver, antimony, bismuth, zinc, iridium, ruthenium, tungsten, manganese, cadmium, mercury, vanadium, chromium, magnesium and nickel and alloys thereof. One skilled in the art can compare the release of various elastomers containing these metal oxides to determine the optimum metal oxide or combinations thereof and concentrations thereof. For example, when the polymeric release agent is one having mercapto functional (thiofunctional) groups, the most preferred metal-containing fillers such as the metal oxides, are those which interact with the sulfur in the mercapto functional group to form metal sulfides. In those embodiments where thermal conductivity is of significance, the preferred metal oxide fillers are those which have greater thermal conductivity. Thus, more desirable metal oxide fillers dispersed in the elastomer material may comprise copper, silver, gold, lead, and the like.

When the metal fillers are incorporated in the elastomer, any stable metal or metal alloy may be used as long as there is no adverse effect upon the elastomer or the polymeric release agent having functional groups and as long as the metal or metal alloy interacts with the functional group or groups of the polymeric release agent. In general, the preferred metals are discussed above relative to their location in the Periodic Table of the Elements. Certain metal or metal alloy fillers will produce superior release when incorporated in the elastomer over other metals or metal alloys, and one skilled in the art can compare the release of various fuser members made in accordance with this invention to determine which metals or metal alloys produce optimum results. Exemplary of the metal or metal alloy fillers useful in the present invention are aluminum, brass, copper, tin, zinc, lead, beryllium, beryllium/copper, steel, iron, platinum, gold, silver, bronze, monel, iridium, ruthenium, tungsten, vanadium, cadmium, chromium, manganese, magnesium, zinc, bismuth, antimony, nickel and alloys of the

foregoing metals.

Metal salts may also be incorporated as the metal-containing filler in the elastomers in accordance with the present invention. Any stable salt or salts of the metals discussed relative to their location in the Periodic Table of Elements capable of interacting with the functional group or functional groups of the polymeric release agent may be used as an elastomeric filler as long as there is no adverse effect upon the elastomer or the polymeric release agent having functional groups. For example, when the functional group of the polymeric release agent is a mercapto or thio group, then the metal salt must be able to interact with the sulfur in the mercapto or thio group to form a metal sulfide interaction product. Thus, a metal salt such as lead carbonate, lead iodide or lead fluoride would interact with the sulfur in the mercapto or thio group to form a lead sulfide interaction product. When the functional group of the polymeric release agent is an amino group, then the metal salt must interact with the nitrogen in the amino group to form a metal-nitrogen interaction product. When the functional group of the polymeric release agent is a hydroxyl group, then the metal salt must interact with the oxygen in the hydroxyl group to form a metal-oxygen interaction product. Exemplary of some of the metal salts of the present invention are the acetates, halides (chlorides, fluorides, iodides, and bromides), carbonates, sulfides, sulfates, phosphates, nitrates and the like of lithium, sodium, potassium, calcium, iron, nickel, copper, zinc, aluminum, cadmium, silver, lead, tin, gold, chromium, tungsten and the like. The most preferred metal salts are the salts of heavy metals which form highly insoluble salts, and there is less tendency of such salts to dissolve in the polymeric release agent having functional groups and thereby produce an adverse effect thereon such as gellation. The least preferred metal salts are those which are soluble in the polymeric release agents having functional groups because such salts would become depleted as a function of time, solubility and use from the surface area of the elastomer (the working surface) and thereby diminish the interaction between the metal and the functional group or groups of the polymeric release agent.

In certain embodiments one or more metals, one or more metal alloys, one or more metal oxides or one or more metal salts may be used in the elastomer, or mixtures of any of the foregoing such as one or more metals with one or more metal oxides, or one or more metal oxide with one

or more metal salt or one or more metal alloy with one or more metal, and the like may be used in the elastomer in accordance with the present invention.

In certain instances, a particular metal, metal alloy, metal oxide, metal salt, or other metal compound may have an adverse effect upon the elastomer or the polymeric release agent having functional groups. For example, it has been determined that calcium oxide causes gellation of mercapto functional polyorganosiloxanes and therefore it is detrimental to the release of thermoplastic resin toners. In other cases certain of the metal-containing fillers may lessen the useful life of an elastomer such as when they are soluble in the polymeric release agent and are leached or otherwise depleted from the working surfaces of the elastomer. When these conditions arise, alternative fillers, elastomers and/or polymeric release agents should be used to produce optimum results.

In one embodiment of the present invention there are at least two layers of elastomer on the fuser member, one layer being a base layer elastomer and the other layer being an outer layer or release layer elastomer as the working surface of the fuser member. Other intermediate or inner elastomer layers may be used between the outer layer elastomer and the base layer elastomer, and these are included in the phrase "at least one base layer". The same elastomer material, having the same metal-containing filler dispersed therein, may be used in all layers, or the same elastomer material having different metal-containing fillers dispersed therein may be used in the layers coated upon the fuser member, or different elastomer materials having the same metal-containing fillers dispersed therein may be used in the layers coated upon the fuser member, or different elastomer materials having different metal-containing fillers dispersed therein may be used in the layers of the fuser member. However, as discussed above, the elastomers used in the inner layer or layers and/or the base layer optionally contain a metal-containing filler, that is, depending upon the circumstances, e.g. to promote thermal conductivity, strength, aging stability, to promote cure initiation, and the like, a metal-containing filler may be incorporated in the elastomer of the base layer and any other inner layer or layers, or it may be omitted therefrom.

The metal-containing filler must be incorporated in the outer or release layer elastomer. The metal-containing filler is also used as desired (optionally) in the base layer and inner layer or layers to promote mechanical (thermal) stability of the elastomer, to promote adhesion to the outer layer, and to promote thermal conductivity. The designation "optionally having metal-containing filler dispersed therein" as used herein defines an elastomer which may have no metal-containing filler therein, trace amounts (less than 1 part by weight based upon the weight of the elastomer) of metal-containing filler therein, or substantially large amounts of metal-containing filler therein, e.g. greater than about 1 part by weight and more preferably from about one to about 95 parts per hundred.

The metal-containing filler may be dispersed in the elastomer material in any suitable or convenient form and manner. The metal containing filler may be in the form of a powder, flakes, spheroids, fibers or any suitable particulate form. It is preferably uniformly dispersed in the elastomer during the compounding of the elastomer, for example, when the elastomer is in the form of a gum, the particulate metal, metal oxide or metal salt or mixture thereof is milled into the gum prior to the curing of the gum to form the elastomer. In general, the metal-containing filler is dispersed in the elastomer layer by mixing the selected particulate metal, metal alloy, metal oxide, metal salt or other metal compound or mixtures thereof with the elastomer gum or other millable form of the elastomeric compound preferably prior to solution or homogenization before application to the base member or other surface undergoing coating. The metal-containing filler may be dispersed in the elastomer by conventional methods known to those skilled in the art, as by any suitable means of stirring or blending the particulate metal, metal alloy, metal oxide, metal salt or other metal compound which is generally in the form of a powder or flakes, into the dissolved elastomer, homogenized elastomer or gum. After this dispersion is made, the elastomer gum having the metal-containing filler and the curing agent dispersed therein is then coated upon the base member, for example a cylindrical fuser roll, or any other suitable surface used in making fuser members by any conventional means. Conventional gum compounding

agents and solvents may be chosen by one skilled in the art and depends upon the particular elastomer. For example, the vinylidene fluoride copolymers may be dissolved in polar oxygenated solvents such as ketones, acetates and the like. Organic rubbers are soluble in such solvents as toluene. The surface of the elastomer layer having the metal-containing filler dispersed therein must be positioned so that it will contact the thermoplastic resin powder image upon the substrate to which it is to be fused or fixed at elevated temperatures. In accordance with the present invention, at the surface of the elastomer layer having a metal-containing filler dispersed therein, there will be provided by any means well known in the art, a polymeric release agent having functional groups for the prevention of offsetting or sticking of the thermoplastic resin powder resin or toner to the fuser surface as the thermoplastic resin powder image or toner image contacts the fuser surface at elevated temperatures.

The surfaces of the fuser members of the present invention are preferably prepared by applying either in one application or by successively applying to the surface to be coated with the elastomer having metal-containing filler dispersed therein, a thin coating or coatings of the elastomer having metal-containing filler dispersed therein. Coating is most conveniently carried out by spraying, dipping, the like, a solution or homogenized suspension of the elastomer containing the filler. Molding, extruding and wrapping are also alternative techniques which may be used to make fuser members in accordance with the present invention. When successive applications are made to the surface to be coated, it is generally necessary to heat the film-coated surface to a temperature sufficient to flash off any solvent contained in the film. For example, when a fuser roll is coated with an elastomer layer having metal-containing filler dispersed therein, the elastomer having metal-containing filler dispersed therein is successively applied to the roll in thin coatings, and between each application, evaporation of the solvent in the film-coated roll is carried out at temperatures of at least about 25°C to about 90°C or higher so as to flash off most of the solvent contained in the film. The temperature of evaporation depends upon the solvent system used. When the desired thickness of coating is obtained, the coating is cured and thereby fused to the roll surface. The elastomer having metal-containing filler dispersed therein may also be applied as a sleeve to a roll or as a mat to flat or other

suitable surfaces. Conventional methods known in the art may be used in providing a surface in accordance with this invention, and the method for coating rollers as taught by Aser et al. in U.S. Patent No. 3,435,500 may be used.

The metal-containing filler must be present in the elastomer or gum in an amount sufficient to interact with the polymeric release agent having functional groups. This generally comprises an amount greater than about 0.05 volume percent based upon the volume of the elastomer. Preferably, the metal-containing filler or mixtures of metal-containing fillers are present in an amount from about 1.0 to about 15 volume percent based upon the volume of the elastomer. The most preferred range is from about 2.0 volume percent to about 8.0 volume percent. The particle size of the metal-containing filler dispersed in the elastomer is preferably from about 1 to about 10 microns in size, although particle size is not a limiting factor except the size of the particle cannot be greater than the thickness of the elastomer layer or coating unless the particles have one dimension which is less than the thickness of the elastomer coating, for example when the metal containing filler is in the form of a fiber, flake or flat plate dispersed in the elastomer.

The fuser roll members of the present invention may be constructed entirely of the elastomer having metal-containing filler dispersed therein, however, in the preferred embodiments, the roll structure comprises a hollow cylindrical core such as copper, aluminum, steel and the like overcoated with at least two layers of elastomer, at least the outer layer of the elastomer forming the working surface having metal-containing filler dispersed therein. In these embodiments, the elastomer coatings are generally at least 0.013mm in thickness and more preferably about 0.10mm to about 0.25mm in thickness. There are many variables which must be taken into consideration in order to provide the most effective fusing operation, and these include such variables as hardness of the fusing surface, thermal conductivity, pressure, roll or contact speed, heat input, heat source and location thereof and the like. The selection and balancing of these variables is well-known in the art and may effect the selection of the particular elastomer, the particular metal-containing filler and the particular polymeric release agent having functional groups which are to be utilized in the fusing process and assembly. In certain instances, there may be a thin

elastomer coating (about 0.025 to 0.25mm) containing metal filler and a conformable pressure or backup roll or a thicker elastomer coating (about 0.65 to 2.5mm) used with a hard pressure or backup roll. If the fuser roll is internally heated, and the thicker elastomer coatings are used therein, then in certain instances additional additives may be used in the elastomer to promote thermal conductivity. Conventional adhesives are generally used to adhere elastomer to the core or base member.

Although the metal-containing filler may be directly incorporated or dispersed in the elastomer, in an alternative embodiment, the metal-containing filler may be thoroughly washed and treated before it is dispersed in the elastomer. One of the preferred methods embraces washing or treating the metal-containing filler with the particular polymeric release agent having functional groups to be used in the fuser assembly prior to dispersion of the metal-containing material as a filler in the elastomer. This process may aid in the dispersion of the metal, metal alloy, metal salt, metal oxide or other metal compound filler in the elastomer and may also be used as a means of controlling the interaction between the metal, the elastomer and the release agent having functional groups applied to the surface of the elastomer. Furthermore, it provides an internal source of the release agent and in certain cases eliminates the need for the external application of the polymeric release agent having functional groups.

Other adjuvants and fillers may be incorporated in the elastomer or gum in accordance with the present invention as long as they do not effect the integrity of the elastomer or the interaction between the metal-containing filler and the polymeric release agent having functional groups. Such fillers normally encountered in the compounding of elastomers and gums including coloring agents, reinforcing fillers, cross-linking agents, processing aids, accelerators and polymerization initiators, may be used.

The invention is also directed to a method of fusing thermoplastic resin toner images to a substrate comprising: (a) forming a film of polymeric release agent having functional groups on the elastomer surface of a fuser member at elevated temperatures, said elastomer surface having metal-containing filler dispersed therein in an amount sufficient to interact with the polymeric release agent having functional groups; (b) contacting the toner images on the substrate with the coated, heated elastomer surface for a period of time sufficient to soften the toner; and (c) allowing the toner to

cool. The polymeric release agent having functional groups may be applied intermittently or continuously as necessary to maintain release of the molten thermoplastic resin toner and to prevent offsetting. The thickness of the film of polymeric release agent having functional groups is not critical, however, in preferred embodiments, the film is maintained at about 0.1 to about 2 microns in thickness.

In accordance with the present invention, the working surface of the fuser member is the elastomer having metal-containing filler dispersed therein. As used herein "working surface" of the fuser member is that surface which contacts the toner to cause the toner to fuse to the substrate upon which it is to be affixed permanently. A release material is applied to the "working surface" to prevent offsetting of the toner, especially heated, molten or tackified toner, to the elastomer surface having metal-containing filler dispersed therein. In accordance with the present invention, these release materials or release agents are polymeric release agents having functional groups which are well known in the art and include the polymer release materials which have reactive functionality and react with the metal-containing filler in the working elastomer surface of the fuser member. Typical of these polymer release materials which have functional groups or reactive functionality are the functionalized polymeric release agents described in U.S. Patent 4,101,686 incorporated herein by reference. In this disclosure, the referenced polymer materials having designated functional groups are applied to a heated fuser member in an electrostatic reproducing apparatus to form thereon a thermally stable layer having excellent toner release properties for electroscopic thermoplastic resin toners. The polyorganosiloxane fluids and other polymeric fluids having functional groups interact with the metal fuser members therein in such a manner as to form an interfacial barrier at the surface of the bare metal fuser member while leaving an unreacted low surface energy release fluid as an outer layer or film. Other release materials are well known in the art and include the polymer release materials which oxidize and react with a metal or metal alloy surface of the fuser member exemplary of which are those described and claimed in U.S. Patent No. 3,937,637 and U.S. Patent No. 4,078,285. Other exemplary polymeric release agents having functional groups are those described in U.S. Patent No. 4,046,795, 4,029,827 and 4,011,362. As used herein, that characteristic of the polymeric release agent

or material applied to the elastomer having metal-containing filler dispersed therein upon the working surface of a fuser member and designated as "reactive functionality" is defined in the foregoing disclosures, and encompasses those polymers which either oxidize and thereby form a functional group which reacts or interacts with the metal filler in the fuser member surface to form the desired toner release layer, or have a built-in functional group or groups which react or interact with the metal of the filler in the fuser member surface to form the desired toner release layer.

A typical fuser member of the present invention is described in conjunction with a fuser assembly as shown in Figure 1 where the numeral 1 designates a fuser roll comprising elastomer surface 2 having metal-containing filler dispersed therein (not shown) upon suitable base member 4 which is a hollow cylinder or core fabricated from any suitable metal such as aluminum, anodized aluminum, steel, nickel, copper, and the like, having a suitable heating element 6 disposed in the hollow portion thereof which is coextensive with the cylinder. Backup or pressure roll 8 cooperates with fuser roll 1 to form a nip or contact arc 10 through which a copy paper or other substrate 12 passes such that toner images 14 thereon contact elastomer surface 2 of fuser roll 1. As shown in Figure 1, the backup roll 8 has a rigid steel core 16 with an elastomer surface or layer 18 thereon. Sump 20 contains polymeric release agent 22 which has chemically reactive functional groups thereon which are capable of interacting with the metal-containing filler dispersed in elastomer surface 2. The polymeric release agent 22 having functional groups thereon, may be a solid or liquid at room temperature, but it is a fluid at operating temperatures. In preferred embodiments, the chemically reactive groups of polymeric release material 22 in sump 20 are mercapto, carboxy, hydroxy, isocyanate, epoxy, and amino. The most preferred polymeric release agents having functional groups thereon used in accordance with the present invention are the mercapto-functional polyorganosiloxanes.

In the embodiment shown in Figure 1 for applying the polymeric release agent 22 to elastomer surface 2, a metering blade 24 preferably of conventional non-swelling rubber is mounted to sump 20 by conventional means such that an edge 26 thereof contacts elastomer surface 2 to serve as a metering means for applying the release agent 22 having chemically reactive groups to fuser member 1 in its liquid or fluid state. By using such a

metering blade, a layer of polymeric release fluid 22 can be applied to elastomer 2 in controlled thicknesses ranging from submicron thicknesses to thicknesses of several microns of release fluid. Thus, by metering device 24, about 0.1 to 2 microns or greater thicknesses of release fluid can be applied to the surface of elastomer 2. In the embodiment shown, a pair of end seals 28, for example, of sponge rubber, are provided to contain the release material 22 in sump 20. One or more stripper fingers 30 may be provided for insuring removal of the substrate 12 from the surface of elastomer 2.

Referring to Figure 2, there is shown a fragmentary view of part of the fuser member of the present invention magnified many times over the member shown in Figure 1 in order to show the thin layers on the fuser member surface. In Figure 2, the base member or other solid structure upon which the elastomer is applied is designated by numeral 70. Elastomer 64 is deposited upon base member 70 by any suitable means such as curing elastomer 64 containing metal-containing filler 66 directly upon base member 70 or most preferably by using various adhesive materials to cause the adhesion of elastomer 64 containing metal filler 66 to base member 70 or by fitting a sleeve of elastomer 64 containing metal filler 66 to base member 70 by any suitable means or by any other manner as desired. As described above, base member 70 is preferably a metal, but it may also be glass or any other suitable material, or as described above the entire fuser member may comprise the elastomer having metal-containing filler therein and the heating element may be external (not shown) rather than internal. The metal-containing filler particles 66 shown in Figure 2 are illustrated as having irregular shapes, however, any form of metal may be used in elastomer 64 including powders, flakes, platelets, spheroids, fibers, ovoid particles and the like. A film of polymeric release agent having functional groups is shown on the surface of elastomer 64 and is designated by numeral 60.

Figures 3 and 4 show one form of fuser member in which there is a layer 68 intermediate the base member 70 and the outer layer 64. The layer 68 may be bonded to member 70 similarly to the way layer 64 was bonded to member 70 as described above with reference to Figure 2. The layer 68 may be referred to as the base layer.

As shown in Figure 3, layer 68 contains no metal-containing filler 66, while Figure 4 shows it as having such a filler 72 dispersed in it.

Additional layers of elastomer may be positioned between layer 64 and 68, and they may similarly contain, or be devoid of, filler.

These intermediate layers may be deposited upon the base layer elastomer 68 by any of the methods described above. The intermediate or inner layers may be optionally used to promote strength and conformability or compressibility when used in conjunction with a backup or pressure roll. In a preferred embodiment, metal-containing filler 66 is dispersed in elastomer 64 in a concentration from about 1.0 to about 15.0 parts by weight of metal-containing filler 66 per 100 parts by weight of elastomer 64. In the embodiment of Figure 3, only trace amounts of metal-containing filler would be used in elastomer 68, eg less than about 0.5 parts of metal containing filler per 100 parts of elastomer. The same concentrations of metal-containing filler also apply to the intermediate or inner layers.

Referring to Figure 4, there is shown a fragmentary view of part of the fuser member of the present invention magnified many times compared with the member shown in Figure 1, in order to show the thin layers on the fuser member surface. In Figure 4, the base member or other solid structure upon which the layers of elastomer are applied, is designated by numeral 70. Elastomer 68 is deposited upon base member 70 by any suitable means, such as curing elastomer 68 directly upon base member 70 or by any of the alternative methods suggested above for Figure 3. In the embodiment shown in Figure 4, metal-containing filler 72 is incorporated or dispersed in elastomer 68. This filler 72 may be the same as, or different from, filler 66 in elastomer layer 64. Elastomer 68 in Figure 4 is also described herein as base layer elastomer or the base layer of elastomer. Elastomer layer 64 is deposited upon elastomer layer 68 by any suitable means, preferably by curing elastomer 64 directly upon elastomer layer 68 or by any other means as described for the elastomer layer of Figure 3. As in Figure 3, the intermediate layers may be deposited upon the base elastomer 68 by any of the methods described above. These intermediate or inner layers may be optionally used to promote strength and conformability or compressibility when used in conjunction with a backup or pressure roll.

The thickness of the elastomer having metal-containing filler dispersed therein is not critical in the practice of the present invention. Generally where the fuser member is heated by internal means, the elastomer having metal filler therein is preferably of such thickness as to constitute a minimal thermal barrier to heat radiating from inside the fuser member to the outermost layer of elastomer having metal filler therein. Recommended thicknesses are generally greater than 0.013 mm but may be from 0.025 mm to about 5 mm the most preferred ranges being from about 0.1 mm to about 2.5 mm. The preferred thickness depends upon the fuser member configuration and the particular backup or pressure member (hard or conformable) being used with the fuser member.

In the embodiments incorporating base layer 68, the preferred base layer elastomer thickness is about 0.15 mm with an outer layer elastomer thickness of about 0.05 mm. The most preferred base layer has about 5.0 to about 20.0 parts by weight metal-containing filler such as magnesium oxide, per 100 parts by weight of elastomer, and the outer layer elastomer has about one to about 95 parts by weight metal-containing filler such as lead oxide, per 100 parts by weight of elastomer.

The release agent may be applied by any suitable means. The sump is illustrated in the drawing, however, the polymeric release agent having functional groups may be applied by spraying from jets or other orifices, by padding from a flat, contoured or other shaped pad made of fabric, sponge, felt or other suitable material, by metering with an applicator roller or series of applicator rollers, or by means of a belt, by means of a solid bar or blade of the release agent material wiping against the fuser members, or by any other suitable applicator means or device. An applicator roll or applicator belt having an elastomer surface with metal-containing filler dispersed therein may also be used to apply the polymeric release agent having functional groups.

The adhesive or primer layer upon the base member to promote the adhesion of elastomer thereto, for example the adhesion of the elastomer to the metal of the base member, is not critical. Anyone skilled in the art can easily select one of many well-known commercial adhesives or primers for adhering particular elastomers or resins to substrates. For

example, silicone rubbers are often adhered to substrates with such primers as vinyltrimethoxysilane, gamma-methacryloxypropyltrimethoxysilane and vinyltris (t-butylperoxy) silane and partially hydrolyzed products thereof. Organic rubbers may be adhered to the core material by a primer/rubber adhesive system such as Chemlok 205/236 which may be applied to a metal core. Chemlok 205 is a mixture of polymers, organic compounds and mineral fillers in a methyl isobutyl ketone solvent system. Chemlok 220 and 236 may be used with Chemlok 205 when the bond must have exceptional resistance to adverse environmental conditions. Chemlok 220 is also used as a single coat adhesive for bonding nitrile elastomers. Dissolved organic polymers and dispersed fillers in a xylene and perchloroethylene solvent system may be used for bonding uncured elastomers to metals during vulcanization. One commercial embodiment of this primer is known as Chemlok 220. Chemlok 608 and other well-known dissolved silane polymers are excellent primers for the fluoroelastomers. Chemlok is a trademark of Hughson Chemical Company. Commercial epoxy compounds are also excellent for the bonding of elastomers to metal, plastic and glass substrates. One family of epoxy adhesives or cements is known commercially by the trademark Thixon. Thixon 300 is an epoxy resin well suited for bonding fluoroelastomers such as the Viton elastomers to metal. Thixon is a trademark of Dayton Chemical Products Laboratories.

The following examples further define and describe fuser rolls prepared by the present invention and illustrate the preferred embodiments of the present invention.

EXAMPLE I

A solution of silicone resin is prepared by mixing the silicone resin with toluene. About 50 grams of Ventron micron-sized copper particles are washed with toluene and dried. The dried copper particles are dispersed in the toluene solution of silicone resin, and after the particles are evenly dispersed throughout the solution, the solution is sprayed on the surface of an aluminum cylinder coated with a conventional silane adhesive material known commercially as Chemlok 608. This results in a fuser roll similar to the type shown in Figure 1. The ratio of copper particles to silicone resin is about 5 volume percent. The roll prepared in the foregoing manner is placed in a fuser assembly as shown in Figure 1 and is used with a mercapto-functional polyorganosiloxane release agent having a molecular

weight of about 14,000 and a mercapto (-SH) concentration of about 0.17 weight percent (based upon the weight of the mercapto-functional polyorganosiloxane). The life of the fuser roll is suitable and excellent release of thermoplastic resin toner is observed with the foregoing fuser roll having copper particles dispersed in silicone rubber. No hot offset is observed when this fuser roll heated at 180°C is used to fix toner images to paper.

EXAMPLE II

This was similar to Example I except particles of aluminium oxide were used instead of copper. After dispersion of the aluminium oxide particles in the silicone elastomer, sufficient solution was sprayed on the adhesive-coated cylinder to produce a dried layer 0.15 mm thick. The elastomer was dried under vacuum at 90°C to remove the solvent. A silicone resin in n-hexane solvent containing 1.5 weight percent micron-sized silver powder (based upon the weight of the resin) uniformly dispersed therein was sprayed upon the dried silicone elastomer layer containing aluminium oxide particles. Sufficient silicone resin solution was sprayed thereon to form a dried layer of about 0.25 mm thick. The n-hexane was evaporated at 60°C. The resulting roll had a configuration similar to that shown in Figure 4.

EXAMPLE III

A fuser member was prepared in accordance with Example I except that two elastomer layers were used, both elastomer layers being of poly(vinylidene fluoride-hexafluoropropylene) copolymer having a molecular weight of 75,000 and identified as 'Viton' GH. Both layers were cured with a peroxide cure system. Both layers were deposited as dispersion in methyl ethyl ketone. The base layer or first layer of 'Viton' GH was about 0.10 mm thick, and the outer layer or second layer of 'Viton' GH was about 0.05 mm thick. The base layer of 'Viton' GH contained about 3 parts by weight based upon the weight of the 'Viton' GH of lead oxide particles having an average particle size of 2 microns to assist the curing of the elastomer. Excellent release was obtained when particles of silver having an average particle size of about 2 microns were present in the outer layer of poly(vinylidene fluoridehexafluoropropylene) at a concentration of about 1.5 volume percent based upon the volume of the elastomer, and the fuser roll was used in a configuration similar to the fuser assembly shown in Figure 1 with a release agent of mercapto-functional polyorganosiloxane blended with polydimethylsiloxane, the blend having a molecular weight of about

11,500 and a mercapto content of about 0.17 weight percent.

EXAMPLE IV

A fuser roll was prepared in accordance with the procedure of Example I except the micron-sized copper particles (50 grams) were reacted with 100 g of a mercapto-functional polyorganosiloxane having a molecular weight of 14,000 and a mercapto content of about 0.17 weight percent for 1 hour at 149°C. The copper particles were then separated from the mercapto functional polyorganosiloxane fluid, washed with toluene and dried. The dried copper particles (representing about 5 volume percent of the silicone resin) were evenly dispersed in a solution of silicone resin in toluene and sprayed on an aluminum cylinder coated with the adhesive material of Example I.

The foregoing roll was placed in a fixture similar to that shown in Figure 1 except that no release agent fluid was placed in the sump, and there was no external application of any release agent. About 7,000 copies were fused with this fuser member before offset occurred.

EXAMPLE V

A fuser member was prepared in accordance with Example I except the elastomer was poly(vinylidene fluoride-hexafluoropropylene) copolymer having a molecular weight of about 100,000 and identified as Viton A. The copolymer was dissolved in methyl ethyl ketone solvent. Excellent release was obtained when particles of silver having an average particle size of about 2 microns were present in the poly(vinylidene fluoride-hexafluoropropylene) at a concentration of about 1.5 weight percent based upon the weight of the elastomer, and the fuser roll was used in a configuration similar to the fuser assembly shown in Figure 1 with a release agent of mercapto-functional polyorganosiloxane blended with polydimethylsiloxane, the blend having a molecular weight of about 11,500 and a mercapto content of about 0.17 weight percent.

EXAMPLE VI

A fuser roll was made similar to the fuser roll described in Example III except that the layers of elastomer were poly(vinylidene fluoridehexafluoropropylene-tetrafluorethylene) terpolymer having a molecular weight of 100,000 and known under the tradename of 'Viton' B using a bisphenol cure system. Excellent release and excellent wear rate were obtained when about 45 parts by weight micron-sized copper particles per 100 parts by weight of 'Viton' B were used in the outer layer, and 3 parts by weight lead oxide were used in the base layer.

Excellent release of thermoplastic resin toner and improved wear are observed when the mercapto-functional polyorganosiloxane of Example I is used as the release agent in a fuser assembly similar to that shown in Figure 1.

EXAMPLE VII

A fuser roll is made similar to the fuser roll described in Example V except the elastomer is poly(vinylidene fluoride-hexafluoropropylene-tetrafluorethylene) terpolymer known under the tradename of Viton B. Excellent release is obtained when about 9 percent (by weight based upon the weight of the elastomer) of micron-sized copper particles similar to the copper particles of Example I, is used. Excellent release of thermoplastic resin toner is observed when the mercapto-functional polyorganosiloxane of Example I is used as the release agent in a fuser assembly similar to that shown in Figure 1.

EXAMPLE VIII

A fuser member was prepared in accordance with Example V except the elastomer was a poly(vinylidene fluoride-hexafluoropropylene) known commercially as Viton E430 (Viton is a trademark of E. I. duPont de Nemours and Co.). The elastomer contained 45 parts by weight lead oxide per 100 parts by weight of the elastomer. In excess of 150,000 copies were fixed in the Xerox 9200 duplicator (Xerox and 9200 are trademarks of Xerox Corporation) using a mercapto-functional polyorganosiloxane release agent having a mercapto content of 0.04 weight percent (based upon the weight of the polyorganosiloxane).

EXAMPLE IX

A fuser member was prepared in accordance with Example VIII except a base layer of a poly(vinylidene fluoride-hexafluoropropylene) known commercially as 'Viton' E60C was interposed between the roll core and the outer layer of 'Viton' E430. An epoxy adhesive known commercially as 'Thixon' 300 was used on the metal core. Both elastomers were cured with the nucleophilic addition curing agent, bisphenol, known commercially as 'Viton' Curatives 20 and 30. The base layer of 'Viton' E60C was 0.15 mm thick, and the outer layer of 'Viton' E430 was 0.025 to 0.05 mm thick. The outer elastomer layer contained 45 parts by weight lead oxide per 100 parts by weight of the elastomer. The inner layer contained 30 parts by weight carbon black and 15 parts by weight magnesium oxide per 100 parts by weight 'Viton' E60C. In

excess of 500,000 copies were fixed in the 'Xerox 9200' duplicator ('Xerox' and '9200') are trademarks of Xerox Corporation) using a mercapto-functional polyorganosiloxane release agent having a mercapto content of 0.10 weight percent (based upon the weight of the polyorganosiloxane) metred upon the fuser roll by a wick. Only minimal wear was observed upon the fuser roll surface 0.0013 mm per 100,000 copies).

EXAMPLE X

A fuser member is prepared in accordance with Example V except the elastomer is poly(vinylidene fluoride-hexafluoropropylene) copolymer known as Viton A cured by a bisphenol curing agent. About 6 percent (by weight based upon the weight of the elastomer) of lead carbonate is dispersed in the elastomer by blending on a rubber mil prior to dissolving in methyl ethyl ketone. Suitable release of thermoplastic resin toner is obtained when mercapto-functional polyorganosiloxane is used as the release agent in the fuser assembly similar to that shown in Figure 1.

EXAMPLE XI

A fuser roll was prepared by coating an aluminum cylinder having an epoxy adhesive known commercially as Thixon 300 thereon, with a solution of Viton GH containing an aliphatic peroxide curing agent. Only trace amounts (less than 1 part by weight based upon the weight of the elastomer) of metal-containing filler were incorporated or dispersed in the poly(vinylidene fluoride-hexafluoropropylene) terpolymer known as Viton GH to assist the cure. The elastomer was cured at 232°C for 24 hours and was placed in a fuser assembly similar to the one shown in Figure 1. A 250 centistoke polyorganosiloxane fuser oil (polydimethylsiloxane) was used as the release agent. Less than 1,000 copies were fused with this system before release failure.

EXAMPLE XII

A fuser roll identical to the fuser roll of Example XI was prepared with only a trace amount of a metal-containing filler to assist curing. Instead of the linear polydimethylsiloxane (silicone oil) used as the release agent in Example XI, a branched silicone oil (branched polydimethylsiloxane having branching of the siloxane backbone) having a viscosity of about 250 centistokes was used. There was only some improvement over the number of copies fused when conventional silicone oil was used as the release agent.

EXAMPLE XIII

A fuser roll identical to the fuser roll of Example XI having an elastomer coating of Viton A cured with a diamine carbamate curing system (DIAK No. 1) and having only trace amounts of metal-containing filler to assist the cure was used. A mercapto-functional polyorganosiloxane fluid having a viscosity of about 250 centistokes, a molecular weight of about 11,500 and a mercapto content of about 0.06 percent (based upon the weight of the polyorganosiloxane) was used as the release agent. Although substantially more copies were fused with the fuser member and release agent of this example over the fuser member and release agent of Example VIII, the results were still less than desirable.

EXAMPLE XIV

A fuser roll having a 0.04mm layer of Viton E430 with a metal-containing filler was placed upon an aluminum roll having the epoxy adhesive of Example XI thereon identical to the procedure and roll of Example XI except there was an intermediate 0.15mm layer of Viton E60C coated upon the epoxy-covered aluminum roll. All conditions were identical to the conditions of Example XI except a metal-containing filler, lead oxide, was incorporated into the 0.04mm thick poly(vinylidene fluoride-hexafluoropropylene) copolymer known as Viton E430 prior to curing with a bisphenol curing system. The lead oxide was about 45 parts per 100 weight of the Viton E430 (7.5 percent by volume). The release agent used in the sump was identical to the release agent used in Example XIII. Nearly 1,000,000 copies were fused with the fuser member and the mercapto-functional polyorganosiloxane release agent before release failure was observed.

A comparison of the results of Example XI through Example XIV shows the remarkable improvement of the present invention when a metal-containing filler is incorporated in the elastomer used as the surface coating of a fuser member when the polymeric release agents having functional groups are used as release agents to fuse thermoplastic resin toner images to substrates such as paper. The number of copies which can be fused with the metal-containing filler in the elastomer are multiples of hundreds of thousands more than the same fuser member containing no filler or only trace amounts of filler in the elastomer even when the system is used with the same polymeric release agent having functional groups.

EXAMPLE XV

The aluminum cylinder fuser roll core having a diameter of 75.8 mm taken from a Xerox 9200 copier (Xerox and 9200 are trademarks of Xerox Corporation) was degreased, grit blasted, degreased and covered with an epoxy adhesive known commercially as Thixon 300. Viton E60C containing carbon black and magnesium oxide was sprayed from a methyl ethyl ketone solution upon the epoxy-coated aluminum roll to produce a layer 0.15mm thick when cured with a bisphenol curing system. A fluoroelastomer copolymer of poly(vinylidene fluoride-hexafluoropropylene) known as Viton E430 having 45 parts of lead oxide filler per 100 parts by weight of the fluoroelastomer blended therein was dissolved in methyl ethyl ketone solvent. The curing or crosslinking agent for both fluoroelastomers was fluorinated bisphenol A. The solution was repeatedly sprayed upon the degreased aluminum base member or core to yield a final thickness of about 0.05 mm. The fluoroelastomer was cured by heating for 16 hours at 232°C. The layer was cooled and sanded. The final thickness of the Viton E430 layer was about 0.04 mm. The roll was placed in a Norman Abrader and wear data were recorded. Another roll prepared identical to that shown above was placed in a Xerox 9200 duplicator having a wick applicator for applying the release agent to the roll (Xerox and 9200 are trademarks of Xerox Corporation) and tested for wear data and release. About 500,000 copies were fused by the roll in the xerographic duplicator using the polymeric release agent of Example XIII. The wear data taken from the xerographic duplicator showed less than 0.0015mm of wear per 100,000 copies and the Norman Abrader showed 100 microinches of wear per 40 cycles.

EXAMPLE XVI

An aluminium roll core similar to that of Example XV was coated with a solution containing 15 parts magnesium oxide filler per 100 parts by weight of the 'Viton' E60C blended therein along with 3.0 parts of carbon black filler per 100 parts by weight of the 'Viton' E60C, was dissolved in methyl ethyl ketone solvent to make an 18 percent solution. The curing or crosslinking agent for this fluoroelastomer was fluorinated bisphenol A. The solution was repeatedly sprayed upon a primed degreased aluminium base member or core to yield a final thickness of 0.15-0.2 mm. The fluorelastomer was cured by heating for one hour at 165°C. The layer was cooled and sanded. The final

thickness of the sanded roll was about 1.3-1.8 mm.

Another fluoroelastomer copolymer of poly(vinylidene fluoride-hexafluoropropylene) known as 'Viton' E430, having 15 parts lead oxide filler per 100 parts by weight of the 'Viton' E430 blended therein, was dissolved in methyl ethyl ketone solvent to form a 10 percent solution. The solution was repeatedly sprayed upon the previously cured layer to form an outer layer or release layer. Sufficient repetitions of the spraying process were made to form a final thickness of the outer layer elastomer of about 0.05-0.06 mm. The fluoroelastomer coating (outer layer) was cured by heating for 16-24 hours at 232°C. The surface of this layer was polished to 0.3-0.4 mm. The roll was placed in a Norman Abrader, and wear data were recorded. Another roll prepared identical to that shown above was placed in a 'Xerox 9200' duplicator having a wick release agent applicator, and tested for wear data and release. Over 1,000,000 copies were fused by the roll in the xerographic duplicator using the polymeric release agent of Example XII. The wear data taken from the xerographic duplicator showed less than 0.0013 mm of wear per 100,000 copies, and the Norman Abrader showed 40 microinches of wear per 40 cycles. The two layers of fluoroelastomer deposited upon the aluminium cylinder displayed no tendency to separate from the cylinder or from each other.

EXAMPLE XVII

Two rolls identical to those described in Example XV were prepared for this experiment except the rolls were coated with a fluoroelastomer terpolymer of poly(vinylidene fluoride-hexafluoropropylene-tetrafluoroethylene) having a copolymerized cure site monomer conferring greatly enhanced curability with aliphatic peroxide systems. The fluoroelastomer contained 45 parts by weight lead oxide per 100 parts by weight of the fluoroelastomer. The fluoroelastomer commercially available under the trade designation Viton GH(a trademark of E. I. duPont Company) was cured with a conventional aliphatic peroxide curing agent. These rolls were also tested in a Norman Abrader and in a Xerox 9200 duplicator (Xerox and 9200 are trademarks of Xerox Corporation). A wear rate of 0.01mm of Viton GH per 100,000 copies was observed in the duplicator, however, 500,000 copies

were fused in the duplicator using the mercapto-functional polyorganosiloxane fuser release agent of Example XIII applied by a wick applicator conventionally used in the Xerox 9200 duplicator. The wear rate observed in the modified paper abrasion fixture (Norman Abrader) for the Viton GH cured with the aliphatic peroxide curing agent was 900 microinches of wear per 40 cycles.

In comparing the data of Examples XV and XVII the magnitude of improvement gained by using the fluoroelastomer cured with the bisphenol curing agent, a nucleophilic addition curing agent, and having the lead oxide metal-containing filler dispersed therein in accordance with the present invention is clearly demonstrated. A comparison of the wear data shows that there is a ten-fold reduction in wear rate while maintaining the desirable release performance when different cure systems are used for the fluoroelastomers containing metal-containing fillers when the fusing process is carried out with a polymeric release agent having functional groups such as mercapto-functional polyorganosiloxane.

EXAMPLE XVIII

A fuser roll similar to the fuser roll of Example XV was prepared for this experiment except only 15 parts by weight per 100 parts of the fluoroelastomer identified commercially as Viton E430 (Viton is a trademark of E. I. duPont Company) was used. All other conditions and materials were identical to those set forth in Example XV. The fuser roll prepared with this poly(vinylidene fluoride-hexafluoropropylene) copolymer showed an even greater improvement in wear rate with acceptable release performance when used with mercapto-functional polyorganosiloxane release agent in a Xerox 9200 copier/duplicator (Xerox and 9200 are trademarks of Xerox Corporation). The Norman Abrader showed 40 microinches of wear per 40 cycles.

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CLAIMS:

1. A member (1) for fusing toner images to a substrate (12) in a process involving the application to the working surface (60) of the fuser member of a polymeric release agent (22, 60), in which the working surface (60) is of elastomeric matt, characterised in that the outer layer (64) of elastomeric material has dispersed in it a metal-containing filler (66) for reacting with the polymeric release agent (22, 60).

2. A member as claimed in Claim 1, characterised by a base layer (68) of elastomeric material intermediate a base member (70) and the outer layer (64) furnishing the working surface (60) and by the base layer having metal-containing filler (72) dispersed therein.

3. A member as claimed in Claim 1 or 2, characterised by the elastomer's having been cured with a nucleophilic addition curing agent.

4. The fuser member of any preceding Claim, characterised in that the metal-containing filler (66, 72) is in the form of a powder, flakes or fibres.

5. The fuser member of any preceding Claim, wherein the metal-containing filler (72, 66) is of metal, metal alloy, metal oxide, or metal salt.

6. The fuser member of any preceding Claim characterised in that the metal-containing filler (66,72) is present in the elastomer (2, 64) in a concentration of about 1.0 volume percent to about 15.0 volume percent based upon the volume of the elastomer.

7. The fuser member of any preceding Claim, characterised in that the metal-containing filler (66, 72) is treated with polymeric release agent (22, 60), prior to dispersion of the metal-containing

filler (66, 72) in the elastomer (2, 64).

8. The fuser member of Claim 2, or Claim 2 and any Claim dependent therefrom, characterised in that the base layer elastomer (68) comprises about 1.0 to about 20.0 parts of metal-containing filler (72) per 100 parts of base layer elastomer, and in that the metal-containing filler (66) of the outer layer elastomer (64) is present in a concentration of about 0.25 to about 95.0 parts of metal-containing filler per 100 parts of outer layer elastomer.

9. The fuser member of any preceding Claim, characterised in that the nucleophilic addition curing agent is a bisphenol crosslinking agent.

10. The fuser member of Claim 9 characterised in that the nucleophilic addition curing agent further comprises an organophosphonium salt accelerator.

11. The fuser member of any of Claims1 to 8, characterised in that the nucleophilic addition curing agent is a diamine carbamate.

12. A method of fusing thermoplastic resin toner images (14) to a substrate (12) characterised by the steps of: (a) forming a film of polymeric release agent (22, 60) having functional groups on an elastomer (2, 64) surface of a fuser member (1) as claimed in any preceding Claim; (b) heating at least the working surface (60) of the fuser member (1); (c) contacting the toner images (14) on said substrate (12) with the coated and heated elastomer (2, 64) surface for a period of time sufficient to soften the toner; and (d) allowing the toner (14) and substrate (12) to cool.

13. A heated pressure fusing system for fusing toner images (14) in an electrostatic reproducing apparatus, characterised in that a fuser roll (1) as claimed in any of Claims 1 to 11, is used in

conjunction with a backup roll (8) to define a contact arc (10) to fuse toner images (14) onto a substrate (12), and in that a release agent (22, 60) is applied to the surface of the fuser roll to prevent toner offset upon the fuser roll (1), said release agent being a polymeric release agent (22, 60) having functional groups which interact with the metal in the filler (66).

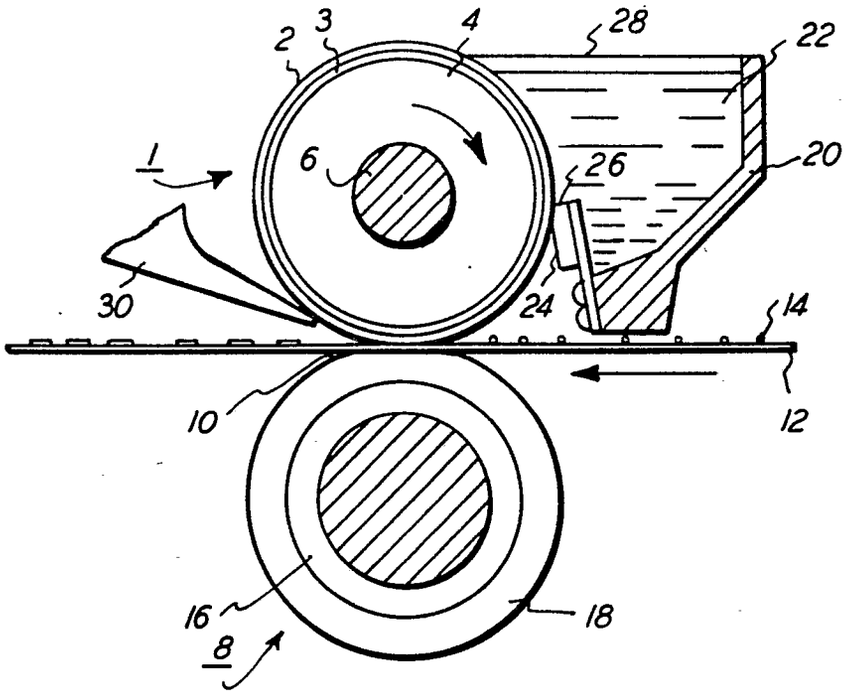

FIG. 1.

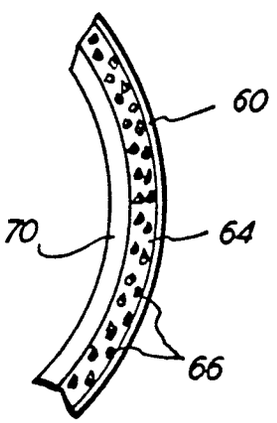

FIG. 2.

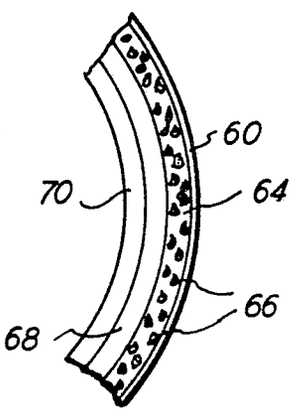

FIG. 3.

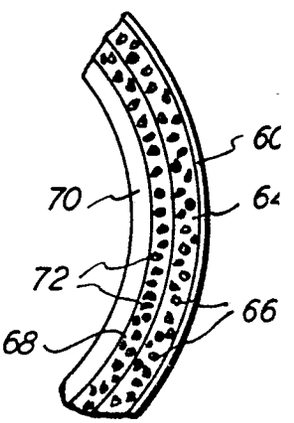

FIG. 4.

European Patent Office

EUROPEAN SEARCH REPORT

0018140
Application number
EP 80 30 1076.8

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.)
	DE - B2 - 2 529 957 (XEROX) * claim 3; column 6, first paragraph; fig. 2 * --	1	G 03 G 15/20
	DE - B - 2 053 167 (MINNESOTA MINING AND MANUFACTURING CO.) * claim 1; column 2, lines 57 to 65 * --	1	
	DE - B2 - 2 306 440 (RICOH) * claims 2, 3; column 5, lines 29 to 40 * --	1	TECHNICAL FIELDS SEARCHED (Int.Cl.)
P	Patents Abstracts of Japan, Vol. 3, No. 56, 15 May 1979 page 97E110 & JP - A - 54 - 34839 --	1	G 03 G 13/00 G 03 G 15/00
	Patents Abstracts of Japan, Vol. 1, No. 58, 6 June 1977 page 114E77 & JP - A - 52 - 2439 ----	1	

CATEGORY OF CITED DOCUMENTS

- X: particularly relevant
- A: technological background
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- E: conflicting application
- D: document cited in the application
- L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	11-08-1980	HOPPE

EPO Form 1503.1 06.78