

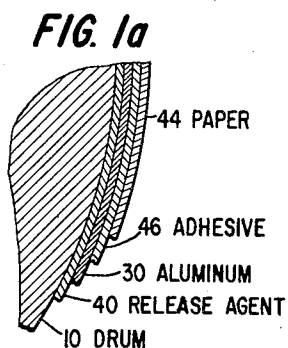
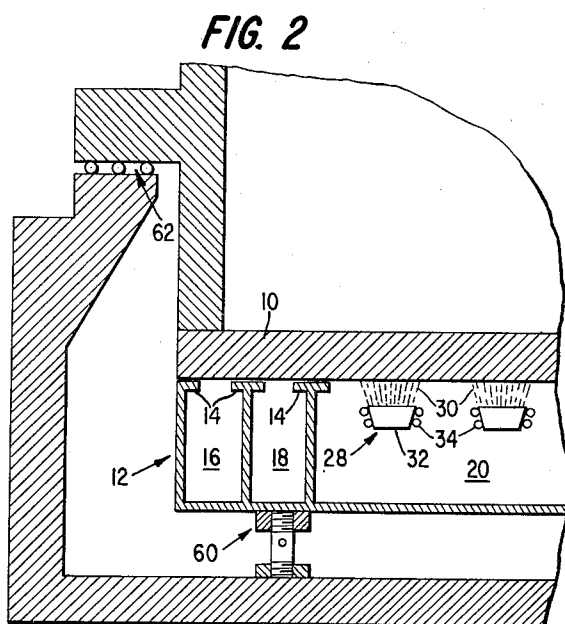
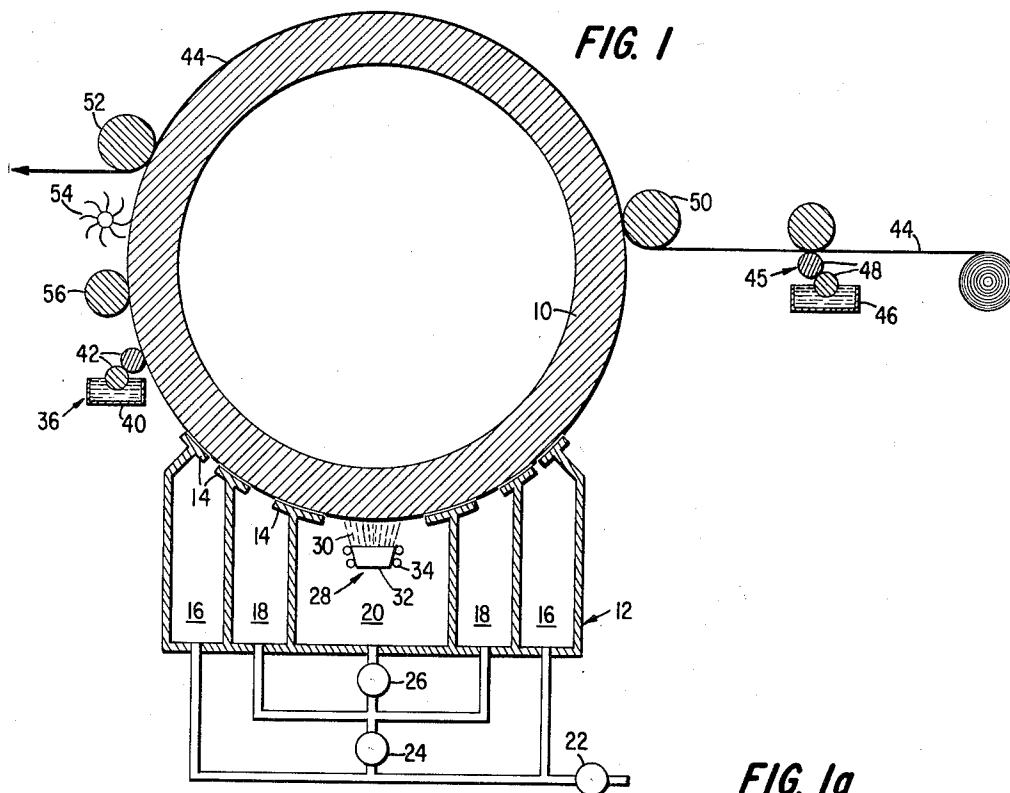
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APPARATUS AND PROCESS FOR METALLIC VAPOR COATING

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APPARATUS AND PROCESS FOR METALLIC VAPOR COATING

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This invention relates to coating, more particularly to coating processes wherein a shiny aluminum film is provided on a non-metallic substrate, such as paper. The vacuum deposition of aluminum and similar materials on paper and other substrates to provide a shiny metallic mirror surface is rapidly becoming a commercially practicable process. However, in many cases where the paper or other substrate contains large quantities of volatile materials such as water vapor, solvents and the like, it is extremely difficult to vacuum deposit an aluminum coating on the substrate without subjecting the substrate to a considerable amount of degassing operations prior to the actual coating operation. The degassing operations are often expensive and can have a deleterious affect upon the properties of the paper. When the paper, for example, contains large quantities of water very close to the surface, it is quite difficult to remove this water in high speed vacuum coating operations with economically feasible coating equipment.

Accordingly, it is a principal object of the present invention to provide a coating apparatus for producing a vacuum deposited shiny aluminum film on the surface of a substrate such as paper with a maximum production rate and at a minimum cost.

Another object of the invention is to provide an apparatus of the above type which is capable of handling many different types of paper having widely varying thicknesses, water content and surface treatments.

Still another object of the invention is to provide an apparatus capable of handling substrates which normally could not, because of contained gases and other volatiles, be practically vacuum-metallized in high-speed continuous machines.

These and other objects of this invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the method involving the several steps and the relation and the order of one or more of such steps with respect to each of the others and the apparatus possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein FIG. 1 is a diagrammatic, schematic sectional view of one embodiment of the invention;

FIG. 1a is an enlarged exaggerated fragmentary view of a portion of FIG. 1 and;

FIG. 2 is another fragmentary sectional view of the apparatus of FIG. 1.

The present invention will be primarily described in connection with the formation of a shiny aluminum surface on a substrate such as paper without intent to so limit the invention.

Paper contains varying amounts of moisture and entrapped gases depending on its past history and method of manufacture. Some papers contain a great deal of moisture and others contain only a small quantity. This invention is particularly applicable to the metalizing of papers having large quantities of moisture which is read-

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ily released from the paper to a vacuum chamber. When an effort is being made to maintain a very low coating pressure (e.g. a millionth of an atmosphere) in the vacuum coating chamber, the release of the moisture at these low pressures requires enormous vacuum pumping capacity.

In the present invention such papers are readily coated with a vacuum deposited metal film by providing a large smooth drum, such as a chrome-plated steel drum. This drum is preferably supported with its axis horizontal and so that a portion of the drum surface serves as one side of a high vacuum coating chamber. A source of metallic coating vapors, such as aluminum vapors, is provided in the high vacuum coating chamber and high vacuum seals are provided which cooperate with the surface of the drum to permit a given portion of the surface to the rotated from the atmosphere to the high vacuum chamber and back to the atmosphere. In the preferred arrangement, the drum itself serves one side of each of these seals and each seal includes several stages so that the complete, millionfold pressure drop is not taken across only one seal. For example, a first portion of the seal may provide a pressure drop of 760 mm. to 100 mm. The second pressure drop can be from 100 mm. to 100 microns. The third pressure drop can be from 100 microns to 1 micron or less.

It is also preferred that only a minor portion of the circumference of the drum be employed for the vacuum seal and wall of the high vacuum coating chamber. The remainder of the surface of the drum is taken up with various other operations. For example, adjacent the inlet to the vacuum seal, there is provided a station for applying a very thin film of a release agent capable of preventing adhesion of a vacuum deposited aluminum film to the chromium surface of the drum. The drum surface containing the release agent travels past the inlet vacuum seals into the high vacuum coating chamber wherein it is exposed to the aluminum vapor which condenses as a shiny film on the surface of the drum in the coating chamber. The thus coated surface then moves past the exit vacuum seals and into contact with an adhesive surface which is carried by a paper substrate. The adhesive is firmly united to the thin aluminum coating so as to bond the aluminum to the paper substrate. When the bonding action is completed, the paper, with the aluminum surface thereon, is then stripped from the drum to provide a shiny metal surface on the paper. The drum then passes a cleaning station to be sure that the drum surface is absolutely clean prior to the application of another very thin layer of release agent and another layer of aluminum.

Referring now to FIGS. 1, 1a and 2, there is schematically illustrated one preferred embodiment of the invention wherein 10 represents a large metal drum having a highly-polished surface. This drum is preferably mounted for counter-clockwise rotation with its axis horizontal and above a coating chamber generally indicated at 12. The surface of the drum cooperates with a number of sealing elements 14 forming part of the coating chamber 12. These sealing elements 14 are preferably small cylindrical sections having an upper surface matching, and concentric with, the outer surface of the drum 10. These sealing elements 14 form vacuum seals with the drum and thus provide a plurality of separate vacuum chambers 16, 18 and 20. The outermost vacuum chambers 16 are maintained at a relatively high pressure, on the order of 100 mm., by means of a pump 22 which removes air leaking into chamber 16 past the narrow slot between the outermost sealing element 14 and drum 10. The next innermost chambers 18 are maintained at a pressure on the order of 100 microns by means of pumps 24. The inner chamber 20 is preferably maintained at a pressure of about 1

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micron or less, by means of a pump 26. In the inner chamber 20, there is provided a source 28 of aluminum 30. The source 28 is schematically indicated as a crucible 32 heated by a suitable induction coil 34.

Adjacent lefthand side of FIG. 1, where the drum approaches the first vacuum seal, there is provided a station 36 for applying a release agent. This preferably includes a supply of the release agent 40 and several printing rolls 42 which put an extremely thin film of the release agent 40 on the surface of drum 10. One preferred type of release agent is glycerine, although numerous others can be employed, as will be described hereafter. The paper to be coated is indicated at 44 as moving from a suitable roll thereof past an adhesive applying station 45 where an adhesive 46 is applied by means of a pair of printing rolls 48. Paper with freshly applied adhesive is pressed by means of roll 50 into firm contact with the layer of aluminum 30 which has been deposited by vapors in coating chamber 20 on top of the layer of release agent 40. While the paper moves from the pressure roll 50 to a stripping roll 52, the adhesive becomes firmly united to the aluminum film 30. At the stripping roll 52, the paper (carrying the adhesive and aluminum layers along with it) is stripped from the drum. The drum surface then rotates to a cleaning station which includes a brush 54 and a grinding roll 56, for removing any adhesive or aluminum which did not transfer to the paper. As shown in FIG. 2, where like numbers refer to like elements in FIG. 1, the coating chamber assembly 12 cooperates with the ends of the drum 10 so that there are only small leaks at the end to the pump chamber 16 adjacent the outer end of the drum. A similar small leak exists between chambers 16, 18 and 20. The whole coating chamber 12 is preferably carried by an adjustable support schematically indicated at 60 which permits movement of the chamber 12 towards or away from the axis of the drum 10, which axis is maintained steady by end bearings 62. This permits the spacing between the sealing elements 14 and the surface of the drum 10 to be reduced or enlarged as desired. When, for any reason, the drum surface or the matching sealing elements 14, become scored or otherwise damaged, it is possible to lap the surfaces together by applying a lapping compound to the drum surface and moving the sealing elements 14 up into engagement with the drum.

In the operation of the invention, a charge of aluminum 30 is placed in the crucible 32 and the coating chamber 12 is moved up so that a very small spacing, on the order of a few thousandths of an inch, exists between the surface of drum 10 and the sealing surfaces 14. The vacuum pumps are then placed in operation to pump out the various chambers. Pump 22 will rapidly pump chamber 16 to a pressure of 100 mm. Pump 24 will soon pump chamber 18 down to a pressure of about 100 microns and pump 26 will reduce the pressure in coating chamber 20, after some period of time, to a pressure of about 1 micron. When the requisite high vacuum has been obtained in coating chamber 20, the aluminum 30 is brought up to vaporization temperature (e.g. 1000° C.) and the rotation of the drum 10 is commenced. As the drum rotates in a counter-clockwise direction, it first picks up a layer of release agent 40 and then a layer of aluminum 30. The drum surface then passes out of the coating chamber where paper 44, containing adhesive layer 46, is pressed into contact with the freshly-deposited aluminum film. The drum surface travels around to the stripping drum 52 where the paper (carrying the adhesive and aluminum films), is stripped from the drum. Any residual release agent, specks of aluminum or adhesive are removed by brush 54 and grinding drum 56. Thereafter the cleaned surface of the drum is ready for another application of release agent.

The release agent applied to the drum can be any of an extremely wide variety of organic and inorganic materials. The only function of the release agent is to prevent a strong adherent bond between the vacuum-deposited aluminum and the surface of the drum. Examples of suitable

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release agents are waxes, organic acids, esters and salts, inorganic salts and other inorganic compounds. These release agents can be applied by spraying, printing, condensation from vapor, dipping and numerous other methods which will deposit an extremely thin layer of the release agent along the surface.

The substrate to be coated can be papers, numerous kinds of cloth, felt, plastic films and other products capable of being at least temporarily held in contact with the drum surface while the drum rotates.

The adhesive can be thermoplastic, thermosetting, solvents-softened, pressure-sensitive, age-hardened and the like. The only requirement of the adhesive is that it be capable of forming, in a relatively short time, a bond between the aluminum and the paper substrate which is stronger than the bond between the adhesive and the drum coated with release agent. The adhesive can be applied to the paper much prior to the use of the paper or can be applied as shown right at the transfer coating drum. It is believed adhesive can in a less preferred embodiment of the invention be applied to the outer surface of the aluminum coating. Adhesive can be applied by spraying, dip coating, vaporizing, printing and other techniques usual in the adhesive application art.

While a metal drum is preferred it can be made of any material such as glass, ceramic, stone or other substance capable of taking a high polish and releasing a vacuum deposited metal films.

Since certain changes may be made in the above apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. Apparatus for applying to a substrate a film of metal having a thickness of only a few millionths of an inch, said apparatus comprising a drum having a smooth shiny surface, the drum being rotatably mounted so as to form one wall of a high vacuum coating chamber, means for evacuating said coating chamber to a pressure substantially less than 100 microns Hg abs. a source of metallic coating vapors in the coating chamber capable of creating a vapor pressure of metal vapors substantially in excess of the pressure in said coating chamber, means forming a first vacuum seal with the surface of the drum to permit the uncoated surface of the drum to move into the coating chamber in position to be exposed to metallic coating vapors which condense on the drum, means forming a second vacuum seal with the surface of the drum to permit the thus coated surface of the drum to pass out of the coating chamber, means for adhesively uniting the metallic coating to the substrate by pressing the substrate against the metallic coating with an interposed layer of adhesive, and means for stripping the substrate and the metallic coating from the drum surface.

2. Apparatus for applying to a substrate a film of metal having a thickness of only a few millionths of an inch, said apparatus comprising a drum having a smooth shiny surface, the drum being rotatably mounted so as to form one wall of a high vacuum coating chamber, means for evacuating said coating chamber to a pressure substantially less than 100 microns Hg abs. a source of metallic coating vapors in the coating chamber capable of creating a vapor pressure of metal vapors substantially in excess of the pressure in said coating chamber, means forming a first vacuum seal with the surface of the drum to permit the uncoated surface of the drum to move into the coating chamber in position to be exposed to metallic coating vapors which condense on the drum, means forming a second vacuum seal with the surface of the drum to permit the thus coated surface of the drum to pass out of the coating chamber, means for applying a film of release agent to the surface of the drum before the drum surface is exposed to the metal coating vapors, means for adhesively uniting the metallic coating to the substrate by pressing the substrate against the metallic coat-

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ing with an interposed layer of adhesive, and means for stripping the substrate and the metallic coating from the drum surface.

3. Apparatus for applying to a substrate a film of metal having a thickness of only a few millionths of an inch, said apparatus comprising a drum having a smooth shiny surface, the drum being rotatably mounted so as to form one wall of a high vacuum coating chamber, means for evacuating said coating chamber to a pressure substantially less than 100 microns Hg abs. a source of metallic coating vapors in the coating chamber capable of creating a vapor pressure of metal vapors substantially in excess of the pressure in said coating chamber, means forming a first vacuum seal with the surface of the drum to permit the uncoated surface of the drum to move into the coating chamber in position to be exposed to metallic coating vapors which condense on the drum, means forming a second vacuum seal with the surface of the drum to permit the thus coated surface of the drum to pass out of the coating chamber, means for applying a film of release agent to the surface of the drum before the drum surface is exposed to the metal coating vapors, means for adhesively uniting the metallic coating to the substrate by pressing the substrate against the metallic coating with an interposed layer of adhesive, and means for stripping the substrate and the metallic coating from the drum surface, and means for cleaning the drum surface prior to application of another layer of release agent.

4. The apparatus of claim 3 wherein only a minor portion of the drum surface is in the vacuum system.

5. The apparatus of claim 3 wherein means is provided for applying a layer of adhesive to one of the two facing surfaces of the substrate and aluminum prior to passage of these surfaces under a pressure roll.

6. The apparatus of claim 3 wherein the vacuum seals comprise curved surfaces matching the curvature of the drum and forming narrow slots therewith, said slots having high impedance to the flow of air therethrough.

7. The apparatus of claim 6 wherein said curved surfaces are supported by means adjustable towards and away from the axis of the drum.

8. The apparatus of claim 3 wherein said vacuum seal comprises a plurality of walls forming narrow slots with the drum surface, said seals extending parallel to the drum axis throughout most of the sealing area and extending parallel to the drum circumference adjacent the ends of the drum.

9. The apparatus of claim 3 wherein a polishing means is provided for polishing the drum surface as it passes from the stripping means to the means for applying the release agent.

10. Process for applying to a flexible substrate a film of metal having a thickness of only a few millionths of an inch, comprising the steps of supporting a drum having a smooth shiny surface so that the drum forms one wall

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of a high vacuum coating chamber over a source of metallic coating vapors with the lower surface of the drum in position to be exposed to metallic coating vapors which condense thereon, rotating the drum so that sequential areas thereof are coated with the metallic coating, adhesively uniting the metallic coating on the drum to the flexible substrate after the surface has been rotated out of the vacuum chamber, and stripping the flexible substrate and the metallic coating from the drum surface.

11. Process for applying to a flexible substrate a film of metal having a thickness of only a few millionths of an inch, comprising the steps of supporting a drum having a smooth shiny surface so that the drum forms one wall of a high-vacuum coating chamber over a source of metallic coating vapors with the lower surface of the drum in position to be exposed to metallic coating vapors which condense thereon, applying a release agent to a portion of the surface of the drum spaced from the lower surface thereof, rotating the drum so that sequential areas thereof are coated with the metallic coating, adhesively uniting the metallic coating on the drum to the flexible substrate after the surface has been rotated out of the vacuum chamber, and stripping the flexible substrate and the metallic coating from the drum surface, the release agent being applied to the drum after the metallic coating has been stripped from the drum and before the next film of metal is deposited thereon.

12. The process of claim 11 wherein the drum surface is thoroughly cleaned after stripping the film therefrom and prior to applying the release agent thereto.

13. The process of claim 11 wherein the high-vacuum coating chamber is evacuated to a pressure of less than 10 microns Hg abs.

14. The process of claim 11 wherein a film of adhesive is spread across one of the facing surfaces of the substrate and the metal film the surfaces are pressed together and held so pressed until the adhesive has formed a bond between the substrate and the metal film which is stronger than the bond between the metal film and the surface of the drum.

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