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(54) **COATING STRIP MATERIAL WITH PROTECTIVE/DECORATIVE LAYERS WHILE AVOIDING USE OF SOLVENTS**

LÖSUNGSMITTELFREIES-BESCHICHTEN VON MATERIALBAHNEN MIT SCHUTZ-UND DEKORSCHICHTEN

ENDUCTION DE BANDES DE METAL AVEC DES COUCHES PROTECTRICES/DECORATIVES SANS DISSOLVANTS

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Description

TECHNICAL FIELD

[0001] This invention relates to a process of coating a surface of an elongated strip article with a layer of polymer material according to the preamble of claim 1 and to an apparatus for coating a surface according to the preamble of claim 15. A process and an apparatus of this type is known from e.g. US-A-4 675 230.

BACKGROUND ART

[0002] Metal sheet material, for example thin aluminum strip used for beverage cans and other purposes, is frequently coated with organic films to provide surface protection and/or decorative finishes. The coatings are typically applied by dissolving or suspending polymers and other components in organic solvents, applying the resulting mixtures to the strip by roller coater or doctor blade, and baking the resulting product to remove the solvents and to cross-link the polymer. Unfortunately, the solvents emitted during this conventional procedure cause environmental problems, thus necessitating the use of expensive pollution control systems and complex ovens to avoid the build-up of flammable vapors to explosive concentrations. Also, in order to ensure that the coating polymers will properly dissolve, it is often necessary to use lower molecular weight polymers than would be desirable for providing ideal coating properties.

[0003] As an alternative to roller coating, so-called "falling film" extrusion coating of aluminum foil and paper with molten polymer coating materials is well known. The thickness of the coating is normally controlled by extruding the molten polymer from a slot in an extrusion head positioned several centimetres above a moving strip in the form of a film having a greater thickness than that finally required and then thinning the film by stretching it as a free (unsupported) film under the combined effect of gravity and tension before applying it to the surface of the strip. This demands special rheological characteristics of the coating material so that it can stretch without breaking. It is also very difficult to achieve thicknesses as low as 2 to 7 microns that are typical for aluminum packaging applications, such as aluminum beverage can ends.

[0004] An alternative means of controlling coating thickness during extrusion coating is to employ an extrusion die movably connected to a supporting structure, having an extrusion opening and die lips of a suitable shape positioned around the extrusion opening. The die lips are moved close to the strip and the clearance between strip and die lips is precisely controlled by adjusting the position of the extrusion head relative to the supporting structure. In such an arrangement, the thickness uniformity of the coating depends on the precision used in the manufacture and control of the die and the precision of the support roll normally used to support the sheet material during coating, as well as the uniformity of the metal gauge along the strip, and it proves very difficult in practice to produce uniform coatings of the desired thickness in an acceptable manner. For example, if a mechanical spacer, such as a roller, is used to maintain a uniform clearance between the die lips and the strip, unsightly marks may be made on the surface of the strip by the spacer and the marks may not be completely hidden by the applied coating.

[0005] An apparatus and method suitable for single-sided coating of a sheet material without reliance on mechanical spacers that contact the strip is disclosed in U.S. Patent No. 4,675,230 of June 23, 1987, assigned to the same assignee as the present application. Moreover, a related apparatus and method of two-sided coating of sheet material is disclosed in PCT Patent Application Serial No. PCT/CA94/00291, filed May 26, 1994, and published on December 8, 1994 as WO 94/27739, and assigned to the same assignee as the present application. The types of apparatus disclosed in this patent and patent application rely on the hydrodynamics of the coating material as it is applied to the strip for control of the film thickness and can readily compensate for variations in the gauge of the strip and any eccentricity of the support roll. This is achieved by using a coating head having a slot and an extended surface on the downstream side of the slot forming an angle with the moving strip converging in the direction of the strip travel. The extended surface directly contacts the coating material as it is applied to the strip, thereby generating hydrodynamic forces that cause the head to "float" on the layer of coating as it is being applied. Direct contact between the strip and the coating head is thus avoided, and this in turn avoids damage to or defacement of the metal or pre-coated metal surface to which the coating is applied.

[0006] The problem with devices of this particular kind is that, while they can generally handle coating materials having viscosities that are greater than the viscosities of coating materials applied by other coating techniques, for example conventional roller coaters, they still require the coating material to be of fairly low viscosity, so it has been necessary to dissolve or suspend the polymeric coating material in a suitable solvent, thereby creating the difficulties mentioned above.

[0007] There is therefore a need for a method and apparatus capable of coating a strip material with a polymeric coating layer in an efficient and convenient way without resort to the use of polymer solutions or dispersions.

[0008] Other types of coaters are known which employ a "doctor blade" to spread the coating material (which could be a molten polymer material). A coater of this kind is disclosed, for example, in US patent 3,690,297 to Dentch et al. Such coaters rely on the use of a thin, flexible blade to meter the fluid onto the moving strip surface. The blade strip is pressed against the strip surface at a suitable pressure (e.g. 30 pounds per inch of blade width). Coaters of this kind can produce very thin coatings of a viscous material because there is essentially no back pressure from the coating fluid against the sharp point of the blade, due to the absence of any significant surface area at the blade tip facing the coating solution. However, doctor blade coaters have the disadvantage that the blade is fixed and consequently does not follow surface irregularities of the surface to be coated. Variations in thickness of the resulting coated layer are therefore common.

[0009] Other patent publications of interest to this invention are European Patent Application 0 135 922 to Nordson Corporation which discloses apparatus for preparing and dispensing thermoplastic resin having a heated chamber provided with a conveyor screw; French FR-A-2 473 361 to Societe Des Bitumes Speciaux which discloses a procedure for coating a synthetic coating material onto a surface; and French FR-A-2 260 395 to AB Inventing which discloses a coating device for coating opposite sides of a strip article with a coating material. The methods and devices of these patents, however, are not particularly suitable for forming polymer layers of even thickness in a rapid and efficient manner.

DISCLOSURE OF INVENTION

[0010] An object of the present invention is to enable the coating of strip material to be carried out without resort to the use of solvents, softeners, suspension media or similar liquids for dissolving, suspending or thinning the polymer coating material.

[0011] Another object of the invention is to make such strip coating possible using equipment that applies the coating material from an extrusion die without resort to stretching of the coating film before its application to the strip surface.

[0012] Yet another object of the invention is to make it possible to coat strip materials with polymeric coatings having thicknesses suitable for aluminum packaging applications without resort to the use of solvents or similar liquids during the coating process.

[0013] The present invention is based on the unexpected finding that modified versions of coating dies of the type disclosed in U.S. Patent 4,675,230 and in WO 94/27739 can be used for the application of high viscosity molten polymers to surfaces of moving strips, if such polymers are maintained at a suitable viscosity, by being suitably heated, and if they are applied to the die under suitable pressures. The disadvantageous use of solvents or other liquids can thus be avoided and yet coatings of the desired thicknesses can be produced.

[0014] According to one aspect of the invention, there is provided a process of coating a surface of an elongated strip article with a layer of polymer material, wherein a strip article having a surface to be coated is advanced in a direction past a coating head provided with an elongated slot and an extended surface adjacent to the slot held at an angle to said surface to form a coating gap converging in the direction advancement of the strip article, coating material is extruded from the slot onto the moving surface to be coated, and the coating head is pushed in the direction of the surface to be coated so that the material extruded from the slot is acted upon by said extended surface in said coating gap to form a layer of said coating material of reduced thickness, relative to an initial coating thickness, on said surface to be coated, said angle being effective in use to cause said coating head to float on said melt in said coating gap as the thickness of the coating is reduced, characterized in that said coating material is a heated polymer melt having a viscosity of at least 1000 centipoise when measured according to ASTM D4440 at 1 radian per second.

[0015] According to another aspect of the invention, there is provided apparatus for coating a surface of an elongated strip article with a solid coating layer of polymer material, including a strip feeder for advancing said elongated strip article in a direction of movement (A), a coating head having an elongated open-sided slot and an extended surface immediately adjacent to the open side of the slot arranged at an angle to surface of said article forming a gap between the coating head and the surface that narrows in the direction of movement of the strip article, said angle being effective in use to cause said coating head to float on said melt in said coating gap as the thickness of the coating is reduced, a support for the coating head holding said head facing said strip article, said support permitting movement of the coating head towards and away from the surface of the strip article, and a load application device for pushing the coating head towards the strip article as said melt is extruded as a coating onto said surface from the slot to reduce thickness of the coating to form a layer by pressing said extended surface of the coating head onto said coating as the coating is formed; characterized in that the apparatus includes melting apparatus for heating a solid polymer material to form a melt having a viscosity of at least 1000 centipoise when measured according to ASTM D4440 at 1 radian per second and for delivering said melt under pressure to said coating head for extrusion through said slot, and a heater for said coating head for maintaining said viscosity of the melt contained within said coating head.

[0016] Particular embodiments of the invention are the subject of the dependent claims.

[0017] The process and apparatus of the invention can surprisingly produce coatings as thin as 1-100 μm, and even 1-25 μm, without resorting to the use of liquids as solvents, diluents, etc. In particular, this means that coatings for aluminum strip in the desired range of 2-7 μm can be produced without the usual attendant disadvantages mentioned above. The use of a "floating" head makes it possible to coat relatively wide strip materials since the coating head can be pushed at various positions across the width of the strip by a suitable load application devices, thus forcing all parts of the coating head to follow both the transverse as well as the longitudinal contours of the strip.

[0018] The polymers employed in the present invention are those which produce shear-thinning fluid melts having viscosities of at least 1000 centipoise, more preferably at least 5000 centipoise, and even more preferably at least 50,000 centipoise, upon being heated above their melting temperatures but below their decomposition temperatures. Shear-thinning fluid melts are those having viscosities that decrease as the shear rates, to which they are subjected, increase. In the present invention, as indicated above, the viscosities are measured by the procedure of standard test ASTM D4440 (approved on November 30, 1984) of the American Society of Testing and Materials at a shear rate of 1 radian per second.

[0019] Without wishing to be bound by any particular theory, it is speculated that the process and apparatus of the present invention are successful in producing thin coatings of polymer materials directly from polymer melts because the polymer melts are subjected to high shear conditions in the coating gap formed between the coating head and the surface of the strip article as the melts are being extruded. Accordingly, because of the shear-thinning nature of the polymer melt, the effective viscosity of the melt in the gap may be much lower than expected (i.e. much lower than the melt when static) and thus thinner coatings than theoretically expected may be metered out.

[0020] The shear rate to which the polymer melt is subjected during coating depends on the velocity (v) of the moving strip and the separation distance (x) between the part of the coating head surface that is closest to the moving strip and strip surface itself. The shear can be represented by the equation:

$$\text{SHEAR} = v/x.$$

[0021] To reduce the viscosity of the melt as much as possible, it is normally desirable to maintain the melt at the highest possible temperature above the polymer melting point (which can be determined by standard differential scanning calorimetry) without causing degradation. This optimum temperature differs from polymer to polymer, but can be determined for any suitable polymer by simple trial and experimentation.

[0022] The pressure at which the fluid melt is applied to the coating head depends on the viscosity of the melt and on any viscosity drop that occurs in the coating gap. Again, suitable pressures can be determined by simple trial and experimentation and can be generated by any suitable means for pressurizing a high viscosity fluid, e.g. high pressure pumps, although it is preferred to use a heated screw type extruder to simultaneously mix, melt, pressurize and deliver the polymer to the coating head.

[0023] While the invention is primarily concerned with the coating of sheet articles made of metals, it should be kept in mind that it may also be used for coating other sheet articles, e.g. paper strip articles.

BRIEF DESCRIPTION OF DRAWINGS

[0024]

Fig. 1 is a side elevational view, partly in cross-section, of an apparatus for carrying out a preferred aspect of the present invention; and

Fig. 2 is a simplified schematic representation of apparatus for carrying out another preferred aspect of the invention.

BEST MODES FOR CARRYING OUT THE INVENTION

[0025] The apparatus shown in Fig. 1 is intended for coating metal strip articles and consists of a coating head 12 similar to the head described in WO 94/27739 mentioned above, except that the head is heated and the interior passages are modified for streamlined polymer flow to improve flow uniformity and to avoid "dead zones" that might cause degradation of the heated polymer.

[0026] The coating head 12 (shown partially in cross-section) applies a layer of polymer coating material 13 onto an aluminum strip 14 passing around a heated backup drum 16 in the direction of the arrow A. The coating head 12 extends over the entire transverse width of the strip at a position, in the path of the strip advance, at which the strip is held firmly against the surface of the backup drum 16. A system of spaced air cylinders 17 (only one of which is shown) urges the coating head 12 towards the strip 14 at a number of locations across the width of the strip to apply a suitable load to the coating material 13 as it is applied to the strip surface, causing the head to "float" on the layer of molten coating material 13 applied through elongated coating slot 15, while metering the thickness of the applied coating. As noted above, the head includes integral heaters (not shown), which may be of a conventional kind, to ensure uniform temperature and viscosity of the extruded polymer.

[0027] The coating head 12 is fed with heated molten polymer coating material from a screw extruder 18 (shown in cross-section) via a heated high pressure hose 19. The hose 19 may be a conventional flexible hose first wrapped with an electrical heating element (wire) and then wrapped with flexible insulation. Several hoses 19 may be provided to supply the melt to different parts of the coating head. The screw extruder 18, which itself is heated by integral heaters 20, heats, mixes, compresses and pressurizes a pelletized plastic coating material 22 withdrawn from a hopper 24. The mixing action takes place as the pressure inside the extruder builds towards the front of the extruder and a backward counterflow of material takes place (as indicated by the small arrows) in the gap between the screw mechanism 26 and the extruder wall 28.

[0028] By heating each of the extruder 18, the high pressure hose 19, the coating head 12 and the backup drum 16, the polymer material 13 can be kept in molten condition within the viscosity range mentioned earlier until applied as a coating to the strip 14. It will be understood that the surface of the strip 14 may bear a previously applied undercoat or primer coat of paint, and the opposite surface of the strip may also be precoated.

[0029] Beyond the drum 16, the strip is allowed to cool sufficiently to solidify the polymer material 13 and can then be coiled in the conventional manner. If necessary, however, the strip may be subjected to a further heat treatment or baking step after being coated in the indicated manner in order to ensure proper curing or bonding of the coating to the strip article.

[0030] By using equipment of this kind, the polymer material can successfully be coated in thin layers onto the strip article 14 by a dynamic load control mechanism as opposed simply to a static adjustment of the gap between the coating head and the strip. This is surprising, because molten polymer has a high viscosity normally in the range of 1,000 to 2,000,000 centipoise (often 10,000 to 1,000,000 centipoise at 1 rad/sec according to the ASTM D4440 test mentioned above).

[0031] It will be seen from Fig. 1 that the coating head 12 forms part of a rigid metal block 30 having a flat or concavely curved coating surface 32 arranged at an angle (normally in the range of 0.1 to 5°, or more preferably 0.5 to 1°) to the surface of the moving strip 14 forming a gap 34 converging in the direction of the strip travel. The part of the coating surface downstream of the coating slot 15 forms an extended surface 32a that contacts the polymer melt as it is applied and receives the hydrodynamic force of the melt as it moves through the converging coating gap 34.

[0032] The elongated extrusion slot 15, which opens outwardly through the surface 32 of the coating head 12, opens inwardly into a melt cavity 40 that is fully enclosed by the coating head 12 except for a polymer delivery aperture 42 communicating with pressure hose 19. The slot 15 is orientated with its long dimension transverse to the direction of advance of the strip 14; most preferably, the long dimension of the slot is perpendicular to the direction of strip advance and parallel to the axis of rotation of the drum 16.

[0033] In operation, heated molten polymer is continuously supplied under pressure by the screw extruder 18 to the internal melt cavity 40 and thence to the slot 15 at a rate sufficient to keep the cavity 40 entirely filled and to force the polymer from the slot 15 under pressure so that the slot, as well, is continuously entirely filled with polymer under pressure.

[0034] The apparatus includes a deck 44 having a flat upper surface on which the metal block 30 rests, the block being thus supported for sliding movement back and forth relative to the deck in a generally horizontal direction as shown by arrow 48. A series of vertically opening slots 46 (only one of which is shown), elongated horizontally in the direction of arrow 48, are formed in the body of the block 30 rearwardly of the cavity 40 at locations spaced along the length of the block. A series of bolts 50 (again only one of which is shown) respectively extend through these slots and are threaded into the deck at one end while having enlarged bolt heads 50a at the other end to retain the block 30 on the deck 44. Interference between the bolt shanks 50b and the side walls of the slots 46 prevents lateral movement of the block 30 relative to the deck, but the elongation of the slots permits the block 30 to move in the direction of arrow 48 through the full range of operative head positions.

[0035] The deck 44 is mounted on a feed frame 52 for pivotal movement about a horizontal axis 54, so as to enable the block 30, with the deck 44, to be swung upwardly (e.g. by suitable pneumatic means, not shown) from the position illustrated in Fig. 1 to a position removed from the path of strip advance. An arm 56, fixedly secured to the frame 52 and underlying the deck 44, carries a screw 58 that projects upwardly from the arm and bears against the lower surface of the deck 44, to enable adjustment of the angular orientation of the head 12 in its operative position.

[0036] The frame 52 is fixed in position relative to the axis of the drum 16, both the frame and the drum being mounted in a common support structure (not shown). Thus, the axis 54 is fixed in position relative to the axis of the drum 16 and when the deck 44 is in the operative position shown in Fig. 1, with the screw 58 set to provide a desired angular orientation, the drum 16 supports the advancing strip 14, opposite the slot 36, at a fixed distance from the deck 44.

[0037] The air cylinders 17 (which may be of generally conventional construction and which act as load application devices) are fixed securely to the deck 44 rearwardly of the block 30. As shown, the cylinders 17 are secured to the rearwardly projecting ledge portions 60 of the deck. Actuation of the cylinders causes the block 30 to be pushed towards the surface of the strip 14. As already noted, this load is opposed by the hydrodynamic fluid pressure of the molten polymer 13 created by the converging gap 34 between the strip surface 14 and the opposed extended surface 32a of the coating head 12 and the head 12 thus "floats" on the polymer layer 13. A metering orifice is thus defined between an upstream edge 62 of the surface 32a and the adjacent surface of the strip 14, the size of the metering orifice being determined (for a given polymer) by the magnitude of the load exerted by the cylinders. Hence, coatings of a desired thickness can be produced, even very thin coatings having thicknesses in the range of 1 to 25 microns, as mentioned previously, and more preferably 2 to 7 microns. No direct mechanical contact takes place between the coating head 12 and the strip 14, so defacement of the surface of the strip is prevented.

[0038] Although the illustrated apparatus is designed for single-sided coating, the invention may also be utilized for two-sided coating using apparatus of the type disclosed in the co-pending PCT application mentioned above, except modified to be fed with a molten polymer as in the apparatus described for single-sided coating.

[0039] An example of an apparatus suitable for double-sided coating is shown schematically in Fig. 2. Metal strip 14 to be coated is continuously advanced, in a direction longitudinally parallel to its long dimension, from a coil 70 along a path represented by arrows A and B extending successively around spaced guide rollers 72, 74 and 75 rotatably supported (by structure not shown) in axially fixed positions. The rollers 72 and 74 cooperatively define a rectilinear portion 76 of the path, in which portion the major surfaces of the advancing strip are substantially planar. At a position in this path portion 76, polymer is applied to both major surfaces 78, 80 of the strip from two coating devices 12, 12' (disposed in register with each other and respectively facing the two major surfaces of the strip article) to establish on each of the strip surfaces a continuous layer or coating of the polymer. The coating devices 12 and 12' may each be the same as the coating device 12 of the embodiment shown in Fig. 1 and may each be provided with heated polymer melt in the same fashion as previously described. As in the case of the previous embodiment, it will be understood that either or both of the strip major surfaces may bear a previously applied undercoat or primer coat of paint.

[0040] After passing roll 75, the coated strip is coiled again, e.g. on a driven rewind reel 82 which constitutes the means for advancing the strip through the coating line.

[0041] Since there is no heated support drum 16 in this embodiment, as there is in the embodiment of Fig. 1, the strip 14 may, if necessary, be advanced through a heating oven 84 immediately upstream of the positions of the coating heads 12, 12', to provide pre-heating of the strip prior to the application of the polymer coating in order to maintain suitable viscosity of the coating at the coating heads.

[0042] Furthermore, the strip may, if necessary, be advanced through a further heating oven 86 after being coated with the polymer coating material if post-coating heating is required to assure proper bonding of the polymer coating to the strip, which may be the case for some polymer coatings and strip surfaces.

[0043] Polymeric materials suitable for use in the apparatus of the invention (i.e. in the embodiments of both Figs. 1 and 2) are those having viscosities in the ranges stated above at temperatures between their melting points and their decomposition temperatures, i.e. normally at temperatures in the range of 150 to 350°C. Examples of suitable polymers include, but are not limited to polyethylene (e.g. EPOLENE® C-17 or C-13 polyethylene wax; effective temperature range 150-260°C), polyethylene terephthalate (e.g. VECODUR® EPPN; effective temperature range 200-340°C) and mixtures of ethylene acrylic acid copolymer and polybutylene (e.g. PRIMACOR® 3440 - 75% PRIMACOR® and 25% SHELL® PB 0300; effective temperature range 160-310°C).

[0044] The invention is illustrated further by the following Examples, which are not intended to limit the scope of the invention.

EXAMPLE 1

[0045] A powerful and sophisticated extruder (model 1.75 18:1 having a 1.9 cm (3/4 inch) screw with an 18 to 1 length to diameter ratio from Bramptom Engineering) was connected to a single-sided coater of the type disclosed in U.S. patent 4,675,230 and a gas heater was installed to preheat the backup drum. The coater head itself was a simple rigid coating head, originally designed for liquid coatings, approximately 125 mm wide with attached heaters.

[0046] This equipment was used to apply films of molten polymer as thin as 3 microns to aluminum can end stock and to foil lidstock for pet food cans. The equipment was operated as fast as 210 metres per minute (690 feet per minute).

[0047] Conditions for and results of various runs employing this equipment were as follows:

Run 1

[0048]

Polymer:	Eastman-Kodak EPOLENE® C-13, a low molecular weight polyethylene modified for good adhesion.
Extruder temperature:	200°C
Hose temperature:	200°C
Head temperature:	220°C
Head angle:	0.6 degrees
Air cylinder pressure:	621 kPa (90 psi)
Extruder drive frequency:	6 Hz
Backup drum temperature:	65°C
Strip speed:	30 metres per minute (100 feet per minute)
Film thickness profile:	14.1, 8.4, 5.0, 6.0, 12.5 (microns)

Run 2

[0049]

Polymer:	EPOLENE® C-17, a low molecular weight polyethylene modified for good

	adhesion
Extruder temperature:	220°C
Hose temperature:	220°C
Head temperature :	240°C
Head angle:	0.6 degrees
Air cylinder pressure:	621 kPa (90 psi)
Extruder drive frequency:	6 Hz
Backup drum temperature:	95°C
Strip speed:	52 metres per minute (170 feet per minute)
Film thickness profile:	8.7, 4.7, 2.4, 6.8, 14.4 (microns)

<u>Run 3</u>

[0050]

Polymer:	Dow-Europe PRIMACOR® 3440 Modified Polyethylene Blend.
Extruder temperature:	220°C
Hose temperature:	220°C
Head temperature:	240°C
Head angle:	0.6 degrees
Air cylinder pressure:	621 kPa (90 psi)
Extruder drive frequency:	6 Hz
Backup drum temperature:	102°C
Strip speed:	52 metres per minute (170 feet per minute)
Film thickness profile:	12.2, 5.3, 3.3, 7.7, 16.8 (microns)

<u>Run 4</u>

[0051]

Polymer:	VECODUR® EPPN polyethylene terephthalate (PET)
Extruder temperature:	210°C
Hose temperature:	200°C
Head temperature:	220°C
Head angle:	0.6 degrees
Air cylinder pressure:	621 kPa (90 psi)
Extruder drive frequency:	6 Hz
Backup drum temperature:	73° C
Strip speed:	20 metres per minute (100 feet per minute)
Film thickness profile:	16.0, 10.6, 9.7, 9.9, 13.3 (microns)

[0052] The viscosity of the EPOLENES C-13 used in runs 1 and 2 was measured according to ASTM D 4440 on a Rheometrics™ System 4 viscometer using a parallel plate measuring unit. The sensor plate had a 12.5 mm radius and clearance of 2 mm. An estimate of the shear rate based on the conditions at the circumference of the plate gives 6.25 sec-1 for 1 rad/sec, and 625 sec-1 for 100 rad/sec. The results for EPOLENE® C-13 at 190°C were:

5180 centipoise at 1 rad/sec
3760 centipoise at 100 rad/sec.

[0053] For Epolene™ C-17, the results were:

578,000 centipoise at 1 rad/sec
114,100 centipoise at 100 rad/sec.

[0054] Other resins used, such as the DOW PRIMACOR® and VECODUR® EPPN, were not measured, but were presumed similar to EPOLENE® C-17.

[0055] The shear rates in the coating gap are much higher than in the test instrument, typically in the range 10,000 sec-1 to 100,000 sec-1. Consequently, the effective viscosity under actual operating conditions may be much lower than measured in a viscometer. The high shear nature of the coater may be the reason why thin coatings can be achieved because the high shear rate may reduce the effective viscosity of the polymer in the gap formed between the coater head and the surface of the strip article.

Claims

1. A process of coating a surface of an elongated strip article with a layer of polymer material, wherein a strip article (14) having a surface to be coated is advanced in a direction past a coating head (12) provided with an elongated slot (15) and an extended surface (32a) adjacent to the slot held at an angle to said surface to form a coating gap (34) converging in the direction advancement of the strip article, coating material is extruded from the slot onto the moving surface to be coated, and the coating head is pushed in the direction of the surface to be coated so that the material extruded from the slot is acted upon by said extended surface in said coating gap to form a layer (13) of said coating material of reduced thickness, relative to an initial coating thickness, on said surface to be coated, said angle being effective in use to cause said coating head to float on said melt in said coating gap as the thickness of the coating is reduced, characterized in that said coating material is a heated polymer melt having a viscosity of at least 1000 centipoise when measured according to ASTM D4440 at 1 radian per second.

2. A process according to claim 1, characterised in that the coating head (12) is pushed towards the surface of the strip article (14) as said melt is extruded from the slot (15) onto the surface of the strip article to be coated with a force to reduce the thickness of said coating to 1 to 100 microns.

3. A process according to claim 1, characterised in that said polymer material is one that, upon being heated above its melting point but below its decomposition temperature, forms a melt having a viscosity of at least 5000 centipoise when measured according to ASTM D4440 at 1 radian per second.

4. A process according to claim 1, characterised in that said polymer material is one that, upon being heated above its melting point but below its decomposition temperature, forms a melt having a viscosity of at least 50,000 centipoise when measured according to ASTM D4440 at 1 radian per second.

5. A process according to claim 1, characterised in that the melt is delivered to the coating head (12) under pressure while being heated to maintain said viscosity.

6. A process according to claim 1, further characterized by heating said extrusion head (12) to maintain said viscosity.

7. A process according to claim 1, characterised in that the melt is formed by mixing and compressing granules (22) of the polymer material and heating said granules to a temperature above a melting point of the polymer material but below its decomposition temperature.

8. A process according to claim 1, characterised in that the coating layer (13) is reduced in thickness to 1 to 25 microns.

9. A process according to claim 1, characterised in that the coating layer (13) is reduced in thickness to 2 to 7 microns.

10. A process according to claim 1, further characterized by applying said coating to aluminum sheet material as said strip article (14).

11. A process according to claim 1, characterised in that said strip article (14) bearing said coating is subjected to a heating step.

12. A process according to claim 1, wherein said strip article (14) has a second surface (78) opposite to a first surface (76), characterized in that said second surface is coated with the same polymer material in the same manner and at the same time as the first surface from a second identical coating head (12') facing said second surface at a position opposite to said coating head (12) facing said first surface.

13. A process according to claim 12, characterized in that the second coating head (12') is pushed towards the second surface (78) of the strip article (14) as said melt is extruded onto the second surface from the second coating head with a force to reduce the thickness of the coating layer on the second surface to 1 to 100 microns.

14. A process according to claim 12, characterized in that the strip article (14) is heated immediately upstream of a location at which the coatings are applied.

15. Apparatus for coating a surface of an elongated strip article (14) with a solid coating layer (13) of polymer material, including a strip feeder (16) for advancing said elongated strip article in a direction of movement (A), a coating head (12) having an elongated open-sided slot (15) and an extended surface (32a) immediately adjacent to the open side of the slot arranged at an angle to said surface of said article forming a gap (34) between the coating head and the surface that narrows in the direction of movement of the strip article, said angle being effective in use to cause said coating head to float on said melt in said coating gap as the thickness of the coating is reduced, a support (44) for the coating head holding said head facing said strip article, said support permitting movement of the coating head towards and away from the surface of the strip article, and a load application device (17) for pushing the coating head towards the strip article as said melt is extruded as a coating onto said surface from the slot to reduce thickness of the coating to form a layer (13) by pressing said extended surface of the coating head onto said coating as the coating is formed; characterized in that the apparatus includes melting apparatus (18) for heating a solid polymer material (22) to form a melt having a viscosity of at least 1000 centipoise when measured according to ASTM D4440 at 1 radian per second and for delivering said melt under pressure to said coating head for extrusion through said slot, and a heater for said coating head for maintaining said viscosity of the melt contained within said coating head.

16. Apparatus according to claim 15 having a supporting drum for supporting said strip article (14) as it is advanced past said coating head (12), characterized by heating means for heating the strip article as it contacts said supporting drum.

17. Apparatus according to claim 15 characterized in that said melting apparatus comprises a heated screw mixer (28) for melting and blending particles (22) of said polymer material.

18. Apparatus according to claim 17, characterized by a heated pressure hose (19) connecting said screw mixer (28) with said coating head (12).

19. Apparatus according to claim 15, further characterized by a second heated coating head (12') for forming a coating of polymer material on a second surface (78) of said strip article (14).

20. Apparatus according to claim 15 further characterized by a heater (84) for heating said strip article (14) positioned upstream of said coating head (12).

Patentansprüche

1. Verfahren zum Beschichten einer Oberfläche einer länglichen Materialbahn mit einer Schicht von Polymermaterial, bei dem eine Materialbahn (14) mit einer zu beschichtenden Oberfläche in einer Richtung an einem Beschichtungskopf (12) vorbei zugeführt wird, der mit einem Längsschlitz (15) und einer dem Schlitz benachbarten verlängerten Fläche (32a) versehen ist, die in einem Winkel zur Oberfläche gehalten wird, um einen in die Zuführrichtung der Materialbahn konvergierenden Beschichtungsspalt (34) auszubilden, Beschichtungsmaterial von dem Schlitz auf die sich bewegende zu beschichtende Oberfläche extrudiert wird, und der Beschichtungskopf in die Richtung der zu beschichtenden Oberfläche derart gedrückt wird, daß auf das aus dem Schlitz extrudierte Material durch die verlängerte Oberfläche in dem Beschichtungsspalt gewirkt wird, um auf der zu beschichtenden Oberfläche eine Schicht (13) des Beschichtungsmaterials von im Vergleich zu einer anfänglichen Beschichtungsdicke verringerten Dicke zu bilden, wobei der Winkel bei der Verwendung wirksam ist, um zu bewirken, daß der Beschichtungskopf auf der Schmelze in dem Beschichtungsspalt schwebt, während die Dicke der Beschichtung verringert wird, **dadurch gekennzeichnet, daß** das Beschichtungsmaterial eine erhitzte Polymerschmelze mit einer Viskosität von zumindest 1000 Centipoise ist, gemessen entsprechend ASTM D4440 bei 1 Radiant pro Sekunde.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** der Beschichtungskopf (12) mit einer Kraft zur Oberfläche der Materialbahn (14) hin gedrückt wird, während die Schmelze aus dem Schlitz (15) auf die zu beschichtende Oberfläche der Materialbahn extrudiert wird, um die Dicke der Beschichtung auf 1 bis 100 µm zu verringern.

3. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** das Polymermaterial eines ist, das beim Erhitztwerden überhalb seines Schmelzpunkts, aber unterhalb seiner Zersetzungstemperatur eine Schmelze bildet, die eine Viskosität von zumindest 5000 Centipoise aufweist, gemessen entsprechend ASTM D4440 bei 1 Radiant pro Sekunde.

4. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** das Polymermaterial eines ist, das beim Erhitztwerden überhalb seines Schmelzpunkts, aber unterhalb seiner Zersetzungstemperatur eine Schmelze bildet, die eine Viskosität von zumindest 50.000 Centipoise aufweist, gemessen entsprechend ASTM D4440 bei 1 Radiant pro Sekunde.

5. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** die Schmelze dem Beschichtungskopf (12) unter Druck zugeführt wird, während sie erhitzt wird, um die Viskosität zu erhalten.

6. Verfahren nach Anspruch 1, weiterhin **gekennzeichnet durch** das Erhitzen des Extrusionskopfs (12), um die Viskosität zu erhalten.

7. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** die Schmelze gebildet wird durch Mischen und Verdichten von Granulat (22) des Polymermaterials, und Erhitzen des Granulats auf eine Temperatur oberhalb eines Schmelzpunkts des Polymermaterials, aber unterhalb seiner Zersetzungstemperatur.

8. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** die Beschichtungsschicht (13) in ihrer Dicke auf 1 bis 25 µm verringert ist.

9. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** die Beschichtungsschicht (13) in ihrer Dicke auf 2 bis 7 µm verringert ist.

10. Verfahren nach Anspruch 1, weiterhin **gekennzeichnet durch** das Aufbringen der Beschichtung auf Aluminiumfolienmaterial als die Materialbahn (14).

11. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** die die Beschichtung tragende Materialbahn (14) einem Heizschritt ausgesetzt wird.

12. Verfahren nach Anspruch 1, wobei die Materialbahn (14) gegenüberliegend einer ersten Oberfläche (76) eine zweite Oberfläche (78) aufweist, **dadurch gekennzeichnet, daß** die zweite Oberfläche von einem zweiten identischen Beschichtungskopf (12'), der der zweiten Oberfläche in einer Position dem der ersten Oberfläche zugewandten Beschichtungskopf (12) gegenüberliegend zugewandt ist, mit demselben Polymermaterial auf dieselbe Weise und zur selben Zeit wie die erste Oberfläche beschichtet wird.

13. Verfahren nach Anspruch 12, **dadurch gekennzeichnet, daß** der zweite Beschichtungskopf (12'), mit einer Kraft zur zweiten Oberfläche (78) der Materialbahn (14) hin gedrückt wird, während die Schmelze aus dem zweiten Beschichtungskopf (12') auf die zweite Oberfläche extrudiert wird, um die Dicke der Beschichtung auf der zweiten Oberfläche auf 1 bis 100 µm zu verringern.

14. Verfahren nach Anspruch 12, **dadurch gekennzeichnet, daß** die Materialbahn (14) unmittelbar stromauf einer Lage erhitzt wird, bei der die Beschichtungen aufgebracht werden.

15. Vorrichtung zum Beschichten einer Oberfläche einer länglichen Materialbahn (14) mit einer festen Beschichtungsschicht (13) aus Polymermaterial, umfassend eine Bahnzuführung (16) zum Zuführen der länglichen Materialbahn in einer Bewegungsrichtung (A), einen Beschichtungskopf (12) mit einem länglichen offenseitigen Schlitz (15) und einer verlängerten Fläche (32a) unmittelbar benachbart der offenen Seite des Schlitzes, die unter einem Winkel zur Oberfläche des Materials unter Bilden eines sich in die Bewegungsrichtung der Materialbahn verengenden Spalts (34) zwischen dem Beschichtungskopf und der Oberfläche angeordnet ist, wobei der Winkel in der Benutzung wirksam ist, um zu bewirken, daß der Beschichtungskopf auf der Schmelze in dem Beschichtungsspalt schwebt, während die Dicke der Beschichtung verringert wird, eine Stütze (44) für den Beschichtungskopf, die den Kopf der Materialbahn zugewendet hält und Bewegung des Beschichtungskopfs zur Oberfläche der Materialbahn hin und von ihr weg ermöglicht, und eine Lastaufbringvorrichtung (17) zum Drücken des Beschichtungskopfs zur Materialbahn hin, während die Schmelze als eine Beschichtung auf die Oberfläche aus dem Schlitz extrudiert wird, um die Dicke der Beschichtung zu verringern, so daß während Ausbilden der Beschichtung durch Pressen der verlängerten Fläche des Beschichtungskopfs auf die Beschichtung eine Schicht (13) ausgebildet ist; **dadurch gekennzeichnet, daß** die Vorrichtung eine Schmelzvorrichtung (18) zum Erhitzen eines festen Polymermaterials (22), um eine Schmelze mit einer Viskosität von zumindest 1000 Centipoise auszubilden, gemessen entsprechend ASTM D4440 bei 1 Radiant pro Sekunde und zum Beschicken des Beschichtungskopfs mit der unter Druck stehenden Schmelze, zur Extrusion durch den Schlitz, und eine Heizung für den Beschichtungskopf umfaßt, um die Viskosität der innerhalb des Beschichtungskopfs enthaltenden Schmelze zu erhalten.

16. Vorrichtung nach Anspruch 15, mit einer Stützwalze zum Stützen der Materialbahn (14), während sie an dem Beschichtungskopf (12) vorbei zugeführt wird, **gekennzeichnet durch** eine Heizeinrichtung zum Erhitzen der Materialbahn, während sie die Stützwalze berührt.

17. Vorrichtung nach Anspruch 15, **dadurch gekennzeichnet, daß** die Schmelzvorrichtung einen beheizten Schraubenmischer (28) zum Schmelzen und Mischen von Partikeln (22) des Polymermaterials umfaßt.

18. Vorrichtung nach Anspruch 17, **gekennzeichnet durch** einen beheizten Druckschlauch (19), der den Schraubenmischer (28) mit dem Beschichtungskopf (12) verbindet.

19. Vorrichtung nach Anspruch 15, weiter **gekennzeichnet durch** einen zweiten beheizten Beschichtungskopf (12'), um auf einer zweiten Oberfläche (78) der Materialbahn (14) eine Beschichtung aus Polymermaterial auszubilden.

20. Vorrichtung nach Anspruch 15, weiterhin **gekennzeichnet durch** eine Heizung (84) zum Erhitzen der Materialbahn (14), die stromauf des Beschichtungskopfs (12) angeordnet ist.

Revendications

1. Procédé de revêtement d'une surface d'un article de bande allongée, avec une couche de matière polymère, dans lequel l'article de bande (14) ayant une surface à revêtir avance dans une direction devant une tête de revêtement (12) munie d'une fente allongée (15) et d'une surface étendue (32a) adjacente à la fente maintenue à un angle par rapport à ladite surface afin de former un intervalle de revêtement (34) qui converge dans la direction d'avancement de l'article de bande, la matière de revêtement est extrudée à partir de la fente sur la surface en déplacement à revêtir, et la tête de revêtement est poussée dans la direction de la surface à revêtir de sorte que ladite surface étendue dans ledit intervalle de revêtement agit sur la matière extrudée provenant de la fente afin de former une couche (13) de ladite matière de revêtement d'une épaisseur réduite, par rapport à une épaisseur de revêtement initiale, sur ladite surface à revêtir, ledit angle étant efficace à l'utilisation pour faire flotter ladite tête de revêtement sur ladite masse en fusion dans ledit intervalle de revêtement à mesure que l'épaisseur de revêtement se réduit, caractérisé en ce que ladite matière de revêtement est une masse fondue polymère chauffée ayant une viscosité d'au moins 1 000 centipoises lorsqu'on la mesure selon ASTM D4440 à 1 radian par seconde.

2. Procédé selon la revendication 1, caractérisé en ce que la tête de revêtement (12) est poussée vers la surface de l'article de bande (14) à mesure que ladite masse fondue est extrudée à partir de la fente (15) sur la surface de l'article de bande à revêtir avec une force réduisant ledit revêtement à une épaisseur de 1 à 100 micromètres.

3. Procédé selon la revendication 1, caractérisé en ce que ladite matière polymère est une matière polymère qui, lorsqu'elle est chauffée au-dessus de son point de fusion mais au-dessous de sa température de décomposition, forme une masse fondue ayant une viscosité d'au moins 5 000 centipoises lorsqu'on la mesure selon ASTM D4440 à 1 radian par seconde.

4. Procédé selon la revendication 1, caractérisé en ce que ladite matière polymère est une matière polymère qui, lorsqu'elle est chauffée au-dessus de son point de fusion mais au-dessous de sa température de décomposition, forme une masse fondue ayant une viscosité d'au moins 50 000 centipoises lorsqu'on la mesure selon ASTM D4440 à 1 radian par seconde.

5. Procédé selon la revendication 1, caractérisé en ce que la masse fondue est délivrée à la tête de revêtement (12) sous pression tout en étant chauffée pour maintenir ladite viscosité.

6. Procédé selon la revendication 1, caractérisé de plus en ce que ladite tête d'extrusion (12) est chauffée pour maintenir ladite viscosité.

7. Procédé selon la revendication 1, caractérisé en ce que la masse fondue est formée en mélangeant et en comprimant des granulés (22) de la matière polymère et en chauffant lesdits granulés à une température au-dessus du point de fusion de la matière polymère mais au-dessous de sa température de décomposition.

8. Procédé selon la revendication 1, caractérisé en ce que la couche de revêtement (13) est réduite en épaisseur entre 1 et 25 micromètres.

9. Procédé selon la revendication 1, caractérisé en ce que la couche de revêtement (13) est réduite en épaisseur entre 2 et 7 micromètres.

10. Procédé selon la revendication 1, caractérisé de plus par l'application dudit revêtement à une matière de feuille d'aluminium en tant que dit article de bande (14).

11. Procédé selon la revendication 1, caractérisé en ce que ledit article de bande (14) portant ledit revêtement est soumis à une étape de chauffage.

12. Procédé selon la revendication 1, dans lequel ledit article de bande (14) possède une deuxième surface (78) opposée à une première surface (76), caractérisé en ce que ladite deuxième surface est revêtue de la même matière polymère de la même manière et en même temps que la première surface à partir d'une deuxième tête de revêtement identique (12') faisant face à ladite deuxième surface à une position opposée par rapport à ladite tête de revêtement (12) faisant face à ladite première surface.

13. Procédé selon la revendication 12, caractérisé en ce que la deuxième tête de revêtement (12') est poussée vers la deuxième surface (78) de l'article de bande (14) à mesure que ladite masse fondue est extrudée sur la deuxième surface à partir de la deuxième tête de revêtement avec une force réduisant la couche de revêtement sur la deuxième surface à une épaisseur de 1 à 100 micromètres.

14. Procédé selon la revendication 12, caractérisé en ce que ledit article de bande (14) est chauffé immédiatement en amont d'une position à laquelle les revêtements sont appliqués.

15. Appareil pour revêtir une surface d'un article de bande allongé (14) d'une couche de revêtement solide (13) de matière polymère, comprenant un dispositif d'alimentation de bande (16) pour faire avancer ledit article de bande allongé dans une direction de mouvement (A), une tête de revêtement (12) ayant une fente allongée ouverte sur un côté (15) et une surface étendue (32a) immédiatement adjacente au côté ouvert de la fente disposé à un angle par rapport à ladite surface dudit article formant un intervalle (34) entre la tête de revêtement et la surface qui se rétrécit dans la direction de mouvement de l'article de bande, ledit angle étant efficace à l'utilisation pour faire flotter ladite tête de revêtement sur ladite masse fondue dans ledit intervalle de revêtement à mesure que l'épaisseur du revêtement se réduit, un support (44) pour la tête de revêtement maintenant ladite tête en face dudit article de bande, ledit support permettant un mouvement de rapprochement et d'éloignement de la tête de revêtement par rapport à la surface de l'article de bande, et un dispositif d'application de charge (17) pour pousser la tête de revêtement vers l'article de bande à mesure que ladite masse fondue est extrudée en tant que revêtement sur ladite surface à partir de la fente pour réduire l'épaisseur du revêtement pour former une couche (13) en pressant ladite surface étendue de la tête de revêtement sur ledit revêtement à mesure que se forme le revêtement; caractérisé en ce que l'appareil comprend un appareil de fusion (18) destiné à chauffer une matière polymère solide (22) en vue de former une masse fondue ayant une viscosité d'au moins 1 000 centipoises lorsqu'elle est mesurée selon ASTM D4440 à 1 radian par seconde et afin de délivrer ladite masse fondue sous pression à ladite tête de revêtement en vue d'une extrusion à travers ladite fente, et un élément chauffant pour ladite tête de revêtement afin de maintenir ladite viscosité de la masse fondue contenue dans ladite tête de revêtement.

16. Appareil selon la revendication 15 ayant un tambour support pour soutenir ledit article de bande (14) à mesure qu'il avance devant ladite tête de revêtement (12), caractérisé par un moyen de chauffage pour chauffer l'article de bande lorsqu'il vient en contact avec ledit tambour support.

17. Appareil selon la revendication 15 caractérisé en ce que ledit appareil de fusion comprend un mélangeur à vis chauffée (28) pour fondre et mélanger les particules (22) de ladite matière polymère.

18. Appareil selon la revendication 17, caractérisé par un tuyau sous pression chauffé (19) raccordant ledit mélangeur à vis (28) à ladite tête de revêtement (12).

19. Appareil selon la revendication 15, caractérisé de plus par une deuxième tête de revêtement chauffée (12') pour former un revêtement de matière polymère sur une deuxième surface (78) dudit article de bande (14).

20. Appareil selon la revendication 15 caractérisé de plus par un élément chauffant (84) pour chauffer ledit article de bande (14) disposé en amont de ladite tête de revêtement (12).

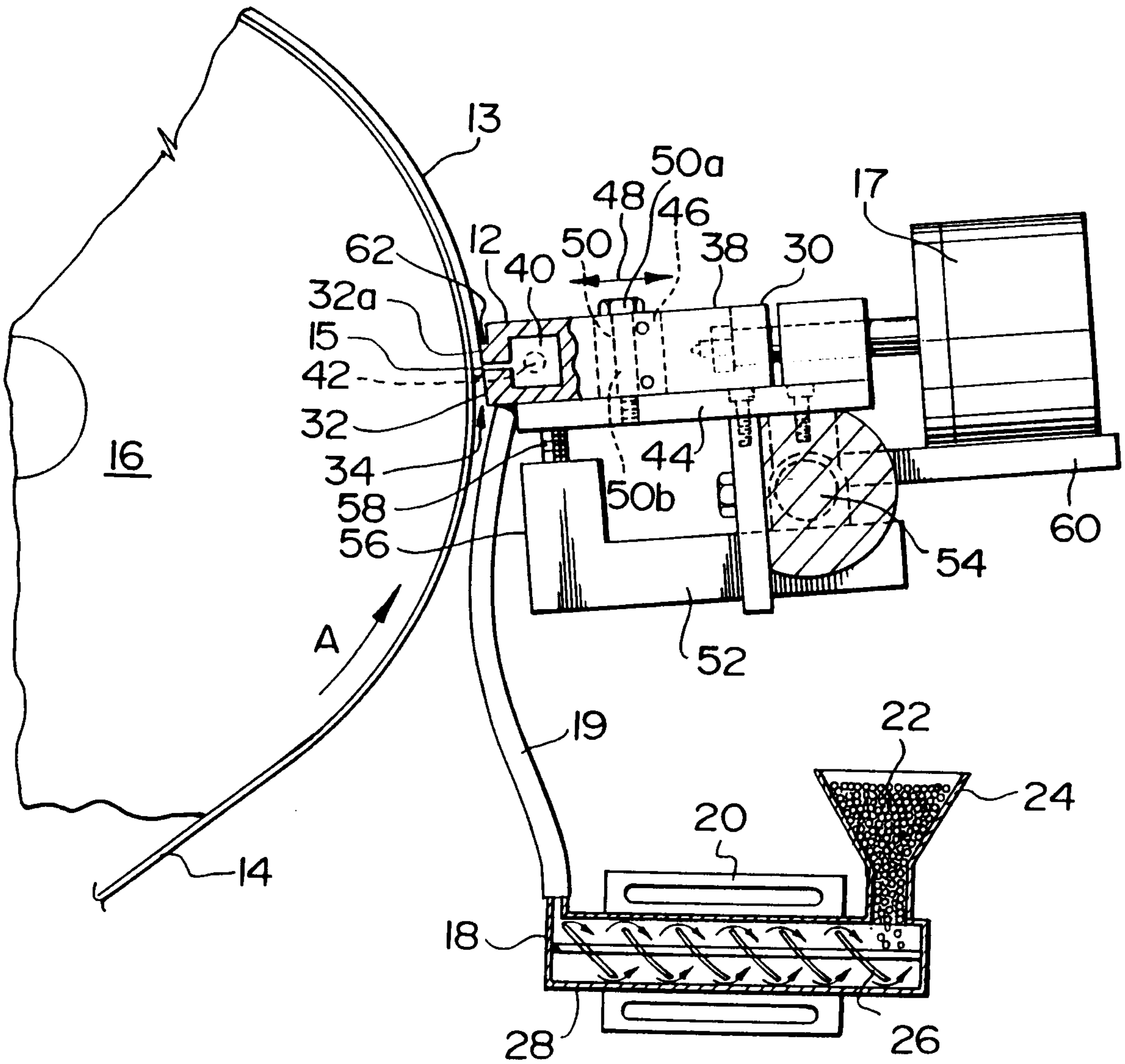
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FIG. 1

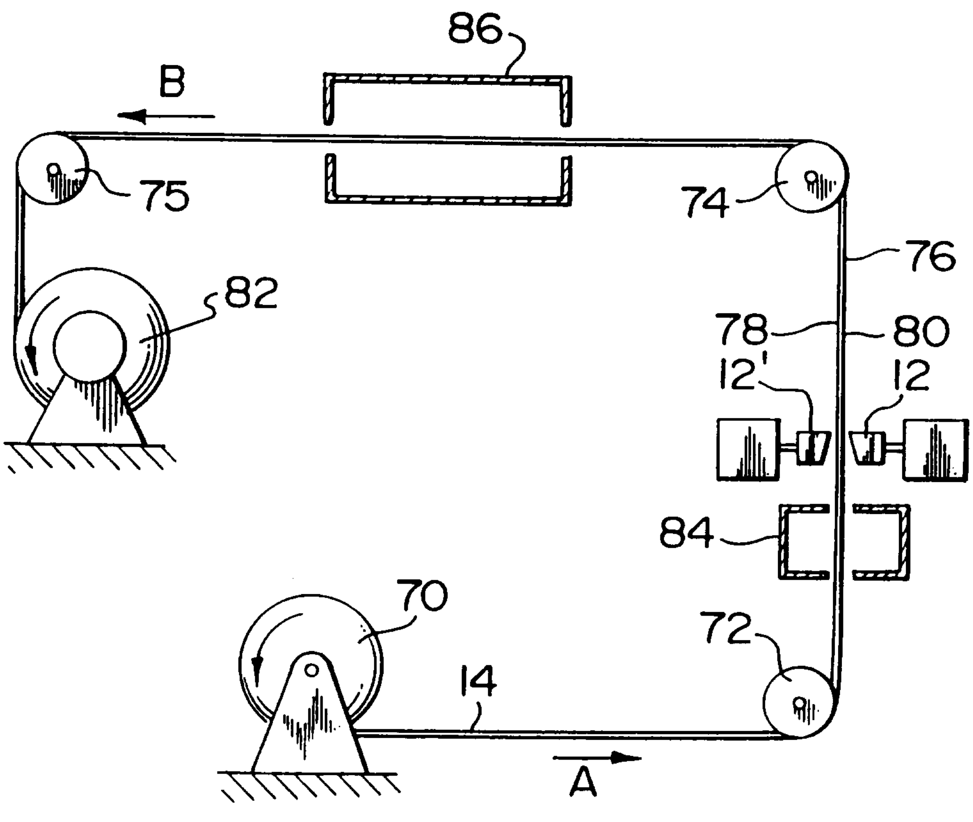

FIG. 2