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METHOD AND APPARATUS FOR CASTING A LIQUID COMPOSITION

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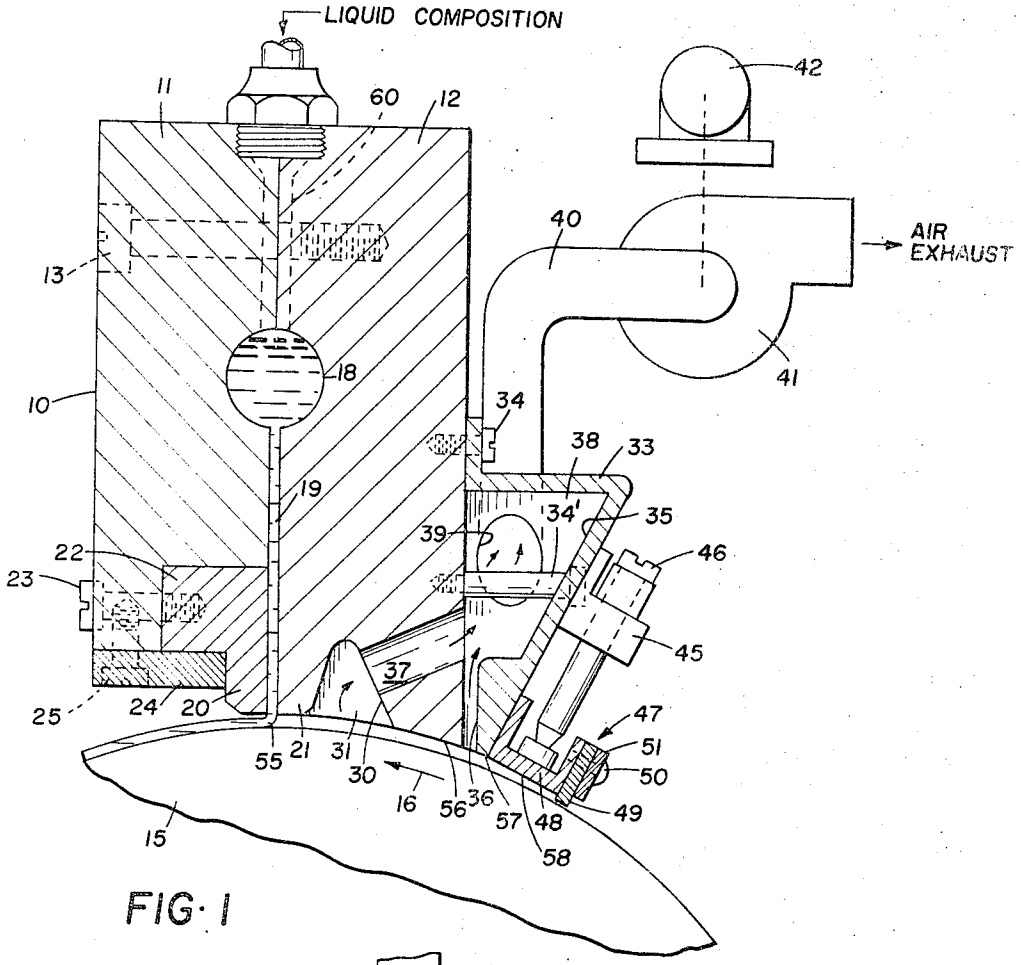

FIG. 1

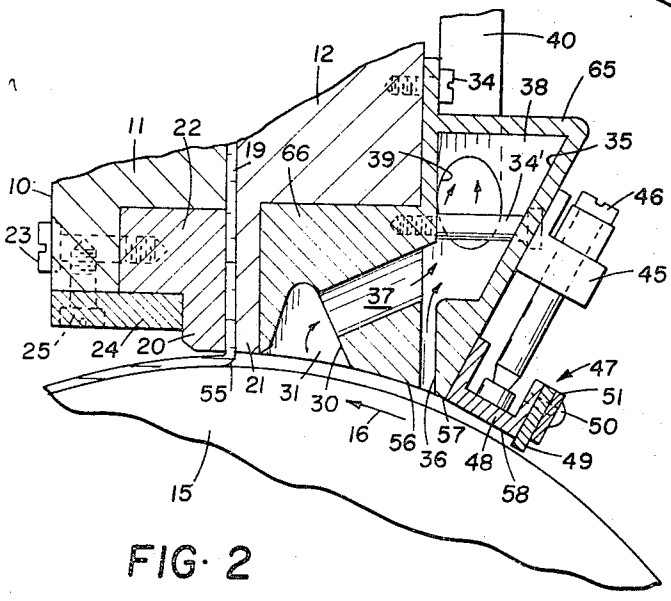

FIG. 2

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METHOD AND APPARATUS FOR CASTING A LIQUID COMPOSITION

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ABSTRACT OF THE DISCLOSURE

Method and apparatus for preventing the entrainment of air beneath a stream of a liquid composition continuously depositing onto a moving casting surface reducing the gas pressure acting on that side of the stream which engages the casting surface to a point below the gas pressure acting on the other side of said stream. This pressure differential is accomplished by reducing the gas pressure on the one side in at least two successive stages in order to decrease the turbulence of the gas in the stage immediately adjacent the point of deposition of the stream.

The present invention relates to a method and apparatus for continuously casting a liquid composition into a thin sheet, and more particularly to a method and apparatus in which the air pressure on one side of the stream of liquid composition being cast is reduced to a sub-atmospheric pressure to increase the intimacy of contact between the stream of liquid composition and the casting surface.

It is well known in the art to cast a liquid composition into a thin sheet or to apply a thin film of such composition to a web of material by flowing a stream of the liquid composition onto a casting surface, or the material to be coated, while continuously moving the surface or material past an application station in a fixed path. While apparatus that is used for the manufacture of such sheeting or film has been satisfactory, it must be operated at a relatively low linear speed to produce sheeting, or a film, that is free of bubbles, puckers and other imperfections which are caused by air becoming entrapped between the stream of liquid composition and the casting surface. If an air pressure differential with respect to the two sides of the stream of liquid composition is maintained at the point where the stream contacts the casting surface, cross lines, or corrugations, are still easily formed in the sheeting or film, particularly where the sheeting or film is very thin, such as .001 inch to .010 inch, due to the relative motion between the extruding die and the casting surface that is caused primarily by vibration of the respective parts.

Such vibrations are imparted to the air drawn into the apparatus on the side of the stream of liquid composition at which a sub-atmospheric air pressure is being maintained, thereby causing the formation of cross lines or corrugations. The frequency of the cross lines or corrugations corresponds substantially to the vibration frequency. The cross lines or corrugations so formed impair the appearance of the sheeting or film to such an extent that its value might be reduced or that it is useless for its intended purpose. To eliminate such vibrations and the consequent cross lines and corrugations would require that the apparatus be completely free of vibration and would not be economically feasible.

One object of the invention is the provision of means for enhancing intimate contact between a stream of liquid composition and the roll or material on which the composition is being cast.

Another object of the invention is the provision of means for creating a sub-atmospheric air pressure on the side of a flowing stream of liquid composition that engages a casting surface, the air pressure differential being created by withdrawing the air in at least two chambers to increase the intimacy of contact between the composition and the casting surface.

Still another object of the invention is the provision of means for creating an air pressure differential with respect to the sides of a stream of liquid composition that is being flowed onto a roll or material by withdrawing the air on one side of the stream in at least two chambers so as to reduce the air turbulence and vibration in the chamber adjacent the stream, thereby assuring intimate contact of the stream of liquid composition with a roll or material on which the composition is being cast and substantially minimizing the formation of cross lines and corrugations.

The above and other objects of the invention are attained by creating a sub-atmospheric pressure, or partial vacuum, on the side of a flowing stream of liquid composition that contacts a rotatable roll, or a material, being moved past an extrusion die for applying the composition. A housing which is made as a removable part, is mounted adjacent the extrusion die and ahead of the line of application of the liquid compositions in the direction of movement of the roll or material. Each of a pair of chambers, one of which can be formed in the extrusion dies and the other of which is part of the housing having an opening which faces the casting surface, that is, the roll or material, the chambers being interconnected and one of the chambers being connected to a vacuum source. An adjustable baffle is positioned ahead of the housing in the direction of movement of the roll and is spaced from the peripheral surface of the roll to provide a slot for regulating the amount of air drawn into the chambers. A large portion of this air is withdrawn through a first chamber so that the air turbulence and vibration in the chamber adjacent to the line of application of the liquid composition to the roll is substantially decreased. With only a small amount of air flowing through the chamber adjacent the stream of liquid composition, it has been found that vibration of the apparatus has substantially no effect on the air in this chamber, so that cross lines and corrugations are practically eliminated. Also, with this arrangement more intimate contact between the stream of liquid composition and the roll, or material is obtained, so that the peripheral speed of the roll can be increased by a relatively large factor.

These and other objects and advantages of the invention will be apparent to those skilled in the art when the following description of the invention is read in conjunction with the drawing. Reference is now made to the drawing in which like reference numerals indicate like parts and wherein:

FIG. 1 is a vertical section through apparatus embodying a preferred form of the invention and showing the structure of an extrusion die and the arrangement of a vacuum chamber relative to the station at which the liquid composition is applied to a roll; and

FIG. 2 is a partial vertical section similar to FIG. 1 showing another embodiment of a vacuum chamber.

With reference to FIG. 1, an extrusion die **10** comprises a pair of plates **11** and **12** which are held in assembled relation by a plurality of screws **13**. The extrusion die **10** is spaced from and extends transversely of a casting roll **15** that is driven continuously, by means not shown, in a direction indicated by arrow **16**. A central opening **18** formed in plates **11** and **12** is connected by a slot **19** to a pair of lips **20** and **21**, the lip **20** being spaced from the surface of roll **15** by a distance greater than the thickness of the sheet being cast and can be of the order of 0.002 inch to 0.500 inch. The lip **20** is formed by a plate **22** that is secured in the end of plate **11** by screws **23** and a bar **24** that is secured in

position on plate 11 by screws 25. The plate 12 is provided with a chamber or recess 30 that extends substantially the width of roll 15 and has an opening at the side facing roll 15, the ends 31 of chamber 30 being closed.

A housing 33 is secured to plate 12 by screws 34 and 34' and is provided with a chamber 35 that is co-extensive with an opening 36 that terminates at the roll 15. The chamber 30 and chamber 35 extend transversely of the roll 15 and are connected by a plurality of openings 37 that are spaced from the roll 15 substantially as shown in FIG. 1. One or both of the ends 38 of housing 33 is provided with an opening 39 that is connected by a conduit 40 to a fan 41 that is driven by a motor 42 for a purpose to be described hereinafter. An angular member 45 is secured to housing 33, as shown in FIG. 1 and carries a plurality of spaced adjusting screws 46 that engage a baffle means 47. The baffle means 47 comprises a resilient channel-shaped member 48 that is fixed to housing 33 and carries a strip 49 of pliable material that is capable of withstanding extrusion temperatures, the strip 49 being secured by screws 50 and a strip 51 to member 48.

From FIG. 1 it will be evident that chamber 30 and opening 36 to chamber 35 are spaced from each other and ahead of the station of application 55 in the direction of movement of roll 15. The bottom surface 56 of plate 12, as well as the bottom surface 57 of the housing 33 and the bottom surface 58 of angular member 48 are spaced from the peripheral surface of roll 15 by a distance of 0.002 inch to 0.500 inch depending on the thickness of the sheeting being cast. The liquid composition that is introduced into the extrusion die 10 via one or more inlets 60 connected to opening 18 flows by gravity, or under pressure through slot 19 and at lips 20 and 21 is applied to the peripheral surface of roll 15. Due to the withdrawal of the air from the chamber 30 and the chamber 35 by fan 41 via openings 37, openings 39 and conduit 40, a negative pressure, or sub-atmospheric pressure, is created on the side of the stream of liquid composition toward chamber 30. This negative pressure can range between 0.1 and 30 inches of water and removes the air that might otherwise become entrapped between the stream of liquid composition and the peripheral surface of the roll 15. The negative pressure therefore draws the sheet of liquid composition into intimate contact with the peripheral surface of roll 15. Since the baffle means 47 can be adjusted relative to the peripheral surface of roll 15 by means of screw 46, the amount of air drawn through the slot formed by strip 49 can be regulated to provide an optimum condition in accordance with the liquid composition that is being applied to roll 15. A large portion of the air that is drawn under baffle 47 by roll 15 is withdrawn through opening 36 and then exhausted from chamber 35 by fan 41. By this arrangement the turbulence and vibration of the air in chamber 30 is substantially minimized, and since this is in a region adjacent to the station 55, cross lines and corrugations are substantially eliminated.

In FIG. 2, the housing 65 is provided with an extension 66 that includes the chamber 30 and openings 37 so that the housing 65 is an integral member having two chambers and cooperating with plate 12 to form a structure similar to that shown in FIG. 1. While the embodiments shown in FIGS. 1 and 2 comprise a chamber 30 and chamber 35, additional chambers can be provided ahead of those shown in the direction of movement of the roll 15 for bypassing the air drawn under the baffle 47.

It has been found that the invention as disclosed above is applicable to the casting of polyolefin films and sheeting, as well as those of polystyrene, polycarbonate, etc. Whether the liquid composition is applied to a chill roll or a heated roll the same intimate contact of the liquid composition to the peripheral surface of the roll 15 is obtained. The invention is also applicable to the coating of a film on a surface of a web of material which can be moved past the lips 20 and 21 in the same manner as the peripheral surface of roll 15. The terms "cast" and "casting," as used in this specification and in the appended claims, are meant to define the formation of unitary, continuous sheeting by applying a flowing stream of a liquid composition to a surface of a continuously moving member from which the sheeting is subsequently removed, and the coating of a surface of a moving web of material with a flowing stream of liquid composition that subsequently becomes a part of the material.

In order to more clearly illustrate the applicability of the invention with respect to continuously casting a liquid composition, or applying a liquid composition to another material, several specific examples are described hereinafter. In addition to these examples reference can also be made to the examples set forth in U.S. Patent 2,681,294, wherein various initial air pressure differentials are disclosed for coating various materials with different fluid compositions. It is to be understood, of course, that the invention is not to be limited to the materials nor the various factors set forth in these examples.

EXAMPLE I

This example shows the speed at which polyethylene sheeting can be cast without any pressure differential existing on the sides of the stream of liquid composition applied to the casting surface. Pellets of polyethylene were first melted and then introduced into the extrusion die at a temperature of 510° F. This melt was applied to the casting roll which was rotated at a linear speed of 16 ft./min. and maintained at a temperature of 115° F. The extrusion die was positioned relative to the peripheral surface of the casting roll to cast a film 0.005 inch thick. With no air pressure differential, the linear speed of the casting roll was determined by the rate at which the melt could be applied to the roll without forming bubbles and puckers caused by air becoming entrapped between the melt and the surface of the casting roll.

EXAMPLE II

To cast polyethylene sheeting of the same thickness, namely 0.005 inch, as in Example I, the polyethylene pellets were melted and then introduced into the extrusion die at a temperature of 525° F. The casting roll was rotated at a linear speed of 37 ft./min. and maintained at a temperature 145° F. A pressure differential of 12 inches of water was maintained on the sides of the stream of polyethylene with the use of two chambers in accordance with this invention. The linear speed of the casting roll was determined primarily by the melting capacity of the extruder that feeds the liquid polyethylene to the extrusion die, the speed being more than twice that of the previous example.

EXAMPLE III

In casting a film of polypropylene 0.0048 inch thick, the polypropylene was introduced into the extrusion die at a temperature of 520° F. The casting roll was rotated at a linear speed of 35 ft./min. and maintained at a temperature of 150° F. A pressure differential of 12 inches of water, by using the method of this invention under similar conditions of vibration, provided intimate contact of the stream of polypropylene with the casting surface without the formation of cross lines or corrugations. As in the previous example, the linear speed of the casting roll was determined primarily by the melting capacity of the extruder which supplies the liquid polypropylene to the extrusion die.

EXAMPLE IV

In casting a film of polycarbonate 0.0055 inch thick, polycarbonate pellets are melted and supplied to the extrusion die at a temperature of 590° F. The casting roll was rotated at a linear speed of 26 ft./min. and maintained at a temperature of 245° F. A pressure differential

of 20 inches of water was maintained on the sides of the stream of polycarbonate, using the method of this invention under conditions of vibration similar to those of Examples II and III. Intimate contact between the stream of polycarbonate and the surface of the casting roll was obtained without the formation of cross lines or corrugations in the resulting sheeting. As in the previous examples, the linear speed of the casting roll is determined by the rate which the melt can be fed to the extrusion die.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention as described hereinabove and as defined in the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a method of casting wherein a continuous stream of liquid composition is applied to a moving receiving member, and the side of said stream, which becomes contiguous to said receiving member, is subjected to a gas pressure that is less than that at the other side of said stream to provide a pressure differential for increasing the intimacy of contact between said stream and said receiving member, the improvement which comprises:

establishing said pressure differential by serially reducing the gas pressure at the first-mentioned side by at least two zones in the vicinity of the first-mentioned side and spaced in the direction of movement of said receiving member for decreasing the turbulence and vibration of the gas in the zone adjacent the first-mentioned side.

2. A method of casting in accordance with claim 1 wherein the pressure differential is of the order of 0.10 inch to 30.00 inches of water.

3. A method of casting in accordance with claim 1 wherein the pressure at said other side of said stream is atmospheric and the pressure at the first-mentioned side is sub-atmospheric.

4. In a casting apparatus having a movable casting surface; extruding means having a slot extending transversely of the direction of movement of said casting surface and spaced from the latter for applying a free and continuous stream of liquid composition to said casting surface; and a first chamber having an opening facing said casting surface that is substantially parallel to and arranged ahead of said slot in said direction of movement; the improvement which comprises:

at least one other chamber having an opening facing said casting surface and arranged substantially parallel to and ahead of said opening in said first chamber in said direction of movement; and

means connected to said chambers for establishing a gas pressure at the side of said stream of liquid composition adjacent said first chamber that is less than that at the other side;

whereby the turbulence and vibration of the gas in said first chamber is decreased and the intimacy of contact of said stream of liquid composition with said casting surface is increased.

5. Casting apparatus in accordance with claim 4 wherein said first chamber is formed integral with said extruding means.

6. Casting apparatus in accordance with claim 4 wherein said first chamber and said other chamber are interconnected by a plurality of openings and said means is connected to said other chamber.

7. In a casting apparatus having a movable casting surface; and extruding means having a slot extending transversely of the direction of movement of said casting surface and spaced from the latter for applying a free and continuous stream of said liquid composition to said casting surface; the improvement which comprises:

a member arranged contiguous to and ahead of said extruding means in said direction of movement and extending transversely of the latter; said member comprising a first chamber arranged substantially parallel to and ahead of said slot in said direction of movement and having an opening facing said casting surface, and a second chamber arranged substantially parallel to and ahead of said first chamber in said direction of movement and having an opening facing said casting surface, said first chamber being connected to said second chamber by a plurality of spaced openings;

baffle means arranged ahead of said second chamber in said direction of movement and movable relative to said casting surface to provide a transverse adjustable slot for regulating the air drawn into said chambers; and

means connected to said second chamber for establishing an air pressure at the side of said stream of liquid composition adjacent said first chamber that is less than that at the other side;

whereby the air turbulence and vibration in said first chamber is decreased and the intimacy of contact of said free stream of liquid composition with said casting surface is increased.

8. Casting apparatus in accordance with claim 7 wherein the air pressure at said other side of said stream is atmospheric and the air pressure at the first-mentioned side is sub-atmospheric.

9. Casting apparatus in accordance with claim 7 including means arranged on said member and coupled to said baffle means for moving the latter relative to said casting surface.

10. Casting apparatus in accordance with claim 8 wherein the air pressure differential is of the order of 0.10 inch to 30.00 inches of water.

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