

- [54] **POLYSTYRENE FOAM SHEET MANUFACTURE**
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- [*] Notice: This patent is subject to a terminal disclaimer.
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- [22] Filed: **Oct. 6, 1997**

Related U.S. Application Data

- [63] Continuation of application No. 08/117,961, Sep. 7, 1993, Pat. No. 5,674,602, which is a continuation of application No. 07/752,430, Aug. 30, 1991, abandoned, which is a continuation of application No. 07/538,291, Jun. 14, 1990, Pat. No. 5,082,608.
- [51] Int. Cl.⁶ **B32B 3/26; B29C 41/00; B29C 17/00**
- [52] U.S. Cl. **428/304.4; 264/51; 264/230; 264/342 R; 264/342 RE**
- [58] Field of Search **428/304.4; 264/51, 264/230, 342 R, 342 RE**

References Cited

U.S. PATENT DOCUMENTS

- 3,796,779 3/1974 Greenberg 264/50
- 4,049,768 9/1977 Luthra 264/45.5

- 4,424,287 1/1984 Johnson et al. 521/74
- 4,436,679 3/1984 Winstead 264/40.3
- 4,486,366 12/1984 Reddy 264/25
- 4,657,715 4/1987 Myers et al. 264/45.5
- 4,663,107 5/1987 Takada et al. 264/519
- 4,747,983 5/1988 Colombo 264/45.5
- 5,082,608 1/1992 Karabedian et al. 264/46.1
- 5,443,769 8/1995 Karabedian et al. 264/46.1
- 5,674,602 10/1997 Karabedian et al. 428/304.4

FOREIGN PATENT DOCUMENTS

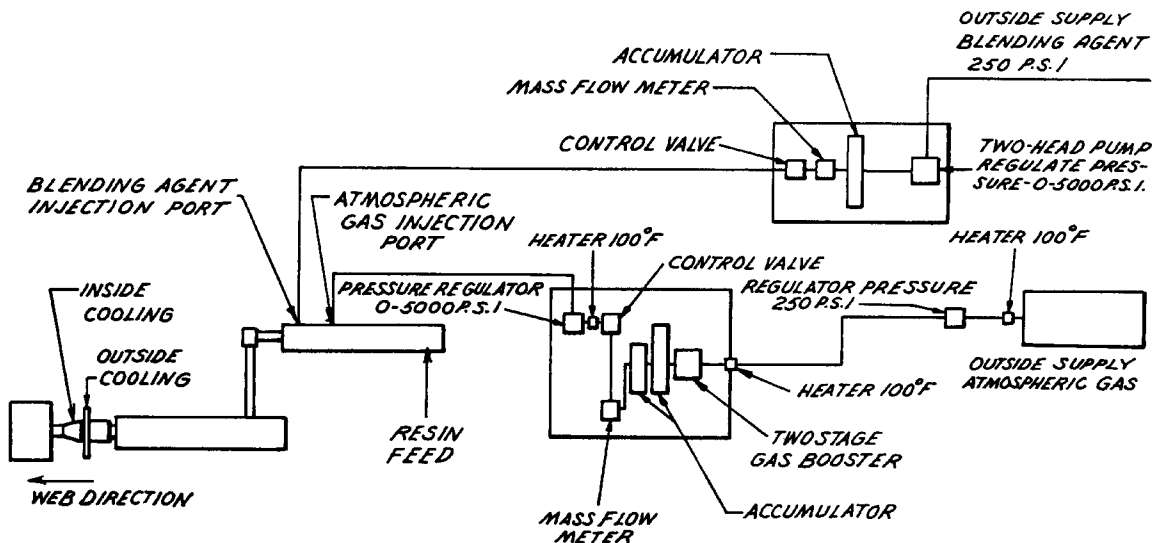
- 7952724 11/1979 Australia .

Primary Examiner—Daniel Zirker

[57] **ABSTRACT**

The method of making polystyrene foam for foam products which comprises utilizing atmospheric gases as the blowing agents or preferably mixing one or more of these gases and a blending agent which is non-volatile at the extrusion temperatures, introducing the mixture to a molten thermoplastic polystyrene resin containing nucleating agents such as sodium bicarbonate and citric acid and extruding the thermoplastic in the form of a foam. The resultant foam has substantially no residual blowing agent, is dimensionally stable at ambient temperatures and when used with a non-volatile blending agent can be made with small amounts of blowing agent permitting cooling of the melt without high loading on the extruder. The foam may be coextruded with one or more layers of thermoplastic film so that the resultant product is adapted for use for plates, cups, food containers or packaging and for labels for containers such as glass and plastic containers and for labels that are shrunk in place on a container.

19 Claims, 3 Drawing Sheets



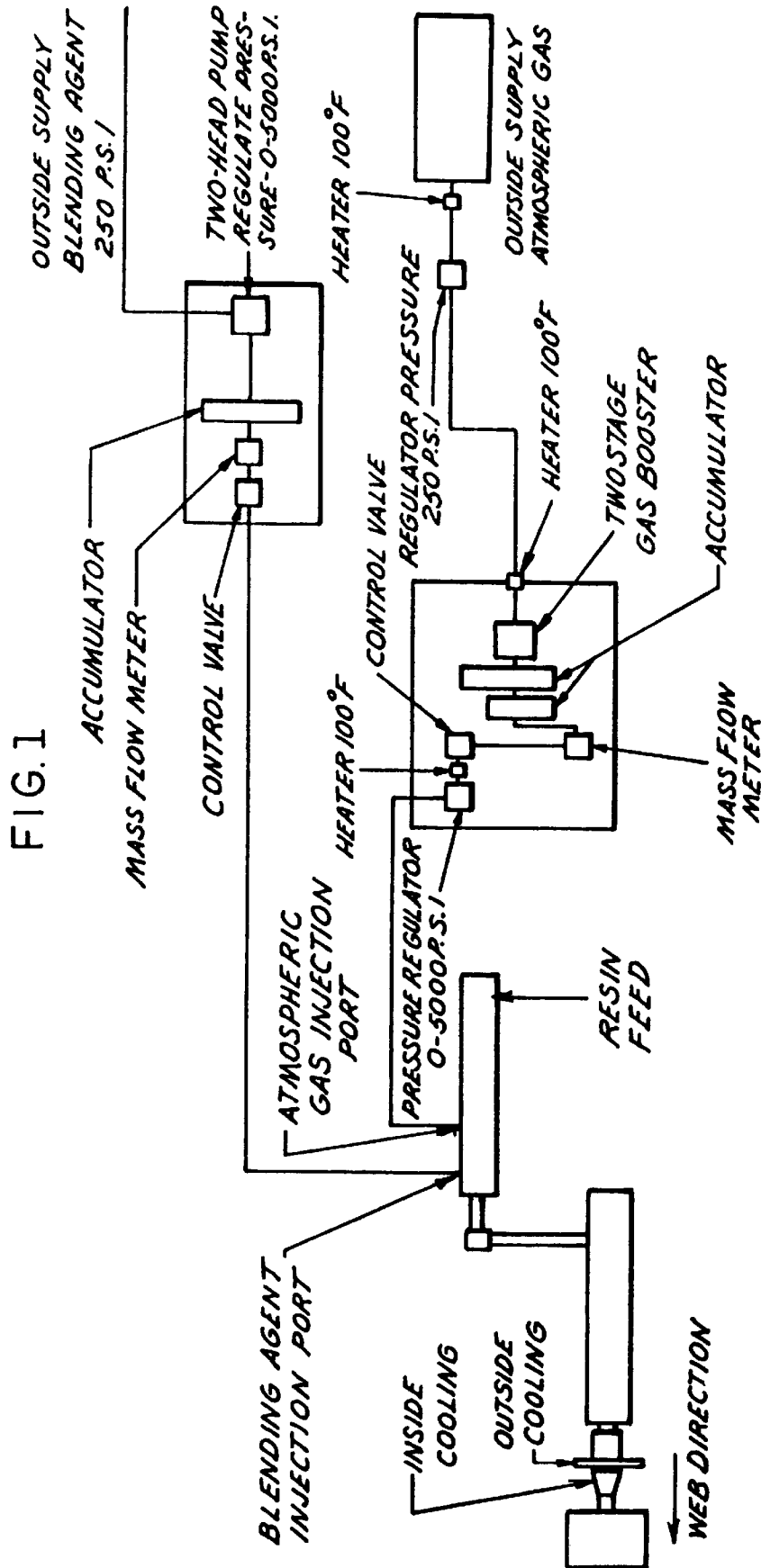


FIG. 2

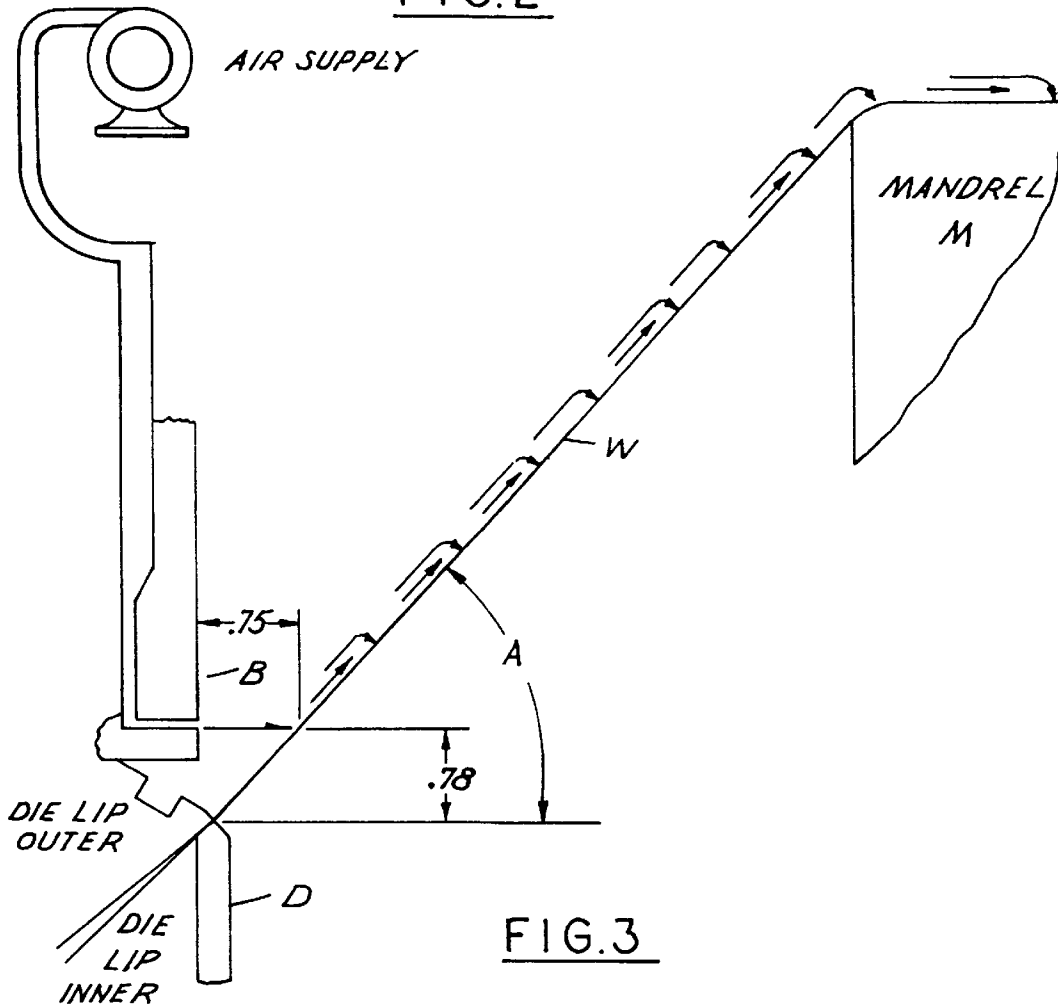
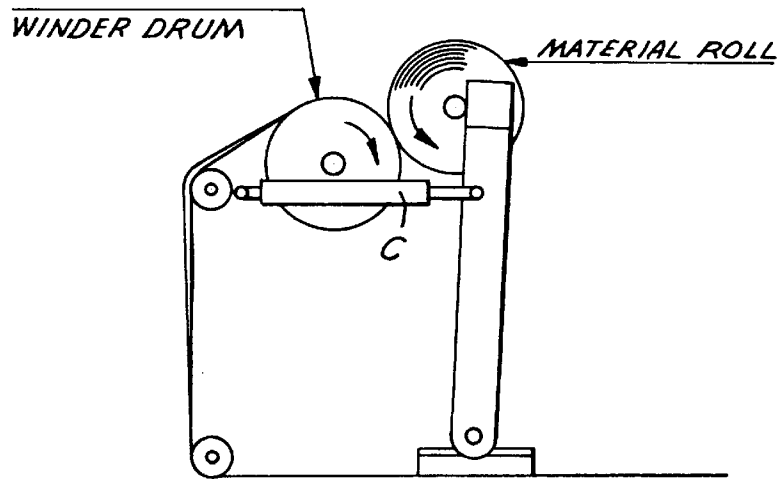
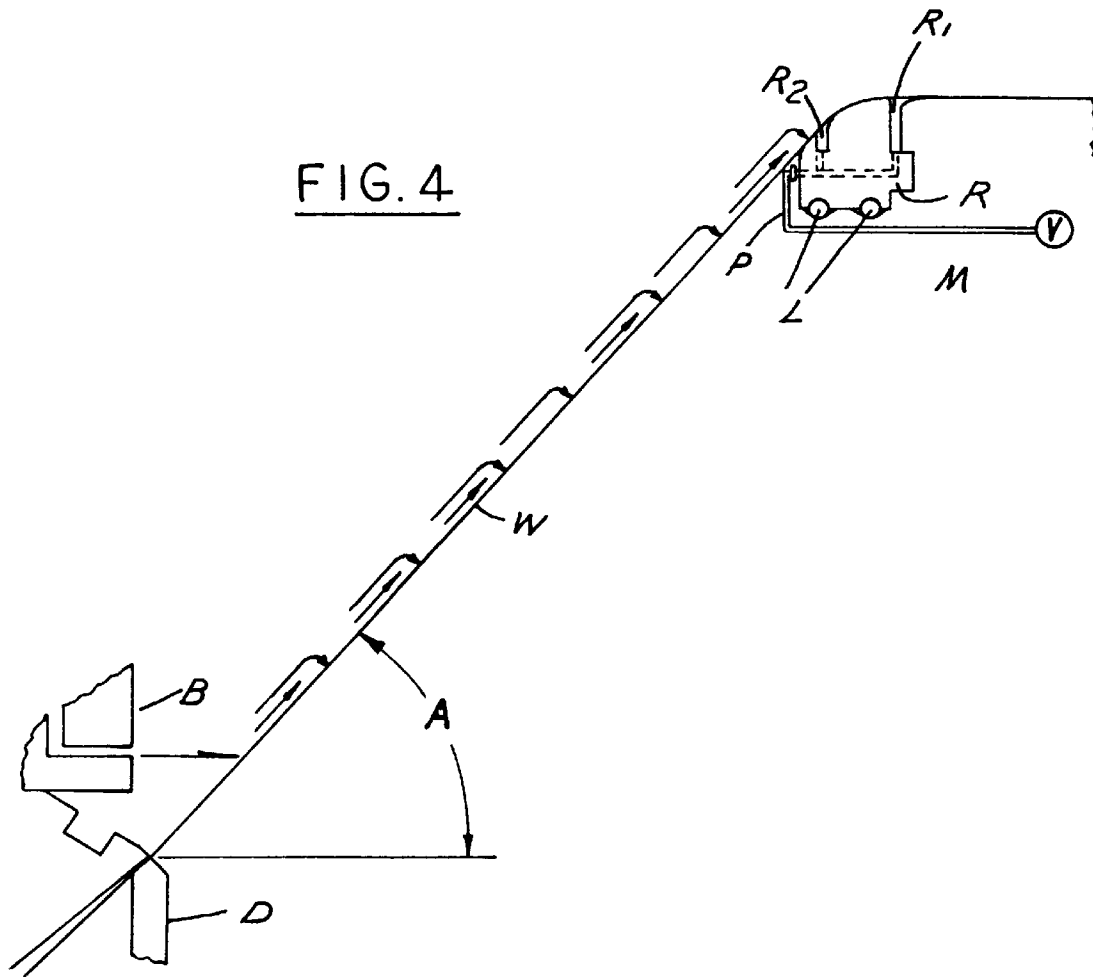


FIG. 3





POLYSTYRENE FOAM SHEET MANUFACTURE

This application is a continuation of application Ser. No. 08/117,961 filed Sep. 7, 1993, now U.S. Pat. No. 5,674,602, which is a continuation of application Ser. No. 07/752,430 filed Aug. 30, 1991 and now abandoned, which is a continuation of application Ser. No. 07/538,291 filed Jun. 14, 1990, now U.S. Pat. No. 5,082,608.

This invention relates to manufacture of foam and particularly the manufacture of polystyrene foam.

BACKGROUND AND SUMMARY OF THE INVENTION

In the manufacture of polystyrene foam, it has been common to utilize blowing agents such as chlorofluorocarbons solely or together with alkanes, usually pentane or isopentane. Such a foam is usually made by extrusion. Due to the solubility of chlorofluorocarbons and certain alkanes in polystyrene, the extrusion melt viscosity is reduced and this permits sufficient cooling of the melt so that high load, indicated by amperage, will not be applied to the extruder drive motor.

Pentane and chlorofluorocarbons such as Freon 11 and 12, for example, are partially soluble in polystyrene and reduce the melt viscosity enabling the extruder adequately to cool and extrude the molten plastic material at lower loads and temperatures in order to generate a good smooth foam surface and appearance, small cell size control for opacity and other foam physical properties such as orientation, shrinkage characteristics and stiffness. Loss of residual blowing agent over a period of time, however, creates a shrinkage in the sheet material, an increase in thickness and an increase in softening point temperature as the residual blowing agent is reduced.

Where the foam is intended for use as a label on glass or plastic containers wherein the label is shrunk in place, the foam material is extruded and stretched in one direction more than the other. Preferably, the label material is coextruded with a plastic film. The gradual loss of residual blowing agent causes the label material to vary in shrinkage characteristics.

U.S. Pat. No. 4,424,287 is directed to a polymer foam process for making thermoformed articles wherein the blowing agent comprises at least an atmospheric gas and at least one volatile plasticizing blowing agent. As stated in this patent, early attempts to mix normally liquid hydrocarbons and normally gaseous blowing agents have not been successful and it is necessary that great care be exercised in production of a polymer foam with highly-volatile blowing agents such as carbon dioxide even in such a mixture. Accordingly, as set forth in this patent, it was thought necessary to utilize both the inert gas such as carbon dioxide and a volatile plasticizing organic blowing agent such as pentane and to thermoform the articles immediately after extrusion.

U.S. Pat. No. 4,436,679 discloses a method of making foam wherein water and natural gas are introduced into a melt.

U.S. Pat. No. 4,470,938 discloses a method of utilizing atmospheric gases for forming thermoformed articles wherein the process includes introducing, to a molten resin charge under pressure, a gas blowing agent from a supply gas source of comparatively higher pressure, said introducing being by means of discrete uniform volumetric charges of gas into said resin, wherein said discrete volumetric

charges are introduced by means of a free piston-cylinder combination given motive power by said supply gas source. Although this patent mentions the use of a number of atmospheric gases, no claim was made as to any beneficial results as to the product and no commercial use has been made of such a process.

Among the objectives of the present invention are to provide a method of making polystyrene foam wherein the method utilizes atmospheric gases as blowing agents which are inherent in the atmosphere; wherein the blowing agent is substantially entirely released when the polystyrene foam is extruded; wherein the melt can be cooled to normal process levels and not create high loading on the extruder or shear heat from high polymer viscosity; wherein the amount of shrinkage can be controlled as may be required for the ultimate use of the foam; wherein the density and cell size can be controlled; and which utilizes conventional extrusion apparatus.

In accordance with the invention, the method of making polystyrene foam comprises mixing an atmospheric gas such as carbon dioxide, nitrogen or air and preferably a non-volatile blending agent, introducing the gas or the mixture to a molten thermoplastic polystyrene resin containing nucleating agents such as sodium bicarbonate and citric acid and extruding the thermoplastic in the form of a foam. The resultant foam has substantially no residual blowing agent, is dimensionally stable at ambient temperatures and when used with a non-volatile blending agent can be made with small amounts of blowing agent permitting melt cooling without high loading on the extruder. The foam may be coextruded with one or more layers of a thermoplastic film so that the resultant product is adapted for use for plates, cups, food containers or packaging and for labels for containers such as glass and plastic containers and for labels that are shrunk in place on the container.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic drawing of an extrusion apparatus utilized in the method.

FIG. 2 is a partly schematic diagram of a portion of the extrusion apparatus.

FIG. 3 is a schematic drawing of an apparatus utilized in the process downstream of the extruder.

FIG. 4 is a partly schematic diagram of a modified form of extrusion apparatus.

DESCRIPTION

In accordance with the invention, an atmospheric gas such as carbon dioxide, nitrogen or air alone or preferably combined with a blending agent which is non-volatile at the extrusion temperatures such as a high molecular weight ester having low volatility at high temperatures is introduced into the thermoplastic molten polystyrene melt, and the mixture is extruded.

Where a mixture of atmospheric gas and a blending agent which is non-volatile at the extrusion temperatures is used, the atmospheric gas and the non-volatile blending agent may be mixed prior to introduction or separately.

Referring to FIG. 1, the atmospheric gas is supplied to the first stage of a tandem extruder system through a pressure regulator, heater, two stage gas booster and accumulator, mass flow meter control valve, second heater and pressure regulator to the molten massive plastic material in the first or primary extruder section. Where the liquid non-volatile blending agent such as the non-volatile ester is used, it is

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