

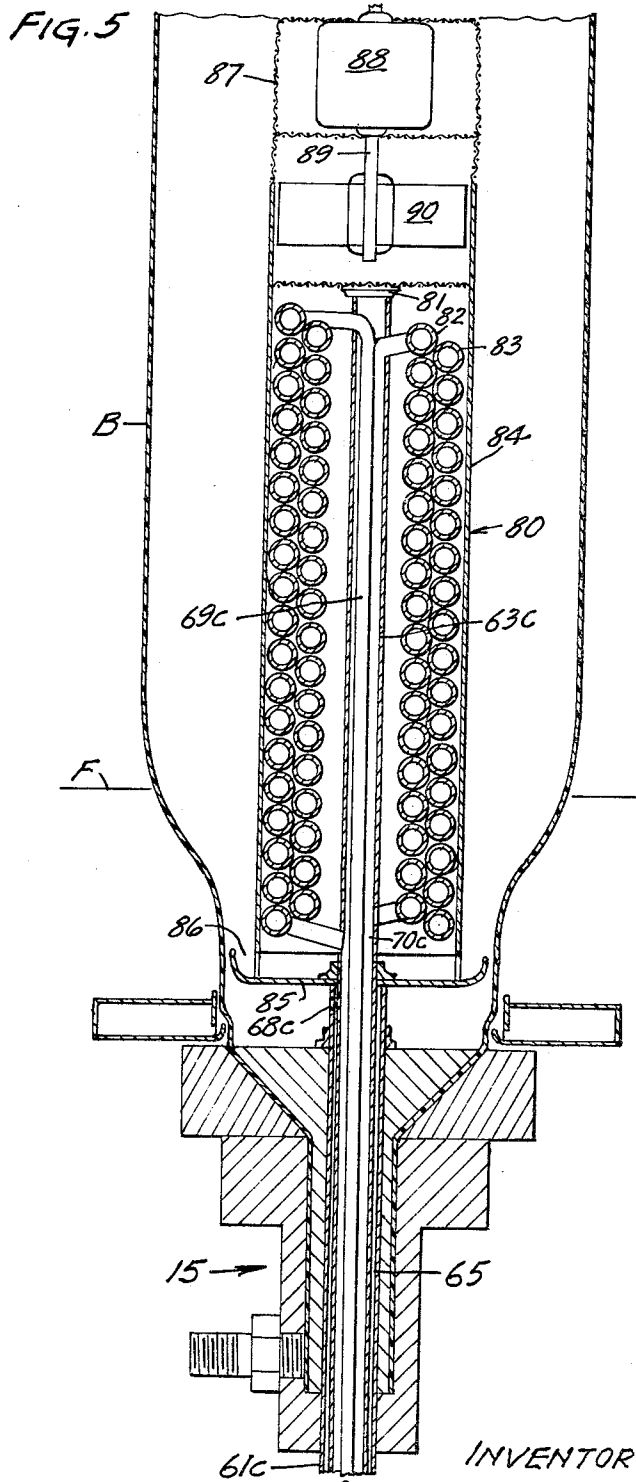
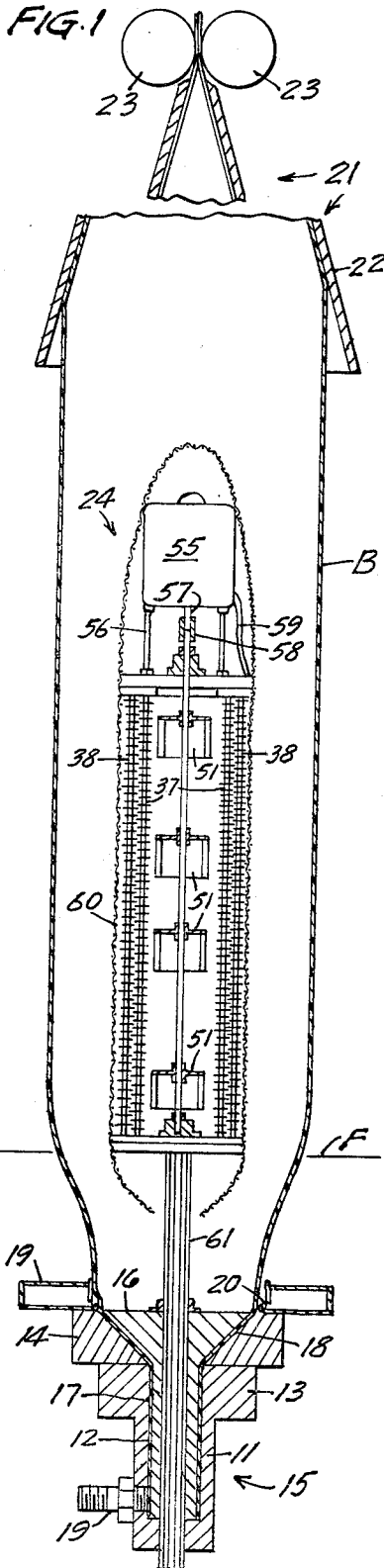
Jan. 13, 1970

A. L. JAMES
PROCESS AND APPARATUS FOR COOLING A BLOWN TUBE
THERMOPLASTIC EXTRUSION

3,488,809

Original Filed Dec. 27, 1965

3 Sheets-Sheet 1



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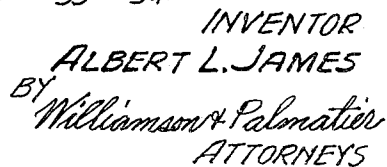
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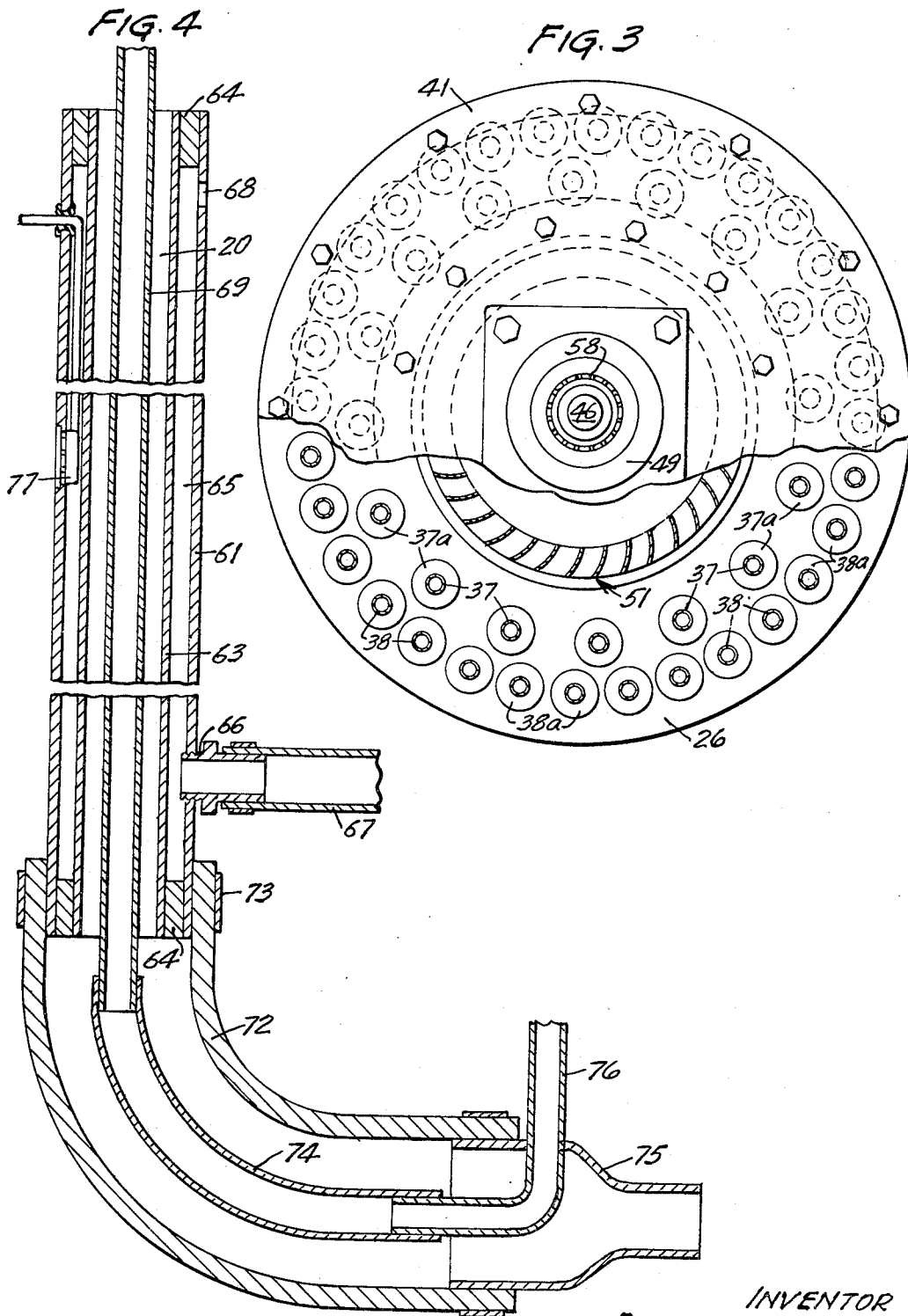
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PROCESS AND APPARATUS FOR COOLING A BLOWN TUBE THERMOPLASTIC EXTRUSION

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Continuation of application Ser. No. 517,519, Dec. 27, 1965. This application Oct. 23, 1968, Ser. No. 770,899

Int. Cl. B29d 23/04

U.S. Cl. 18-14

3 Claims

ABSTRACT OF THE DISCLOSURE

Process and apparatus for cooling a blown tube thermoplastic extrusion wherein molten plastic film is extruded from an extrusion die and is expanded into an elongate bubble by trapped encapsulated air between the die and a bubble closing medium including cooperating nip rollers located remotely from the die. A heat exchanger positioned within the bubble and including a plurality of elongate tubes extending axially of the bubble and arranged in circular fashion and through which a liquid coolant flows. The heat exchanger having a cross-sectional size substantially smaller than the internal cross-sectional diameter of the bubble so that a relatively large annular unobstructed volumetric space is defined between the inner surface of the bubble and the heat exchanger. A coolant supply conduit and a coolant return conduit connected with a refrigeration system located exteriorly of the bubble and extending through the extrusion die and into the bubble. The supply conduit being connected with the tubes at points remote from said extrusion die and said coolant, return conduit being connected with said tubes at points adjacent said extrusion die. A blower device positioned within the bubble and being operable to circulate the encapsulated trapped air within the bubble or said tubes and throughout the interior of the bubble at a substantially uniform pressure.

This application is a continuation of Ser. No. 517,519, filed Dec. 27, 1965, now abandoned.

An object of this invention is to provide a novel blown tube process for making film tubing and sheeting from fluid thermoplastic material wherein an elongate bubble or tube of film is extruded and formed, and in which the interior of the bubble is cooled through the medium of a heat exchanger with circulation of a gaseous medium.

These and other objects and advantages of the invention will more fully appear from the following description made in connection with the accompanying drawings, wherein like character references refer to the same or similar parts throughout the several views, and in which:

FIG. 1 is a diagrammatic side view partly in section and partly in elevation of the bubble forming apparatus foreshortened for clarity.

FIG. 2 is a detail vertical cross-sectional view on an enlarged scale of the cooling device.

FIG. 3 is a plan view of the cooling device on the same scale as FIG. 3 partly in section and partly in elevation, illustrating details of construction of the cooling device.

FIG. 4 is a fragmentary vertical sectional view on an enlarged scale illustrating details of construction of the lower portion of the cooling device, and

FIG. 5 is a diagrammatic side elevational view illustrating a modified form of the cooling device.

Referring now to the drawings and more specifically to FIGS. 1-4, it will be seen that one embodiment of the bubble forming extruder apparatus designated generally by the reference numeral 10 is thereshown.

The extruder apparatus 10 is of conventional construction such as any of the commercial available extruders

in which the blown tube or bubble is vertically extruded through a tower to collapsing rolls which flattens the cylindrical tube, the flattened tube finally being rewound over a core into a roll. This extruder apparatus 10 is therefore comprised of a conventional tubular blown film die including a lower die body 11 having a bore 12 therethrough and having an enlarged collar 13 integrally formed at the upper end thereof.

It will be noted that the bore 12 through the lower die body 11 is reduced at its lowermost end as best seen in FIG. 1. An upper die body 14 is fixedly attached to the collar 13 of the lower die body by any conventional securing means (not shown) such as bolts or the like. The upper die body 14 has a vertically disposed generally frusto-conical recess therein which communicates with the bore 12 of the lower die body 11. A generally cylindrical mandrel or core 15 having a generally frusto-conical upper portion 16 integrally formed therewith is positioned within the lower and upper die bodies as best seen in FIG. 1 so that a vertically oriented passage is formed including a cylindrical lower portion 17 and an upwardly opening frusto-conical upper portion 18. The annular opening of the die passage constitutes the lips of the die.

The fluid thermoplastic material is fed through a core or opening 19 into the passage and is extruded through the frusto-conical portion of the passage vertically in the form of a cylinder. When this cylinder is vertically drawn, a continuous operation may be effected and conventional cooling means are provided for cooling the film cylinder or bubble. This cooling means comprises a generally annular shape hollow air ring structure or plenum 19 which is connected to a source of air under pressure and which is positioned in very close proximity to the discharge end of the upper portion 18 of the passage through which the fluid thermoplastic material is extruded. This ring structure 19 has an annular vertically oriented passage 20 which, as shown, discharges a continuous stream of air against the exterior surface of the film tube or bubble just as the film is extruded and this cylindrical curtain of air is intended to cool the film bubble in its upward path of travel. In order to cool effectively, it is essential to produce a high velocity curtain or stream of air and it will therefore, be noted that the discharge passage 20 is of venturi construction to thereby produce an increase in velocity of air that is discharged in its upward pattern of travel.

The extruded thermoplastic material or bubble after having been cooled sufficiently to a degree to avoid blocking or sticking is collapsed inwardly as the bubble passes through a collapsing frame 21 which is comprised of a pair of collapsing frame members 22 that converge upwardly. A pair of collapsing nip rolls 23 are positioned above and in close proximity to the upper terminal ends of the collapsing frame members 22 and completely collapse the tubular film so that the film may be rewound over a bore into a roll. In the event that sheeting is desired, the thermoplastic tubing or bubble is slit in a manner well known in the art.

Although the size of the tubing or bubble being extruded is to some degree determined by the size of the extruding dies, the major factor that determines the diameter of the tube being formed is the volume of air that is encapsulated within the bubble or tubing during formation of the latter. To this end it is pointed out that as the extruding process is begun, the upper end of the tubing is closed and is thereafter pulled through the collapsing tower and through the collapsing nip rolls and trained over the core or rewind roll. Air is then introduced into the interior of the bubble to distend the same to the desired diameter and this air is encapsulated within the bubble since the collapsing nip rolls also seal the upper end portion of the film bubble. In the event that

the bubble is torn or there is some leakage therein, additional encapsulating air will be introduced into the bubble or tube.

The above described apparatus and process is conventional in the blown film art and the air which is discharged by the air ring structure 19 constitutes the primary cooling medium for the film tube or bubble of the thermoplastic material being extruded. In the event that polyethylene film is being extruded, the hot film will have a temperature of about 300–350 degrees F. as the polyethylene is drawn from the die and this film temperature must be reduced to approximately 100 degrees F. or the interior surfaces of the film tube will block and stick together and will, therefore, be impossible to open. In this conventional process, it will be seen that the heat given off from the polyethylene must be removed from outside the bubble and this heat is transmitted to the sluggishly moving air of the building interior and especially at the upper levels of the tower. When relatively heavy gauge film is being extruded, because of the relatively poor heat removal properties of sluggishly moving air, the extruding operation must be run at a relatively low linear speed or alternatively a relatively high tower is required in order to achieve a sufficient reduction in temperature (100 degrees F. for polyethylene) to permit collapsing of the film. It is also pointed out that in the conventional air blown extrusion systems not only is air a relatively poor heat transfer medium, but the convection currents produced are of such low velocity especially at upper levels of the building interior whereby these convection currents do not bring a sufficient amount of air in contact with the surfaces of the film to be cooled. Further, even though polyethylene film, for example, is a very poor heat conductor, the conventional blown film process requires the transmission of the heat through the thickness dimension of the film.

In the present invention, not only is the exterior cooling means retained, but provision is also made for cooling the interior of the bubble through the medium of a heat exchanger with circulation of a gaseous medium. With this type of arrangement, some of the functional advantages obtained are: The exposed surface area of the film being cooled is substantially doubled; there is no necessity of removing the heat from within the bubble by transmitting this heat through the film to the outside; and rapid circulation within the bubble constitutes a more efficient heat transfer means.

The cooling device designated generally by the reference numeral 24 is comprised of a bottom plate assembly 25. This bottom plate assembly is of generally circular configuration.

The bottom plate assembly 25 is comprised of a substantially circular flat top plate 26 which has a first set of circumferentially arranged openings 27 therethrough and a second or outer set of circumferentially arranged openings 27a therethrough. It is pointed out that the two sets of openings 27 and 27a are circularly arranged and are concentric relative to each other.

A generally flat center plate 28 having an upturned annular flange formed at the periphery thereof is secured to the upper plate 26 by suitable bolts 30 that extend through apertures in the center plate and engage in threaded apertures in the upper plate. It will be noted that this center plate 28 has a plurality of circumferentially arranged openings 28a therein that are circumferentially arranged and extend axially through the annular flange 29 thereof. It is pointed out that each of the openings 28a in the center plate 28 is disposed in registering relation with one of the openings 27a of the top plate 26.

It will be noted that the upper surface of the upturned flange 29 of the center plate engages the lower surface of the upper plate 26 so that these plates are spaced from each other and define a generally large chamber or passage 31 that communicates with the openings 27 in the upper plate 26. It will also be noted that the center

plate 28 is also provided with a centrally located opening 28b therein as best seen in FIG. 2.

The bottom plate assembly 25 also includes a generally flat lower plate 32 having an upturned annular flange 33 integrally formed therewith. This annular flange is suitably apertured to permit passage of suitable bolts 34 therethrough and through registering apertures in the center plate, each bolt threadedly engaging one of a plurality of apertures in the upper plate 26 whereby the three plates are rigidly affixed to each other. It will be noted that the lower plate 32 is spaced downwardly from the center plate 28 to define a generally large distribution chamber or passage 35 therebetween through which a liquid coolant flows. It will further be noted that the inner vertical surface of the upturned annular flange 33 is spaced outwardly of the exterior surface of the upturned annular flange 29 of the center plate 28 so that passages 27a and 28a communicate with the chamber 35. It will further be noted that the lower plate 32 has a centrally located opening 36 therein which is of substantially greater diameter than the opening 28b or the center plate 28.

Referring again to FIG. 2 it will be noted that a plurality of vertically extending pipes or tubes 37 are provided and are arranged in a cylindrical fashion, each being rigidly secured at its lower end to the upper plate 26 and each communicating with one of the passages 27. Each of the tubes 37 is provided with a plurality of radially extending cooling fins 37a. The cooling device also includes a second set of pipes or tubes 38, similar in size to the tubes 37 and arranged in a cylindrical fashion in the manner of the tubes 37. It will also be noted that the second set of tubes 38 are spaced radially outwardly but concentrically of the tubes 37 and each is provided with a plurality of radially extending cooling fins 38a. The lowermost ends of each of the tubes 38 is rigidly affixed to the upper plate 26 and communicates with one of the openings 27a, an opening 28a and the chamber 35.

A chamber defining annular ring structure 39 having upturned annular flanges 40, the latter having threaded taps therein, is secured to a generally flat circular top plate assembly 41 by bolts 42 that project through apertures in the top plate assembly 41 and threadedly engage in the threaded taps of the flanges 40. It will be noted that the flanges 40 are concentrically arranged with respect to each other and each engages a lower surface of the top plate assembly 41 so that a chamber 43 is defined by the chamber defining ring structure and top plate assembly. It will be noted that the ring structure 39 has a first set of openings 44 therein which extends axially therethrough and which arranged in a circular pattern. This ring structure 39 also has a second set of openings 45 therethrough which are also circumferentially arranged exteriorly and concentrically of the first set of openings.

It will be seen that the tubes 37 are fixedly connected at their upper ends to the ring structure 39 and communicate with the openings 44 therein. Similarly, the tubes 38 are also fixedly connected at their upper end to the ring structure 39 and communicate with the openings 45 therein. Referring now to FIG. 4 it will be seen that the inner set of tubes 37 are fewer in number than the outer set of tubes 38 but that these tubes intercommunicate at their respective upper ends by means of the chamber 43.

A suitable liquid coolant, such as water or the like, flows upwardly through the inner set of tubes through the chamber 43 and downwardly through the outer set of tubes 38. Therefore, when a gaseous medium such as air is circulated between the tubes, a very effective heat exchange action will take place and air will be cooled.

Means are therefore provided for circulating the air and in the embodiment shown in FIGS. 1–4 an elongate shaft 46 projects through a centrally located opening 41a in the top plate assembly 41 and is journaled in a centrally located flange bearing 47 which is bolted to the upper central portion of the top plate 26 of the bottom plate

assembly 25. The flange bearing 47 has a suitable ball bearing unit 48 therein to thereby reduce the friction load during revolving movement of the shaft 46. A similar centrally located flange bearing 49 is bolted to the top plate assembly 41 and this bearing 49 has an opening therethrough which communicates with the opening 41a in the top plate assembly. The flange bearing 49 is provided with a ball bearing unit 50 therein and the upper end portion of the shaft 46 is journaled in the upper bearing structure.

The shaft 46 is provided with a plurality of squirrel-cage type blower units affixed thereto for rotation therewith and each blower unit 51 including a hub 52 having a plate 53 integrally formed therewith and projecting radially outwardly therefrom, with the conventional cylindrical cage member 54 rigidly attached to the plate 53. The cylindrical cage member 54 is provided with struck fins thereon to permit the discharge of air outwardly therethrough. The hubs 52 of each blower unit are keyed to the shaft and it will be seen that all but the lowermost blower unit are similarly oriented so that the open end of the squirrel-cage member is disposed downwardly, the lowermost lower unit having its open end oriented upwardly. With this particular arrangement an efficient circulation of air is obtained with respect to the tubes 37 and 38 and with respect to the inner surface of the film tube to be cooled.

Means are provided for revolving the shaft 46 and this means includes a suitable electric motor 55 which is mounted by suitable bracket means 56 on the top plate assembly 41. The output shaft 57 of the electric motor 55 is connected by a suitable coupling 58 to the upper end of shaft 46 and when the motor 55 is energized, the shaft 46 will also be rotated. The electric motor 55 is connected by a suitable electrical conductor cable 59 to a source of electric current. An open mesh type shield structure 60 preferably formed of a metallic material is provided and covers the cooling device to shield the same against contact with the hot thermoplastic material during the extrusion operation.

The cooling tubes 37 and 38 are provided with a liquid coolant preferably water and to this end it will be seen that mandrel 15 has a bore therethrough and a large outer pipe or tube 61 projects therethrough and extends upwardly into the opening 36 in the lower plate 32 of the bottom plate assembly. A stiffening collar 62 embraces the upper end of the pipe 61 and is secured to the lower plate 32 as best seen in FIG. 2. It will also be seen that the pipe 61 projects downwardly beyond the lower end of the lower die body 11.

A central pipe or tube 63 is disposed concentrically within the outer pipe 61 and suitable spacers 64 are interposed and engage the respective outer and center pipes. Thus an annular passageway 65 is defined by the space between the pipes as best seen in FIG. 4. An inlet fitting 66 is connected to the outer pipe 61 and this inlet fitting is also connected to a flexible conduit 67 which in turn is connected to a source of air under pressure. It will be noted that this air inlet communicates with the passage 65 at a point spaced below the lower die body 11. An air outlet 68 is also formed in the outer pipe 61 at a point spaced in close proximity to but below the bottom plate assembly 25 of the cooling device 24. The air which is supplied through the passage 65 constitutes the encapsulating air for inflating or distending the film tube or bubble to the desired size. Although not shown in the drawing, a suitable control valve will be interposed in flow controlling relation with respect to the conduit 67 to permit air to be supplied to the bubble or tube when desired. It is pointed out that the air stream passing through passage 65 also defines a thermal insulating medium to prevent the coolant from reducing the temperature of the extrusion die which would interfere with the extrusion operation.

An inner tube or pipe 69 is concentrically positioned within the center tube 63 so that a passage 70 is defined

between the inner and center pipes. It will be seen that the hollow interior of the inner pipe 69 communicates with the chamber 31 while the passage 70 communicates with the chamber 35.

Referring again to FIG. 4 it will be seen that the lower end of the inner pipe 69 projects downwardly beyond the respective lower ends of the center and outer tubes, the passage 65 being closed at the lower terminal ends of the center and outer pipes by one of the spacers 64. A flexible conduit 72 is clamped to the exterior lower end of the outer tube 61 by a suitable hose clamp 73 and a flexible conduit 74 is connected to the lower terminal end of the lower end of the inner pipe 69. It will be seen that while the annular passage 65 is closed, and does not continue through the flexible conduits, the passage 70 communicates with the interior of the conduit 72.

The end of the flexible conduit 72 is clamped to a reducing coupling 75 by suitable hose clamp and it will be noted that this reducing coupling has an opening in the wall thereof. An elbow type coupling 76 projects through this opening in the reducing coupling and is connected in sealing relation with respect to the flexible conduit 74 by suitable clamp means. This reducing coupling 75 and the elbow coupling 76 are each connected by suitable conduits to a circulating pump (not shown). The water coolant is supplied through the elbow 76, flexible conduit 74 and inner pipe 69 and is returned through the passage 70 and through the reducing coupling 75 to the pump. It will also be seen that the cable for the electric motor 55 also extends through the annular passage 65, and is connected to a conventional cable connector 77 which is mounted in sealed relation in the outer pipe 61 as best seen in FIG. 4.

During operation of the apparatus, and in carrying out my novel process, the thermoplastic material will first be extruded from the extrusion passage 17, 18 and this initial cylindrically extruded material will be pulled upwardly around the cooling device 24, and will then be closed and pulled through the collapsing tower and through the nip rolls, and thereafter trained around the core or rewind roll. Air will then be introduced through the annular passage 65 to inflate the tube or bubble to the desired degree and the extrusion operation will then be continued in the usual manner. However, during the extrusion operation not only will the exterior surface of the film tube be cooled by the air discharged through the annular passage 20 of the air ring structure 19, but the cooling device 24 will very effectively cool the interior surface of the film tube. The electrical motor 55 is of variable speed type which permits a wide range of adjustment for producing effective circulation and cooling in accordance with changes in the gauge size and the bubble size.

The liquid coolant will be forced through the interior of the inner pipe 69, through the passage 31 and thereafter into the inner set of tubes 37. This liquid coolant will then pass through the chamber 43 downwardly through the outer set of tubes 38, then through the chamber 35 and into the passage 70 and returned to the pump. A suitable refrigeration type cooling system may be used to cool the water coolant. It is pointed out that additional kinds of coolants such as freon, brine and the like may also be used in lieu of water.

As the liquid coolant is circulated through the tubes 37, the motors 55 will be energized to revolve the squirrel-cage blower units 51 and air will be moved axially and then radially through these blower units and outwardly between the cooling tubes 37 and 38. The cooling fins or tubes substantially increase the surface area wherein the heat exchange action takes place. This air which is being circulated is the encapsulated air and it will be seen that this continuous low velocity circulation through the heat exchange very effectively cools the air which serves to cool the inner surface of the film tube. Thus it will be seen that through the use of a circulating gaseous medium which is continuously cooled by a heat

exchanger located within the film tube being extruded, the film tube may be very effectively and quickly cooled both exteriorally and interiorally. The surface area of the film which is exposed to a gaseous cooling medium is substantially doubled as compared to the conventional systems. This system has been found to be especially adaptable for use in forming heavy gauge polyethylene film although it is quite capable of being utilized in the blown tube, process for extruding other film materials. It is pointed out that although a plurality of rotors are used, the cooled air within the bubble or film tube is impinged against a substantial inner surface area of the bubble above the frost line of the bubble wall. By utilizing a low velocity circulating system, there will be little, if any, tendency of the air to distort the cylindrical configuration of the deformable plastic bubble wall.

Reference is now made to FIG. 5 wherein a different embodiment of the cooling device is shown. This cooling device is designated generally by the reference numeral 80 and while utilizing the same principal of circulating the encapsulated through a heat exchanger, is intended to operate at a much higher velocity, the air being initially impinged against the bubble wall at points spaced below the frost line, the air then being directed upwardly to follow the inner surface of the bubble wall before it is recirculated again. The frost line is designated by the reference line F in FIG. 5.

It will be seen that the cooling device 80 is provided with an outer pipe 61c which projects through the mandrel 15 and that a center pipe 63c is positioned in concentric relation within the outer pipe 61c so that a passage 65 is defined therebetween. The passage 65 is connectable by suitable conduit means to a source of air under pressure and the outer pipe 61c has an outlet 68c therein through which the encapsulated air is exhausted. An inner pipe 69c is provided whereby a passage 70c is defined between the inner and center pipe through which liquid coolant is returned. The upper end of the center pipe 63c is sealed by a closure member 81 and it will be seen that the inner pipe 69c branches at its uppermost end each branch projecting through the wall of the center pipe, one branch being connected in communicating relation to an inner helical cooling coil 82 having suitable fins thereon. The other branch of the center pipe 69c is connected to an outer helical cooling coil 83 which is provided with suitable cooling fins. It will be noted that both the inner and outer helical cooling coils are connected at their lowermost ends in communicating relation with the passage 70c so that the liquid coolant is directed downwardly through the heating coils and returned to the circulating pump and the refrigeration system by means of the passage 70c.

The inner and outer heating coils are positioned within an imperforate cylinder 84, the upper end of which is open and the lower end being closed by a lower wall member 85 having a central opening therein and mounted in sealing relation upon the center pipe 63c. It will be noted that the peripheral portions of the lower wall 85 of the cylinder 84 are curved upwardly and an annular opening 86 is formed in the lower end portion of the cylinder 84 to define with the lower wall, a venturi passage whereby air in the cylinder will be directed outwardly and upwardly at a relatively high velocity. It is pointed out that this venturi passage is located below the frost line of the film bubble or tube whereby the air will be impinged against the inner surface thereof at the point where the temperature of the molten fluid thermoplastic material is the greatest.

The upper end of the cylinder has a perforated metallic cylindrically shaped guard 87 rigidly mounted thereon and projecting upwardly therefrom. An electric motor 88 is suspended from the upper closed end of the cylindrical guard 87 and the output shaft 89 of the motor has a bladed rotor or fan blower 90 keyed thereto for rotation

therewith. A perforated shield 91 extends across the upper end of the cylinder 84.

During operation of the cooling device 80, the liquid coolant will be supplied to the inner and outer helical cooling coils 82 and 83 and when the electric motor 88 is energized, air will be blown downwardly completely through the imperforate cylinder 84 and will be discharged through the venturi passage 86. This cooled air will be discharged generally radially at a relatively high velocity at a zone located below the frost line of the film tube B and the air will then be directed axially upwardly along the inner surface of the bubble or tube B. With this type of arrangement, a continuous scrubbing action by the high velocity stream of air increases the solid to gas heat transfer action very substantially as a result of the action of the high velocity of stream of cool air on the stagnant insulating air layer that surrounds and adheres to such solid surfaces.

It is pointed out that the entire cooling device 80 including the inner and outer tubes may be vertically shifted relative to the extruding structure and the air ring whereby the particular zone at which the air stream strikes the inner surface of the film bubble may be adjusted.

When the air cooler device 80 is used, the cooling device will be positioned to approximately 12 to 15 inches above the die lips to permit clear access to those lips. The bubble or tube size, the running speed, etc., will then be approximately established. When the motor 88 is energized, and the correct operating speed thereof is adjusted, the cooling device is then lowered to the correct operating level with respect to the die lips so that the cooled air will be discharged against the inner surface of the bubble film or tube below the frost line.

From the foregoing description it will be seen that I have provided apparatus and process steps to improve the efficiency of conventional blown tube process for extruding plastic tubing. It will be noted that my novel process and apparatus permits extrusion of relatively heavy gauge thermoplastic tubing at relatively high linear speeds and within conventional building structures in a manner heretofore not possible with the conventional extrusion systems.

It will, of course, be understood that various changes may be made in the form, details, arrangement and proportions of the various parts without departing from the scope of my invention.

What I claim is:

1. In a blown tube extrusion apparatus for making film tubing and sheeting from molten thermoplastic material, and including an extrusion die having an annular extrusion outlet through which an elongate sleeve of film is extruded, means for collapsing and closing said sleeve at a point remote from said die structure to incapsulate air therein and to form an elongate bubble of film, an air supply conduit extending through said extrusion die for supplying the trapped incapsulated air into the bubble, a coolant supply conduit and a coolant return conduit connected with a refrigeration system located exteriorly of the bubble of film and extending through the extrusion die, a heat exchanger comprising a plurality of elongate tubes extending axially and interiorly of the bubble, said tubes being connected in communicating relation to said coolant supply conduit at points remote from the extrusion die, and said tubes being connected in communicating relation with the coolant return conduit at points adjacent the extrusion die, said tubes being arranged in a cylindrical pattern, an elongate generally cylindrical shield structure having openings therein and positioned around said tubes in close proximity thereto and having a cross-sectional size essentially smaller than the cross-sectional size of the bubble whereby said heat exchanger is spaced substantially inwardly of the inner surface of the bubble to define the relatively large cylindrical unobstructed volumetric space between the inner surface of the bubble and the

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heat exchanger, a motor positioned within the bubble exteriorly of and above said tubes and having a revolvable output shaft, a bladed fan device connected to the output shaft for revolving movement therewith to impel and circulate the trapped incapsulated air axially and radially over said tubes throughout the interior of the bubble at a substantially uniform pressure for cooling the same.

2. The apparatus as defined in claim 1 wherein said bladed fan device comprises an elongate shaft connected with the output shaft of the motor and spaced inwardly from said tubes, said shaft having a length dimension corresponding to the length of said elongate tubes and having a plurality of longitudinally spaced-apart fans secured thereto throughout the length thereof.

3. The apparatus as defined in claim 1 wherein said tubes are helically arranged into a coil, said coolant supply conduit being connected to the coil at a point remotely spaced from the extrusion die, said coolant return conduit being connected in communicating rela-

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tion with the coil at a point adjacent the extrusion die, said shield structure comprising an elongate imperforate cylinder positioned around said coil and having an open end and a closed end, the latter located in close proximity to the extrusion die, an annular outlet in said cylinder adjacent said closed end, said bladed fan device being positioned in said cylinder adjacent said open end and above said coiled tubes for circulating air axially through the cylinder and thereafter outwardly through the annular outlet.

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