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[54] **METHODS OF TREATING ELONGATED MATERIAL**

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[51] **Int. Cl.** **F26b 7/00**

[58] **Field of Search** 34/9, 20, 23, 155, 34/160, 148, 13, 62; 117/119.2, 119.4

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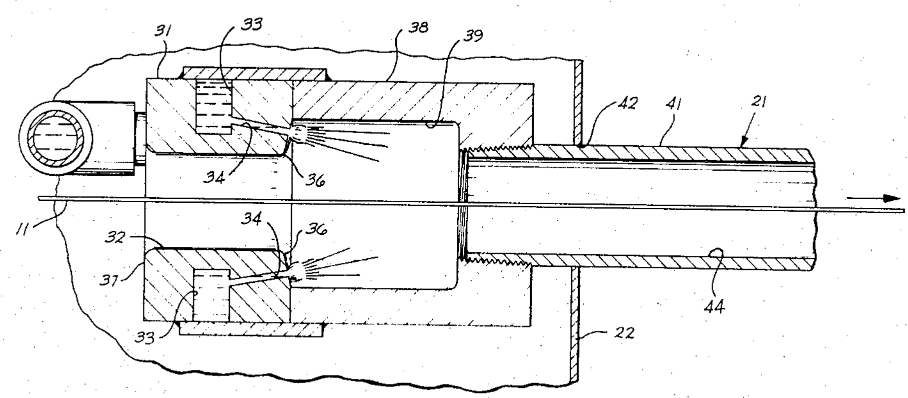
[57] **ABSTRACT**

Successive sections of a strand material are advanced along a predetermined path into an entrance end of, through, and then out of a laterally closed chamber. The entrance end of the chamber is in communication with the air of the ambient atmosphere. High velocity jet streams of treating material are directed into the chamber toward oblique converging engagement with the successive sections of the strand material. Substantial components of the velocities of the jet streams are in the direction of travel of the strand material. The minimum cross-sectional area of the passages of the chamber through which the streams are directed and the strand material travels are substantially greater than that of the strand material. The velocity of the jet streams and the geometrical relationship of passages of the chamber through which the strand material and the jet streams pass and the pressure of the air are such as to create pressure differentials sufficient to cause air to be drawn into the entrance of the chamber at a volumetric flow which is substantially greater than that of the treating material. The air is mixed with the treating material to produce a vapor mixture which moves through the chamber along the path of the strand material to treat the strand material.

15 Claims, 2 Drawing Figures



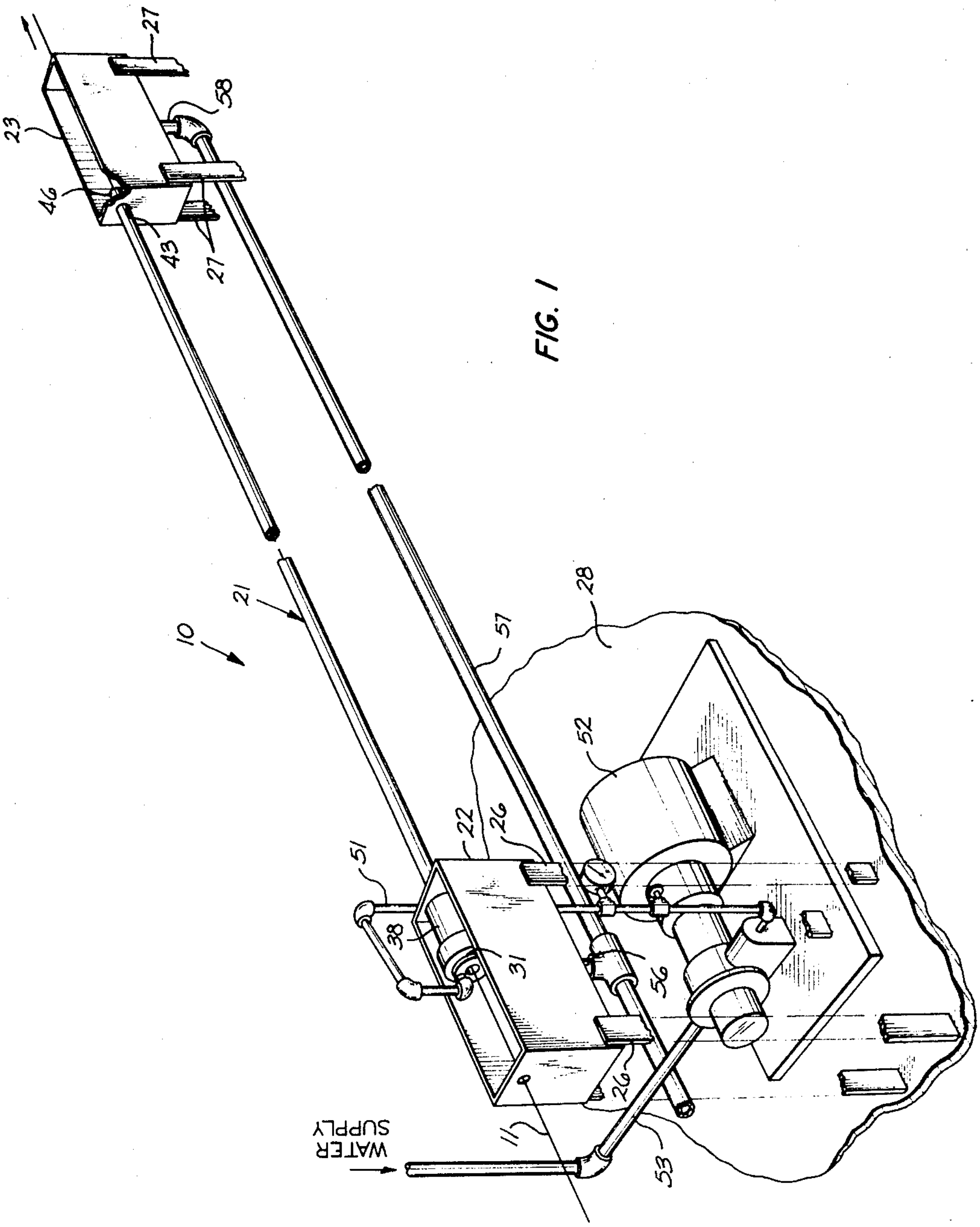


FIG. 1

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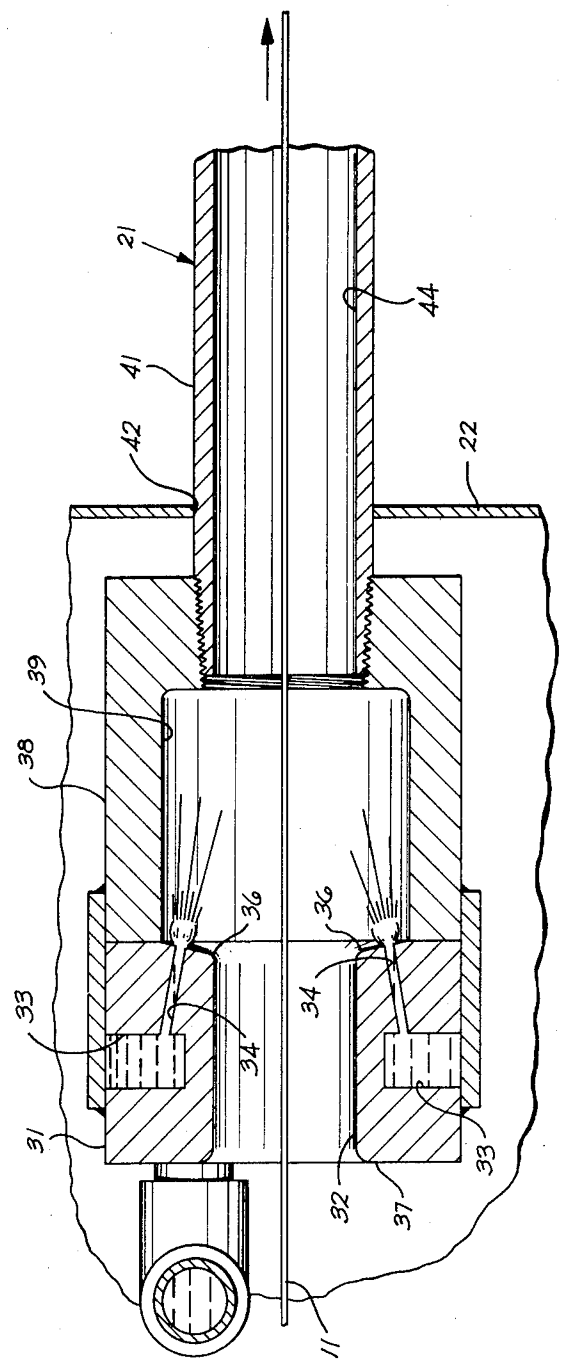

FIG. 2

METHODS OF TREATING ELONGATED MATERIAL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to methods of and apparatus for treating elongated material, and more particularly to methods of and apparatus for directing a cooling material into engagement with a strand material being advanced through a laterally closed chamber, the velocity of the cooling material and geometrical configuration of the chamber and the pressure of air at ambient atmosphere in direct communication with an upstream portion of the chamber being such that portions of the air are drawn into the chamber in sufficient volume to mix with the cooling material to cool the elongated material.

2. Description of the Prior Art

In the manufacture of electrical conductor wire having plastic insulation, the wire is generally advanced from an extrusion die in which the plastic is extruded onto the wire, through the atmosphere and into an entrance end of a water cooling trough. As the wire is advanced into and through the cooling trough, the temperature of the plastic insulation is reduced substantially by a coolant material with an accompanying reduction in expansion.

Some of the prior known cooling troughs have not proven altogether satisfactory for producing conductors having the most desirable characteristics for communication uses. As the insulated wire is advanced into the cooling trough, a column of air is drawn along with the wire into the trough. This causes the formation of air bubbles on the surface of the insulation which tends to prevent the cooling water from engaging and cooling the insulation evenly. Also, as the wire is advanced through the cooling trough, additional air bubbles tend to form on the surface of the insulation as a result of air voids within the cooling water adjacent the insulation. Moreover, these air voids also cause uneven cooling of the insulation which results in undue stresses in the conductor.

At least one system teaches the use of a substantially enclosed container filled with cooling liquid which flows in a direction counter to that in which a strand material is advanced to prevent air from being drawn into the container along with the advancing strand.

Other problems may be involved in using conventional cooling troughs. Generally, the cooling apparatus includes a trough of considerable length. This requires the allocation of adequate amounts of floor space which is a valuable commodity in manufacturing facilities. Additionally, the conventional cooling troughs require high quantities of cooling water to fill the troughs and immerse the wire being advanced therethrough. This requirement also adds to the expense of this stage of the manufacturing process. Finally, the use of lengthy cooling troughs causes inherent separation of equipment at either end thereof. The length of physical separation of the equipment increases the operator costs over that which could be achieved if the the cooling trough could be shortened.

The advancement of the wire through a water-filled cooling trough or chamber in a direction with or counter to that of the advancement of a strand material also requires a certain unpredictable amount of tension in the wire as applied by the capstan between the capstan and the extruder head to overcome the drag exerted by the water. Generally, the tension applied to the wire may reach the level of 7 to 8 pounds which tends to stretch the wire and to an uncontrollable extent. Consequently, the nominal diameter of the wire must be increased to insure that the final gauge wire will be within acceptable tolerance limits and to avoid the wire undergoing a permanent deformation. If the drag could be eliminated or substantially reduced, and a predetermined amount of tension applied to the wire, then the loss in outside diameter of the wire could be exactly determined. This would permit economical control of the material size required for acceptable tolerance limits.

The undue tensions in expecially the finer gauge wire may cause excessive wire breaks. This, of course, requires additional operator time to restring the apparatus, often at the expense of some other operation that requires the attention of the operator. If the drag on the wire could be reduced, the tension in the wire could be reduced with an accompanying reduction in the frequency of wire breaks.

Various arrangements for bringing cooling, coating or other treating materials into contact with an advancing strand material are known in the art. In one prior art patent, U.S. Pat. No. 1,741,815, issued on Dec. 31, 1929 to J. E. Boynton, cable sheathing is advanced from an extruding die through a restricted opening and then through a chamber of gradually increasing cross section wherein it is subjected to a cooling medium such as water which is introduced at a high velocity through an annular groove and arcuate passages. This produces an aspiratory action thus preventing leakage of the water back through the restricted opening. The water is directed equally around the sheath, completely submerging it, after which the water is evacuated laterally of the chamber through a discharge tube as the cable is advanced out of the chamber through a restricted opening.

Some cooling systems show the cooling of elongated shapes by supplying annular jet streams of a cooling material into engagement with an advancing elongated material with the cooling material submerging the elongated material and exiting therewith or laterally thereof. Other systems include the use of plurality of jet streams of cooling material sprayed upstream with respect to the direction of travel of the elongated material being treated.

In yet another system for cooling extruded products, jet streams of water spaced along and within a chamber spray water onto a cable sheath being extruded onto a core by a die adjacent an upstream end of the chamber. The amount of water supplied is greater than that required to cool the cable in order that an aspiratory action is produced to draw air along passages coaxial with the sheath and through restricted openings near the one end of the chamber which serves to keep the water from undesirably backwashing against the extrusion die. This system is not readily adaptable for cooling individual insulated conductors in a modern high speed insulating line. The excessive water increases, not reduces, drag forces on the conductor. This is not a problem in cooling a cable sheath where the line speed is slower and the material being advanced is many times the size of an individual conductor.

Solutions to the problems of excessive drag, requirements of high amounts of floor space and uniform cooling were sought by using an air-water mixture introduced into a chamber by a nozzle arrangement.

One such arrangement in the prior art involves passing a gas through a nozzle to produce a suction to draw air in through an aperture which is coaxial with the nozzle. A strand material is advanced through a coating material and then through the nozzle and aperture counter to the flow of the gas. The inflow of air is adjusted until a mixture of air and gas is obtained which will provide a desired effect on the coating on the strand material.

Other treating systems direct pressurized air past a nozzle connected to a supply of liquid to create an aspiratory action to form atomized water which is introduced under pressure into a chamber to cool a cable which is being advanced through the chamber. The injector arrangement described sucks liquid up through a supply into the chamber and the mixture of air and liquid is driven at a high velocity to treat the wire. The air-liquid mixture has the liquid dispersed in the air and expands along the chamber. As it expands, the mixture looses speed and is forced into an adjoining chamber and then laterally into the open air and on a recirculation bath. In systems such as this, it is not uncommon for strand material to be advanced in a direction counter to the flow of the atomized mist mixture.

Another system for treating strand material includes directing of liquid under pressure obliquely into a chamber and then through baffle plate which causes the water to whirl around and continue in a helically turbulent course into contact with a strand material within a restricted throat portion of a chamber and then along an expanded portion of the chamber. The whirling action of the water eventually dies out and the water drains out of the chamber laterally of the strand material (see U.S. Pat. No. 2,347,392).

Successive sections of a strand material may be cooled by passing the strand material through a tube into which liquid carbon dioxide is introduced into the tube under pressure, (see U.S. Pat. No. 2,993,114 issued on July 18, 1961 to T. T. Bunch et al.) through a nozzle. The liquid carbon dioxide expands into a gas and rapidly cools the strand material. The amount of cooling of the strand material is influenced by the amount of clearance between the strand material and an internal surface of orifices at each end of the tube. The amount of cooling of the strand material may also be regulated by changing the liquid pressure and the velocity of the liquid carbon dioxide being fed into the tube.

SUMMARY OF THE INVENTION

It is an object of this invention to provide improved methods of and apparatus for the treating of elongated material.

It is also an object of this invention to provide improved methods of and apparatus for cooling advancing strand material in such a way as to substantially reduce the drag and tension in the strand material with reduced requirements of floor space and cooling material, and which results in an improved more uniform cooling.

A method of treating elongated material embodying certain features of the invention may include the steps of causing relative movement along a predetermined path between a laterally closed chamber and successive sections of an elongated material, the elongated material extending into an entrance end of the chamber, through, and then out of an exit end of the chamber, an upstream portion of the chamber communicating with a fluid material capable of being in a gaseous state, and directing at least one high velocity jet stream of treating material into the chamber downstream from the portion of the chamber communicating with the fluid material, the direction of the jet stream being such that a substantial component of the velocity of the jet stream is in the direction of travel of the successive sections of the elongated material, the minimum cross-sectional area of portions of the chamber through which the stream is directed and the successive sections of the elongated material extend being substantially greater than the cross-sectional area of the elongated material. The velocity of the jet stream of treating material and the geometrical relationship of the cross-sectional areas of the portions of the chamber through which the successive sections of the elongated material extend and the jet stream passes and the pressure of the fluid material in direct communication with the upstream portion of the chamber are such as to create a pressure differential sufficient to cause portions of the fluid material in direct communication with the upstream portion of the chamber to be drawn into the chamber in a gaseous state at a volume of flow per unit time which is substantially greater than the volume of flow of the treating material unit time to mix with the treating material and produce a vapor mixture which moves through the chamber along the path of the elongated material to treat the elongated material.

An apparatus for treating elongated material embodying certain features of the invention may include a laterally enclosed chamber having an entrance end and an exit end, an upstream portion of the chamber communicating with a fluid material capable of being in a gaseous state, facilities for causing relative movement along a predetermined path between the laterally closed chamber and successive sections of the elongated material, and facilities for directing at least one high velocity jet stream of treating material into the chamber downstream from the portion of the chamber communicating with the fluid material. The direction of the jet stream is such that a substantial component of the velocity of the jet stream is in the direction of travel of the successive sections of the elongated material. The mimimum cross-sectional area of portions of the chamber through which the stream is directed and the successive sections of the elongated material extend are substantially greater than that the cross-sectional area of the elongated material. The velocity of the jet stream of treating material, the geometrical relationship of the portion of the chamber through which the successive sections of the elongated material extend and the jet stream pass, and the pressure of the fluid material in direct communication with the upstream portion of the chamber are such as to create a pressure differential sufficient to cause portions of the fluid material communicating with the upstream portion of the chamber to be drawn into the chamber in a gaseous state at a volume of flow per unit time which is substantially greater than the volume of flow of the treating material per unit time to mix with the treating material and produce a vapor mixture which moves through the chamber to treat the elongated material.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and features of the present invention will be more readily understood from the following detailed description of specific embodiments thereof when read in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view of an apparatus which embodies certain principles of this invention and which includes a laterally enclosed chamber through which successive sections of a strand material are advanced and having facilities for supplying water at a high velocity into an upstream end thereof;

FIG. 2 is an enlarged detail view of an upstream portion of the apparatus shown in FIG. 1 which includes provisions for directing a plurality of high velocity jet streams of water into the chamber.

DETAILED DESCRIPTION

Referring now to FIG. 1 there is shown an apparatus, designated generally by the numeral 10, for cooling successive sections of a strand material 11. The successive sections of the strand material 11 are formed from successive sections of a conductor which are advanced into and through an extruder (not shown) which applies a covering of plastic insulative material thereto. Subsequently, the successive sections of the strand material 11 are advanced into and through the cooling apparatus 10 by a capstan (not shown) after which the strand material is wound on a take-up reel (not shown).

As can best be seen in FIG. 1, the cooling apparatus 10 includes a laterally closed chamber, designated by the numeral 21, which extends between and is supported on spaced catch basins 22 and 23. An upstream end portion (with respect to the advancement of the successive sections of the strand material 11) of the chamber 21 is connected to the catch basin 22 while a downstream end of the chamber is connected to the catch basin 23. The catch basins 22 and 23 are supported, respectively, on columns 26 and 27 which are mounted to a supporting surface 28. Intermediate supports for the chamber 21 may be used as required.

The laterally enclosed chamber 21 shown in FIG. 1 includes three successive adjoining and communicating portions. As can best be seen in FIG. 2, a first or upstream one 31 of the portions is positioned at the upstream end of the chamber 21 and has a passage 32 formed therethrough. Further, the first one 31 of the portions has an annular cavity 33 formed therein which communicates with the passage 32 through a plurality of passageways 34—34 that open to a beveled face 36. The first one 31 of the portions includes an entrance end 37 to the laterally enclosed chamber 21 at the upstream end of the passage 32. Finally, the first one 31 of the portions of the chamber 21 is in communication with a fluid material capable of being in a gaseous state. In the embodiment shown in FIGS. 1 and 2, the first one 31 of the portions communcates with the air of the ambient atmosphere at the entrance end 37.

An intermediate or second one 38 of the three adjoining portions is connected to the downstream side of the first one 31 of the portions (see FIGS. 1 and 2). The second portion 38 has a passage 39 formed therethrough which is aligned with and communicates with the passage 32 in the first one of the portions. The cross-sectional area of the passage 39 is larger that the cross-sectional area of the passage 32. In a typical arrangement, a cross-sectional shape of the passages 32 and 39 is circular having diameters of approximately 1 inch and 2 inches, respectively.

Finally, a third one 41 of the portions is connected to the downstream side of the second portion 38 (see FIG. 2) and extends through an opening 42 in the catch basin 22 and then into an opening 43 of the catch basin 23 (see FIG. 1). The third portion 41 has a passage 44 formed therethrough which communicates with and is aligned with the passages 32 and 39 and which opens to an exit end 46 of the chamber 21. The cross-sectional area of the passage 44 is smaller than that of the passage 39 of the second one 38 of the portions. In one embodiment of the invention, the third one 41 of the portions is a pipe having an inside diameter of approximately one inch.

The communicating passages 32, 39 and 44 of the chamber 21 shown in FIG. 2 are shown as being coaxial with the longitudinal axes of the advancing successive sections of the strand material 11. While this is the usual practice in installations of this nature, it is not essential to the operation of an embodiment of this invention.

In order to cool successive sections of the strand material 11 which are advanced through the chamber 21, provisions are made for supplying water to the chamber adjacent the upstream end thereof. The annular cavity 33 is connected through a riser 51 to a pump 52 supported on the surface 28. The riser 51 is connected through a conduit 53 to a supply (not shown) of cooling water.

The cooling water is forced up the riser 51 and into the annular cavity 33, then through the passageways 34—34 to form a plurality of converging jet streams of water being directed into the chamber 21 (see FIG. 2). The passageways 34—34 are formed so that the longitudinal axes thereof tend to converge within the chamber 21 and downstream of the first one of the portions with respect to the travel of the successive sections of the strand material 11. The slope of the passageways 34—34 is such that a substantial component of the velocity of each of the jet streams of water that are forced through the passageways is moving in the same direction as the successive sections of the strand material. In an apparatus constructed in accordance with the principles of the invention, the longitudinal axes of the passageways 34—34 are inclined at an angle of 10 to 20° with a line parallel to the longitudinal axes of the successive sections of the strand material 11.

Provisions are made for draining the water which emerges from the exit end 46 of the chamber 21 into the catch basin 23 and that which may backwash through the entrance end 37 into the catch basin 22. As can best be seen in FIG. 1, a vertical conduit 56 connects an opening in the bottom of the catch basin 22 with a conduit 57, and a vertical conduit 58 connects an opening in the bottom of the catch basin 23 with the conduit 57. The conduit 57 is run to a drain (not shown) where the reclaimed water may be accumulated and then routed through refrigerating apparatus (not shown) and recirculated to the pump 52 for resupply to the apparatus 10.

In order to cool the successive sections of the strand material 11 in a uniform matter with a substantial reduction in drag forces imparted to the wire by the cooling material and with reduced requirements of floor space, the relative flow rates of the cooling material and the gaseous medium communicating with the first one 31 of the portions of the chamber 21 assume a critical role. Desirably, the volume of flow of the cooling material per unit time is substantially less than the volume of flow of the air per unit time. It has been found that the relative flow rates depend on the creation of a pressure differential. The creation of a pressure differential sufficient to result in these relative volumetric flow rates depends on the velocities of the jet streams, on the geometrical relationship of the cross-sectional areas of the portions of the chamber 21 through which the successive sections of the strand material 11 are advanced and the jet streams pass, and on the pressure of the fluid material in direct communication with the upstream or first one 31 of the portions of the chamber.

The selection of the pump 52 and the geometry of the passageways 34—34 is made so that the water in the jet streams which impinges on the successive sections of the strand material 11 is of a high velocity. A jet stream consonant with this scheme would have a minimum velocity of approximately 150 feet per second with that used in one installation constructed in accordance with the principles of this invention being 210 feet per second. The jet streams, which number four in the hereinbefore described embodiment, are forced through very small diameter passageways. For example, in the constructed embodiment, the passageways 34—34 are 50/1,000 inch in diameter. As will be recalled, the inside diameter of the passage 32 in the first one 31 of the portions is approximately 1 inch.

The geometrical considerations of chamber 21 apply not only as between the cross-sectional areas of the portions of the chamber, but also extend to the relationship of the cross-sectional area of the chamber to the cross-sectional area of the strand material 11. Generally, the minimum cross-sectional area of the portions of the chamber 21 through which the jet streams pass and through which the successive sections of the strand material 11 are advanced are many times greater than the cross-sectional area of the strand material. For example, in an apparatus constructed in accordance with the principles of this invention, the minimum diameter of any portion of the chamber through which the strand material 11 is advanced and through which the jet streams pass is approximately 1 inch compared to the diameter of 18 to 26 AWG gauge wire being advanced therethrough.

Moreover, the length of the third one 41 of the portions is substantial compared to the length of the first one 31 or the second one 38 of the portions. For example, in the embodiment constructed in accordance with the principles of the invention, the length of the third portion 41 is 10 feet, while the length of the first one 31 of the portions approximately is 1 to 2 inches and the length of the second one 38 of the portions is approximately 2 to 3 inches.

As successive sections of the strand material 11 are advanced into and through the chamber 21 and the jet streams of water are directed from the passageways 34—34 into engagement with the strand material, a drop in pressure on the order of 10 to 12 inches of mercury occurs between the first portion 31 of the chamber and the passage 39. This causes portions of the air of the ambient atmosphere surrounding or communicating with the first one 31 of the portions of the chamber 21 to be drawn into the chamber through the entrance end 37 thereof. It should be observed that the first portion 31 could just as well be in communication with a supply of fluid material capable of being in a gaseous state. The important condition is that a pressure differential is created.

Using these velocities, dimensions, and pressures, measurements of the flow rates of water and air have been made. In one test, with 4 gallons per minute of water being moved through the combination of the four passageways 34—34, it was determined that approximately 53 cubic feet of air per minute were being drawn into the chamber 21.

Of course, the overall structure of the first one 31 of the portions, the second one 38 and the third one 41, which performs as a restricted throat portion, could be redesigned into a shape which follows the stream lines of the flow patterns of the water and air. For example, the entrance end 37 could be funnel-shaped and the longitudinal walls of the second portion 38 could slope toward the throat portion having rounded entrance and even exit corners. The benefits derived from such a redesign may be lower frictional head losses.

The chamber 21 may be constructed with a downstream portion of the third one 41 of the portions having a passage formed therethrough which has a larger cross-sectional area than that of the passage 44. However, any such enlargement of the passage 44 should occur only after a substantial length of throat section of the passage immediately downstream of and communicating with the second one 38 of the portions. If the passage 44 is suddenly enlarged too close to the upstream end thereof, the water velocity will more likely than not not be affected. But the air will expand to fill the enlarged portion and consequently, the water velocity will exceed the air velocity which in the preferred embodiment are substantially equal. Should the air velocity be reduced, the water may not remain as intimately in contact with successive sections of the strand material 11 as it would if the air did not expand and tend to hold the water against the strand material.

OPERATION

In the operation of the apparatus 10, successive sections of the strand material 11 are advanced from the extruder (not shown) into the entrance end 37 and then through and out of the exit end 46 of the chamber 21. An operator controls the operation of the pump 52 to supply water through the riser 51 to the annular chamber 33 and through the passageways 34—34 into the chamber 21.

As the streams of water emerge from the passageways 34—34, the water tends to diffuse somewhat in a diverging spray (see FIG. 2). The jet streams of water tend to converge on the successive sections of the strand material 11 within the chamber 21 to substantially contact the entire periphery of the successive sections of the strand material.

The high velocity of the jet streams of the water, the geometrical relationship of the cross-sectional areas of the chamber and the pressure of the air of the ambient atmosphere create a pressure differential. This pressure differential is sufficient to cause the air surrounding the entrance end 37 of the chamber 21 to be drawn into the chamber at a volumetric flow rate which is substantially greater than that of the water. As the air is drawn into the second one 38 of the portions of the chamber, the air tends to mix with the water to create a vapor mixture. The vapor mixture moves through the chamber 21 being constantly in contact with the advancing strand material **11** to cool the strand material. The velocity of the air in the constructed embodiment is approximately 10,000 feet per minute compared to a water velocity of approximately 12,000 feet per minute.

A small quantity of water which does not combine with the air to form a vapor mixture accumulates at the bottom of the third one **41** of the portions of the chamber and merely drains out by gravity into the catch basin **23.** The vapor mixture of air and water emerges continuously from the exist end **46** of the third one **41** of the portions at which time some of the momentum thereof has been dissipated so that there is some condensation into the catch basin **23.** It has been observed that the water accumulating at the bottom of the chamber **21** does not reach that proportion required to engage the strand material **11** and exert a drag force thereon. It has also been observed in numerous readings that the temperature of the water at the exit end **46** of the chamber **21** is at least as low as the temperature of the water in the annular cavity **33** despite the heat exchange with the plastic insulation.

Various modifications could be made to the apparatus **10** described hereinbefore and still be within the scope of the invention. For example, although four jet streams were shown, the only requirement is that at least one jet stream be used. Also, although the adjoining communicating portions of the chamber **21** shown in FIGS. **1** and **2** have varying cross-sectional areas, the cross-sectional area of the portions of the chamber through which the successive sections of the strand material **11** pass and the jet stream pass need not vary, and may be constant.

What is important is the interreaction of three parameters to create a pressure differential sufficient to obtain the relative volumetric flow rates of water and air. The parameters are the velocity of the at least one jet stream of water, the geometrical relationship of the cross-sectional areas of the chamber **21** through which the successive sections of the strand material and the jet streams pass and the pressure of the fluid material in direct communication with the upstream portion of the chamber.

Certainly, the position of the jet stream passageways **34—34** may be repositioned with respect to the longitudinal axis of the chamber **21.** For example, the passageways **34—34** could be repositioned further downstream. However, if the jet streams were further downstream, some of the vacuum effect would be lost due to increased frictional head losses. The lowest static pressure within the chamber **21** is within the conical area formed between the jet streams eminating from the passageways **34—34.** Some of the pressure drop would be required to overcome the drop in pressure head over the longer distance than if the jet streams were further upstream.

It is also within the scope of this invention that the cooling of some materials which are used to insulate conductors may require repetitive installations of the three-portion chamber described hereinbefore or of successive constant portion chambers, each of the series of repetitive arrangements having at least one jet stream. In such an arrangement, a common manifold supply system, as well as a common drain system, could be used.

It is to be understood that the above-described arrangements are simply illustrative of the principles of the invention. Other arrangements may be devised by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof.

What is claimed is:

1. A method of treating elongated material, which comprises the steps of:

providing a laterally confined path for successive sections of an elongated material with the minimum cross-sectional area of the path being substantially greater than the cross-sectional area of the elongated material and with an upstream portion of the laterally confined path communicating with a fluid material capable of being in a gaseous state;

causing relative movement along the laterally confined path between successive sections of the elongated material and the laterally confined path, the elongated material extending into an entrance end of the laterally confined path through, and then out of an exit end of the laterally confined path;

providing at least one flow-path for a stream of treating material into the laterally confined path downstream from the portion of the laterally confined path communicating with the fluid material such that a substantial component of the velocity of the stream is in the direction of travel of the successive sections of the elongated material; and,

directing a jet stream of treating material along the flow-path at velocities sufficiently high with respect to the cross-sectional areas of the portions of the laterally confined path through which the successive sections of the elongated material extend and the jet stream passes and cooperating with the pressure of the fluid material in direct communication with the upstream portion of the laterally confined path to create a pressure differential sufficient to cause portions of the fluid material in direct communication with the upstream portion of the laterally confined path to be drawn into the laterally confined path in a gaseous state at a volume of flow per unit time which is substantially greater than the volume of flow of the treating material per unit time, to mix with the treating material and produce a vapor mixture which moves through the laterally confined path of the elongated material to treat the elongated material.

2. A method of treating strand material, which comprises the steps of:

providing a laterally confined path for successive sections of a strand material with a minimum cross-sectional area of the laterally confined path being substantially greater than that of the cross-sectional area of the strand material and such that an upstream portion of the laterally confined path communicates with a fluid material capable of being in a gaseous state;

advancing successive sections of the strand material along the laterally confined path into an entrance end of, through and then out of an exit end of the laterally confined path;

providing a plurality of flow-paths for streams of treating material into the laterally confined path downstream from the portion of the confined path which communicates with the fluid material such that substantial components of the velocity of the streams of treating material are in the direction of travel of the successive sections of the strand material; and

directing jet streams of treating material along the flow-paths at velocities sufficiently high with respect to the cross-sectional areas of the laterally confined path through which the strand material is advanced and cooperating with the pressure of the fluid material in direct communication with the upstream portion of the laterally confined path to create a pressure differential sufficient to cause portions of the fluid material in direct communication with the upstream portion of the laterally confined path to be drawn into the laterally confined path in a gaseous state at a volume of flow per unit time which is substantially greater than the volume of flow of the treating material per unit time to mix with the treating material and produce a vapor mixture which, moves through the laterally confined path to treat the strand material.

3. The method of claim **2,** wherein the fluid material is in direct communication with an entrance end of the laterally confined path.

4. The method of claim **2,** wherein the mixture of treating material and the material in a gaseous state exit from a downstream portion of the laterally confined path with successive sections of the strand material.

5. The method of claim **2,** wherein the upstream portion of the laterally confined path and a downstream portion of the laterally confined path open to the air of the ambient atmosphere.

6. A method of treating strand material, which comprises the steps of:

advancing successive sections of a strand material along a predetermined path into an entrance end of, through, and then out of an exit end of a laterally closed chamber, an upstream portion of the chamber communicating with a fluid material capable of being in a gaseous state;

directing a plurality of high velocity jet streams of treating material into the chamber downstream from the portion of the chamber communicating with the fluid material;

the direction of the jet streams being in oblique converging engagement with the successive sections of the strand material such that substantial components of the velocity of the jet streams are in the direction of travel of the successive sections of the strand material;

the minimum cross-sectional area of portions of the chamber through which the streams are directed and the successive sections of the strand material pass being substantially greater than the cross-sectional area of the strand material;

the velocity of the jet streams of the treating material and the geometrical relationship of the cross-sectional areas of the portions of the chamber through which successive sections of the strand material and the jet streams pass and the pressure of the fluid material in direct communication with the upstream portion of the chamber being such as to create a pressure differential sufficient to cause portions of the fluid material in direct communication with the upstream portion of the chamber to be drawn into the chamber in a gaseous state at a volume of flow per unit time which is substantially greater than the volume of flow of the treating material per unit time to mix with the treating material and produce a vapor mixture which moves through the chamber along the path of the strand material to treat the strand material.

7. The method of claim **6** wherein the velocity of the jet streams is greater than 150 feet per second.

8. The method of claim **6,** wherein the treating material is water.

9. A method of treating strand material, which comprises the steps of:

advancing successive sections of a strand material along a predetermined path

providing lateral confinement for a predetermined length of the path with the cross-sectional area of confinement along the length being substantially greater than the cross-sectional area of the strand material and being a maximum along a section intermediate the ends of the length with an upstream portion of the laterally confined length of the path communicating with a fluid material capable of being in a gaseous state;

providing a plurality of flow-paths for streams of treating material into the laterally confined length downstream from the portion communicating with the fluid material and such that substantial components of the velocities of the streams are in the direction of travel of the successive sections of the strand material;

directing the jet streams of the treating material along the flow paths at velocities sufficiently high with respect to the cross-sectional areas of confinement through which the successive sections of the strand material and the jet streams pass and cooperating with the pressure of the fluid material in direct communication with the upstream portion of the laterally confined length of the path to create a pressure differential sufficient to cause portions of the fluid material in direct communication with the upstream portion of the laterally confined length to be drawn into the laterally confined length in a gaseous state at a volume of flow per unit time which is substantially greater than the volume of flow of the treating material per unit time to mix with the treating material and produce a vapor mixture which moves along the laterally confined length of the path to treat the strand material.

10. The method of claim **9,** wherein the mixture of the treating material and the material in the gaseous state exit from the downstream portion of the laterally confined length of the path with successive sections of the strand material.

11. The method of claim **9,** wherein the downstream portion of the laterally confined length of the path is substantially longer than the upstream portion of the laterally confined path and substantially longer than the intermediate portion thereof.

12. The method of claim **9,** wherein the jet streams of treating material are directed toward the laterally confined path and into oblique converging engagement with successive sections of the strand material.

13. The method of claim **12,** wherein the jet streams of treating material tend to coverge on a portion of the path between the upstream end of the intermediate portion of the laterally confined path and the downstream end of the downstream portion of the laterally confined path.

14. The method of claim 12, wherein the step of providing lateral confinement is accomplished so that the upstream end of the upstream portion and the downstream end of the downstream portion of the adjacent portions open to the air of the ambient atmosphere.

15. The method of claim 12, wherein further the jets are directed so that the mixture of air and treating material exit from the downstream portion of the laterally confined length of the path with successive sections of the strand material.

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