

- [54] **IRRIGATION TUBE**
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- [63] Continuation-in-part of Ser. No. 293,822, Oct. 2, 1972, abandoned.
 [52] U.S. Cl. **239/542, 239/450, 239/566**
 [51] Int. Cl. **B05b 15/00**
 [58] Field of Search 239/145, 450, 542, 547,
 239/566, , 558; 61/12

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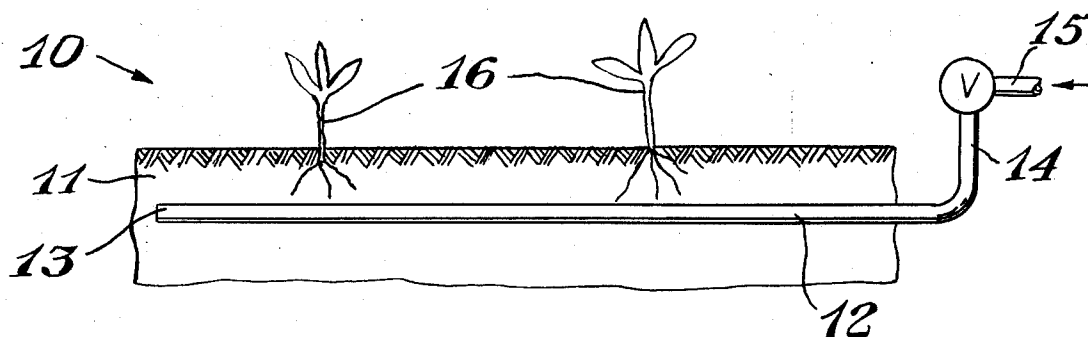
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[57]

ABSTRACT

Plastic low pressure irrigation tube is prepared by forming a two-passageway tube having a supply and discharge passage. The wall separating the two passages is perforated to permit liquid to flow from the supply to the discharge passage. The external wall forming the discharge passage is perforated at locations remote from perforations connecting the supply and discharge passages to provide relatively even distribution of water therefrom with variations in the pressure head on the inner tube.

8 Claims, 7 Drawing Figures



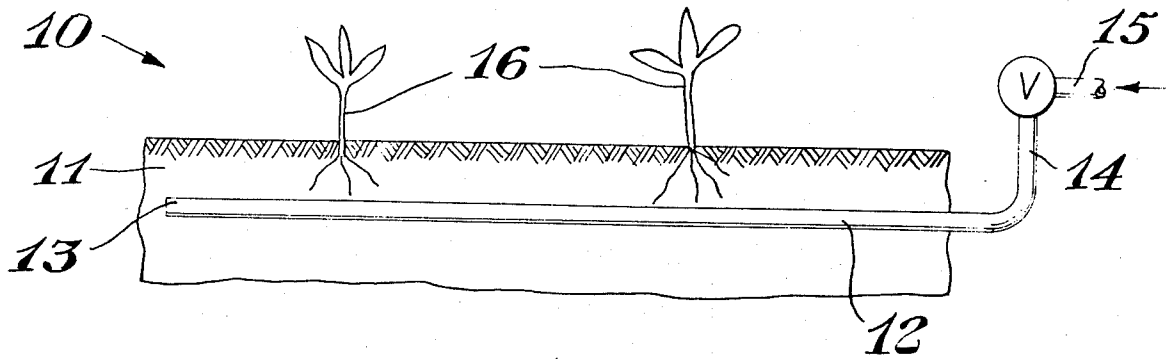


Fig. 1

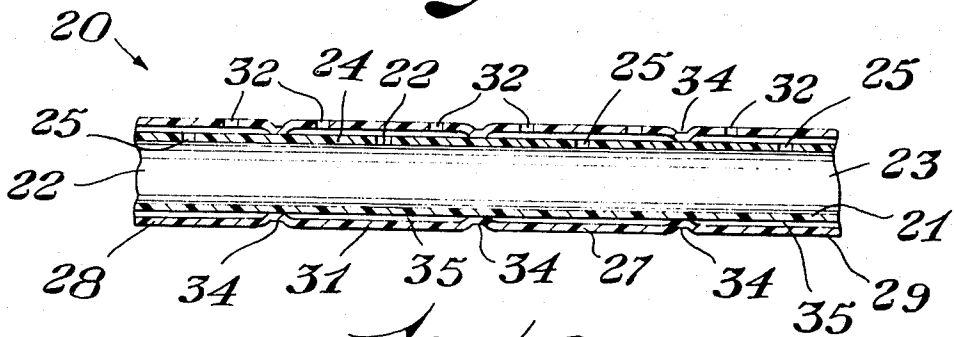


Fig. 2

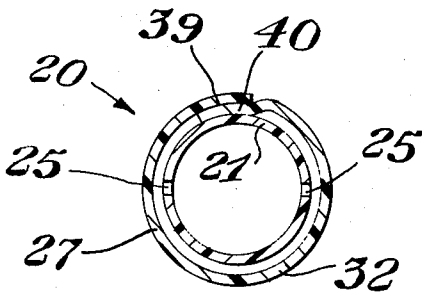


Fig. 3

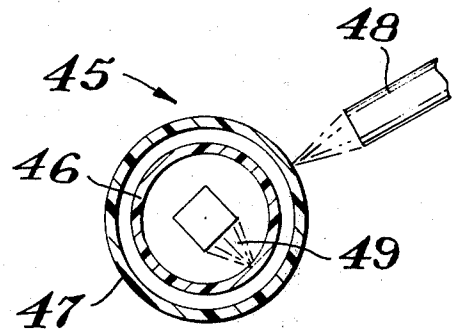


Fig. 4

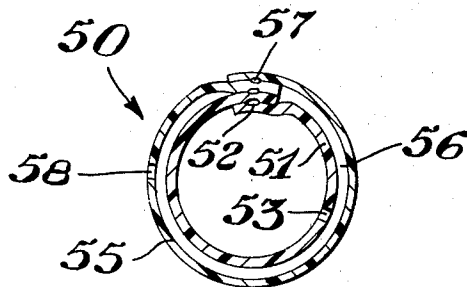


Fig. 5

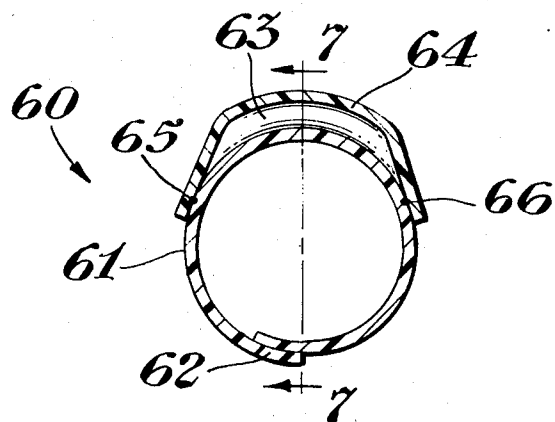


Fig. 6

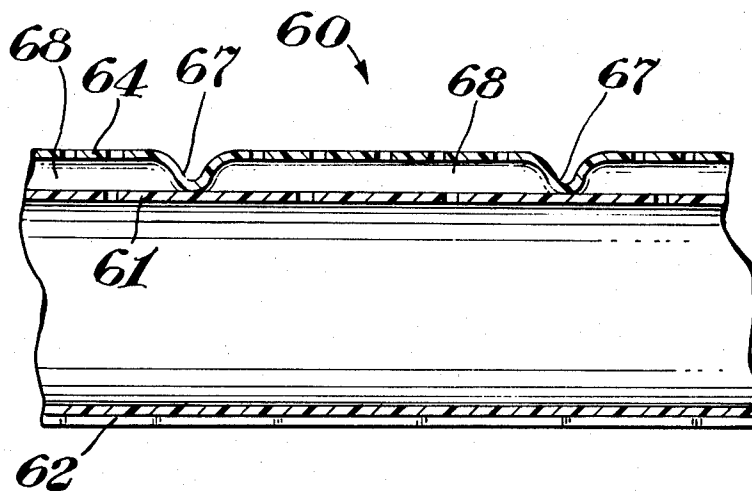


Fig. 7

IRRIGATION TUBE

This application is a continuation-in-part of my co-pending application Ser. No. 293,822, filed Oct. 2, 1972, now abandoned.

Plastic irrigation tube is known which consists of multiple passage tubing such as a double wall tube having perforations in both the inner or supply and outer or discharge tubes, the area of the perforations in the outer tube being substantially greater than perforations on the inner tube. Thus, pressure of a liquid in the inner tube may vary but the volume of water discharged from the outer tube will vary to a degree significantly less than if a single perforated tube is employed. Such commercially available tubes are prepared from thin plastic film wherein two flat strips previously perforated are placed in face to face relationship, folded and heat sealed to form a fin seal. For example, if a plastic film is wrapped about a mandrel and end portions brought into abutting relationship wherein the end portion of the surface contacting the mandrel is brought into contact with itself and sealed, the result is a fin seal. Such a seal usually is weak when internal pressure is applied. Such plastic irrigation tubing is of substantial benefit particularly in arid climates. The light nature of the tubing permits it to be readily buried by hand or beneficially by the use of a mole plow, wire laying plow or like apparatus to convenient depth in the soil. By maintaining water pressure, usually on the order of a few pounds per square inch, a continuous supply of moisture is fed into the soil generally in the region of the plant roots. Such an irrigation system is relatively low in cost to install and presents substantial economies in the utilization of water wherein surface evaporation is significantly reduced over irrigation techniques such as spraying and the like. Generally when employing such a low pressure irrigation system it is necessary that the plastic tubing be installed in such a manner that its elevation is maintained reasonably constant, otherwise flow in lower portions will be much greater than in higher portions.

It would be desirable if there were available an improved surface or subsurface irrigation tubing.

It would also be desirable if there were available an improved irrigation tubing which is more tolerant of elevation.

These benefits and other advantages in accordance with the present invention are achieved in an irrigation tubing comprising a first conduit, the first or supply conduit having generally constant wall thickness, a plurality of perforations disposed in the wall of the first conduit providing a plurality of passages through the wall thereof, a second or discharge conduit having at least a portion of the wall of the first conduit common thereto, the common portion of the wall having the perforations, the second conduit having a plurality of openings passing through the wall thereof not common to the first conduit, the total cross-sectional area of the openings per unit length of the conduits being greater in the second conduit than in the first conduit, the first and second conduits being of flexible plastic material readily deformable to a flat ribbon-like shape, with the further limitation that the second tube defines a plurality of generally elongated compartments.

Further features and advantages of the present invention will become more apparent from the following specification taken in connection with the drawing wherein:

FIG. 1 schematically depicts the application of conduit in accordance with the present invention.

FIG. 2 is a schematic longitudinal sectional view of a conduit in accordance with the present invention.

FIG. 3 is a schematic cross-sectional view of a conduit such as the conduit of FIG. 2.

FIGS. 4 and 5 depict an alternate conduit in accordance with the present invention.

FIG. 6 is a cross-sectional view of another embodiment of the invention.

FIG. 7 is a longitudinal sectional view of a portion of the embodiment of FIG. 6.

In FIG. 1 there is depicted an installation of tubing in accordance with the present invention generally designated by the reference numeral 10. The installation 10 comprises earth 11 having disposed therein perforate irrigation tube 12. The tube 12 has a closed terminal end 13 having an inlet end 14 in operative communication with a water source 15. Water from the source 15 flows into the open end 14 and is gradually discharged into the earth 11 in proximity to the roots of plants 16 disposed within the earth 11.

In FIG. 2 there is schematically depicted an axial cross-sectional view of a tube in accordance with the present invention designated by the reference numeral 20. The tube 20 comprises an inner or supply tube 21 having a first end 22 and a second end 23. The tube 21 has an annular wall 24 of generally constant thickness and is of seamless extruded construction. The wall 24 defines a plurality of openings 25. The openings 25 provide communication between the interior and the exterior of the tube. About the inner tube 21 is disposed an exterior outer adjacent tube 27. The exterior tube 27 encloses the interior tube 21. The tube 27 has a first end 28 and a second end 29 and a wall portion 31. The wall portion 31 defines a plurality of openings 32. The openings 32 have a substantially greater cross-sectional dimension per unit of length of the tube 20 than do the openings 25 in the wall 24 of the tube 21. A plurality of regions of reduced diameter 34 are defined by the tube 27. The regions of reduced diameter are generally circumferentially extending and axially spaced. Between adjacent regions of reduced diameter 34 are defined a plurality of generally annular, longitudinally spaced compartments 35.

In operation of the tube such as the tube 20 of FIG. 2, one end such as the end 23 is closed by heat sealing or suitable plug and a liquid under pressure applied to the remaining end such as the end 22. Liquid under pressure flows within the tube 21, passes within the openings 25 into the various compartments 35. From the compartments 35 the fluid is discharged through the openings 32. By appropriate selection of the relative cross-sectional areas of the openings 25 and 32 and the cross-sectional area of the compartments 35, a relatively large pressure drop is caused to occur in the liquid as it passes from the inner tube 21 into the annular space or compartment 35. As the area of the openings 32 is substantially greater than the area of the openings 25, a relatively small pressure drop occurs in the liquid as it is passed from the compartment 35 to the space external to the tube. The compartments 35 are separated from each other at least to a substantial degree by the regions of reduced diameter 34. The regions 34 beneficially may form liquid-tight seals. Thus, if the tube 20 of FIG. 2 is disposed with the end 22 higher or lower than the end 23, the influence of gravity on the

volume of liquid being discharged from any given region between the area of reduced diameter will be significantly and substantially less than the differences in volume discharged if the regions of reduced diameter were omitted. Thus, irrigation tubing such as the tubing of FIG. 2 can readily be installed in a field or plot of earth with substantially less concern for difference in elevation than in conventional irrigation tubes wherein an annular space such as the space 35 is generally continuous along substantial lengths of the tubing. Employing conventional irrigation tubing in order to maintain uniform irrigation, it is generally desirable that the level be maintained within about one foot, whereas tubing in accordance with the present invention provides very desirable irrigation where levels may vary as much as 6 feet or more.

FIG. 3 schematically depicts a cross-sectional view of the tube 20 of FIG. 2 showing the outer tube 27 having openings 32 disposed about the inner tube 21 having openings 25. The outer tube 27 as depicted in FIG. 3 has been formed by folding a ribbon about the inner tube 21 and forming a lap seal in the region designated by the reference numeral 39. Optionally, if desired, an additional longitudinal seal is readily made at a location indicated by the reference numeral 40 which effectively seals the inner and outer tubes into a single unit.

FIG. 4 schematically depicts an alternate tube of the present invention wherein there is shown a coaxial tube assembly 45. The assembly 45 comprises a first or inner tube 46 and a second or outer tube 47 generally coaxially disposed. Beneficially, tubes such as the tube 45 are readily extruded from coaxial annular tubing dies in communication with a single or double source of plastified synthetic resinous material. A first laser or source of coherent electromagnetic radiation 48 is disposed adjacent the tube 45 and is focused on a wall of the outer tube 47. A second laser or source of coherent electromagnetic radiation 49 is disposed within and focused on a wall of the inner tube 46. The source 49 is conveniently supported on the extrusion die and energy brought through the die and focused on the tube by a mirror. By pulsing and laser energy a desired pattern of openings is readily prepared in both the inner and outer tubes. At the location where the electromagnetic energy from the laser source 49 passes the wall of the tube 47, insufficient energy is localized in the wall 47 to cause perforation thereof. A generally similar situation exists with regard to the tube 46 and the electromagnetic energy from the laser 48. Thus, the tubes 46 and 47 are independently perforated although they are simultaneously prepared one inside the other. The tubes 46 and 47 may be joined to each other to form compartments as in FIG. 2 when they are extruded by pinching the tube 47 onto the tube 46, or the outer tube 47 may be reheated and pinched to heat seal to the tube 46.

In FIG. 5 there is schematically depicted a cross-sectional configuration of an alternate irrigation tube in accordance with the present invention generally designated by the reference numeral 50. The tube 50 comprises an inner tube 51 having a lap seal 52 and perforations 53 in the walls of the tube 51. An outer tube 55 surrounds the tube 51 and defines a generally annular space 56 therebetween. The tube 55 has a lap seal 57 which is integrally bonded or sealed to the seal 52 of the tube 51. The tube 55 has a plurality of perforations 58 in the walls thereof, beneficially in axial spaced rela-

tionship to perforations 53 in the tube 51. The embodiment of FIG. 5 is readily prepared without the use of a tubing extruder.

In FIG. 6 there is depicted an end view of a tube in accordance with the present invention generally designated by the reference numeral 60. The tube 60 comprises a first or supply conduit 61 formed of a single piece of film having a lap seal 62. A second conduit 63 is defined by a second conduit wall 64 and an adjacent portion of the conduit 61. The second conduit wall 64 has a generally arcuate configuration and is affixed to the conduit 61 at locations 65 and 66 which are radially separated by about 120°.

FIG. 7 depicts a longitudinal sectional view of the conduit 60 of FIG. 6. The second conduit wall 64 is sealed or joined to the conduit 61 at a plurality of locations 67 to form a plurality of compartments 68 along the length of the tube 60.

The embodiment of FIGS. 6 and 7 is particularly convenient in that a distribution conduit is obtained employing a minimal quantity of raw material and formation of the tube is accomplished readily.

Tubes in accordance with the present invention are readily prepared from a wide variety of plastic materials, the selection of the particular plastic materials depending primarily upon service conditions and economic conditions. Any extrudable water resistant synthetic resinous plastic which is sufficiently flexible to be wound upon a roll as a flattened tube can be used. Particularly desirable plastic materials include nylon 66, polyvinylchloride, polyethylene, polypropylene and the like. Generally for most applications the outer tube, such as the tubes 27 and 47, are of an ultraviolet and water resistant material such as polyethylene containing 2 percent by weight carbon black. For most applications it is desirable that the thickness of the individual tubes be between about 2 and 20 mils, depending upon the size, the manner of installation and the like. Generally satisfactory service is obtained wherein the individual tubes have a wall thickness of from about 3 to 12 mils. It is very desirable that the tubing in accordance with the present invention be prepared from materials which are flexible under ambient conditions. By "flexible" is meant that the tubes have sufficient flexibility that they may be flattened into the form of a ribbon, wound onto a reel, unwound from the reel and re-inflated with an irrigating liquid such as water. Polyethylene terephthalate; nylon; plasticized polyvinylchloride; olefin polymers including polyethylene, polypropylene and ethylene; copolymers of ethylene and propylene are all eminently satisfactory.

It is essential in the practice of the present invention that at least the inner tube and beneficially the outer tube also, have not more than one edge portion exposed on the outer surface of the particular tube. Tubes which meet these requirements include seamless extruded tubes and tubes having a longitudinal lap seal (as depicted in FIGS. 3 and 5). More stringently stated, a tube suitable for use as an inner tube, when expanded to generally cylindrical form by internal pressure within the tube, may have a tangent to the cross-sectional configuration placed on the outer surface thereof and the tangent shall pass through not more than one layer of tube-forming material. A tube having a fin seal is unsuitable for the inner tube of irrigation tubing in accordance with the present invention.

It is advantageous in the practice of the present invention to maintain the area of the openings in the outer tube greater than the inner tube; that is, for a unit length of irrigation tubing in accordance with the invention the sum of the cross-sectional areas in the outer tube should exceed the sum of the area of the opening in the inner tube. Beneficially, the area ratios per unit length are within the range of from about 1.1 to about 50, and more beneficially in the range of from about 2 to 10.

In the preparation of tubing such as that depicted in FIGS. 2 and 3, the inner tubes such as the tube 21 are extruded from the tubing die and flattened, perforated by any convenient means including hot metal punch to provide openings on the opposite sides of the tube. In general it is usually undesirable to form the openings such as the openings 25 by means of slitting with a sharp blade or similar device. Such openings have a tendency to tear when higher pressures are applied to the interior. Usually it is desirable to employ a means that raises the temperature of the plastic in the region of the opening to a sufficient degree that at least some plastic flow occurs and a relatively smooth opening is obtained generally having a somewhat eyelet-like configuration. Such techniques of perforating plastic film are well known in the art and are typified by perforation with a hot needle. Electromagnetic radiation such as is obtainable from a coherent light beam or laser is very satisfactory for perforating tube. Such laser beams will radiate small openings without stress concentrating leaks or fissures.

A particularly desirable embodiment of the present invention employs inner and outer tubes of about equal diameter; i.e., tube which on inflation exhibits a minimal difference in diameter while still providing an annular space for the flow of irrigating fluid therebetween. By providing such a narrow annular space, a further pressure drop is obtained in the annular space as well as through the openings in the walls of the inner and outer tubes. Beneficially the diameter difference between the outer tube and the inner tube is from about 0.1 percent to about 10 percent of the diameter of the inner tube, and advantageously up to about 4 percent. In a preferred embodiment, the diameter difference is from 0.2 percent to about 2 percent. By the term "diameter difference" is meant the percentage difference between the outside diameter of the inner tube and the inside diameter of the outer tube. In installing irrigation tubing of the present invention it is oftentimes desirable to orient the openings in the outer tubing in a downward direction, particularly if the inner tube is unattached to the outer tube and the resin from which the inner tube is prepared is lighter than water. Occasionally such tubing exhibits a tendency for the inner tube to float due to the presence of water and restrict the flow from some of the openings in the outer tube. Tubes in accordance with the present invention are readily prepared employing one or more perforate tubes between the inner and outer tubes to provide increased pressure drop if desired.

By way of further illustration, an inner tube is prepared having a wall thickness of 10 mils and a width of 1.3 inches when flat. One opening about 0.015 inch in diameter is formed with a laser beam at 6 foot intervals. An outer tube is formed about the inner tube from a strip of 6 mil thick polyethylene containing an ultraviolet light stabilizer. The strip has perforations of about

0.015 inch spaced every 2 feet along its length. The strip for the outer wall is about 3.25 inches in width and is folded about the inner tube and is heat sealed to form a lap joint. The composite tube is heat sealed transversely at one end. The remaining end is connected to a water source after the tube has been buried about 8 inches below the surface of the ground. A generally uniform supply of moisture to the ground is obtained.

An irrigation tube is provided by employing an inner tube of like dimensions to that applied to the previous illustration with the exception that openings of about 0.015 inch diameter are formed through both walls of the flattened tube by means of the laser beam. The outer wall is formed from the strip as employed in the previous illustration with the additional step that locations spaced about 18 feet apart are heated with a blast from an electric hot air gun to cause shrinkage of the exterior tube about the interior tube when the composite tube is installed. In a manner similar to the foregoing illustration and a difference in level of 5 feet between one end and the other, satisfactory distribution of moisture into the soil is obtained.

An irrigation tube is prepared employing a continuous seamless polyethylene tube having a diameter of 0.80 inch, overall wall thickness of 0.010 inch having an opening through the wall of about 0.022 inch spaced on about 5 foot centers. The outer tube has perforations of 0.012 inch on about 2 foot centers. The diameter of the outer tube, which is polyethylene, is about 0.82 inch and has a wall thickness of about 0.006 inch. The tubing is closed at one end and water under a pressure of about 7 pounds per square inch applied to the remaining end. Flow rate from various openings is determined as the height of various portions of the tube is varied. The flow is maintained within 14 percent of the average for all holes with height variations of 6 feet. The slowest flow rate observed for a hole is 79 percent of the average for all holes.

As is apparent from the foregoing specification, the present invention is susceptible of being embodied with various alterations and modifications which may differ particularly from those that have been described in the preceding specification and description. For this reason, it is to be fully understood that all of the foregoing is intended to be merely illustrative and is not to be construed or interpreted as being restrictive or otherwise limiting of the present invention, excepting as it is set forth and defined in the hereto-appended claims.

What is claimed is:

1. An irrigation tubing comprising
 - a first or inner conduit, the inner conduit having generally constant wall thickness,
 - a plurality of perforations disposed in the wall of the inner conduit providing a plurality of passages through the wall thereof,
 - an outer adjacent conduit enclosing the inner conduit, the adjacent conduit having
 - a plurality of openings passing through the wall thereof, the total cross-sectional area of the openings per unit length of the conduits being greater in the outer conduit than in the inner conduits, the inner and adjacent conduits being of flexible plastic material readily deformable to a flat ribbon-like shape, with the further limitation that
 - the outer adjacent tube has spaced apart annular regions of reduced diameter and the inner tube and

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the outer tube define a plurality of generally annular elongated compartments therebetween.

2. The tubing of claim 1 wherein the plastic tubing has a wall thickness of from about 2 to 20 mils.

3. The tubing of claim 2 wherein the inner and adjacent tubes have a wall thickness of from about 3 to 12 mils.

4. The tubing of claim 1 wherein the ratio of the area of the openings in the adjacent tube to the area of the openings in the inner tube is from about 1.1 to 50.

5. The tubing of claim 1 wherein the inner tube is an extruded seamless tube.

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6. The tubing of claim 1 wherein the inner and outer adjacent tubes each have a longitudinal axial lap seal.

7. The tubing of claim 1 wherein the inside diameter of the outer adjacent tube and the outside diameter of the inner tube differ by about 0.1 to about 10 percent of the diameter of the inner tube.

8. The tubing of claim 7 wherein the inside diameter of the outer adjacent tube and the outside diameter of the inner tube differ by about 0.2 to about 4 percent of the diameter of the inner tube.

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