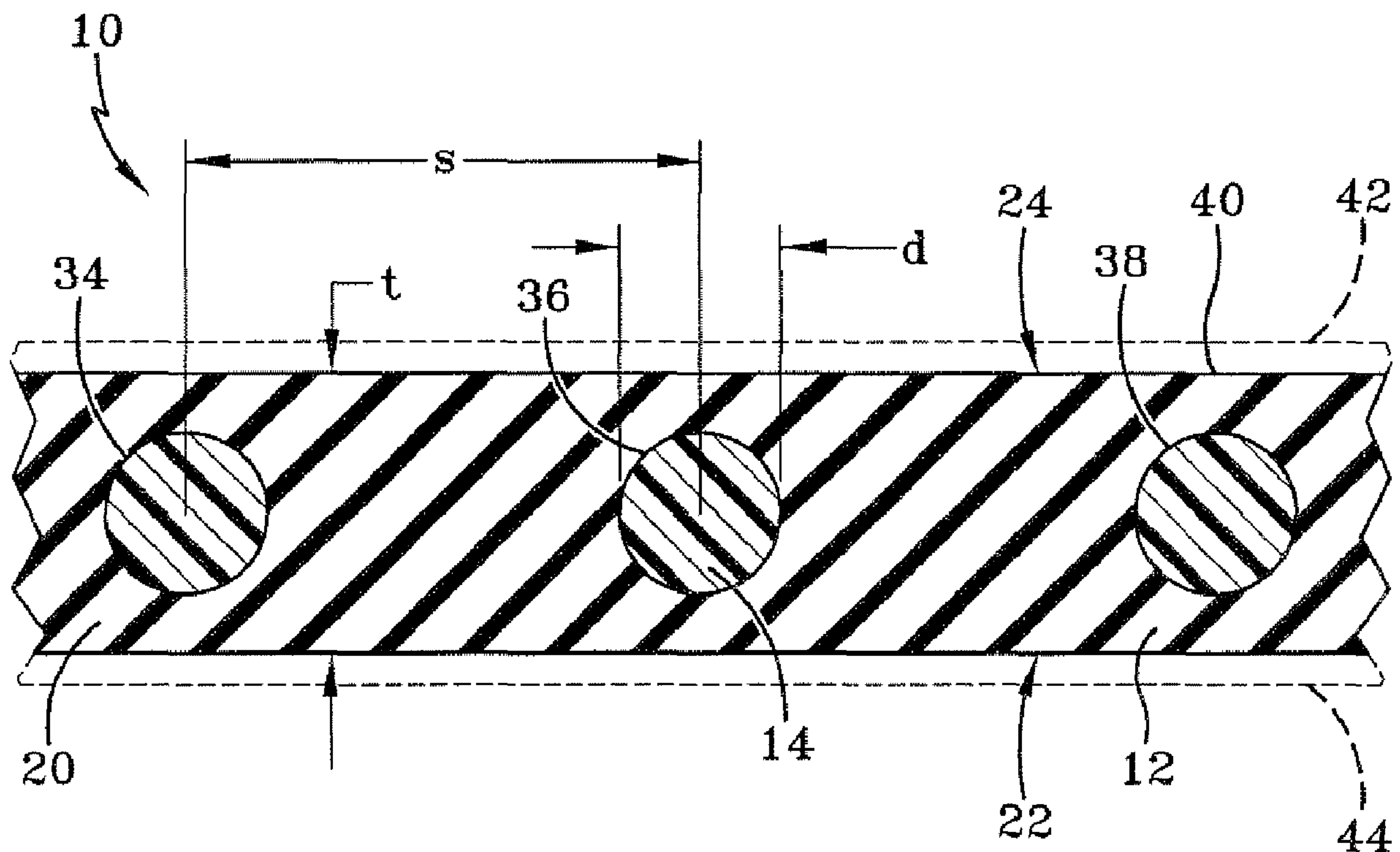




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(72) Inventeurs/Inventors:
BURROWES, THOMAS GEORGE, US;
MAGUIRE, DAVID JOSEPH, US;
GILG, DOUGLAS MICHAEL, US;
YU, JENNY ZHAOXIA, US
(73) Propriétaire/Owner:
VEYANCE TECHNOLOGIES, INC., US
(74) Agent: SMART & BIGGAR

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(54) Title: KINK, CRUSH, AND BURST RESISTANT FLEXIBLE HOSE CONSTRUCTION



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A flexible hose (10) construction with kink, crush, and burst resistance. The hose (10) is constructed of a tubular member (12) and a reinforcement strip (14) at least partially embedded in the tubular member (12). The reinforcement strip (14) is wound in a helical pattern encircling a central lumen (16) of the tubular body (12). The material forming the reinforcement strip (14) has a greater initial modulus than the material forming the tubular member (12).



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(74) Agents: **CHAMBERS, Gregory, J.** et al.; Wood, Heron & Evans, L.L.p., 441 Vine Street, 2700 Carew Tower, Cincinnati, OH 45202 (US).

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(71) Applicant (*for all designated States except US*):
VEYANCE TECHNOLOGIES, INC. [US/US]; 703 S. Cleveland-Massillon Road, Fairlawn, OH 44333 (US).

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(72) Inventors; and

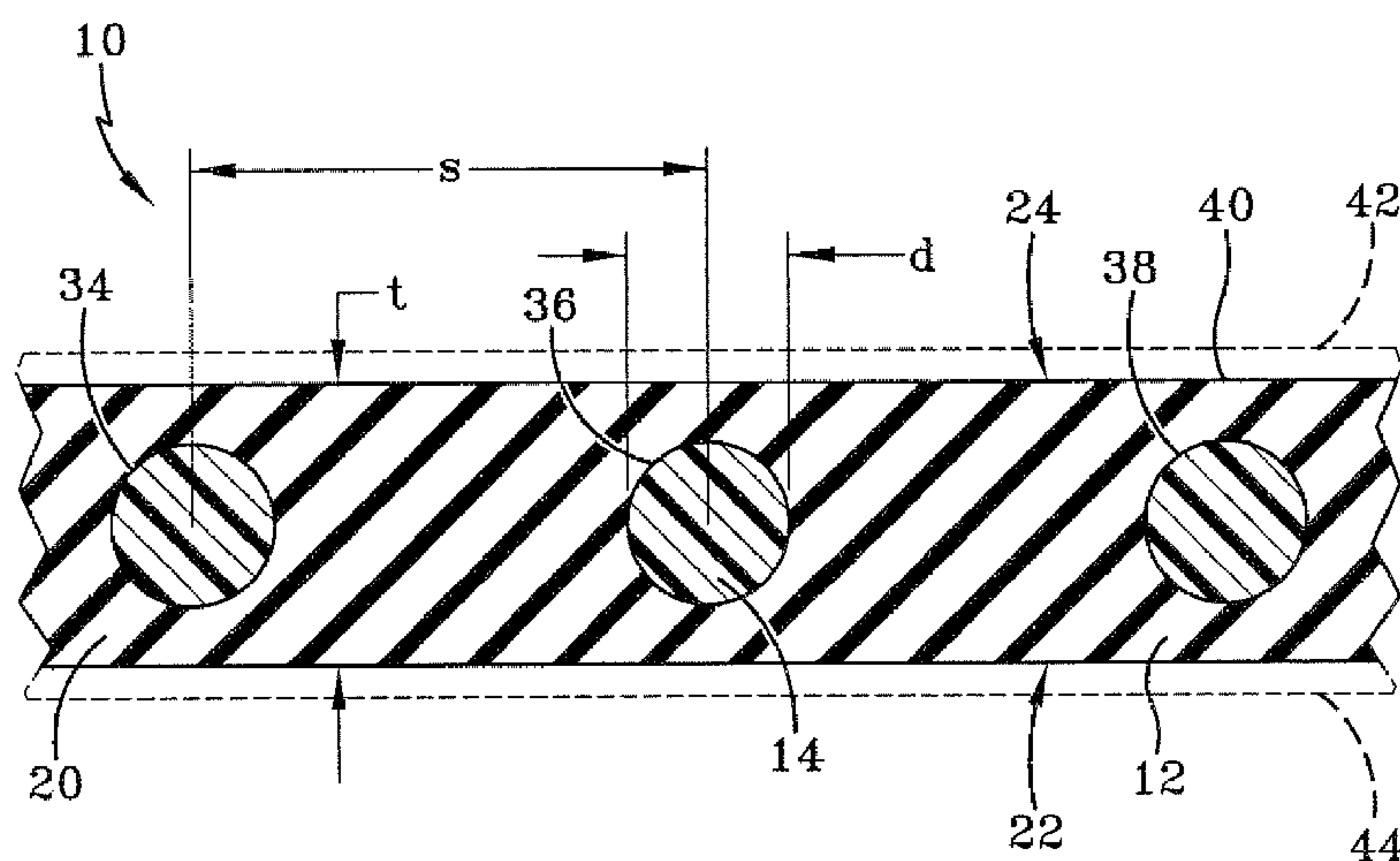
(75) Inventors/Applicants (*for US only*): **BURROWS, Thomas, George** [GB/US]; 2683 Radford Street Nw, North Canton, OH 44720 (US). **MAGUIRE, David, Joseph** [US/US]; 5697 Abbyshire Drive, Hudson, OH 44236 (US). **GILG, Douglas, Michael** [US/US]; 8511 Augusta Drive, Lincoln, NE 68526 (US). **YU, Jenny, Zhaoxia** [US/US]; 42 Stratford Road, Hudson, OH 44236 (US).

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(54) Title: KINK, CRUSH, AND BURST RESISTANT FLEXIBLE HOSE CONSTRUCTION



(57) Abstract: A flexible hose (10) construction with kink, crush, and burst resistance. The hose (10) is constructed of a tubular member (12) and a reinforcement strip (14) at least partially embedded in the tubular member (12). The reinforcement strip (14) is wound in a helical pattern encircling a central lumen (16) of the tubular body (12). The material forming the reinforcement strip (14) has a greater initial modulus than the material forming the tubular member (12).

WO 2008/039750 A3

KINK, CRUSH, AND BURST RESISTANT FLEXIBLE HOSE CONSTRUCTION

FIELD OF THE INVENTION

[0001] The invention relates generally to flexible hoses and, more particularly, to flexible hoses having a hose construction that is kink, crush, and burst resistant.

BACKGROUND

[0002] Conventional flexible hoses have been manufactured for many years, first out of natural rubber and more recently out of petrochemical derivatives such as synthetic rubber, thermoplastic rubbers, or polymers. Conventional flexible hoses commonly have a layered construction consisting of an inner tubular conduit, a spiraled, braided, or knitted reinforcement wrapped about the tubular conduit, and an outer cover.

[0003] "Kinking" is a phenomenon that may occur when the hose is doubled over or twisted. A consequence of kinking is that the fluid flow through the hose can be either severely restricted or blocked. Kinking is a nuisance that causes the user to waste time unkinking the hose. Extreme kinking may occur when, for example, a newly purchased coiled garden hose is initially used. At the time of initial use, a coupling at one end of the hose is fastened to a faucet. The user typically grasps the opposite end of the hose and move away from the faucet without allowing the coiled hose to untwist. Kinking also occurs after the initial use as a consequence of routine movements by the user.

[0004] When a hose kinks, water flow through the hose is blocked. The user must then attempt to remove the blockage by manual manipulation, such as by swinging the hose to relax the kink or approaching the kinked location and manually straightening the kink. Certain kinks may require the user to return to the faucet, shut off the flow at the faucet to release the fluid pressure in the hose, and then manually unkink the hose. The user suffers further inconvenience because he or she must walk back, reestablish the flow of water through the hose, and then return to the opposite end of the hose to continue use. An even more acute problem arises when the user has already attached a large sprinkler device, such as an oscillating sprinkler to the end, and is forced to untwist the hose with this device attached.

[0005] The tendency of flexible hoses to kink may be at least partially alleviated by winding a helical wrap about the exterior of the inner tubular conduit. However, because of the choice of construction materials for the wrap and conduit, such kink resistant hoses achieve

51973-2

enhanced flexibility by sacrificing crush resistance to an externally applied force. When these reinforced hoses are deformed, for example by walking on or driving over them with a car, the helical wrap tends to permanently deform. The permanent deformation restricts the fluid path. Another approach for increasing the kink resistance of flexible hoses is to increase the wall thickness of the tubular conduit. However, increasing the wall thickness sacrifices hose flexibility such that these hoses are more cumbersome for a user to handle and manipulate. Increasing the wall thickness also makes the hose heavier.

[0006] Thus, an improved hose construction is desired that is characterized by a suitable physical property combination of kink resistance, crush resistance, and burst resistance.

SUMMARY

[0007] The invention provides for a hose construction that is concurrently kink, crush, and burst resistant to an extent unachievable by conventional hoses. The hose is constructed of a tubular member and a reinforcement strip at least partially embedded inside a sidewall of the tubular member. The reinforcement strip may be wound in a helical pattern encircling the central lumen of the tubular body. The kink, crush, and burst resistance of the hose is optimized by selection of materials for the tubular body and reinforcement strip. In particular, the material forming the reinforcement strip has a greater initial modulus than the material forming the tubular member. The hose may be suitable for various different household and industrial applications.

[0007a] According to one aspect, the present invention provides for a hose comprising: a tubular member comprising a sidewall aligned along a longitudinal axis and a lumen radially inside said sidewall, said sidewall having an inner surface and an outer surface defining the boundaries of the sidewall, wherein the outer surface is substantially smooth longitudinally along the hose, said tubular member being comprised of polyvinylchloride having an initial modulus of about 3,000 psi or less; and a helical reinforcement strip at least partially embedded within said sidewall of said tubular member and helically wound with a pitch about said lumen of said tubular member, said reinforcement strip being comprised of a blend of an

51973-2

ethylene-butene copolymer and polypropylene, wherein said blend has a zero or positive tangent modulus value up to a strain level of about 20 percent and an initial modulus of about 5000 psi or more.

[0007b] According to another aspect, the present invention provides for a hose
5 comprising: a tubular member comprising a sidewall aligned along a longitudinal axis and a lumen radially inside said sidewall, said sidewall having an inner surface and an outer surface defining the boundaries of the sidewall, wherein the outer surface is substantially smooth longitudinally along the hose, said tubular member being comprised of polyvinylchloride having an initial modulus of about 3,000 psi or less; and a helical reinforcement strip at least
10 partially embedded within said sidewall of said tubular member and helically wound with a pitch about said lumen of said tubular member, said reinforcement strip being comprised of a blend of an ethylene-butene copolymer and polypropylene, wherein said blend has a zero or positive tangent modulus value up to a strain level of about 20 percent and an initial modulus of about 5000 psi or more.

15 **[0007c]** According to still another aspect, the present invention provides for a hose comprising: a tubular member comprising a sidewall aligned along a longitudinal axis and a lumen radially inside said sidewall, said sidewall having an inner surface and an outer surface defining the boundaries of the sidewall, wherein the outer surface is substantially smooth longitudinally along the hose, said tubular member being comprised of an ethylene-octene
20 copolymer having an initial modulus of about 3,000 psi or less; and a helical reinforcement strip at least partially embedded within said sidewall of said tubular member and helically wound with a pitch about said lumen of said tubular member, said reinforcement strip being comprised of a blend of an ethylene-butene copolymer and polypropylene, wherein said blend has a zero or positive tangent modulus value up to a strain level of about 20 percent and an
25 initial modulus of about 5000 psi or more.

[0008] The invention will become more readily apparent from the following Detailed Description taken in conjunction with the accompanying drawings.

51973-2

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with a general description of the invention given above, and the detailed description given below, serve to
5 explain the principles of the invention.

[0010] FIG. 1 is a perspective view of a hose constructed with a tubular member and a reinforcement strip wound about the tubular member in accordance with an embodiment of the invention;

[0011] FIG. 2 is a perspective view of a portion of the hose of FIG. 1 in which the
10 tubular

member is partially removed to reveal the reinforcement strip;

[0012] FIG. 3 is a cross-sectional view taken along a vertical section of FIG. 2;

[0013] FIG. 4 is a cross-sectional view similar to FIG. 3 of a hose in accordance with an alternative embodiment of the invention;

[0014] FIG. 5 is a cross-sectional view similar to FIGS. 3 and 4 of a hose in accordance with an alternative embodiment of the invention;

[0015] FIG. 6 is a cross-sectional view similar to FIGS. 3-5 of a hose in accordance with an alternative embodiment of the invention;

[0016] FIG. 7 is an engineering stress-strain curve for a representative rigid material useable for constructing the reinforcement strip of the hose of FIGS. 1-3; and

[0017] FIG. 8 is an engineering stress-strain curve for a representative flexible material useable for constructing the inner tubular member of the hose of FIGS. 1-3.

DETAILED DESCRIPTION

[0018] With reference to FIGS. 1-3, a flexible hose 10 includes a tubular member 12 and a reinforcement strip 14 concentrically arranged about an open channel or lumen 16 extending along the length of the flexible hose 10. The reinforcement strip 14 is wound about a longitudinal axis 18 that is central to the lumen 16. The tubular member 12 includes an annular sidewall 20 with an inner and outer diameter separated by a wall thickness, t , which may vary along the axial length of the hose 10 because of the presence of the reinforcement strip 14 at least partially embedded within the sidewall 12. The tubular member 12 extends axially to an indefinite length along the central longitudinal axis 18. The inner and outer diameter dimensions and length dimension may vary depending upon the particular fluid conveying application involved.

[0019] The thickness, t , of the sidewall 20 is measured as a radial dimension between an interior or inner surface 22 of the inner diameter and an exterior or outer surface 24 of the outer diameter. The inner and outer surfaces 22, 24 define the boundaries of the sidewall 20. The inner surface 22, which borders and defines the lumen 16, is exposed to the fluid conveyed through the lumen 16 and is typically substantially smooth. The outer surface 24 is exposed to the working environment of the hose 10. Opposite ends 26, 28 of the flexible hose 10 are terminated by conventional hose fittings 30, 32, respectively, used for coupling the flexible hose 10 to a fluid source, a fluid drain, a fluid dispenser, or even another hose or conduit. The inner surface 22 of

the tubular member 12 may have an inner diameter of, for example, 1/4", 3/8", 1/2", 5/8", 3/4", or 1".

[0020] The reinforcement strip 14 includes a plurality of continuous coils or turns, such as representative turns 34, 36, 38 (FIG. 3). The turns 34, 36, 38 are wound with a spiral or helical winding pattern having a helical pitch measured along the central longitudinal axis 18 such that adjacent pairs of turns 34, 36, 38 are non-contacting and, thereby, separated or spaced apart from each other by a center-to-center or centerline spacing, s . The centerline spacing, s , may range from about 110 percent to about 500 percent of the diameter, d , of the individual turns 34, 36, 38. The turns 34, 36, 38 of the reinforcement strip 14 may have a round geometrical shape depicted in FIGS. 2 and 3, an oval geometrical shape, a hexagonal geometrical shape, or another suitable geometrical shape. The interstitial spaces between adjacent turns 34, 36, 38 of the reinforcement strip 14 are filled by the material of the tubular member 12.

[0021] The cross-sectional area of the turns 34, 36, 38, as well as the helical pitch of the reinforcement strip 14, may influence the flexibility of the hose 10 and its strength against flattening and against pressure to resist bursting. Increasing the helical pitch of the reinforcement strip 14 in the axial direction increases the centerline spacing, s , which increases the flexibility of the hose, but may decrease the strength against flattening and pressure resistance against bursting. Increasing the cross-sectional area of the turns 34, 36, 38 increases the crush resistance against flattening but may reduce flexibility.

[0022] As best shown in FIGS. 2 and 3, the turns 34, 36, 38 of the reinforcement strip 14 may be completely encapsulated or embedded within the tubular member 12. In this instance, a continuous portion of the tubular member 12 comprises a thin outer skin or cover 40 that encases the turns 34, 36, 38 of the reinforcement strip 14 within the sidewall 20 and separates the turns 34, 36, 38 from the outer surface 24. Alternatively, the turns 34, 36, 38 of the reinforcement strip 14 may be partially exposed through the outer surface 24 of the sidewall 20. The material forming the tubular member 12 fills the spaces between adjacent turns 34, 36, 38 of the reinforcement strip 14.

[0023] An optional sheath layer 42 may be applied about the outer surface 24 of the tubular member 12 for the purpose of imparting abrasion resistance or chemical resistance. The construction material for the optional outer sheath 42 may comprise thermoplastic elastomer (TPE) or PVC added to hose 10 by, for example, a sequential extrusion process. In addition, an

optional liner layer 44 may be applied on the inner surface 22 of the tubular member 12 by, for example, a sequential extrusion process. The liner layer 44 may be composed of a chemical-resistant material, such as rubber, that is chemically inert and resistant to permeation by the conveyed fluid in the lumen 16.

[0024] In one aspect, the reinforcement strip 14 comprises a high modulus material having a greater initial modulus than a low modulus material forming the tubular member 12. Because of the higher initial modulus, the high modulus material forming the reinforcement strip 14 has a greater rigidity (or lower flexibility) than the low modulus material forming the tubular member 12. As understood by a person having ordinary skill in the art, the initial modulus is a physical property of a material measured from the slope of an engineering stress-strain curve at low strain levels near zero strain. An engineering stress-strain curve is a graph representing an experimental measurement derived from measuring load (i.e., stress) versus extension (i.e., strain) for a sample of a material. The shape and characteristics of the stress-strain curve vary with the type of material. The stress-strain curve features an initial elastic region over an initial range of relatively low applied stresses, followed by a plastic region over another range of moderate applied stresses, and ultimately fracture at a sufficiently high applied stress.

[0025] The high modulus material of reinforcement strip 14 may be a TPE, a blend of two or more TPE's, a blend of TPE with polyethylene, or a blend of TPE with polypropylene. In particular, the high modulus material of reinforcement strip 14 may comprise a blend of a TPE and polypropylene having a composition ranging from about 80 percent by weight (wt.%) TPE to about 20 percent by weight TPE. A particularly useful polymer blend is believed to comprise a composition of about 50 percent by weight TPE and about 50 percent by weight polypropylene. Increasing the percentage by weight of polypropylene in the blend relative to percentage by weight of TPE is believed to increase the kink resistance of the hose 10, but reduce the flexibility. High modulus materials suitable for constructing the reinforcement strip 14 may comprise a blend of polypropylene and a TPE selected from the ENGAGE[®] family of TPE's commercially available from Dow Chemical Company (Midland, Michigan). A particularly useful polymer blend comprises ENGAGE[®] ENR[™] 7256 ethylene-butene copolymer and polypropylene combined in a ratio of about 50 wt.% TPE to about 50 wt.% polypropylene, which has an initial modulus of about 40,000 psi. ENGAGE[®] ENR[™] 7256 is characterized by a density of 0.885 grams per cubic centimeter (ASTM D792) and a melt mass flow rate of 0.80 grams per ten minutes (190°C/2.16

kg, ASTM D1238).

[0026] The high modulus material of reinforcement strip 14 is selected with a composition that exhibits a minimum initial modulus of about 5,000 pounds per square inch (psi). The high modulus material constituting reinforcement strip 14 may also exhibit a minimum tensile strength of about 1000 psi, or greater. The selected composition of the high modulus material of reinforcement strip 14 may also exhibit a zero or positive value of tangent modulus on the engineering stress-strain curve through a strain level of at least 20 percent as measured with a variation of ASTM standard D412 at crosshead speed of about two inches per minute. The tangent modulus is the slope of the engineering stress-strain curve at a given level of stress or strain. The tensile strength represents the stress at the inflection point or maximum on the engineering stress-strain curve, which corresponds to the maximum stress that can be sustained by a structure in tension. For applied stresses exceeding the tensile strength, the tangent modulus becomes negative because of permanent and non-recoverable deformation as the tested specimen extends. In one embodiment, the high modulus material of reinforcement strip 14 is characterized by an initial modulus of about 40,000 psi or more, a tensile strength of about 1600 psi or more, and a zero or positive value of tangent modulus on an engineering stress-strain curve through a strain level of at least 20 percent.

[0027] Although not wishing to be limited by theory, the relatively high initial modulus of the high modulus material of reinforcement strip 14 is believed to impart appreciable kink resistance to the hose 10. Although not wishing to be limited by theory, the minimum tensile strength of the high modulus material of reinforcement strip 14 is believed to impart appreciable burst strength to the hose 10. Although not wishing to be limited by theory, the positive tangent modulus of the high modulus material of reinforcement strip 14 is believed to impart appreciable crush resistance to the hose 10 by limiting the permanent deformation of the strip 14 in response to a crushing force tending to flatten the coils 34, 36, 38.

[0028] The low modulus material constituting the tubular member 12 is significantly more flexible than the high modulus material constituting the reinforcement strip 14. In one aspect, the low modulus material constituting the tubular member 12 exhibits a maximum initial modulus of about 3000 psi and, typically, an initial modulus between about 200 psi and about 3000 psi. In one embodiment, the initial modulus of the low modulus material may range from about 600 psi to about 1,000 psi. The minimum stress at 250 percent strain of the low modulus material may be

about 400 psi and, in certain embodiments, the stress at 250 percent strain may range from about 750 psi to about 1250 psi.

[0029] The low modulus material constituting the tubular member 12 may be a polymer such as TPE, a blend of two or more TPE's, or polyvinylchloride (PVC), although the invention is not so limited. Low modulus materials suitable for constructing the tubular member 12 may be a TPE selected from the family of polyolefin elastomers commercially available under the trade name ENGAGE[®] from Dow Chemical Company (Midland, Michigan). A particularly useful TPE for forming tubular member 12 is ENGAGE[®] 8180 polyolefin elastomer, which is an ethylene-octene copolymer characterized by a density of 0.863 grams per cubic centimeter (ASTM D792) and a melt mass flow rate of 0.50 grams per ten minutes (190°C/2.16 kg, ASTM D1238).

[0030] In certain embodiments, one or more conventional additives, such as a crosslinking agent, may be added to either the low modulus material of tubular member 12 or the high modulus material of the reinforcement strip 14. For example, silane may be added as a crosslinking agent to the low modulus material constituting the tubular member 12. In particular, the low modulus material of tubular member 12 may comprise a blend of ENGAGE[®] 8180 with the crosslinking agent SILCAT[®] RHE silane, which is a crosslinking vinylsilane agent commercially available from General Electric Advanced Materials (Wilton, Connecticut). Depending upon the composition, the addition of SILCAT[®] RHE silane provides an initial modulus of approximately 600 psi to 1000 psi and a stress at 250 percent strain of 750 psi to 1250 psi.

[0031] In an alternative embodiment, the low modulus material of the tubular member 12 may be foamed to reduce the weight and increase the flexibility of the hose 10. The blowing agent works by expanding the low modulus material of the tubular member 12 to produce a cellular structure having significantly less density than the polymer itself. The foamed structure may be achieved by introducing a conventional blowing agent into the low modulus material of tubular member 12 during extrusion. The blowing agent may be any chemical agent that liberates gas when heated above a characteristic decomposition temperature (e.g., sodium bicarbonate that liberates CO₂ when heated above its decomposition temperature), any physical agent such as any gas (e.g., gaseous nitrogen or carbon dioxide), or any other known type of blowing agent. As the low modulus material of the tubular member 12 cools and hardens, gas-filled bubbles originating from the blowing agent define a closed cellular structure of a given density throughout the tubular member 12.

[0032] The combination of a low modulus material for the tubular member 12 and a high modulus material for the reinforcement strip 14 is selected to construct a hose 10 that, in comparison with conventional hose constructions, exhibits acceptable flexibility, kink resistance, and crush resistance under zero- and low-fluid pressure conditions without sacrificing strength that resists bursting. In certain embodiments of the invention, the materials for the tubular member 12 and reinforcement strip 14 may be selected to operate under internal working fluid pressures ranging from about 15 psi to about 500 psi.

[0033] The hose 10 may be manufactured or fabricated using extrusion techniques known to a person having ordinary skill in the art. For example, one extrusion technique involves feeding a continuous extruded body of molten material tangentially relative to a rotating cylindrical mandrel. The molten extruded body, before contacting the rotating mandrel, consists of an outer shell of the low modulus material of the tubular body 12 and an inner core of the high modulus material of the reinforcement strip 14. As the extruded body contacts the rotating mandrel, the molten extruded body coils in a multiplicity of successive loops about the circumference of the mandrel. Confronting edges of adjacent loops merge or fuse together in the molten state to form a continuous and integral tubular body or mass in which the inner core remains segregated from the outer shell. When cooled, the tubular body 12 and reinforcement strip 14 are defined from the outer shell and the inner core, respectively, as a continuous length of tubing defining hose 10 without additional processing steps. The tubing is cut to length and the hose fittings 30, 32 are attached.

[0034] The high modulus and low modulus materials constituting the reinforcement strip 14 and tubular member 12, respectively, are compatible in that they mutually adhere together to create a cohesive, strongly bonded integral composite structure. An intermediate tie or bonding layer (not shown), which may be co-extruded between the outer shell and inner core, may be formed of a material that is adhesion bond compatible with both the materials of reinforcement strip 14 and tubular member 12.

[0035] Hose 10 may be adapted for use in a wide variety of industrial or household applications. One commercial application for hose 10 is a garden or water hose for household or industrial use. Another commercial application for hose 10 is a drop hose mainly used for the transfer of various fluids including, but not limited to, gasoline, petroleum based products, chemicals, petrochemicals, and fluid food products. Hose 10 may be also used to make pneumatic

hoses for pneumatic tools and the like.

[0036] With reference to FIG. 4 and in accordance with an alternative embodiment of the invention, a hose 50 includes hose 10 with tubular member 12 and reinforcement strip 14, a tubular member 52 formed from a low modulus material, and a layer 54 of yarn arranged radially between the tubular members 12, 52. The added yarn layer 54 is believed to increase the burst strength of hose 50, in comparison with hose 10 (FIGS. 1-3), and may be used for operating hose 50 at a working fluid pressure as high as about 500 psi (i.e., 2000 psi burst strength). The yarn layer 54 may comprise a knit fabric, a spiral or continuous strand helically wound about the inner tubular member 52 as shown in FIG. 4, or a braided fabric. The yarn layer 54 may be composed of any suitable material, such as polyester, nylon, rayon, aramid, carbon fiber, ceramic fibers such as silicon carbide, polyvinyl alcohol (PVA), Poly p-phenylene-2,6-benzobisoxazole (PBO) or polypropylene, as understood by a person having ordinary skill in the art, and may have the form of a monofilament or a multi-filament material.

[0037] In the hose construction of hose 50, the yarn layer 54 and inner tubular member 52 are disposed radially inside of the inner surface 22 of tubular layer 12. The yarn layer 54 is disposed radially between the tubular member 12 and inner tubular member 52. After the tubular member 52 is formed, the yarn layer 54 is applied about tubular member 52 before the extrusion forming hose 10 is applied about the exterior of the yarn layer 54.

[0038] With reference to FIG. 5 and in accordance with an alternative embodiment of the invention, a hose 60 includes a layer 62 of yarn added about the outer surface 24 of hose 10 (FIGS. 1-3). The yarn layer 62 may be constructed as described above with regard to yarn layer 56 (FIG. 4). The yarn layer 62 is disposed radially outside of the outer surface 24. In the hose construction of hose 60, the yarn layer 62 is applied about outer surface 24 after the hose 10 is formed.

[0039] With reference to FIG. 6 and in accordance with an alternative embodiment of the invention, a hose 70 includes a strand 72 of yarn added as a core inside the reinforcement strip 14. The material constituting yarn strand 72 may be a continuous monofilament or a multi-filament strand of polyester, nylon, rayon, aramid, polypropylene, or another suitable material. In the hose construction of hose 70, the yarn strand 72 may be combined with the shell and core such that the yarn strand 72 resides inside the reinforcement strip 14 after the extrusion process.

[0040] References herein to terms such as "inner" or "interior" and "outer" or "exterior"

51973-2

refer, respectively, to directions toward and away from the center of the referenced element, and the terms "radial" and "axial" refer, respectively, to directions perpendicular and parallel to the longitudinal central axis of the referenced element are made by way of example, and not by way of limitation, to establish a frame of reference. It is understood that various other reference frames may be employed for describing the invention.

[0041] The embodiments described above may be further appreciated with consideration of the following example.

[0042] Example

[0043] The properties of candidate high modulus and low modulus materials for a flexible hose as described herein were tested. The candidate high modulus material for the reinforcement strip 14 was selected to be ENGAGE® ENR™ 7256 and polypropylene blended in a nominal ratio of about 50 percent by weight TPE to about 50 percent by weight PP. As indicated in FIG. 7, the blended material was measured an initial modulus of about 40,000 psi, a zero or positive tangent modulus at 20 percent strain, and a tensile strength of about 1,600 psi. The candidate low modulus material of the tubular member 12 was selected to be ENGAGE® 8180 with the crosslinking agent SILCAT® RHE silane. As shown in FIG. 8, the initial modulus is about 750 psi and the stress at 250 percent strain is about 770 psi. With this combination of physical properties, a flexible hose constructed from these materials is predicted to burst at a minimum fluid pressure of about 300 psi.

[0044] To generate the engineering stress-strain curves of FIGS. 7 and 8, dumbbell shaped test specimens (Die C per ASTM 412) of the two materials comprising the flexible hose were tensile tested on a United tensile test machine at a speed of 2 inches per minute for the high modulus material and on an Instron tensile test machine a speed of 20 inches per minute for the low modulus material. All testing was conducted with the test specimens at room temperature.

[0045] While the invention has been illustrated by a description of various embodiments and while these embodiments have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. The invention in its broader aspects is therefore not limited to the specific details, representative apparatus and methods, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the scope of applicants' general

inventive concept. The scope of the invention itself should only be defined by the appended claims, wherein we claim:

51973-2

CLAIMS:

1. A hose comprising:

a tubular member comprising a sidewall aligned along a longitudinal axis and a lumen radially inside said sidewall, said sidewall having an inner surface and an outer surface
 5 defining the boundaries of the sidewall, wherein the outer surface is substantially smooth longitudinally along the hose, said tubular member being comprised of polyvinylchloride having an initial modulus of about 3,000 psi or less; and

a helical reinforcement strip at least partially embedded within said sidewall of said tubular member and helically wound with a pitch about said lumen of said tubular
 10 member, said reinforcement strip being comprised of a blend of an ethylene-butene copolymer and polypropylene, wherein said blend has a zero or positive tangent modulus value up to a strain level of about 20 percent and an initial modulus of about 5000 psi or more.

2. The hose of claim 1 wherein the polyvinylchloride has a minimum stress of about 400 psi at a 250 percent strain.

15 3. The hose of claim 1 wherein the blend of ethylene-butene copolymer and polypropylene has a tensile strength of about 1000 psi or more.

4. The hose of claim 1 wherein said initial modulus of said blend of ethylene-butene copolymer and polypropylene is about 40,000 psi or more.

5. The hose of claim 4 wherein said blend of ethylene-butene copolymer and
 20 polypropylene has a tensile strength of about 1600 psi or more.

6. The hose of claim 1 wherein said initial modulus of said polyvinylchloride ranges from about 600 psi to about 1,000 psi, and said polyvinylchloride has a stress at 250 percent strain ranging from about 750 psi to 1250 psi.

7. The hose of claim 1 wherein said sidewall is bounded between an inner surface
 25 and an outer surface radially outward of said inner surface, and further comprising:

51973-2

a tubular yarn layer radially inside said inner surface; and

a tubular conduit radially inside said yarn layer, said tubular conduit bordering said lumen.

8. The hose of claim 1 wherein said sidewall is bounded between an inner surface
5 and an outer surface radially outward of said inner surface, and further comprising:

a tubular yarn layer radially outside of said outer surface.

9. The hose of claim 1 further comprising:

a continuous strand of yarn inside said reinforcement strip.

10. A hose comprising:

- 10 a tubular member comprising a sidewall aligned along a longitudinal axis and a lumen radially inside said sidewall, said sidewall having an inner surface and an outer surface defining the boundaries of the sidewall, wherein the outer surface is substantially smooth longitudinally along the hose, said tubular member being comprised of polyvinylchloride having an initial modulus of about 3,000 psi or less; and

- 15 a helical reinforcement strip at least partially embedded within said sidewall of said tubular member and helically wound with a pitch about said lumen of said tubular member, said reinforcement strip being comprised of a blend of an ethylene-butene copolymer and polypropylene, wherein said blend has a zero or positive tangent modulus value up to a strain level of about 20 percent and an initial modulus of about 5000 psi or more.

- 20 11. The hose of claim 10 wherein said blend comprises twenty percent by weight to eighty percent by weight of said ethylene-butene copolymer, with the balance of the blend being polypropylene.

12. The hose of claim 10 wherein said sidewall is bounded between an inner surface and an outer surface radially outward of said inner surface, and further comprising:

51973-2

a tubular yarn layer radially inside said inner surface; and

a tubular conduit radially inside said yarn layer, said tubular conduit bordering said lumen.

13. The hose of claim 10 wherein said sidewall is bounded between an inner
5 surface and an outer surface radially outward of said inner surface, and further comprising:

a tubular yarn layer radially outside of said outer surface.

14. The hose of claim 10 further comprising:

a continuous strand of yarn inside said reinforcement strip.

15. The hose of claim 10 wherein said polyvinylchloride is in the form of a closed-
10 cell foam.

16. A hose comprising:

a tubular member comprising a sidewall aligned along a longitudinal axis and a lumen radially inside said sidewall, said sidewall having an inner surface and an outer surface defining the boundaries of the sidewall, wherein the outer surface is substantially smooth
15 longitudinally along the hose, said tubular member being comprised of an ethylene-octene copolymer having an initial modulus of about 3,000 psi or less; and

a helical reinforcement strip at least partially embedded within said sidewall of said tubular member and helically wound with a pitch about said lumen of said tubular member, said reinforcement strip being comprised of a blend of an ethylene-butene copolymer
20 and polypropylene, wherein said blend has a zero or positive tangent modulus value up to a strain level of about 20 percent and an initial modulus of about 5000 psi or more.

17. The hose of claim 16 wherein ethylene-octene copolymer is crosslinked with a silane crosslinking agent.

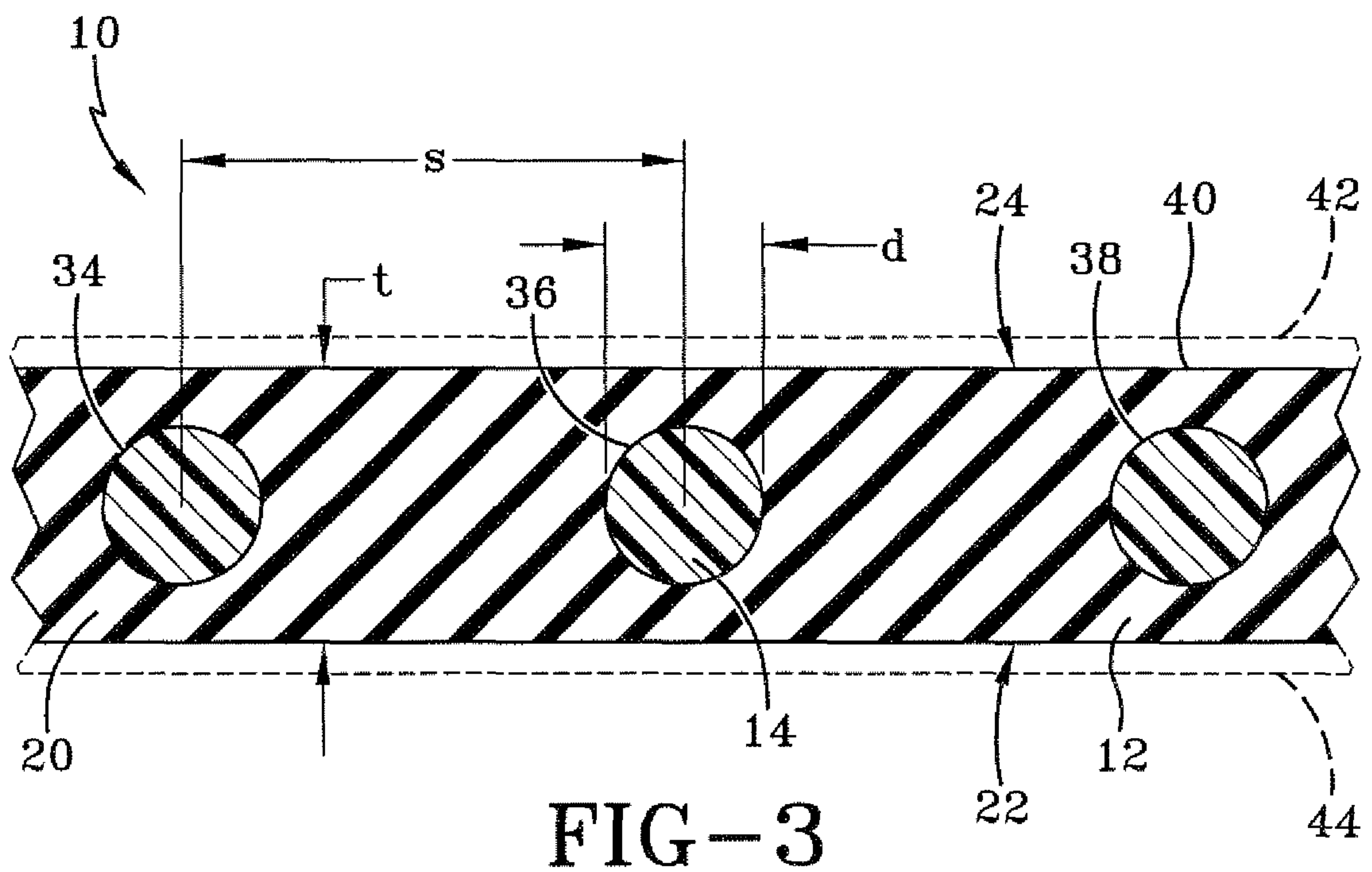
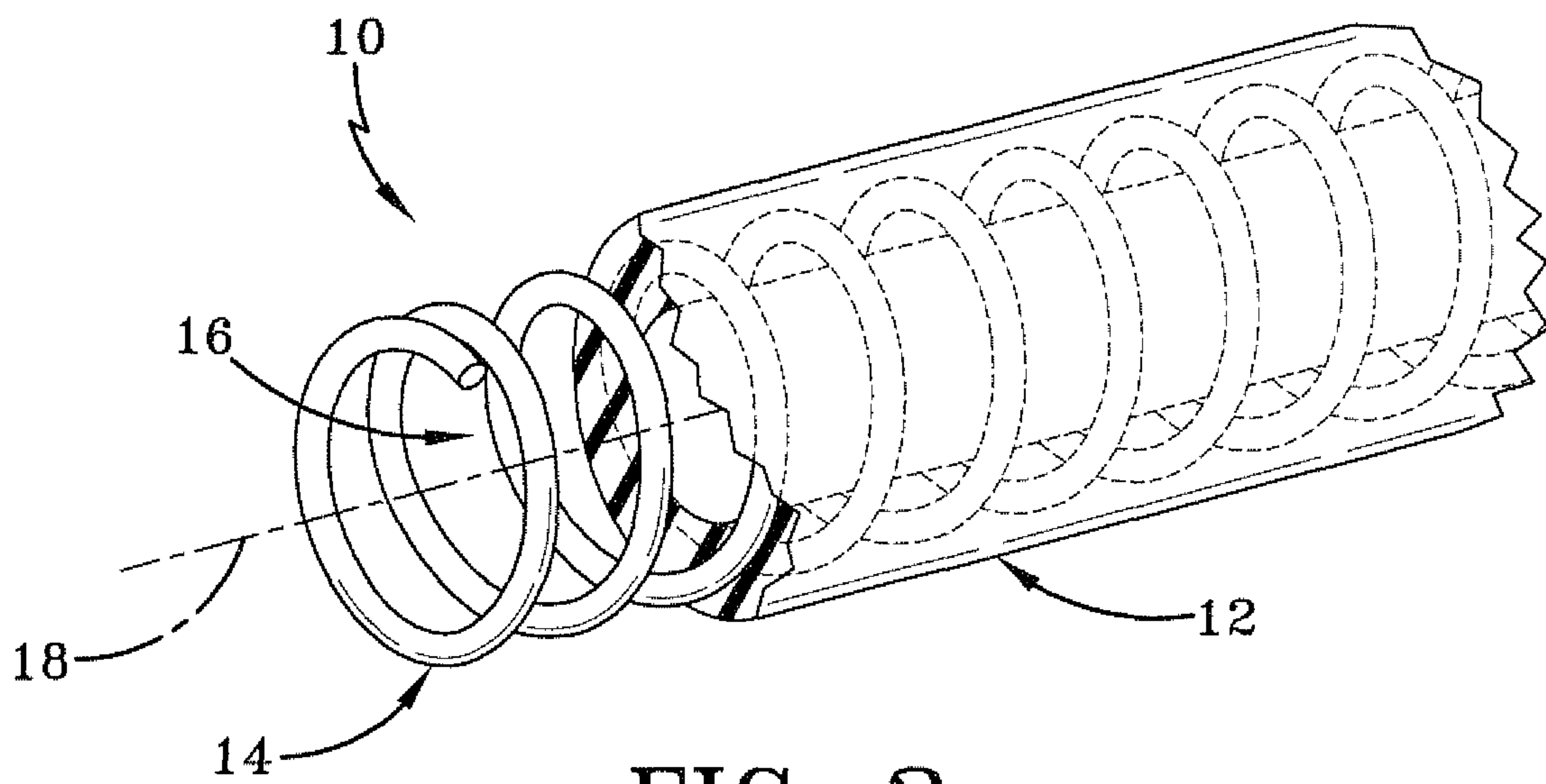
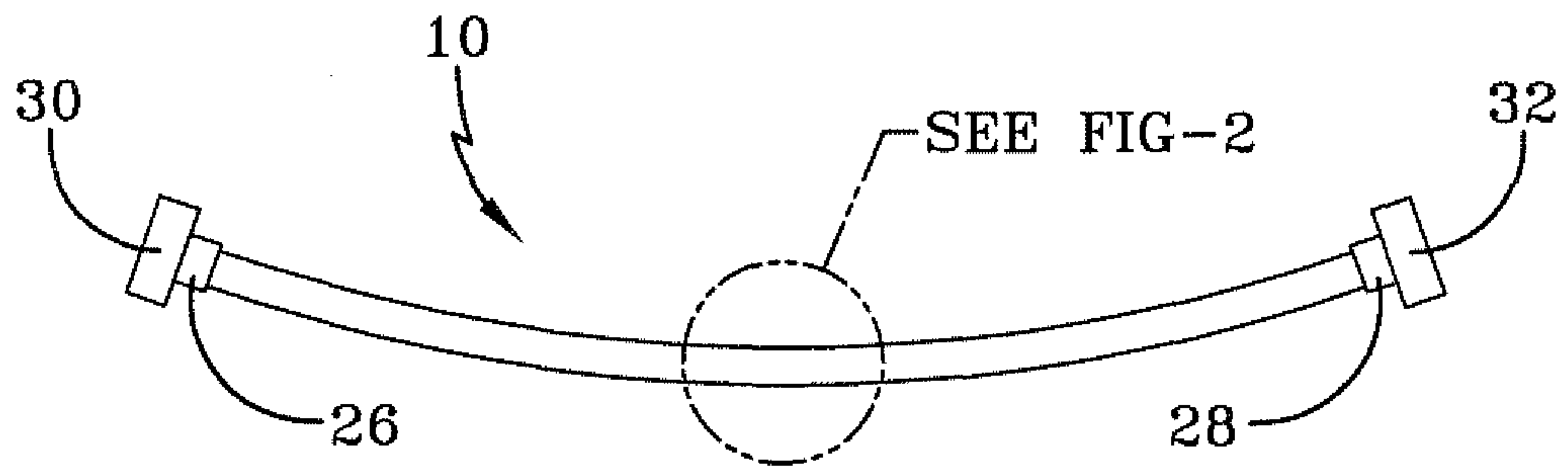
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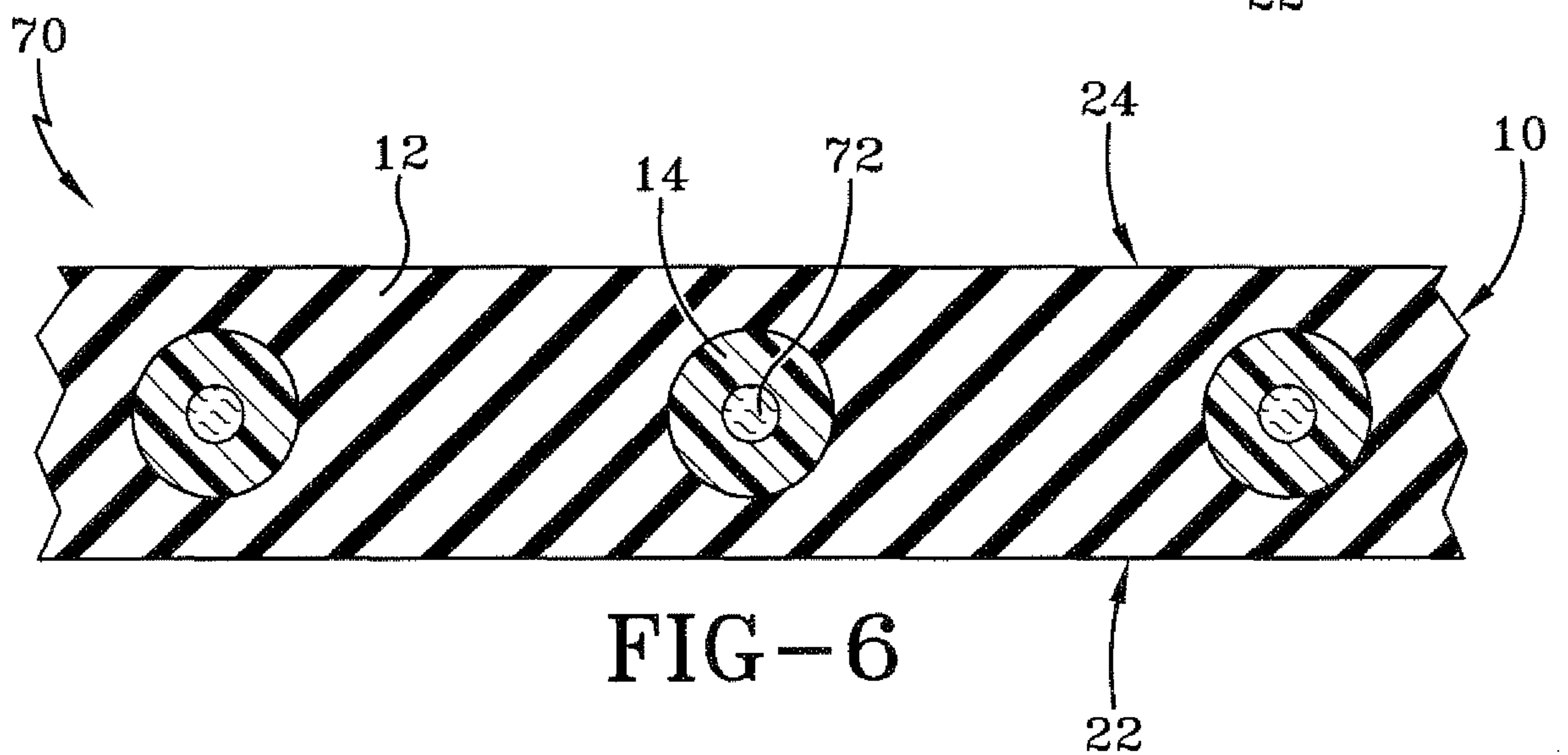
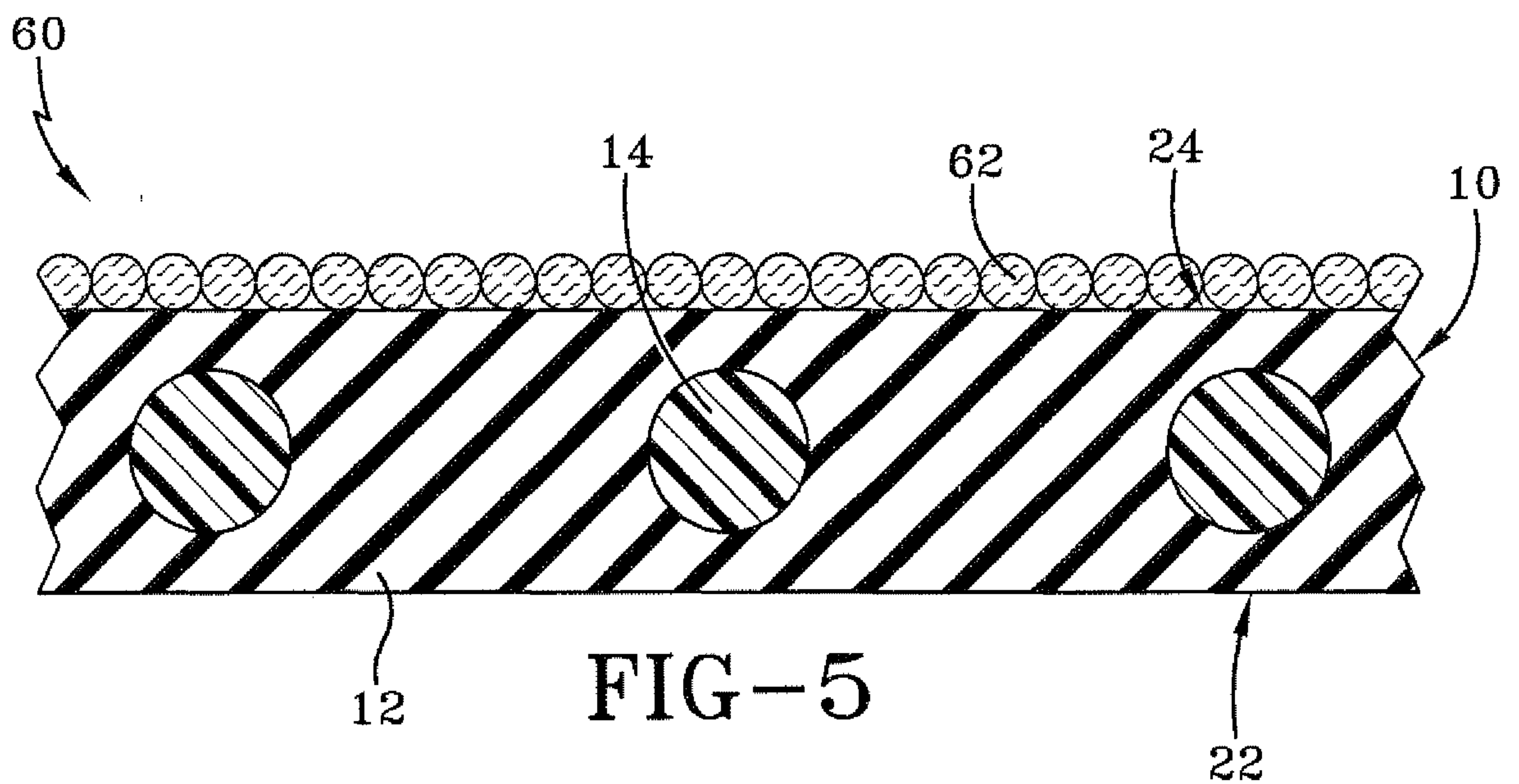
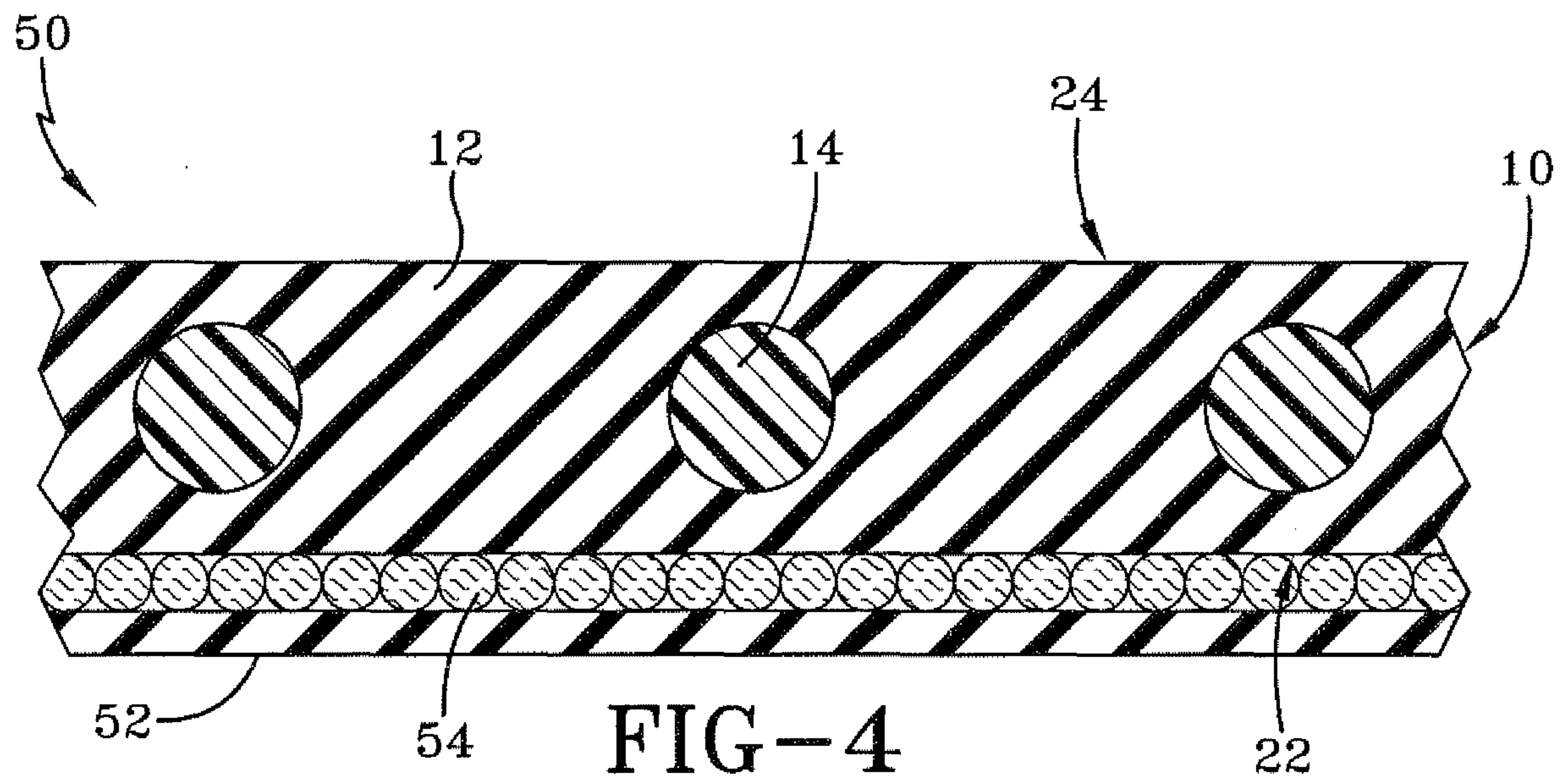
18. The hose of claim 17 wherein the ethylene-octene copolymer has a density of about 0.863 grams per cubic centimeter as measured by ASTM procedure D792 and a melt mass flow rate of about 0.50 grams per ten minutes as measured by ASTM procedure D1238.

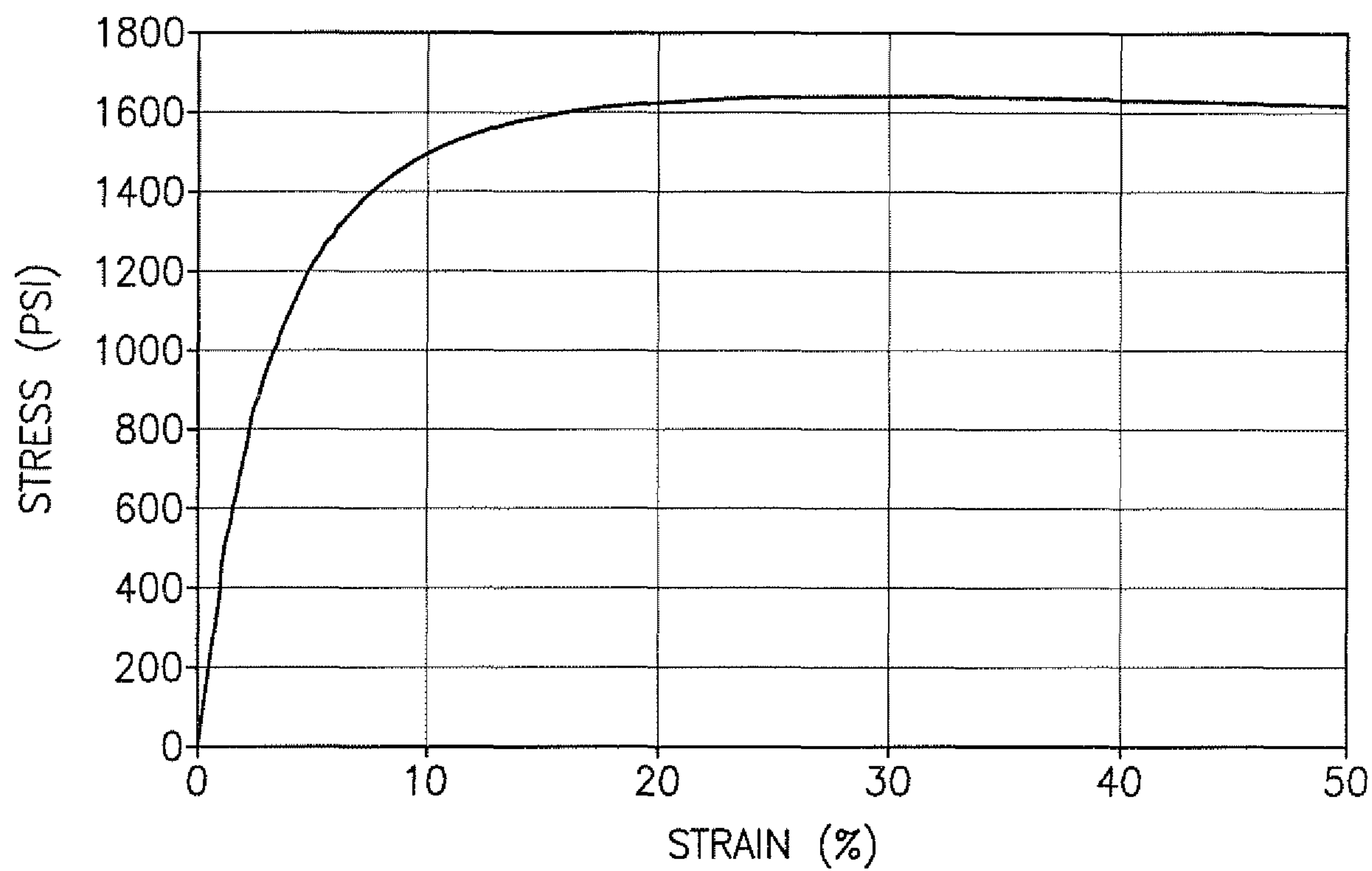
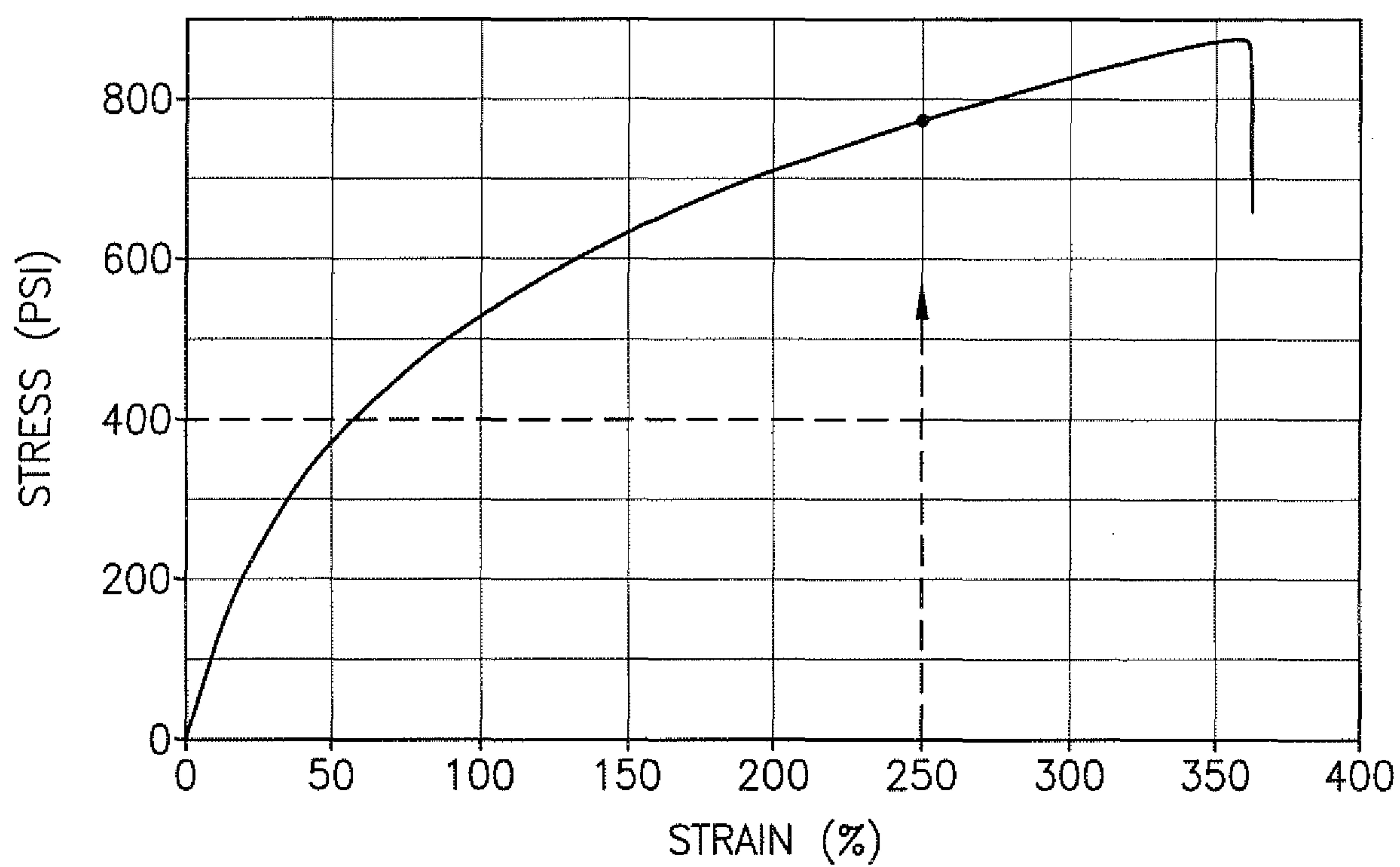
19. The hose of claim 18 wherein the helical reinforcement strip is wound as a
5 continuous coil having turns such that adjacent pairs of turns are non-contacting and spaced apart from each other by a centerline spacing.

20. The hose of claim 19 wherein the centerline spacing is within the range of 110 percent to about 500 percent of the diameter of the individual turns.

21. The hose of claim 20 wherein the ethylene-butene copolymer has a density of
10 about 0.885 grams per cubic centimeter as measured by ASTM procedure D792 and a melt mass flow rate of about 0.80 grams per ten minutes as measured by ASTM procedure D1238.





**FIG-7****FIG-8**

