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(54) Title: MALLEABLE PACKING (57) Abstract Malleable packing compositions are provided which include a major fraction of graphite dispersed in a viscous lubricant, and are provided in solid form. Preferred compositions further include a blend of solid fillers. The packing compositions are used in sealing shafts in fluid handling devices.		

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- 1 -

MALLEABLE PACKINGBackground of the InventionField of the Invention

5 This invention relates to packing materials for sealing fluids. More particularly this invention relates to packing materials and compositions useful as packings for sealing the area surrounding a shaft in a fluid handling device, e.g., in a pump or valve. This
10 invention also relates to methods of using such packings.

Background

 In fluid handling devices such as pumps and valves, it is necessary to seal the pump shaft or valve stem where it exits the device housing to prevent undue
15 leakage. Typically such fluid handling devices are provided with a stuffing box in the housing which defines an annular space between the housing and the shaft. To seal the shaft, packing or a mechanical seal is placed in the stuffing box surrounding the shaft, sealing against
20 both the shaft and the wall of the stuffing box to prevent leakage.

 Mechanical seals work well for sealing fluids and achieve zero or near zero fluid leakage. Mechanical seals, however, are relatively expensive.

25 Packings have been utilized for many years for sealing such shafts and are significantly less costly than mechanical seals. Typically, today, packings are made of braided synthetic or graphite fibers, impregnated with lubricants and blocking agents, to limit passage of
30 fluid through the interstices between the fibers. Such packings are cut to appropriate length to form annular packing rings, a plurality of which are inserted in a stuffing box about a shaft.

- 2 -

To seal a stuffing box having a plurality of packing rings therein, a seal gland is mounted to the housing at the open end of the stuffing box and pressure is applied, compressing the packing as the gland is
5 tightened onto the housing. The gland is tightened until leakage is satisfactorily controlled. Zero leakage is not typically achieved utilizing packing for sealing pumps. With braided packing some leakage is tolerated, e.g., 6-10 ml per minute, lest too much pressure on the
10 packing cause excess heat buildup or scoring of the pump shaft.

Solid graphite has been suggested as a substitute for braided packing. The natural lubricity of graphite, its chemical resistance, its thermal stability and its
15 heat conductive properties, important for transmitting heat generated by friction at the shaft-packing interface, make it a desirable material for such usage. The heat resistance of graphite likewise makes it a suitable substitute for asbestos. On the other hand,
20 packing rings formed from graphite, e.g., die formed from graphite tape, have limited compressibility and conform poorly to opposing surfaces of the shaft and stuffing box. To enhance sealing, it has been proposed that such graphite rings be formed in a wedge shaped cross-section,
25 with the points of the wedges alternating in contact with the shaft and the stuffing box (i.e., facing the inside and outside of the ring) in order that axial pressure exerted by the seal gland be translated radially against the shaft and the stuffing box. The limited
30 compressibility of the graphite wedges, however, limits conformance of the graphite to localized irregularities in the surfaces of the shaft and stuffing box and some leakage must still be tolerated.

- 3 -

Summary of the Invention

The invention features, in one aspect, malleable packing compositions in shaped self supporting form. The compositions include a major fraction of graphite dispersed in a viscous lubricant. In preferred embodiments, the lubricant is a grease, more preferably a petroleum derivative. Preferred compositions further comprise a malleable, self supporting elongate filler selected from the group consisting of clay fillers, exfoliated vermiculite, organic or inorganic fibers, powdered polytetrafluoroethylene (PTFE) and mixtures thereof; more preferably these compositions contain a blend of these fillers. Preferred fibers include novoloid phenolic fibers; a preferred clay filler is bentonite. Preferred compositions have a density of from about 1.4 to 1.7 g/cc.

In another aspect, the invention features a malleable, self supporting elongate packing stick, formed from a packing composition of the invention. The packing stick is preferably substantially cylindrical, but may also be an elongated stick having an oval, square or rectangular cross-section, or any other suitable shape. The length and diameter of the sticks may be varied for use with shafts/stuffing boxes having different dimensions. Typically, the sticks are from 1 inch to 8 inches long and from about 0.125" to 1" in diameter.

In yet another aspect, the invention features a packing system for sealing a shaft that is disposed within a stuffing box which includes a seal gland. The system includes a plurality of packing sticks, as described above, of substantially equal predetermined diameter, and a pair of end rings dimensioned to cover the ends of the sticks when they are placed about the circumference of the shaft. Typically, each end ring has an inner diameter slightly larger than the diameter of

- 4 -

the shaft and a width (between its inner and outer diameter) approximately equal to the diameter of the packing sticks.

In use, one of the end rings is placed in the stuffing box, the packing sticks are placed in the stuffing box such that their longitudinal axes are substantially parallel to the longitudinal axis of the shaft, with one end of the sticks abutting the end ring, and the other end ring is disposed at the other end of the packing sticks to hold the packing sticks in place during compression and prevent packing material from extruding out of the packing box. The seal gland is then tightened to compress the packing sticks, causing them to coalesce into a unitary mass about the shaft in the stuffing box. In preferred embodiments, the end rings are formed from graphite coated PTFE fibers or rings of compressed graphite tape or bulk braided products of exfoliated graphite, e.g., as described in copending application U.S. Serial No. 07/692,495, filed April 29, 1991.

The packing materials of the invention are asbestos-free, provide virtually zero leakage, and can be used with worn or pitted shafts because of the high malleability of the packing which allows it to readily conform, when compressed, to irregularities on the shaft and stuffing box surfaces. Further, when the packing material is used in the form of a plurality of sticks, the sticks can be placed around the shaft without necessitating any disassembly of the fluid handling device. The packing materials may be used over a wide range of temperatures, pH and pressures without leakage.

Other features and advantages of the invention will be apparent from the description of the preferred embodiments, the drawings and the claims.

- 5 -

Brief Description of the Drawings

Fig. 1 is a perspective view of a solid stick of packing material according to one embodiment of the invention.

5 Fig. 2 is a front plan view of a stuffing box and seal gland, containing a packing system according to one embodiment of the invention, prior to compression of the packing by the seal gland.

Fig. 2a is a cross-sectional view of the stuffing
10 box of Fig. 2, taken along line A-A.

Fig. 3 is a front plan view of the stuffing box of Fig. 2, subsequent to compression of the packing system by the seal gland.

Fig. 3a is a cross-sectional view of the stuffing
15 box of Fig. 3, taken along line A-A.

Detailed Description of the Preferred Embodiments

Packing material according to preferred
embodiments of the present invention comprises a
composite of graphite, a semi-solid, viscous lubricant
20 binder, and solid fillers which act as blocking agents,
binding agents and solid lubricants.

Graphite comprises the major fraction of the
packing and is utilized because of its heat conductive
and lubricant properties. In particular embodiments, a
25 natural graphite is utilized. One grade of graphite
which may be utilized for use in a composition to be
formed in a ram extruder is commercially available from
Graphite Products Corp., Brookfield, Ohio, under the
tradename LS 1675 graphite. This graphite has a true
30 density of from about 2.1 to 2.3 g/cc and a bulk density
of from about 0.4 to 0.5 g/cc. This graphite has
particle size of from about 1 to 50 microns.

- 6 -

When the composition is to be formed in a screw extruder larger graphite particle sizes are preferred. Thus in a particular embodiment for screw extruder use the graphite, also available from Graphite Products Corp., with a bulk density of about 0.448 g/cc and a true density of about 2.3g/cc, has approximately the following screened size distribution:

	+ 20 mesh	5 - 15%
	+ 30 mesh	15 - 30
10	+ 40 mesh	15 - 30
	+ 50 mesh	15 - 35
	+ 60 mesh	0 - 20
	+ 80 mesh	0 - 10
	Pan	0 - 5

15 Preferred compositions include from about 50 to 60 weight percent graphite, more preferably about 55 weight percent. Higher levels of graphite may reduce the cohesive strength of the packing, while lower levels may reduce the heat transfer properties of the packing.

20 In preferred embodiments, grease is employed as the semi-solid, viscous lubricant binder. Preferably the grease employed is one which will not degrade or leach from the packing at high temperatures, e.g., 204°C (400°F), and which can be utilized at low temperatures, 25 e.g., -18°C (0°F) without becoming unsuitably viscous and, hence, losing its viscous flow and lubricant characteristics. A particular grease suitable as the binder is High Temperature Grease 615 sold by A.W. Chesterton Company, Stoneham, Massachusetts, U.S.A. This 30 grease comprises a high fuel grade mineral oil, a polymeric Extreme Pressure (EP) additive, and an organo sulfonate calcium complex thickener system. Other suitable greases are those which have a high load wear index (ASTM D-2596), preferably at least 70, a high base 35 oil viscosity (ASTM D-2161), preferably at least 800 centistokes at 38°C and 80 centistokes at 100°C, and a

- 7 -

high dropping point (ASTM D-2265), preferably at least 250°C. Silicone greases may be used, as well as fats and paraffin. It is preferred that the packing compositions contain from about 15 to 25 weight percent grease, more preferably about 15 to 20 weight percent.

Preferred packings contain a blend of solid fillers. The blend preferably comprises bentonite, polytetrafluoroethylene (PTFE) powder, exfoliated vermiculite, and thermosetting novoloid phenolic fibers. Preferably, the packing composition includes from about 15 to 35 weight percent filler.

Bentonite is included as a bulk filler, to reduce the amount of more costly vermiculite which is necessary to form a solid composition. Other fillers having good high temperature stability would also be suitable. Amorphous bentonite is preferred. A suitable grade of bentonite is commercially available from Cabot Industries, Boston, Massachusetts under the tradename BENTONE 85 powder. This grade has a maximum particle size of 325 mesh. Preferred compositions contain from about 10 to 20 weight percent bentonite, preferably about 15 percent. Higher levels of bentonite may cause heat buildup in the packing material, while lower levels may increase the level of vermiculite required, thereby increasing the cost of the packing material.

Powdered PTFE binds the composition, improves moldability, and increases the softness and resiliency of the packing material. A preferred grade of powdered PTFE is FLUON CD-1P powder, commercially available from ICI Corporation, Wilmington, Delaware. It is preferred that the powder have a particle size of from 400 to 600 microns and a bulk density of from 500 to 600 g/l. Preferred compositions contain from about 5 to 10 weight percent powdered PTFE, preferably about 7 percent. Higher levels of PTFE may cause glazing of the packing

- 8 -

surface under elevated temperatures, while lower levels may result in poor moldability.

Exfoliated vermiculite particles improve the heat resistance of the composition and are believed to bind to each other within the composition to provide a tortuous path which improves the barrier properties of the composition. Exfoliated vermiculite is commercially available from W.R. Grace & Co.-Conn., Cambridge, Massachusetts, under the tradename MICROLITE® Powder.

10 Preferred compositions contain from about 1 to 7 weight percent exfoliated vermiculite, preferably about 2 to 3 percent. Higher levels of vermiculite may cause the composition, when compressed, to be overly dry and crumbly, while lower levels may cause the composition to

15 be too soft and fluid.

Phenolic fibers improve the cohesiveness of the packing composition. Preferred are cured phenol-aldehyde fibers commercially available from Nippon Kynol, Inc., under the tradename KYNOL™ novoloid fibers; a

20 particularly preferred grade is KYNOL™ KF-02BT. The preferred fibers contain approximately 76% carbon, 18% oxygen and 6% hydrogen, and are made by acid-catalyzed cross-linking of melt-spun novolac resin to form a fully cross-linked three-dimensional, amorphous network polymer

25 structure, and have an average diameter of from about 14 to 33 microns. Novoloid fibers are particularly preferred for use in high temperature applications, as they are carbon precursors and thus will not burn at elevated temperatures. Preferred compositions contain

30 from about 0.1 to 1 weight percent phenolic fibers. Higher levels may cause the composition to be too dry and crumbly, while lower levels may cause the composition to be too soft and fluid.

The compositions are preferably formed by

35 combining the graphite, bentonite, PTFE, vermiculite, and

- 9 -

fibers and mixing until homogeneous, then adding the grease and again mixing until homogeneous. The mixture can then be formed under pressure, e.g., into billets, and extruded in a ram extruder into desired shapes. A
5 suitable mixer is Liquid-Solids Blender # C090690, from Patterson-Kelley Co., East Stroudsburg, Pennsylvania; a suitable extruder can be made by using a Schrader cylinder to drive a ram which forces the mix through an extruder die.

10 More preferably, the homogenous mixture is added to a screw extruder, thus avoiding the added step of making billets; the mix is then extruded through an appropriate die.

The packing compositions may be provided in any
15 suitable shape. A preferred shape is that of an elongated, cylindrical stick 10 having a substantially round cross-section, as shown in Fig. 1. This shape is preferred both because it is simple and economical to form, e.g., by extrusion, and because it allows the
20 packing composition to be utilized in the system shown in Figs. 2 and 2a. In alternate embodiments, the compositions may be molded into other shapes, e.g., rings.

Referring to Figs. 2 and 2a, a plurality of
25 packing sticks 10 are placed axially around the circumference of shaft 12, in stuffing box 14, such that their longitudinal axes are substantially parallel to axis B of shaft 12. The packing sticks have substantially the same diameter, and their diameter is
30 approximately equal to the distance between the shaft and the inner wall of stuffing box 14. Their diameter is preferably very slightly, e.g., from 0.010 to 0.015 inch, larger than this distance, for a friction fit between the sticks and the stuffing box. End rings 16a, 16b are
35 placed at either end of the packing sticks, to hold the

- 10 -

packing sticks in place and prevent the packing material from extruding out during compression. End rings 16a, 16b include cuts 18a, 18b, as is conventional.

As shown in Figs. 3 and 3a, after the packing sticks and end rings are placed in the stuffing box, seal gland 20 is tightened, by turning screws 22 against plate 24 (arrows C), causing the packing sticks to be compressed between the end rings, shaft and stuffing box. During compression, the malleable material of the packing sticks coalesces to form a unitary mass 10', creating an integral seal which provides virtually fluid tight sealing, and which can be removed as a single unit after the packing has served its purpose.

The invention is illustrated by the following example of a mix formed in a ram extruder.

Example

Solid malleable packing compositions having the formulations shown in Table 1 were formed by mixing the graphite, bentonite, PTFE, vermiculite and phenolic fibers for 5 minutes, then adding the grease and mixing for 10 minutes. The compositions were then formed into 2" diameter billets by applying a pressure of 500 psi for 45 seconds. The billets were extruded at a pressure of 750 psi in a Schrader 5" bore cylinder with a 10" stroke driving a 2" diameter ram. The extruded material had a diameter of about $\frac{3}{8}$ inch, and was cut into sticks about 3 inches long. 26 of the sticks formed from each composition were placed in a stuffing box (2.5 inch diameter), around a shaft (1.75 inch diameter). The sticks were held in place by end rings formed of braided graphite coated PTFE packing (Chesterton Style 1760, A.W. Chesterton Co., Stoneham, Massachusetts). The seal glands of the stuffing boxes were then compressed by finger tightening the screws until resistance to hand turning of the shaft was felt, then wrench tightening as

- 11 -

fluid flows until zero leakage was obtained. Compression of the seal glance caused the sticks to coalesce into a unitary mass. The resulting seals were tested under 30 psi at 1750 rpm (a 790 ft/min shaft velocity) with ambient temperature fluid. The seal formed using Composition 1 ran for 316 hours with virtually no detectable leakage (a drop every few hours), after which the test was discontinued. The seal formed using Composition 2 ran for 100 hours at 1 ml/min maximum leakage.

Table 1

Component	Composition 1		Composition 2	
	Weight	Weight %	Weight	Weight
15 %				
Graphite LS1675	303.6 g.	55.42	303.6	51.44
Bentonite	84.4	15.41	84.4	14.30
PTFE powder	42.0	7.67	84.4	14.30
High Temp Grease 615	96.3	17.58	96.3	16.32
20 MICROLITE® powder	19.0	3.47	19.0	3.22
KYNOL KF-02BT fibers	2.5	0.46	2.5	0.42

As above noted, use of a screw-extruder is preferred as a manufacturing convenience. It has been found, however, that the larger graphite particle sizes, above noted, are desirable to obtain a suitable end product from a screw extruder. A particular composition utilizing such larger particle sizes in a screw extruder is set forth in Table 2.

Table 2

	Weight %
Graphite	55
Bentonite	15
35 PTFE Powder	7
High Temperature Grease 615	20
Microlite® Powder	2
Kynol KF - 02BT fibers	1

Other embodiments are within the claims.

- 12 -

CLAIMS

1. A malleable packing composition comprising, in shaped, self supporting, form, a major fraction of graphite dispersed in not more than about 25 weight percent of a viscous semi-solid lubricant.
2. The packing composition of claim 1 in which said lubricant comprises a grease.
3. The packing composition of claim 2 in which said grease is a petroleum derivative.
- 10 4. The packing composition of claim 1 in which said packing has a density of 1.4-1.7 g/cm³.
5. The packing composition of claim 1 further comprising a minor portion of exfoliated vermiculite platelets.
- 15 6. The packing composition of claim 1 or 5 further comprising organic or inorganic fibers.
7. The packing composition of claim 6 in which said fibers are phenolic novoloid fibers.
8. The packing composition of claim 1 further
20 comprising a solid filler.
9. The packing composition of claim 8 wherein said filler is selected from the group consisting of clay fillers, exfoliated vermiculite, organic or inorganic fibers, powdered PTFE, and mixtures thereof.
- 25 10. The packing composition of claim 9 wherein said clay filler is bentonite.

- 13 -

11. The packing composition of claim 9 wherein said fibers are novoloid fibers.

12. The packing composition of claims 1 or 7 wherein said composition comprises from 50 to 60 weight percent graphite, from 15 to 25 weight percent lubricant, and from 15 to 35 weight percent solid filler.

13. The packing composition of claim 12 in which said packing has a density of 1.4-1.7 g/cm³.

14. The packing composition of claim 9 wherein said composition comprises from 50 to 60 weight percent graphite, from 15 to 25 weight percent lubricant, from 10 to 20 weight percent clay filler, from 5 to 10 weight percent powdered PTFE, from 1 to 7 weight percent exfoliated vermiculite, and from 0.1 to 1 weight percent organic or inorganic fibers.

15. The packing composition of claim 14 in which said packing has a density of 1.4-1.7 g/cm³.

16. The packing composition of claim 13 wherein said fibers are novoloid fibers.

17. A malleable, self supporting, elongate packing stick comprising a major fraction of graphite dispersed in a viscous lubricant and provided in the form of an elongate stick.

18. The packing stick of claim 17 wherein said stick is substantially cylindrical.

- 14 -

19. The packing stick of claim 17 wherein said stick is from about 1 inch to 8 inches long and from about 0.125" to 1" in diameter.

20. A packing system for sealing a shaft,
5 disposed within a stuffing box which includes a seal gland, comprising a plurality of malleable, self supporting, elongate packing sticks of substantially equal predetermined diameter, each stick comprising a major fraction of graphite dispersed in a viscous
10 lubricant, and a pair of end rings dimensioned to cover the ends of said sticks around the circumference of the shaft.

21. The system of claim 20 wherein the end rings are formed from graphite coated PTFE fibers.

15 22. The system of claim 20 wherein the end rings are formed from compressed graphite tape or braided exfoliated graphite.

23. A method of sealing a shaft, disposed within a stuffing box which includes a seal gland, comprising
20 the steps of:

- a) providing a packing system comprising a plurality of elongate malleable packing sticks and a pair of end rings;
- b) placing one of the end rings in the stuffing
25 box;
- c) placing the packing sticks in the stuffing box such that their longitudinal axes are substantially parallel to the longitudinal axis of the shaft, one end of the sticks abutting the one end ring;
- 30 d) placing the other of the end rings at the other end of the packing sticks; and

- 15 -

e) tightening the seal gland to compress the packing sticks, causing them to coalesce into a unitary mass about the shaft within the stuffing box.

24. A method of claim 23 wherein said malleable
5 packing sticks comprise a major fraction of graphite dispersed in a viscous lubricant.

25. A method of making a malleable, self supporting, elongate packing stick comprising the steps of:
10 dispersing a major fraction of graphite in a viscous lubricant to form a malleable composition; and extruding said composition to form the elongate packing stick.

26. A method of claim 25 further comprising
15 compressing said composition to form a solid billet before extruding said composition.

27. A method of claim 25 wherein one or more solid fillers are dispersed with said graphite in said viscous lubricant.

20 28. A method of claim 25 wherein said viscous lubricant is a grease.

29. A method of claim 25 further comprising the step of cutting the elongated packing stick into a plurality of sticks of predetermined length.

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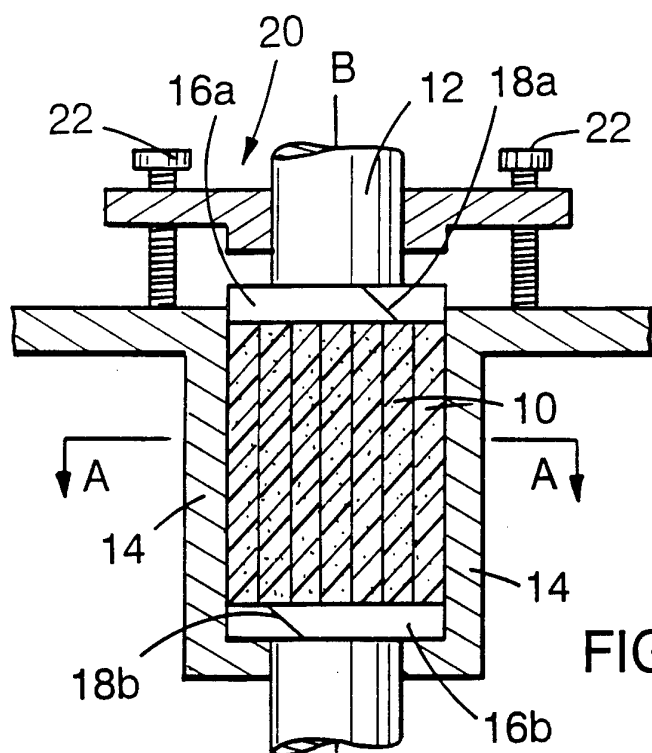
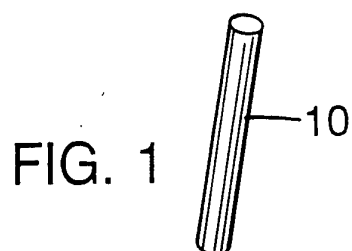


FIG. 2

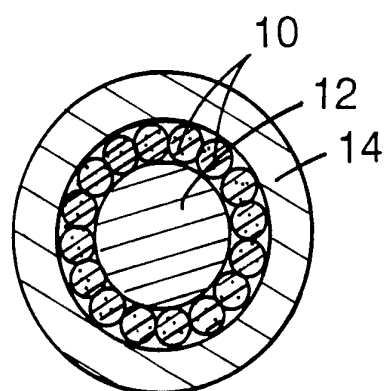


FIG. 2a

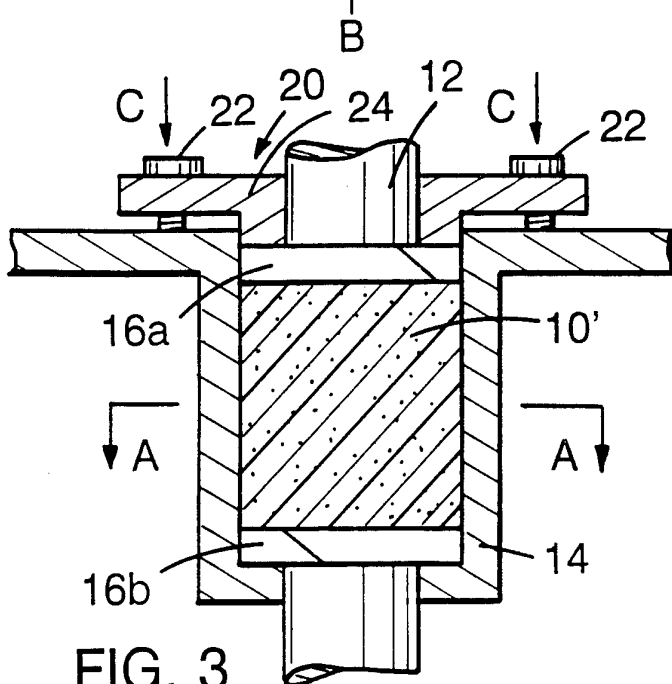


FIG. 3

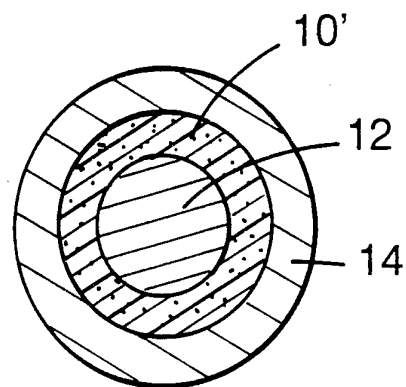


FIG. 3a