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(54) Title: MULTI-LAYER FILM PERMEABLE TO UV RADIATION

(54) Bezeichnung : UV-STRAHLUNG DURCHLÄSSIGE MEHRSCICHTFOLIE

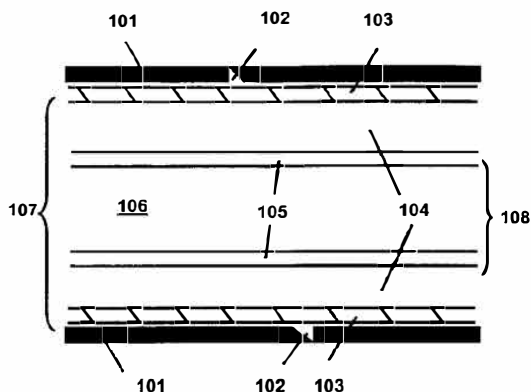


Fig. 1

(57) Abstract: The invention relates to a liquid-tight multi-layer film, preferably in the form of a tubular film, which is at least partially permeable to UV radiation, comprising a sequence of layers composed of a layer (a) on the basis of at least one thermoplastic olefin homopolymer or copolymer as one of the outside layers, an adhesion promoter layer (b), an interior layer (c) on the basis of at least one homopolyamide and/or copolyamide, an adhesion promoter layer (d), and a layer (e) on the basis of at least one homopolyamide and/or copolyamide as one of the outside layers, wherein the thermoplastic olefin homopolymer or copolymer of layer (a) has a VICAT softening temperature of at least 100°C. The invention further relates to the use of such a multi-layer film as an interior tube for an insert tube for refurbishing underground pipes, to such an insert tube, and to a pipe refurbishment system suitable for refurbishing underground pipes, preferably underground sewer pipes.

(57) Zusammenfassung:

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Die vorliegende Erfindung betrifft eine für UV-Strahlung zumindest teilweise durchlässige, flüssigkeitsdichte Mehrschichtfolie, vorzugsweise in Form einer Schlauchfolie, umfassend eine Schichtfolge aus einer Schicht (a) basierend auf wenigstens einem thermoplastischen Olefin-Homo- oder Copolymeren als eine der Außenschichten, einer Haftvermittlerschicht (b), einer innenliegende Schicht (c) basierend auf wenigstens einem Homo- und/oder Copolyamid, einer Haftvermittlerschicht (d), einer Schicht (e) basierend auf wenigstens einem Homo- und/oder Copolyamid als eine der Außenschichten, wobei das thermoplastische Olefin-Homo- oder Copolymer der Schicht (a) eine VICAT Erweichungstemperatur von wenigstens 100°C aufweist, die Verwendung einer solchen Mehrschichtfolie als innenliegenden Schlauch eines Einlegeschlauchs zur Sanierung von unterirdischen Rohren, ein solcher Einlegeschlauch und ein Rohrsanierungssystem geeignet zur Sanierung von unterirdischen Rohren, vorzugsweise unterirdischen Kanalrohren.

Multi-layer film permeable to UV radiation

The present invention relates to a multilayer film that is impermeable to liquid and that is at least to some extent permeable to UV radiation, preferably in the form of a tubular film, comprising a layer sequence made of a layer (a) based on at least one thermoplastic olefin homo- or copolymer, as one of the external layers, an adhesive-promoter layer (b), an internally situated layer (c) based on at least one homo- and/or copolyamide, an adhesive-promoter layer (d), and a layer (e) based on at least one homo- and/or copolyamide, as one of the external layers, where the VICAT softening point of the thermoplastic olefin homo- or copolymer of the layer (a) is at least 100°C, to the use of this type of multilayer film as internally situated tube of an insertion tube for the renovation of subterranean pipes, to an insertion tube of this type, and to a pipe-renovation system suitable for the renovation of subterranean pipes, preferably subterranean sewer pipes.

The prior art has already disclosed multilayer films which are permeable to UV radiation and inter alia can be used in the renovation of pipes.

By way of example, EP-A-0 342 897 describes a multilayer film which has a polyamide layer as a first surface layer and an ionomer sealing layer as a second surface layer. If the multilayer film is used for pipe renovation, the polyamide layer is bonded to a fibrous nonwoven by heating, and this is then saturated with a hardenable resin. After conditioning of the film, this is applied, together with the resin that, after the saturation process, is located on the surface, onto the region requiring renovation on the internal wall of the pipe, over the entire pipe circumference. After hardening of the resin by means of UV radiation, a stable pipe section at the internal pipe wall requiring

renovation is obtained. The two ends of the film are then sealed to one another by way of the ionomer sealing layer.

5 In another known process for the renovation of
subterranean pipes, a flexible insertion tube is
provided, and is drawn into the pipe requiring
renovation. Said insertion tube comprises two tubes,
10 preferably plastics tubes, with different diameter,
between which a support material saturated with a
reactive synthetic resin has been introduced. After the
introduction of the collapsed insertion tube into the
pipe and inflation of the insertion tube to the
15 diameter of the pipe, the synthetic resin is hardened
between the two tubes in order to obtain, after removal
of the internal tube, a stable pipe at the internal
pipe wall requiring renovation. The hardening can be
achieved via irradiation with UV radiation. In order to
20 prevent undesired premature hardening of the synthetic
resin prior to introduction into the pipe requiring
renovation, it is necessary that the externally
situated tube of the insertion tube has a protective
layer or is composed thereof, in order to prevent
25 premature exposure to external UV radiation and thus
premature curing of the resin. In contrast, the
internally situated tube of this type of insertion tube
has to have permeability to UV radiation, in order to
permit, in the inflated condition, the hardening
procedure.

30 The internally situated tube of this type of insertion
tube, or a corresponding multilayer film, preferably in
the form of a tube, used for pipe renovation and as
disclosed by way of example in EP-A-0 342 897, is
35 subject to stringent mechanical requirements, in order
that it can withstand loads arising during its
handling, for example those occurring during
introduction into the pipe requiring renovation, during
the inflation of the respective film within the pipe,

or - after successful renovation - during removal from the pipe.

5 A disadvantage of a multilayer film disclosed in EP-A-0
342 897 is that it has a point of weakness at least in
the region of the seal seam, and/or a disadvantage with
conventional tubular films which are used as internally
situated tubes of an insertion tube during pipe
renovation is that these do not have the mechanical
10 properties required in order to withstand the loads
described above. To this end, conditioning can
optionally be used in order to achieve an improvement
in conventional films, where these have at least one
layer based on a polyamide.

15 There is therefore a need for multilayer films which do
not have the abovementioned disadvantages.

20 It was therefore an object of the present invention to
provide a multilayer film, in particular in the form of
a tubular film, which is suitable as internally
situated tube of an insertion tube for the renovation
of subterranean pipes, preferably subterranean sewer
pipes, since it has not only the necessary permeability
25 to UV radiation but also mechanical properties that are
sufficiently good for it to withstand the high loads
that arise during pipe renovation.

30 Said object is achieved via provision of the multilayer
film of the invention that is impermeable to liquids
and that is at least to some extent permeable to UV
radiation, preferably in the form of a tubular film,
comprising a layer sequence made of

35 (a) a layer (a) based on at least one thermoplastic
olefin homo- or copolymer, as one of the external
layers, or surface layers,

(b) an adhesive-promoter layer (b),

(c) an internally situated layer (c) based on at least one homo- and/or copolyamide,

5 (d) an adhesive-promoter layer (d), and

(e) a layer (e) based on at least one homo- and/or copolyamide, as one of the external layers, or surface layers,

10

where the VICAT softening point of the thermoplastic olefin homo- or copolymer of the layer (a) is at least 100°C.

15 Surprisingly, it has been found that the multilayer film of the invention features an excellent barrier effect in relation to drying-out of the resin used for pipe renovation, and therefore in relation to the loss, i.e. migration, of monomers or of other saturation
20 means. It has moreover been established, surprisingly, that the multilayer film of the invention, in particular in the form of a multilayer tubular film, or else in the form of a multilayer film sealed to give a tube, features very good mechanical properties, in
25 particular very good extensibility, in such a way that it withstands the loads that arise during the renovation of subterranean pipes, in particular during inflation within the pipe system, during the preceding transport, the preceding storage, and the entry into
30 the pipe requiring renovation, and moreover, after the hardening of the resin, can be withdrawn therefrom without any break-off, splitting or tearing. It has moreover been found, surprisingly, that the multilayer film of the invention has the very good mechanical
35 properties even without prior conditioning, thus rendering a conditioning step unnecessary.

For the purposes of this invention, the expression "tubular film" means a multilayer film produced by

(co)extrusion, preferably by blown-film (co)extrusion, and having no seal seam.

For the purposes of this invention, the expression "UV
5 radiation" means electromagnetic radiation in a wavelength range from 200 to 400 nm.

The multilayer film of the invention is at least to some extent permeable to UV radiation, preferably
10 permeable to an extent of at least 80%, particularly preferably permeable to an extent of at least 90%.

In one preferred embodiment, the multilayer film of the invention is not only at least to some extent permeable
15 to UV radiation, but also at least to some extent permeable to short-wave, visible light, preferably to an extent of at least 80%, particularly preferably to an extent of at least 90%.

20 For the purposes of this invention, the expression "short-wave, visible light" means electromagnetic radiation in a wavelength range from 400 to 500 nm, preferably from 400 to 450 nm.

25 The multilayer film of the invention features excellent mechanical properties (determined by the method described below), in particular by virtue of very good extensibility. The extensibility of the multilayer film of the invention - even in the nonconditioned state -
30 is preferably at least 15%, particularly preferably at least 18%, very particularly preferably at least 20%, in particular at least 30%.

For the purposes of this invention, the expression
35 "conditioning" means the reversible process of absorption of moisture, preferably of water, by a material, preferably by a thermoplastic material, such as a homo- or copolyamide, or a corresponding film, such as the multilayer film of the invention, until

constant weight has been achieved. The conditioning usually leads to improved mechanical properties.

A suitable material for the production of the layer (a)
5 of the multilayer film of the invention is at least one thermoplastic olefin homo- or copolymer.

Thermoplastic olefin homo- or copolymers of
10 α,β -unsaturated olefins having from 2 to 10 carbon atoms can preferably be used for the production of the layer (a) of the multilayer film of the invention. Suitable olefin homopolymers are preferably those selected from the group consisting of ethylene homopolymers (polyethylenes, PE), preferably LDPE and
15 HDPE, propylene homopolymers (polypropylenes, PP), butylene homopolymers (polybutylenes, PB), and isobutylene homopolymers (polyisobutylenes, PI), and mixtures of at least two of the polymers mentioned. "LDPE" means low-density polyethylene with a density in
20 the range from 0.86 to 0.93 g/cm³, featuring a high degree of branching of the molecules. "HDPE" means high-density polyethylene having only a small amount of branching of the molecular chain, and the density here can be in the range from 0.94 to 0.97 g/cm³. Suitable
25 olefin copolymers are preferably copolymers of ethylene and/or propylene and of at least one α -olefin having at least 4, preferably from 4 to 10, particularly preferably from 4 to 8, carbon atoms, and very particular preference is given to copolymers of
30 ethylene and/or propylene with at least one α -olefin selected from the group consisting of butene, hexene, and octene. The proportion of α -olefin in the olefin copolymer is preferably at most 25% by weight, particularly preferably at most 15% by weight, based in
35 each case on the total weight of the olefin copolymer. Particularly suitable copolymers of ethylene and of at least one α -olefin having at least 4 carbon atoms are LLDPE and/or mPE. "LLDPE" means linear low-density ethylene copolymers, characterized by the presence of a

linear main chain with side chains located thereon, with a density in the range from 0.86 to 0.94 g/cm³. "mPE" means ethylene copolymers polymerized by means of metallocene catalysts with density preferably in the
5 range from 0.88 to 0.93 g/cm³. Preferred olefin homo- or copolymers for the production of the layer (a) are ethylene homo- or copolymers and/or propylene homo- or copolymers. A particularly preferred material for the production of the layer (a) is a mixture of at least
10 one ethylene homopolymer such as LDPE, and of at least one ethylene copolymer such as LLDPE and/or mPE.

The VICAT softening point of the thermoplastic olefin homo- or copolymer of the layer (a) of the multilayer
15 film of the invention is at least 100°C. The VICAT softening point (VST A/120) is determined in accordance with DIN EN ISO 306/ASTM D1525.

The thickness of the layer (a) of the multilayer film
20 of the invention is preferably from 10 µm to 500 µm, particularly preferably from 20 µm to 400 µm, very particularly preferably from 30 µm to 300 µm.

In one preferred embodiment, the thickness of the layer
25 (a) of the multilayer film of the invention is at least 40% of the total thickness of the multilayer film, preferably at least 50%, particularly preferably from 50% to 90%.

30 A suitable material for the production of the layers (c) and (e) of the multilayer film of the invention - respectively mutually independently - is at least one homo- and/or copolyamide.

35 Suitable homo- or copolyamides for the production of the layers (c) and (e) of the multilayer film of the invention are preferably those selected from the group of thermoplastic aliphatic, semiaromatic, or aromatic homo- or copolyamides. Said homo- or copolyamides can

be produced from diamines, such as aliphatic diamines having from 2 to 10 carbon atoms, in particular from hexamethylenediamine and/or from aromatic diamines having from 6 to 10 carbon atoms, in particular from p-phenylenediamine and from aliphatic or aromatic dicarboxylic acids having from 6 to 14 carbon atoms, e.g. adipic acid, terephthalic acid, or isoterephthalic acid. It is moreover possible to produce homo- or copolyamides from lactams having from 4 to 10 carbon atoms, e.g. from ϵ -caprolactam. Polyamides used in the invention are preferably PA 6, PA 12, PA 66, PA 6I, PA 6T, or corresponding copolymers, or a mixture of at least two of the polyamides mentioned.

It is preferable that the layers (c) and layer (e) of the multilayer film of the invention have an identical layer structure, particularly preferably an identical layer thickness, and/or identical polyamide components, and/or an identical composition.

In another preferred embodiment of the multilayer film of the invention, the layers (c) and layer (e) of the multilayer film of the invention have a different layer structure, particularly preferably a different layer thickness, and/or different polyamide components, and/or an composition.

It is particularly preferable that the layers (c) and (e) respectively comprise the same polyamide.

The thickness of the layers (c) and (e) of the multilayer film of the invention is preferably respectively mutually independently from 5 μm to 100 μm , particularly preferably from 10 μm to 60 μm .

Conventional adhesion promoters can be used for the production of the adhesive-promoter layers (b) and (d) of the multilayer film of the invention. It is preferable that the adhesive-promoter layers (b) and

(d) are respectively mutually independently based on at least one modified thermoplastic polymer, preferably on at least one modified olefin homo- or copolymer. Olefin homo- or copolymers used here can be the olefin homo- or copolymers that are also suitable for the production of the layer (a), but after modification. It is particularly preferable that the adhesive-promoter layers (b) and (d) are respectively mutually independently based on at least one modified ethylene homo- or copolymer and/or at least one modified propylene homo- or copolymer modified with at least one organic acid or with at least one preferably cyclic organic anhydride, preferably maleic anhydride.

The thickness of the adhesive-promoter layers (b) and (d) of the multilayer film of the invention is preferably respectively mutually independently from 1 μm to 30 μm , particularly preferably from 2 μm to 20 μm .

The layers (a), (c), and (e), and also the adhesive-promoter layers (b) and (d), of the multilayer film of the invention can, if necessary, respectively mutually independently comprise additives selected from the group consisting of antistatic agents, antioxidants, antiblocking agents, antifogging agents, antimicrobial ingredients, dyes, color pigments, stabilizers, preferably heat stabilizers, process stabilizers, processing aids, flame retardants, nucleating agents, crystallization aids, preferably crystal-nucleating agents, lubricants, optical brighteners, flexibilizers, sealing aids, plasticizers, silanes, spacers, fillers, peel additives, waxes, wetting agents, surface-active compounds, preferably surfactants, and dispersing agents, to the extent that these additives do not impair permeability to UV radiation.

The layers (a), (c), and (e), and also the adhesive-promoter layers (b) and (d), of the multilayer film of

the invention can, if necessary, respectively mutually independently comprise at least 0.01-20% by weight, preferably at least 0.1-10% by weight, in each case based on the total weight of an individual layer, of at least one of the abovementioned additives.

In one very preferred embodiment, the multilayer film of the invention has five layers, i.e. consists of the layers (a), (b), (c), (d), and (e), and there is therefore bonding between the two polyamide layers (c) and (e) by way of an adhesive-promoter layer (d).

The total thickness of the multilayer film of the invention is preferably from 20 to 2000 μm , particularly preferably from 50 to 1500 μm , very particularly preferably from 100 to 1000 μm , in particular from 120 to 400 μm .

The multilayer films of the invention can be produced by known, conventional processes, where there is preferably no need to condition the multilayer film.

In one preferred embodiment, all of the layers, preferably the layers (a), (b), (c), (d), and (e), of the multilayer film of the invention can be produced and processed in the form of an entire multilayer film in the form of a tubular film.

In one particularly preferred embodiment, the multilayer film of the invention is a multilayer tubular film with no seal seam.

In another preferred embodiment, all of the layers, preferably the layers (a), (b), (c), (d), and (e), of the multilayer film of the invention can be produced and processed in their entirety in the form of a cast film. It is preferable that a resultant cast film of the invention is processed to give a tube via sealing of the layer (a). This also applies to multilayer films

of the invention which can also be obtained in the form of flat films by other, conventional processes.

Accordingly, the production of all of the individual
5 layers, preferably the layers (a), (b), (c), (d), and (e), of the multilayer film of the invention can also be achieved via (co)extrusion.

The multilayer film of the invention, preferably made
10 of the layers (a), (b), (c), (d) and (e), is preferably produced by (co)extrusion, particularly preferably by blown-film (co)extrusion, or by cast (co)extrusion, and very particularly preferably by blown-film (cc)extrusion, in the form of a tubular film.

15 As an alternative, it is also possible to produce individual layers of the multilayer film of the invention in the form of a layer composite by (cc)extrusion.

20 The person skilled in the art is well aware of these production processes and of corresponding production parameters.

25 The multilayer film of the invention can preferably have been embossed.

The multilayer film of the invention can moreover preferably have been printed.

30 It is preferable that the multilayer film of the invention has been neither monoaxially nor biaxially oriented, and this means that it is not subjected to any orientation after its production, preferably by
35 extrusion. The multilayer film of the invention is practically not shrinkable, in particular not even by heating.

The multilayer film of the invention is preferably sealable via the layer (a).

5 The multilayer film of the invention is preferably transparent.

As mentioned above, the multilayer film of the invention is at least to some extent permeable to UV radiation.

10 The multilayer film of the invention, preferably in the form of a tubular film, or else in the form of a multilayer film sealed to give a tube, is therefore suitable as internally situated tube of an insertion
15 tube for the renovation of subterranean pipes, preferably sewer pipes.

The present invention therefore also provides the use of the multilayer film of the invention, preferably in
20 the form of a tubular film, as internally situated tube of an insertion tube for the renovation of subterranean pipes, preferably subterranean sewer pipes, where these may have defects. Because the multilayer film of the invention here, preferably in the form of a tubular
25 film, is at least to some extent permeable to UV radiation, it permits the hardening of a reactive synthetic resin situated between an externally situated simple- or multilayer tube and the internally situated multilayer tube of the invention, or of a support
30 material saturated with reactive synthetic resin.

Support material that can be used preferably comprises glass nonwovens made of glass fibers (glassfiber material), nonwovens, and/or nonwoven textile products,
35 optionally in the form of multiple plies, respectively saturated with at least one reactive synthetic resin, preferably respectively saturated with at least one unsaturated polyester resin and with α,β -unsaturated monomers, such as styrene. Glassfiber materials here

are known inter alia as glassfiber-reinforced plastics (GRP).

As stated above, it is unnecessary to condition the
5 multilayer film of the invention, preferably in the
form of a tubular film, since even without this
conditioning it features very good mechanical
properties, e.g. good extensibility. It is therefore
preferable that the multilayer film of the invention,
10 preferably in the form of a tubular film, in the form
of an internally situated tube of an insertion tube for
the renovation of subterranean pipes, preferably
subterranean sewer pipes, is nonconditioned.

15 The present invention further provides an insertion
tube suitable for the renovation of subterranean pipes,
preferably subterranean drainage pipes, comprising a
preferably nonconditioned multilayer film of the
invention that is impermeable to liquids, preferably in
20 the form of a tubular film, as internally situated
tube, and an externally situated single- or multilayer
tubular film which is impermeable to liquids, and which
reflects and/or absorbs UV radiation and/or short-wave,
visible light, as externally situated tube, and,
25 situated between the two tubes, a support material
saturated with a reactive synthetic resin. The
renovated drainage pipe is formed from said saturated
support material, after hardening. After the hardening
process, the multilayer film of the invention,
30 preferably in the form of a tubular film, as internally
situated tube, is preferably withdrawn from the
renovated drainage pipe made of hardened plastic and
support material, but as an alternative it can also
remain within the renovated pipe.

35
The person skilled in the art is aware of the
production of insertion tubes of this type, for example
from WO 2007/054350 A1 or EP-B 1 155 256.

Figure 1 shows by way of example a longitudinal section through an insertion tube (107) of the invention after insertion into a pipe (101) which has a region (102) requiring renovation. The insertion tube comprises an
5 externally situated single- or multilayer tubular film which is impermeable to liquids, and which reflects and/or absorbs UV radiation and/or short-wave, visible light, as externally situated tube (103), and a preferably nonconditioned multilayer film of the
10 invention that is impermeable to liquids, preferably in the form of a tubular film, as internally situated tube (105), and a support material (104) situated therebetween and saturated with a reactive synthetic resin. After inflation of the insertion tube (107) as
15 far as the diameter of the pipe (101), the insertion tube (107) has a cavity (106) into which it is possible to introduce a source which emits UV radiation and/or short-wave, visible light, and which is preferably moveable, preferably a UV source, where the source
20 brings about hardening of the support material (104) saturated with a reactive synthetic resin. The renovated pipe (108) is formed from said saturated support material (104) after hardening and optionally after withdrawal of the internally situated tube (105).
25 The width of the subsequently renovated pipe (108) has been shown as comparatively small in figure 1 merely for reasons of clarity.

The manner in which the multilayer film of the
30 invention is used as internally situated tube in the insertion tube of the invention is preferably such that the resin requiring hardening, or the support material saturated with a resin requiring hardening, is directly adjacent to the external layer or surface layer (e) of
35 the internally situated tube.

A suitable externally situated tube of an insertion tube of the invention is in principle any conventional single- or multilayer tubular film that is impermeable

to liquid and that absorbs and/or reflects UV radiation and/or short-wave, visible light.

It is preferable that the single- or multilayer tubular
5 film used as externally situated tube in the invention
of this type of insertion tube is a tubular film that
is at least contact-transparent, and that reflects
and/or absorbs UV radiation and/or short-wave, visible
light. It is particularly preferable that the simple-
10 or multilayer tubular film used as externally situated
tube in the invention comprises at least one layer
based on at least one optionally modified thermoplastic
olefin homo- or copolymer comprising a combination of
at least one organic or inorganic color pigment or dye
15 that reflects and/or absorbs short-wave, visible light
and of at least one organic or inorganic compound that
reflects and/or absorbs UV radiation. Optionally
modified olefin homo- or copolymers used here can be
the optionally modified thermoplastic olefin homo- or
20 copolymers that are also suitable for the production of
the layer (a), and/or of the adhesive-promoter layers
(b) and (d), of the multilayer film of the invention.

For the purposes of this invention, the expression
25 "contact-transparent" means that the tubular film used
in the invention in the form of a simple- or multilayer
tube of this type of insertion tube is transparent at
least to the extent that makes it possible to monitor
the uniform saturation of the support material by the
30 resin requiring hardening. This is based on checking of
the lightness of color of the saturated support
material.

It is preferable that the simple- or multilayer tubular
35 film used as externally situated tube in the invention
comprises at least one organic or inorganic color
pigment or at least one organic or inorganic dye
selected from the group consisting of carbonyl dyes,
preferably quinone dyes, indigo dyes, and

quinacridones, azo compounds, cyanine compounds, preferably triphenylmethane compounds, azomethines, iscindolines, dioxazines, metal oxides, transition metal oxides, metal oxide hydrates, and transition

5 metal oxide hydrates. It is particularly preferable that, from these dye groups or color pigments, the yellow dye groups or color pigments are selected. It is preferable that an organic, yellow color pigment or an organic, yellow dye selected from the group consisting

10 of benzimidazole derivatives, benzotriazole derivatives, 1,4-quinone derivatives, 1,4-naphthoquinone derivatives, 9,10-anthraquinone derivatives, and phenylazophenol derivatives, in each case in the form of the free compounds, in the form of tautomers,

15 or of the salts of acids or bases, or of the solvates, preferably the hydrates, is present. It is preferable that an inorganic, yellow color pigment or an inorganic, yellow dye selected from the group consisting of transition metal oxides and transition

20 metal oxide hydrates is present. Particular preference is given to a yellow color pigment or a yellow dye selected from the group consisting of 4-phenylazophenol, 2-(2'-methyl)phenylazo-4-methylphenol, N-(4-phenylazo)phenyldiethanolamine, benzotriazoles,

25 benzimidazolone, iron oxide and iron oxide hydrate, and very particular preference is given to benzimidazolone. It is preferable that the organic or inorganic color pigment or the organic or inorganic dye absorbs and/or reflects short-wave, visible light in the wavelength

30 range from 400 to 500 nm, particularly preferably in the wavelength range from 400 to 450 nm, preferably respectively to an extent of more than 90%.

In one preferred embodiment, the simple- or multilayer

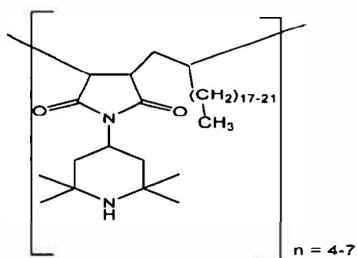
35 tubular film used as externally situated tube in the invention preferably comprises at least one organic or inorganic compound selected from the group consisting of metal oxides, transition metal oxides, metal oxide hydrates, transition metal oxide hydrates, phosphites,

benzophenones, anthranilates, salicylates, dibenzoylmethane derivatives, p-aminobenzoic acid derivatives, cinnamic acid derivatives (phenylacrylic acid derivatives), benzimidazole derivatives, 5 benzotriazole derivatives, cyanoacrylates, benzotriazole derivatives, β,β' -divinylacrylates, alkyl α -cyano- β,β' -divinylacrylates, 1,3,5-triazine compounds and sterically hindered amines, respectively in the form of the free compounds, in the form of their 10 tautomers, or respectively their salts of acids or bases, as UV-radiation-absorbing and/or -reflecting compound. Some compounds of this type are marketed products, e.g. Uvinul® products from BASF AG.

15 The expression "sterically hindered amines" means compounds where there is/are one or more bulky organic moieties bonded to at least one trivalent nitrogen atom. These preferably involve aromatic or aliphatic, acyclic or cyclic, secondary and tertiary amines, such 20 as N,N'-disubstituted p-phenylenediamines, or substituted (amino)piperidines.

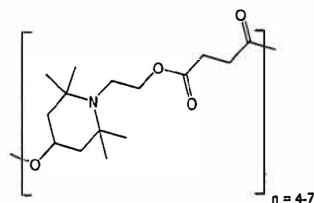
It is particularly preferable to use, as organic or inorganic compounds that reflect and/or absorb UV 25 radiation, at least one compound from the group consisting of zinc oxide, titanium dioxide, 2-ethoxyethyl p-methoxycinnamate, diethanolamine p-methoxycinnamate, octyl p-methoxycinnamate, 2-ethylhexyl 2-cyano-3,3-diphenylacrylate, potassium cinnamate, 30 propyl 4-methoxycinnamate, amyl 4-methoxycinnamate, α -cyano-4-methoxycinnamic acid and the corresponding hexyl ester, cyclohexyl 4-methoxycinnamate, glyceryl p-aminobenzoate, amyl p-dimethylaminobenzoate, ethyl 4-bis(hydroxypropyl)aminobenzoate, octyl p-dimethylaminobenzoate, ethoxylated 4-aminobenzoic acid, octyl 35 salicylate, triethanolamine salicylate, salts of salicylic acid, 4-isopropylbenzyl salicylate, 2-ethylhexyl 2-(4-phenylbenzoyl)benzoate, homomenthyl salicylate, 2-hydroxy-4-methoxybenzophenone, 2,4,6-

trianilino(p-carbo-2-ethylhexyloxy)-1,3,5-triazine, 2-phenylbenzimidazole-5-sulfonic acid, 1-(4-tert-butylphenyl)-3-(4-methoxyphenyl)propane-1,3-dione, p-cumenyl-3-phenylpropane-1,3-dione, 1,3-bis(4-methoxyphenyl)propane-1,3-dione, menthyl anthranilate, homomenthyl N-acetylanthranilate, 2-hydroxy-4-octylbenzophenone (Uvinul® 3008, Uvinul® 3008 FL), 6-tert-butyl-2-(5-chloro-2H-benzotriazol-2-yl)-4-methylphenol (Uvinul® 3026, Uvinul® 3026 GR), 2,4-di-tert-butyl-6-(5-chloro-2H-benzotriazol-2-yl)phenol (Uvinul® 3027), 2-(2H-benzotriazol-2-yl)-4,6-di-tert-pentylphenol (Uvinul® 3028, Uvinul® 3028 GR), 2-(2H-benzotriazol-2-yl)-4-(1,1,3,3-tetramethylbutyl)phenol (Uvinul® 3029, Uvinul® 3029 GR), 1,3-bis[(2'-cyano-3',3'-diphenylacryloyl)oxy]-2,2-bis[(2'-cyano-3',3'-diphenylacryloyl)oxymethyl]propane (Uvinul® 3030, Uvinul® 3030 GR), 2-(2H-benzotriazol-2-yl)-4-methylphenol (Uvinul® 3033 P), 2-(2H-benzotriazol-2-yl)-4,6-bis(1-methyl-1-phenylethyl)phenol (Uvinul® 3034), ethyl 2-cyano-3,3-diphenylacrylate (Uvinul® 3035), 2-ethylhexyl 2-cyano-3,3-diphenylacrylate (Uvinul® 3039), N,N'-bisformyl-N,N'-bis(2,2,6,6-tetramethyl-4-piperidiny)hexamethylenediamine (Uvinul® 4050 H) bis(2,2,6,6-tetramethyl-4-piperidyl) sebacate (Uvinul® 4077 H, Uvinul® 4077 GR), bis(1,2,2,6,6-pentamethyl-4-piperidyl) sebacate, methyl (1,2,2,6,6-pentamethyl-4-piperidyl) sebacate (Uvinul® 4092 H),



(Uvinul® 5050 H)

and (Uvinul® 5062 H, Uvinul® 5062 GR).



30

It is preferable that the organic or inorganic compound reflects and/or absorbs UV radiation in a wavelength range from 200 to 400 nm, particularly preferably from

300 to 400 nm, preferably in each case to an extent of more than 90%.

It is preferable that the simple- or multilayer tubular
5 film used as externally situated tube in the invention
comprises from 0.05 to 20% by weight, particularly from
0.1 to 5% by weight, very particularly from 0.1 to 2%
by weight, based in each case on the total weight of
10 the film, of the combination of at least one organic or
inorganic color pigment or dye and of at least one
organic or inorganic compound. It is preferable that
the simple- or multilayer tubular film used as
externally situated tube in the invention comprises
15 from 0.05 to 10% by weight, particularly from 0.1 to 3%
by weight, based on the total weight of the film, of
the organic or inorganic color pigment or dye. It is
preferable that the simple- or multilayer tubular film
used as externally situated tube in the invention
20 comprises from 0.05 to 10% by weight, particularly from
0.1 to 2% by weight, based on the total weight of the
film, of the organic or inorganic compound. It is
preferable that each component of the combination is
stable at temperatures up to 300°C.

25 The single- or multilayer tubular film used as
externally situated tube in the invention preferably
has a plurality of layers. It is preferable that a
multilayer tubular film used as externally situated
tube in the invention comprises at least one barrier
30 layer, particularly one oxygen-barrier layer or water-
vapor-barrier layer, or one oil-barrier layer.

A suitable material for the production of the barrier
layer is preferably at least one homo- or copolyamide,
35 ethylene-vinyl alcohol copolymer (EVOH), polyvinyl
alcohol (PVOH), cyclic olefin copolymer (COC),
polyvinylidene chloride (PVdC) or a mixture of at least
two of the polymers mentioned, and particularly
preferably at least one homo- or copolyamide. Homo- or

copolyamides that can be used here are the homo- or copolyamides that are also suitable for the production of the layers (c) and (e) of the multilayer film of the invention. The polyvinyl alcohols used for the
5 production of the barrier layer are produced via complete or incomplete hydrolysis of corresponding polyvinyl acetates (PVA), and therefore comprise not only partially hydrolyzed polyvinyl acetates with a degree of hydrolysis of from 50 to 98 mol% but also
10 completely hydrolyzed polyvinyl acetates with a degree of hydrolysis $\geq 98\%$. The ethylene-vinyl alcohol copolymers (EVOH) used for the production of the barrier layer are obtained via complete or incomplete hydrolysis of corresponding ethylene-containing
15 polyvinyl acetates (EVAc), and comprise especially completely hydrolyzed ethylene-containing polyvinyl acetates with a degree of hydrolysis of $\geq 98\%$. The cyclic olefin copolymers (COC) used for the production of the barrier layer can also be copolymers of
20 α,β -unsaturated cyclic olefins having from 4 to 10 carbon atoms, e.g. norbornene, and of α,β -unsaturated olefins, such as ethylene or propylene.

It is preferable that at least one surface layer of the
25 multilayer tubular film used as externally situated tube in the invention is based on at least one optionally modified thermoplastic olefin homo- or copolymer which is preferably sealable. Optionally modified olefin homo- or copolymers that can be used
30 here are the optionally modified thermoplastic olefin homo- or copolymers that are also suitable for the production of the layer (a) and/or of the adhesive-promoter layers (b) and (d) of the multilayer film of the invention. There can preferably be an adhesive-promoter layer, preferably comprising at least one
35 modified olefin homo- or copolymer, arranged here between a surface layer and the barrier layer. Modified olefin homo- or copolymers that can be used here are the modified thermoplastic olefin homo- or copolymers

that are also suitable for the production of the adhesive-promoter layers (b) and (d) of the multilayer film of the invention.

- 5 In one preferred embodiment, each of the surface layers of the multilayer tubular film used as externally situated tube in the invention is based on at least one preferably sealable olefin homo- or copolymer and respectively has been bonded to the barrier layer by
- 10 way of an adhesive-promoter layer described above. In one preferred embodiment, at least one of the internally situated layers of the multilayer tubular film used as externally situated tube in the invention comprises the combination which is made of at least one
- 15 organic or inorganic color pigment or dye and of at least one organic or inorganic compound, and which reflects and/or absorbs the detrimental radiation. It is preferable that the components of the combination are present in the same layer of the single- or
- 20 multilayer tubular film used as externally situated tube in the invention, particularly in an adhesive-promoter layer. Each of the adhesive-promoter layers of the multilayer tubular film used as externally situated tube in the invention can preferably comprise the
- 25 combination which is made of at least one organic or inorganic color pigment or dye and of at least one organic or inorganic compound, and which reflects and/or absorbs detrimental radiation.
- 30 In another preferred embodiment, the components of the combination are present in different layers of the multilayer tubular film used as externally situated tube in the invention. It is preferable that the color pigment or the dye is present in at least one surface
- 35 layer and that the organic or inorganic compound is present in at least one internally situated layer of the multilayer tubular film used as externally situated tube in the invention. Each of the adhesive-promoter layers of the multilayer tubular film used as

externally situated tube in the invention can preferably comprise at least one organic or inorganic compound. In another preferred embodiment, each of the layers of the multilayer tubular film used as
5 externally situated tube in the invention, with the exception of the barrier layer, can comprise at least one organic or inorganic color pigment or dye.

The present invention further provides a pipe-
10 renovation system suitable for the renovation of subterranean pipes, preferably subterranean drainage pipes, comprising an insertion tube which is provided for insertion into the pipe requiring renovation, preferably drainage pipe, and which is made of a
15 preferably nonconditioned multilayer film of the invention that is impermeable to liquids, preferably in the form of a tubular film, as the internally situated tube, and an externally situated single- or multilayer tubular film which is impermeable to liquids, and which
20 reflects and/or absorbs UV radiation and/or short-wave, visible light, as externally situated tube, and, situated between the two tubes, an impregnated support material that can be hardened by UV radiation, preferably a support material saturated with a
25 reactive, unsaturated resin system, particularly preferably a glassfiber material saturated with a reactive, unsaturated resin system, and a source that emits UV radiation and/or short-wave, visible light, and that is preferably moveable, preferably a UV
30 source.

By virtue of the use of the pipe-renovation system of the invention, in particular by virtue of the multilayer film of the invention, preferably in the
35 form of a tubular film, as internally situated tube of an insertion tube, the insertion tube drawn into the drain requiring renovation can be drawn into the pipe without difficulty, i.e. without splitting or break-off, and can be inflated without bursting, thus

achieving problem-free hardening, by means of UV radiation, of the support material situated in the tube and saturated with the liquid saturation material. After the hardening process, once the strengthened, 5 renovated drainage pipe made of the hardened support material is in place, the multilayer film of the invention, preferably in the form of a tubular film, as internally situated tube, can preferably be withdrawn therefrom without break-off or tearing, and/or 10 hindrance to movement.

Determination of extensibility

The extensibility of a multilayer film is determined as described below, by means of an inflation test.

5

If the multilayer film is a tubular film, extensibility can be determined directly as described below. Here, if the multilayer film is not a tubular film, but instead is by way of example a flat film, this is processed by sealing to give a tube, and the extensibility of said tube is determined.

10

Two metal disks with a diameter of respectively 270 mm and a width of 150 mm are used to provide an air-tight seal at both ends of a tube of length 5 m, of a tubular film of length 5 m, with a collapsed width of 435 mm. Tension belts and commercially available textile adhesive tape can be used as aids here. One of the two metal disks has been provided with a valve through which compressed air is passed into the tubular film or into the tube. The compressed air is used to inflate the tubular film or the tube until it bursts. The juncture immediately prior to the bursting of the tubular film or of the tube here is indicated by a locally delimited blister in the inflated tubular film or the inflated tube, where finally continued introduction of compressed air then produces a crack which leads to the bursting of the tubular film or of the tube.

20

25

30

The tensile strain achieved is determined by measuring the collapsed width of the tube or of the tubular film at its widest point after inflation, and using the following formula to calculate the relationship between this and the initial collapsed width.

35

Extensibility = (collapsed width after inflation / initial collapsed width prior to inflation - 1) · 100

The extensibility achieved is stated in percent.

Examples

5 The inventive examples and comparative examples below serve to illustrate the invention, but are not to be interpreted as restrictive.

10 **I. Chemical characterization of the raw materials used:**

Durethan CI 31F: Copolyamide from Lanxess, formed
from ϵ -caprolactam, hexamethylene-
15 diamine, and isophthalic acid
Grillon CA6E: PA 6/12 copolymer
PA6: Homopolyamide from Lanxess, formed
from ϵ -caprolactam
Admer NF 498 E: LDPE from Mitsui (adhesion
20 promoter), modified with maleic
anhydride groups
Lupolen 2420 F: LDPE from BASF
Exceed 1327 CA: Ethylene copolymer produced by
25 means of metallocene catalysis,
polymerized by using hexene as
further comonomer alongside
ethylene,
Surlyn 1652-SB1: Zinc salt of an ethylene-
methacrylic acid copolymer from
30 DuPont

II. Production of the multilayer films

35 The multilayer films of comparative examples 1-3 (CE1-CE3) consist of three (CE2), four (CE1) or five layers (CE3). The multilayer films of the invention of inventive examples 1-4 (IE1-IE4) respectively consist of five layers. The individual layers of the multilayer films are respectively immediately adjacent to one

another in the sequence in which they have been listed below. The multilayer films of comparative examples **CE1-CE3**, and also of inventive examples 1-2 and 4 (**IE1-IE2** and **IE4**) were respectively produced in the form of tubular films by blown-film coextrusion. The multilayer film of inventive example 3 (**IE3**) was produced in the form of a flat film by cast-film coextrusion, and then sealed to give a tube.

III. Inventive examples and comparative examples

All of the % data below are respectively % by weight. All of the μm data below relate to the respective layer thickness of the multilayer films.

III.1 Comparative examples 1-3 (CE1-CE3**)**

The multilayer film **CE1** corresponds, in layer structure, to the multilayer film specified in example 2 of EP-A-0 342 897, but was produced in the form of a tubular film.

Table 1

Layer structure CE1-CE3	Raw materials CE1	Raw materials CE2	Raw materials CE3
Layer (a)	-	Lupolen 2420 F (70%), Exceed 1327 CA (30%) 145 μm	Lupolen 2420 F (70%), Exceed 1327 CA (30%) 40 μm
Adhesive-promoter layer (b)	Surlyn 1652-SB1 (100%) 140 μm	Admer NF 498 E (100%) 15 μm	Admer NF 498 E (100%) 15 μm
Layer (c)	PA6 (100%) 10 μm	-	Durethan CI 31F (100%) 40 μm

Adhesive-promoter layer (d)	Surlyn 1652-SB1 (100%) 110 µm	-	Admer NF 498 E (100%) 15 µm
Layer (e)	Grillon CA6E (100%) 30 µm	Durethan CI 31F (100%) 40 µm	Lupolen 2420 F (70%), Exceed 1327 CA (30%) 40 µm

The total thickness of the multilayer film of **CE1** is 300 µm. The total thickness of the multilayer film of **CE2** is 200 µm. The total thickness of the multilayer film of **CE3** is 150 µm.

III.2 Inventive examples 1-4 (IE1-IE4)

Table 2

10

Layer structure IE1-IE4	Raw materials IE1	Raw materials IE2	Raw materials IE3	Raw materials IE4
Layer (a)	Lupolen 2420 F (70%), Exceed 1327 CA (30%) 80 µm	Lupolen 2420 F (70%), Exceed 1327 CA (30%) 80 µm	Lupolen 2420 F (70%), Exceed 1327 CA (30%) 80 µm	Lupolen 2420 F (70%), Exceed 1327 CA (30%) 155 µm
Adhesive-promoter layer (b)	Admer NF 498 E (100%) 15 µm	Admer NF 498 E (100%) 15 µm	Admer NF 498 E (100%) 15 µm	Admer NF 498 E (100%) 15 µm
Layer (c)	Durethan CI 31F (100%) 15 µm	Durethan CI 31F (100%) 20 µm	Durethan CI 31F (100%) 15 µm	PA6 (100%) 20 µm
Adhesive-promoter layer (d)	Admer NF 498 E (100%) 15 µm	Admer NF 498 E (100%) 15 µm	Admer NF 498 E (100%) 15 µm	Surlyn 1652-SB1 (100%) 80 µm

Layer (e)	Durethan CI 31F (100%)	Durethan CI 31F (100%)	Durethan CI 31F (100%)	Grillon CA6E (100%)
	15 µm	20 µm	15 µm	30 µm

The total thickness of the multilayer films of **IE1** and **IE3** is respectively 140 µm. The total thickness of the multilayer film of **IE2** is 150 µm. The total thickness of the multilayer film of **IE4** is 300 µm.

Determination of extensibility

The extensibility of the multilayer films of the invention of inventive examples 1-4 (**IE1-IE4**), and also of the multilayer films of comparative examples 1-3 (**CE1-CE3**), was determined respectively by the method described above.

The extensibility of the multilayer films of inventive examples 1-4 (**IE1-IE4**) and of comparative examples 1-3 (**CE1-CE3**) was determined here in the nonconditioned state of the multilayer films.

Table 3

Inventive example/ Comparative example	Conditioning	Extensibility [%]
IE1	no	80.2
IE2	no	34.1
IE3	no	39.4
IE4	no	16.9
CE1	no	9.2
CE2	no	12.9
CE3	no	13.2

What is claimed is:

1. A multilayer film that is impermeable to liquids
and that is at least to some extent permeable to
5 UV radiation, comprising a layer sequence made of
 - (a) a layer (a) based on at least one
thermoplastic olefin homo- or copolymer, as
one of the external layers,
10
 - (b) an adhesive-promoter layer (b),
 - (c) an internally situated layer (c) based on at
least one homo- and/or copolyamide,
15
 - (d) an adhesive-promoter layer (d), and
 - (e) a layer (e) based on at least one homo-
and/or copolyamide, as one of the external
20 layers,preferably in the form of a tubular film,

where the VICAT softening point of the
25 thermoplastic olefin homo- or copolymer of the
layer (a) is at least 100°C.
2. The multilayer film as claimed in claim 1,
characterized in that the thickness of the layer
30 (a) is at least 40%, preferably at least 50%, of
the total thickness of the multilayer film.
3. The multilayer film as claimed in claim 1 or 2,
characterized in that the layer (a) is based on at
35 least one ethylene homo- or copolymer and/or on at
least one propylene homo- or copolymer.
4. The multilayer film as claimed in any of the
preceding claims, characterized in that the layers

5 (c) and the layer (e) have an identical layer structure, preferably an identical layer thickness, and/or identical polyamide components, and/or an identical composition, preferably an identical polyamide component.

10 5. The multilayer film as claimed in any of claims 1 to 3, characterized in that the layers (c) and the layer (e) have a different layer structure, preferably a different layer thickness, and/or different polyamide components, and/or a different composition.

15 6. The multilayer film as claimed in any of the preceding claims, characterized in that the adhesive-promoter layers (b) and (d) respectively mutually independently are based on at least one modified thermoplastic olefin homo- or copolymer, preferably respectively mutually independently on
20 at least one modified thermoplastic ethylene homo- or copolymer, and/or at least one modified propylene homo- or copolymer.

25 7. The multilayer film, preferably multilayer tubular film, as claimed in any of claims 1 to 6, characterized in that it consists of the layers (a)-(e).

30 8. The multilayer film as claimed in any of the preceding claims, characterized in that the multilayer film is permeable to an extent of at least 80%, preferably at least 90%, to UV radiation, preferably to UV radiation in a wavelength range from 200 to 400 nm.

35 9. The use of a multilayer film as claimed in any of the preceding claims as internally situated tube of an insertion tube for the renovation of

subterranean pipes, preferably subterranean drainage pipes.

- 5 10. The use as claimed in claim 9, characterized in that the multilayer film is nonconditioned.
- 10 11. An insertion tube suitable for the renovation of subterranean pipes, preferably subterranean sewer pipes, comprising a preferably nonconditioned multilayer film that is impermeable to liquids, preferably in the form of a tubular film, as claimed in any of claims 1 to 8, as internally situated tube, and an externally situated single- or multilayer tubular film which is impermeable to liquids, and which reflects and/or absorbs UV radiation and/or short-wave, visible light, as externally situated tube, and, situated therebetween, a support material saturated with a reactive synthetic resin.
- 15 12. The insertion tube as claimed in claim 11, characterized in that the surface layer (a) of the multilayer film as claimed in any of claims 1 to 8 is directly adjacent to the support material.
- 20 13. A pipe-renovation system suitable for the renovation of subterranean pipes, preferably subterranean sewer pipes, comprising an insertion tube which is provided for insertion into the pipe requiring renovation, preferably drainage pipe, and which is made of a preferably nonconditioned multilayer film that is impermeable to liquids, preferably in the form of a tubular film, as claimed in any of claims 1 to 8, as an internally situated tube, and an externally situated single- or multilayer tubular film which is impermeable to liquids, and which reflects and/or absorbs UV radiation and/or short-wave, visible light, as externally situated tube, and, situated between
- 25 30 35

the two tubes, an impregnated support material
that can be hardened by UV radiation, preferably a
support material saturated with a reactive,
unsaturated resin system, particularly preferably
5 a glassfiber material saturated with a reactive,
unsaturated resin system, and a source that emits
UV radiation and/or short-wave, visible light, and
that is preferably moveable, preferably a UV
source.

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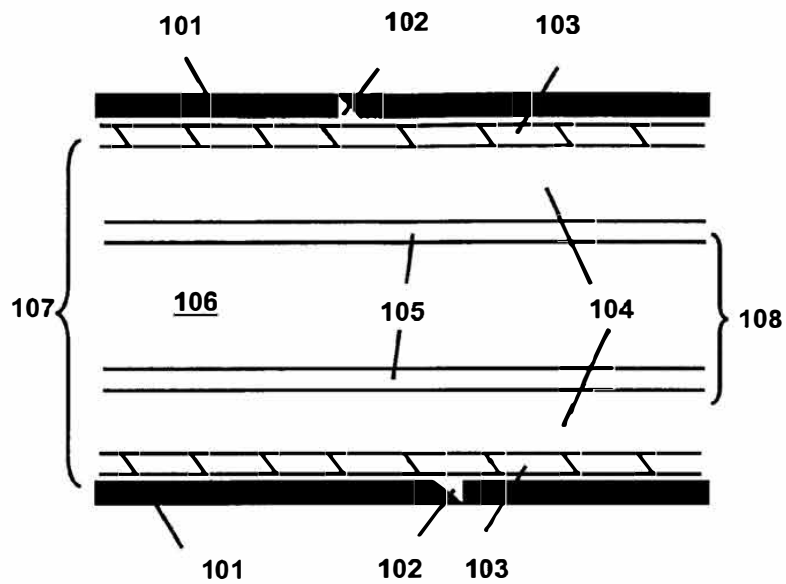


Fig. 1