(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 June 2016 (23.06.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/098095 A1

(51) International Patent Classification:
F16L 55/128 (2006.01) *C09K 3/12* (2006.01)
F16L 55/18 (2006.01) *F16L 55/164* (2006.01)
F16L 55/38 (2006.01)

(21) International Application Number:
PCT/IL2015/000053

(22) International Filing Date:
16 December 2015 (16.12.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/093,839 18 December 2014 (18.12.2014) US

(71) Applicant: **CURAPIPE SYSTEM LTD.** [IL/IL]; P.O. Box 7284 Abba Hillel Junction, Yakhin Park, Ashkelon 7817201 (IL).

(72) Inventors: **PERSTNEV, Samuel**; P.O.Box 389, 7941100 Mercaz Shapira (IL). **NATAPOV, Boris**; Rambam 12/27, 7862518 Ashkelon (IL). **PERSTNEV, Alexander**; Eli Kogen 38/16, 78625 Ashkelon (IL). **UKHANOV, Reonald**; Shani Elivahu 6, 7830012 Ashkelon (IL).

(74) Agents: **LIFSHITZ, Susan Eve** et al.; I.P. Israel Patents Ltd., P.O. Box 45376, 91451 Jerusalem (IL).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,

[Continued on next page]

(54) Title: SYSTEMS, COMPOSITIONS AND METHODS FOR CURING LEAKAGES IN PIPES

(57) Abstract: The present invention provides leakage plugging devices and methods for sealing a leakage at a remote site in a pipe, the device including a porous carrier plug of a deformable material including pores and at least one sealant composition disposed in the pores, wherein the porous carrier plug is adapted to transport the at least one sealant composition from a first site to a remote site and to plug the leakage at the remote site.

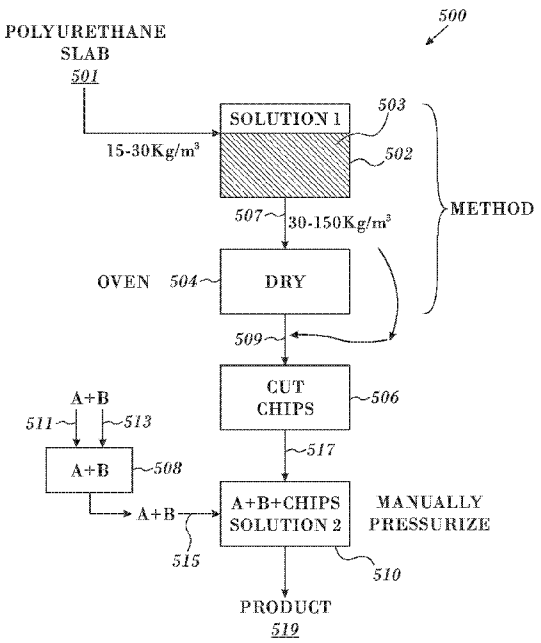

Fig. 5

WO 2016/098095 A1

TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

SYSTEMS, COMPOSITIONS AND METHODS FOR CURING LEAKAGES IN PIPES

FIELD OF THE INVENTION

The present invention relates generally to pipeline leakages, and more specifically to methods and apparatus for curing pipeline leakages.

BACKGROUND OF THE INVENTION

Many liquids are transported via subterranean/underwater pipelines. When a leakage crack or hole forms is the pipeline, the liquid leaks therefrom. Often, it takes a long time to detect a leakage and yet longer to locate the leakage site. Oil, gas and water transportation are thus subject to tremendous losses due to pipeline leakage.

There is thus a need to maintain and seal subterranean/underwater pipelines quickly *in situ*.

Several patent publications in the field include US3523826A, which relates to a process for cleaning a piping system which is characterized by circulating in, and through said system a thixotropic emulsion having a hi.-h volume ratio of internal phase to external phase, the emulsion having an emulsifying agent, an emulsifiable oil and a non-oil, the emulsion being an oil-in-non-oil or a non-oil-in-oil emulsion, the internal phase of said emulsion being present in said emulsion in an amount of at least 80% by volume of the emulsion, said emulsion having the characteristics of a solid when at rest and the characteristics of a liquid when a force is exerted on it, said emulsion tending to be non-adhesive, said emulsion having a critical shear point sufficient to permit pumping at high rates, and said emulsion having an apparent rest viscosity greater than about 1000 cps.

US4216026 describes a method for removing fluid and/or particulate debris from a pipeline, a Bingham plastic fluid plug is passed through a pipeline and the fluid and/or debris are collected by the plug. The plug is pushed through the pipeline with a scraper which in turn may be pushed by liquid or gas pressure. Where the fluid to be removed is water, the Bingham plastic fluid plug employed preferably is a composition of water and a xanthan gum, and the gum may be cross-linked with a multivalent metal. Where the fluid to be removed is a hydrocarbon, the Bingham

plastic fluid plug employed preferably is a composition of a mineral oil and an organo-modified smectite, and may also include a particulate filler such as powdered coal.

US4252465A describes a gel plug, which is employed during construction of an offshore pipeline to separate a gas-filled portion of the pipeline from a water-flooded portion, and to facilitate control and movement of the gas/gel plug/water interface as desired to assist in construction operations.

US4254559A relates to an interior surface of a pipeline being dried by sequentially passing through the pipeline (a) an aqueous cross-linked gelled pig, (b) a fluid mobility buffer comprising a non-crosslinked gelled ankanol of from one to three carbon atoms, (c) a dessicating amount of a liquid alkanol from one to three carbon atoms. For example, a pipeline was dried by sequentially passing through it (a) a borate cross-linked hydroxypropyl guar gum pig, (b) a fluid mobility buffer comprising methanol thickened with hydroxypropyl cellulose, and (c) methanol.

US4379722 discloses a gel plug of mineral oil, organo-modified smectite, and a particulate filler such as powdered coal, or a gel plug of mineral oil and organo-modified smectite is employed during construction of an off-shore pipeline to separate a gas-filled portion of the pipeline from a water-flooded portion, and to facilitate control and movement of a gas/gel plug/water interface as desired to assist in construction operations.

US4416703 describes a method to remove particulate debris from a pipeline, a plug train including at least one gel plug having debris entraining characteristics and at least one pseudoplastic plug is passed through a pipeline and the debris is collected by the gel plug. The gel plug is pushed through the pipeline with a scraper which in turn may be pushed by liquid or gas pressure.

US4321968A discloses gelled compositions comprising carboxymethylhydroxyethyl cellulose in aqueous brine solutions, which are gelled by the addition of an alkaline earth metal hydroxide such as calcium hydroxide. The gelled compositions have utility as water diversion agents, pusher fluids, fracturing fluids, drilling muds, work-over fluids, and completion fluids.

US5346339A provides a method of cleaning a pipeline using a gel pig of a

graft copolymer of a hydroxyalkyl cellulose prepared by a redox reaction with vinyl phosphonic acid. The gel pig is formed by hydrating the graft copolymer in an aqueous liquid. The gel pig is crosslinked by the addition of a Lewis base or Bronsted-Lowry base, to the gel in an amount sufficient to initiate crosslinking of the graft copolymer. Contaminants entrained in the crosslinked gel pig during the cleaning process may be separated by the addition of a pH reducing agent to the pig whereby the viscosity of the gel is caused to decrease. The gel may be used for further cleaning after contaminant separation by addition of an additional quantity of the Lewis base or Bronsted-Lowry base.

WO2008081441 describes a method of repairing leakage in pipelines comprising the steps of forming a first and second openings in the pipeline upstream and downstream, respectively, of the leakage location, inserting through the first opening a first body, filling the space arrear of the first body (C1) with a first viscous sealing material (M1), inserting through the first opening a second body (C2) arrear of the first viscous sealing material (M1) compressing the first sealing material by applying a pressure against the first and the second bodies (C1, C2) in opposite directions, causing the first and second bodies (C1, C2) and the compressed first sealing material (M1) to move in unison in the direction of the second opening, and retrieving the first and second bodies (C1, C2). Preferably, the method is performed using three bodies (C1, C2, C3) and two sealing materials (M1, M2).

Prior art systems often have the following drawback, namely that hardening material which is not in the optimal ratio is fed into the pipeline. Additionally, after exposure of the material in the hole in the pipe, it can remain and may also exit pressure pipe. There are thus still many types of pipeline leakages, which cannot be cured using the aforementioned prior art materials and methods. There thus remains an urgent need to develop systems and methods for curing pipeline leakages.

SUMMARY OF THE INVENTION

It is an object of some aspects of the present invention to provide methods of forming plugging devices for use in systems and methods for sealing pipeline leakages.

The present invention provides leakage plugging devices and methods for sealing a leakage at a remote site in a pipe, the device including a polymeric carrier plug of a deformable material including pores and at least one sealant composition disposed in the pores, wherein the polymeric carrier plug is adapted to transport the at least one sealant composition from a first site to a remote site and to plug the leakage at the remote site.

In other embodiments of the present invention, a method and system are provided for sealing water transport pipelines.

There is thus provided according to an embodiment of the present invention, a leakage plugging device for sealing a leakage at a remote site in a pipe, the device including;

a. a polymeric carrier plug of a deformable material including pores; and
b. at least one sealant composition disposed in the pores, wherein the polymeric carrier plug is adapted to transport the at least one sealant composition from a first site to a remote site and to plug the leakage at the remote site.

Additionally, according to an embodiment of the present invention, the device is of a first dimension and the leakage is of a second dimension.

Furthermore, according to an embodiment of the present invention, the first dimension is in a range of 0.1 mm to 100 mm.

Moreover, according to an embodiment of the present invention, the first dimension is in a range of 1 mm to 50 mm.

Further, according to an embodiment of the present invention, the first dimension is in a range of 2 mm to 15 mm.

Additionally, according to an embodiment of the present invention, the polymeric carrier plug is adapted to penetrate the remote site.

Preferably, according to an embodiment of the present invention, the polymeric carrier plug or a multiplicity of polymeric carrier plugs are adapted to fill at least one of a hole, a crack and breakage causing the leakage at the remote site.

Furthermore, according to an embodiment of the present invention, the polymeric carrier plug or a multiplicity of polymeric carrier plugs are adapted to be condensed at the remote site.

Yet further, according to an embodiment of the present invention, the at least one sealant composition resides within the condensed carrier plug or a multiplicity of polymeric carrier plugs to fill the leakage at the remote site.

Additionally, according to an embodiment of the present invention, the polymeric carrier plug is of a shape selected from the group consisting of wedge-shaped, rhomboid, cubic, polygon, spherical, ovular, egg-shaped, diamond-shaped and pyramid-shaped.

Moreover, according to an embodiment of the present invention, the polymeric carrier plug includes a polymer selected from the group consisting of a foamed material, a polyurethane material, an expanded material, a natural material and a biodegradable polymeric material.

Further, according to an embodiment of the present invention, the at least one sealant composition includes;

a. an adhesive;
b. a hardener; and
c. at least one filler.

Additionally, according to an embodiment of the present invention, the deformable material includes polyurethane and the at least one sealant composition further includes a fatty acid liquid composition.

Furthermore, according to an embodiment of the present invention, the fatty acid liquid composition includes a vegetable oil.

Moreover, according to an embodiment of the present invention, the vegetable oil is selected from the group consisting of sunflower oil, safflower oil, corn oil, soybean oil, canola oil, olive oil and rapeseed oil.

Additionally, according to an embodiment of the present invention, the polymeric carrier plug is adapted to form a narrow head part and wider tail part, wherein the head part is lodged within a hole, a crack and breakage causing the

leakage at the remote site.

Further, according to an embodiment of the present invention, a density of the device is increased at least threefold after plugging the site.

There is thus provided according to another embodiment of the present invention, a method for sealing a leakage at a remote site in a pipe, the method including;

a. introducing a fluid carrier including a plurality of leakage plugging devices according to claim 1, into the pipe at the first site under pressure;

b. allowing the fluid carrier to transport the devices to the remote site, wherein at least one the devices penetrates the leakage thereby sealing the leakage.

Additionally, according to an embodiment of the present invention, the method further includes;

c. curing the at least one sealant composition within the devices at the remote site, thereby forming at least one hardened increased-density device.

Additionally, according to an embodiment of the present invention, the method further includes;

d. removing excess plugging devices and sealant compositions from the pipe after the allowing step.

Moreover, according to an embodiment of the present invention, the sealing includes a hardening step followed by a curing step.

Additionally, according to an embodiment of the present invention, the hardening step occurs within twenty minutes and the curing step occurs within eight to twenty hours.

Furthermore, according to an embodiment of the present invention, the hardening step occurs within ten minutes and the curing step occurs within two hours.

In some cases, the hardening step occurs within five minutes and the curing step occurs within one hour. The present invention will be more fully understood from the following detailed description of the preferred embodiments thereof, taken together with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in connection with certain preferred embodiments with reference to the following illustrative figures so that it may be more fully understood.

With specific reference now to the figures in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

In the drawings:

Figs. 1A-1C show simplified images of a leakage plugging device for *in situ* repair of a pipe, in accordance with an embodiment of the present invention;

Figs 2 shows a simplified image of a leakage plugging device for *in situ* repair of a pipe, in accordance with an embodiment of the present invention;

Fig. 3 shows a simplified schematic diagram of the end product of repair - the pipe from the outside after repair with a sealant plug, in accordance with an embodiment of the present invention;

Fig. 4 shows a simplified schematic diagram of the end product of repair - the pipe from the inside after repair with a sealant plug, in accordance with an embodiment of the present invention; and

Fig. 5 shows a simplified flowchart of a method for the preparation of a sealant plug in accordance with an embodiment of the present invention.

In all the figures similar reference numerals identify similar parts.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In the detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those skilled in the art that these are specific embodiments and that the present invention may be practiced also in different ways that embody the characterizing features of the invention as described and claimed herein.

The present invention provides systems and methods for repairing leaking pipes *in situ*, apparatus and systems for method implementation, materials and sealant compositions.

The present invention provides leakage plugging devices and methods for sealing a leakage at a remote site in a pipe, the device including a polymeric carrier plug of a deformable material including pores and at least one sealant composition disposed in the pores, wherein the polymeric carrier plug is adapted to transport the at least one sealant composition from a first site to a remote site and to plug the leakage at the remote site.

Prior art systems often have the following drawback, namely that hardening material which is not in the optimal ratio is fed into the pipeline. Additionally, after exposure of the material in the hole in the pipe, it can remain and may also exit pressure pipe.

One of the aims of the present invention is to eliminate the drawbacks of the prior art, that is, the development of a reliable pipe repair process from the inside, as well as development of basic devices, materials and other items needed for reliable pipe repair in real conditions.

When the carrier plugs that are suspended in a composite sealant composition approach the holes in the pipe, they go into the holes and plug them. The remaining plugs and composition are ejected from the pipe and disposed of. Carrier plugs, which have come through the holes in the pipe after the specified time harden and form strong plug, termed herein leakage plugging devices. The pipe is cleaned from residues of the additional material/sealant compositions and plugs. This leaves the final pipeline repaired with *in situ* leakage plugging device(s) and no/negligible leakage.

Reference is now made to Figs. 1A-1C, which show simplified images of a leakage plugging device 100, 110, 120, for *in situ* repair of a pipe, in accordance with an embodiment of the present invention.

Device 100 is comprises a polymer carrier plug 102 of general three-dimensional shape before use and at least one sealant composition carried therein (not seen). The carrier plug has a height h_1, width, l_1 and thickness w, before use. After use its shape is changed 110 and forms a head section 112 and tail section 114. The head section is of a length h_2 and diameter d. The head section is often of a cylindrical shape if it stoppers a circular hole or often termed pinhole. The tail section may be of a regular or irregular shape of height h_3 and width l_2. The dimensions after curing (use) depend on the degree of compacting/increasing density thereof. The density may typically increase 1-10 fold and dimensions decrease respectively. The density is typically non-uniform, being greater in the head section and lower in the tail section.

Figs 2 shows further simplified images of a leakage plugging device for *in situ* repair of a pipe before use 210, during the curing process 210 and after the curing process 220.

Fig. 3 shows a simplified schematic diagram of the end product of repair - a pipe from the outside after repair 302 with a sealant plug 300 showing part of head section 112.

Fig. 4 shows a simplified schematic diagram 400 of the end product of repair - the pipe from the inside after repair 402 with a sealant plug tail (partial view) 114, in accordance with an embodiment of the present invention.

Sealant compositions are introduced into carrier plugs. The unloaded carrier plugs are constructed and configured to:

a. receive at least one sealant composition thereby forming a loaded carrier plug;
b. transport the at least one sealant composition along the pipe;
c. enable the at least one sealant composition to harden and/or expand/and or polymerize and/or be retained *in situ* at the leakage site (hole/crack/other) thereby forming a leakage plugging device.

The carrier plugs thus form a novel system for plugging/sealing leakage sites in pipes.

The sealant compositions of the present invention may further comprise other

particles/solids which remain in the leakage site outside the carrier plugs.

A composite sealant composition may comprise:

a. one or more sealant compositions;
b. one or more type of loaded or unloaded carrier plugs;
c. optionally, at least one filler or particulate; and
d. other optional additives.

The composite sealant composition comprising some or all of the above, are adapted to be introduced into a pipeline by the help of special devices.

Reference is now made to Fig. 5, which shows a simplified flowchart 500 of a method for the preparation of a sealant plug in accordance with an embodiment of the present invention.

In a first mixing step 502, a polymeric condensable material 501 is introduced into a first solution or suspension 503. The polymeric condensable material, may be, for example, polyurethane of a density of 15-30 kg/m^3. According to some embodiments, the density is 15-18 kg/m^3.

According to some embodiments, the first solution (solution 1, Fig. 5) is in accordance with that described in US 6,057,378 (Fig. 3 and example 1), incorporated herein by reference.

According to some other embodiments, solution 503 comprises:

a) At least one polymer, selected from polyurethane, polyacrylate, rubber, plastic, cellulose and combinations thereof in a weight ratio of 5-20% wt/wt.
b) At least one organic or inorganic filler selected from carbon ash, aluminum hydroxide, calcium carbonate, calcium hydroxide, magnesium hydroxide, magnesium carbonate, titanium hydroxide, silica, similar fillers and combinations thereof in a weight ratio of 40-90 % wt/wt.
c) At least one surfactant selected from an ionic surfactant, an anionic surfactant, a detergent, an edible oil, an inedible oil and combinations thereof in a weight ratio of 0.01 to 4% wt/wt.
d) At least one gelling agent selected from carrageenan, agar agar, hydroxymethylcelluose, hydroxyethyl cellulose, hydroxypropyl cellulose and combinations thereof in a weight ratio of 0.01 to 4% wt/wt.
e) An antifoam in a weight ratio of 0.01 to 4% wt/wt.

f) A coloring agent selected from a water soluble dye, a water insoluble dye, a paint, an oxide, a metal oxide and combinations thereof in a weight ratio of 0.01 to 1% wt/wt.

The resultant wet impregnated material 507 is typically of a density of 30-150 kg/m^3.

The wet impregnated material 507 is then dried in a drying step 504. The drying step may be conducted in a belt dryer, tray drier, oven or any other commercially available drying method, known in the art. The resultant product is a dried impregnated material 509.

In parallel, a second solution or suspension 515 is prepared from a first composition 511 and a second composition 513 in a second mixing step 508. The first composition acts as a hardener.

Some non-limiting examples of the first composition 511 (A) are:-

a) A premixed hardening agent comprising polyoxypropylene triamine in a weight ratio of 50 to 90% wt/wt.

b) At least one organic or inorganic filler selected from carbon ash, aluminum hydroxide, calcium carbonate, calcium hydroxide, magnesium hydroxide, magnesium carbonate, titanium hydroxide, silica, similar fillers and combinations thereof in a weight ratio of 2-20 % wt/wt.

c) A coloring agent selected from a water soluble dye, a water insoluble dye, a paint, an oxide, a metal oxide and combinations thereof in a weight ratio of 0.01 to 1% wt/wt.

d) At least one surfactant selected from an ionic surfactant, an anionic surfactant, a detergent, an edible oil, an inedible oil and combinations thereof in a weight ratio of 0.01 to 15 % wt/wt.

e) At least one aqueous agent selected from sea water, tap water, distilled water, ice and combinations thereof in a weight ratio of 0.01 to 15 % wt/wt.

The second composition (B) 513, Fig. 5 acts as a resinous composition. Some examples of the second composition (B) are:-

a) At least one resinous agent selected from bisphenol A, glycidyl ether, bisphenol S, EPI-001 and combinations thereof in a weight ratio of 20 to

90 % wt/wt.

b) At least one organic or inorganic filler selected from carbon ash, aluminum hydroxide, calcium carbonate, calcium hydroxide, magnesium hydroxide, magnesium carbonate, titanium hydroxide, silica, similar fillers and combinations thereof in a weight ratio of 2-20 % wt/wt.

c) A coloring agent selected from a water soluble dye, a water insoluble dye, a paint, an oxide, a metal oxide and combinations thereof in a weight ratio of 0.01 to 1% wt/wt.

d) At least one surfactant selected from an ionic surfactant, an anionic surfactant, a detergent, an edible oil, an inedible oil and combinations thereof in a weight ratio of 0.01 to 15 % wt/wt.

e) At least one aqueous agent selected from sea water, tap water, distilled water, ice and combinations thereof in a weight ratio of 0.01 to 15 % wt/wt.

Thereafter, in a cutting step 506, the dried impregnated material 509 is cut either manually or by machine into little chips in a cutting step 506 to form chips 517.

The chips are typically wedge-shaped having dimensions, such as 0.1-8 cm height, 0.1-6 cm width and 1-30 mm thickness. Additionally or alternatively, the chips may be arrow-shaped, cylindrical, cubic or any other suitable shape.

The chips are mixed with second solution or suspension 515 in a third mixing step 510 to form a plug product 519. According to some embodiments, the chips may be placed under pressure, and upon release, they will suck up some of the second solution or suspension. The plug product 519 may be used for plugging a hole or crack in a pipe.

Some examples of the sealant compositions are provided in the following examples.

Example 1.

In this example, the values percent of the fundamental materials A1 and B1, and exemplary weight concentration ranges outside elements.

Composition of material A1 (%):
Bisphenol A 50.0-70.0 (%)
Glycidyl Ether 7.0-20.0 (%)
Inert powdered filler 10.0-20.0 (%)
Clay 0-2.0 (%)
A detergent precursor 0-5.0 (%)
A corrosion resistance provider 0-3.0 (%)
Hydrophobic liquid filler 2.0-5.0 (%)
Inert liquid filler 4.0-7.0 (%)
Silicon dioxide 0.5-1.0 (%)
Iron oxide hydroxyl 0.1-0.5 (%)

Composition of material B1 (%):
Diethylene thiamine 0-23.0 (%)
4.4 - isopropylidenediphenol 0-16.0 (%)
Isophorondiamine 0-31.0 (%)
Benzyl alcohol 0-31.0 (%)
A surfactant 0-1.0 (%)
Detergent precursor 0-5.0 (%)
Inert powdered filler 5-15.0 (%)
Polyoxypropylene thiamine 0-70.0 (%)
A corrosion resistance provider 0-5.0 (%)
Clay 0-4.0 (%)
4 -nonylphenol, branched 0-15.0 (%)
Silicon dioxide 0.2-2.0 (%)
Iron oxide hydroxyl 0-0.6 (%)
Inert liquid filler 1-6.0 (%)
Hydrophobic liquid filler 1.0-6.0 (%)

These materials once cured serve to provide robust long term plugging of the leakage with a longevity of similar order of magnitude to the remaining useful life of the host

pipe. They also serve to withstand changing environmental conditions. The cured product having a similar thermal coefficient in order of magnitude to the host pipe typically expands and contracts under changing temperatures in unison with the host pipe so as not to create a secondary leak under these conditions.

Example 2.

This example shows the composition of the sealant plug covering the hole in the pipe and the pipe remains in the field of repair of.

CAS #	Name component material	Content,%
80-05-7	Bisphenol A	39
668609-97-2	Glycidyl ether	11
21645-51-2	Inert powder filler (synthetic aluminum	20
67-53-0	A corrosion resistance provider	3
120962-03	Rapeseed oil	6.1
112945-52	Silicon dioxide	1
20344-49	Iron oxide hydroxyl	0.3
1140-40-0	Diethylene thiamine	3.5
80-05-74.4	Isopropylidenediphenol	2.5
2855-13-2	Isophorondiamine	4
100-51-6	Benzyl alcohol	4
9009-54-5	Polyurethane	2
9003-04-7	Polyacrylate (Tamcril- 15)	3
9004-62-9	Berol NP- 10 (9)	0.4
9004-62-0	Hydroxyethyl cellulose	0.1
8050-81-5	Antifoam APRU DF- 7010	0.1

The references cited herein teach many principles that are applicable to the

present invention. Therefore the full contents of these publications are incorporated by reference herein where appropriate for teachings of additional or alternative details, features and/or technical background. It is to be understood that the invention is not limited in its application to the details set forth in the description contained herein or illustrated in the drawings. The invention is capable of other embodiments and of being practiced and carried out in various ways. Those skilled in the art will readily appreciate that various modifications and changes can be applied to the embodiments of the invention as hereinbefore described without departing from its scope, defined in and by the appended claims.

CLAIMS

1. A leakage plugging device for sealing a leakage at a remote site in a pipe, the device comprising:
   a. a porous carrier plug of a deformable material comprising pores carrying a first density enhancing dried composition; and
   b. at least one sealant composition disposed in said pores, wherein said porous carrier plug is adapted to transport said at least one sealant composition from a first site to a remote site and to plug said leakage at said remote site.
2. A leakage plugging device according to claim 1, wherein said device is of a first dimension and said leakage is of a second dimension.
3. A leakage plugging device according to claim 2, wherein said first dimension is in a range of 0.1 mm to 100 mm.
4. A leakage plugging device according to claim 3, wherein said first dimension is in a range of 1 mm to 60 mm.
5. A leakage plugging device according to claim 5, wherein said first dimension is in a range of 2 mm to 15 mm.
6. A leakage plugging device according to claim 1, wherein said porous carrier plug or a multiplicity of porous carrier plug filled with at least one sealant composition adapted to penetrate said remote site.
7. A leakage plugging device according to claim 6, wherein said porous carrier plug or a multiplicity of porous carrier plug are adapted to fill at least one of a hole, a crack and breakage causing said leakage at said remote site.
8. A leakage plugging device according to claim 7, wherein said porous carrier plug or a multiplicity of porous carrier plug are adapted to be condensed at said remote site to form a condensed carrier plug.
9. A leakage plugging device according to claim 8, wherein said at least one sealant composition resides within said condensed carrier plug or plugs to fill said at least one of a hole, a crack and breakage causing leakage at said remote site.
10. A leakage plugging device according to claim 1, wherein said porous carrier plug or plugs are of a shape selected from the group consisting of wedge-shaped,

rhomboid, cubic, polygon, spherical, ovular, egg-shaped, diamond-shaped and pyramid-shaped.

11. A leakage plugging device according to claim 1, wherein said porous carrier plug or plugs comprise a polymer selected from the group consisting of a foamed material, a polyurethane material, an expanded material, a natural material and a biodegradable porous material.

12. A leakage plugging device according to claim 1,wherein said at least one sealant composition comprises:

    a. an adhesive;
    b. a hardener; and
    c. at least one filler.

13. A leakage plugging device according to claim 12, wherein said deformable material comprises polyurethane and said at least one sealant composition further comprises a fatty acid liquid composition.

14. A leakage plugging device according to claim 13, wherein said fatty acid liquid composition comprises a vegetable oil.

15. A leakage plugging device according to claim 13, wherein said vegetable oil is selected from the group consisting of sunflower oil, safflower oil, corn oil, soybean oil, olive oil, canola oil and rapeseed oil.

16. A leakage plugging device according to claim 7, wherein said porous carrier plug is adapted to form a narrow head part and wider tail part, wherein said head part is lodged within said remote site.

17. A leakage plugging device according to claim 16, wherein an average density of said device is increased at least twofold after plugging said site.

18. A leakage plugging device according to claim 17, wherein an average density of said narrow head part is increased at least threefold after plugging said site.

19. A leakage plugging device according to claim 1, wherein said first density enhancing dried composition comprises at least one polymer, at least one filler and at least one gelling agent.

20. A method for sealing a leakage at a remote site in a pipe, the method comprising:

    a. introducing a fluid carrier comprising a plurality of leakage plugging devices according to claim 1, into the pipe at said first site under pressure; and

b. allowing said fluid carrier to transport said devices to said remote site, wherein at least one of said devices penetrates said leakage thereby sealing said leakage.

21. A method according to claim 20, further comprising:

c. curing said at least one sealant composition within said devices at said remote site, thereby forming at least one hardened increased-density device.

22. A method according to claim 21, further comprising:

d. removing excess plugging devices and sealant compositions from said pipe after said allowing step.

23. A method according to claim 20, wherein said sealing comprises a curing step which takes 0.2 to ten hours.

24. A method according to claim 23, wherein said curing step occurs within twenty minutes to 4 hours.

25. A leakage plugging device according to claim 1, wherein said carrier plug or plugs are adapted to conform at least in part to a shape of said leakage at said remote site.

26. A leakage plugging device according to claim 25, wherein said carrier plug or plugs are adapted to conform to said shape of said leakage at said remote site.

27. A leakage plugging device according to claim 25, wherein said carrier plug or plugs are adapted to form a wedge shape.

28. A method according to claim 20, wherein said allowing step further comprises condensing said at least one of said devices at said leakage.

29. A method according to claim 28, wherein said condensing step concentrates said at least one sealant composition at said remote site.

30. A leakage plugging device according to claim 3, wherein said second dimension is in a range of 0.1 mm to 60 mm.

31. A method according to claim 20, wherein said leakage is selected from the group consisting of a hole, a crack, a vein, a crater and combinations thereof.

32. A method according to claim 31, wherein said leakage leaks 10 to 30,000 L/hr.

33. A method according to claim 32, wherein said leakage leaks 50 to 5000 L/hr.

34. A method for sealing multiple leakages at remote sites in a pipeline, the method comprising:

a. introducing a fluid carrier comprising a plurality of leakage plugging devices according to claim 1, into the pipeline at said first site under pressure; and

b. allowing said fluid carrier to transport said devices to said remote sites, wherein at least one of said devices penetrates at least some of said leakages thereby sealing at least some of said leakages.

35. A method according to claim 34, wherein said allowing step comprises sealing all of said leakages.

36. A method according to claim 34, further comprising:

c. curing said at least one sealant composition within said devices at said remote sites, thereby forming a plurality of hardened increased-density devices.

37. A method according to claim 36, further comprising repeating steps a and step b.

38. A method according to claim 37, further comprising repeating step c after said steps a and step b.

39. A method according to claim 20, further comprising

d. flushing said fluid carrier from said pipe.

40. A method according to claim 39, wherein said flushing step comprises creating a high speed flow of a fluid normally carried in said pipe to flush out said fluid carrier and said plurality of leakage plugging devices from said pipe.

41. A method according to claim 40, wherein said flushing step leaves said pipe sealed with said cured devices.

42. A leakage plugging device according to claim 1, wherein said porous carrier plug comprises said pores in a plurality of at least partially fluidly interconnected elements.

43. A leakage plugging device according to claim 42, wherein said plurality of at least partially fluidly interconnected elements is maze-like.

44. A leakage plugging device according to claim 3, wherein said third dimension is in a range of 0.1 mm to 30 mm.

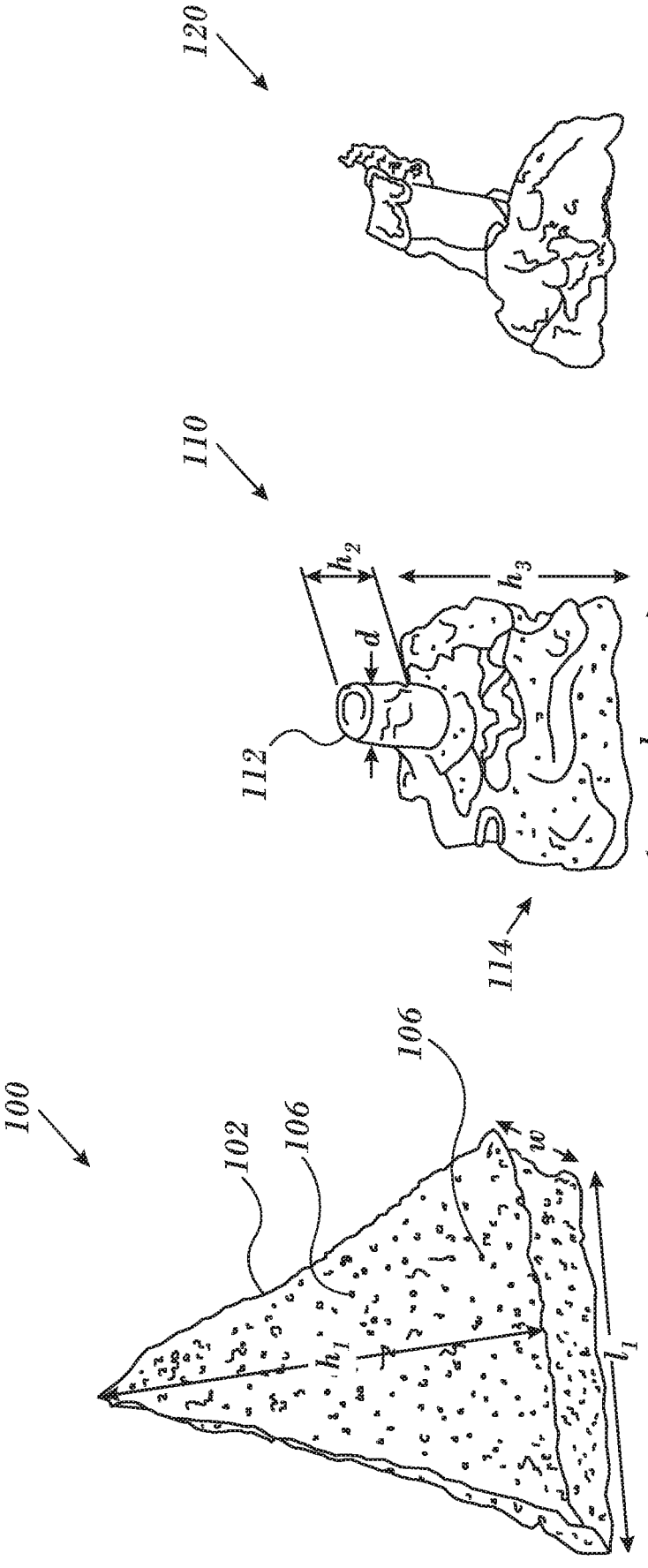

Fig. 1A

Fig. 1B

Fig. 1C

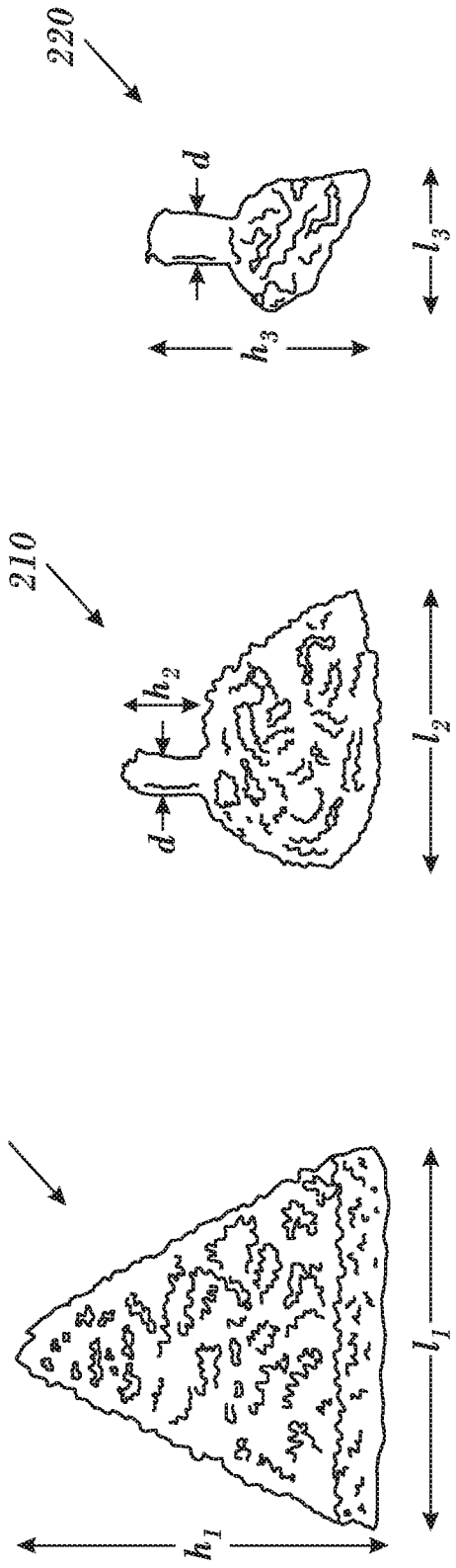

Fig. 2

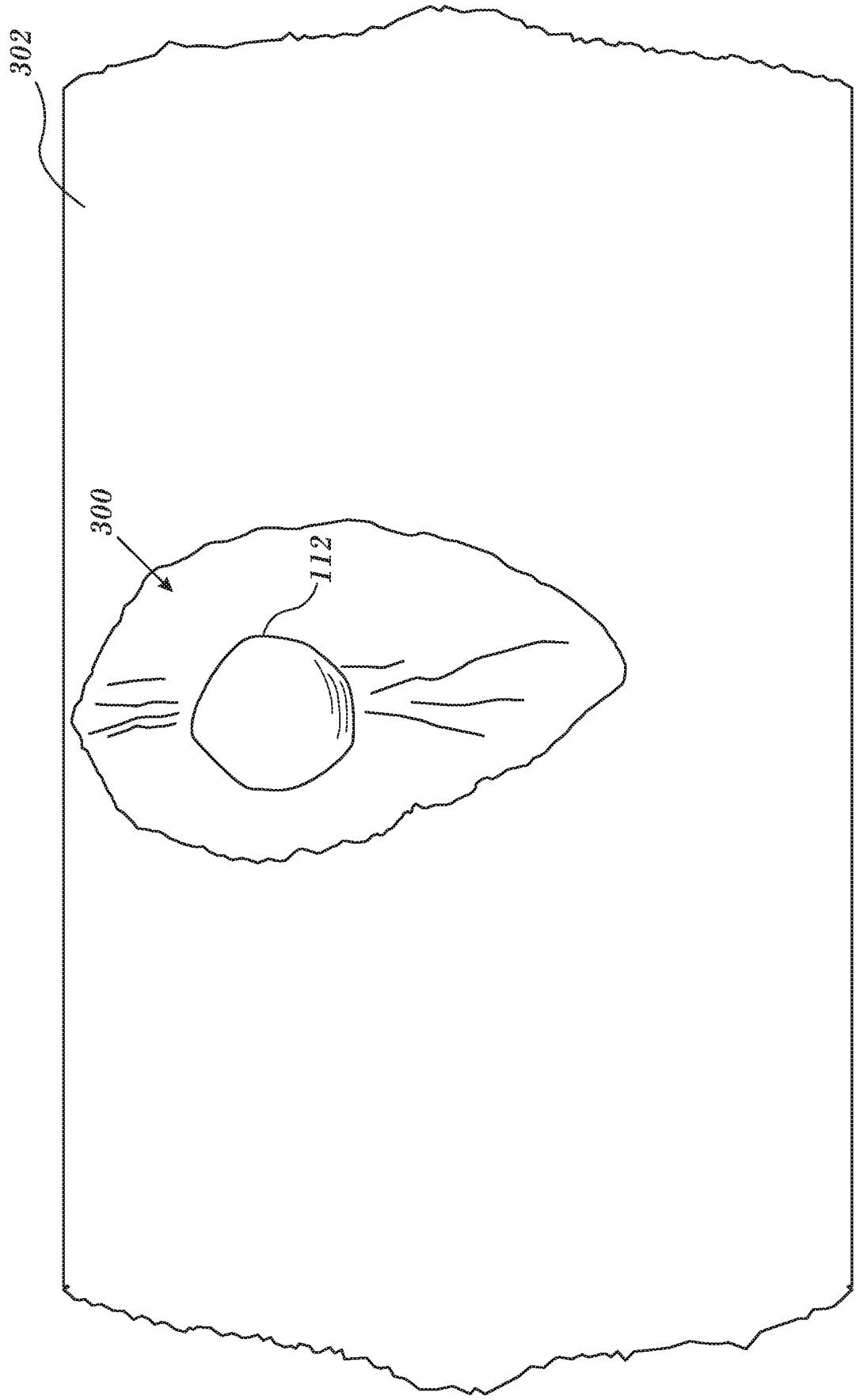

Fig. 3

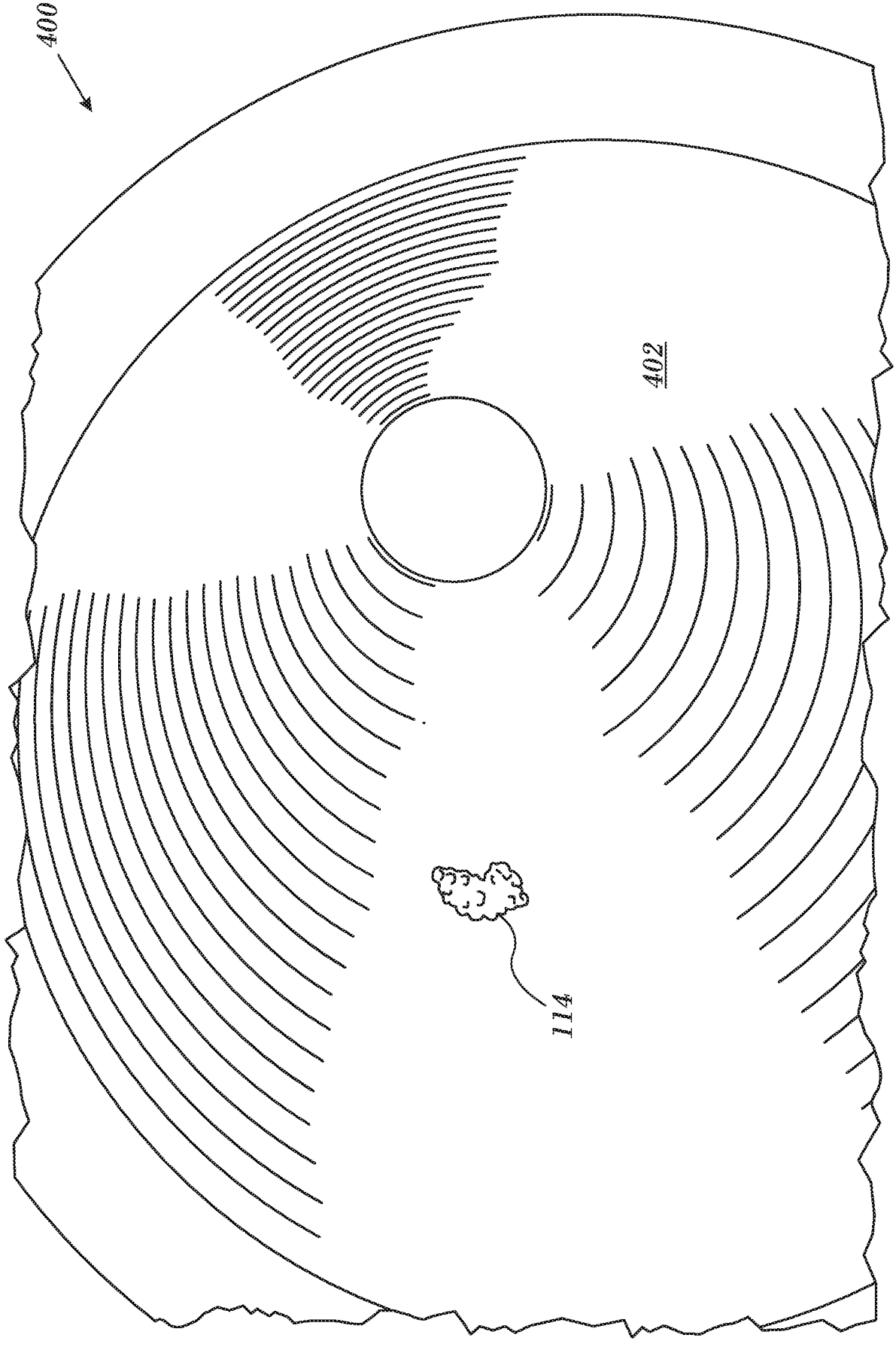

Fig. 4

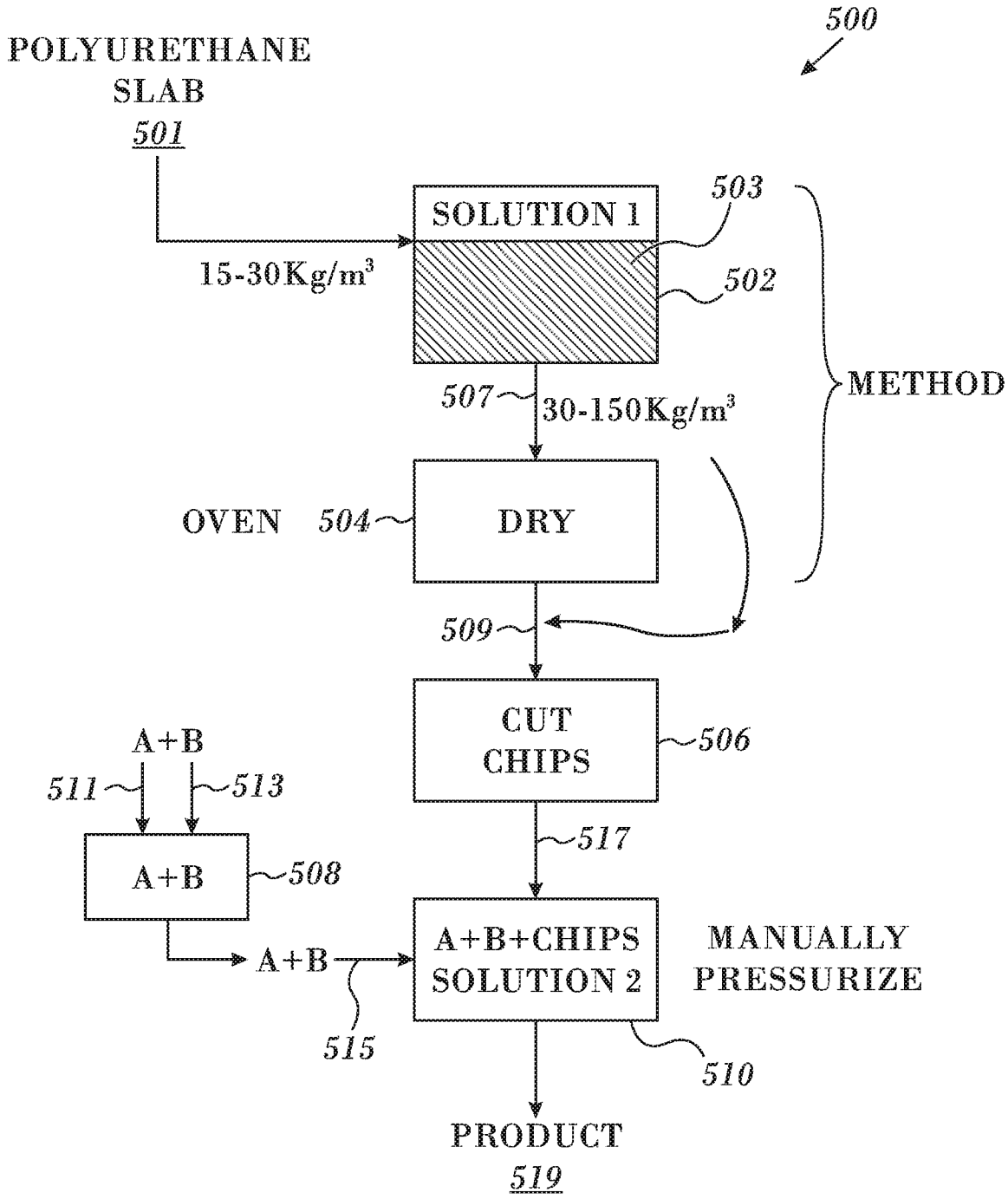
500
POLYURETHANE SLAB
501
SOLUTION 1
503
502
15-30Kg/m3
METHOD
507
30-150Kg/m3
OVEN
504
DRY
509
CUT CHIPS
506
A+B
511
513
A+B
508
517
A+B
A+B+CHIPS SOLUTION 2
MANUALLY PRESSURIZE
515
510
PRODUCT
519

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2015/000053

A. CLASSIFICATION OF SUBJECT MATTER

IPC (2016.01) F16L 55/128, F16L 55/18, F16L 55/38, C09K 3/12, F16L 55/164

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC (2016.01) F16L 55/128, F16L 55/18, F16L 55/38, C09K 3/12, F16L 55/164

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Databases consulted: Google Patents, PatBase
Search terms used: leak, seepage, fracture, hole, crack, plug, slug, pig, pill, gel, polyurethane, cure, condense, repair, seal, oil, pipe, pore, porous, sponge

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012067447 A1 (RYAN NICHOLAS JOHN, ; BRINKER TECHNOLOGY LTD) 22 Mar 2012 (2012/03/22) Paragraphs: 0004, 0014-0018, 0028-0030, 0040, 0046, 0047, 0049, 0060-0061, 0080-0081, 0090, 0102-0104, 0108, 0110, 0113, 0121.	1,5-21,23-29,31-38, 42,43
Y		2-4,22,30,39-41,44
Y	US 2005284530 A1 (ABERDEEN UNIVERSITY, ; BRINKER TECHNOLOGY LIMITED) 29 Dec 2005 (2005/12/29) Paragraphs: 0018-0027, 0039, 0060.	2-4,22,30,39-41,44
A		1,5-21,23-29,31-38, 42,43
A	EP 0473103 A1 (MITSUI PETROCHEMICAL INDUSTRIES, LTD) 04 Mar 1992 (1992/03/04) Column 3 lines 6-35, column 4 line 50, column 5 lines 5-7	1-44

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 Apr 2016	20 Apr 2016

Name and mailing address of the ISA:	Authorized officer
Israel Patent Office Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel Facsimile No. 972-2-5651616	Aamidor Josh Telephone No. 972-2-5651722

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2015/000053

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2274699 A (AMEC UTILITIES LTD) 03 Aug 1994 (1994/08/03) Page 3 lines 16-23	1-44
A	US 4582091 A (THE BRITISH PETROLEUM COMPANY P.L.C) 15 Apr 1986 (1986/04/15) Column 1 line 60 - column 2 line 68	1-44
A	US 2014311605 A1 (CURAPIPE SYSTEM LTD) 23 Oct 2014 (2014/10/23) Paragraph 0012 [disclosed by the applicant].	1-44
A	US 2013118401 A1 (HORN MICHAEL J, ; PLASTOCOR, INC) 16 May 2013 (2013/05/16)	1-44
A	US 2014100304 A1 (CADIX ARNAUD, ; RACHED RABIH, ; ARDAUD PIERRE, ; RHODIA OPERATIONS) 10 Apr 2014 (2014/04/10)	1-44

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2015/000053

Patent document cited search report	Publication date	Patent family member(s)	Publication Date
US 2012067447 A1	22 Mar 2012	US 2012067447 A1	22 Mar 2012
		US 8950438 B2	10 Feb 2015
		CA 2758336 A1	21 Oct 2010
		DK 2419670 T3	16 Nov 2015
		EP 2419670 A1	22 Feb 2012
		EP 2419670 B1	19 Aug 2015
		EP 2419670 B8	24 Feb 2016
		GB 0906541 D0	20 May 2009
		GB 201006373 D0	02 Jun 2010
		GB 2469580 A	20 Oct 2010
		GB 2469580 B	12 Oct 2011
		WO 2010119296 A1	21 Oct 2010
US 2005284530 A1	29 Dec 2005	US 2005284530 A1	29 Dec 2005
		US 7810523 B2	12 Oct 2010
		AU 2003224318 A1	17 Nov 2003
		AU 2003224318 A8	17 Nov 2003
		BR 0309789 A	22 Feb 2005
		CA 2485180 A1	13 Nov 2003
		CA 2485180 C	30 Nov 2010
		EA 006935 B1	30 Jun 2006
		EP 1499827 A2	26 Jan 2005
		GB 0209771 D0	05 Jun 2002
		NO 20045231 A	29 Nov 2004
		WO 03093713 A2	13 Nov 2003
		WO 03093713 A3	08 Jan 2004
EP 0473103 A1	04 Mar 1992	EP 0473103 A1	04 Mar 1992
		EP 0473103 B1	03 May 1995
		AT 122135 T	15 May 1995
		CA 2050029 A1	01 Mar 1992

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2015/000053

Patent document cited search report	Publication date	Patent family member(s)	Publication Date
		CN 1060419 A	22 Apr 1992
		CN 1026865 C	07 Dec 1994
		DE 69109403 D1	08 Jun 1995
		DE 69109403 T2	12 Oct 1995
		HK 56496 A	03 Apr 1996
		JP H05169020 A	09 Jul 1993
		JP 2975461 B2	10 Nov 1999
		KR 0172604 B1	18 Feb 1999
		US 5202157 A	13 Apr 1993
GB 2274699 A	03 Aug 1994	GB 9401191 D0	16 Mar 1994
		GB 2274699 A	03 Aug 1994
		GB 2274699 B	10 Jul 1996
		GB 9301767 D0	17 Mar 1993
US 4582091 A	15 Apr 1986	US 4582091 A	15 Apr 1986
		CA 1200968 A	25 Feb 1986
		GB 8302605 D0	02 Mar 1983
		GB 2114258 A	17 Aug 1983
		GB 2114258 B	17 Apr 1985
		JP S58134296 A	10 Aug 1983
		NO 830338 A	03 Aug 1983
		NO 160812 B	20 Feb 1989
US 2014311605 A1	23 Oct 2014	US 2014311605 A1	23 Oct 2014
		CA 2673798 A1	10 Jul 2008
		EP 2104796 A1	30 Sep 2009
		EP 2104796 B1	04 Dec 2013
		ES 2448582 T3	14 Mar 2014
		IL 180474 A	31 Dec 2013
		US 2010116372 A1	13 May 2010

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2015/000053

Patent document cited search report	Publication date	Patent family member(s)	Publication Date
		US 9045648 B2	02 Jun 2015
		WO 2008081441 A1	10 Jul 2008
US 2013118401 A1	16 May 2013	US 2013118401 A1	16 May 2013
		US 8833293 B2	16 Sep 2014
		AT 419926 T	15 Jan 2009
		AT 422398 T	15 Feb 2009
		BR PI0512166 A	12 Feb 2008
		CA 2569515 A1	26 Jan 2006
		CA 2569515 C	20 Sep 2011
		CN 101378843 A	04 Mar 2009
		CN 101378843 B	27 Mar 2013
		DE 602005012274 D1	26 Feb 2009
		DE 602005012700 D1	26 Mar 2009
		EP 1773509 A2	18 Apr 2007
		EP 1773509 A4	29 Aug 2007
		EP 1773509 B1	07 Jan 2009
		EP 1773510 A2	18 Apr 2007
		EP 1773510 A4	24 Oct 2007
		EP 1773510 B1	11 Feb 2009
		ES 2320569 T3	25 May 2009
		ES 2321854 T3	12 Jun 2009
		RU 2006143568 A	27 Jul 2008
		RU 2343999 C2	20 Jan 2009
		US 2005287294 A1	29 Dec 2005
		US 7270847 B2	18 Sep 2007
		US 2006068092 A1	30 Mar 2006
		US 7717056 B2	18 May 2010
		US 2010192845 A1	05 Aug 2010
		US 8359996 B2	29 Jan 2013
		WO 2006009815 A2	26 Jan 2006

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2015/000053

Patent document cited search report	Publication date	Patent family member(s)	Publication Date
		WO 2006009815 A3	01 Mar 2007
		WO 2006009926 A2	26 Jan 2006
		WO 2006009926 A3	28 Sep 2006
US 2014100304 A1	10 Apr 2014	US 2014100304 A1	10 Apr 2014
		AU 2012228447 A1	26 Sep 2013
		AU 2012228447 B2	21 May 2015
		CA 2829508 A1	20 Sep 2012
		CN 103502385 A	08 Jan 2014
		EP 2497809 A1	12 Sep 2012
		EP 2683787 A1	15 Jan 2014
		MX 2013010442 A	03 Oct 2013
		RU 2013145514 A	20 Apr 2015
		RU 2579098 C2	27 Mar 2016
		WO 2012123319 A1	20 Sep 2012