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(54) **Title:** MULTI-LAYER ANTI-CORROSIVE COATING

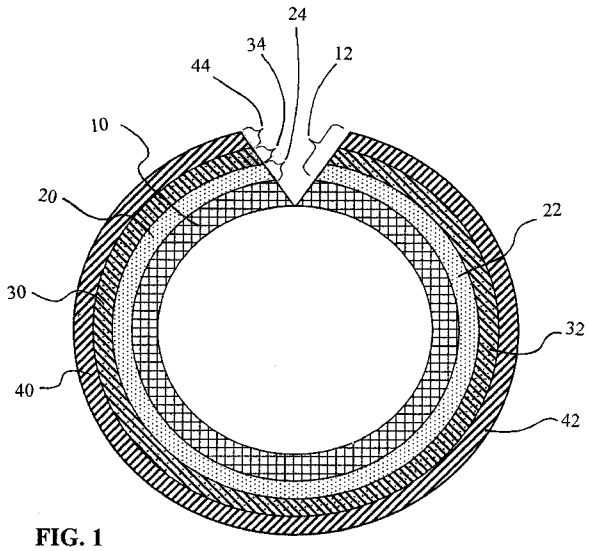


FIG. 1

(57) **Abstract:** A multilayer coating has a first coating layer deposited on a substrate; a second coating layer deposited on the first coating layer; and a third coating layer deposited on the second coating layer. The first coating layer is substantially a metal, the second coating layer is a mixture of the metal and a polymeric material, and the third coating layer is substantially the polymeric material. The substrate is at least one of iron, iron pipe, steel, copper, nickel, concrete, wood, wood products, fiberglass, ceramic, plastic, and any other metal or non-metal material that can be used as a substrate, and the metal is at least one of zinc, aluminum, magnesium, indium, gallium, tellurium, and alloys thereof, whereby the metal used is anodic to the substrate. The polymeric material is at least one of polyethylene, polypropylene, nylon, polytetrafluorethylene (PTFE), ethylene methacrylate acid copolymer (EMAA), a thermoplastic material and a thermoset material.

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MULTI-LAYER ANTI-CORROSIVE COATING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon U.S. Provisional Application No. 60/992,143 filed on December 4, 2007, the disclosure of which is hereby incorporated-by-reference thereto in its entirety and the priority of which is claimed under 35 U.S.C. §119(e).

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

REFERENCE TO A COMPACT DISK APPENDIX

[0003] Not applicable.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0004] The invention relates generally to apparatus and methods relating to the application of coatings, and more particularly to a multilayer anti-corrosive coating for a metallic substrate such as an iron pipe.

2. Description of Related Art

[0005] Iron-based pipes have been used in transporting water from different sources for many years. Over time, these pipes exhibit corrosion and, depending on their use, may require frequent replacement. Replacing iron-based pipes is costly for the material, the labor, and the down-time to the consumer.

[0006] Cathodic protection is one technique used to control corrosion of a metal surface. This is done by making the surface to be protected the cathode of an electrochemical, or galvanic cell. This is most commonly done using alloys of zinc, magnesium and aluminum. These galvanic anodes are designed and selected to have a greater negative electrochemical potential than the metal they are protecting, which is typically steel. As the galvanic anode electrode corrodes, the anode material is consumed until it must be replaced.

[0007] Galvanizing, or more specifically hot-dip galvanizing is the process whereby steel is coated with a layer of metallic zinc. Galvanized coatings are extremely durable in most environments because of their barrier properties and cathodic protection. If, or when, the zinc coating is breached or scratched, exposing the steel surface, the zinc coating acts as an anode to form a galvanic cell, thereby protecting the steel from corrosion. This is also known as localized cathodic protection.

[0008] Coatings to iron-based pipes have also been developed utilizing epoxy compositions that result in good corrosion resistance. For example, thermoset polymers are widely used to protect steel pipes, concrete reinforcing bars (rebar), pipe connections, valves and the like from corrosion. The most commonly used thermoset polymer for this type of application is fusion bonded epoxy. Fusion bonded epoxy is typically applied to a steel pipe that is preheated to the application temperature where the fusion bonded epoxy transforms to a liquid. The liquid fusion bonded epoxy flows and solidifies on the pipe, pipe joint, and the like. Coating thickness of the fusion bonded epoxy is around 250 to 500 microns. However, the thickness of these coatings vary, are difficult to apply especially at the joints, and different coatings are required depending on the environmental exposure of the iron-based pipes.

[0009] With fusion bonded epoxy, any breach in the coating will result in corrosion of the coated material.

BRIEF SUMMARY OF THE INVENTION

[0010] A multilayer coating that is corrosion resistant has a first coating layer on a substrate; a second coating layer deposited on the first coating layer; and a third coating layer deposited on the second coating layer; wherein the first coating layer is substantially a metal, the second coating layer is a mixture of the metal and a polymeric material, and the third coating layer is substantially the polymeric material.

[0011] The substrate can be any of iron, iron pipe, steel, copper, nickel, concrete, wood, wood products, fiberglass, ceramic, plastic, and any other metal or non-metal material that can be used as a substrate. The metal used for the first and second coating layers is at least one of zinc, aluminum, alloy of zinc-aluminum, magnesium, alloy of zinc-magnesium, alloy of aluminum-magnesium, indium, alloy of zinc-indium, alloy of aluminum-indium, alloy of magnesium-indium, gallium, alloy of zinc-gallium, alloy of aluminum-gallium, alloy of magnesium-gallium, alloy if indium-gallium, tellurium, alloy of zinc-tellurian, alloy of

aluminum-tellurium, alloy of magnesium-tellurium, alloy of indium-tellurium, and alloy of gallium-tellurium.

[0012] In one embodiment, the substrate is iron pipe and the first coating layer comprises a metal that is anodic to the substrate, preferably 99% zinc or aluminum-zinc having a ratio of about 85% aluminum to about 15% zinc.

[0013] In one embodiment, the polymeric material comprises at least one of polyethylene, polypropylene, polyester, nylon, polytetrafluorethylene (PTFE), ethylene methacrylate acid copolymer (EMAA), a thermoplastic material and a thermoset material. In one embodiment the polymeric material is polyethylene or polypropylene.

[0014] The thickness of the multilayer coating varies with the thickness of the various layers. The thickness of the first coating layer is approximately 25 microns to approximately 200 microns; the thickness of the second coating layer is approximately 5 microns to approximately 200 microns; and the thickness of the third coating layer is approximately 5 microns to approximately 200 microns. In one embodiment, the thickness of the first coating layer is approximately 70-80 microns, the thickness of the second coating layer is approximately 20-30 microns, and the thickness of the third coating layer is approximately 95-105 microns.

[0015] In another embodiment, a method is provided for applying a multilayer coating and has the steps of first applying a first coating layer on a substrate; a second step of applying a second coating layer on the first coating layer; and a third step of applying a third coating layer on the second coating layer; wherein the first coating layer is substantially a metal, the second coating layer is a mixture of the metal and a polymeric material, and the third coating layer is substantially the polymeric material.

[0016] In one embodiment of the multilayer coating, the first coating layer, the second coating layer and the third coating layer are each applied sequentially using thermal spray. Additionally, the second coating layer may be applied as a mixture, or applied as separate materials that mix during the application processes. More specifically, the metal is applied utilizing a first application means, and the polymer material is applied utilizing a second application means, and the materials mix to form the second coating layer at the application site.

[0017] The method of providing the multilayer coating may also include the step of heating the substrate to approximately the fusing temperature of the metal when applying the first coating layer.

[0018] The method of providing the multilayer coating may also includes the step of heating the substrate to approximately the fusing temperature of the polymeric material when applying the third coating layer.

[0019] Other exemplary embodiments and advantages of the present invention may be ascertained by reviewing the present disclosure and the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The present invention is further described in the detailed description which follows, in reference to the noted drawing by way of a non-limiting example of an exemplary embodiment of the present invention, and wherein:

[0021] FIG. 1 is a cross section of a pipe with a multilayer coating.

DETAILED DESCRIPTION OF THE INVENTION

[0022] The particulars shown herein are by way of example and for purposes of illustrative discussion of the 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 present invention. In this regard, no attempt is made to show structural details of the present invention in more detail than is necessary for the fundamental understanding of the present invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the present invention may be embodied in practice.

[0023] Figure 1 shows a cross-sectional view of a substrate 10 having a multilayer corrosion resistant coating 12. The substrate 10 may be any of iron, iron pipe, steel, copper, nickel, concrete, wood, wood products, fiberglass, ceramic, plastic, and any other metal or non-metal material that can be used as a substrate. The corrosion resistant coating 12 is made up of three distinct coating layers 20, 30, 40.

[0024] The first coating layer 20 is substantially a metal layer that is applied using cold spray or thermal spray techniques. It is understood that thermal spray includes the use of various techniques, including, but not limited to, combustion flame, combustion wire, high velocity oxygen fuel (HVOF), high velocity liquid fuel (HVLF), high velocity air-fuel (HVAF), and plasma.

[0025] The metal 22 is typically at least one of zinc, aluminum, alloy of zinc-aluminum, magnesium, alloy of zinc-magnesium, alloy of aluminum-magnesium, indium, alloy of zinc-indium, alloy of aluminum-indium, alloy of magnesium-indium, gallium, alloy of zinc-gallium, alloy of aluminum-gallium, alloy of magnesium-gallium, alloy if indium-gallium, tellurium, alloy of zinc-tellurian, alloy of aluminum-tellurium, alloy of magnesium-tellurium, alloy of indium-tellurium, and alloy of gallium-tellurium. Other metals may also be considered. In one embodiment, the substrate 10 is iron pipe and the first coating layer 20 is a metal 22 that is anodic to the substrate 10. When this is the configuration, the metal 22 is preferably one of 99% zinc and aluminum-zinc having a ratio of about 85% aluminum to about 15% zinc, and the thickness 24 of the first coating layer is approximately 25 microns to approximately 200 microns. In another embodiment the thickness 24 of the first coating layer is approximately 70-80 microns.

[0026] In one embodiment the first coating layer 20 is applied utilizing thermal spray techniques, where the metal 22 is fed as a powder or a wire. The metal 22 is preferably applied at the fusing temperature of the anode, that is, for example, if the substrate 10 is an iron pipe and the metal 22 is zinc, the fusing temperature is approximately 850°F.

[0027] The second coating layer 30 is a mixture of the metal 22 and a polymeric material 32. The polymeric material 32 may be applied using thermal spray or cold spray techniques. The polymeric material 32 is at least one of polyethylene, polypropylene, polyester, nylon, polytetrafluorethylene (PTFE), ethylene methacrylate acid copolymer (EMAA), a thermoplastic material and a thermoset material. In one embodiment the polymeric material 32 is at least one of polyethylene and polypropylene. The thickness 34 of the second coating layer 30 is approximately 5 microns to approximately 200 microns. In another embodiment, the thickness 34 of the second coating layer 30 is approximately 20-30 microns.

[0028] The second coating layer 30 is preferably applied utilizing thermal spray techniques, where the polymeric material 32 is powder fed through a hopper. The polymeric material 32

is preferably applied at the fusing temperature of the polymeric material 32, that is, for example, at a temperature of approximately 450°F.

[0029] In one embodiment, the metal 22 and the polymeric material 32 are applied substantially simultaneously from two or more applicator guns, the mixing occurring at the deposition site.

[0030] The third coating layer 40 is made up essentially of the polymeric material 32. The polymeric material 32 may be applied using thermal spray or cold spray techniques. The polymeric material 32 is at least one of polyethylene, polypropylene, polyester, nylon, polytetrafluorethylene (PTFE), ethylene methacrylate acid copolymer (EMAA), a thermoplastic material and a thermoset material. In the preferred embodiment the polymeric material 32 is at least one of polyethylene and polypropylene. The thickness 44 of the third coating layer 40 is approximately 5 microns to approximately 200 microns. In the preferred embodiment, the third thickness 44 of the third coating layer is approximately 95-105 microns.

[0031] The third coating layer 40 is preferably applied utilizing thermal spray techniques, where the polymeric material 32 is powder fed through a hopper. The polymeric material 32 is preferably applied at the fusing temperature of the polymeric material 32, that is, for example, at a temperature of approximately 450°F. This is similar to the application of the polymeric material as part of the second layer.

[0032] The multi-layer coating 12 is applied to the substrate 10 by first applying the first coating layer 20 onto the substrate 10. This is followed by applying the second coating layer 30 onto the first coating layer. The second coating layer 30 is applied by spraying a mixture of the metal 22 used in the first layer 20 with a polymeric material 32.

[0033] It should be noted that the second coating layer 30 can be applied to the first coating layer 20 utilizing a single spray gun or a multiple spray gun method. When a two spray gun method is used, the metal 22 is sprayed from a first spray gun towards the outer surface of the first coating layer 20 while the polymeric material 32 is sprayed from a second spray gun towards the outer surface of the first coating layer 20. Mixing of the coating materials 22, 32 takes place, for example, prior to the coating material reaching the outer surface of the first coating layer 20 by firing the spray guns substantially simultaneously, or upon impact at the outer surface of the first coating layer 20.

[0034] In one embodiment, the polymeric coating material 32 is applied first to the outer layer of the first coating layer 20, and the metal coating material 22 embeds into the polymeric material 32 forming the second coating layer 30.

[0035] In another embodiment, the multiple spray guns release the coating materials 22, 32 substantially simultaneously to form the second coating layer 30.

[0036] It is noted that the foregoing examples have been provided merely for the purpose of explanation and are in no way to be construed as limiting of the present invention. While the present invention has been described with reference to an exemplary embodiment, it is understood that the words which have been used herein are words of description and illustration, rather than words of limitation. Changes may be made, within the purview of the appended claims, as presently stated and as amended, without departing from the scope and spirit of the present invention in its aspects. Although the present invention has been described herein with reference to particular means, materials and embodiments, the present invention is not intended to be limited to the particulars disclosed herein; rather, the present invention extends to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims.

CLAIMS

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A multilayer coating comprising:

a first coating layer on a substrate;

a second coating layer deposited on the first coating layer; and

a third coating layer deposited on the second coating layer;

wherein the first coating layer is substantially a metal, the second coating layer is a mixture of the metal and a polymeric material, and the third coating layer is substantially the polymeric material.

2. The multilayer coating of claim 1, wherein the substrate comprises at least one of iron, iron pipe, alloys of iron, steel, copper, alloys of copper, nickel, alloys of nickel, concrete, wood, wood products, fiberglass, ceramic and plastic.

3. The multilayer coating of claim 1, wherein the metal comprises at least one of zinc, aluminum, alloy of zinc-aluminum, magnesium, alloy of zinc-magnesium, alloy of aluminum-magnesium, indium, alloy of zinc-indium, alloy of aluminum-indium, alloy of magnesium-indium, gallium, alloy of zinc-gallium, alloy of aluminum-gallium, alloy of magnesium-gallium, alloy if indium-gallium, tellurium, alloy of zinc-tellurian, alloy of aluminum-tellurium, alloy of magnesium-tellurium, alloy of indium-tellurium, and alloy of gallium-tellurium.

4. The multilayer coating of claim 3, wherein the zinc is at least 99% zinc.

5. The multilayer coating of claim 3, wherein the aluminum-zinc ratio is about 85% aluminum to about 15% zinc.

6. The multilayer coating of claim 1, wherein the substrate is a metallic material, and wherein the metal is anodic to the substrate.

7. The multilayer coating of claim 1, wherein the polymeric material comprises at least one of polyethylene, polypropylene, nylon, polytetrafluorethylene (PTFE), ethylene methacrylate acid copolymer (EMAA), a thermoplastic material and a thermoset material.

8. The multilayer coating of claim 7, wherein the thermoset material is a fusion bonded epoxy.

9. The multilayer material of claim 1, wherein a first thickness of the first coating layer is approximately 25 microns to approximately 200 microns.

10. The multilayer material of claim 1, wherein a first thickness of the first coating layer is approximately 50 microns to approximately 100 microns.

11. The multilayer material of claim 1, wherein a second thickness of the second coating layer is approximately 5 microns to approximately 200 microns.

12. The multilayer material of claim 1, wherein a second thickness of the second coating layer is approximately 5 microns to approximately 100 microns.

13. The multilayer material of claim 1, wherein a third thickness of the third coating layer is approximately 5 microns to approximately 200 microns.

14. The multilayer material of claim 1, wherein a third thickness of the third coating layer is approximately 50 microns to approximately 150 microns.

15. The multilayer coating of claim 1, wherein the multilayer coating forms a corrosion resistant coating.

16. A multilayer coating comprising:

a first coating layer deposited on a substrate;

a second coating layer deposited on the first coating layer; and

a third coating layer deposited on the second coating layer;

wherein the first coating layer is substantially a metal, the second coating layer is a mixture of the metal and a polymeric material, and the third coating layer is substantially the polymeric material;

wherein the substrate comprises at least one of iron, iron pipe, alloys of iron, steel, copper, alloys of copper, nickel, alloys of nickel, concrete, wood, wood products, fiberglass, ceramic and plastic;

wherein the metal comprises at least one of zinc, aluminum, alloy of zinc-aluminum, magnesium, alloy of zinc-magnesium, alloy of aluminum-magnesium, indium, alloy of zinc-indium, alloy of aluminum-indium, alloy of magnesium-indium, gallium, alloy of zinc-gallium, alloy of aluminum-gallium, alloy of magnesium-gallium, alloy if indium-gallium, tellurium, alloy of zinc-

tellurian, alloy of aluminum-tellurium, alloy of magnesium-tellurium, alloy of indium-tellurium, and alloy of gallium-tellurium;

wherein when the substrate comprises a metallic material, and wherein the metal is anodic to the substrate;

wherein the polymeric material comprises at least one of polyethylene, polypropylene, nylon, polytetrafluorethylene (PTFE), ethylene methacrylate acid copolymer (EMAA), a thermoplastic material and a thermoset material;

wherein a first thickness of the first coating layer is approximately 25 microns to approximately 200 microns;

wherein a second thickness of the second coating layer is approximately 5 microns to approximately 200 microns; and

wherein a third thickness of the third coating layer is approximately 5 microns to approximately 200 microns.

17. A method of providing a multilayer coating comprising:

applying a first coating layer on a substrate;

applying a second coating layer on the first coating layer; and

applying a third coating layer on the second coating layer;

wherein the first coating layer is substantially a metal, the second coating layer is a mixture of the metal and a polymeric material, and the third coating layer is substantially the polymeric material.

18. The method of providing the multilayer coating of claim 17, wherein the first coating layer, the second coating layer and the third coating layer are applied sequentially using at least one of cold spray, thermal spray and plasma spray.

19. The method of providing the multilayer coating of claim 17, further comprising the step of heating the substrate to approximately the fusion temperature of the metal when applying the first coating layer.

20. The method of providing the multilayer coating of claim 17, further comprising the step of heating the substrate to approximately the fusion temperature of the polymeric material when applying the third coating layer.

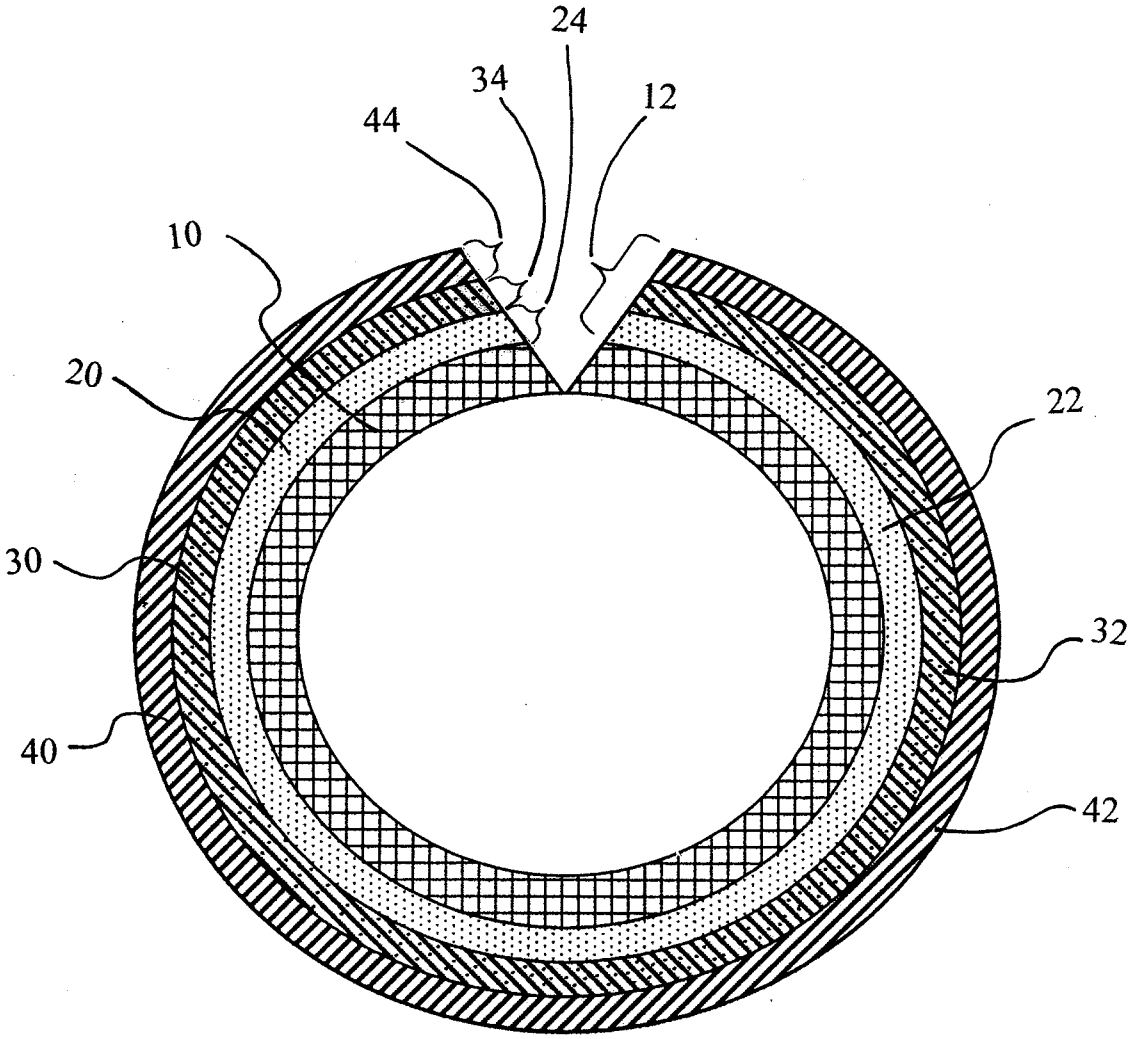


FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 08/85396

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B05D 5/12; B32B 3/00, 15/08 (2008.04)
USPC - 428/419; 252/500
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(8) - B05D 5/12; B32B 3/00, 15/08 (2008.04)
USPC - 428/419; 252/500

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IPC(8) - B05D 5/12; B32B 3/00, 15/08 (2008.04) (text search only - see search history printout)
USPC - 428/419; 252/500 (text search only - see search history printout)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
(USPT, PGPB, EPAB, JPAB); Google Patent, Google Scholar, Dialog Web
coating, multilayer, iron, concrete, steel, aluminum, zinc, metal, epoxy, thermoset, corrosion, anodic, polyethylene, polyropylene, nylon, ptfe, polytetrafluoroethylene, ethylene methacrylate, galvanize, thermoplastic, third layer, three layer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/0048533 A1 (Spriestersbach et al.) 01 Mar 2007 (01.03.2007) (Abstract, para [0001], [0006], [0009], [0010], [0011], [0022]).	1-4, 6-20
Y		5
Y	US 3,952,120 A (Horton et al.) 20 Apr 1976 (20.04.1976) (Abstract, Col. 4, lines 37-60).	5

☐ Further documents are listed in the continuation of Box C. ☐

* 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
13 Jan 2009 (13.01.2009)	04 FEB 2009
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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