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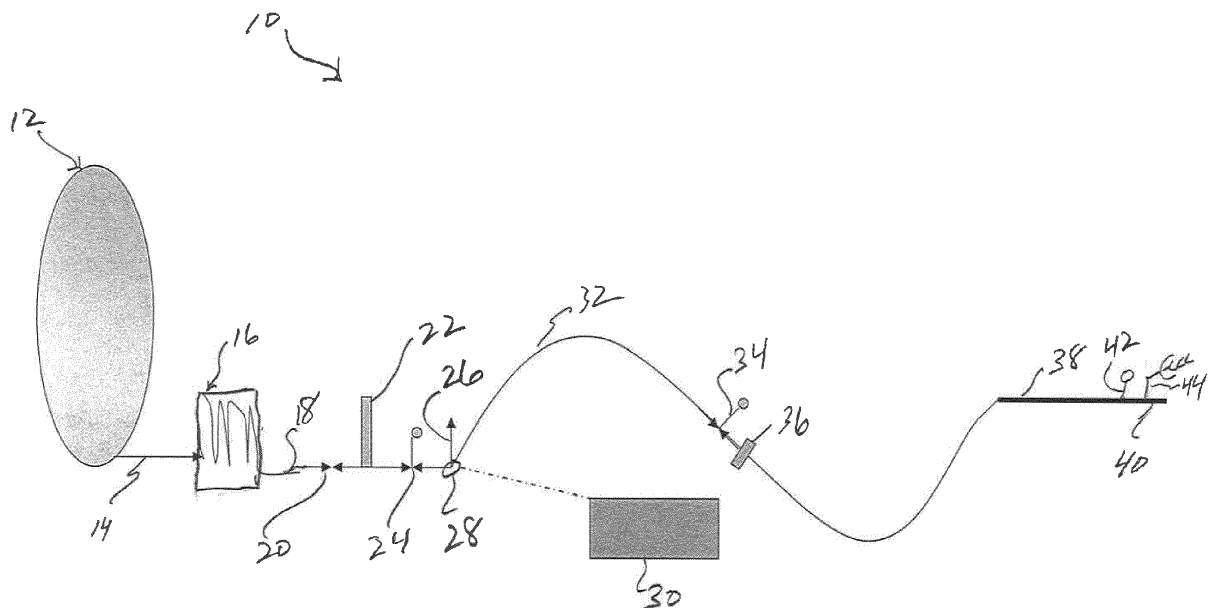
(54) Apparatus and method for suppressing and extinguishing a fire

(57) In order to effectively deliver inert gas to the source of a fire underground, an apparatus (10) for suppressing and extinguishing the fire includes

- a source (12) of cryogen;
- a flexible hose (32) having
 - a first end connected to the source (12) of cryogen, and
 - a second end for being guided to the combustible material; and

- at least one discharge member (38) having
 - a proximate end in fluid communication with the second end of the flexible hose (32), and
 - a distal end constructed to penetrate the combustible material for introducing the cryogen to said combustible material.

A method of suppressing and extinguishing a fire underground is also provided.



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Description

Technical field of the present invention

[0001] The present invention relates to systems and methods using inert gases to extinguish fires, especially fires within combustible material masses.

[0002] More particularly, the present invention relates to an apparatus for suppressing and extinguishing fires underground as well as to a method of suppressing and extinguishing a fire underground.

Technological background of the present invention

[0003] Unwanted, self-igniting fires may occur where large quantities of combustible carbon based materials are stored. Examples of such situations include landfill sites and the storage and transportation of biofuels (organically derived materials such as wood pellets, straw, etc.). Smoldering fires may occur when chemical and biological reactions generate heat and combustible volatile materials or gases.

[0004] When such reactions occur within large masses or bodies of material, the heat generated is often unable to dissipate as quickly as it is generated, due to the poor thermal conductivity/insulating effect of the mass of surrounding material. This results in the rate of all chemical and biological reactions increasing, with increased temperature within the material mass, thereby resulting in a self-perpetuating and increasing cycle of elevated temperatures.

[0005] It is widely accepted that for a fire to occur there must be three components present - fuel, oxidant and energy - commonly known as the combustion or fire triangle. In the case of land fills, fuel stores, etc., there is fuel, which is volatilized through heat and/or biological chemical reactions - such volatile products generally have lower auto-ignition temperatures than the original source material.

[0006] The material also generally contains a source of oxygen, via the air occupying void spaces between the solid materials. And finally, the source of energy is supplied due to the effect of heat generated by the heat of decomposition and biological/chemical activity within the material mass.

[0007] Generally, a fire requires a spark of sufficient energy to cause the fuel and oxygen to react and start the burning reaction. However, this is not always the case. In circumstances where a material is sufficiently hot, and in the presence of an oxidant such as oxygen, materials will spontaneously ignite. This is known as the material's auto-ignition temperature.

[0008] Clearly, there are many potentially detrimental effects posed by the propagation of fires within landfill and biofuel masses, including risk to health, property and the environment.

[0009] The process of smothering and preventing fires by using an inert gas is widely known and used as a

method of fire prevention and suppression. In the aforementioned scenarios, however, a key problem in the use of inerting as a method of fire control and suppression is actually being able to provide an inert gas to the site of the fire or ignition.

[0010] The scale of this problem is such that operators are often forced to use heavy digging and earth moving equipment (JCBs, etc.) to move hundreds of tonnes of material to expose the source of the fire and then extinguish it with water (which often creates additional environmental runoff consequences and concerns).

[0011] Landfill and biomass fires are relatively common. The use of biomass based fuels for energy generation is an increasing trend, driven by the target of reduced carbon footprint and the need to find less environmentally damaging electrical energy sources - hence, the increasing need for a method of rapidly extinguishing unwanted fires *in situ* in bulk combustible materials. The more quickly a fire is extinguished, the greater the reduction in cost, safety and environmental consequences.

[0012] The general benefit of extinguishing fires by means of inert gases (as opposed to water, foams and chemicals, for example) is the negligible secondary environmental impact of such an approach.

[0013] However, an important challenge in the use of inert gases for suppressing and extinguishing fires in bulk combustible materials is being able to effectively deliver the inert gas to the source of the fire.

Disclosure of the present invention: object, solution, advantages

[0014] Starting from the disadvantages and shortcomings as described above and taking the prior art as discussed into account, an object of the present invention is to overcome the problems that earlier apparatus and methods have experienced, in particular to provide for an apparatus as well as for a method by which the inert gas is effectively delivered to the source of the fire.

[0015] This object is accomplished by an apparatus comprising the features of claim 1 as well as by a method comprising the features of claim 12. Advantageous embodiments and expedient improvements of the present invention are disclosed in the respective dependent claims.

[0016] The present invention basically provides for an apparatus and method for suppressing and extinguishing, in particular smoldering, fires within combustible material masses.

[0017] More particularly, the present inventive embodiments enable use of inert gases to be delivered to and administered effectively and precisely for suppressing and extinguishing of fires *in situ* within large masses of material. The benefits of such embodiments include: rapidity to execute, reduced cost, reduced operational and environmental impact, and improved operator safety.

[0018] The inventive embodiments administer inert gases to extinguish fires in combustible materials that

are underground or buried. The present invention can be administered more quickly and conveniently to control a fire earlier and prevent additional losses and damage.

[0019] There are also safety benefits for operational personnel, i.e. such personnel can be positioned at a location remote from the fire source, as opposed to digging out the fire with bulldozers or drilling holes and inserting lances, etc. which creates hazards to operators.

[0020] Exposing the fire directly to the atmosphere increases oxygen availability and the potential for the spread of sparks or embers to other combustible material, thereby resulting in increased difficulty to suppress and extinguish the fire.

[0021] The ability to accurately introduce inert gas to the exclusion of oxygen is also important.

[0022] According to the present invention, there is provided an apparatus for suppressing and extinguishing a fire underground, which includes a source of cryogen; a flexible hose having a first end connected to the source of cryogen and a second end for being guided to combustible material of the fire; and at least one discharge member having a proximate end in fluid communication with the second end of the flexible hose, and a distal end constructed to penetrate the combustible material for introducing the cryogen to said combustible material.

[0023] According to an advantageous embodiment of the present invention, the cryogen of the apparatus may include a substance selected from the group consisting of liquid carbon dioxide, gaseous carbon dioxide, liquid nitrogen, and gaseous nitrogen.

[0024] According to an expedient embodiment of the present invention, the apparatus may further include a pipe having a first end and a second end, the first end in fluid communication with the cryogen source, and the second end in fluid communication with the flexible hose.

[0025] According to a favoured embodiment of the present invention, the apparatus may further include a vaporizer in fluid communication with the pipe; in particular, the source of cryogen may be connected by the pipe to an outlet of the vaporizer.

[0026] According to a preferred embodiment of the present invention, the apparatus may further include a regulator in fluid communication with the pipe; in particular, an outlet of the vaporizer may be connected to a pipe having the regulator interposed therein.

[0027] According to an advantageous embodiment of the present invention, the apparatus may further include a flow indicator in fluid communication with the pipe downstream of the regulator.

[0028] According to an expedient embodiment of the present invention, the apparatus may further include a flow control valve in fluid communication with the pipe downstream of the flow indicator.

[0029] According to a favoured embodiment of the present invention, the apparatus may further include a pressure relief valve and a thermocouple in fluid communication with a flow of cryogen through the pipe.

[0030] According to a preferred embodiment of the

present invention, the apparatus may further include a temperature reading device in, in particular wireless or other, communication with the thermocouple.

[0031] According to an advantageous embodiment of the present invention, the apparatus may further include a valve in fluid communication with the flexible hose to, in particular manually or otherwise, control a flow of the cryogen passing through the flexible hose.

[0032] According to an expedient embodiment of the present invention, the apparatus may further include a filter disposed within the flexible hose, in particular downstream of the valve, to remove any particulate matter which may have inadvertently been introduced into the cryogen.

[0033] According to a favoured embodiment of the present invention, the flexible hose between the filter and the at least one discharge member may be perforated to begin introducing the cryogen into the surrounding area of the combustible material.

[0034] According to a preferred embodiment of the present invention, a head of the at least one discharge member may further include a built-in pressure relief valve to release the inerting gas when the head of the at least one discharge member is at the desired position to suppress and/or extinguish the fire.

[0035] According to an advantageous embodiment of the present invention, the at least one discharge member may be able to be moved or propelled through unconsolidated material which would otherwise prevent conventional drilling or boring techniques to be used.

[0036] According to an expedient embodiment of the present invention, the at least one discharge member may further include a calibrated hose metering component to enable location and if necessary penetration of the head of the at least one discharge member into the target material mass.

[0037] According to a favoured embodiment of the present invention, the at least one discharge member may further include a thermal couple temperature sensor in the head to enable detection and distance from the fire source and appropriate positioning of the head.

[0038] According to a preferred embodiment of the present invention, the at least one discharge member may further include a transmitter so that the at least one discharge member can be electronically tracked as it moves through the ground for the operators to identify the position of the at least one discharge member with respect to the surface and the combustible material to which the inerting gas is to be applied.

[0039] According to an advantageous embodiment of the present invention, a plurality of discharge members may be used, in particular at different locations, surrounding the combustible material so as to provide an inert gas curtain to contain the spread of the combustion or fire and effectively smother same.

[0040] According to an expedient embodiment of the present invention, the apparatus may further include a calibrated hose metering device to enable location/pen-

etration into the target material.

[0041] According to a favoured embodiment of the present invention, the apparatus may further include electronic tracking equipment to enable the exact position of the at least one discharge member to be determined from the surface and/or from the material mass.

[0042] According to a preferred embodiment of the present invention, the at least one discharge member may be powered by use of pressure generated from the source of cryogen; in particular, the hose may be of a dual purpose construction so that the at least one discharge member can be driven pneumatically by a compressed air supply.

[0043] According to an advantageous embodiment of the present invention, the hose may further be constructed with predetermined, annular, self-sealing holes such that the holes can be caused to open and release gas into the surrounding material mass by increasing internal inert gas supply pressure within the hose.

[0044] According to the present invention, there is also provided a method of suppressing and extinguishing a fire underground, which includes connecting at least one delivery member to a source of cryogen; moving the at least one delivery member to combustible material of the fire; delivering cryogen through the at least one delivery member to the combustible material; and displacing oxygen and heat at the combustible material with the cryogen for suppressing and extinguishing the fire.

[0045] According to an expedient embodiment of the present invention, the step of displacing can continue until the fire is extinguished.

[0046] According to a favoured embodiment of the present invention, the cryogen of the method may include a substance selected from the group consisting of liquid carbon dioxide, gaseous carbon dioxide, liquid nitrogen, and gaseous nitrogen.

[0047] According to a preferred embodiment of the present invention, the method may further include powering the at least one delivery member with compressed air for moving said delivery member through the underground.

Brief description of the drawings

[0048] For a more complete understanding of the present embodiment disclosures and as already discussed above, there are several options to embody as well as to improve the teaching of the present invention in an advantageous manner. To this aim, reference may be made to the claims dependent on claim 1 and on claim 12; further improvements, features and advantages of the present invention are explained below in more detail with reference to preferred embodiments by way of non-limiting example and to the appended drawing figure taken in conjunction with the following description of the embodiments, of which:

The drawing figure shows an embodiment of an ap-

paratus according to the present invention, said apparatus working according to the method of the present invention.

5 Detailed description of the drawings; best way of embodying the present invention

[0049] Before describing the present inventive embodiments in detail, it is to be understood that the inventive embodiments are not limited in their application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the present invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

[0050] Referring to the drawing figure, there is shown an apparatus 10 for extinguishing smoldering fires within combustible material masses which are underground. The apparatus 10 includes a cryogenic source, such as a storage vessel 12 for containing liquid or gaseous carbon dioxide or nitrogen.

[0051] The storage vessel 12 is connected by a pipe 14 or conduit to an outlet of a vaporizer 16, and an outlet of the vaporizer 16 is connected to a pipe 18 having a regulator 20 interposed therein.

[0052] A flow indicator 22 is in communication with the pipe 18. Further downstream of the flow indicator 22 in the pipe 18 is provided a flow control valve 24. A pressure relief valve 26 and a thermocouple 28 are also in communication with a flow of cryogen through the pipe 18. The thermocouple 28 is communication, wirelessly or otherwise, with a temperature reading device 30.

[0053] An end of the pipe 18 is connected to a flexible pipe, hose or conduit 32 which has disposed therein a valve 34 to manually or otherwise control the flow of the cryogen through the flexible pipe 32. A filter 36 is positioned in the flexible pipe 32 downstream of the valve 34 to remove any particulate matter which may have inadvertently been introduced into the cryogen.

[0054] A distal end of the flexible hose 32 is connected to a mole 38 or nozzle-like delivery member which is the inerting apparatus to be introduced into the combustible material mass to displace oxygen therefrom with the cryogen. The flexible hose 32 between the filter 36 and the mole 38 may be perforated to begin introducing the cryogen into the surrounding area of the combustible material mass.

[0055] A head 40 of the mole 38 may also include a built-in pressure relief valve to release the inerting gas when the mole head 40 is at the desired position to suppress and/or extinguish the fire.

[0056] The mole 38 is able to be moved or propelled through unconsolidated material which would otherwise prevent conventional drilling or boring techniques to be used. The mole 38 may include a calibrated hose metering component to enable location and if necessary pen-

etration of the head into the target material mass, and/or a thermal couple temperature sensor 42 in the mole head 40 to enable detection and distance from the fire source and appropriate positioning of said head 40.

[0057] The mole 38 may also include a transmitter 44 so that the mole 38 can be electronically tracked as it moves through the ground for the operators to identify the position of the mole 38 with respect to the surface and the combustible material mass to which the inerting gas is to be applied.

[0058] Similarly, if the combustible material mass is of an unusually large volume, a plurality of the moles 38 may be used at different locations surrounding the mass so as to provide an inert gas curtain to contain the spread of the combustion or fire and effectively smother same.

[0059] In another embodiment, the apparatus 10 may include a calibrated hose metering device to enable location/penetration into the target material.

[0060] In still another embodiment, the apparatus 10 may include electronic tracking equipment to enable the exact position of the mole 38 to be determined from the surface and from the material mass.

[0061] The mole 38 is "powered" by use of pressure that is generated from the inert gas storage vessel 12. For example, the hose 32 can be of a dual purpose construction so that the mole can be driven pneumatically by a compressed air supply. That is, the hose 32 will be used to supply pressure energy to the mole 38 to induce forward motion.

[0062] The hose 32 is also constructed with predetermined, annular, self-sealing holes such that the holes can be caused to open and release gas into the surrounding material mass by increasing internal inert gas supply pressure within the hose 32.

[0063] It will be understood that the embodiments described herein are merely exemplary, and that one skilled in the art may make variations and modifications without departing from the spirit and scope of the present invention. All such variations and modifications are intended to be included within the scope of the present invention as described herein. Further, all embodiments disclosed herein are not necessarily in the alternative, as various embodiments of the present invention may be combined to provide the desired result, and various elements of the claims may be combined in different arrangements within the claims.

List of reference numerals

[0064]

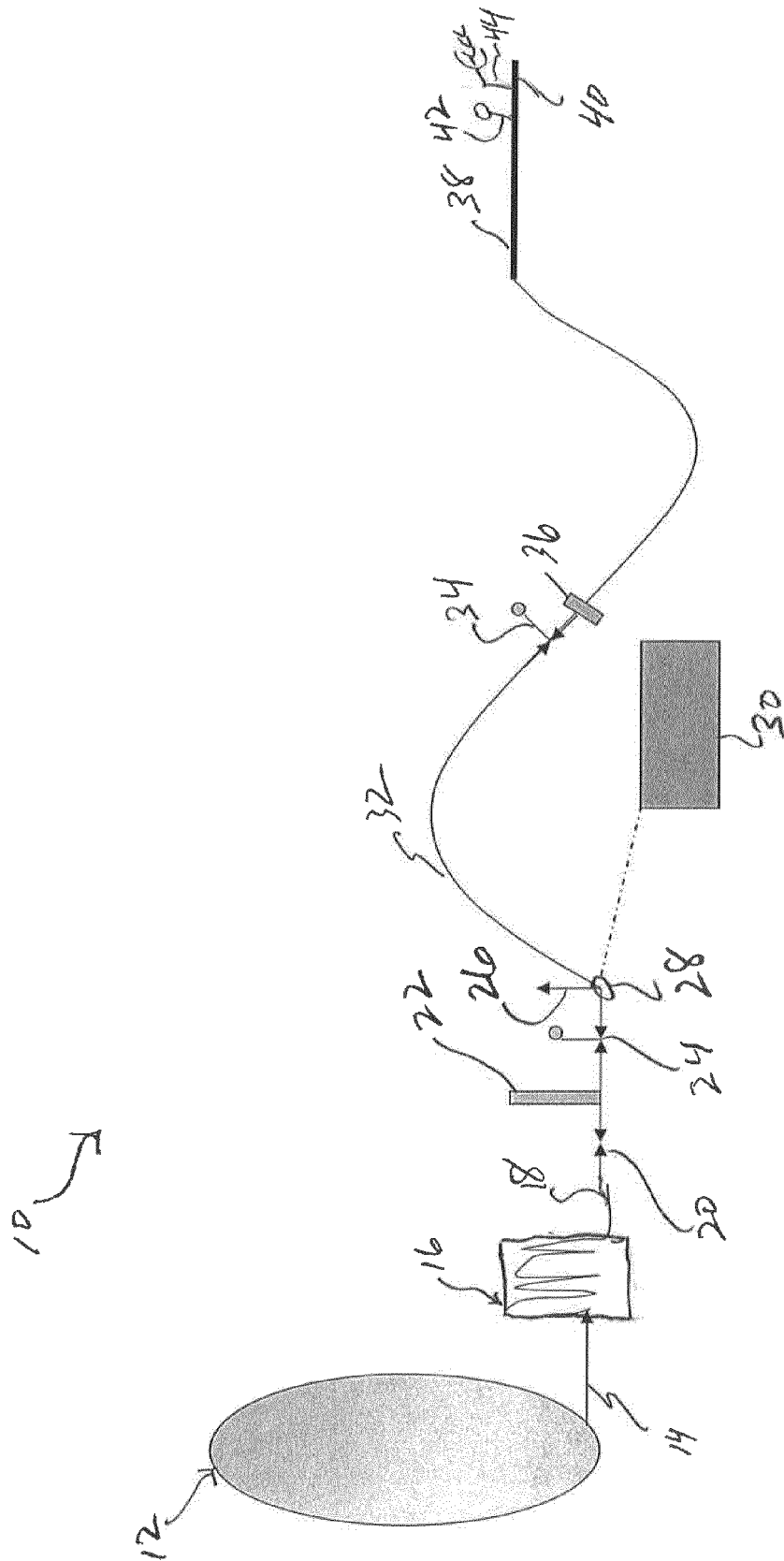
10 apparatus
12 cryogenic source, in particular storage vessel, for example inert gas storage vessel
14 pipe or conduit
16 vaporizer
18 pipe
20 regulator

22 flow indicator
24 flow control valve
26 pressure relief valve
28 thermocouple
30 temperature reading device
32 pipe, hose or conduit, in particular flexible pipe, hose or conduit
34 valve
36 filter
38 discharge member or delivery member, for example mole or nozzle-like delivery member
40 head of discharge member 38
42 thermal couple temperature sensor
44 transmitter

Claims

1. An apparatus (10) for suppressing and extinguishing fires underground, comprising:
 - a source (12) of cryogen;
 - a flexible hose (32) having
 - a first end connected to the source (12) of cryogen, and
 - a second end for being guided to the combustible material; and
 - at least one discharge member (38) having
 - a proximate end in fluid communication with the second end of the flexible hose (32), and
 - a distal end constructed to penetrate the combustible material for introducing the cryogen to said combustible material.
2. The apparatus according to claim 1, further comprising a pipe (14) having
 - a first end in fluid communication with the source (12) of cryogen, and
 - a second end in fluid communication with the flexible hose (32).
3. The apparatus according to claim 2, further comprising a vaporizer (16) in fluid communication with the pipe (14).
4. The apparatus according to claim 2 or 3, further comprising a regulator (20) in fluid communication with the pipe (14).
5. The apparatus according to claim 4, further comprising a flow indicator (22) in fluid communication with the pipe (14) downstream of the regulator (20).

6. The apparatus according to claim 5, further comprising a flow control valve (24) in fluid communication with the pipe (14) downstream of the flow indicator (22). 5
7. The apparatus according to at least one of claims 2 to 6, further comprising a pressure relief valve (26) and a thermocouple (28) in fluid communication with the pipe (14). 10
8. The apparatus according to claim 7, further comprising a temperature reading device (30) in communication with the thermocouple (28).
9. The apparatus according to at least one of claims 1 to 8, further comprising a valve (34) in fluid communication with the flexible hose (32) to control a flow of the cryogen passing through the flexible hose (32). 15
10. The apparatus according to at least one of claims 1 to 9, further comprising a filter (36) disposed within the flexible hose (32) to remove particulate matter from the cryogen. 20
11. The apparatus according to at least one of claims 1 to 10, further comprising 25
- a thermal couple temperature sensor (42) in a head (40) of the at least one discharge member (38), and/or 30
 - a transmitter (44) so that the at least one discharge member (38) can be electronically tracked.
12. A method of suppressing and extinguishing a fire underground, comprising: 35
- connecting (32) at least one delivery member (38) to a source (12) of cryogen;
 - moving the at least one delivery member (38) to combustible material of the fire; 40
 - delivering cryogen through the at least one delivery member (38) to the combustible material; and
 - displacing oxygen and heat at the combustible material with the cryogen for suppressing and extinguishing the fire. 45
13. The method according to claim 12, wherein the displacing continues until the fire is extinguished. 50
14. The method according to claim 12 or 13, wherein the cryogen comprises a substance selected from the group consisting of liquid carbon dioxide, gaseous carbon dioxide, liquid nitrogen, and gaseous nitrogen. 55
15. The method according to at least one of claims 12
- to 14, further comprising powering the at least one delivery member (38) with compressed air for moving said delivery member (38) through the underground.





EUROPEAN SEARCH REPORT

Application Number

EP 14 17 8092

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 16 September 2014	Examiner Zupancic, Gregor
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EPO FORM 1503 03.02 (P04C01)



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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
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