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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 December 2015 (17.12.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/189536 A1

(51) International Patent Classification:
E21F 17/107 (2006.01)

(21) International Application Number:
PCT/GB2015/000163

(22) International Filing Date:
10 June 2015 (10.06.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1410252.9 10 June 2014 (10.06.2014) GB

(71) Applicant: **THE SECRETARY OF STATE FOR DEFENCE** [GB/GB]; DSTL, Porton Down, Salisbury, Wiltshire SP4 0JQ (GB).

(72) Inventor: **THOMPSON, Duncan Godfrey Mervyn**; DSTL IP Group, G01-B Building 005, Porton Down, Salisbury, Wiltshire SP4 0JQ (GB).

(74) Agent: **FARNSWORTH, Alastair Graham**; DIPR Formalities Section, Poplar 2#2214, MOD Abbey Wood, Bristol, BS34 8JH (GB).

(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, 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,

[Continued on next page]

(54) Title: A TUNNEL PLUG

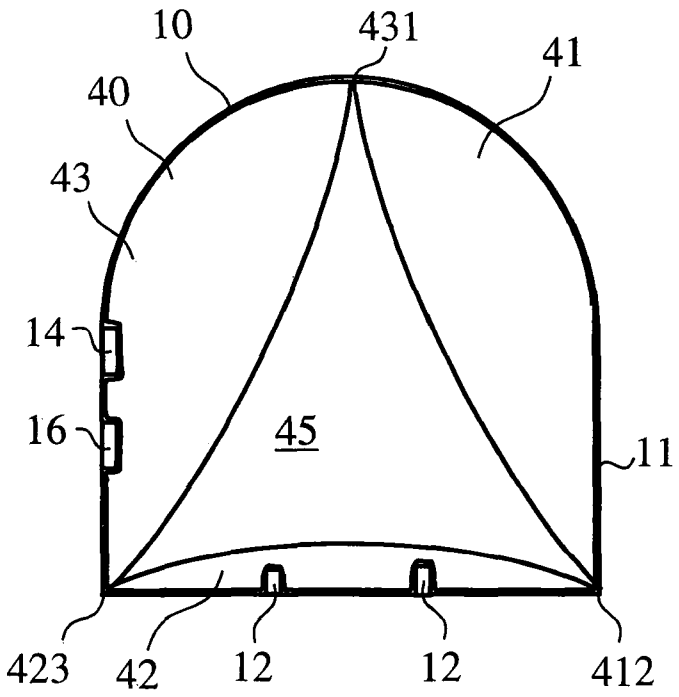

Fig. 3a

(57) Abstract: There is provided a tunnel plug (20) for blocking a tunnel (10). The tunnel plug (20) comprises a plurality of inflatable segments (21, 22, 23) forming an outer periphery that extends around a perimeter of the tunnel plug, the outer periphery for sealing against internal surfaces of the tunnel, wherein a first one (21) of the inflatable segments extends around a first part of the perimeter, and a second one (22) of the inflatable segments extends around a second part of the perimeter, and wherein the first inflatable segment (21) and the second inflatable segment (22) are pivotally connected to one another.

WO 2015/189536 A1

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))*

A TUNNEL PLUG

Technical Field of the Invention

This invention relates to a tunnel plug, for example for blocking a tunnel.

Background to the Invention

Tunnel plugs are known in the art, and may be installed into tunnels in a packed state. If a need arises to block the tunnel, then the tunnel plug can be deployed, for example by inflating the tunnel plug to unpack it. One of the main purposes of tunnel plugs is to disrupt movement of air through the tunnels, for example to prevent smoke or fumes travelling along the full length of the tunnel. Furthermore, the deployment of two tunnel plugs on either side of a fire in the tunnel can starve the fire of oxygen to help put the fire out.

The patent publication US 4,023,372 discloses a tunnel plug for mines, wherein the tunnel plug has an inflatable outer that can be filled with gas to deploy the tunnel plug and block the mine. However, the shape of the inflatable outer needs to match the shape of the mine in order to fully block the mine tunnel.

Even if an inflatable outer of the type described above is shaped to substantially match the tunnel, the inflatable outer still may not create a very good seal against the corners of the tunnel. The gas pressure inside the inflatable outer tends to make the inflatable outer arc across corners, rather than filling them fully, leaving gaps where air can bypass the tunnel plug.

An improved seal between the tunnel plug and the internal surfaces of the tunnel is desirable to improve the sealing offered by the tunnel plug and the resulting restriction of airflow. An improved seal may be particularly important if the tunnel plug is intended to block toxic fumes or biological agents from passing along a tunnel to where people or animals are located.

It is therefore an aim of the invention to provide a tunnel plug that provides improved sealing against internal surfaces of a tunnel.

Summary of the Invention

According to a first aspect of the invention, there is provided a tunnel plug for blocking a tunnel, wherein the tunnel plug comprises a plurality of inflatable segments forming an outer periphery that extends around a perimeter of the tunnel plug, the outer periphery for sealing against internal surfaces of the tunnel, wherein a first one of the inflatable segments extends around a first part of the perimeter, and a second one of the inflatable segments extends around a second part of the perimeter, and wherein the first inflatable segment and the second inflatable segment are pivotally connected to one another.

Since the first and second inflatable segments are pivotally connected to one another, when the plurality of the inflatable segments are inflated within a tunnel, the first and second inflatable segments push against one another and pivot with respect to one another to help fully fill the interior of the tunnel.

The first and second inflatable segments are typically pivotally connected to one another at ends of the first and second inflatable segments. The first and second inflatable segments may be pivotally connected to one another at a corner of the tunnel plug, so that as the first and second inflatable segments push against one another, ends of the first and second inflatable segments pivot with respect to one another to enable them to move further into the corner of the tunnel. Or, the first and second inflatable segments may be pivotally connected to one another at a top of the tunnel plug, so that they are able to pivot about one another according to how large a distance exists between opposing sides of the tunnel.

The perimeter of the tunnel plug is typically in a plane perpendicular to the length of the tunnel plug, the length of the tunnel plug being aligned with the length of the tunnel and filling a length portion of the tunnel. For a horizontal tunnel, the perimeter typically lies in a substantially vertical plane when the tunnel plug is deployed.

The corner of the tunnel may be a corner between the base of the tunnel and a side of the tunnel, but could alternatively be another corner such as a corner between a side of the tunnel and a lighting strip or cable trunking mounted on the side of the tunnel.

Advantageously, a third one of the plurality of inflatable segments may extend around a third part of the perimeter of the tunnel plug, and the third inflatable segment and the second inflatable segment may also be pivotally connected to one another, for example at another corner of the tunnel plug. Accordingly, the second and third inflatable segments will push against one another during inflation of the tunnel plug, and the pivotal connection between the second and third inflatable segments allows the second and third segments to pivot with respect to one another, helping the tunnel plug to more fully fill the tunnel.

The third inflatable segment may for example be a base segment and the first and third segments may for example be side segments which connect to the base segment at opposing bottom corners of the tunnel plug. Then, the opposing bottom corners of the tunnel plug may squeeze into opposing bottom corners between the base and the sides of the tunnel when the tunnel plug is inflated within the tunnel.

Furthermore, the first inflatable segment and the third inflatable segment may be pivotally connected to one another at a top of the tunnel plug, so that they are able to pivot about one another according to how large a distance exists between opposing sides of the tunnel.

The tunnel plug may comprise an anchor at one of the pivotal connections, for example the pivotal connection between the first and second inflatable segments when the first and second inflatable segments are connected at the top of the tunnel, or an anchor between the first and third inflatable segments when the first and third inflatable segments are connected at the top of the tunnel. The anchor may be configured to anchor the tunnel plug to the top of the tunnel. Then, the tunnel plug can be packed in a non-inflated state at the top of the tunnel for storage at times when it is not required, and when the tunnel plug is to be deployed it can be inflated to plug the tunnel.

The first and second parts of the perimeter are typically two distinct parts of the perimeter, and, when present, the third part of the perimeter is another distinct part of the perimeter. The perimeter is typically a boundary line that extends fully around the outer periphery of the tunnel plug so as to form a closed shape.

The plurality of inflatable segments may each comprise a respective chamber into which fluid can be passed to inflate the inflatable segment. Each inflatable segment may be formed from one or more flexible layers of material defining a closed interior that constitutes the chamber of the inflatable segment. The chamber may be filled with fluid to inflate the inflatable segment when the tunnel plug is to be deployed to plug the tunnel. Each inflatable segment may comprise only one chamber for filling with fluid.

Advantageously, the tunnel plug may further comprise an inflation device for filling the plurality of inflatable segments with fluid to inflate the inflatable segments upon deployment of the tunnel plug. The fluid is normally gaseous, although the use of liquids would also be possible. The inflation device may comprise a gas/smoke sensor for automatically triggering the inflation device, and/or the inflation device may be remotely triggered by an operator via radio communications or wiring, in order to deploy (unpack) the tunnel plug. The inflation device may comprise an explosive for producing fluid, a store of compressed fluid, or a pump for pumping fluid, such as a fan.

The storage of the tunnel plug at the top of the tunnel may be particularly advantageous when the tunnel plug comprises a smoke sensor, since any smoke is likely to rise to the top of the tunnel.

The inflation device may comprise a first fluid output connected to the first inflatable segment for filling the first inflatable segment, and a second fluid output connected to the second inflatable segment for filling the second inflatable segment. Alternatively, the inflation device may be configured to fill the first inflatable segment with fluid via the second inflatable segment.

Advantageously, the inflation device may be configured to inflate at least one of the inflatable segments prior to inflation of at least one other of the inflatable segments upon the deployment of the tunnel plug. Then, the inflatable segments can be inflated in an order that helps to ensure the tunnel plug will conform to the particular cross section of the tunnel when fully inflated. For example, if the tunnel plug is anchored to the top of the tunnel, and comprises a first inflatable segment for expanding against a right side of the tunnel, a second inflatable segment for expanding against a base of the tunnel, and a third inflatable segment for expanding against a left side of the tunnel, then the inflation device may be configured to

inflate the first and third inflatable segments prior to the second inflatable segment, to prevent the second inflatable segment from fouling against the sides of the tunnel and preventing the first and third inflatable segments from moving the second inflatable segment down to the base of the tunnel. The first and third inflatable segments when fully inflated will apply pressure downwards on the second inflatable segment, to help prevent the second inflatable segment from arching upwardly away from the base of the tunnel.

Preferably, the tunnel plug is larger than the tunnel which it is intended to fill, for example 5% larger, so that there is ample material available for the plurality of inflatable portions to push against each other and pivot with respect to one another to enable the tunnel plug to fill a variety of differently dimensioned sections along the tunnel. The tunnel plug may comprise a centre portion spanning between the plurality of inflatable segments, and the centre portion may be non-inflatable. For example, the centre portion may be a single layer of material, such as a wall or web. The centre portion could comprise more than one layer of material, for example to improve the strength of the centre portion. Preferably, the centre portion fully extends over an area enclosed by the plurality of inflatable segments, so that the centre portion together with the plurality of inflatable segments fully blocks the tunnel when the tunnel plug is deployed.

Advantageously, the centre portion may comprise a door which is openable to allow a person to pass through the centre portion. Then, the deployment of the tunnel plug will not risk trapping people since person(s) can use the door to move through the tunnel plug.

Brief Description of the Drawings

Embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Fig. 1 shows a schematic diagram of a tunnel incorporating a tunnel plug in a packed configuration, the tunnel plug according to a first embodiment of the invention;

Fig. 2a shows a schematic diagram of the tunnel of Fig. 1 with the tunnel plug in an unpacked configuration following its deployment within the tunnel;

Fig. 2b shows a schematic cross-sectional diagram of the tunnel plug of Fig. 2a, the cross-section taken along line AA marked on Fig. 2a;

Fig. 2c shows a schematic perspective diagram of a top part of the tunnel plug of Fig. 2a;

Fig. 3a shows a schematic diagram of the tunnel of Fig. 1, with a tunnel plug according to a second embodiment of the invention in an unpacked configuration following its deployment within the tunnel;

Fig. 3b shows a perspective diagram of the tunnel plug of Fig. 3a.

The drawings are purely illustrative and are not to scale. Same or similar reference signs denote same or similar features.

Detailed Description

A first embodiment of the invention will now be described with reference to the schematic diagrams of Fig. 1 to Fig. 2c, which show schematic diagrams of a tunnel 10 and tunnel plug 20. The schematic diagram of Fig.1 shows a view of the tunnel 10 taken in a direction along the length of the tunnel 10.

As shown in Fig. 1, the tunnel 10 comprises railway lines 12 at a base of the tunnel for guiding railway cars, a lighting strip 14 mounted at the left side of the tunnel for lighting the tunnel, a cable trunking 16 mounted at the left side of the tunnel beneath the lighting strip 14, and the tunnel plug 20 mounted at the top of the tunnel. The cable trunking 16 supports cables carrying power and/or signals relevant to the railway, for example power and/or signals for railway signalling equipment. The railway lines 12, lighting strip 14, and cable trunking 16 extend substantially along the full length of the tunnel, and the tunnel plug 20 extends only a short distance along the length of the tunnel, for example 2 metres. In this embodiment, further tunnel plugs the same as the tunnel plug 20 are mounted at 100 metre intervals along the length of the tunnel.

The tunnel plug 20 is shown in a packed configuration in Fig. 1, and only takes up a small portion of the tunnel 10, so as not to impede railways cars travelling through the tunnel along the railway lines 12. The tunnel plug 20 comprises an inflation device 28, which in this embodiment is a container 28 of compressed air. A valve of the container 28 may be opened to release the compressed air from the container 28 when the tunnel plug 20 is to be deployed. Electrical wiring (not shown in Figs) is connected between the container 28 and a

control centre (also not shown in Figs) external to the tunnel to control the opening of the valve of the container 28. Optionally, the inflation device 28 may also comprise a gas or smoke sensor configured to automatically open the valve of the container 28 when gas or smoke is detected.

The schematic diagram of Fig. 2a shows the tunnel plug 20 once it has been deployed within the tunnel 10. In order to deploy the tunnel plug 20 into the unpacked configuration shown in Fig. 2a, the control centre signals the valve of the container 28 to open via the electrical wiring, and the compressed air within the container 28 exits the container 28 to inflate the tunnel plug 20 and unpack it.

The tunnel plug 20 comprises a centre portion 25, which spans between a first inflatable segment 21, a second inflatable segment 22, and a third inflatable segment 23. The first and second inflatable segments are pivotally connected to one another at their ends, at the top of the tunnel 10, at the same location where the tunnel plug was stored in the packed configuration. The third inflatable segment 23 is connected between the ends of the first and second inflatable segments that are opposite to the ends of the first and second inflatable segments where the pivotal connection is made. Accordingly, an outer periphery of the first inflatable segment 21 seals against the right side 11 of the tunnel 10, an outer periphery of the second inflatable segment 22 seals against the left side of the tunnel 10 having the cable trunking 16 and lighting strip 14, and an outer periphery of the third inflatable segment 23 seals against the bottom of the tunnel 10 having the railway lines 12. The outer peripheries of the first, second, and third inflatable segments together extend around a perimeter of the tunnel plug 20.

The inflatable segments 21, 22, 23 are all formed of a plasticised fabric material, although the plasticised fabric material could be replaced by other types of flexible air-tight materials in alternate embodiments of the invention, for example glass fibre fabric coated with silicone rubber. The container 28 is inside of the inflatable segments.

The centre portion 25 is formed of a web of plasticised fabric material that fully extends over the region enclosed by the inflatable segments 21, 22, and 23. The centre portion 25 comprises a door 30 that is defined by a zip 32, the zip 32 allowing part of the

centre portion to be unzipped from the remainder of the centre portion so that a person can move through the door 30 if required.

The inflatable segments are formed larger than the size of the tunnel 10 so that there is ample material of the inflatable segments to conform to the shapes of the railway lines 12 and the lighting strip 14 and cable trunking 16. The container 28 holds sufficient compressed air to inflate the inflatable segments to a pressure of 100KPa above atmospheric pressure. Clearly, other values of pressures may alternatively be used by setting the amount of compressed air in the container 28.

The schematic diagram of Fig. 2b shows a cross-section of the tunnel plug 20 taken along line AA marked on Fig. 2a. As shown, the inflatable segments 21 and 22 have a generally rectangular cross-section, and are connected by the non-inflatable centre portion 25 which is a thin and flexible layer of plasticised fabric material. The inflatable segments 21 and 22 may alternatively have other cross-sections, for example oval cross-sections.

The schematic diagram of Fig. 2c shows an exploded perspective view of the region EV1 marked on Fig. 2a, where further details of the pivotal connection between the first and second inflatable segments 21 and 22 can be seen. Specifically, the ends of the first and second inflatable segments are both connected to a plastic anchor 27 for anchoring the tunnel plug 20 to the top of the tunnel 10. The ends of the first and second inflatable segments are adhered or welded to the plastic anchor 27, and pivot about one another via local deformation of the first and second inflatable segments adjacent the plastic anchor 27, in the manner of a living hinge. The plastic anchor 27 is fixed to the top of the tunnel 10 when the tunnel plug 20 is installed in the tunnel 10 in the packed configuration, for example by bolting the plastic anchor 27 to the top of the tunnel 10. When the tunnel plug 20 is deployed within the tunnel 10, the pivotal connection between the first and second inflatable segments at the plastic anchor 27 allows the first inflatable segment 21 to pivot in a direction PR to seal against the right side of the tunnel, and allows the second inflatable segment 22 to pivot in a direction PL to seal against the left side of the tunnel. The pivoting allows a wide range of tunnel shapes to be sealed by the tunnel plug 20.

Fig. 2c also shows a part 29 of the perimeter which extends all of the way around the outer periphery of the tunnel plug 20. A first part 29a of the perimeter is formed by the outer

periphery of the first inflatable segment 21, and a second part 29b of the perimeter is formed by the outer periphery of the second inflatable segment 22.

In alternative embodiments, other types of hinges could be used to connect the ends of the inflatable segments to the plastic anchor 27. The anchor 27 may be formed from materials other than plastics, for example fibreglass.

A second embodiment of the invention will now be described with reference to Figs. 3a and 3b. The schematic diagram of Fig. 3a shows a tunnel plug 40 in an unpacked configuration after deployment within the tunnel 10 of Fig. 1, and the schematic diagram of Fig. 3b shows a perspective view of the tunnel plug 40 without the tunnel 10. The tunnel plug 40 comprises a central portion 45 similar to the central portion 25, a first inflatable segment 41, a second inflatable segment 42, and a third inflatable segment 43. The first, second, and third inflatable segments each have one respective chamber that is filled with fluid when the tunnel plug 40 is deployed within the tunnel 10.

The centre portion 45 spans between the first, second, and third inflatable segments. The first and second inflatable segments are pivotally connected to one another at their ends 412, the second and third inflatable segments are pivotally connected to one another at their ends 423, and the third and first inflatable segments are pivotally connected to one another at their ends 431. An outer periphery OP1 of the first inflatable segment 41 seals against the right side of the tunnel 10, an outer periphery of the second inflatable segment 42 seals against the bottom of the tunnel 10, and an outer periphery of the third inflatable segment 43 seals against the left side of the tunnel 10. A perimeter PRM extends fully around the tunnel plug 40, part of the perimeter formed by the outer periphery OP1, another part of the perimeter formed by the outer periphery OP2, and another part of the perimeter formed by the outer periphery OP3.

The tunnel plug 40 further comprises an inflation device 80, which in this embodiment is an air pump. The air pump 80 comprises an aerial 85 for receiving radio signals to control the air pump, and a gas sensor 86 for sensing non-breathable gases, for example smoke. The air pump 80 has a first fluid outlet pipe 71 that is connected to the first inflatable segment 41, a second fluid outlet pipe 72 that is connected to the second inflatable

segment 42, and a third fluid outlet pipe 73 that is connected to the third inflatable segment 43.

The tunnel plug 40 is normally in a packed configuration at the top of the tunnel 10 along with the inflation device 80, similar to the packed tunnel plug 20 shown in Fig. 1. However, when the aerial 85 receives a radio signal commanding the deployment of the tunnel plug 40, or when the gas sensor 86 detects the presence of on-breathable gases, the air pump 80 pumps air along the first and third fluid outlet pipes 71 and 73, into the first and third inflatable segments 41 and 43, to inflate the tunnel plug 40 downwardly into the tunnel. Once the first and third inflatable segments 41 and 43 are inflated, the air pump 80 pumps air along the second fluid outlet pipe 72, to inflate the second inflatable segment 42. As the second inflatable segment 42 inflates, the first and third inflatable segments 41 and 43 are forced apart from one another by the second inflatable segment 42, pivoting away from one another at their ends 431. The ends 431 are connected to a plastic anchor 47, the same as the plastic anchor 27 of the first embodiment.

Furthermore, the ends 412 of the first and second inflatable segments pivot about one another as the inflation forces the ends 412 into the bottom right corner of the tunnel 10, and the ends 423 of the second and third inflatable segments pivot about one another as the inflation forces the ends 423 into the bottom left corner of the tunnel 10.

Various other embodiments falling within the scope of the appended claims will also be apparent to the skilled person.

CLAIMS

1. A tunnel plug for blocking a tunnel, wherein the tunnel plug comprises a plurality of inflatable segments forming an outer periphery that extends around a perimeter of the tunnel plug, the outer periphery for sealing against internal surfaces of the tunnel, wherein a first one of the inflatable segments extends around a first part of the perimeter, and a second one of the inflatable segments extends around a second part of the perimeter, and wherein the first inflatable segment and the second inflatable segment are pivotally connected to one another.

2 The tunnel plug of claim 1, wherein the pivotal connection between the first and second inflatable segments is at a corner of the tunnel plug.

3. The tunnel plug of claim 1 or 2, wherein a third one of the plurality of inflatable segments extends around a third part of the perimeter of the tunnel plug, and wherein the third inflatable segment and the second inflatable segment are pivotally connected to one another.

4. The tunnel plug of claim 3, wherein the third inflatable segment is a base segment of the tunnel plug, and wherein the first and third inflatable segments are side segments of the tunnel plug.

5. The tunnel plug of claim 3 or 4, wherein the first inflatable segment and the third inflatable segment are pivotally connected to one another at a top of the tunnel plug.

6. The tunnel plug of any preceding claim, wherein the tunnel plug comprises an anchor at one of the pivotal connections, the anchor for anchoring the tunnel plug to the tunnel.

7. The tunnel plug of any preceding claim, wherein the tunnel plug further comprises an inflation device for filling the plurality of inflatable segments with fluid to inflate the plurality of inflatable segments upon deployment of the tunnel plug.

8. The tunnel plug of claim 7, wherein the inflation device comprises an explosive for producing fluid, a store of compressed fluid, or a pump for pumping fluid.

9. The tunnel plug of claim 7 or 8, wherein the inflation device comprises at least one of a gas sensor or a smoke sensor for automatically triggering the inflation device

10. The tunnel plug of claim 7, 8, or 9, wherein the inflation device is configured to inflate at least one of the inflatable segments prior to inflation of at least one other of the inflatable segments upon the deployment of the tunnel plug.

11. The tunnel plug of any preceding claim, wherein the plurality of inflatable segments each comprise a respective chamber into which fluid can be passed to inflate the inflatable segment.

12. The tunnel plug of any preceding claim, wherein the tunnel plug comprises a centre portion spanning between the plurality of inflatable segments.

13. The tunnel plug of claim 12, wherein the centre portion is non-inflatable.

14. The tunnel plug of claim 12 or 13, wherein the centre portion fully extends over an area enclosed by the plurality of inflatable segments.

15. The tunnel plug of claim 12, 13, or 14, wherein the centre portion comprises a door which is openable to allow a person to pass through the centre portion.

16. A tunnel plug substantially as described herein with reference to the accompanying drawings.

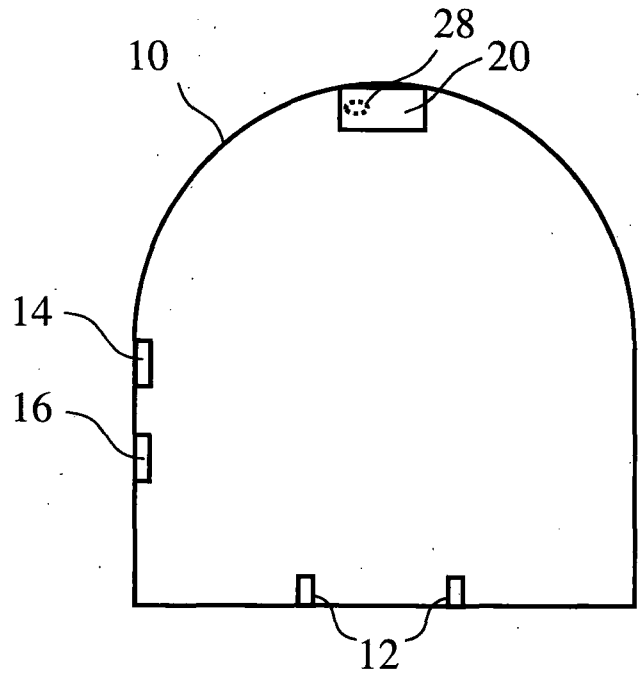

Fig. 1

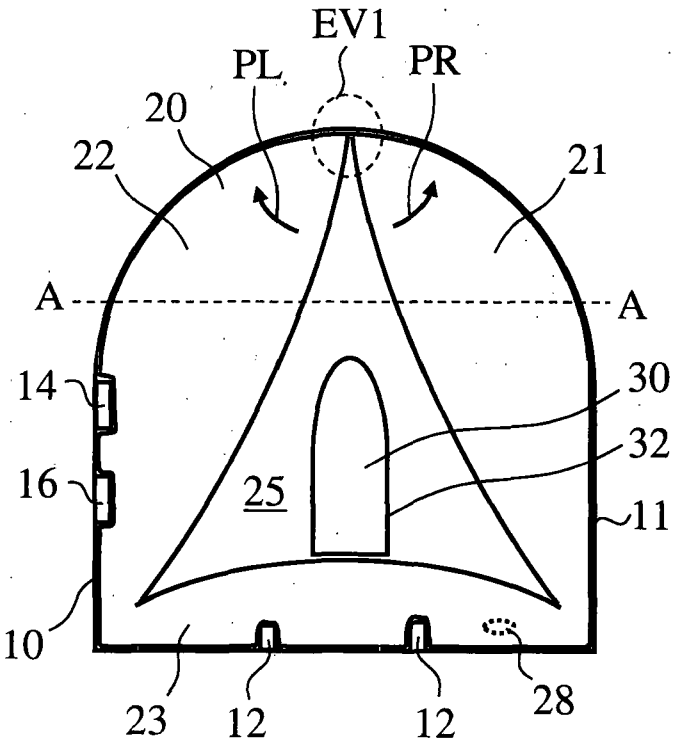

Fig. 2a

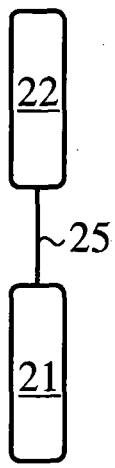

Fig. 2b

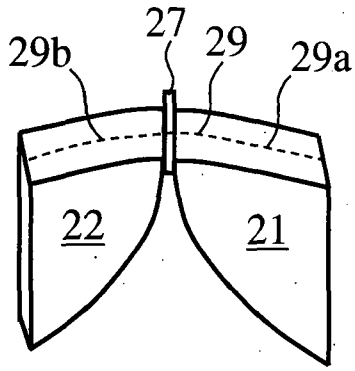

Fig. 2c

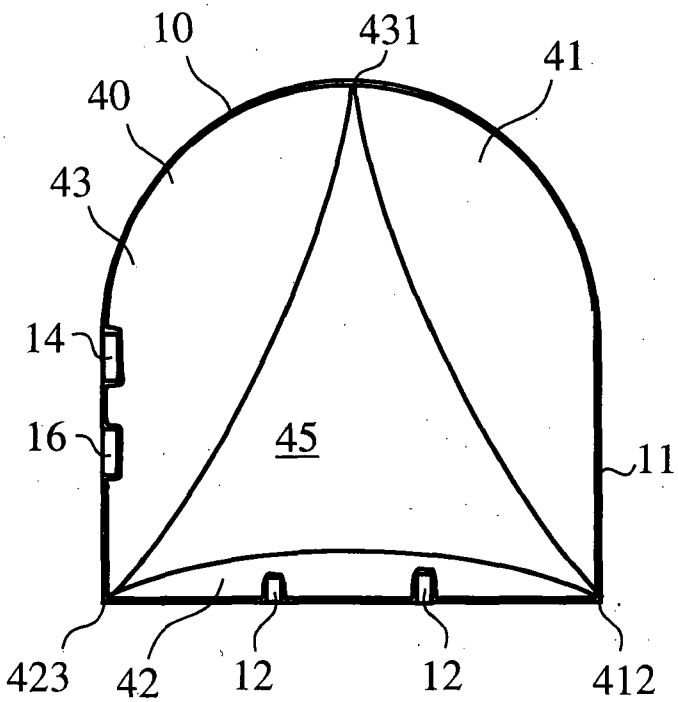
10
431
41
40
43
14
16
45
11
423
42
12
12
412

Fig. 3a

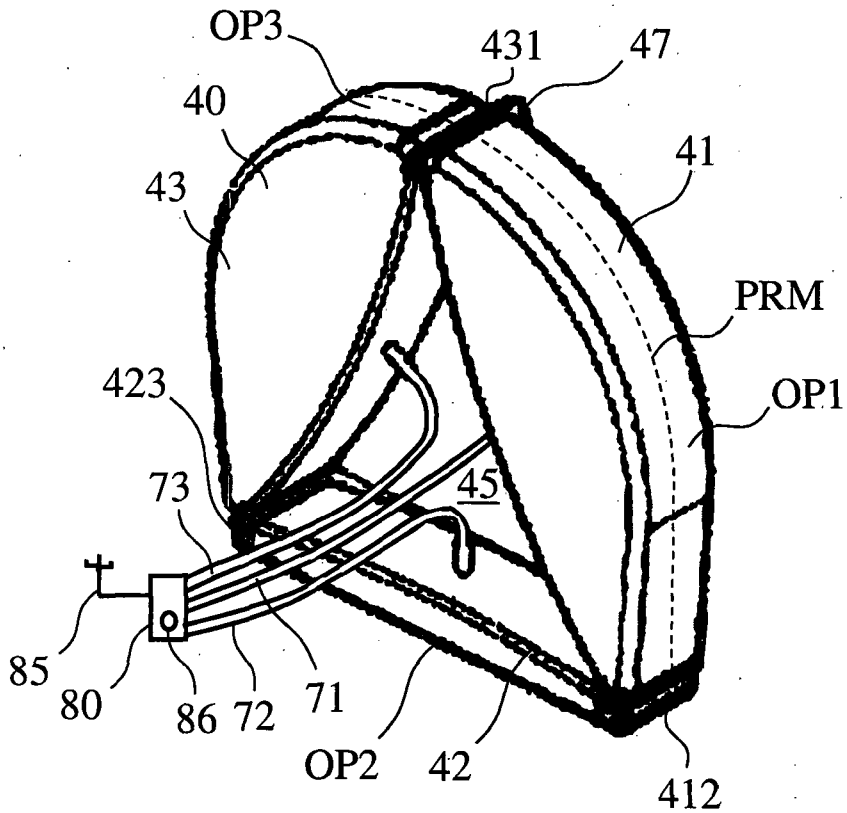
OP3
431
47
40
41
43
PRM
423
OP1
73
45
85
80
86
72
71
OP2
42
412

Fig. 3b

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2015/000163

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21F17/107
ADD.

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)
E21F

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 00/19063 A1 (THAMES WATER UTILITIES [GB]; SMITH ALAN JAMES [GB]; WATERS COLIN JOHN) 6 April 2000 (2000-04-06) abstract; figures 1-3 page 7, paragraph 5	1-16
A	WO 2007/142917 A2 (BATTELLE MEMORIAL INSTITUTE [US]; REUTHER JAMES J [US]; GIVENS RICHARD) 13 December 2007 (2007-12-13) abstract figures 1,5 page 2, paragraph 4 page 4, paragraph 3	1-16
A	GB 787 680 A (ELLIOT EQUIPMENT LTD) 11 December 1957 (1957-12-11) abstract; figures 1-3 page 1, column 2, paragraph 1	1-16

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

☒ 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
23 September 2015	02/10/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Wehland, Florian

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2015/000163

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0019063 A1	06-04-2000	AU 6104899 A	17-04-2000
		EP 1115962 A1	18-07-2001
		JP 2002525471 A	13-08-2002
		WO 0019063 A1	06-04-2000
WO 2007142917 A2	13-12-2007	AU 2007255054 A1	13-12-2007
		US 2009197518 A1	06-08-2009
		WO 2007142917 A2	13-12-2007
		ZA 200809795 A	28-10-2009
GB 787680 A	11-12-1957	NONE	