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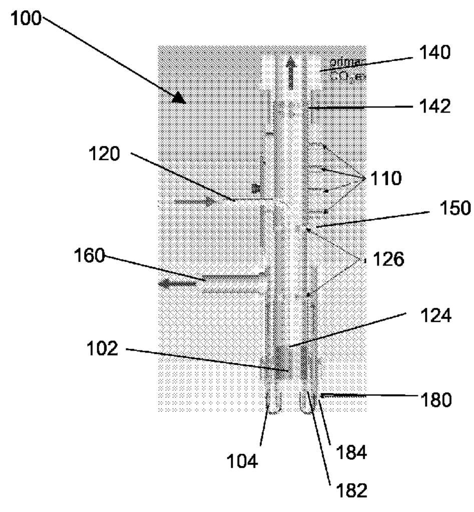
(54) Title: IMPROVEMENTS RELATING TO COOLANT DELIVERY



(57) Abstract: A coolant delivery device (100) comprises a coolant outlet (124) and an exhaust (140, 160). The coolant outlet (124) is contained within a housing (150) that 5 has an opening provided with sealing means (180), to which opening the coolant outlet (124) is arranged to direct a coolant. In use of the device, coolant is delivered to a surface to be cooled, and the coolant vaporises at the surface so as to produce coolant gas. Since the sealing means (180), in use of the device, form a seal between the housing (150) and the surface, the coolant gas 10 is constrained to escape the device through the exhaust (140, 160), and does not disturb or disrupt the ambient environment. The device is particularly useful for applying thermal tensioning to welds through the delivery of a cryogenic spray to a weld line.

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IMPROVEMENTS RELATING TO COOLANT DELIVERY

This invention relates to improvements to coolant delivery. More particularly, this invention relates to a coolant delivery device for delivering coolant to a surface, thereby cooling the surface. The invention also relates to a method of cooling a surface. The inventive device and method are expected to find application in the field of welding, amongst other fields.

The intense and localised thermal cycles applied to workpieces during welding produce residual stresses that often lead to distortion in welded components. Welding distortion is a significant problem in the fabrication of welded structures, and requires the application of expensive post-weld repair procedures in order to correct distorted components. A recent report (Cole, B. R., 'Manufacturing Process Improvement, Reduction of Flame Straightening', The National Centre for Excellence in Metalworking Technologies and The Navy Joining Centre Workshop, August 29-30, 1995) estimates the total cost of correcting weld-induced distortion to be £2.2M per ship. A known solution to this problem is the use of stress engineering techniques, such as thermal tensioning, during welding. Thermal tensioning can be applied using cryogenic liquid to induce local tensile stresses in order to balance the stresses.

Unfortunately, application of thermal tensioning to welds using cryogenic liquids is not currently practical. The intensity of the cryogen spray required to produce the necessary cooling effect is such that it disrupts most welding processes. For example, EP 1,151,820 discloses a welding method using a liquid cryogen spray to provide thermal tensioning. A spray of cryogen is directed towards the weld line, and no attempt is made, when using the apparatus disclosed, to contain evolved gas. The method is thus unfortunately only applicable to friction stir welding, and not, for example, to arc welding processes that are particularly sensitive to the ambient gas environment, and therefore easily disrupted where gas evolved from cryogen sprays is not suitably contained.

Some trials have been performed using a barrier (such as a metal plate) positioned between the spray and the welding source. However, such barriers have not been successful, either at containing the spray, or at containing evolved gas, and thus disruption to the welding process still results. Even if a barrier could be made effective, the intensity of cryogen spray required to provide the necessary cooling would be likely to result in molten material being ejected from the weld line. Clearly, any such process would be dangerous if applied in a manufacturing environment. Thus it has previously been necessary to apply the coolant cryogen from the opposite side of the workpiece to the welding source. However, during the fabrication of welded structures, the reverse side is often not accessible, and so such techniques are not industrially practical.

There is therefore a need for an improved method of delivering a coolant to a surface, and an improved coolant delivery device, that avoid, or at least reduces the effects of, some of the above-mentioned problems. Accordingly it is an object of the present invention to provide a coolant delivery device, and a method of cooling, that enable coolant to be delivered to a surface in a manner which does not disrupt or significantly disturb the ambient environment of the device. More particularly, it is an object of the invention to provide a coolant delivery device that enables coolant to be delivered to a welded surface in a manner which does not disrupt or significantly disturb the ambient welding environment of the device. It is a further object of the invention to provide a device that allows effective thermal tensioning to be applied to any welding method.

In broad terms, the present invention resides in the concept of providing a coolant delivery device, for delivering coolant to a surface, that incorporates extraction means for extracting any gas that evolves from the action of the coolant on the surface. By extracting gas, it is ensured that the ambient external environment is not affected by the cooling, and thus that the device can be used in conjunction with a wide variety of welding devices. The invention extends to the concept of providing a method of cooling ensures that the ambient environment is not affected by the cooling process.

In accordance with a first aspect of the present invention, there is provided a coolant delivery device comprising a coolant outlet within a housing; the housing defining an opening and an exhaust, the opening being provided with sealing means; and the coolant outlet being arranged to direct a coolant towards the opening; such that, in use of the device to deliver the coolant to a surface to be cooled, at which surface the coolant vaporises to produce coolant gas, the sealing means are operable to form a seal between the housing and the surface, thereby constraining the coolant gas to escape the device through the exhaust. Since the evolved gas can escape only through the exhaust, the external environment is not affected by cooling applied using the coolant delivery device. This is advantageous where the device is to be used for applications such as the application of thermal tensioning to the arc welding process, which is highly sensitive to the ambient environment.

Preferably, the exhaust is connectable to extraction means operable to extract coolant gas from the device. The device may then be connected to extraction means, such as a vacuum pump, so that the coolant gas can be extracted more rapidly.

Conveniently, the exhaust comprises primary and secondary exhausts. The primary and secondary exhausts may be independently connectable to extraction means. For example, if the extraction means are provided by vacuum equipment, the exhausts may be independently connected to the same vacuum pump, or may be connected to separate vacuum pumps. Provision of both a primary and a secondary exhaust enables the in-flow of coolant to the device to be more easily balanced with the out-flow of coolant gas. Such flow balancing advantageously ensures that leakage of coolant gas through the sealing means is limited whilst efficient cooling is maintained.

The sealing means optionally comprises first and second sealing members, each operable to form a seal between the housing and the surface. Preferably, the first and second sealing members define a space therebetween, which space provides a part of a passageway through which coolant gas can reach the secondary exhaust. The secondary exhaust can then provide extraction power at the surface, through the first sealing member. This reduces the likelihood of coolant being extracted from the device directly through the primary exhaust, before it reaches the surface, and thus enables a high cooling efficiency to be achieved whilst maintaining the seal between the device and the surface. In one embodiment, the second sealing member encloses the first sealing member. The sealing means may comprise a flexible seal. Flexible seals provide a simple method of forming a seal between the surface and the housing, whilst advantageously still allowing the device to move along the surface without breaking the seal. For example, the sealing means may comprise a PTFE flexible seal. PTFE, advantageously, is suitable for use both at low temperatures (and therefore can be used with cryogenic coolants) and at high temperatures (and therefore can be placed in contact with a just-welded, still-hot surface without incurring damage). PTFE is therefore suitable for use where the device is to be used to provide thermal tensioning to a weld. In accordance with one preferred embodiment, the housing is generally cylindrical, and the exhaust and the sealing means are located at opposite ends of the housing.

Preferably, the exhaust comprises adjustment means operable to adjust the rate of extraction of coolant gas from the device. The adjustment means may be provided in the primary exhaust. Such adjustment means may be a valve provided in the primary exhaust, operable to choke the flow through the exhaust, or may simply be arranged to allow a variable amount of air into the flow through the exhaust. Advantageously, when adjustment means are present in the exhaust, the rate of flow of coolant gas through the exhaust can be varied. This enables the device to achieve the appropriate rate of extraction of coolant gas over a range of values of coolant in-flow rate. The adjustment means may alternatively be provided in both the primary and the secondary exhausts, leading to greater flexibility in the flow parameters, and thus enhanced flexibility.

The cooling power exerted by the device, in use, may be varied by changing the rate of in-flow of coolant to the device. The height of the coolant outlet may also be adjustable, thereby providing an alternative means of adjusting the cooling power.

Preferably, the coolant is a cryogen. Cryogens are able to exert large cooling powers since they are ejected from the coolant outlet at a low temperature. More preferably, the coolant comprises liquid carbon dioxide.

Liquid carbon dioxide is stored under pressure, and, on entry into an atmospheric pressure environment, solidifies. When impacting on the surface, the solid carbon dioxide sublimes, thus absorbing a large latent heat. Carbon dioxide is therefore an effective coolant. The device is optionally fabricated at least partly from PTFE. PTFE is an appropriate material to use in conjunction with cryogens.

Optionally, the device is adapted for use with welding apparatus. The device may comprise attachment means for attaching the device to a welding rig comprising a welding tool. A particular benefit of the invention is that it may be easily retro-fitted to existing welding rigs. The device is particularly useful in the field of welding since it allows thermal tensioning to be effectively applied to a weld, from the weld side of the workpieces to be joined, without disrupting the welding process. Thus, through use of the invention, thermal tensioning can be applied in an industrially practical manner. In particular, arc-welding processes, that are sensitive to the ambient atmosphere, are expected to benefit from the invention, since it allows thermal tensioning to be applied without coolant gas escaping into the vicinity of the weld tool. Furthermore, the containment of the cryogen spray combined with the extraction of the evolved gas has been found to negate the problem of molten material being ejected from the weld line.

The attachment means may be configured such that the position of the device relative to the welding tool is adjustable. The appropriate position of the device relative to the weld tool will vary in dependence on the nature of the weld. By configuring the attachment means such that this distance can be varied, the device is made more flexible, and can be used to apply thermal tensioning to a wider range of welds, and to a wider range of welding processes.

According to a second aspect of the invention, there is provided a method of cooling a surface comprising the steps of: delivering coolant to the surface, such that coolant gas evolves; and extracting coolant gas from the vicinity of the surface through an exhaust, so as to provide mitigation of the effects of leakage of coolant gas into the ambient environment. By extracting the coolant gas from the vicinity of the surface, it is advantageously ensured that the ambient environment is not affected by the coolant delivery. The inventive method may therefore be applied to provide thermal tensioning to arc welding processes. The method may further comprise the step of balancing the rate of delivery of coolant with the rate of extraction of coolant gas so as to provide the mitigation. Such balancing can be accomplished, for example, by varying the extraction power exerted through the exhaust, and allows efficient cooling to be combined with minimal coolant gas leakage for a given application. The invention extends to a welding method comprising cooling the welded surface according to the above method.

A preferred embodiment of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a perspective view of a device according to a first embodiment of the invention;

Figure 2 is a cross sectional view of the device shown in Figure 1;

Figure 3 is a photograph of the device shown in Figures 1 and 2 in use with a welding tool;

Figure 4 is a graph illustrating the variation in distortion of welded panels with cooling power applied using a method in accordance with an embodiment of the invention;

Figure 5 is a photograph of a device according to a second embodiment of the invention; and

Figures 6a and 6b are photographs of a device according to a third embodiment of the invention.

Referring firstly to Figures 1 and 2, there is shown schematically a coolant delivery device 100 according to a first embodiment of the invention. Figure 1 is a perspective view of the device 100, and Figure 2 is a cross-sectional view of the device 100. Device 100 is intended to be used to cool a surface by delivering a coolant that will vaporise on contact with the surface. Cooling results primarily through the latent heat of vaporisation of the coolant. Such coolants may be cryogenic fluids or solids. Device 100 is therefore made primarily from PTFE, a material that is compatible with cryogenic materials that are typically at very low temperatures. Solid carbon dioxide, for example, sublimes at atmospheric pressure and 194.7 K. It also exhibits a large latent heat and is therefore a particularly efficient coolant. Furthermore, it may be stored, under pressure, as a liquid, solidifying only on entry into an atmospheric pressure environment, and thus it may be easily directed at the surface to be cooled.

Device 100 comprises a housing 150 that is generally cylindrical, hollow, and open at both ends. Coolant enters the device 100 through coolant inlet 120, which extends into the interior of device 100 (as can be seen most clearly from Figure 2) and then axially within the device through centring rings 126, before terminating at nozzle 124. Nozzle 124 ejects the coolant towards one end of the device, at which end there is a seal 180. In operation of the device 100, seal 180 forms a seal between the device and the surface. The coolant, once ejected from the nozzle 124, moves towards the seal end of device 180, where it impacts the surface. The coolant vaporises on contact with the surface, thereby cooling the surface and evolving coolant gas.

The evolved coolant gas is unable to escape device 100 at the seal end of the device due to the operation of seal 180. Instead, coolant gas is substantially constrained to move to the opposite end of the device, at which end is formed primary exhaust 140. Seal 180 in fact comprises two flexible seals: an inner flexible seal 182 and an outer flexible seal 184 (shown in Figure 2). By using flexible seals, it is ensured that the device 100 can move along a surface without breaking the seal between the device and the surface. Inner and outer flexible seals 182 and 184 are concentric, and together define an annular hollow space 104 (shown in Figure 2) in between them. The annular hollow space 104 extends part way up the side of the device 100 to a secondary exhaust 160. Inner brush seal 182 separates the lower part of the interior of device 100 from the lower part of annular hollow space 104, whilst outer brush seal 184 separates annular hollow space 104 from the external environment. Both primary and secondary exhausts 140 and 160 are connectable to vacuum pumps (not shown), so that coolant gas can be actively extracted from the device.

Device 100 is configured so that the coolant in-flow to the device, through inlet 120 (shown by the inwardly directed arrows in Figures 1 and 2), can be balanced with the coolant gas out-flow through the primary and secondary exhausts (shown by the outwardly directed arrows in Figures 1 and 2). This flow balancing is a key property of device 100: if the extraction power is too great in comparison to the coolant in-flow, efficient cooling is not possible since the coolant is extracted from the device before it reaches the surface. On the other hand, if the coolant in-flow is too great in comparison to the extraction power, there will inevitably be leakage of coolant gas through brush seals. When flow balancing is achieved, efficient cooling is combined with minimal leakage of coolant gas. Flow balancing is achieved by varying appropriate flow parameters of the device 100.

The extraction power exerted through the primary exhaust 140 can be varied using collar 142. Collar 142 is provided with a number of holes, as shown most clearly in Figure 1, and is rotatable such that the holes may be aligned to a varying extent with cut-out parts of the upper section of the device 100. A variable amount of air is thus let into the flow through the primary exhaust 140, correspondingly reducing the extraction power exerted at the seal end of the device 100. Flow balancing can thereby be achieved through varying the position of collar 142. Provision of the additional, secondary exhaust 160 enables flow balancing to be achieved more easily. It is thought that this is because, by providing an additional source of extraction power at the to-be-cooled surface, the likelihood of coolant ejected from the nozzle 124 escaping directly through the primary exhaust, without impacting the surface, is lessened. In addition, by exerting extraction power though the annular hollow space 104 surrounding inner flexible seal 182, the likelihood of coolant gas leakage into the external environment is also lessened: in effect, there is provided a double-barrier (by inner and outer flexible seals 182 and 184) against coolant leakage. The extraction power exerted through secondary exhaust 160 is also variable, independently of the primary exhaust extraction power. This independence may be obtained, for example, by choking the flow through the secondary exhaust 160 to the required extent using a valve in the pumping line (not shown).

In practice, flow balancing is achieved entirely through altering the extraction power exerted through the primary and secondary exhausts 140 and 160. Of course, other flow parameters may also be varied. For example, the height of the coolant inlet 120, and thus the coolant nozzle 124, can be varied using sliding height adjuster 122. Furthermore, the rate of coolant in-flow is variable - either through altering the size of nozzle 124, through use of a valve at the coolant inlet 120, or through altering the pressure at which coolant is supplied to the device 100. However, the height of the nozzle 124 and the rate of coolant in-flow are determined by the cooling power required by a given application, and so it is not usually possible to alter either of these parameters in order to achieve flow balancing. In contrast, altering the extraction power exerted though the primary and secondary exhausts 140 and 160 does not alter the cooling power exerted by the device, unless the primary exhaust extraction power is sufficiently large to extract coolant from the device before it reaches the surface.

Whilst coolant delivery devices in accordance with the invention may be used in a wide variety of applications, device 100 is particularly suited to providing thermal tensioning to a weld. As such, device 100 is provided with threaded inserts 110 for attaching device 100 to a welding rig. Device 100 is, in such an application, positioned approximately 60 - 90 mm behind the welding tool or torch, and moves with the welding tool or torch along the weld line as the welding process is carried out. Generally, the higher the thermal input from the welding process, the greater the separation required. The device 100 is attached to the welding rig such that its position relative to the welding tool 300 can be varied so as to optimise their separation. Figure 3 is a photographic image illustrating device 100 in situ attached to a MIG (metal inert gas) welding tool 300, an arc-welding tool. In use, carbon dioxide coolant is used, and the device 100 is adjusted to balance the in-flow of coolant with the out-flow of vaporised carbon dioxide. No carbon dioxide escapes into the ambient environment, and therefore the welding process is not affected.

The results of the application of the thermal tensioning process are illustrated in Figure 4, which is a graph showing the variation in distortion index (on the vertical axis) for three different welded panels (labelled with reference numerals 401, 402, and 403). The distortion index is a measure of the amount of distortion present in a panel. Panels 401 and 402 have been welded using device 100 to apply thermal tensioning to the weld, with a higher cooling power being applied to panel 401 (through use of a larger nozzle size, which permits a more rapid flow of coolant to the welded workpiece surface). Panel 403 has been welded without the application of thermal tensioning. As is seen, panel 403 exhibits the highest distortion index, whilst panels 402 and 401 exhibit progressively less distortion. Whilst some residual distortion is present, even in panel 401, it is thought that this could be eradicated by lessening the separation between the welding torch and the device. In the early stage trials whose results are shown here, this separation was limited to 95 mm minimum, in comparison to an expected optimum separation of 60 mm.

A photograph of a coolant delivery device 500 according to a second embodiment of the invention is shown in Figure 5. The device 500 is very similar to the device 100 of the first embodiment of the invention, and delivers coolant in the same way as is described above in relation to the first embodiment of the invention. The only difference between the device 500 and the device 100 is that the head portion 510 of the device, which contacts the surface to be cooled, is angled slightly relative to the main body 520 of the device 500. In the example shown, the head portion 520 is angled at approximately 30 degrees relative to the main body 520 of the device. As can be seen from Figure 5, this enables the separation between the welding torch 550 and the coolant delivery device 500 to be lessened in comparison to the minimum possible with the device 100 of the first embodiment of the invention. In the case of the device 100, as can be seen from Figure 3, other parts of the welding rig prevent the coolant delivery device from being positioned very closely adjacent to the welding torch: this problem is avoided, in the case of the welding rig on which these tests were carried out, by the slight angling of the head portion 510 of the device 500 relative to the main body 520.

In the case of the arrangement shown in Figure 5, the separation between the device 500 and the welding torch is 60 mm. This separation was chosen in light of the initial trials performed using device 100, and was expected to result in significantly less weld-induced distortion than that found using the device 100. It was found that the distortion of panels welded using the device 500 in the welding rig shown was comparable to the distortion found in plate material free from welds, demonstrating the successful application of thermal tensioning to the arc-welding process. Those skilled in the art will appreciate that similar optimisation of the separation between coolant delivery device and welding torch could be carried out for other welding tasks.

Figures 6a and 6b are side photographic views of a coolant delivery device 600 in accordance with a third embodiment of the invention intended for use with fillet welds rather than butt welds. The device 600 is again very similar to the device 100 of the first embodiment of the invention, and to the device 500 of the second embodiment of the invention, and delivers coolant to a surface in the same way as described above in relation to the first embodiment of the invention. As in the case of the second embodiment of the invention, the head portion 610 of the device 600 is angled slightly relative to the main body 620 of the device. The only difference to the second embodiment of the invention is in the part of the head portion 620 that contacts the surface to be cooled: it is shaped to be conformal with the T-shape of a fillet weld. A flexible seal is also present at the conformal part of the head portion 620 in order to provide a seal between the device and the surface to be cooled, although this is not shown in Figures 6a or 6b.

It is to be appreciated that the above described embodiments are purely exemplary. As will be understood by those skilled in the art, it is possible for a coolant delivery device according to the invention to be made without, for example, means for adjusting the height of the coolant outlet, or indeed without any of the adjustment means included in device 100: in particular, where such a device is to be used repetitively for a single task only, it may be advantageous to produce a device specifically designed to balance coolant in-flow and coolant gas out-flow for that single task. It is noted also that any coolant may be used in conjunction with device 100 – for example, cryogens other than solid carbon dioxide could be used, such as liquid nitrogen. Furthermore, whilst it has been described above to use PTFE to fabricate the device 100, it will be understood by those skilled in the art that any cryogen-compatible material could be used to fabricate the device. Moreover, any flexible seal compatible with cryogenic conditions could be used for seal 180.

Whilst devices according to the embodiments described above are configured to deliver coolant to a planar surface or a surface incorporating a right angle such as may be the case where it is desired to deliver coolant to a fillet weld, it is noted that the device could be modified in order to deliver coolant to any shape of surface. It is envisaged that one device could be provided with means for connecting a variety of head portions, such that one coolant delivery device could be used for a number of different weld configurations. It is also envisaged that the device may be adapted to provide a thermal tensioning mechanism appropriate for use in any type of welding.

The above-described and other variations and modifications are possible without departing from the scope of the invention, which is defined in the accompanying claims. Furthermore, it is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other of the embodiments.

CLAIMS

1. A coolant delivery device comprising a coolant outlet within a housing; the housing defining an opening and an exhaust, the opening being provided with sealing means; and the coolant outlet being arranged to direct a coolant towards the opening; such that, in use of the device to deliver the coolant to a surface to be cooled, at which surface the coolant vaporises to produce coolant gas, the sealing means are operable to form a seal between the housing and the surface, thereby constraining the coolant gas to escape the device through the exhaust.

2. A device as claimed in claim 1 wherein the exhaust is connectable to extraction means operable to extract coolant gas from the device.

3. A device as claimed in claim 1 or claim 2 wherein the exhaust comprises primary and secondary exhausts.

4. A device as claimed in claim 3 wherein the sealing means comprises first and second sealing members, each operable to form a seal between the housing and the surface.

5. A device as claimed in claim 4 wherein the first and second sealing members define a space therebetween, which space provides a part of a passageway through which coolant gas can reach the secondary exhaust.

6. A device as claimed in claim 4 or claim 5 wherein the second sealing member encloses the first sealing member.

7. A device as claimed in any of claims 3 to 6 wherein the primary and secondary exhausts are independently connectable to extraction means.

8. A device as claimed in any of claims 2 to 7 wherein the exhaust comprises adjustment means operable to adjust the rate of extraction of coolant gas from the device.

9. A device as claimed in claim 8 wherein the adjustment means are provided in the primary exhaust.

10. A device as claimed in any preceding claim wherein the housing is generally cylindrical, and the exhaust and the sealing means are located at opposite ends of the housing.

11. A device as claimed in any preceding claim wherein the sealing means comprises a flexible seal.

12. A device as claimed in any preceding claim fabricated at least partly from teflon.

13. A device as claimed in any preceding claim adapted for use with welding apparatus.

14. A device as claimed in any of claims 1 to 13 further comprising attachment means for attaching the device to a welding rig comprising a welding tool.

15. A device as claimed in claim 14 wherein the attachment means are configured such that the position of the device relative to the welding tool is adjustable.

16. A device as claimed in any preceding claim, wherein the coolant is a cryogen.

17. A coolant delivery device substantially as described herein with reference to the accompanying drawings.

18. A method of cooling a surface comprising the steps of:

delivering coolant to the surface, such that coolant gas evolves; and

extracting coolant gas from the vicinity of the surface through an exhaust, so as to provide mitigation of the effects of leakage of coolant gas into the ambient environment.

19. A method as claimed in claim 18, further comprising the step of balancing the rate of delivery of coolant with the rate of extraction of coolant gas so as to provide the mitigation.

20. A method of cooling a surface as substantially as described herein with reference to the accompanying drawings.

21. A welding method comprising cooling the welded surface according to the method of any of claims 18 to 20.

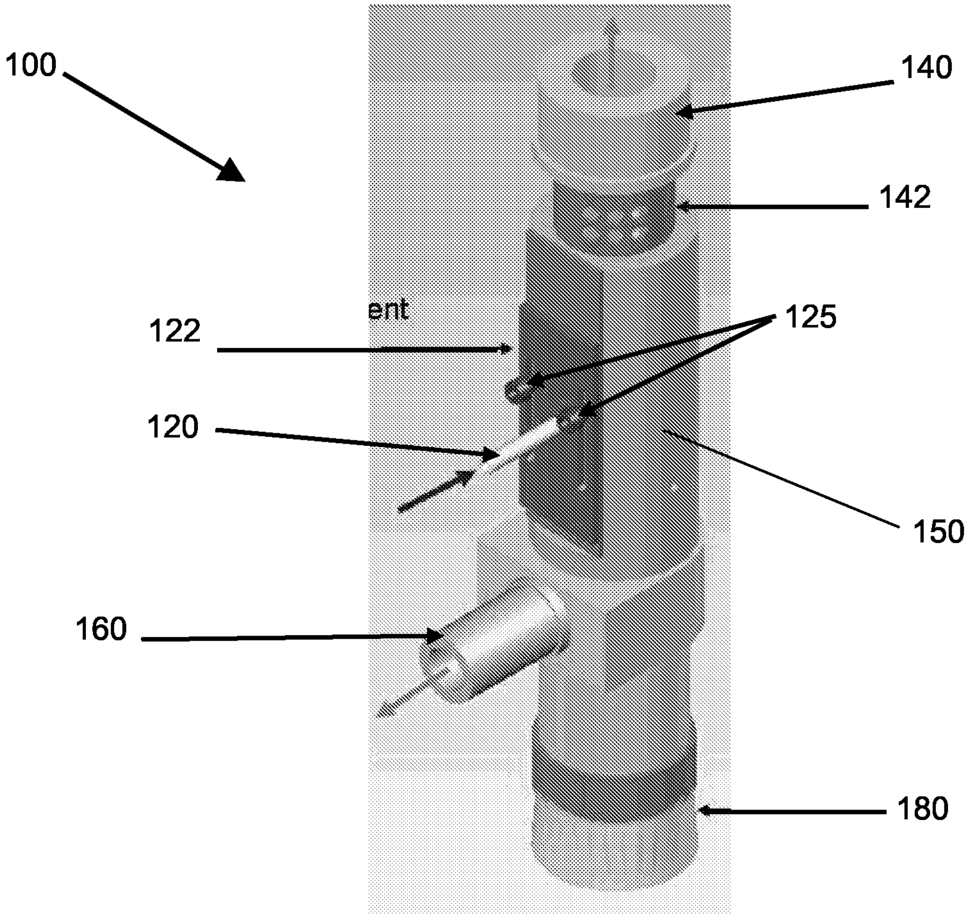

Fig. 1

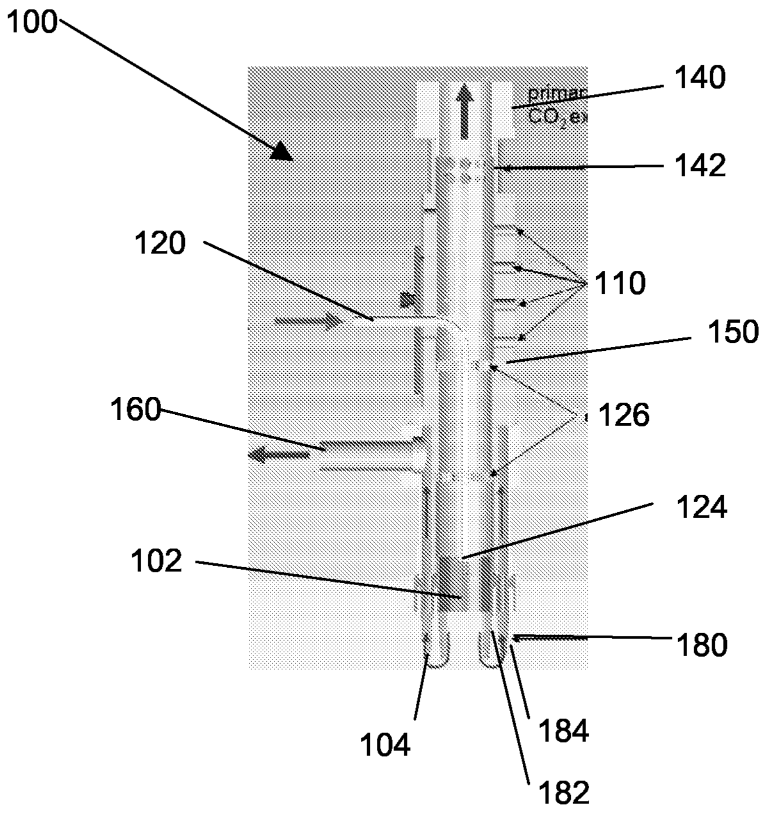

Fig. 2

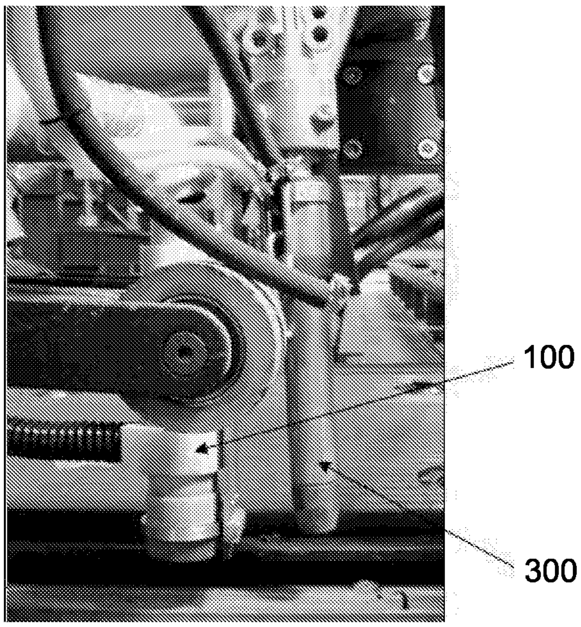

Fig. 3

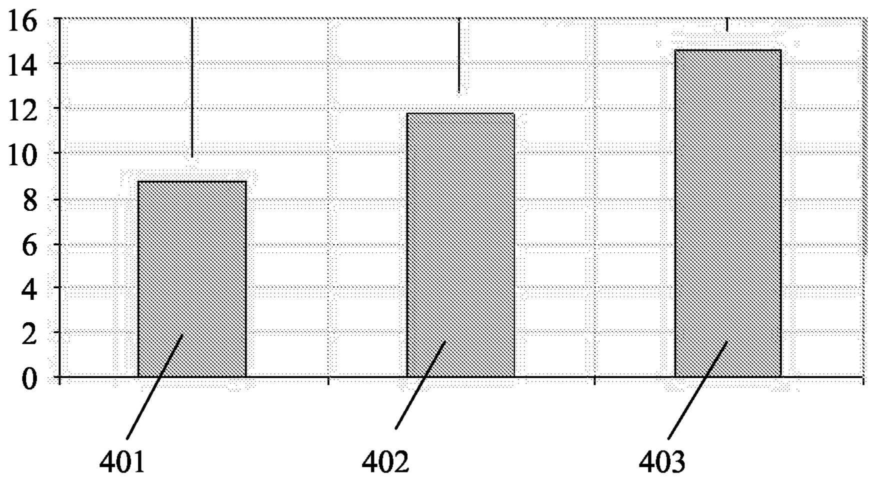

Fig. 4

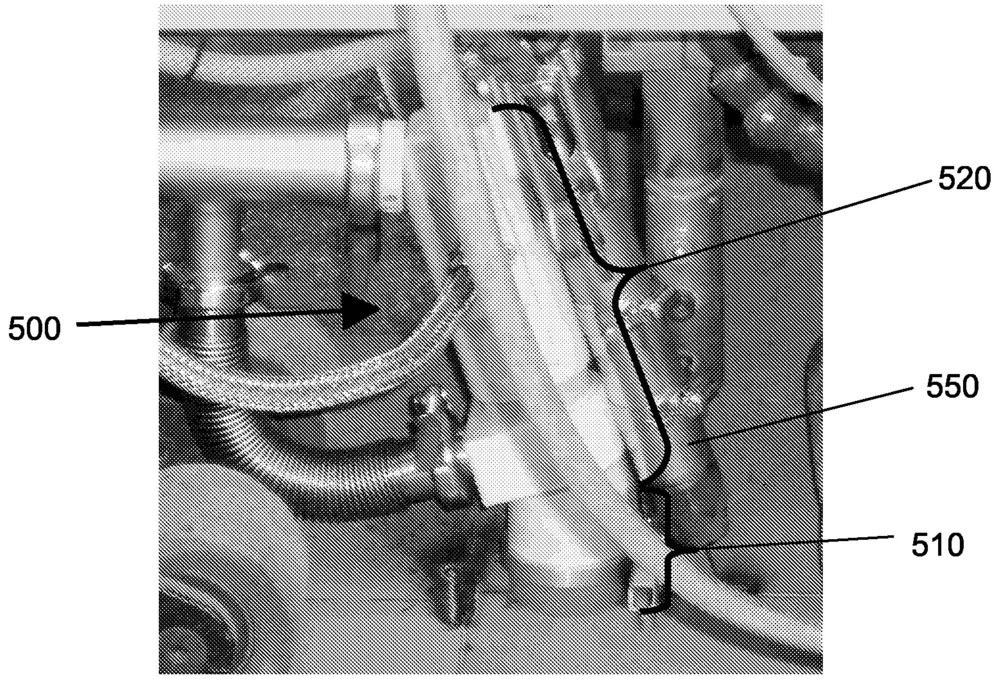

Fig. 5

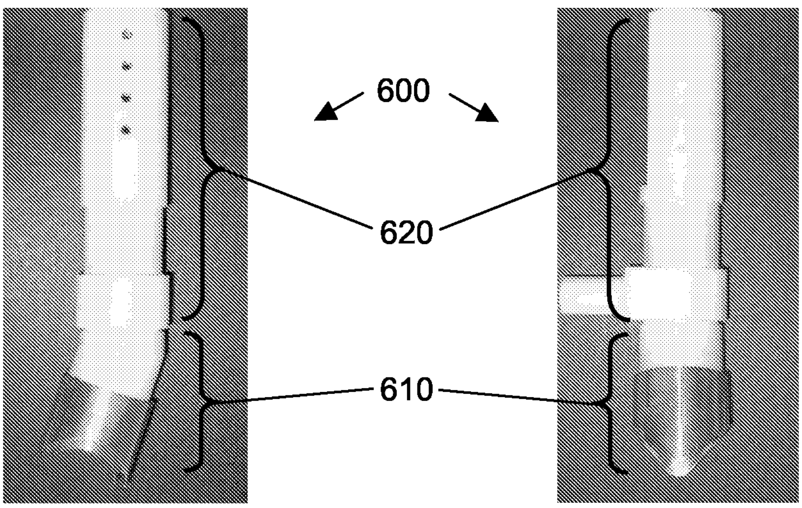

Fig. 6a

Fig. 6b

ERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. B23K37/00

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)
B23K

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 practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 2002, no. 09, 4 September 2002 (2002-09-04) -& JP 2002 153988 A (MITSUBISHI HEAVY IND LTD), 28 May 2002 (2002-05-28) abstract	1,3,4, 13,14
X	EP 1 151 820 A (THE BOC GROUP PLC) 7 November 2001 (2001-11-07) cited in the application the whole document	18,21

☐ 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 document 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
12 April 2007	24/04/2007

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, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	CAUBET, J

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 17,20

Claims 17 and 20 do not comprise any clearly defined feature

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2006/050458

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. [X] Claims Nos.: 17,20
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

ERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2006/050458

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
JP 2002153988	A	28-05-2002	NONE		
EP 1151820	A	07-11-2001	JP	2002028792 A	29-01-2002
			US	2001054639 A1	27-12-2001