(12) UK Patent Application (19) GB (11) 2 257 163 (13) A

(43) Date of A publication 06.01.1993

(21) Application No 9114222.4

(22) Date of filing 02.07.1991

(71) Applicant
Research and Development Chief Controller
Ministry of Defence, Government of India,
New Delhi, India

(72) Inventors
Arvind Bharti
Vikas Kumar Saxena

(74) Agent and/or Address for Service
Urquhart-Dykes & Lord
91 Wimpole Street, London, W1M 8AH,
United Kingdom

(51) INT CL[5]
C22F 1/18

(52) UK CL (Edition L)
C7N N4D1 N4F

(56) Documents cited
GB 2164358 A US 4294631 A US 4287740 A

(58) Field of search
UK CL (Edition K) C7N
INT CL[5] C21D, C22F

(54) **A process for improving the fatigue crack growth resistance**

(57) The present invention relates to a process for improving the fatigue crack growth resistance of α - β titanium alloys and the like alloys/metals which comprises in making, after sandblasting, a single laser trail on the sheet or component of alloy/metal with above a selected power and scan speed and with the focal spot being up to 200 μm above or below the glazing surface. The width of the trail is measured so as to adjust a job manupulator to cause successive scans with an overlap of 5 to 50%. The component is covered by successive scanning under an inert gas at a pressure of 20-48 PSI.

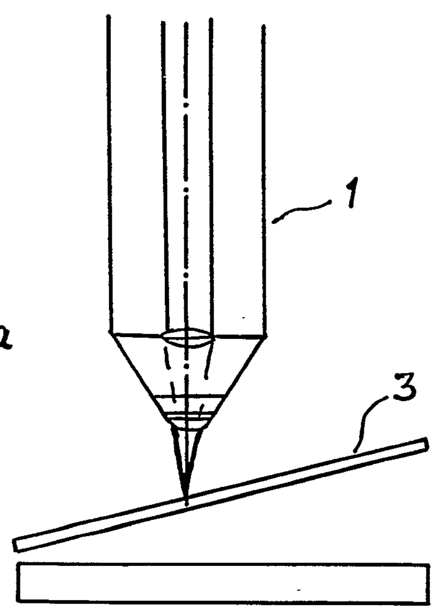


Fig. 1a

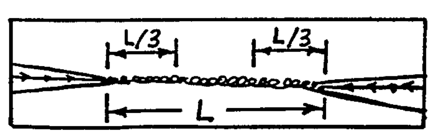


Fig. 1b

GB 2 257 163 A

Fig. 1a

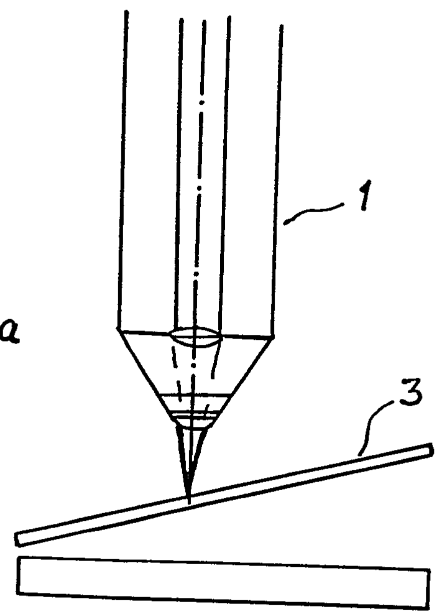
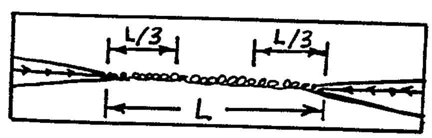


Fig. 1b



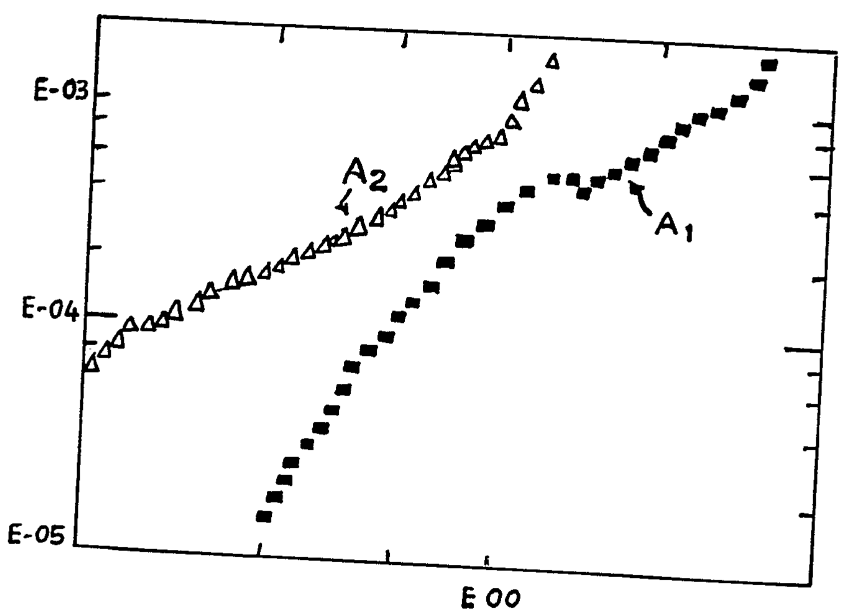


Fig. 2

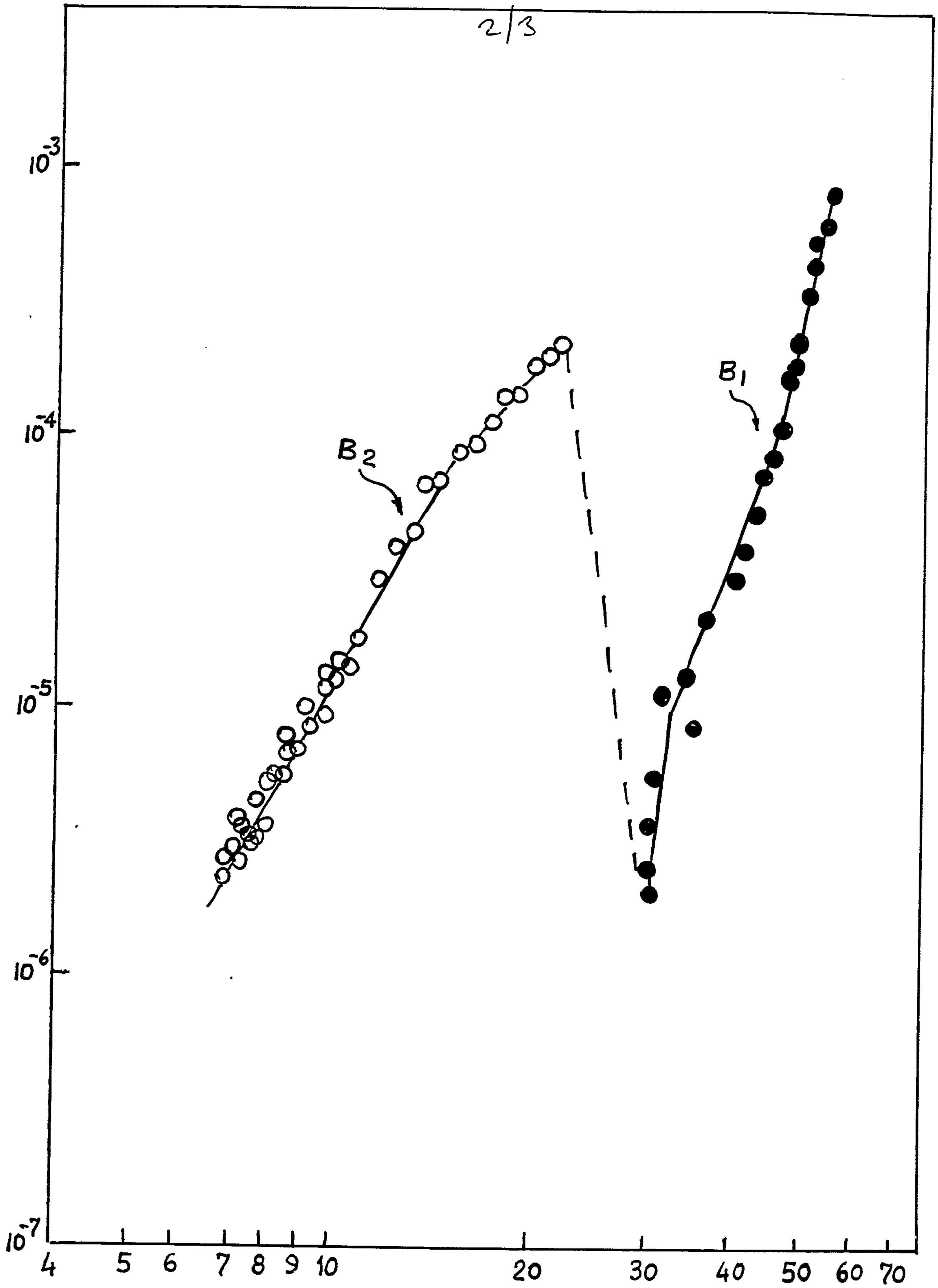


Fig. 3

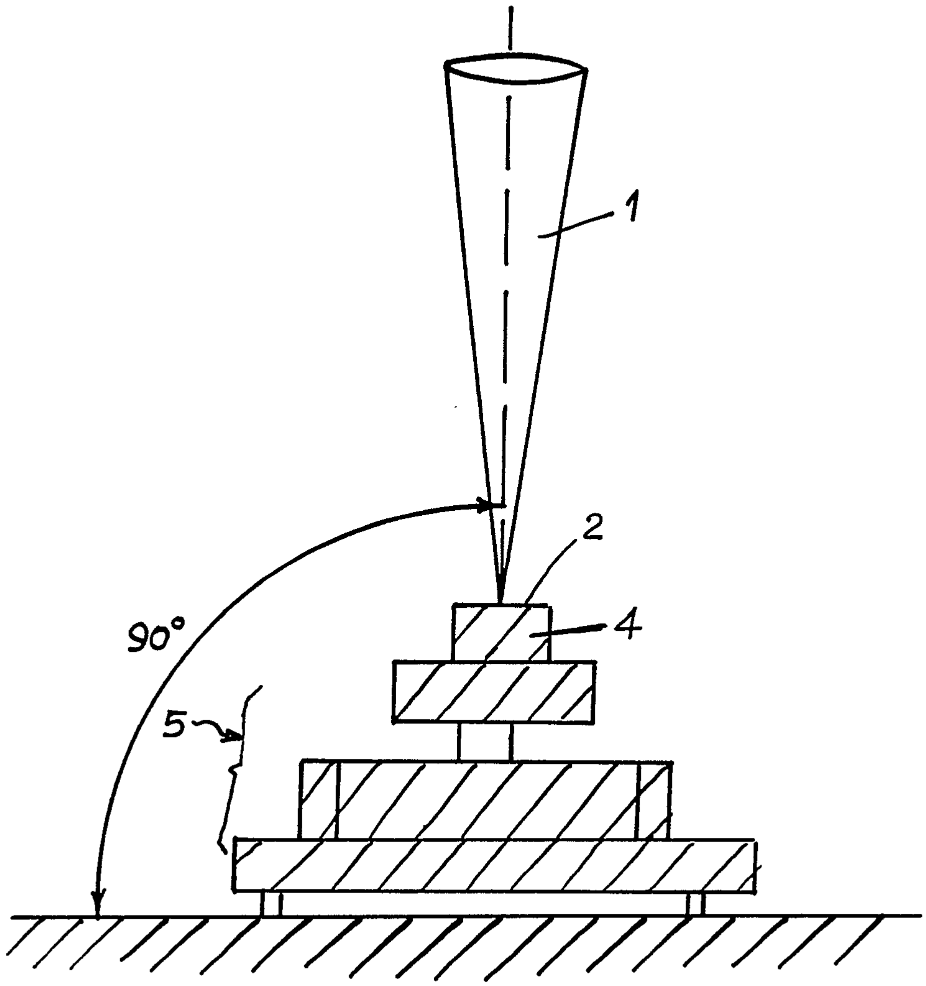


Fig. 4

A PROCESS FOR IMPROVING THE FATIGUE CRACK GROWTH RESISTANCE

FIELD OF INVENTION

This invention relates to a process for improving the fatigue crack growth of Titanium alloys and the like alloys/metals. Specifically, but without implying any limitation thereto, the process of the present invention has a beneficial application in improving the fatigue crack growth resistance of Ti-6.5 Al-3.5 Mo-1.9 Zr-0.23 Si alloy, alpha (α) beta (β) titanium alloys and other alloys/metals capable of retaining a metastable phase on rapid cooling.

PRIOR ART

Titanium alloys have useful applications as aerospace materials, and are employed in aerospace frames as structural material and also in turbine blades of jet engines. Due to the nature of loading in aerospace frames, fatigue properties are of utmost importance. With the emerging use of non-metallic composites for aircraft wings and other structures, titanium alloys have assumed a greater importance as the joining structure for metallic and non metallic components such as wings to the main body of the aircraft.

OBJECTS OF THE INVENTION

The present invention envisages a process for increasing the fatigue crack growth resistance of the

$\alpha-\beta$ titanium alloys and other metallic materials hence increasing its utility and compatibility with new generation non-metallic aerospace components.

Accordingly, a primary object of the present invention is to propose a novel process for improving the fatigues crack growth resistances of titanium alloys and the like alloys/metals.

SCOPE OF THE INVENTION

According to this invention there is provided a process, for improving the fatigue crack growth resistance of titanium alloys and the like alloys/metals, comprising in the steps of sand blasting the alloy component, detemining the exact position and depth of focal spot of laser beam, selecting the scanning speed for the available power of the laser beam, making a single laser trail on a sheet of the same material as component or the component itself with the selected power and scan speed such that focal spot is upto 200 μm above or below the glazing surface, measuring the width of the trail so as to adjust job manupulator in such a way that in successive scans there is an overlap of 5 to 50%, covering the sand blasted surface of the component by successive scanning under a shield of any inert gas such as argon at a pressure of 20-48 PSI.

In accordance with the present invention a sheet or component of alloy/metal is sand blasted with alumina (Al_2O_3). The focal spot of the laser beam is determined and also the scanning speed for the available power of the laser beam is selected for making the laser trail on said sheet/workpiece. The width of the trail is measured so as to provide a predetermined overlap in the successive scans depending upon the thickness of sheet/workpiece. During trail making the distance between the nozzle and the workpiece is kept in the range of 10-25mm.

DESCRIPTION OF INVENTION WITH REFERENCE TO ACCOMPANYING DRAWINGS

Fig.1(a) shows schematic set up for determining the focal spot;

Fig.1(b) shows the shape of laser trail;

Fig.2 shows characteristics of fatigue crack growth;

Fig.3 shows characteristics of fatigue crack growth resistance;

Fig.4 shows the schematic position laser beam, workpiece and the work stations.

The alloy/metal component or sheet is first sand blasted with alumina sand (Al_2O_3) for example of -100 mesh size, at a flow rate of 500 gm/min from a 6mm nozzle at 60-90 PSI pressure, and then the focal spot using a CO_2

laser beam is determined. The determination of the focal spot is in order to ascertain the precise location of the focal point of the invisible infrared CO_2 laser beam (10.6 μm wave length). Such a step is be repeated every time after the laser has been returned after maintanance. This is necessary as after every tuning, the mode configuration changes and the change affects the position of focal spot.

As shown schematically in Fig.1 (a) of the accompanying drawings a long plate 3, such as of 10" (inches) long of the same alloy or metal is moved under the focussed laser beam 1 of 3 Kw at 200 inches per minutes (IPM) velocity at any angle preferably at an angle of 10-15° from horizontal plane. The laser trail is shown in Fig.1(b). As shown in Fig.1b, one third portion of the centre of trail, which have uniform melt width, is the region where the beam is most tightly focussed. Exact angle from the horizon and the location of plate with respect to laser beam helps in calculating depth of focus and the location of the spot with respect to tip of the nozzel.

A high purity argon gas shield is maintained over the component by means of a blowing nozzle having a shield gas pressure of for example 36 PSI for getting optimum result. The improvement in fatigue crack growth resistance are achieved at a pressure of 20-48 PSI. Focal spot is kept between 200 µm above the alloy/metal sheet and 200 µm below the said sheet, and keeping a distance of 10-25mm between nozzle tip and said sheet. Preferably, the focal spot is kept 50 µm above the plate keeping clear distance of 18mm between the nozzle tip and plate, a single trail is again created at the selected scan velocity and laser power combination. Width of this trail is measured. During the processing of actual component, the component and/or the beam movement is controlled in such a way that 10% of the trails are overlapped in the successive passes, and linear velocity of the surface thus glazed should be kept constant throughout the process. The overlapping is varied from 5 to 50% depending upon the thickness of the sheet or workpiece.

With the said conditions of the laser power, scan speed, shield gas pressure, distance from the tip of the blowing nozzle and sand blasted surface the component surface can be covered by successive scanning with laser beam. The process of the present invention provides an increase in the fatigue crack growth resistance of bulk component by a factor ranging from 3 to 100 times.

EXAMPLE 1

6mm thick sheet of an ($\alpha-\beta$ titanium alloy) was treated in above described conditions using 3 Kw power and 40 IPM scan velocity on the surface of a CT (compact tension) sample (specification; width 50mm, half-height to width ratio of 0.6 with L-T orientation). The CT sample thus prepared was precracked under cyclic loading and fatigue crack propagation behaviour was studied.

The result showed minimum of 400% (four times) improvement in fatigue crack growth resistance of the alloy.

EXAMPLE 2

The same alloy was subjected to the process of the present invention described in example No.1 with a different scan velocity of 60 IPM at 3 Kw power. The comparative results are shown in Fig.2a and wherein graph A_1 is with respect to the laser treatment and graph A_2 is that by the conventional treatment.

EXAMPLE 3

A pure iron CT specimen was treated with the process of the present invention described in example no.1 with scan speed of 40 IPM and power 3 Kw. The comparative results are shown in Fig.3 (c) which shows upto 75 times improvement in fatigue crack growth resistance and wherein graph B_1 is the treated glazed surface and B_2 is of the unglazed surface.

The considerable improvement reported in the examples 1 to 3 is due to the following reasons. Firstly, heating the cooling conditions which result due to localized heating by focused laser beam and self quenching, results in retained metastable phases, certain amount of epitaxy and residual stresses on the component surface. Secondly, there is a possibility of some atmospheric nitrogen getting first dissolved in the super hot liquid pool then diffusing to interstitial lattice sites. Such nitrogen may be present there only in traces.

The interstitial nitrogen may also be a contributing factor to the improvement in the fatigue crack growth resistance.

The nitrogen pick up is indirectly controlled by shield gas pressure, shape of the nozzle and the clear distance between the nozzle and work piece.

Configuration, that is the position of the work piece and the position of the focused laser beam should be same as shown in Fig.4 and that movement of the glazing surface, 2, should be parallel to the ground and laser beam 1, should reach it from top perpendicular to the ground.

Any variation in this configuration will affect the location of laser induced plasma and its interaction with incoming laser beam, which may result in variation in the reported properties.

In Fig.4 orientation of the component, 4 to be glazed is showed with respect of laser on a work station, 5.

CLAIMS

1) A process for improving the fatigue crack growth resistance of $\alpha-\beta$ titanium alloys and the like alloys/metals (capable of retaining a metastable phase on rapid cooling) comprising in the steps of sand blasting the alloy component, determining the exact position and depth of focal spot of laser beam selecting the scanning speed for the available power of the laser beam, making a single laser trail on the sheet or component of alloy/metal with above selected power and scan speed such that focal spot is upto 200 μm above or below the glazing surface, measuring the width of the trail so as to adjust job manupulator in such a way that in successive scans there is an overlap of 5 to 50%, covering the sand blasted surface of the component by successive scanning under a shield of any inert gas such as argon at a pressure of 20-48 PSI.

2) A process as claimed in claim 1 wherein the position of the focal spot is 50 μm above the glazing surface.

3) A process as claimed in claim 1 wherein the pressure of said shield of argon is 36 psi.

4) A process as claimed in Claim 1 wherein the nozzle and the workpiece or component is maintained at a distance between 10 to 25 mm.

5) A process as claimed in any of the Claims 1 to 3 wherein said sheet/component is kept at any other angle with respect to the laser beam.

6) A process for improving the fatigue crack growth resistance of $\alpha - \beta$ titanium alloys and the like alloys/metals (capable of retaining a metastable phase on rapid cooling), substantially as hereinbefore described with reference to the accompanying drawings.

7) A process for improving the fatigue crack growth resistance of $\alpha - \beta$ titanium alloys and the like alloys/metals (Capable of retaining a metastable phase on rapid cooling), substantially as hereinbefore described in EXAMPLE 1 or EXAMPLE 2 or EXAMPLE 3.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

9114222.4

Relevant Technical fields

(i) UK Cl (Edition K) C7N

(ii) Int Cl (Edition 5) C21D, C22F

Databases (see over)

(i) UK Patent Office

(ii)

Search Examiner

R B LUCK

Date of Search

12 DECEMBER 1991

Documents considered relevant following a search in respect of claims 1-7

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2164358 (SAIPEM SPA)	1
A	US 4294631 (GEC)	1
A	US 4287740 (ROCKWELL)	1

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

Published 1992 at The Patent Office, Concept House, Cardiff Road, Newport, Gwent NP9 1RH. Further copies may be obtained from Sales Branch, Unit 6, Nine Mile Point, Cwmfelinfach, Cross Keys, Newport, NP1 7HZ. Printed by Multiplex techniques ltd, St Mary Cray, Kent.