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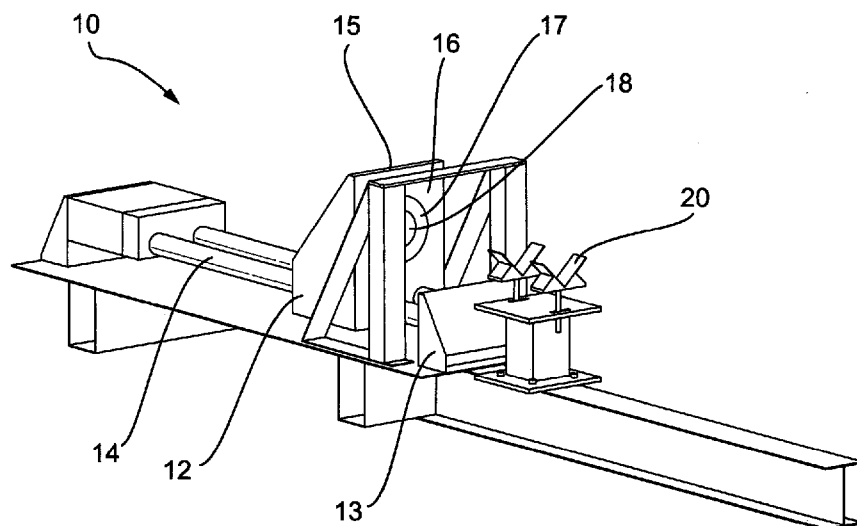
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(54) Title: TEST-RIG AND METHOD FOR ASSESSING THE PERFORMANCE OF BARRELLED DISRUPTORS

Fig. 1



(57) Abstract: A test-rig (10) for assessing the performance of a liquid-jet barrelled disruptor (19) comprises a mount (20) for supporting a disruptor at a predetermined stand-off from an impact surface (16). The total linear momentum delivered by the jet at the impact surface (16) is measured using a ballistic sled (12) and the central axial impulse load of the jet is measured using a pressure gauge (18), such that a coherence metric, which characterises how focussed the jet is, can be derived. A method for assessing the performance of a liquid-jet barrelled disruptor is also described.



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TEST-RIG AND METHOD FOR ASSESSING THE PERFORMANCE OF BARRELLED DISRUPTORS

Technical Field of the Invention

The invention relates to the field of barrelled disruptors and more specifically to a test-rig and method for assessing the performance of barrelled disruptors.

Background to the Invention

Disruption is a process utilised in Explosive Ordnance Disposal (EOD) and Improvised Explosive Device Disposal (IEDD), whereby the key components of an explosive device are rapidly separated to ensure the threat is rendered safe without initiating the device and causing significant damage. One of the tools which can be used to achieve this desirable result is a liquid-jet barrelled disruptor, which utilises a high speed jet or plume of liquid to penetrate a device's outer wall, rapidly break apart critical components and open up the device (or container housing the device, e.g. rucksack, briefcase, etc.) to allow a clear inspection to be made of the debris.

Many different types of disruptors exist, however all models work on the same set of principles. They typically comprise a metal barrel with a breech on one end housing a propellant cartridge. A plastic piston is inserted down the other end of the barrel which is then filled with liquid, typically water, creating a reservoir. Once the cartridge is initiated, the resulting gas pressure accelerates the piston which compresses the liquid to form a high-speed jet which exits the barrel and strikes the target. The impact and transfer of the jet's momentum achieves the desired penetration and device break-up, whilst the hot, rapidly expanding gases generated behind the piston also rush into the target and contribute to the desirable bursting effect which opens it up.

The aim of a water-jet barrelled disruptor is to neutralise an explosive device by disrupting key components of its initiation train without detonating the explosive, thus preventing the device from functioning as intended. Benefits of this approach include the non-sparking

nature of the water jet and the fact that the components of the device are left clearly separated by the jet, rendering the device visibly safe.

The shape and velocity gradient of the water-jet is complex and affected by several factors such as the internal bore and muzzle profiles, the cartridge performance and other effects associated with the internal ballistics of the disruptor. Consequently the performance of different barrelled disruptors is observed to vary significantly, with some being better suited to the barrier penetration and direct impact parts of the disruption process, and others more adept at generating orthogonal effects and bursting open targets. If these effects can be characterised and quantified it is conceivable that disruptors can be designed, to some extent, to generate jets having specific characteristics, more suited to different targets and applications.

Comparative assessment of disruptor performance is generally achieved by firing at generic targets and qualitatively assessing the damage caused. However, the assessment is highly subjective and dependent on the assessor's opinion and a generic target is not representative of the wide range of devices which could be encountered. In addition, the manufacturing costs to produce these targets and the time taken to conduct accurate post-shot assessments results in a time consuming and expensive procedure.

It is an aim of the invention to provide a test-rig and method for assessing the performance of barrelled disruptors, which mitigates the disadvantages identified above.

Summary of the Invention

According to a first aspect of the invention, there is provided a test-rig for assessing the performance of a liquid-jet barrelled disruptor, the test-rig comprising a mount for supporting a disruptor at a predetermined stand-off from a target reference point, means for measuring the total linear momentum delivered by the jet at the target reference point and means for measuring the central axial impulse load of the liquid jet at the target reference point, such that a coherence metric, which characterises how focussed the jet is, can be derived.

A liquid-jet barrelled disruptor is an EOD tool which produces a high velocity jet or plume of liquid to penetrate the outer wall of an explosive device and disrupt it. The liquid may

conveniently be water but may comprise some other aqueous or non-aqueous liquid including gels and liquefying materials.

The test-rig provides the opportunity to physically measure specific parameters of disruptor performance in a repeatable, reliable and cost-effective manner, allowing the performance of different disruptors to be compared in a quantitative and non-subjective way. Specifically the test-rig provides means to measure:

- the central axial impulse load, which is the impulse load exerted normally upon a target by a predetermined central portion of the jet; and
- the total linear momentum delivered by the whole jet as a result of the total impulse load exerted upon a target.

These measurements can be used to derive a coherence metric, which provides a comparative indicator of the degree of focus of the jet.

By dividing the central axial impulse load by the total linear momentum a unit-less value between 0-1 will indicate how focussed the jet is i.e. 1.0 = very focussed (depending on the size of the predetermined central portion of the jet) and < 1.0 will indicate that the area over which the total force is acting on the target exceeds the diameter of the central gauge (i.e. the jet has a broader plume).

The two measured values together with the jet coherence metric provide valuable comparative data for assessing the relative performance of liquid-jet disruptors. For example, the disruptor which provides the highest total linear momentum combined with the most focussed jet (maximum coherence metric = 1.0) might be expected to perform best at simple barrier penetration. However a highly focussed jet might not be so effective in bursting open a container housing an explosive device, because the terminal effects will be localised to the jet trajectory. Therefore, for any given target device there will be an optimum combination of penetration capability and orthogonal effects required to achieve the desired result of rendering the device safe and also opening it up to allow a clear post-assessment.

The means for measuring the total linear momentum may conveniently comprise an impact plate, having an impact surface positioned at the target reference point. The impact surface could optionally be associated with a pressure gauge to directly measure the total axial

impulse load. However, in a preferred embodiment, the impact plate is configured to be movable from a first position. By providing means for timing the relative displacement of the impact plate from its first position then velocity and acceleration can also be calculated. This may be achieved through the provision of a simple pull-wire gauge attached either directly or indirectly to the impact plate, although other timing mechanisms can be envisaged, for example by means of video capture or laser displacement gauge. Assuming that the total mass being displaced is known, then the total linear momentum imparted by the disruptor jet onto the impact surface can be calculated using the equation: $\text{momentum} = \text{mass} \times \text{velocity}$.

It will be appreciated that the effect of friction on the motion of the impact plate should ideally be minimised or at least standardised. One way to achieve this is to mount the impact plate on a ballistic sled, which is slidably mounted on at least one rail, to provide for low friction movement. However, it will be apparent to those skilled in the art that alternative arrangements to provide low friction movement could be considered, such as a pendulum or similar.

The means for measuring the central axial impact load of the liquid jet conveniently comprises a pressure gauge, which may be embedded within the impact surface of the impact plate. Preferably, the pressure gauge is provided substantially centrally of the impact surface and is circular in shape. The mount is configured to support a disruptor aimed at the centre of the pressure gauge. In this way the pressure gauge will record only the axial impulse from the focused central region of the jet, whilst the ballistic sled momentum corresponds to the momentum transferred over the whole area of the impact surface.

Those skilled in the art will appreciate that a maximum theoretical coherence metric of 1.0 is based on an assumption that the total impulse load delivered by the jet is translated into kinetic energy of the impact plate. Any friction losses in the rig will reduce the measured total linear momentum, thereby increasing the calculated coherence metric, which could, in practice, be greater than 1.0 for a very focussed jet. However, provided the test-rig arrangement remains constant for all tests, the coherence metric will remain a valid comparator.

The means for measuring the total linear momentum delivered by the jet and the means for measuring the central axial impulse load of the jet are preferably connected to means for processing data, for example a computer system, which can be configured to record the test-rig measurements and to calculate the required functions, including the coherence metric. Conveniently there is also provided an output means, such as a display or print function, to provide comparative data to the user, for example in the form of pressure versus time traces, momentum versus time traces and coherence metric.

On firing, the disruptor will recoil from the mount. For this reason the test-rig is preferably provided with recoil capture means to absorb the recoil energy and stop the disruptor. The recoil capture means can conveniently be a sheet or net made from Kevlar or other suitable material, absorbent padding, sand bagging, a tether or any other equivalent means.

According to a second aspect of the invention there is provided a method for assessing the performance of a liquid-jet barrelled disruptor comprising the steps of:

- a. Providing a test-rig comprising means for measuring the total linear momentum delivered by the jet and means for measuring the central axial impulse load of the jet;
- b. Supporting a disruptor at a predetermined stand-off from an impact surface of an impact plate;
- c. Aiming the disruptor at the centre of a pressure gauge embedded within the impact surface the impact plate;
- d. Firing the disruptor such that a liquid jet impacts the pressure gauge and causes the impact plate to move from a first position;
- e. Recording the displacement of the impact plate against time and calculating total linear momentum; and
- f. Recording the central axial impulse load measured by the pressure gauge.

A coherence metric can then be calculated by dividing the central axial impulse load by the total linear momentum.

Conveniently the impact plate may be mounted on a ballistic sled which is slidably mounted on a set of low-friction rails.

Brief Description of the Drawings

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

Fig. 1 shows an embodiment of an experimental test-rig for assessing the performance of a liquid-jet barrelled disruptor in accordance with the invention; and

Fig. 2 shows an illustration of a liquid-jet impacting the impact surface of the test-rig.

The drawings are for illustrative purposes only and are not to scale.

Detailed Description

Figures 1 and 2 illustrate an embodiment of an experimental test-rig 10 for assessing the performance of a liquid jet barrelled disruptor 19. The test-rig 10 comprises a ballistic sled 12 set upon a pair of low-friction rails 14. An impact plate 15, having an impact surface 16, is mounted on the ballistic sled 12. A pull-wire gauge (not shown) is connected between the ballistic sled 12 and the end-stop 13 in order to record displacement versus time data. A circular pressure gauge 18 is embedded in the impact plate 15 to form a central part of the impact surface 16. The experimental test-rig of Figure 1 is adapted to receive circular pressure gauges of different diameters, the impact surface 16 including a blanking plate 17 inserted around the pressure gauge 18, as necessary.

A water-jet barrelled disruptor 19 is aimed at the centre of the pressure gauge 18 and supported in position by a disruptor mount 20. The position of the disruptor mount 20 can be adjusted to vary the stand-off distance between the disruptor 19 and the impact surface 16. A Kevlar net (not shown) is arranged behind the disruptor to capture it as it recoils from the disruptor mount 20 after firing.

In use the disruptor 19 is fired to produce a high velocity jet of water 22 directed towards the impact surface 16. The jet imparts an impulse on the impact plate 15 across the impact area 24, which causes the ballistic sled 12 to move along the rails 14. The pull-wire gauge (not shown) registers the displacement as a function of time and this is recorded by a computer

system (not shown). A central portion of the jet impacts the pressure gauge 18, exerting a central axial impulse load which is registered by the pressure gauge 18 and recorded by the computer system (not shown).

The computer system calculates the velocity and acceleration of the sled 12, using the known mass of the combined sled/impact plate arrangement, and hence the total linear momentum delivered to the impact plate. This data is provided to the user in the form of a printed trace. Similarly the central axial impulse load recorded by the pressure gauge can also be provided to the user in the form of a printed load versus time trace.

The performance of different disruptors can be compared by analysing these outputs. To improve consistency the same type of disruptor can be tested several times and the results combined to provide a “standardised” output.

The computer system also calculates the coherence metric by dividing the central axial impulse load by the total linear momentum.

The test-rig and method could form the basis for a standard test protocol for assessing the performance of liquid-jet barrelled disruptors.

CLAIMS

1. A test-rig for assessing the performance of a liquid-jet barrelled disruptor, the test-rig comprising a mount for supporting a disruptor at a predetermined stand-off from a target reference point, means for measuring the total linear momentum delivered by the jet at the target reference point and means for measuring the central axial impulse load of the jet at the target reference point, such that a coherence metric, which characterises how focussed the jet is, can be derived.
2. A test-rig as claimed in claim 1 wherein the means for measuring the total linear momentum comprises an impact plate, having an impact surface positioned at the target reference point.
3. A test-rig as claimed in claim 2 wherein the impact plate is configured to be movable from a first position.
4. A test-rig as claimed in claim 3 which further comprises means for timing the relative displacement of the impact plate from its first position.
5. A test-rig as claimed in claim 3 or claim 4 wherein the impact plate is mounted on a ballistic sled, the ballistic sled being slidably mounted on at least one rail.
6. A test-rig as claimed in any preceding claim wherein the means for measuring the central axial impact load of the liquid jet comprises a pressure gauge.
7. A test-rig as claimed in claim 6 wherein the pressure gauge is embedded within the impact surface of the impact plate.
8. A test-rig as claimed in claim 6 or claim 7 wherein the mount is configured to support a disruptor aimed at the centre of the pressure gauge.
9. A test-rig as claimed in any preceding claim further comprising recoil capture means.
10. A method for assessing the performance of a liquid-jet barrelled disruptor comprising the steps of:

- a. Providing a test-rig comprising means for measuring the total linear momentum delivered by the jet and means for measuring the central axial impulse load of the jet;
 - b. Supporting a disruptor at a predetermined stand-off from an impact surface of an impact plate;
 - c. Aiming the disruptor at the centre of a pressure gauge embedded within the impact surface of the impact plate;
 - d. Firing the disruptor such that a liquid jet impacts the pressure gauge and causes the impact plate to move from a first position;
 - e. Recording the displacement of the impact plate against time and calculating total linear momentum; and
 - f. Recording the central axial impulse load measured by the pressure gauge.
11. A method as claimed in claim 10 further comprising the step of deriving a coherence metric by dividing the central axial impulse load by the total linear momentum.
12. A method as claimed in claim 10 or claim 11 wherein the impact plate is mounted on a ballistic sled, the ballistic sled being slidably mounted on a set of low-friction rails.

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Fig. 1

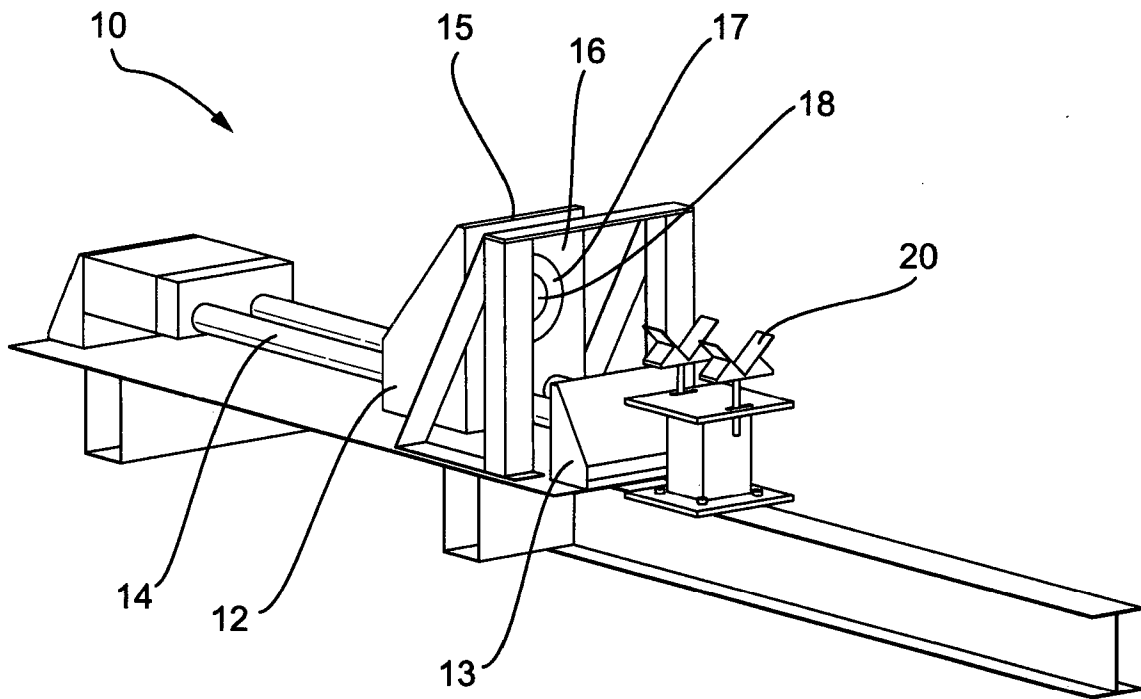
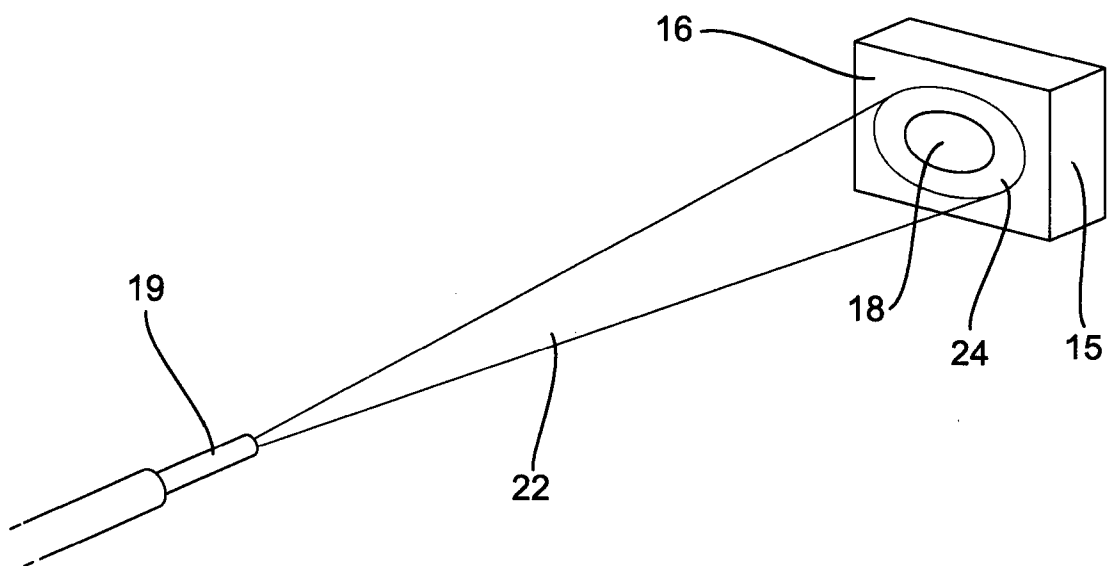


Fig. 2



INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2019/000172

A. CLASSIFICATION OF SUBJECT MATTER

INV. F42B35/00 G01L5/14
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)

F41A F41B F42B G01L

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	US 8 479 435 B1 (GLADWELL T SCOTT [US] ET AL) 9 July 2013 (2013-07-09) column 1, line 15 - line 18; claim 1; figure 1a -----	1,10
A	US 3 444 733 A (CURCHACK HERBERT D) 20 May 1969 (1969-05-20) claim 1; figures 1-5 -----	1,10
A	EP 3 093 608 A1 (RUAG AMMOTEC AG [CH]) 16 November 2016 (2016-11-16) claim 1; figure 1 -----	1,10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 8479435	B1	09-07-2013	NONE
US 3444733	A	20-05-1969	NONE
EP 3093608	A1	16-11-2016	NONE