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(54) Laser detonator

(57) Laser detonator (3) of DDT-type (Deflagration to Detonation Transition) that comprises at least a frame structure (4, 5) and a detonating material (7) placed inside the frame structure, as well as an optical input arranged in the frame structure to guide a detonating pulse, i.e. laser pulse to the detonating material (7). The detonating material (7) of the laser detonator (3) is in an overpressurized state when compared to the normal air pressure to reduce the energy of the detonating pulse required for igniting the detonating material. Furthermore, the invention relates to a detonating system comprising at least the above-described laser detonator (3) as well as a control unit (1) for producing a laser pulse, i.e. the detonating pulse and an optical fiber (2) connecting the laser detonator and the control unit.

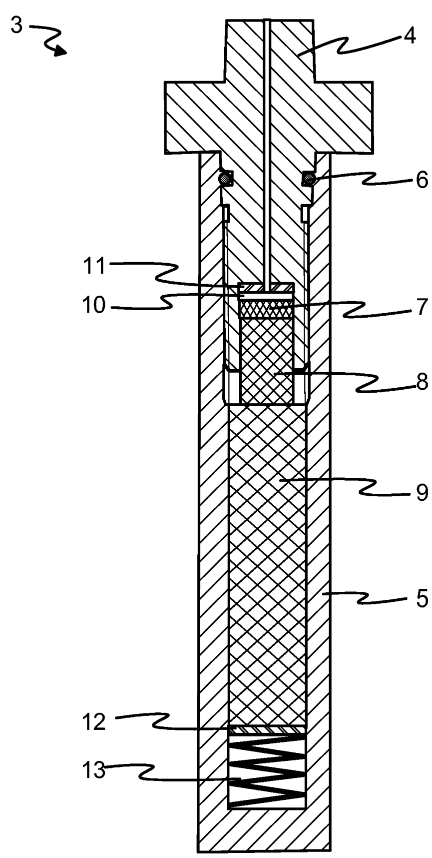

Fig. 2

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Description

[0001] The invention relates to a laser detonator of DDT-type (Deflagration to Detonation Transition) that comprises at least a frame structure and detonating material placed inside the frame structure, as well as an optical input arranged in the frame structure to guide a detonating pulse, i.e. laser pulse to the detonating material. Furthermore, the invention relates to a detonating system comprising at least an above-described DDT-type laser detonator as well as a control unit for producing a laser pulse, i.e. a detonating pulse and an optical fiber for transmitting the detonating pulse.

[0002] There are different kinds of electric blasting caps and detonators that are typically used for detonating various fixed military and civilian explosives in a controlled manner and from a distance. In these solutions electric cables that can often be remarkably long are used for the transmission of the detonating signal. It is possible that electric currents caused by electromagnetic fields and interferences are produced in the long electric cables. Such interferences include for example EMP, lightnings, strong radio transmitters, microwaves, or a rapidly changing strong magnetic field. At present, the number of various devices, such as radio devices that transmit electromagnetic radiation has increased, and they have also become more powerful, wherein the possibility of erroneous detonating signals also increases. Therefore for example various optical solutions have been developed for transmission of the detonating signal, said solutions being characterized in that the detonating signal is transmitted from a control unit to the explosive charge via an optical fiber.

[0003] One military laser application is the ignition of the explosive material in the detonator directly with a laser pulse. The optical ignition chain (i.e. laser beam and optical fiber) from the control unit to the detonator is insensitive to electromagnetic interference. Furthermore, some laser detonators are safe to handle because they do not contain sensitive initial explosives.

[0004] In the future, it is in some applications possible to replace a conventional hot-wire detonator with a laser detonator. As examples it is possible to mention sea mines, ignition of rocket powder, pyrocartridges belonging to the survival systems of aeroplanes as well as exploding bolts and devices relating to space technology.

[0005] The detonation of an insensitive explosive is ignited either with a heat or impulse ignition. In the heat ignition a sufficiently powerful laser pulse is introduced on the surface of the explosive material, said laser pulse producing first a deflagration and immediately thereafter a detonation. Such a detonator is called a DDT detonator (Deflagration to Detonation Transition). In the impulse ignition, in turn, a laser pulse produces a shock wave in a thin metal or carbon film (the speed of said shock wave being typically approximately 6000 m/s), which produces a detonation when meeting the explosive material. Such a detonator, in turn, is called a slapper detonator.

[0006] In the above-mentioned solutions high-power lasers are required to produce a deflagration and/or detonation in a reliable manner in the explosive material of the detonator. High-power laser transmitters, in turn, are expensive, large in size and difficult to move, and therefore the aim has been to develop more sensitive detonators that would operate with lower power.

[0007] US patent publication 4,898,095 discloses a detonator discharged with a laser beam, in which a laser beam produced with a laser, such as a YAG laser is guided to the detonating part of the detonator, which according to said invention is manufactured of an explosive material that is well capable of absorbing the energy of the laser beam. It is suggested that such a laser detonator functions at the lower maximum power of the laser pulse of an oscillating laser transmitter. However, such a laser detonator requires a relatively efficient laser transmitter to be able to function, said laser transmitter being large in size and too expensive for wide-ranging use on the field.

[0008] The main purpose of the present invention is to disclose a laser detonator of DDT-type that can be discharged with low laser pulse energy.

[0009] To attain this purpose the laser detonator according to the invention is primarily characterized in that the detonating material is in an overpressurized state when compared to the normal air pressure to reduce the energy of the detonating pulse required for igniting the detonating material.

[0010] The detonating system according to the invention, in turn, is primarily characterized in that the detonating material is in an overpressurized state when compared to the normal air pressure to reduce the energy of the detonating pulse required for igniting the detonating material.

[0011] The other, dependent claims will present some preferred embodiments of the invention.

[0012] It is the basic idea of the invention to produce the detonating unit of the detonator in such a manner that the energy level required by the detonating pulse is low. According to the invention, the energy level can be reduced sufficiently by pressurizing the detonating unit, and especially the compressed detonating material that is made of a suitable material such as penthrite, hexogen (RDX), octogen (HMX), trinitrotoluene (TNT) or tetryl. The pressure prevailing in the detonating unit is advantageously 20 to 50 bar, i.e. 2 to 5 MPa, preferably over 30 bar, i.e. 3 MPa. A detonating pulse, i.e. a laser pulse is conveyed optically to the detonating unit. In its impact point the energy of the detonating pulse causes the deflagration of the compressed detonating material, said deflagration rapidly transforming itself into detonation. From the detonating unit the reaction proceeds to the actual ignition point via the compressed detonating material and detonating fuses.

[0013] The detonator implemented in accordance with the invention can be made to function at a lower detonating pulse energy when compared to known solutions. The detonating pulse can be advantageously produced with a low-power laser that can be easily moved, preferably with a semiconductor laser such as a diodelaser. Said laser unit and its equipment and power sources can be easily carried by one person, because of its very small size, and it is possible to use batteries as an energy source therein.

[0014] Furthermore, said semiconductor lasers are considerably less expensive than solid lasers and gas lasers, and therefore it is possible to use a semiconductor laser widely in so-called mass products.

[0015] In the following, the invention will be described in more detail with reference to the appended principle drawings, in which

Fig. 1 shows an embodiment of the laser detonating system according to the invention,

Fig. 2 shows an embodiment of the laser detonating device according to the invention in a cross-section, and

Fig. 3 shows the energy of a detonating pulse required for the ignition of an energetic material in different pressure values.

[0016] For the sake of clarity, the Figures only show the details necessary for understanding the invention. The structures and details which are insignificant in view of understanding the invention but which are obvious for anyone skilled in the art, have been omitted from the Figures in order to emphasize the characteristics of the invention.

[0017] Figure 1 shows, in principle, a laser detonator 3 and a control unit 1 according to the invention. The laser detonator 3 is typically placed in the explosive charge to be detonated, but the laser detonator can also be used for another purpose, still maintaining the basic idea of the present invention.

[0018] By means of the control unit 1 a detonating pulse, i.e. a laser pulse is produced by means of a suitable laser that is preferably a semiconductor laser, such as a diodelaser. If the aim is to produce a detonating pulse for several different laser detonators 3 by means of one control unit 1, and/or if the laser detonators are located substantially far away, it is in some cases advantageous to use a more powerful laser than for example an Nd-YAG laser.

[0019] From the control unit 1 the detonating pulse is transferred to the laser detonator 3 via an optical fiber structure 2, i.e. an optical fiber. Suitable optical fiber type 2 is selected according to the operating conditions, but typically a single mode fiber is used. The optical fiber 2 is connected both to the control unit 1 and to the laser detonator 3, advantageously by means of a connector.

[0020] The laser detonator 3 according to the invention can be formed in several different ways, but Fig. 2 shows in cross-section one advantageous embodiment of the laser detonator. Said laser detonator 3 comprises a frame part 4 and a sleeve 5 attached thereto, the other end of said sleeve 5 being closed. The frame part 4 and the sleeve 5 can be made of many suitable materials, such as metal or composite material, but preferably they are made of steel or aluminium. The sealing between the frame part 4 and the sleeve 5 is by means of a suitable structure, such as an O-ring seal 6 presented in the example, but it is also possible to apply other ways and to maintain the basic idea of the present invention. The possible connection must, however, enable the pressurization of the compressed detonating material 7 in accordance with the invention.

[0021] In the embodiment according to the example, a compressed detonating material 7, an intermediate detonating fuse 8 and a detonating fuse 9 made of suitable explosive materials are placed in the cavity inside the frame part 4 and the sleeve 5. The compressed detonating material 7 is made of an explosive material with suitable reaction properties. Advantageous materials include for example penthrit, hexogen (RDX), octogen (HMX), trinitrotoluene (TNT), tetryl, CL-20 (i.e. hexanitrohexaazaisowurtzitane i.e. HNIW), FOX-7 (i.e. diamino-dinitroethene) as well as various explosives based on the PBX technology (Plastic Bonded Explosives).

[0022] The intermediate detonating fuse 8 and the detonating fuse 9 are made of such a suitable explosive material by means of which a reaction speed suitable for the purpose can be attained. Advantageous explosive materials include for example the aforementioned penthrit, RDX, HMX, TNT, tetryl, CL-20, FOX-7 and PBX-explosives.

[0023] In the embodiment according to the example, the cavity inside the frame part 4 and the sleeve 5 is overpressurized when compared to normal air pressure. In practice, an advantageous pressure level is 2 to 5 MPa, preferably over 3 MPa. In said embodiment the overpressurized space contains the compressed detonating material 7, the intermediate detonating fuse 8, and the detonating fuse 9, because said space is undivided. In view of the invention it is an essential aspect that at least the compressed detonating material 7 is placed in the space in which overpressure prevails. In some embodiments it is possible to place the intermediate detonating fuse 8 and/or the detonating fuse 9 in a space having a pressure level that deviates from the pressure level of the compressed detonating material 7. It is, however, often most advantageous to construct the laser detonator 3 according to the invention in such a manner that the same pressure prevails in the compressed detonating material 7 and in the possible intermediate detonating fuse 8 and/or detonating fuse 9.

[0024] Furthermore, the laser detonator 3 comprises other necessary structures by means of which the sealing of the structure and the stability of the different parts are ensured. The embodiment of the laser detonator 3 shown in Fig. 2 comprises for example a supporting ring

11, a supporting plate 12 and a spring 13, as well as a quartz glass window 10 via which the laser pulse is guided to the compressed detonating material 7. The window structure 10 can also be made of other suitable material than quartz glass, such as for example sapphire.

[0025] The detonating pulse coming from the laser, preferably diodelaser of the control unit 1 is transmitted on the surface of the compressed detonating material 7 via a suitable optical input arranged in the laser detonator 3. The optical input can be constructed in various ways, and of several suitable materials, and it is advantageous to form the optical input in accordance with the laser that is being used. In the example, the optical input is arranged via an optical fiber placed via holes formed in the frame part 4 and in the supporting ring 11 of the laser detonator 3 further via the quartz glass window 10 on the surface of the compressed detonating material 7. When the energy of the detonating pulse is sufficiently high at the impact point, deflagration is generated in the compressed detonating material 7, said deflagration transforming rapidly into detonation, which, in turn, proceeds through said compressed detonating material, propagating to the intermediate detonating fuse 8 and to the detonating fuse 9 and therefrom to the actual detonating target.

[0026] By means of the pressurization of the laser detonator 3 according to the invention it is possible to reduce the energy of the detonating pulse necessary for ignition of the explosive material, wherein the detonating pulse can be produced with a lower-power laser, for example advantageously with a diodelaser. Fig. 3 shows the energy necessary for the ignition of an energetic material in millijoules (mJ) when the pressure varies between 10 and 50 bar (i.e. 1 and 5 MPa). The results according to the example are obtained by using RDX as the energetic material and a diodelaser of 2.6 W as the laser, the length of the pulse being 100 ms and the wavelength 808 nm. The Figure shows that for example by increasing the pressure from 10 bar to 50 bar (i.e. from 1 MPa to 5 MPa), the energy required for the ignition is reduced from 12 mJ to 3.6 mJ. The magnitude of the ignition energy is, of course, different for different materials, but the presented reduction in the required ignition energy while the pressure increases is common to the above-mentioned explosive materials. For this reason different materials have slightly different pressure levels which typically exceed 2 MPa.

[0027] The more precise type of the laser that is being used is advantageously selected in accordance with the material used as the compressed detonating material 7. It is advantageous to select the laser in such a manner that the power required therefrom is as low as possible, and therefore the length of the pulse as well as the wavelength should be such that the energy of the pulse would be absorbed as well as possible in said energetic material, thus producing deflagration.

[0028] It is, of course, obvious that the invention is not limited solely to the embodiment presented in the example above, but for example the laser detonator 3 can be formed in various different ways, wherein for example its shape as well as the location and number of its parts can deviate from that presented in the example. Furthermore, the explosive material that is being used can deviate from the one presented in the example, and the number, shape and mutual location of separate compressed detonating materials 7 and detonating fuses 8, 9 can vary in accordance with the purpose of use.

[0029] In some embodiments, it is also possible to replace the laser with another radiating radiation source whose radiation can be transmitted via optical structures and whose ignition energy is sufficiently high.

[0030] By combining, in various ways, the modes and structures presented in connection with the different embodiments of the invention presented above, it is possible to produce various embodiments of the invention in accordance with the spirit of the invention. Therefore, the above-presented examples must not be interpreted as restrictive to the invention, but the embodiments of the invention can be freely varied within the scope of the inventive features presented in the claims hereinbelow.

Claims

1. A laser detonator (3) of DDT-type, comprising at least

   - a frame structure (4, 5),
   - a detonating material (7) placed inside the frame structure (4, 5), and
   - an optical input that is arranged in the frame structure (4, 5) to guide the detonating pulse i. e. laser pulse to the detonating material (7),

   characterized in that the detonating material (7) is in an overpressurized state when compared to the normal air pressure to reduce the energy of the detonating pulse required for igniting the detonating material.

2. The laser detonator (3) according to claim 1, **characterized in that** the magnitude of the overpressure is 2 to 5 MPa.

3. The laser detonator (3) according to claim 1, **characterized in that** the detonating material (7) is made of penthrite, hexogen (RDX), octogen (HMX), trinitrotoluene (TNT), tetryl, FOX-7, CL-20 or PBX explosive material.

4. The laser detonator (3) according to any of the preceding claims, **characterized in that** it also comprises at least

   - an intermediate detonating fuse (8)
   - a detonating fuse (9)

that are made of penthrite, hexogen (RDX), octogen (HMX), trinitrotoluene (TNT), tetryl, FOX-7, CL-20 or PBX explosive material.

5. The laser detonator (3) according to any of the preceding claims, **characterized in that** it also comprises at least a quartz glass window (10) as a part of the optical input structure.

6. A detonating system that comprises at least

- a control unit (1) for producing a laser pulse, i.e. a detonating pulse,
- a laser detonator (3) of DDT-type, comprising at least
    - a frame structure (4, 5),
    - a detonating material (7) placed inside the frame structure (4, 5), and
    - an optical input that is arranged in the frame structure (4, 5) to guide a detonating pulse to the detonating material (7),
- an optical fiber (2) for transmitting the detonating pulse,

characterized in that the detonating material (7) is in an overpressurized state when compared to the normal air pressure to reduce the energy of the detonating pulse required for igniting the detonating material.

7. The detonating system according to claim 6, **characterized in that** the magnitude of the overpressure is 2 to 5 MPa.

8. The detonating system according to claim 6, **characterized in that** the laser pulse is generated by means of a semiconductor laser.

9. The detonating system according to claim 6, **characterized in that** the laser pulse is generated by means of a diodelaser.

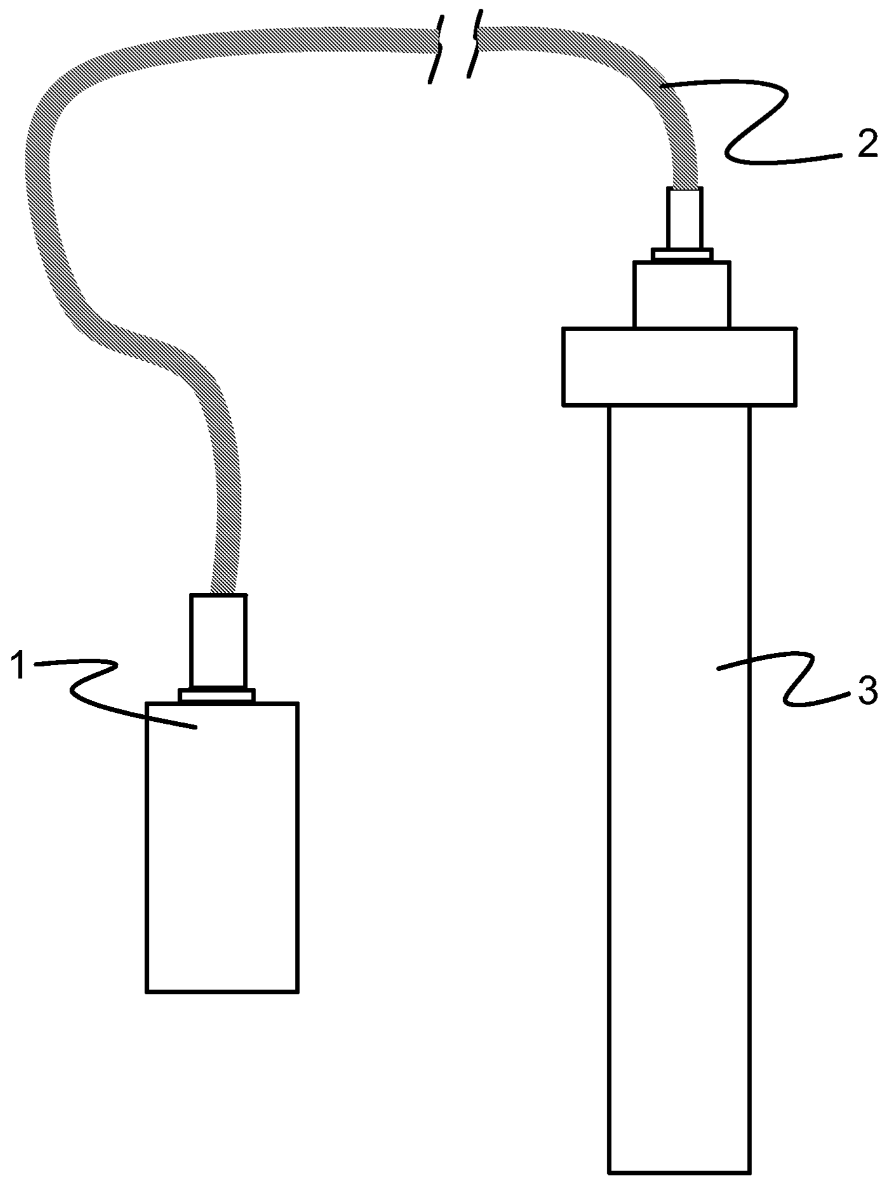

Fig. 1

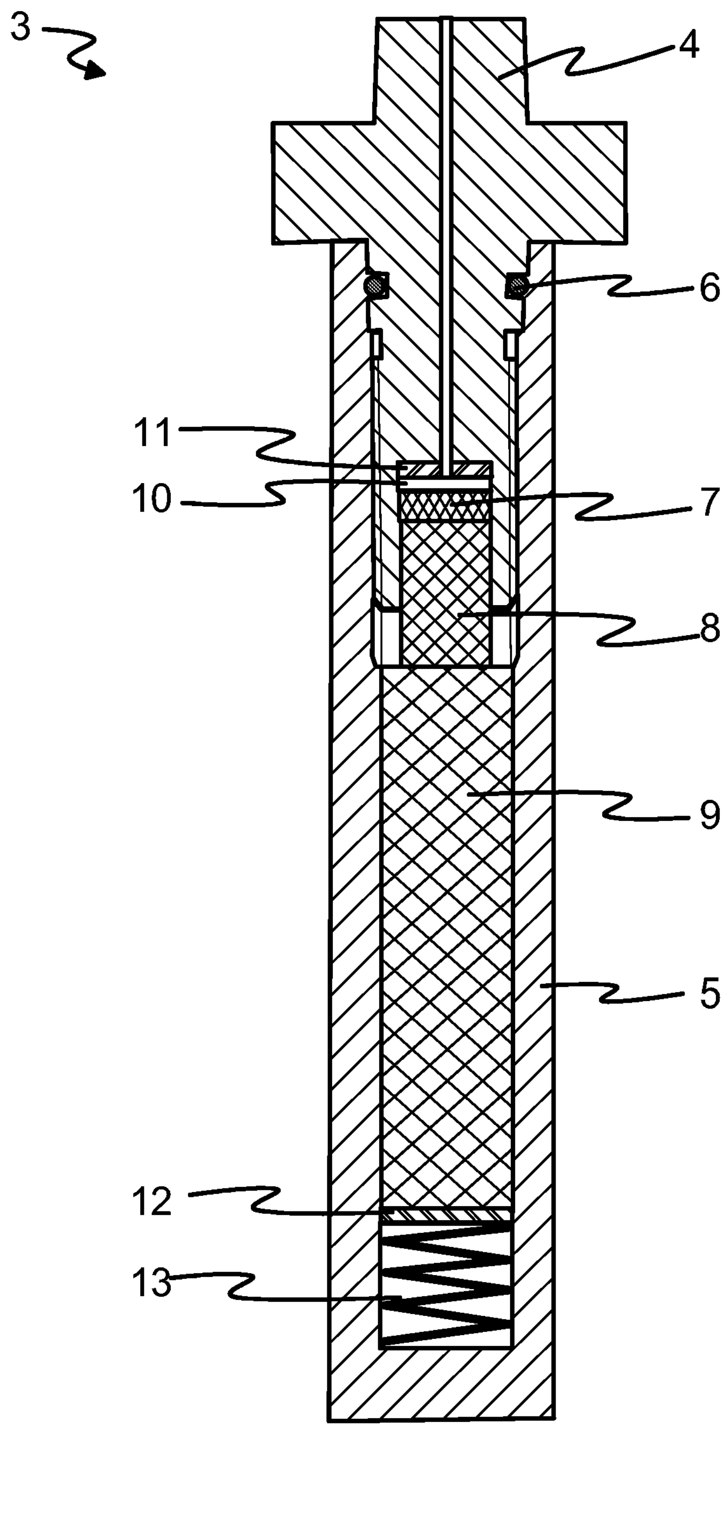

Fig. 2

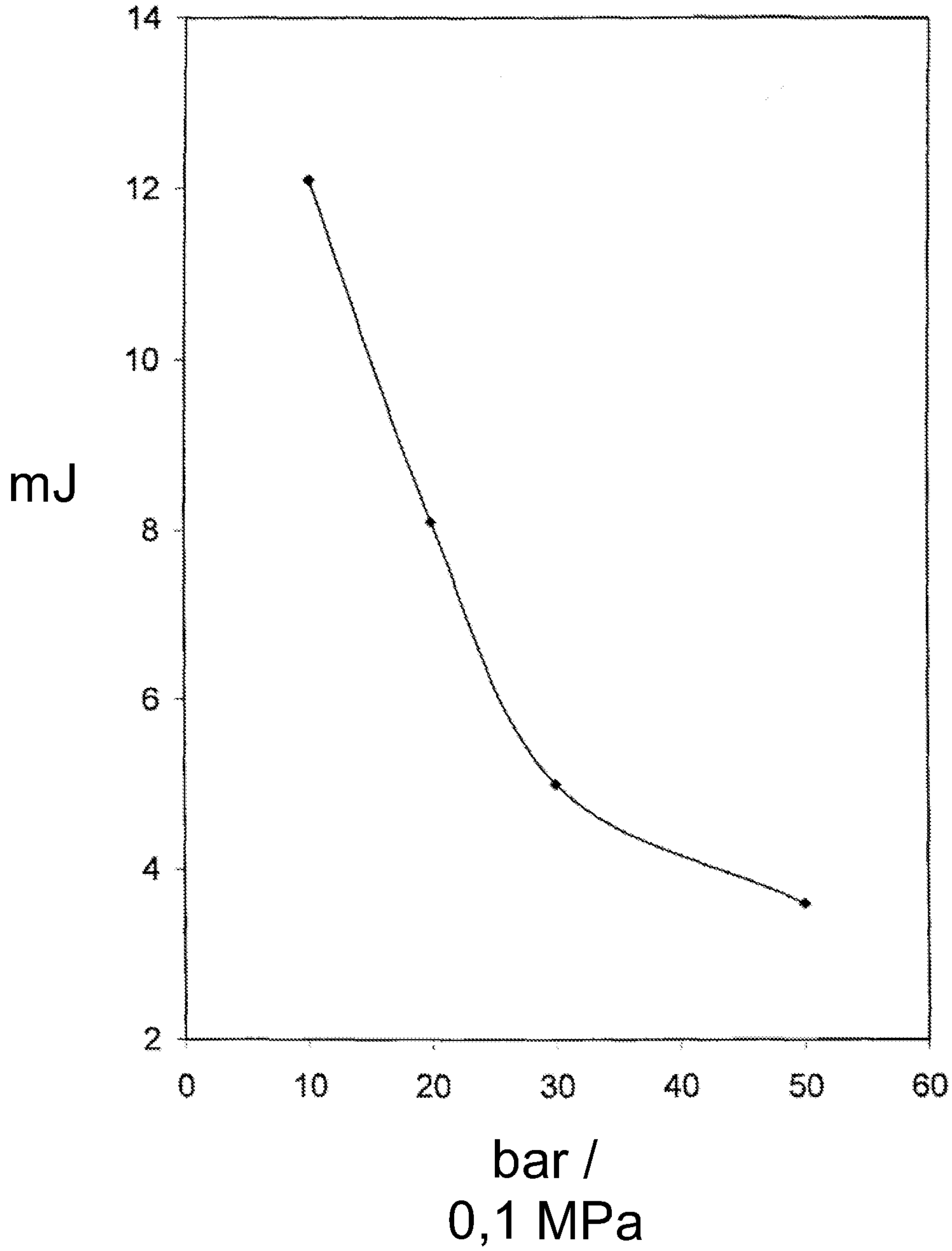

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 04 39 7005

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 5 099 761 A (BETTS ROBERT E ET AL) 31 March 1992 (1992-03-31) * column 3, line 30 - column 4, line 30; figures 1-4 * ---	1	F42B3/113
A	US 6 276 276 B1 (ERICKSON KENNETH L) 21 August 2001 (2001-08-21) * column 4, line 55 - column 7, line 10; figure 1 * ---	1	
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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 April 2004	Van der Plas, J

CATEGORY OF CITED DOCUMENTS

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