

Device for Inscribing Materials with a Laser

Description

- 5 The invention relates to a device for inscribing materials with a laser according to the introductory clause of Claim 1.

10 The text, Walter W. Weinfurtner, "Licht schreibt - Beschriften mit dem Laser in der Industrie: Grundlagen und Einsatzgebiete", Expert-Verlag 1995 (Kontakt & Studium; Volume 479) disclosed the principle and the basic structure of a laser inscriber, consisting of a solid-state laser with a laser head with for example an optical
15 path, on which the individual optical components are mounted in such a way as to ensure temperature stability and mechanical stability.

20 In the laser head of the solid-state laser there is a resonator, which consists of a so-called pump chamber, two reflectors and an acoustic-optical switch, a so-called Q-switch. In the pump chamber there is a YAG crystal rod and one or several krypton arc-lamps whose light is reproduced in the crystal rod which emits light with a certain
25 wavelength at both ends. This light is reflected by the two reflectors back into the crystal rod, whereby the reflector at the rear end of the resonator reflects around 99.9%, whereas the front reflector transmits 12% and thus forms the operating beam. The Q-switch interrupts the

operating beam up to 40,000 times per second and thus produces output peaks up to 1000 times the continuous wave laser operation.

5 Furthermore, the resonator contains a mechanical switch (shutter) for interrupting the laser beam and a support, in which a mode filter is set to suit the specific application, in order to achieve higher beam quality (including for example in basic mode operation). In a beam
10 spreader, the laser beam leaving the resonator is spread by factor 2 to 10. The spread laser beam is refracted in a refraction unit by means of two galvanometer reflectors in x and y direction and focused on a work-piece by means of a flat field focusing lens.

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Further components of the existing laser inscriber are a computer for driving a control unit which controls the refraction device, a Q-switch driver and a power pack. An additional, costly cooling device is provided for cooling
20 the pump chamber.

The existing laser inscriber is formed as a laser installation with an x-y stage table, a round switching table with input and output tunnel and possibly a twin-
25 head configuration, like when it is used as a solid-state laser for material processing too, i.e. for separating, joining, boring and the like with high laser power, whereby the laser is additionally to be connected to a power supply cabinet and possibly to an external heat
30 exchanger. A laser inscription installation of this nature, as is also the object of DE 33 18 768 A1, has a bulky construction and can therefore only be used at fixed locations. Such an installation also has a considerable power consumption and a low rate of efficiency, as a large
35 proportion of the power must be removed by means of the cooling device in order to ensure problem-free operation.



5 A laser installation of this nature has considerable dimensions and requires a water supply for cooling the laser. It also requires a three-phase current connection with a power consumption of around 8 kW. This laser installation requires much maintenance, as the presence of the water supply means that an ion exchanger and a particle filter are necessary. High lamp consumption and considerable wear and tear of the pump chamber must also
10 be taken into consideration.

As can be seen from DE 33 18 768 A1, a laser inscription installation of this nature also requires a costly alignment device and a refraction head containing numerous
15 optical components whereby there is a scattering lens and a converging lens of the widening lens system, reflectors and the like. These make the manufacture, maintenance and operation of the existing laser inscription installation expensive.

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It is an object of the present invention to create a device for inscribing virtually any materials with a laser with considerably smaller dimensions and considerably lower weight as well as optimum handling and the greatest
25 possible mobility whereby this is achieved with low manufacture and operating costs, as well as low power consumption, low maintenance requirements, and high down times.

30 According to the invention, this object is achieved by the characteristics of Claim 1.

The solution according to the invention creates a mobile device for inscribing objects with a solid-state laser,
35 whereby this device is characterised by small dimensions and low weight as well as by simple construction. The form

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of the inscription device can differ both in relation to data input and in relation to the output head. It can also be connected to any peripheral devices such as a digital video camera, a CCD image sensor, a scanner and the like.

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By bringing together several respective components in at least one package, the configuration of the inscription laser can correspond to an application-oriented structure.

10 In a first embodiment of the solution according to the invention, the inscription device consists of a hand-held device which contains a refraction unit and a solid-state laser and is connected by means of a cable connection to a support device which has a control unit and a power pack -
15 for example an accumulator and / or a mains unit. In addition, there is an interface for connecting the control unit to an external control and / or input unit.

In a second embodiment of the solution according to the
20 invention, the hand-held device contains only the refraction unit and is connected by means of a glass fibre cable to a support device which contains the solid-state laser, the control unit and the power pack. In this case also, there is an interface for connecting the control
25 unit to the external control and / or input unit.

In a third embodiment of the invention, all the components can be brought together in one package which is formed as a hand-held device or a desk-top device.

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In all three embodiments of the invention, the dimensions are so compact that the hand-held device can for example be formed as a gun and the support device can be housed in a package which can be attached to a user by means of a
35 waist and / or shoulder strap. With this construction,

maximum mobility is achieved and this enables the user to carry out laser inscriptions at any location independently of a power supply cabinet and the like.

5 It is particularly advantageous if the hand-held device is connected to a sensor unit, for example a scanner, a video camera or a digital camera. For example, this enables an image to be recorded with the sensor unit and to be produced on an object by means of the hand-held device.
10 Therefore, the device is preferably suited for the administration of a warehouse used for the storage of goods which have a bar-code for identification purposes. For example, the bar-codes are read by means of the scanner, transmitted to a computer located in the hand-
15 held device or to another superordinate central computer, where they are processed. Should it ever be necessary to change the bar-code, the old bar-code can easily be made indecipherable / removed by means of the hand-held device and the new bar-code can be put on the goods.

20 In an advantageous embodiment of the solution according to the invention, there is a recording unit for the objects which are to be inscribed, whereby this recording unit contains a distance-measuring device for emitting a
25 distance reading which controls the focusing of the laser beam. The recording unit also contains a switching device for releasing the laser beam when the object to be inscribed is correctly positioned. As an alternative, there is a mechanical catch for static focusing of the
30 laser beam.

The inclusion of a recording unit for objects to be inscribed ensures reliable positioning of the object in the focal plane of the laser beam. It also ensures
35 reliable operation of the inscription device.

As an alternative or in addition thereto, there is a lens system, for example a lens system of an auto-focus camera, for the purpose of adjusting the focus distance.

- 5 In a preferred embodiment of the invention, in order to ensure maximum mobility of the unit, the control unit is connected to an external control and / or input unit wirelessly by means of a radio, infra-red or ultrasound transceiver.

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The control unit and possibly components of the power pack are preferably composed from foil circuits using SMD technology. They are therefore particularly suitable for a compact structure and housing in component packages which
15 can be carried on the body of the user.

- In order to ensure the smallest possible dimensions and a maximum efficiency rate, the laser consists of a solid-state laser which is pumped longitudinally with a laser
20 diode, whereby this solid-state laser contains a laser bank with a laser crystal, a Q-switch, a highly-reflecting resonator reflector and an output reflector. The laser crystal thereby preferably has no tension birefringence / has a tension birefringence which is as low as possible,
25 and in addition it has high fluorescence durability and the smallest possible dimensions.

- The solid-state laser can be equipped with an active Q-switch, i.e. with an opto-acoustic crystal, or with a
30 passive Q-switch and a laser diode, which amongst other things is driven in pulsed operation.

- The efficiency rate of the laser diode is preferably as high as possible. In order to ensure that this efficiency
35 rate remains stable, the laser diode is cooled with a cooling component, for example a Peltier component. It is

provided that both the laser diode driver and the Peltier driver are positioned either in the hand-held device or in the support device. The term "driver" is used here to denote the corresponding circuit board of a component.

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The individual laser components are preferably in a very compact arrangement in relation to one another, in order to achieve minimum dimensions and thus ensure mobile operation.

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In particular, short resonator geometry is used, which means that very short laser pulses and thus a high pulse peak output are achieved. In order to ensure a configuration that is as compact as possible with small external dimensions, the short resonator geometry is preferably achieved by means of a folded optical train brought about by an appropriate reflector configuration, for example two reflectors positioned at 45° to the axis of the beam.

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In addition, the device has another lens system for spreading the beam, preferably by means of two lenses. Alternatively or in addition thereto, the beam is spread by means of a further reflector system comprising at least two reflectors, whereby this reflector system preferably also has a folded optical train through multiple reflection.

In a preferred embodiment of the invention, polarisers are provided, in order to generate polarised laser light. This light can, however, also be generated through the laser crystal itself. In this way, it is possible to increase the diffraction efficiency rate of an acoustic-optical Q-switching component. This is particularly advantageous because the device according to the invention preferably has at least one lens system with a high diffraction

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efficiency rate, in particular a crystal, whereby this lens system efficiently interrupts the laser process in the resonator at the same time as there is low high-frequency power input.

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In order to further increase the compactness and to minimise the weight, the components of the device according to the invention are manufactured from fibre reinforced materials, ceramics or synthetic materials. In addition, the lens systems are put together and / or secured by means of sticking.

15 In order to ensure a fast, accurate and cost-effective drive for the refraction unit, in a preferred embodiment of the invention, the motor of the drive unit, by means of which the refraction unit is adjusted, is constituted by a drive unit of a read / write head of a data storage unit, in particular a magnetic or optical data storage unit. However, the invention is not restricted to this type of drive unit. Moreover, conventional drive units, for example galvanometer scanners, can also be provided as drive units for the refraction unit.

25 By reference to the embodiments of the invention shown in the drawings, the thought behind the invention will now be examined in greater detail. The drawings show:

Figure 1 a schematic functional block diagram of a hand-held laser inscription device with a solid-state laser positioned in a support device.

Figure 2 a schematic functional block diagram of a hand-held laser inscription device with a solid-state laser positioned in the hand-held device.

Figure 3 a schematic diagram of a user with a hand-held device and a support device positioned on a waist strap.

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Figure 4 a schematic functional block diagram of a hand-held laser inscription device with wireless signal input; and

10 Figure 5 possible reflector configurations for shortening the resonator length.

The schematic functional block diagrams shown in Figures 1 and 2 for devices for inscribing objects with a solid-state laser show different configurations of the same components. They can be supplemented by further embodiments of the invention which consist of similar configurations - for example bringing together all of the components in a laser inscription device with one package, whereby this device is in the form of a desk-top device as a mobile inscription station.

The term "inscription" is used to denote any form of object markings, for example marking with any type of script, as well as generating images and three-dimensional engravings. Furthermore, the term "inscription" is understood to include the removal of inscription elements by taking away layers of surface material (e.g. bar-codes, graffiti, etc.) and the like.

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Figure 1 shows the functional block diagram of a compact hand-held laser inscription device which comprises a hand-held device 1 and a one-part or two-part support device 2. In this embodiment of the invention, the hand-held device 1 contains a refraction unit 7 which is placed in front of

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the object to be inscribed / which can be connected to a recording unit for recording and aligning the object which is to be inscribed. Furthermore, the hand-held device 1 contains a sensor unit 8, which can for example consist of
5 a scanner, a CCD image sensor or a digital video camera.

The support device 2 contains a control unit 21, a solid-state laser 4 and a power pack 22, which is connected to the units of the support device. The control unit 21 has a
10 microprocessor 11, a high-frequency generator 12, a read / write storage unit or another storage medium 13, signal amplifiers 200 for amplifying the control signals for the reflector alignments (galvanometer scanners) in the refraction unit 7 and an input and monitoring unit 14. The
15 solid-state laser 4 consists of a laser bank 5 (or another mechanically stable construction of the laser components) and a laser diode 6. The laser bank 5 contains a longitudinally or transversally pumped laser crystal 50, a Q-switch 51 (active or passive Q-switching), a highly-
20 reflecting resonator reflector 52 and an output reflector 53.

The drive of the reflector alignments in the refraction unit 7 may be constituted by a drive unit of a read /
25 write head of a data storage unit, in particular a magnetic data storage unit. In this case, it is possible to omit the signal amplifiers 200, as the drive unit of the read / write head itself already has such signal amplifiers.

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The end of the solid-state laser 4 is connected to the refraction unit 7 by means of a glass fibre cable 17. The glass fibre cable 17 can be combined with an electric cable containing connection wires 31 between the
35 microprocessor 11 and the sensor unit 8, the microprocessor 11 and the refraction unit 7, as well as a

- power supply cable for connecting the power pack 22 to the hand-held device 1. If the control unit 21 and the solid-state laser 4 are positioned separately from the power pack 22 - for example in different packages or sections of a package - an additional power supply cable must be provided between the control unit 21 and the solid-state laser 4 on the one hand and the power pack 22 on the other hand.
- 10 The power pack 22 comprises an accumulator 9 and a mains component 10. Also positioned in this power pack is the driver of a Peltier component for cooling (which is not illustrated).
- 15 An interface 15 connects an external control and monitoring unit 3 to the microprocessor 11 of the control unit 21 for the purpose of inputting data as required. Instead of an external control and monitoring unit 3 which can be connected to the control unit 21 by means of a cable, wireless transmission is also possible. This means that instead of an interface connection point for the interface 15, there can be electro-magnetic, electro-optical or electro-acoustic transmission of signals between an external control and monitoring unit and the control unit 21. Alternatively, there can be direct data input, for example by means of a miniature lap-top.
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- 25
- 30 The solid-state laser 4 consists of a solid-state laser which is longitudinally or transversally pumped with the laser diode 6, whereby the laser bank 5 of the solid-state laser does not contain any polarisers for the purpose of increasing the efficiency rate and thus ensuring maximum output. The laser crystal 50 is a crystal without tension birefringence or with tension birefringence that is as low as possible, whereby the dimensions of the crystal are as small as possible. In association with low output of a
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high-frequency generator, the high-frequency output of which is for example less than or equal to 2 to 4 watts, and an optimum choice of laser crystal 50, the construction of the laser bank 5 can be extremely compact, since low power consumption leads also to only limited heat emission.

The operation of the laser bank 5 can be continuously pumped with an active Q-switch (high-frequency source), using an opto-acoustic crystal, or it can take place with a passive Q-switch.

The compactness of the device according to the invention can be further increased by using a folded optical train with reflectors and the like in the refraction unit 7 or in the laser head. All in all, a portable laser inscription device with the smallest possible external dimensions and weight is thus created.

According to an embodiment of a laser inscription device which is shown in Figure 2 as a functional block diagram, the solid-state laser 4 is brought together with the refraction unit 7 in a hand-held device 1. Furthermore, the control unit 21 is brought together with the power pack 22 in a support device 2.

The control and supply device is connected to the hand-held device 1 by means of an electric cable 18. By means of an interface 15, there is a further connection with an external control and monitoring unit 3 and with a sensor unit 8. As in the embodiment of the invention according to Figure 1, this sensor unit 8 can consist of a digital (video) camera, a CCD image sensor or a scanner. Also, as in the embodiment according to Figure 1, the sensor unit 8 can be coupled with the hand-held device 1, in such a way that the hand-held device 1 can also be used for receiving

signals. Also positioned in the support device 2 are two (not illustrated) signal amplifiers for amplifying the control signals for the reflector alignments in the refraction unit 7.

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Figure 3 shows a schematic drawing of the use of the hand-held laser inscription device according to the invention and its composition from a hand-held device 1 and a support device 2, which in this embodiment of the invention can be secured around the waist of a user with a waist or pelvis strap 16. Alternative methods of securing the support device are a ruck-sack form with a support device to be secured on the back of the user as well as side (belt) attachments.

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The connection between the hand-held device 1 and the support device 2 is achieved by means of a cable connection 17, 18, whereby this consists of a glass fibre cable and / or an electric connection cable.

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The hand-held device 1 can for example be coupled with a video camera 80, which for the purpose of signal input allows images to be recorded of objects or people, whereby these recordings are further processed by means of signal processing of the control unit for the purpose of controlling the solid-state laser and the refraction unit.

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In a configuration according to Figure 1, the hand-held device 1 contains the refraction unit 7 and possibly the sensor unit 8 / 80. In this embodiment of the invention, the support device 2 contains the solid-state laser, the control unit and power pack.

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In a configuration according to Figure 2, the hand-held device 1 contains the laser arrangement and the refraction unit 7, possibly in association with a sensor component.

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In this configuration, the support device 2 contains the control unit and the power pack. On the front side of the support device 2 there is a connection point 15 of the support device 2 for the connection 17, 18 to the hand-held device and for an external control and monitoring unit.

In order to reduce the dimensions of the support device 2, the latter contains so far as possible foil circuits in association with SMD components, in such a way that the support device 2 can be positioned comfortably around the waist of a user. As an alternative, instead of the foil circuits, multi-layer configurations with SMD components can also be provided.

The embodiment of a hand-held laser inscription device shown as a functional block diagram in Figure 4 shows the configuration of a semi-conducting laser with a laser diode 6 and a collimator lens system 55, as well as the control unit with a processor 11 and a storage component 13 in a support device. The power pack 9 (accumulator) can be coupled with the support device or it can constitute a separate support device.

According to this embodiment of the invention, the hand-held device 1 contains a refraction unit 7 with two reflectors. Furthermore, as in the embodiment according to Figure 1, a sensor unit 8 can be connected to the hand-held device 1.

The signal input can take place by means of the sensor unit or by means of a wireless connection from an external data input device 3. For this purpose, there is a radio, infra-red or ultrasound transceiver which is connected to a transceiver component 19 on the side of the control

unit. A corresponding transceiver component is provided on the external control unit 3.

5 Figures 5a to 5d show the resonator which consists of the crystal 50, the reflector 52 reflecting at 99.9% and the output reflector 53 which reflects around 88% of the light and transmits 12% of the light.

10 Figure 5a shows a configuration of the resonator component which has been generally used up to now. The two reflectors 52 and 53 as well as the crystal 50 are arranged behind one another in such a way that the laser beam leaves the output reflector 53 directly without any deflection.

15 In order to make the hand-held laser inscription device even more compact, the resonator according to Figure 5b has - in addition to the afore-mentioned resonator components - a reflector 100 which is positioned at an angle of 45° to the axis of the beam. As a result of this configuration, the laser beam is deflected by 90° before it leaves through the output reflector 53. The deflection results in a folded optical train which allows more compact construction of the resonator and thus a further increase in the compactness of the hand-held laser inscription device.

30 As is shown in Figure 5c, this effect is intensified still further as the laser beam deflected according to Figure 5b is deflected again by 90° by means of a further reflector 101 positioned at an angle of 45° to the axis of the beam before it leaves through the reflector 53.

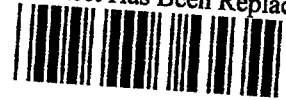
35 The folded optical train resulting from this deflection facilitates such a compact construction of the resonator that the length of the resonator in comparison with

conventional resonators and the entire dimensions of the device are clearly reduced.

Figure 5d shows a further embodiment following Figure 5c.
5 According to the embodiment shown in Figure 5d, the optical train also has a Q-switch 51 (active or passive Q-switching) between the two reflectors 100 and 101. Also, after the reflector 53 there is a shutter 103, which is used to release the laser beam when the object to be
10 inscribed is correctly positioned. Behind the shutter 103 there is a reflector system 300 for spreading the laser beam whereby this reflector system consists of two reflectors 301 and 302. The laser beam going into the reflector system 300 is not output until after multiple
15 reflection on the two reflectors 301 and 302.

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Claims

1. A device for inscribing materials with a laser, a
5 refraction unit, a control unit and a power pack

characterised in that

the laser (4), the refraction unit (7), the control unit
10 (21) and the power pack (22) consist of compact,
transportable components.

2. A device according to Claim 1 **characterised in that**
15 several components are brought together in at least one
package.

3. A device according to Claim 2 characterised by a
20 hand-held device (1) containing the refraction unit (7)
and the laser (4), and a support device (2) containing the
control unit (21) and the power pack (22) as well as an
interface (15) for connecting the control unit (21) to an
external control and / or input unit (3).

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4. A device according to Claim 2 **characterised in that** a
hand-held device (1) contains the refraction unit (7),
whereby this hand-held device (1) is connected by means of
30 a glass fibre cable (17) to a support device (2) which
contains the laser (4), the control unit (21) and the



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power pack (22) as well as an interface (15) for connecting the control unit (21) to an external control and / or input unit (3).

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5. A device according to Claim 2 **characterised in that** all the components are brought together in a hand-held device (hand-held laser inscriber).

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6. A device according to one of the Claims 3 to 5 **characterised in that** the hand-held device (1) is connected to a sensor unit (8), in particular to a scanner, video camera, digital camera or similar.

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7. A device according to at least one of the preceding Claims 3 to 6 **characterised in that** the hand-held device (1) is in a form suited to the anatomy of the hand.

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8. A device according to at least one of the preceding claims **characterised in that** the support device (2) can preferably be connected to a waist and / or shoulder strap (16).

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9. A device according to at least one of the preceding claims **characterised in that** there is a recording unit for objects to be inscribed, whereby this recording unit has a distance-measuring device for emitting a distance reading which controls the focusing of the laser beam, and a switching device for releasing the laser beam when the object to be inscribed is correctly positioned (dynamic focusing).

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10. A device according to at least one of the preceding claims **characterised in that** for the purpose of adjusting the focus distance, there is a lens system, in particular a lens system of an auto-focus camera.

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11. A device according to at least one of the preceding claims **characterised in that** there is a recording unit with a mechanical catch (static focus) for objects to be inscribed.

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12. A device according to at least one of the preceding claims **characterised in that** the control unit (21) is connected to an external control and / or input unit wirelessly by means of a radio, infra-red or ultrasound transceiver.

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13. A device according to at least one of the preceding claims **characterised in that** at least the control unit (21) and / or the power pack (22) consists of foil circuits with components secured in SMD technology.

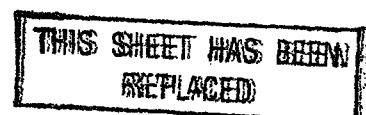
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14. A device according to at least one of the preceding claims **characterised in that** the laser (4) consists of a solid-state laser which is longitudinally or transversally pumped with a laser diode (6), whereby the pump volume thereof preferably corresponds to the basic mode volume of the material to be pumped, and further characterised in

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that the laser (4) has a laser bank (5) with a laser crystal (50), a Q-switch (51), a highly-reflecting resonator reflector (52) and an output reflector (53).

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15. A device according to Claim 14 **characterised in that** the laser crystal (50) does not have tension birefringence / its tension birefringence is as low as possible, and that the laser crystal has high fluorescence durability
10 as well as having the smallest possible dimensions.

16. A device according to Claim 14 or Claim 15 characterised by a solid-state laser (4) which is
15 continuously pumped and is Q-switched / modulated by means of an opto-acoustic crystal, FTIR crystal or similar.

17. A device according to Claim 14 or Claim 15
20 **characterised in that** there is a solid-state laser (4) driven by means of a passive Q-switch component and a continuous wave or pulse-controlled laser diode (6).

25 18. A device according to at least one of the preceding claims **characterised in that** the efficiency rate of the laser diode (6) is as high as possible.

30 19. A device according to at least one of the preceding claims **characterised in that** the device for cooling the laser diode has a cooling component, in particular a Peltier component.

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20. A device according to Claim 19 **characterised in that** both the laser diode driver and the Peltier driver are positioned either in the hand-held device or in the support device.

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21. A device according to at least one of the preceding claims **characterised in that** there is a compact configuration of the individual laser components including
10 a resonator length which is as short as possible, in particular by means of a folded optical train.

22. A device according to at least one of the preceding
15 claims characterised by a reflector system as a widening lens system, in particular with a reflector configuration with a folded optical train, and / or a widening lens system by means of two lenses.

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23. A device according to at least one of the preceding claims **characterised in that** the reflector configuration has at least two reflectors positioned at 45° to the axis of the beam.

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24. A device according to at least one of the preceding claims characterised by optical components or by the laser crystal for generating polarised light, in order to
30 increase the diffraction efficiency rate of the acoustic-optical Q-switching component.

25. A device according to at least one of the preceding
35 claims **characterised in that** there is at least one lens system with a high diffraction efficiency rate, in

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particular a crystal, whereby this lens system efficiently interrupts the laser process in the resonator at the same time as there is low high-frequency power input.

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26. A device according to at least one of the preceding claims characterised by components made from fibre-reinforced material, ceramics and / or synthetic material, as well as by stuck-on components.

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27. A device according to at least one of the preceding claims **characterised in that** the motor of the drive unit, by means of which the refraction unit is adjusted, is
15 constituted by the drive unit of a read / write head of a data storage unit, in particular a magnetic or optical data storage unit.

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