(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 954 004 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
24.07.2024 Bulletin 2024/30

(21) Application number: **20736484.5**

(22) Date of filing: **24.06.2020**

(51) International Patent Classification (IPC):
H01S 3/041 *(2006.01)* ***H01S 3/03*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
H01S 3/041; H01S 3/0305

(86) International application number:
PCT/SK2020/000004

(87) International publication number:
WO 2021/002807 (07.01.2021 Gazette 2021/01)

(54) **METHOD FOR LIMITING THE DEFLECTION OF A LASER BEAM FROM A LASER HEAD DURING TEMPERATURE CHANGES AND A LASER HEAD**

METHODE ZUR EINSCHRÄNKUNG DER UMLENKUNG EINES LASERSTRAHLS VON EINEM LASERKOPF WÄHREND TEMPERATURÄNDERUNGEN UND EIN LASERKOPF

PROCÉDÉ POUR LA LIMITATION DE LA DÉFLECTION DU FAISCEAU LASER D'UNE TÊTE LASER PENDANT DES CHANGEMENTS DE TEMPÉRATURE ET UNE TÊTE LASER

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **03.07.2019 SK PP782019**
03.07.2019 SK PV992019

(43) Date of publication of application:
16.02.2022 Bulletin 2022/07

(73) Proprietor: **SEC Technologies, S.R.O.**
031 01 Liptovsky Mikulas (SK)

(72) Inventors:
- **VICENIK, Jiri**
  031 04 Liptovsky Mikulas (SK)
- **SEDLACKOVA, Zina**
  031 04 Liptovsky Mikulas (SK)

(74) Representative: **Jeck, Jonathan**
JECK, FLECK & Partner mbB
Klingengasse 2
P.O.Box 14 69
71665 Vaihingen/Enz (DE)

(56) References cited:
JP-A- S58 151 079
US-A- 5 982 803
US-A1- 2012 219 028
US-A1- 2014 202 998

EP 3 954 004 B1

Description

Technical field

[0001] The invention relates to a method for limiting the deflection of a laser head during temperature changes and to the actual construction of the laser heads with a resonator firmly connected to the head body used in systems whose operating temperature can change significantly and rapidly. These temperature changes can be caused by external influences when the system with "storage" temperature must suddenly operate in an environment with a significantly different temperature, or by internal influences when the laser head is heated by waste heat during intensive laser operation. The invention falls within the field of laser technology.

Background of the invention

[0002] Laser heads of several laser types, e.g. "TEA" (Transversally Excited at Atmospheric pressure), are often designed so that the heat transfer between the head and the environment is significant only through a part of their surface. Such laser heads are namely often designed as blocks that have good thermal contact with the environment through only one of 6 walls of such a block. At least two walls, usually three, are namely equipped with high-voltage bushings, the other two carry elements of the optical resonator of the head, where on one wall there is a semi-transparent mirror and on the opposite wall there is a "totally" reflecting mirror. Thus, four to five walls out of six are logically excluded from significant heat transfer. The sixth wall is connected via a low thermal resistance to a cooler mediating heat exchange with the environment.

[0003] Under these circumstances, a thermal gradient develops on the head. The thermal resistance of the sixth wall of the head, which is usually the largest wall in the surface, to the environment is small. The resistance of the remaining walls is large. Since the material of the head has certain, often non-negligible, thermal expansion, it comes to deformation - to the deflection of the laser head. The described process cannot be symmetrical with respect to the resonator axis. Since the simplest and in several respects also the most advantageous design of the head uses resonator elements directly and firmly connected to the head body, it leads to the misplacement of the resonator mirrors, as they cease to be ideally parallel. The consequence of such a condition is a deterioration of the parameters, or even a failure of the laser.

[0004] In order to reduce the influence of thermal dynamics on the mechanical stability of the optical resonator of the laser, an opportunity arose to solve this problem by technical means which are able to provide more stable laser parameters. A result of this effort is a further described method for limiting the deflection of the laser head during temperature changes and a modified construction of the laser head according to the present invention.

[0005] From US 5, 982, 803 a pair of elongated parallel electrodes are known, which are insulative Li mounted within the tubular housing filled with laser gas mixture between an arrangement of the reflective optical elements sealingly mounted at each end of the housing. The electrodes from a rectangular gas discharge area the minimum spacing between which is the diameter of the fundamental free-space mode of the stable laser resonator formed in the gap when the electrodes are RF excited.

[0006] US 2014/020298 A1 teaches a laser device comprising at least 2 gas laser units, stacked in layers each laser unit comprising a plurality of resonator tubes, the resonated pipes being in fluidic communication with each other and forming a common tabular space, connecting elements for connecting adjacent resonator tubes so as to form a loop, mirrors arranged in the connecting elements for reflecting the laser light between the resonator tubes and the rear mirror and a partially reflecting output coupler for coupling of the laser beam.

Summary of the invention

[0007] The above stated drawbacks are largely eliminated by the method for limiting the deflection of the laser head during temperature changes and by the actual construction of the laser head according to the invention, the essence of which is that in the method for limiting the deflection of the laser head during temperature changes the temperature difference between the warmest and coldest part of the laser head is reduced by metal plate parts with high thermal conductivity attached by a thermally conductive joint to the side walls connecting the upper wall and the lower wall of the laser head. The metal plate parts having a low specific weight, e.g. aluminum, are attached by a thermally conductive joint to the side walls connecting the upper wall and the lower wall of the laser head. Due to weather and / or operating conditions, it is possible that the lower wall of the laser head will be the warmest and the upper wall will be the coldest.

[0008] Laser heads of TEA lasers, i.e. gas lasers, are constructed of materials that have good vacuum properties and are also well weldable. A suitable material is e. g. stainless steel. These materials have, however, only low thermal conductivity and high specific weight. The essence of the construction of the laser head according to the present invention lies in the fact that plates of material with high thermal conductivity but also with low specific weight (e.g. aluminum) are thermally conductively attached to the side walls of the laser head, which transfer heat between the warmest upper wall and the coldest lower wall of the head.

[0009] The advantages of the method for limiting the deflection of the laser head during temperature changes and the actual construction of the laser head according to the invention are apparent from the effects which are exerted externally. In general, it can be stated that the

originality of the solution lies in the fact that with a slight increase in the weight of the head, it is possible to significantly reduce the thermal resistance between the warmest and coldest wall of the head. The result is a reduction in the temperature difference between the walls of the head, which significantly reduces the influence of thermal dynamics on the mechanical stability of the optical resonator and thus leads to more stable laser parameters.

Brief description of the drawings

[0010] A method for limiting the deflection of the laser head during temperature changes and a laser head according to the present invention is illustrated in the attached drawings. Fig. 1 shows the actual laser head in a side view and in section A - A. Fig. 2 shows the actual laser head in a top view and in a front view.

Examples of embodiment of the invention

Example 1

[0011] In this example of a particular embodiment of the invention, a solution of the method for limiting the deflection of the laser head during temperature changes according to the present invention is described. The method is applied to a TEA laser head of a CO2 laser in the shape of a block made of stainless steel. From Fig. 1 and 2 it is apparent that the front wall 5 and the rear wall 6 carry resonator mirrors 7, while the HV bushing 8 of the main discharge electrodes is located on the upper wall 2. The left and right side walls 1 carry HV bushings 8 of pre-ionizers. The last lower wall 3 is smooth and heat is lead away from the head through it. The thermal gradient that deforms the head, originates between the warmest upper wall 2 and the coldest lower wall 3 and detuns the resonator as a result. This thermal gradient or temperature difference is, however, significantly limited in such a way that between the warmest upper wall 2 and the coldest lower wall 3 of the laser head, metal plate parts 4 with high thermal conductivity and low specific weight are attached by a thermally conductive joint to the side walls 1 connecting the upper wall 2 and the lower wall 3 of the laser head.

Example 2

[0012] In this example of a particular embodiment of the invention, the construction of TEA head of a CO2 laser in the shape of a block made of stainless steel is described, as shown in Fig. 1 and 2. The laser head TEA of a CO2 laser basically described in Example 1 is further solved in such a way that four metal plate parts 4 with high thermal conductivity and with a low specific weight, what aluminum is suitable for are attached on each side by a thermally conductive joint to the side walls 1 connecting the warmer upper wall 2 and the colder lower wall 3 of the laser head.

Industrial usability

[0013] The method for limiting the deflection of the laser head during temperature changes and a laser head is usable in applications of laser technology.

Claims

1. Method of limiting the deflection of a laser head during temperature changes,
   wherein

   the temperature difference between the upper wall (2) and the lower wall (3) of the laser head is reduced by metal plate parts (4) with high thermal conductivity and low specific weight attached by a thermally conductive joint to the side walls connecting the upper wall (2) and the lower wall (3) of the laser head,
   wherein the upper wall (2) is the warmest wall and the lower wall (3) is the coldest wall during operation of the laser head, as the lower wall is connected via a low thermal resistance to a cooler for exchanging heat with the environment. $

2. A laser head with limited deflection during temperature changes consisting of an upper wall (2) carrying a HV bushing (8) of main discharge electrodes and a lower wall (3), side walls (1) with bushings (8), a front wall (5) and a rear wall (6) with elements of an optical resonator,
   wherein metal plate parts (4) with

   high thermal conductivity and low specific weight are attached by a thermally conductive joint to the side walls (1) connecting the warmest / coldest upper wall (2) and the coldest / warmest lower wall (3) of the laser head,
   wherein the coldest wall is the wall which is connected via a low thermal resistance to a cooler for exchanging heat with the environment.

3. A laser head with limited deflection during temperature changes according to claim 2, wherein the metal plate parts (4) have a low specific weight.

Patentansprüche

1. Verfahren zur Begrenzung der Ablenkung eines Laserkopfes bei Temperaturänderungen, wobei der Temperaturunterschied zwischen einer oberen Wand (2) und einer unteren Wand (3) des Laserkopfes durch Metallplattenteile (4) mit hoher Wärmeleitfähigkeit und geringem spezifischem Gewicht ver-

ringert wird, die über eine wärmeleitende Verbindung an den die obere Wand (2) und die untere Wand (3) des Laserkopfes verbindenden Seitenwänden angebracht sind, wobei die obere Wand (2) die wärmste Wand und die untere Wand (3) die kälteste Wand im Betrieb des Laserkopfes ist, da die untere Wand über einen geringen thermischen Widerstand mit einem Kühler zum Wärmeaustausch mit der Umgebung verbunden ist.

2. Laserkopf mit begrenzter Ablenkung bei Temperaturänderungen, bestehend aus einer oberen Wand (2), die eine HV-Durchführung (8) von Hauptentladungselektroden trägt und einer unteren Wand (3), Seitenwänden (1) mit Durchführungen (8), einer Vorderwand (5) und einer Rückwand (6) mit Elementen eines optischen Resonators, wobei an den Seitenwänden (1), welche die wärmste/kälteste obere Wand (2) und die kälteste/wärmste untere Wand (3) des Laserkopfes verbinden, Metallplattenteile (4) mit hoher Wärmeleitfähigkeit und geringem spezifischem Gewicht durch eine wärmeleitende Verbindung angebracht sind, wobei die kälteste Wand diejenige Wand ist, die über einen geringen thermischen Widerstand mit einem Kühler zum Wärmeaustausch mit der Umgebung verbunden ist.

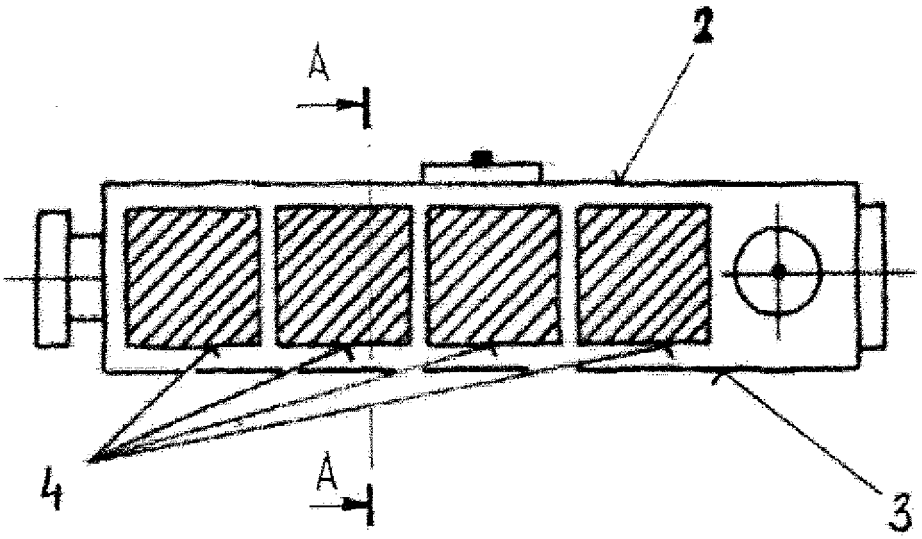
3. Laserkopf mit begrenzter Durchbiegung bei Temperaturänderungen nach Anspruch 2, wobei die Metallplattenteile (4) ein geringes spezifisches Gewicht aufweisen.

Revendications

1. Procédé pour la limitation de la déviation d'une tête laser lors de changements de la température où la différence de la température entre une paroi supérieure (2) et une paroi inférieure (3) de la tête laser est réduite à travers des parties sous forme de plaque (4) avec une haute conductivité thermique et peu de poids spécifique qui sont disposées via une connexion thermoconductrice reliant la paroi supérieure (2) à la paroi inférieure (3) de la tête laser des parois latérales où la paroi supérieure (2) est la paroi chaude et la paroi inférieure (3) est la paroi froide en fonctionnement de la tête laser puisque la paroi inférieure est reliée via une résistance minime thermique à un refroidisseur pour l'échange de la chaleur avec l'environnement.

2. Tête laser avec une déviation limitée lors de changements de la température se composant d'une paroi supérieure (2) portant une exécution à haute tension (8) d'électrodes à décharge principale et d'une paroi inférieure (3), de parois latérales (1) avec des passages (8), d'une paroi avant (5) et d'une paroi arrière (6) avec des éléments d'un résonateur optique où des parties sous forme de plaque (4) avec une haute conductivité thermique et peu de poids spécifique via une connexion thermoconductrice sont disposées au niveau des parois latérales (1) reliant la paroi supérieure la plus chaude/la plus froide (2) et la paroi inférieure la plus froide /la plus chaude (3) de la tête laser où la paroi la plus froide est celle qui est reliée via une résistance minime thermique à un refroidisseur pour l'échange de la chaleur avec l'environnement.

3. Tête laser avec une déviation limitée lors de changements de la température selon la revendication 2 où des parties sous forme de plaque (4) présentent un poids minime spécifique.



SECTION A - A

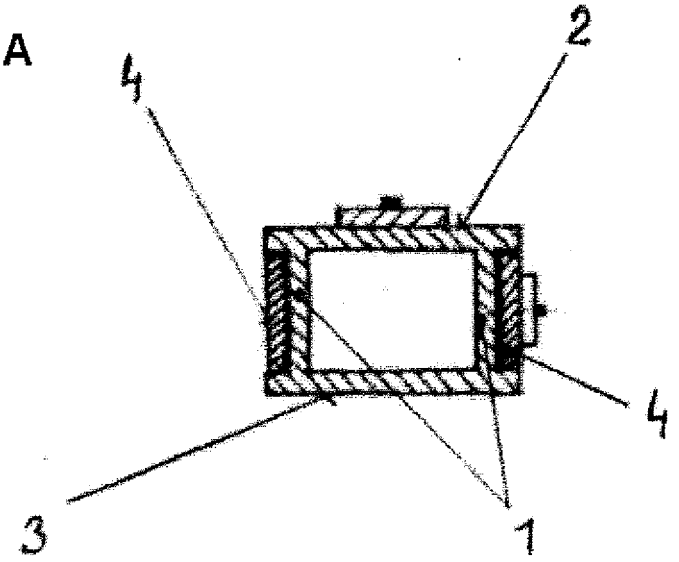


Fig. 1

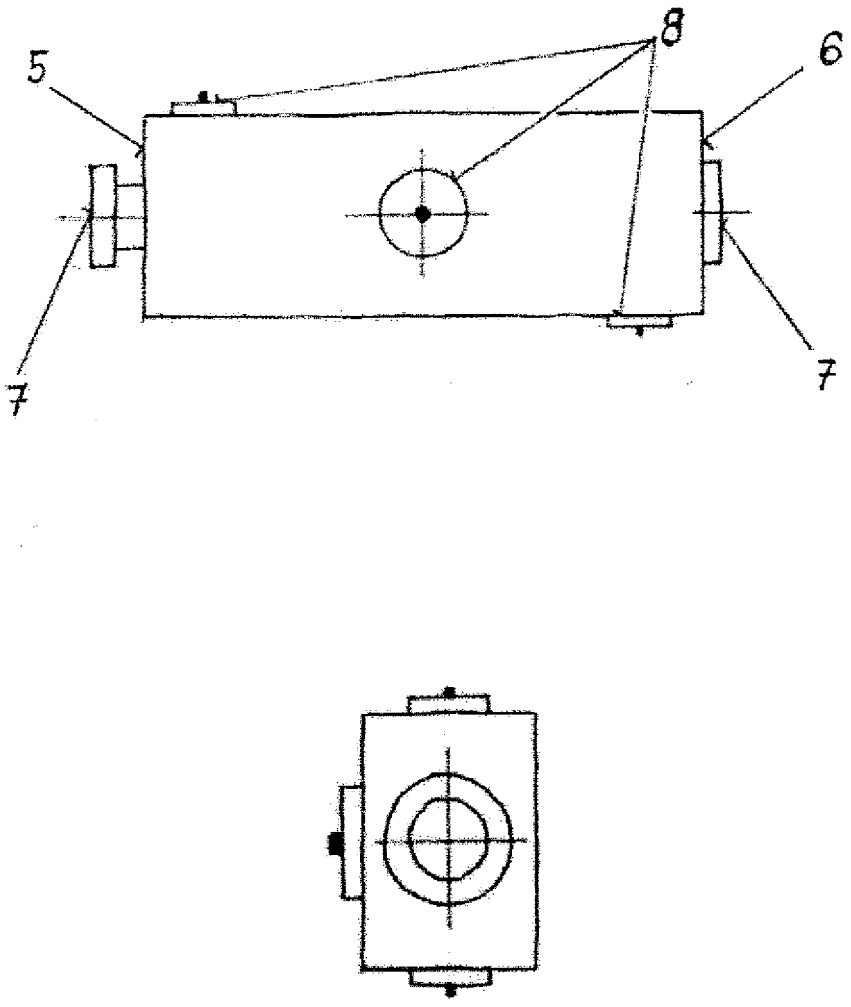


Fig. 2

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 5982803 A **[0005]**
- US 2014020298 A1 **[0006]**