The Patents Act, 1970

Section 15, 25(1)

Patent Application No: 1643/MUM/2008

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VS

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Uttar Pradesh, India ………….. **Opponent**

DECISION

The Applicant filed this application No. **1643/MUM/2008** for the grant of patent on **01/08/2008** for the invention titled "**GEMSTONE PROCESSING MACHINE**".
In this matter, the facts that have come to my knowledge and made available to me can be traced as follows:

01/08/2008:- Application for grant of patent was filed.

16/03/2016:- First examination report (FER) was issued to the Applicant.

01/06/2016:- Reply to FER and amendments to claims were submitted by the Applicant.

25/04/2018:- Pre grant opposition u/s 25(1) of the Patents Act,1970 (as amended) was filed.

22/10/2018:- Intimation of pre-grant opposition u/s 25 (1) issued to the Applicant by electronic communication. Hearing under Section 14 was fixed on **04/12/2018** and objections were communicated to both parties Applicant for Patent and Opponent.

09/11/2018: As per Request by Opponent for Adjournment of Hearing u/r 129A in connection with the opposition in respect to the Patent Application No. 1643/ MUM/2008, u/s 25 (1), Rule 55 of the Patents Act, 1970 and Patent Rules, 2006.

26/11/2018: Extended Hearing Notice Letter was issued by scheduling hearing on 08/01/2019.

20/12/2018: Email Communication by this office that hearing already scheduled on 08/01/2019 will also take place under rule 55(5) of the Patents Rules (as amended).

24/12/2018: Applicant requested three months from the date of receipt of the notice under Rule 55 (3) over email dated 20/12/2018.

28/12/2018: Email Communication by this office as:

"As both (Applicant and Opponent) do not agree over controller's opinion to conduct hearing for the said matter under rule 55(5) of the Patents Rules (as amended), it has been decided to hear matter under section 14 of the Patents Act, 1970(as amended) on 08 Jan 2019 को 03:00 PM To 03:30 PM for objections out standing objections of FER and Hearing Notice only.
Separate hearing for Pre-grant opposition filed under 25(1) of the Patents Act, 1970(as amended) will be conducted, if required.
However, Opponent herein may be attend the hearing on 08 th January, 2019.

03/01/2019: Request for adjournment of hearing from Applicant received u/r 129A

21/01/2019: Reply Statement from Applicant filed under Rule 55(4) to the Written statement of Pre-Grant Opposition to Patent Application No.1643/MUM/2008

19/02/2019: Opponent filed replication to statement and evidence filed on dated 21/01/2019 by the Applicant

06/05/2019: Extended herein notice was issued by this office scheduling hearing on 12/06/2019 to both (the Applicant and the Opponent)

07/06/2019: Request for adjournment regarding hearing scheduled on 12/06/2019 received u/r 129A from the Opponent.

14/06/2019: Extended herein notice was issued by this office scheduling hearing on 18/07/2019 to both (the Applicant and the Opponent)

18/07/2019:- Hearing under Section 14 and hearing for pre-grant opposition were conducted and attended both parties Applicant for Patent and Opponent.

01/08/2019:- Written submission for the hearing dated **18/07/2019** was submitted by the opponent.

02/08/2019: Written submissions for the hearing dated **18/07/2019** were submitted by the Applicant.

During hearing held on 18/07/2019, it was decided that amended claims filed on 21/01/2019 shall be considered as current amended claims for said hearing matter u/s 14 and hearing for pre-grant opposition and same was agreed by the Applicant and the Opponent herein.

<u>CURRENT PRINCIPLE CLAIM:</u>

<u>i.e. Claim 1</u>

1. A gemstone processing machine (200) for processing a gemstone, said gemstone processing machine (200) comprising:

a laser resonator (205), wherein said laser resonator (205) comprises:

a laser source (210) to generate a laser beam;

a first reflective member (230) optically coupled to said laser source (210), wherein said laser beam is incident on said first reflective member (230) through a first aperture (220) placed on a first side (245) of said laser source (210) adjacent to the first reflective member (230); and

a second reflective member (235) optically coupled to said laser source (210);

a second aperture (225) positioned on said first side (245) adjacent to said second reflective member (235);

an operating assembly (255) operably connected to said laser resonator (205); characterized in that,

said first reflective member (230) is inline with said laser source (210), and positioned on a first side (245) of said laser source (210), wherein said first reflective member (230) reflects back said incident laser beam to a second side of said laser source through said first aperture (220);

said second reflective member (235) is offset from said laser source (210), and positioned on said first side (245) of said laser source (210); and said laser resonator (205) comprises:

at least a first beam bender (265) is placed inline with said laser source (210), and positioned on said second side (260) of said laser source (210) to reflect said laser beam incident from said first reflective member (230), at a first angle of reflection being 45°; and

at least a second beam bender (270) is placed offset from said laser source (210), and positioned on said second side (260) to reflect said laser beam reflected by said first beam bender (265) to said second reflective member (235) through said second aperture (225), at a second angle of reflection being 45°.

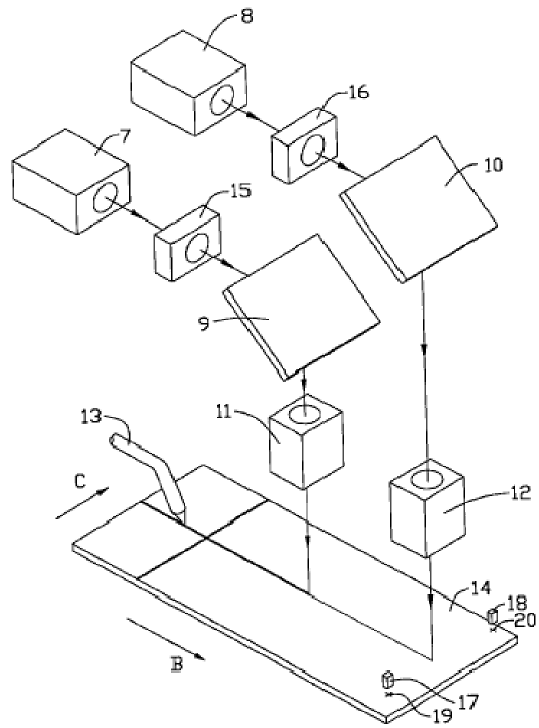
SCIENTIFIC AND TECHNICAL ANALYSIS

Upon perusal of records, I found that the objection raised in Hearing notice dated **22/10/2018, 26/11/2018, 28/12/2018, 06/05/2019** and **14/06/2019** under Section 14 and hearing for pre-grant opposition with respect to lack of inventive step still stands, over considering hearing and written submission filed as the applicant fails to persuade the same. Features of current amended claims are not inventive and are not allowable u/s 2(1)(ja) of the Act over considering scientific and technical analysis of cited documents in combination as:

D1: JPS60217678A,
D2: JP2007152958A,
D3: US5862726A,
OD1: US4677639,
OD2: US20040262274 and
OD3: US4499582

Document D2 discloses in Figure 2, the laser cutting apparatus includes a first laser unit, second laser unit, and a cooling system 13. The first laser unit, and the first laser beam unit 7 includes a first reflecting mirror 9 and the first focusing lens assembly 11 to form a first laser beam for irradiating the substrate 14. The second laser unit includes a second laser beam unit 8 includes a second reflecting mirror 10 and the second focus lens assembly 12 to form a second laser beam to focus on the surface of the substrate 14. In the present embodiment, the first laser beam is a carbon dioxide laser beam, the second laser beam is a laser beam of ultraviolet wavelength (UV Laser). Wherein the first laser beam through a first reflection mirror 9, after being reflected on the first focusing lens assembly 11, to irradiate the substrate 14 in a non-focus method in a non-focus position of the first focus lens assembly 11 . The second laser beam through the second reflecting mirror 10, is reflected to the second focus lens assembly 12 is focused on the substrate 14 in a focus system to the focus position of the second focus lens assembly 12. The cooling system 13 may be a single liquid, mixture or mixtures of one or more gas and liquid in the single gas and a single liquid and the like. For example, it is air, pure water, cooling oil, such as helium nitrogen or liquid fluid.

【図 2】



Referring to FIG. 2, the cooling system 13 along the cutting direction B, the first laser unit and said second laser unit is arranged in order. When cutting the substrate 14, via the second reflecting mirror 10 to the second laser light is a suitable material, is reflected to the second focusing lens assembly 12, the second focusing lens assembly 12, the the energy of the second laser beam to focus on the surface of the substrate 14. At this time, using a frequency of power and high pulse of high pulse of the second laser beam to remove material of the surface of the substrate 14 to form a pre-cut line of a predetermined depth in the substrate 14. (English Translation of description D2)

D2 also discloses a second laser beam to form a pre-cut line on the substrate 14, it is reflected by the first focusing lens assembly 11 via the first reflecting mirror 9, wherein the first laser beam is made of suitable material, a first focus lens assembly 11, to irradiate the substrate surface in advance along a line unfocused manner the energy of the first laser beam to thermally expand the substrate, thereby, the compression stress is generated inside the substrate.

After the first laser light is heated precut line of the substrate, the cooling system 13 is rapidly inject atomized cooling liquid to the substrate 14 along the pre-cut line is heated. Therefore, drops rapidly the temperature of the substrate surface, a tensile stress is generated inside the substrate is contracted.

Local of the substrate, because generates abrupt stress change in a short time, to form a crack along the pre-cut line is formed from the substrate second laser beam. Since the cracks are extended along the cutting plane, thereby completely separating the substrate. This implements the cutting of the substrate 14.

Factors to separate the substrate are many, but mainly is the stress generated in the glass. The stress is to display the official below.

Here, sigma is the magnitude of the stress generated in the glass faceplate, alpha inside the thermal expansion coefficient of the glass faceplate, E is the modulus of longitudinal elasticity of the glass faceplate, T1 is the temperature of the glass faceplate which has been heated to a laser cutting device , T2 is the temperature of the glass faceplate after cooling.

The number 1 and number 2 and the size of the glass faceplate internal stress is found to be directly proportional to temperature difference to be formed on the glass faceplate thermal expansion coefficient of the material, Young's modulus, and by the laser and the cooling system . The maximum value of T1 is not greater than the vaporization temperature of the glass faceplate.

If stress and laser heating device and the cooling system to form the substrate is greater than the burst strength of the substrate material, cracks are formed on the substrate surface. The cracks, by the manufacturing method, the surface of the glass, for example, exhibit different growth forms, such as the substrate is completely separated.

Referring to FIG. 2, in the present invention, because it forms a pre-cut line on a surface of the substrate 14 in the second laser beam, the uniformity is high in the pre-cut surface is formed, it does not form a primary crack. In this way, in the cutting process, it is possible to secure high cutting quality. In addition, the depth and the cutting quality of the cutting line the second laser beam of ultraviolet wavelength is formed on the surface of the substrate 14, the magnitude of the power of the laser beam, the laser spot size, cutting speed, and related to the pulse frequency of the laser light. When cutting with a pulse frequency is small (100~200KHz) said second laser beam forms a discontinuous opening to the cross section of the pre-cut line. If the pulse frequency is greater than 200KHz is a pre-cross-section of the cutting line smooth, rather than discontinuous openings, not crack at the intersection of the vertical cutting lines to form a pre-cut line with the surface of the substrate 14.

In the cutting process, the path pre-cutting path the second laser beam is formed on the substrate 14, the path and cooling system first laser beam is irradiated onto the substrate 14 is injected into the substrate 14 is positioned on the same straight line. (English Translation of description D2)

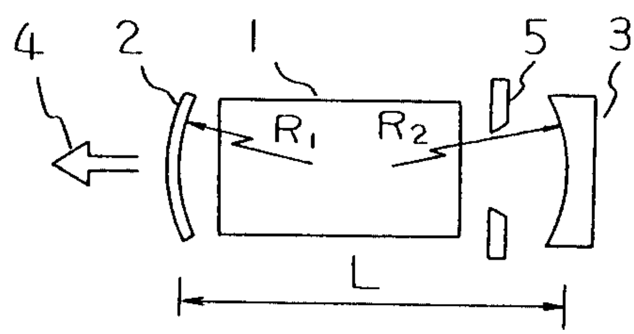
D2 further discloses that it takes time from the state in which the laser beam is close to a state of outputting flare and stably, in order to output the laser beam stably, first between the first laser beam unit 7 and the first reflecting mirror 9 It established the Ikko breaker 15, installing a second optical interrupter 16 between the second laser beam unit 8 and the second reflecting mirror 10. By the optical interrupter, it can be controlled to output the laser beam on the surface of the substrate 14. That is, the switch laser beam is passed or blocked the light breaker. Accordingly, in the manufacturing process, it is not necessary to control the laser unit, when controlling only the closing and putting the light interrupter, can control the output of the laser beam.

In the present invention, the mounting substrate 4 to the substrate mounting table, the substrate mounting table is a linear or rotary motion. As shown in FIG. 2, the laser cutting apparatus of the present invention, the cutting direction B, can be cut along the C. Specifically, the cutting device, in all cases, after cutting along the cutting direction C, it is possible to cut along the cutting direction B. Alternatively, it may be cut by the contradictory order. After cutting repeatedly along the cutting direction C, and the substrate 4 is rotated, it may be cut along the cutting direction B. The angle of rotation is to be noted that not limited to 90 degrees.

In addition, in order to satisfy the cutting accuracy, the substrate 4 must guarantee the accuracy of attaching the mounting table board. A first positioning point 19 on the substrate 4, and the second positioning point 20, the first positioning point 19, the first image sensor 17 and the second image sensor 18 respectively corresponding to the second positioning point 20 is installed. A first positioning point 19 by the first image sensor 17 and the second image sensor 18 with scanning the position of the second positioning point 20, to adjust the rotation and movement of the substrate table, accurately purpose of determining the position of the substrate 4 It can be realized. (English Translation of description D2)

Document D1 discloses high-power laser oscillator having surface roughness of an outer circumferential section except a section in the vicinity of the center is made coarse in at least one of reflecting mirrors 2, 3 for a laser resonator in which an enclosure, in which a laser medium 1 is encapsulated, and a plurality of the reflecting mirrors 2, 3 resonating laser beams are opposed to each another. With the total reflecting mirror such as one 3, the quality of a material is of oxygen-free copper, the surface is finished through diamond cutting, and surface roughness is made coarse gradually toward an outer circumference from the section of a diameter slightly smaller than the diameter of an aperture. Surface roughness is adjusted by using 100- 1000# abrasive paper, and the mean of surface roughness processed through a chucking to a lathe is brought to approximately 1mum. Accordingly, beams having the desired distribution of intensity can be obtained even on an application to a resonator having Fresnel of numeral 3. (Abst of D1)
D1 also discloses in FIG. 1, structure of a conventional laser resonator with the simplest 11 configurations, many high-power lasers use folded resonators. The laser medium 1 is excited by glow discharge, for example, in the case of a CO2 laser, in which a thin debris mainly composed of CO2N and He is enclosed.

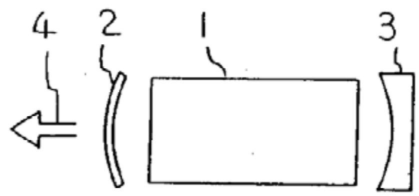
第1図



The laser light is amplified by the laser medium 'Jd 1 while being reciprocally reflected between the pair of reflecting bones, that is, between the translucent output teacher 2 and the entire anti-duck 3, and a part of the laser light is output from the output steep 2. 4 is taken out to the outside. A hollow disc having an inner diameter 2a, which is called "chassis 5", is inserted between the output rod 2 and the all-reverse button +3. The aperture 5 is used for the purpose of limiting the beam diameter, increasing the difference in the measurement of the components in the resonator, and obtaining a quality beam. Generally, the aperture 5 is arranged near the total reflection button 3. Is done. Now, the radius of curvature of the output ll 2 is R13, the radius of curvature of the total reflection C3 is R7, the resonator length, that is, the distance between the output 2 and the total reflection 3 is L, and R1, R, 2, Il , A is called a resonator parameter. When the laser bond 1 is a uniform medium and the Fresnel number is very small, to obtain a beam with a Gaussian intensity distribution, the resonator parameter satisfies the equation (1), and the left side is greater than the right side. This can be achieved by selecting a VC so that it is as small as possible. (English translation of description of D1)

D1 further discloses actually, the laser medium ηl is not uniform and may slightly deviate from the equation (1). Here, λ is the wavelength of the laser. However, when the Fresnel number (a2 / λL) becomes larger than 1, the beam having the target Gaussian intensity distribution does not oscillate even if the resonator parameter is selected so as to satisfy the equation (1). In order to solve this problem, the inventors studied by experiment and calculation. For this examination, a folded CU2 laser having a cavity length of 5 m was used. First, in an experiment using the aperture 5 having an inner diameter of 13 m so that the Fresnel number becomes 0.8, the intensity distribution of the laser light 4 immediately after exiting the output mirror 2 was a Gaussian distribution as intended. Further, the intensity distribution 15 m away from the output mirror 2 was also a Gaussian distribution. Next, in an experiment using the aperture 5 having an inner diameter of 25 mm so that the Fresnel number becomes 3, the intensity distribution of the laser beam 40 immediately after exiting the output rod 2 is as shown in FIG. 2 (aJ r It was a very turbulent intensity distribution. Further, 15 nl ahead of the output shelf I, as shown in FIG. 2B, was an intensity distribution of Gaussian distribution as expected. As a result of pursuing this phenomenon, y is because the periphery of the beam being amplified is cut by the aperture 5 and a harmonic due to diffraction is generated at the saddle interface, and this harmonic propagates while being attenuated. In order to eliminate the harmonic component, it is necessary to propagate the distance more than the distance corresponding to the Fresnel number of 1. I understood. According to the present invention, the surface roughness of the entire JJ, l− constituting the resonator is gradually roughened as it goes to the outer periphery, thereby preventing the beam peripheral portion from being suddenly cut as in the case of the conventional aperture. Harmonics are prevented from occurring in the resonator having a number of 1 or more. Another method is to attach a dielectric film on the surface of the reflector, and the reflectance is high at the center and gradually decreased toward the outer periphery. Since the beam intensity is weak and reliability is low, it is not suitable for a high-power laser and is 81-valent. An embodiment of the present invention will be described below with reference to FIGS. 3 and 4.

第3図



第4図

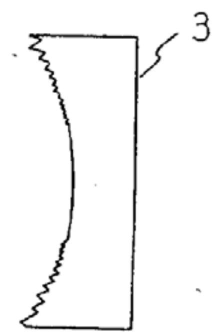


FIG. 3 is a block diagram of the C02 laser resonator according to the present invention, and FIG. 4 is an enlarged view of the total reflection LM3 in FIG. The total reflection rod 3 is made of oxygen-free copper, and after surface finishing by diamond cutting, the surface roughness is gradually increased from the portion having a diameter slightly smaller than the aperture diameter 2a shown in FIG. 1 toward the outer cylinder. (English translation of description of D1)

Document OD1 discloses laser device 10 of the type having a pulsed laser beam output 11. The laser device includes an elongated generally rectangular box-type housing 12 for an optical resonator 13 that utilizes an elongated cylindrical ruby rod 14 as the lasing medium source. The device also includes a means for pumping energy into the lasing material and which is shown in the form of an elongated xenon flashlamp 15.

The optical cavity or resonator light path 16 in the illustrated embodiment includes horizontally extending parallel linear light paths 17 and 18 that are laterally offset and interconnected by a light path 57 within the prism component of the resonator. The opposite end terminals 19 and 20 of the cavity 16 are formed and defined by flat planar mirror surfaces 21 and 22 that are formed by means of coatings 21a and 22a which are fixed to the exterior surface 23a of a rigid unitary component 23 that provides the base support structure for the mirror coatings. The laser rod 14 is mounted with its longitudinal axis 24 in a coaxial arrangement with light path 17 so that the photon beams produced along the rod axis may be propagated in the cavity 16. The laser beam 50 produced by the lasing action is translated and reflected between the light paths 17 and 18 by means of a corner prism 25 that is arranged at the prisms ends 26 and 27 of the light paths 17 and 18. These path ends 26 and 27 are opposite the respective terminal ends 19 and 20 of the cavity.

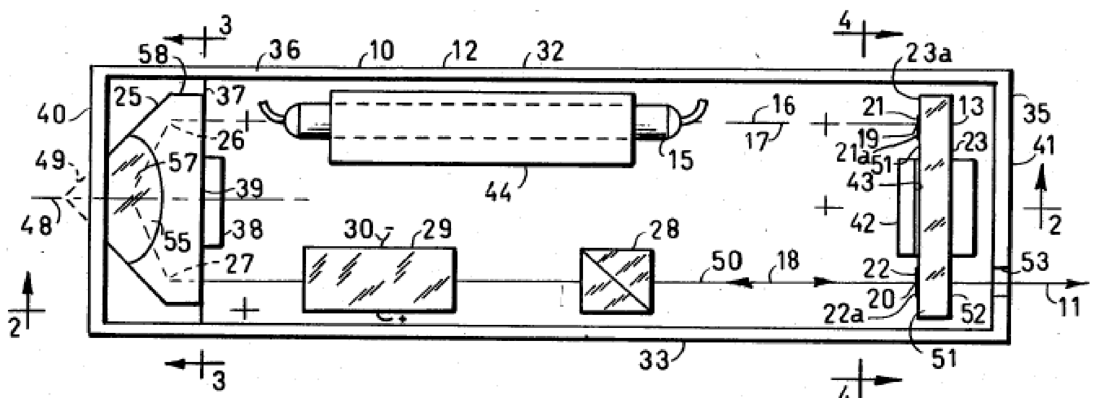


FIG. 1

The device also includes, in the illustrated embodiment, a dielectric polarizer 28 which is mounted in path 18 and a Q-switch which is shown in the form of a pockels cell 29 that is also mounted in the path 18. These components 28 and 29 are supported in path 18 by rigid supports (not shown) but which are securely mounted on the bottom wall 31 of housing 12. The components 28 and 29 are conventional components used in laser applications and which cooperate in providing a pulse output 11 when the pockels cell is subjected to successive applications of a D-C voltage as through leads 30.

The housing includes opposite side walls 32 and 33, opposite end walls 34 and 35, and an open top wall 36 in addition to the bottom wall 31 of the resonator enclosing structure. At one end 50 of the housing, the housing in internally equipped with a form fitting mount 37 for the corner prism 25 and which is integral with the bottom wall and adjacent end wall 34. The mounting 37 has an upright section 38 which confronts a center portion of the prism face 39 between the paths 17 and 18. It serves to maintain the planar facial surface portion 39 of the prism substantially in parallel with the inside planar surface portion 51 of the mirror base 23 at the other end 41 of the housing, and thus also in parallel with the mirror surfaces 21 and 22.

Generally intermediate the opposite side walls 32 and 33 and located adjacent end wall 35, the housing is internally equipped with an upright rigid mounting block 42 for the base component 23 for the mirrors. Block 42 is integrally formed with the bottom wall of the housing and has a transversely extending vertical slot 43 in which the base component 23 is fixed. As thus fixed, the mirror surfaces 21 and 22 that form and define the end terminals 19 and 20 are laterally offset from the mount 42 and arranged in the light paths 17 and 18.

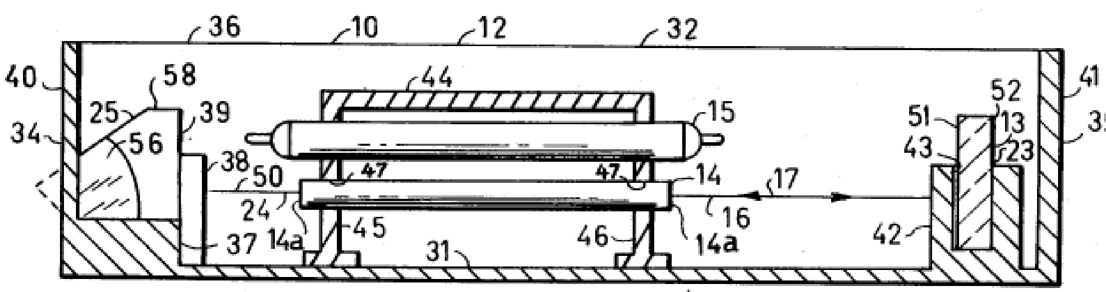


FIG. 2

The flashlamp 15 and laser rod 14 are mounted on an inverted rigid U-shaped support 44 that is fixed to the bottom wall 31 and located adjacent side wall 32. Support 44 has spaced apart upright legs 45 and 46 with appropriate horizontally aligned apertures for their mounted positions. These components 15 and 16 of the device are vertically spaced apart on support 44 and horizontally arranged in parallel as seen in FIG. 2. The laser beam 50, under such circumstances, passes through the aligned leg apertures 47 for rod 14 as it traverses the path 17 through the rod.

The mirror base component 23 of the resonator is generally rectangular in the illustrated embodiment and preferably made of fused quartz material because of its low temperature coefficient of expansion as well as the desire, in the illustrated embodiment, for transparency to facilitate the transmission of the laser output 11. The oppositely facing surface portions 51 and 52 of the flat base component 23 are plane parallel surfaces and the mirror surfaces and the mirror surfaces 21 and 22 that form and define the end terminals of the cavity are embodied and fixed on the inside facing planar surface portion 51 so as to provide a coplaner arrangement of the mirror surfaces and facilitate a generally parallel arrangement with the face 39 of prism 25. The mirror surfaces 21 and 22 may be formed from any suitable coating material providing the desired reflectivity. Coating 21a may be formed from conventional dielectric coating materials that provide a maximum reflectance and coating 22a may be formed from conventional dielectric material providing a lesser reflectance at surface 22 so that a portion of the light incident to the latter surface 22 may be transmitted through the base as the output beam 11. Typically, the coating 22a may provide 60% reflectance of the incident light at surface 22 so that a portion of the incident light impinging on the surface 22 passes through the quartz base component and then through the aligned aperture 53 in end wall 35 to provide the laser output beam 11.

The mirror surfaces 21 and 22 on the quartz structure 23 are spaced apart and face in a common direction toward the prism face so that incident beam light impinging on each surface is reflected 180° and thus back along the path of incidence at the terminal mirror.

The corner prism 25 in the illustrated embodiment is formed from a cylindrical quartz component 58 that is provided with three orthagonally arranged reflective surfaces 54, 55, and 56. The components 58 is truncated and, as seen in FIG. 3, has a flat surface 59 that is normal to the facial surface 39 and in parallel with the axis 48 through the apex 49 of the component, the arrangement being provided to facilitate the mounting of the prism in mount 37. As thus arranged in the resonator, the axis 48 of the prism is generally normal to the flat face 51 of the base component 23 so that surfaces 39 and 51 of the resonator components 25 and 23 are generally parallel. However, substantial deviation in the parallel arrangement can be tolerated because of the optical nature of the prism and which translates and reflects the incident light along parallel paths.

In normal operation of the laser device 10, the flashlamp 15 is initially energized so as to provide a means for pumping energy into the lasing medium of rod 14. When an electron population inversion is attained, a lasing action transpires and the photon or light beams produced in the medium along the rod axis 24 are propagated back and forth between the end terminals 19 and 20. At end terminal 19 the incident beam light along path 17 is normal to the plane surface 51 and upon impinging upon surface 21 is reflected back along the path 17 of incidence thereto. At the opposite ends of rod 14, the rod is equipped with planar end surface portions 14a that are normal to the path 17 to avoid light refraction in the illustrated embodiment. However, to avoid the resulting etalon effect at the rod ends, conventional wedging practices may be followed as will be apparent to those skilled in the art. In transversing the rod along path 17, the reflected beam light further stimulates photon beam emission as is well known. At the prism end 26 of path 17, the incident light beam 50 passes through the prism face 39 and encounters the orthogonally arranged reflective surface 54 of prism 25 and is thereby reflected along the path 57 of translation between paths 17 and 18 as best seen in FIGS. 1 and 3. In traversing the path 57, the light reflected by surface 54 thereafter impinges upon the orthogonal surfaces 55 and 56. At surface 56 the translated beam light is reflected into path 18 and emerges from the prism 25 through the prism face 39. The end surfaces of components 29 and 28 are normal to the path 18 to avoid nonlinearity in path 18 and after traversing the pockets cell 29 and polarizer 28, the beam light impinges upon mirror surface 22. Here a portion of the beam light incident to the surface 22 is reflected back along the path 18 while the balance of the incident light passes through the coating 22a and component 23 and thence, through aperture 53 to provide the laser output 11. The beam light reflected by the terminal forming surface 22, of course, then retraces the paths 18, 57, and 17 to the other terminal end 19 of the cavity and is again reflected so that further photon beam emission is stimulated during each traverse of the rod 14.

The Q-switching function of the Pockets cell 29 is deemed obvious to those skilled in the art. Briefly, however, the cell 29 is subjected to a pulsating D-C voltage that successively activates the cell so that the beam propagation is periodically interrupted when the cell is activated. During the activated period, pumping continues and the inversion builds up to be released during the intervals of voltage removal from the cell so that the output is concentrated in short pulsating burts of coherent light. (Col. 4-7, Line 38-68, 1-68, 1-68, 1-8 Resp. of OD1)

OD1 also discloses in FIGS. 5-8 and wherein the invention is seen as embodied in a laser device 60 of the type having a continuous beam output 61. The device 60 is quite similar in structure to the device illustrated in the previous embodiment with provisions, however, being made for a generally lateral and continuous beam output 61. Again, the device includes an elongated generally rectangular housing 62 for the optical resonator 63. The resonator 63 utilizes an elongated cylindrical YAG rod 64 as a source of lasing medium and an elongated cylindrical krypton lamp 65 as the means for pumping energy into the lasing medium.

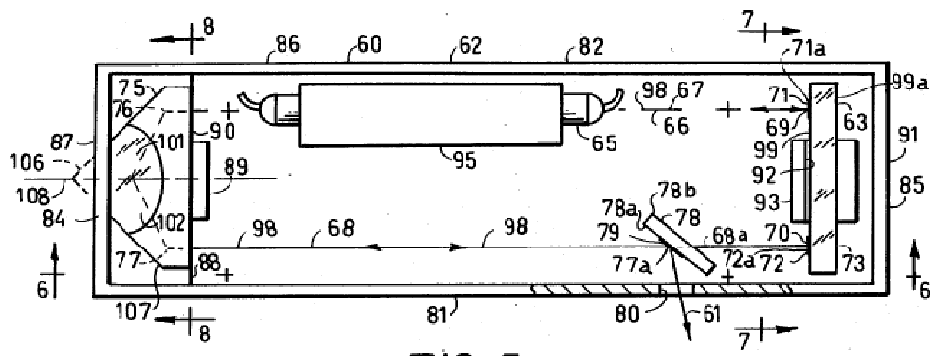


FIG. 5

The resonator path or optical cavity 66 again has horizontally extending linear light paths 67 and 68a which terminate at the end terminals 69 and 70 and are parallel and laterally offset as seen in the drawings. The end terminals 69 and 70 of the cavity 66 are formed and defined by mirror surfaces 71 and 72 that are embodied in another rigid unitary quartz component 73 that forms the base structure for mirror coatings 71a and 72a. The longitudinal axis 74 of the laser rod 64 is coaxially arranged with light path 67 to again facilitate propagation of the photon beams which are produced in the medium along the rod axis. The beam 98 developed by the lasing action is translated and reflected between parallel light paths 67 and 68a by means of another corner prism 75 which is structurally identical to that described in the previous embodiment and by means of a quartz component 78 that serves as the base for the pick-off mirror coating 79. Prism 75 is arranged at the prism ends 76 and 77 of the paths 67 and 68. The opposite ends of the path 67 are designated at 76 and 69, whereas the opposite ends of the path 68 are designated at 77 and 77a respectively.

At path end 77a, the laser device is provided with a flat, transparent and rectangular quartz component 78 that serves as a mount providing a surface 78a for a suitable dielectric coating 79 which laterally reflects a portion of the light through an aperture 80 in the housing side wall 81 to thus provide the output beam 61. The balance of the light incident to the coated surface 78a is transmitted by the transparent component 78 and due to refraction is translated to emerge from component 78 at the opposite surface 78b along the path 68a. Path 68a is offset from path 68 but nevertheless parallel to both paths 67 and 68.

As in the arrangement shown in the previous embodiment, the housing 62 has opposite side walls 81 and 82, opposite end walls 84 and 85, and an open top wall 86 in addition to the bottom wall 83 of the structure. At one end 87 of the housing, the housing is internally equipped adjacent end wall 84 with a form fitting mount 88 for the corner prism 75. Mount 88 includes an upright section 89 that confronts a center portion of the plane facial surface portion 90 of the prism and which is located between the parallel light paths 67 and 68 for purposes of maintaining a substantially parallel arrangement of the prism face 90 with the inside planar surface portion 99 of the mirror base 73 at the other end 91 of the housing. The laser beam along paths 67 and 68 is accordingly normal to the prism face 90 upon emergence and entry of the prism.

The terminal mirror base component 73 is mounted in a transversely arranged slot 92 in a rigid block 93 and which is formed integral with the bottom wall and generally located adjacent to end wall 85 and intermediate the opposite side walls 81 and 82. The rigid rectangular base component 73 is fixed in the slot 92 and arranged with the end terminal forming and defining mirror surfaces 71 and 72 laterally offset from the block and in the light paths 67 and 68a at the end terminals 69 and 70 of the cavity.

The lamp 65 and rod 64 are mounted on another inverted rigid U-shaped component 95 that is fixed to the bottom wall and located adjacent side wall 82. The legs 96 and 97 of the support 95 are spaced apart and are provided with horizontally aligned apertures for receiving the opposite ends of the laser rod and flashlamp in their mounted positions. These components 64 and 65 are also vertically spaced apart and horizontally arranged in parallel as seen in FIG. 6, the arrangement being such that the laser beam 98 passes through the aligned leg apertures 104 in traversing the light path 67 through rod 64. The opposite end plane surface portions 64a of rod 64, are normal to path 67 in the illustration so as to avoid refraction and simplify the structural requirements. Again however, conventional wedging practices may be used to avoid the etalon effects if desired.

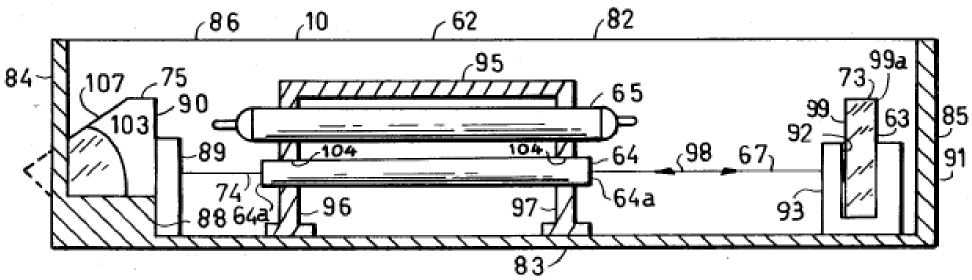


FIG. 6

The base component 73 is generally rectangular as seen in the drawings, and may be made, in this embodiment, from any suitable opaque or transparent material providing the desired rigidity for the structure. A fused quartz glass material is entirely suitable and preferred however, because of its low temperature coefficient of expansion. The inside facing surface portion 99 of the outer surface 99a of the base 73 is a plane surface, and the mirror surfaces 71 and 72 that define and form the end terminals of the cavity are provided by reflective coatings 71a and 72a that are fixed to the flat surface 99. These coatings may be formed by conventional dielectric coating materials and which, in this embodiment, provide a maximum reflectance at both mirror surfaces 71 and 72. These surfaces 71 and 72 may of course, be provided by a continuous noninterrupted coating that covers the entire surface 99 if desired. The mirror surfaces 71 and 72 face in a common direction toward the prism face, and as such, the incident beam light that falls on the surfaces 71 and 72 is reflected by each surface back along its path of incidence thereto and toward the prism face.

The corner prism 75, like the corner prism in the previous embodiment is made from a cylindrical quartz component 107 that is provided with orthogonally arranged flat plane light reflective surfaces 100, 102 and 103. The component is truncated as seen in the drawings, and also has a flat surface 105 which is parallel with the prism axis through the apex 108 to facilitate the mounting of the structure in the housing. The face 90 of the prism is, of course, perpendicular to the axis 106 and in mounting the component 73, the face 99 of the component is arranged generally normal to the prism axis 106 so that the mirror surfaces 71 and 72 are generally parallel with the face 90 of the prism 75.

When the laser device 60 is rendered operational, the lamp 65 is energized to provide the means for pumping energy into the lasing medium of the rod 64. As the population inversion is attained, the photon or light beams produced in the medium along the rod axis 74 are again propagated back and forth between the end terminals 69 and 70 of the cavity. At terminal 69, the path 67 for the incident beam light is normal to surface 99 and mirror surface 71 so that it is reflected back along the path 67 and through the rod 64 to further stimulate photo beam emission. At the prism end 76 of path 67, the beam enters the face 90 of prism 75 and encounters the reflective surface 100 of the corner prism 75. Here the incident light in path 67 is reflected along the path 101 for translating the beam between paths 67 and 68 as seen in FIGS. 5 and 8. Along this path 101, the beam light impinges upon orthogonally arranged surfaces 102 and 103 and from surface 103 is reflected along the linear light path 68 to emerge through the prism face 90. At end 77a of path 68, a portion of the beam light is laterally reflected as the output 61 by the coating 79. The balance of the light passes through component 78 and is refracted to emerge at surface 78b along path 68a. The translated beam light thereafter impinges upon mirror surface 72. Here, the path 68a is normal to the base surface 99 and surface 72 and hence, the incident light is again reflected back along the path 68a and thereafter retraces the paths 68, 101 and 67 to the other end terminal 69. Again, as the light passes along the path 67 through rod 64, further stimulated emission is, of course, developed.

In this embodiment, the corner prism 75 and component 78 reflect and translate the beam between the offset and parallel paths 67 and 68a that terminate at the planar surface and the base, and the surfaces 71 and 72 of the coatings are arranged to reflect the incident light at the terminal ends 69 and 72 back along the respective paths 67 and 68a.(Col. 7-9, Line 10-68, 1-68, 1-35 Resp. of OD1)

OD1 further discloses in FIG. 10 schematically illustrates a laser device embodying principles of the invention and in which a solid state laser rod constitutes the unitary base structure for the cavity and terminal mirrors.

The device 10 has a resonator 161 which includes an elongated cylindrical YAG rod 162 that provides the source of lasing material. It also includes an elongated cylindrical krypton lamp 163 that provides the means for pumping energy into the lasing medium. The laser beam 164 is developed along the axis 165 of the rod and resonates and is propagated back and forth between the end terminals 166 and 167 of the resonator cavity or light path 168.

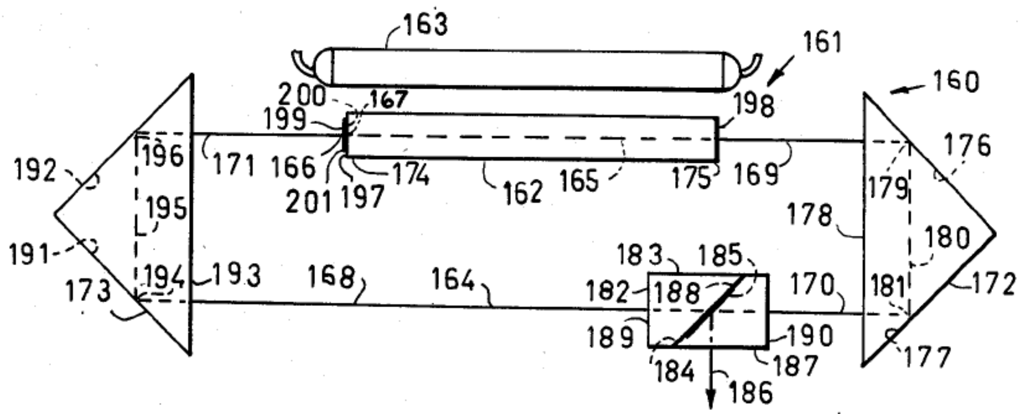


FIG. 10

The beam path 168 includes parallel linear light paths 169 and 170 and a linear light path 171 which is coaxial with path 169 and the rod axis 165 and also laterally offset from path 170. The beam is translated and reflected between the paths 171 and 169 that terminate at the cavity terminals 166 and 167 by means of a pair of porro, or roof top prisms which are designated at 172 and 173. These prisms, as seen in the drawings, are spaced apart from the opposite ends 174 and 175 of the laser rod.

Porro prism 172 has a pair of orthogonally arranged planar light reflective surfaces 176 and 177 and a flat planar facial surface portion 178 in the isosceles arrangement. The facial surface 178 is arranged perpendicular to the light path 169 and to the axis of the rod so that beam light along path 169, which is incident to the face 178 enters the prism and at the end 179 of path 159 impinges on and is reflected by the orthogonal surface 176 along a linear light path 180 in the prism. Path 180 is parallel to the prism face 178 and light incident to the prism surface 177 at the end 181 of path 180 is reflected along path 170 and in parallel with the light in path 169.

The base component of the pick-off mirror for the resonator is shown in the form of a wedge member that is designated at 183. It has a flat planar surface 184 which is inclined to the linear path 170 and provided with a suitable dielectric coating that is fixed to the surface 184 and serves to laterally reflect a portion of the beam light as the laser beam output 186. The wedge 183 of the pick-off mirror is transparent and preferably formed from a suitable quartz or other light transmitting material. To avoid beam refraction and non-linearity in the path 170 traversed between the prisms 173 and 172, a compensating wedge 187 made of like transparent material is provided. Wedge 187 has an inclined surface 188 that confronts the inclined surface 184 of member 183 in the assembled arrangement and is contiguous with the coating on surface 184. At the opposite ends of the wedge assembly, the wedge members 183 and 187 have flat plane surface portions 189 and 190. These surfaces are normal or perpendicular to the light path 170 so that refraction of light at the surfaces 189 and 190 is avoided and light reflected by the prism 172 along path 170 traverses a linear route to prism 173.

Prism 173 is also a porro prism and has orthogonally arranged planar light reflective surfaces 191 and 192, as well as a flat planar facial surface portion 193 in the isosceles arrangement. The face 193 of prism 173 is perpendicular to path 170 and parallel to the face 178 of prism 172. Beam light along path 170 that is incident to the normally arranged face 193 of the prism enters the prism and, at the end 194 of path 170, is reflected along the linear path 195 through the prism 173. At the other end 196 of path 195, light incident to the orthogonally arranged surface 192 is reflected toward the rod 162 along path 171 and, after emerging from the prism face 193, is reflected at the cavity end terminal 166 to again traverse the paths 171, 195, 170, 180 and 169 back to the other end terminal 167.

At the opposite ends 174 and 175 of the rod, the rod 162 is equipped with planar exterior surface portions 197 and 198. These surfaces are parallel to each other and to the faces 178 and 193 of the prisms, and hence are normal to the coaxial paths 171 and 169. The arrangement at end 175 permits the beam light along path 169 to enter or exit the end 175 without refraction. This rod end 175 can, of course, be provided with an inclined surface and a compensating wedge component if avoidance of the etalon effect is desired.

The end terminals 166 and 167 in this embodiment are formed by oppositely facing reflective or mirror surfaces 199 and 200 that are provided by a coating 201 of suitable light reflective material that is applied and fixed to the end surface 197 of rod 162. In this arrangement of the coating, surface 200 confronts the planar end surface 199 of the rod and the surfaces 199 and 200 are also normal to the light paths 171 and 169. The paths 171 and 169 accordingly extend in opposite directions from the end surface portion 201 of rod 162 with the beam light generated along the rod axis and incident to surface 200 being reflected toward prism 172 along the path 169 through the rod 162 while beam light incident to surface 199 is reflected back along path 171.

In this arrangement, the laser rod provides the rigid unitary structure for the coating that forms and defines the end terminals and has the advantage that proper orientation of the rod in the resonator arrangement serves to automatically arrange the terminal mirrors in the laser device.

FIG. 11 schematically illustrates an arrangement in a laser device and in which the envelope for a fluid lasing medium constitutes the rigid unitary base structure for the cavity end terminal mirrors.

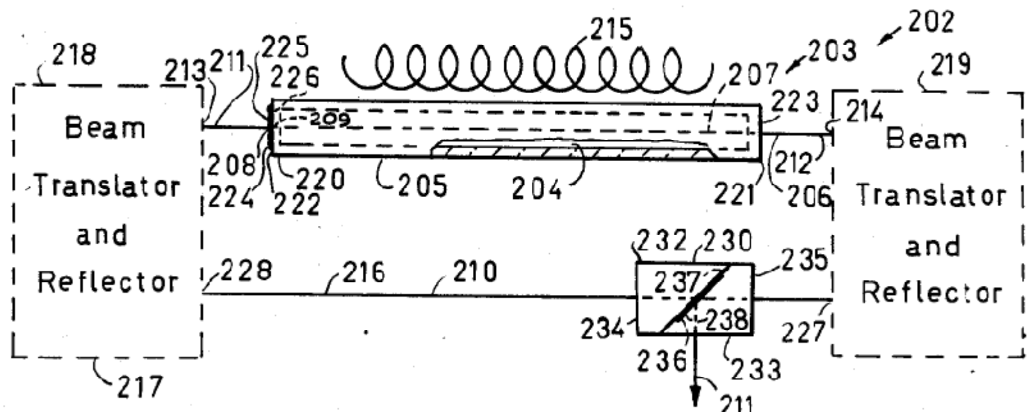


FIG. 11

The lasing device 202 shown in FIG. 11 has a resonator 203 which includes a fluid lasing medium 204 that is shown in the form of a He-Ne gas lasing medium. The medium 204 is housed in an elongated hollow envelope 205 made from transparent material, such as a suitable quartz glass. The means for pumping energy into the medium is shown in the form of an R-F coil 215 that serves, when energized, to establish the population inversion that causes the lasing action. The lasing action develops a beam 206 along the axis 207 of the envelope and which resonates back and forth between the opposite end terminals 208 and 209 of the resonator cavity or light path 210.

The cavity 210 includes coaxial linear light paths 211 and 212 which terminate at the terminals 208 and 209. At the other ends 213 and 214 of the paths 211 and 212, suitable means 217 is provided for translating and reflecting the beam light along a linear light path 216 which is laterally offset from and in parallel with the light paths 211 and 212 that terminate at the end surface 222 of the envelope.

The translating and reflecting means 217 may be formed by any suitable optical system such as a pair of mirror clusters or prisms having appropriately arranged reflective surfaces. In the illustration depicted, the means 217 is shown as having spaced apart translator and reflector components 217 and 218. Each of these components may be formed by a corner prism or by three orthogonally arranged mirrors in a mirror cluster. Component 218 serves to translate and reflect the laser beam between offset and parallel light paths 211 and 216 while component 219 serves to translate the beam between paths 212 and 216.

The housing envelope 205 for the gas lasing medium 204 has opposite ends 220 and 221, and the envelope is equipped with planar exterior surface portions 222 and 223 at these opposite ends 220 and 221. Surface 223 is normal to path 212 so that refraction is avoided during the light passage through the surface. Surface 222 is parallel to the surface 223 and hence, normal to the light paths that terminate at the end surface 222. The envelope 205 has a uniform thickness at its opposite ends 221 to provide interior end surfaces in the envelope that are normal to path 212 and to thus avoid refraction as the light passes between the medium and end walls at the interior of the envelope.

The end terminals are formed by a mirror surface forming coating 224 that is fixed to the planar end surface 222 of envelope 205. The coating may be formed by any suitable material, such as by one or more of the dielectric coating materials commonly used in laser applications for such purposes. The coating 224 provides oppositely facing mirror surfaces 225 and 226 that respectively define and form the end terminals 208 and 209, and, in the arrangement surface 226 confronts the planar end surface 222 of the envelope.

Paths 211 and 212 extend in opposite directions that are normal to the end surface 222 of the envelope, and in operation, beam light produced along the axis 207 of the envelope 205 which is incident to the mirror surface 226 is reflected back from the cavity terminal 209 and along the path 212 through the lasing medium. At the end 214 of the path, the beam light is translated and reflected by component 219 into path 216. As the light passes from one end 227 of path 216 to the other end 228, it encounters the output beam pick-off assembly 230 and a portion of the beam is laterally reflected as the laser rod output beam 231.

Assembly 230 is like that described in the previous embodiment, and has a pair of transparent wedge members 232 and 233 that are made from like materials and respectively provided with planar facial surface portions 234 and 235. These surface portions are arranged normal to the light path 216 to avoid refraction. The wedges 232 and 233 have confronting planar surface portions 236 and 237 that are inclined to the light path 216, and wedge 232 has a suitable reflective coating 238 that is fixed to surface 236. This coating 238 serves to laterally reflect a portion of the incident light as the laser output and pass the balance of the light along the path 216 to the translating and reflecting component 218.

At the end 228 of path 216, component 218 serves to translate and reflect the light incident to the component into path 211. This light is transmitted along the path to surface 225 and at the cavity terminal 208 is reflected by the surface back along the path 211. The light incident to component 218 at the path end 213 is again translated and traverses paths 216 and 212 through the opposite end terminal 209. As the beam traverses the path 212 through the medium, further emission is, of course, stimulated.

In this arrangement, the laser envelope provides the rigid unitary structure for the coating that forms and defines the end terminals and again has the advantage that proper orientation of the laser envelope in the resonator arrangement serves to automatically arrange the terminal mirror without the need for separate means for facilitating the adjustments and maintenance of the proper orientations. (Col. 11-14, Line 21-68, 1-68, 1-22 Resp. of OD1)

OD1 also discloses FIG. 12 illustrates an arrangement in which the rigid base component for the terminal mirrors is provided in an assembly that establishes offset and parallel light paths at the cavity terminals and also provides the output beam for the laser device. The laser device 240 has a resonator 244 which includes an elongated cylindrical YAG rod 241. Rod 241 provides a source of lasing medium, and the pumping of the medium is accomplished by energizing an elongated krypton lamp 242. The beam 245 developed by the lasing action is propagated along the rod axis 243 and resonates back and forth between the end terminals 246 and 247 of the resonator cavity or light path 248.

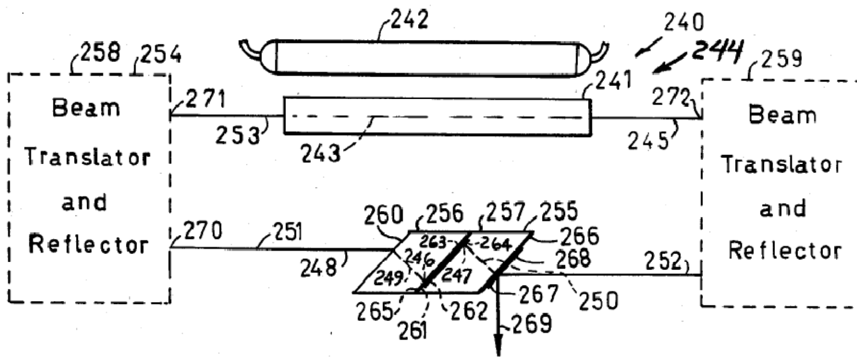


FIG. 12

The cavity path 248 includes parallel linear light paths 249 and 250 in the terminal forming and light pick-off assembly 255. It also includes parallel linear light paths 251 and 252 and a linear light path 253 which is offset and parallel with paths 251 and 252. Path 253 extends through the laser rod 241 and is coaxial with the axis of the rod.

The means 254 for translating and reflecting the beam 245 between the light paths 249 and 250 that terminate at the cavity terminals includes an assembly 255 of transparent wedge members 256 and 257 and a pair of beam translating and reflecting components 258 and 259. Component 258 serves to translate and reflect the laser beam 245 between linear light paths 251 and 253. It may take the form of any suitable optical system providing the desired translation. A corner or porro prism that is appropriately arranged may be used as well as a mirror cluster having a reflective surface arrangement that is comparable to either of the aforementioned prisms. Component 259 serves to translate and reflect the laser beam 254 between linear light paths 252 and 245 and may also take the form of one of the arrangements contemplated for component 258.

The wedge assembly 255 includes transparent wedge members 256 and 257. In this embodiment, wedge member 255 consititutes the rigid unitary base component for the end terminal forming mirror coating and it has oppositely facing planar exterior end surface portions 260 and 261. These surfaces 260 and 261 are parallel and inclined to light path 251 so that the light is refracted in passing between paths 251 and 249. Surface 261 has a coating 262 of suitable dielectric material that forms the oppositely facing planar light reflective or mirror surfaces 263 and 264 that form and define the end terminals 246 and 247. As the coating 262 is fixed to the member 256, surface 263 confronts the end surface 261. The other wedge member 257 of the assembly 255 also has oppositely facing planar exterior end surface portions 265 and 266. These surfaces 255 and 266 are parallel to each other and are arranged in parallel with surfaces 260 and 261 in the assembly 255. Surface 265 confronts the coated surface 261, and surface 266 is inclined to the light path 252 so that the light is refracted in passing between paths 250 and 252. Member 257 is fixed to member 256 and provides the base for the beam pick-off mirror. Member 257 is provided with a suitable dielectric coating 267 that is fixed to the end surface 266 and the coating serves to laterally reflect a portion of the light incident to the surface 268 as the output beam 269 while passing the balance of the light through the surface 266 and along path 250. (Col. 14-15, Line 23-68, 1-18 Resp. of OD1)

Document OD2 discloses laser diamond sawing machine is a non-contact very fast process of cutting the diamond compared to conventional process. This machine consists of Laser source, CNC Interface, Beam delivery system, RF Q-Switch driver. Chiller unit, CCTV & CCD camera. Power supply unit, Servo Stabilizer and Computer unit. The sawing occurs automatically by commands of computer. To avoid errors, simultaneously the process is seen on the CCTV. By this twin side sawing system 6-9 dies containing diamond can be processed. (Abst of OD2)

OD2 discloses in FIG. 7 Twin Side Sawing (TSS) 28 is an assembly with a provision to place 6-6 dies on both the sides having two sensor—one is sensing forward direction 24 and another is sensing backward direction 25. This assembly is also provided with limit switches with screw adjustment for precise setting of 180 degree for double side sawing.

TSS Fixture 29 is to Move TSS 28 upto 180 degree by software command with the help of fixture's motor. Laser head 4 is the most important component to produce the laser light. This head 4 consists rod and lamp. Rod is made of Nd:YAG and it works as a pumping source to produce more photons. These photons fall on lamp of Krypton which ultimately produce laser light. Two mirrors 1 & 7 are placed at each end of laser chamber—FIG. 5 to amplify the laser light by feedback mechanism. Power supply controls the intensity of beam. Beam expander 13 reduces the divergence and improves directionality of the beam, making the beam thin and parallel. Q-switch 5 produces a powerful pulse from the continuous beam. An aperture 3 & 6 restricts the light amplification along the axis of laser chamber and thus provides sharp frequency band. Beam coming out from the laser source is bended at 90 degree to reach to the diamond. Then through focusing lens 14, beam gets focused on the diamond. Through computer card, movement of the axes can be controlled. In case of power failure a safety shutter blocks the laser beam.

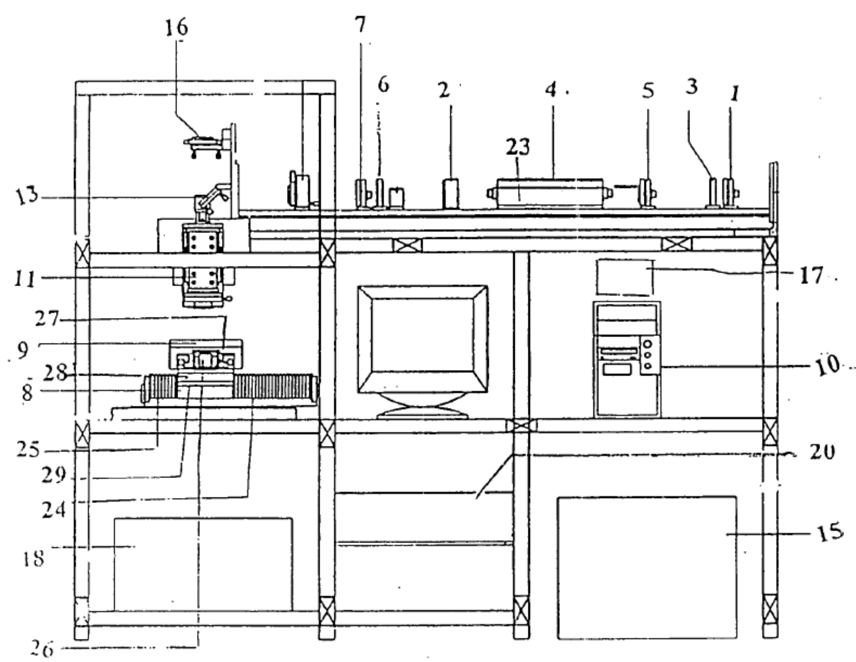


Fig. 1

In cooling unit 31 is a switch, 32 is start switch, 33 is flow switch, 34 is low water level switch, 35,36,37 & 38 are temperature setting switches and 39 is alarm switch.

In RF Q Switch driver 40 is mode switch, 41 is enter switch, 42 is power switch and 43 is start switch.

When TSS 28 filled with dies with 12 mm distance between each die is placed on the fixture and the machine is switched on first computer, starts with “Shortcut to Multi sawing” icon. When this icon is double clicked, on screen, “set diamond data” is seen containing options like: center point, start point, end point, focus point, size of diamond, step size, saw width, minimum width and start at. After entering all the relative data and then clicking on “start sawing” all the data are displayed on the screen. If any particular diamond is to skip then parameters are set for the next diamond. To stop the sawing process press “escape”.

Speed setting, extra setting, axes setting, fixture setting, key direction, step size, ramping, shutter on/off etc. are done by selection from appropriate advance setup. (Para 34-39 of OD2)

OD2 also discloses Laser source unit/resonator has a laser head 4, a Q-switch 5, two apertures 3 & 6, front mirror 1 & back mirror 7, a safety Shutter 2, and a beam expander. Laser head 4 is the crucial part to generate the laser light. Front and back mirror 1 & 7 amplifies the laser light by providing the feedback. Q-switch 5 is used to store the laser light energy to emit as a burst of high peak power. Shutter 2 block the laser beam in case of electrical failure and hence it is called as a safety shutter. An aperture 3 & 6 controls the light amplification along the off-axis of the resonator FIG. 5 to provide the sharp frequency band. As per the name indicates, beam expander 13 expands the laser beam to minimize its divergence.

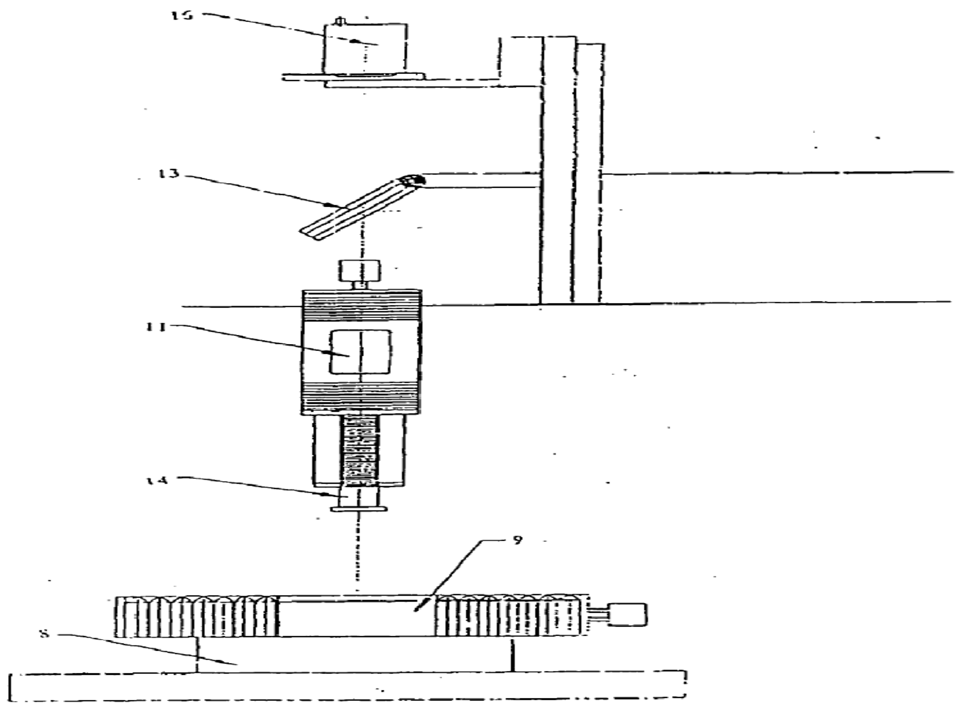


Fig. 2

CNC Interface consists of X 8 or Y 9 or Z 11 axis and the computer unit 10. For this purpose, inside the computer 10, a control card is placed which is connected to the rear portion of the accupos 18 having a 37-pin connector/parallel port. A beam attenuator—safety shutter 2 must be provided which will enable user to terminate lasing without turning off the main power switch 12. The safety shutter 2 is located inside the laser head assembly 4 and is actuated by the toggle switch 19. The shutter 2 terminates lasing by blocking the laser beam path and preventing emission of laser radiation out of the head assembly 4.

Beam delivery system consists a beam bender 13 and a focusing lens 14. The laser beam coming from the beam expander of the laser source is to be sent to the work-surface. Beam bender 13 bends the beam at 90° which is then focused by the focusing lens 14. By changing the focal length of focusing lens 14, power density and depth of the focus can be altered. The alignment of the focus is very important because if the beam center does not co-inside with center of the lens then the beam after the lens will not be straight and therefore the cutting efficiency drastically decreased.

RF Q-Switch driver to get the pulsed output with high peak power, the laser is operated in Q-switched mode 5. To get the radio frequency RF generator 20 is used. Due to this high frequency it is also cooled by chilled water by chilling unit 21.

Chiller unit is used for two purpose;

(1) three phase chiller system which is used for providing the chilled water to the laser head 4 and Q-switch 5.

(2) Pump system 22 which is mainly used for circulating the water from chiller to the laser head via water to water heat exchanger 15.

Inside laser cavity 23 both Nd:YAG rod and the lamp are immersed in flowing cold water. The De-ionized water is used as it has high transparency and low electrical conductivity. Water temperature is regulated by means of a solenoid 30 CCD camera 16 gives 75 times magnification for on-line viewing the process. And this process can be seen on CCTV 17 to avoid errors.

Power supply unit ignites and controls the intensity of the laser light emitted by the laser lamp. This is the main power supply unit which controls the laser output. In many application laser is not used continuously, therefore the power supply is provided with a special feature of standby mode. This arrangement is very much useful in increasing the operational life of lamp and also that of power supply.

Servo Stabilizer prevents the whole machine from the variations of the electricity supply.(Para 24-33 of OD2)

Document D3 discloses in FIG. 2, three mirror configuration of the present invention, which also comprises primary mirror M1, secondary mirror M2 and tertiary mirror M3, is quite distinct from the prior art configuration of FIG. 1. More specifically, it will be seen in FIG. 2 that the three mirrors all share a common axis and that furthermore, the primary mirror M1 and the tertiary mirror M3 share a common vertex. It will be seen hereinafter that in addition to sharing a common vertex, primary mirror M1 and tertiary mirror M3 are fabricated on a common substrate, thereby fixing their relative positions to one another during fabrication and thus obviating the requirement for alignment upon assembly of the optical system.

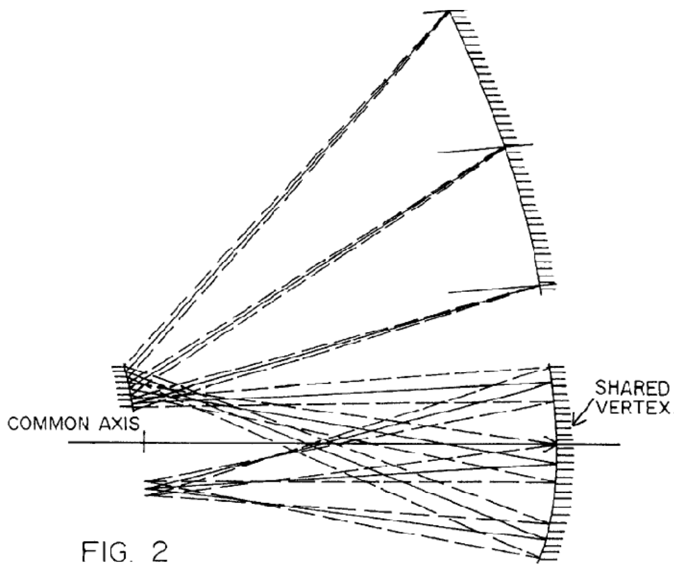


FIG. 2

The meaning of a common axis and a shared vertex may be better understood by reference to FIG. 3, wherein it will be seen that each mirror M1, M2 and M3 may be characterized as a selected portion of a curved surface. The surfaces of M1 and M2 are spherical and the surface of M3 is an ellipsoid. Each such surface is associated with an axis, and as shown in FIG. 3, all three such surfaces are configured to have a common unitary axis. Furthermore, the spherical surface of M1 and the ellipsoid surface of M3 are positioned to share a common vertex as shown in the right-hand portion of FIG. 3. An additional feature of the present invention, the most significant one thereof from the standpoint of manufacturability, is the shared common substrate of both M1 and M3, as seen best in FIGS. 4 and 5. FIGS. 4 and 5 are the front view and side view respectively, of a primary and tertiary mirror of the present invention fabricated on a common substrate and representing an actual reduction to practice of the invention herein disclosed.

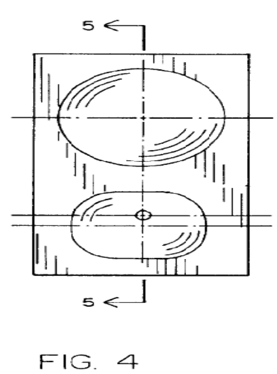


FIG. 4

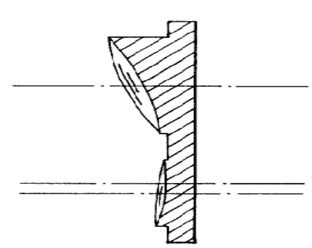
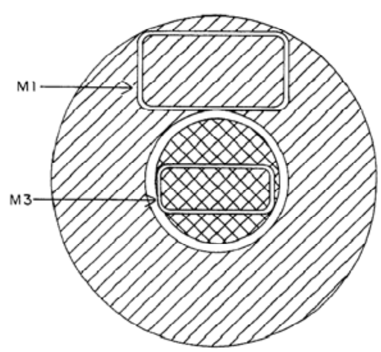


FIG. 5

In the configuration illustrated in FIGS. 4 and 5, the primary mirror M1 is substantially circular in shape, having a vertically projected diameter of 6.25 inches, a vertex radius of 20 inches and a conic constant of -0.771. The tertiary mirror M3 is substantially rectangular, but having rounded corners with a radius of about 0.75 inches, a vertical length of 4.245 inches and a horizontal width of 5.186 inches. The distance between the center lines of the primary mirror M1 and the tertiary mirror M3 is 6.726 inches and the common optical axis line is 0.691 inches above the center line of the tertiary mirror M3. Tertiary mirror M3 has a vertex radius of 8.456 inches and a conic constant of -0.124. The substrate material may, by way of example, be aluminum, beryllium, silicon carbide or SXA. (Col. 4-5, Line 36-67,1-13 Resp. of D3)

D3 also discloses FIG. 7, it will be seen that in the present invention there is no overlap between the machined regions of the primary and tertiary mirrors M1 and M3 respectively, and in fact as shown in FIG. 7, there is a gap or clearance annulus represented by the unshaded area in FIG. 7 between the outer fabrication circle of tertiary mirror M3 and the inner fabrication circle of primary mirror M1. More specifically, in FIG. 7, the cross-hatched area represents the machined region of the tertiary mirror M3 and the shaded area represents the machined region of the primary mirror M1. The machining of M3 is accomplished by moving the diamond turning tool radially from the center vertex point at the center of the circles of FIG. 7, outward in a radial direction. The same is true for the fabrication of M1.

FIG. 7



However, the radial travel of the cutting tool for fabrication of M3 is entirely distinct from and non-overlapping with the radial travel of the cutting tool for fabrication of M1. (Col. 5-6, Line 65-67, 1-14 Resp. of D3)

D3 further discloses in FIG. 8 illustrates test set-ups for initial alignment and subsequent interferometer analysis of a three-mirror optical system using the present invention. For purposes of illustration, the primary mirror M1 and the tertiary mirror M3 are shown in FIG. 8 on a common substrate that is cut down in size compared to the substrate shown previously in FIGS. 4 and 5. Initially, alignment of M2 relative to M1 and M3 is achieved without the laser interferometer and without the large reference surface, both of which are shown in FIG. 8.

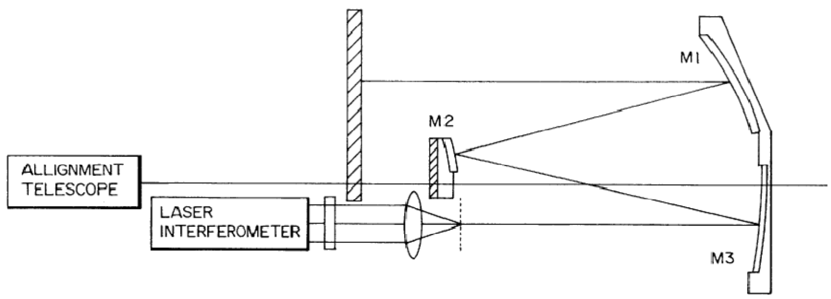


FIG. 8

The back side of the secondary mirror M2 is provided with a reference mirror surface which has an alignment mark thereon. Similarly, M3 is also provided with an alignment mark at the intersection of the common axis with M3. The distance between M2 and the substrate upon which M1 and M3 are located, is determined by a housing based upon precise calculation and design. On the other hand, the position of M2 in and out of FIG. 8 and vertically along FIG. 8 is determined by the alignment scope based upon the coincidence of the mark on the back reference mirror of M2 and the mark on M3 as viewed through the alignment scope. The principal significance of FIG. 8 is effectively what it does not show. More specifically, it does not show any need to reposition M1 relative to M3, which as previously noted are fixed relative to one another during the fabrication process because of the diamond turning of both mirrors on a common substrate. This results in a significant reduction in the number of variables that must be dealt with during the alignment process. As those having skill in the art to which the present invention pertains will readily perceive, if it were necessary, as it is in the prior art, to reposition M1 and M3 relative to one another, each such repositioning would require realignment of M2 relative to M1 and M3. The commensurate increase in the number of variables would grossly complicate the alignment process, making alignment more of an emperical process with more than one solution, some of which would not be as optimal as desired. On the other hand, as shown in FIG. 8, with M1 and M3 fixed relative to one another, and fixed also relative to the housing by means of the substrate upon which they are fabricated, the only variables are the relative position of M2 in three linear directions and in its angular orientation relative to the substrate upon which M1 and M3 are mounted. Thus, the process of alignment is far simpler and less time-consuming and thus less costly as a result of the unique fabrication process of the present invention.

After the alignment of M2 relative to the substrate of M1 and M3 is completed, the test process continues with the use of the laser interferometer and the large reference surface which receives and reflects the laser image wavefront from M1. The laser interferometer test process is a standard one in the art and need not be described herein in detail. Suffice it to say that the laser interferometer is operated in conjunction with a lens for providing an image plane upon which there is generated an interference pattern, the character of which depends upon the proper alignment and orientation of each of the mirror elements of the optical system shown in FIG. 8. Basically, the interferometer measurement is a precise means for assessing the accuracy of the alignment of M2 as previously described. In the event that the interferometer test shows that alignment is still not precisely correct, the system may still be aligned using the interferometer while making very precise minor adjustments with respect to M2 only. The fine adjustment of only M2 to optimize the alignment of the optical system of FIG. 8 is made possible as a result of the common substrate manufacturing process of the present invention which obviates adjustment of M1 and M3 in this final stage of alignment. (Col. 6-7, Line 20-67, 1-19 Resp. of D3)

Document OD3 discloses in FIG. 1 shows the laser 1 having a housing 2 surrounding the resonator or discharge volume 5 and enclosing the electrode system 10-14. The two endfaces 8 and 9 of the housing serve mostly to hold the mirrors 17-21. The system of electrodes 10-14 has an external voltage supply lead and consists of the central electrode 11 located on the longitudinal axis of the housing 2 and having an outer contour that defines two oppositely directed discharge surfaces 12 and 13, each of which cooperates with an associated opposite electrode 10 and 14 located inside the housing along the longitudinal wall, with discharge surfaces 3 and 4, respectively.

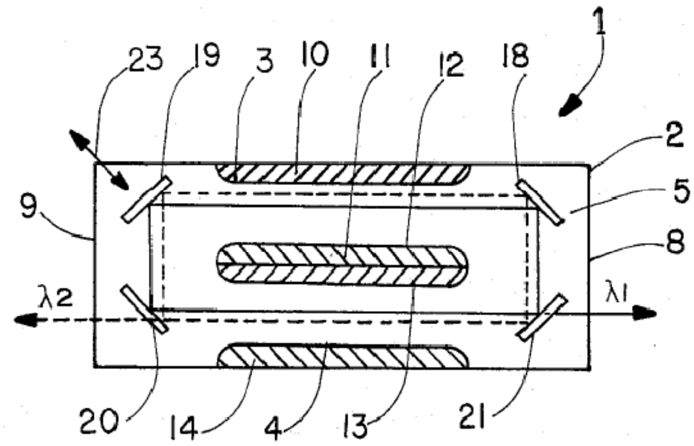


Fig. 1

The three totally reflecting elements 18-20, for example, mirrors, and the partially transmissive optical element 21, possibly another, suitably constructed mirror, are disposed at the end faces 8 and 9 at the level of the free spaces between the electrodes, all for the case of a beam of wavelength λ1 as shown in solid lines. The surfaces of the mirrors face one another and make an angle of 45° with the beam path. When the gas in the resonator chamber is excited, the emissions constitute a ring laser whose radiation is coupled out through the partially transmitting mirror 21. If a ring laser with two wavelengths λ1 and λ2 is used, another totally reflecting mirror, for example mirror 20, must be replaced by a partially transmitting mirror. An example of a laser with four different extractable wavelengths λ1 and λ4 is illustrated in FIG. 3. In this case, transmission is set at 85% and reflection at 15%. Of course, these percentages of transmission and reflection can be changed for other embodiments and could even be different for any of the four optical elements of the example shown. (Col. 4, Line 8-40 of OD3)

Document OD3 also discloses in FIG. 2 the mirrors 19' and 20', including their associated gratings, are rotatable in the direction of the double arrows. As shown, the mirror 19' has been turned by approx. 45° so that the mirrors 19' and 20' now only reflect along parallel lines, in the longitudinal direction of the housing 2, toward the associated transparent or partially transparent mirrors 18' and 21' which may be moved in the direction of the double arrows and can replace the wall at this location.

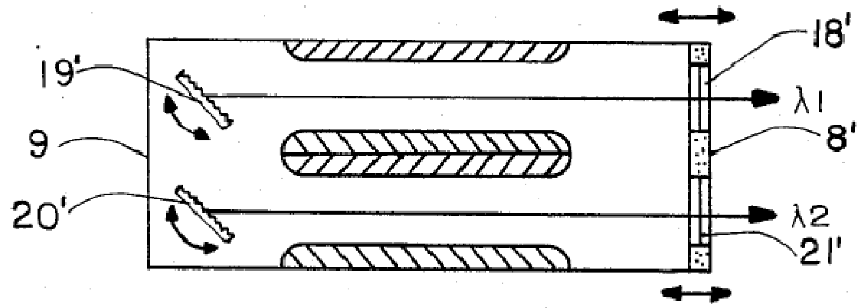


Fig. 2

This construction permits an adjustment of the length of the laser and operation of the laser with two synchronous pulses of wavelengths λ1 and λ2, extracted separately by mirrors 18' and 21', respectively. Other wavelength-selective optical elements, for example, prisms, could be used instead of the gratings. The grating constants corresponding to the mirrors associated with different wavelengths can be different. The displacement of the optical elements and/or the sidewall on which they are mounted takes place with the aid of the piezoelectric drive 23, in each case perpendicular to the plane of these elements or sides.

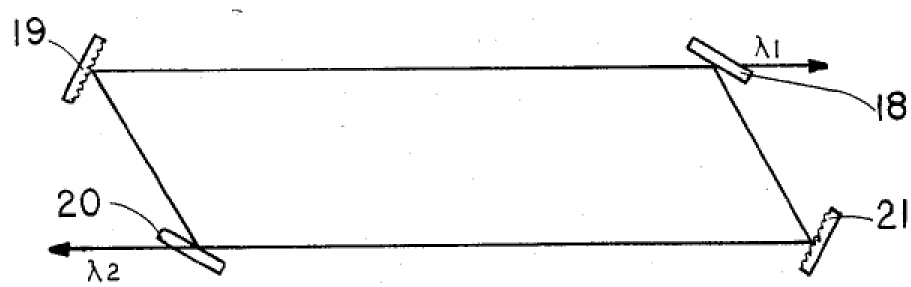


Fig. 4

In the embodiment of FIG. 4, the beam path forms a parallelogram. This is due to the fact that only diagonally opposite mirrors 18 and 20 on the one hand, and 19 and 21 on the other hand, or their gratings, subtend the same angle of the beam. In this instance, two beams with different wavelengths λ1 and λ2 are coupled out by 80%-transmitting mirrors 18 and 20.

FIGS. 5a and 5b show the endwalls 8 and 9 separately. They may be made of glass, glass-ceramic material, quartz, plastic, germanium, CdTe or zinc selenide. In the present example, the two mirrors 18' and 21' are fixed in their mutual relationship of surfaces. The mirror 18' is totally reflecting while the mirror 21' has an outer, partially transmitting region and a fully transparent center created by the hole 7'. Depending on the type of laser used, from 10 to 90% of the surface may be taken up by the opening. In another embodiment, not shown in the drawing, there is no hole; in that case, the "mirror" must be thought of as being transparent, with only low absorption. It would also be possible to make the entire endwall of transparent material and only cause total reflection at the desired location, for example, by vapor deposit of a layer of gold. The totally reflecting mirrors and the partially transmissive layers could also be imbedded in the wall. A plate so constructed may be used as a mode selector.

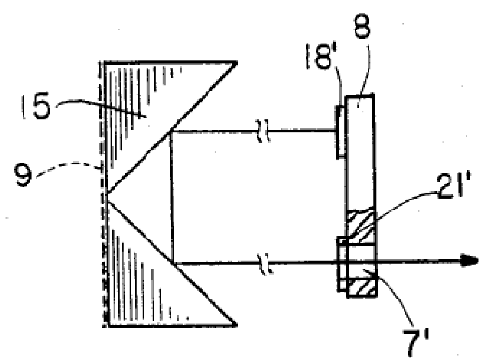


Fig. 5a

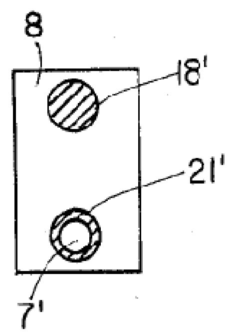


Fig. 5b

In another embodiment, shown in FIG. 5a, the totally reflecting mirrors of the wall 9 may be replaced by a prism block 15 or, as shown in FIG. 6, by a triple mirror 16. The latter should be so placed in the beam that only its surface areas 16' are optically active, but not its ridges 16". (Col. 4-5, Line 41-68, 1-25 Resp. of OD3)

Document OD3 discloses in FIG. 8, the beam can be guided and shaped while being folded outside of the housing. As shown in dashed lines, this processing can also take place within the housing.

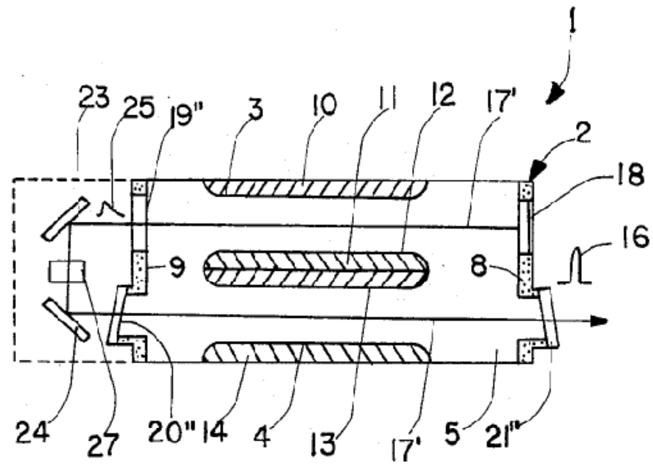


Fig. 8

In this example, only a totally reflecting element, 18, for example a mirror, is fastened to, or inserted in the wall 8, while part of the wall 9 is replaced by an at least partially transmissive optical element 19", for example another suitably constructed mirror, or the wall is made transparent to the laser radiation at this location. Brewster angle windows 20" and 21" are inserted into the walls 8 and 9 between the electrodes 11 and 14.

In this arrangement, the laser beam 17' is fully reflected at the mirror 18 and then passes through the discharge channel formed by the electrodes 10 and 11, e.g., a laser oscillator. It is then coupled out at the other side and deviated by 90° at the mirror 23 which is positioned at a 45° angle with respect to the beam. The beam then enters the element 27 that processes the beam temporally or spatially. This is the preferred position for the element 27 but, in principle, it may be located anywhere in the beam path.

If it is necessary to incorporate an element 27 that influences the time behavior of the beam, also called a mode-locking element, that element may be an active or passive Q-switch. The active switch may have, as effective component, an electro-optical crystal of CdTe or an acousto-optical crystal, while the passive switch can contain a saturable absorber of Ge, SF6 or hot CO2. In the latter case, the crystal itself has the property of acting as an optical switch due to saturation absorption, while this effect is created by optical triggering in the former case. A laser spark gap may be used to trigger the electro-optical switch in order to change the transmission. If it is necessary to alter the spatial properties of the pulse, that means the laser pulse must be made wider or changed from a narrow to a broad shape. The beam can also be rotated or polarized or its phase fronts may be changed by adaptive optics. The deviating elements may also be adaptive mirrors. After exiting from the element 27, the laser beam is again deviated by 90°, into the opposite direction of its original direction, by the mirror 24, also set at 45° relative to the beam. It passes through the Brewster angle window 20" in the end wall 9 into the channel formed by the electrodes 11 and 14, serving as an amplifier in the present example. At the other end, the laser beam is then extracted through the Brewster angle window 21" in the end wall 8, in the direction of the arrow.

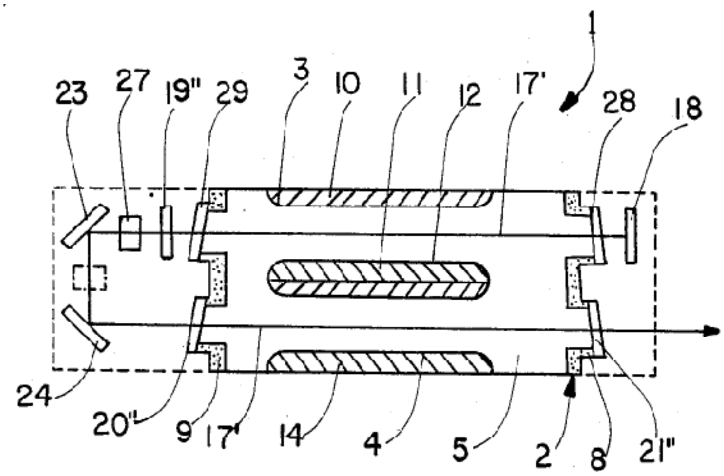


Fig. 9

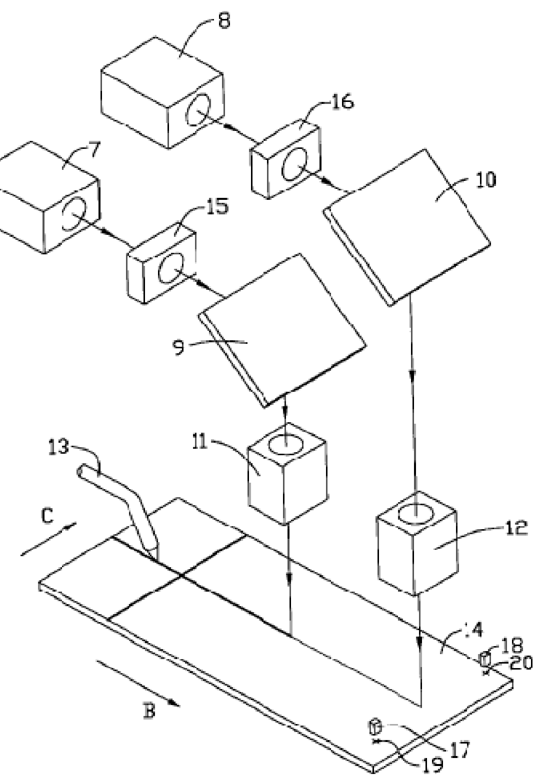
FIG. 9 differs from FIG. 8 mainly only in that the optical elements 18 and 19" in the side walls 8 and 9 are replaced by the Brewster angle windows 28 and 29. The optical elements 18 and 19" are disposed, in this example, outside of the housing 2, in each case directly adjacent the associated Brewster angle window 28, 29. (Col. 5-6, Line 31-68, 1-17 Resp. of OD3)

SCIENTIFIC AND TECHNICAL ANALYSIS FOR APPLICANT'S ARGUMENTS

Technical feature "gemstone processing machine (200) for processing a gemstone, said gemstone processing machine (200) comprising: a laser resonator (205), wherein said laser resonator (205) comprises: a laser source (210) to generate a laser beam; a first reflective member (230) optically coupled to said laser source (210),wherein said laser beam is incident on said first reflective member (230) through a first aperture (220) placed on a first side (245) of said laser source (210) adjacent to the first reflective member (230); and a second reflective member (235) optically coupled to said laser source (210); a second aperture (225) positioned on said first side (245) adjacent to said second reflective member (235); an operating assembly (255) operably connected to said laser resonator (205); characterized in that, said first reflective member (230) is inline with said laser source (210), and positioned on a first side (245) of said laser source (210), wherein said first reflective member (230) reflects back said incident laser beam to a second side of said laser source through said first aperture (220); said second reflective member (235) is offset from said laser source (210), and positioned on said first side (245) of said laser source (210); and said laser resonator (205) comprises: at least a first beam bender (265) is placed inline with said laser source (210), and positioned on said second side (260) of said laser source (210) to reflect said laser beam incident from said first reflective member (230), at a first angle of reflection being 45°; and at least a second beam bender (270) is placed offset from said laser source (210), and positioned on said second side (260) to reflect said laser beam reflected by said first beam bender (265) to said second reflective member (235) through said second aperture (225), at a second angle of reflection being 45°" has not been disclosed by cited documents.

Applicant's above argument has been fully considered but it is not persuasive as Document D2 discloses in Figure 2, the laser cutting apparatus includes a first laser unit, second laser unit, and a cooling system 13. The first laser unit, and the first laser beam unit 7 includes a first reflecting mirror 9 and the first focusing lens assembly 11 to form a first laser beam for irradiating the substrate 14. The second laser unit includes a second laser beam unit 8 includes a second reflecting mirror 10 and the second focus lens assembly 12 to form a second laser beam to focus on the surface of the substrate 14. In the present embodiment, the first laser beam is a carbon dioxide laser beam, the second laser beam is a laser beam of ultraviolet wavelength (UV Laser). Wherein the first laser beam through a first reflection mirror 9, after being reflected on the first focusing lens assembly 11, to irradiate the substrate 14 in a non-focus method in a non-focus position of the first focus lens assembly 11 . The second laser beam through the second reflecting mirror 10, is reflected to the second focus lens assembly 12 is focused on the substrate 14 in a focus system to the focus position of the second focus lens assembly 12. The cooling system 13 may be a single liquid, mixture or mixtures of one or more gas and liquid in the single gas and a single liquid and the like. For example, it is air, pure water, cooling oil, such as helium nitrogen or liquid fluid.

【図 2】



Referring to FIG. 2, the cooling system 13 along the cutting direction B, the first laser unit and said second laser unit is arranged in order. When cutting the substrate 14, via the second reflecting mirror 10 to the second laser light is a suitable material, is reflected to the the second focusing lens assembly 12, the second focusing lens assembly 12, the the energy of the second laser beam to focus on the surface of the substrate 14. At this time, using a frequency of power and high pulse of high pulse of the second laser beam to remove material of the surface of the substrate 14 to form a pre-cut line of a predetermined depth in the substrate 14. (English Translation of description D2)

D2 also discloses a second laser beam to form a pre-cut line on the substrate 14, it is reflected by the first focusing lens assembly 11 via the first reflecting mirror 9, wherein the first laser beam is made of suitable material, a first focus lens assembly 11, to irradiate the substrate surface in advance along a line unfocused manner the energy of the first laser beam to thermally expand the substrate, thereby, the compression stress is generated inside the substrate.

After the first laser light is heated precut line of the substrate, the cooling system 13 is rapidly inject atomized cooling liquid to the substrate 14 along the pre-cut line is heated. Therefore, drops rapidly the temperature of the substrate surface, a tensile stress is generated inside the substrate is contracted.

Local of the substrate, because generates abrupt stress change in a short time, to form a crack along the pre-cut line is formed from the substrate second laser beam. Since the cracks are extended along the cutting plane, thereby completely separating the substrate. This implements the cutting of the substrate 14.

Factors to separate the substrate are many, but mainly is the stress generated in the glass. The stress is to display the official below.

Here, sigma is the magnitude of the stress generated in the glass faceplate, alpha inside the thermal expansion coefficient of the glass faceplate, E is the modulus of longitudinal elasticity of the glass faceplate, T1 is the temperature of the glass faceplate which has been heated to a laser cutting device , T2 is the temperature of the glass faceplate after cooling.

The number 1 and number 2 and the size of the glass faceplate internal stress is found to be directly proportional to temperature difference to be formed on the glass faceplate thermal expansion coefficient of the material, Young's modulus, and by the laser and the cooling system . The maximum value of T1 is not greater than the vaporization temperature of the glass faceplate.

If stress and laser heating device and the cooling system to form the substrate is greater than the burst strength of the substrate material, cracks are formed on the substrate surface. The cracks, by the manufacturing method, the surface of the glass, for example, exhibit different growth forms, such as the substrate is completely separated.

Referring to FIG. 2, in the present invention, because it forms a pre-cut line on a surface of the substrate 14 in the second laser beam, the uniformity is high in the pre-cut surface is formed, it does not form a primary crack. In this way, in the cutting process, it is possible to secure high cutting quality. In addition, the depth and the cutting quality of the cutting line the second laser beam of ultraviolet wavelength is formed on the surface of the substrate 14, the magnitude of the power of the laser beam, the laser spot size, cutting speed, and related to the pulse frequency of the laser light. When cutting with a pulse frequency is small (100~200KHz) said second laser beam forms a discontinuous opening to the cross section of the pre-cut line. If the pulse frequency is greater than 200KHz is a pre-cross-section of the cutting line smooth, rather than discontinuous openings, not crack at the intersection of the vertical cutting lines to form a pre-cut line with the surface of the substrate 14.

In the cutting process, the path pre-cutting path the second laser beam is formed on the substrate 14, the path and cooling system first laser beam is irradiated onto the substrate 14 is injected into the substrate 14 is positioned on the same straight line. (English Translation of description D2)

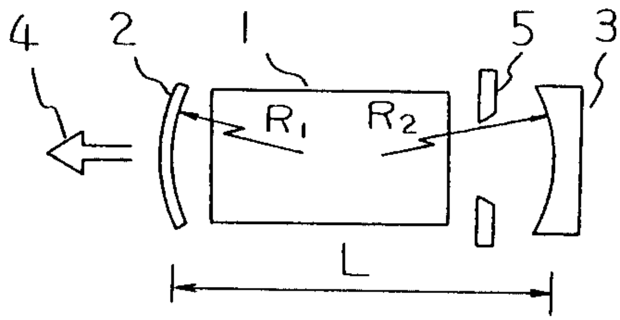
D2 further discloses that it takes time from the state in which the laser beam is close to a state of outputting flare and stably, in order to output the laser beam stably, first between the first laser beam unit 7 and the first reflecting mirror 9 It established the Ikko breaker 15, installing a second optical interrupter 16 between the second laser beam unit 8 and the second reflecting mirror 10. By the optical interrupter, it can be controlled to output the laser beam on the surface of the substrate 14. That is, the switch laser beam is passed or blocked the light breaker. Accordingly, in the manufacturing process, it is not necessary to control the laser unit, when controlling only the closing and putting the light interrupter, can control the output of the laser beam.

In the present invention, the mounting substrate 4 to the substrate mounting table, the substrate mounting table is a linear or rotary motion. As shown in FIG. 2, the laser cutting apparatus of the present invention, the cutting direction B, can be cut along the C. Specifically, the cutting device, in all cases, after cutting along the cutting direction C, it is possible to cut along the cutting direction B. Alternatively, it may be cut by the contradictory order. After cutting repeatedly along the cutting direction C, and the substrate 4 is rotated, it may be cut along the cutting direction B. The angle of rotation is to be noted that not limited to 90 degrees.
In addition, in order to satisfy the cutting accuracy, the substrate 4 must guarantee the accuracy of attaching the mounting table board. A first positioning point 19 on the substrate 4, and the second positioning point 20, the first positioning point 19, the first image sensor 17 and the second image sensor 18 respectively corresponding to the second positioning point 20 is installed. A first positioning point 19 by the first image sensor 17 and the second image sensor 18 with scanning the position of the second positioning point 20, to adjust the rotation and movement of the substrate table, accurately purpose of determining the position of the substrate 4 It can be realized. (English Translation of description D2)

Document D1 discloses high-power laser oscillator having surface roughness of an outer circumferential section except a section in the vicinity of the center is made coarse in at least one of reflecting mirrors 2, 3 for a laser resonator in which an enclosure, in which a laser medium 1 is encapsulated, and a plurality of the reflecting mirrors 2, 3 resonating laser beams are opposed to each another. With the total reflecting mirror such as one 3, the quality of a material is of oxygen-free copper, the surface is finished through diamond cutting, and surface roughness is made coarse gradually toward an outer circumference from the section of a diameter slightly smaller than the diameter of an aperture. Surface roughness is adjusted by using 100- 1000# abrasive paper, and the mean of surface roughness processed through a chucking to a lathe is brought to approximately 1mum. Accordingly, beams having the desired distribution of intensity can be obtained even on an application to a resonator having Fresnel of numeral 3. (Abst of D1)

D1 also discloses in FIG. 1, structure of a conventional laser resonator with the simplest 11 configurations, many high-power lasers use folded resonators. The laser medium 1 is excited by glow discharge, for example, in the case of a CO2 laser, in which a thin debris mainly composed of CO2N and He is enclosed.

第1図



The laser light is amplified by the laser medium 'Jd 1 while being reciprocally reflected between the pair of reflecting bones, that is, between the translucent output teacher 2 and the entire anti-duck 3, and a part of the laser light is output from the output steep 2. 4 is taken out to the outside. A hollow disc having an inner diameter 2a, which is called "chassis 5", is inserted between the output rod 2 and the all-reverse button +3. The aperture 5 is used for the purpose of limiting the beam diameter, increasing the difference in the measurement of the components in the resonator, and obtaining a quality beam. Generally, the aperture 5 is arranged near the total reflection button 3. Is done. Now, the radius of curvature of the output ll 2 is R13, the radius of curvature of the total reflection C3 is R7, the resonator length, that is, the distance between the output 2 and the total reflection 3 is L, and R1, R, 2, Il , A is called a resonator parameter. When the laser bond 1 is a uniform medium and the Fresnel number is very small, to obtain a beam with a Gaussian intensity distribution, the resonator parameter satisfies the equation (1), and the left side is greater than the right side. This can be achieved by selecting a VC so that it is as small as possible. (English translation of description of D1)

Document OD1 discloses laser device 10 of the type having a pulsed laser beam output 11. The laser device includes an elongated generally rectangular box-type housing 12 for an optical resonator 13 that utilizes an elongated cylindrical ruby rod 14 as the lasing medium source. The device also includes a means for pumping energy into the lasing material and which is shown in the form of an elongated xenon flashlamp 15.

The optical cavity or resonator light path 16 in the illustrated embodiment includes horizontally extending parallel linear light paths 17 and 18 that are laterally offset and interconnected by a light path 57 within the prism component of the resonator. The opposite end terminals 19 and 20 of the cavity 16 are formed and defined by flat planar mirror surfaces 21 and 22 that are formed by means of coatings 21a and 22a which are fixed to the exterior surface 23a of a rigid unitary component 23 that provides the base support structure for the mirror coatings. The laser rod 14 is mounted with its longitudinal axis 24 in a coaxial arrangement with light path 17 so that the photon beams produced along the rod axis may be propagated in the cavity 16. The laser beam 50 produced by the lasing action is translated and reflected between the light paths 17 and 18 by means of a corner prism 25 that is arranged at the prisms ends 26 and 27 of the light paths 17 and 18. These path ends 26 and 27 are opposite the respective terminal ends 19 and 20 of the cavity.

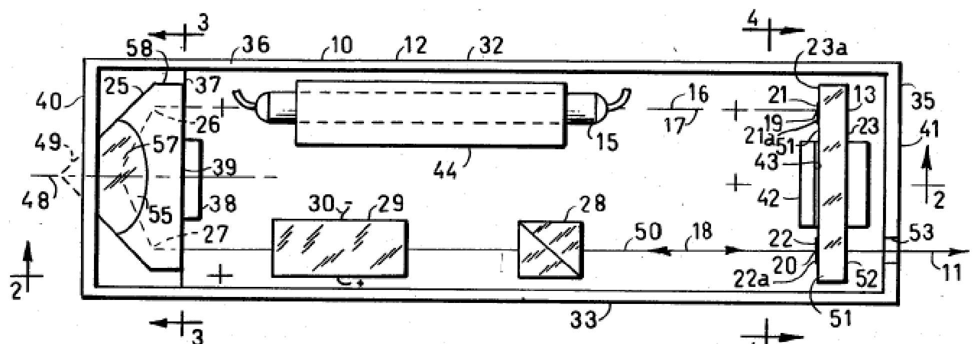


FIG. 1

The device also includes, in the illustrated embodiment, a dielectric polarizer 28 which is mounted in path 18 and a Q-switch which is shown in the form of a pockels cell 29 that is also mounted in the path 18. These components 28 and 29 are supported in path 18 by rigid supports (not shown) but which are securely mounted on the bottom wall 31 of housing 12. The components 28 and 29 are conventional components used in laser applications and which cooperate in providing a pulse output 11 when the pockels cell is subjected to successive applications of a D-C voltage as through leads 30.

The housing includes opposite side walls 32 and 33, opposite end walls 34 and 35, and an open top wall 36 in addition to the bottom wall 31 of the resonator enclosing structure. At one end 50 of the housing, the housing in internally equipped with a form fitting mount 37 for the corner prism 25 and which is integral with the bottom wall and adjacent end wall 34. The mounting 37 has an upright section 38 which confronts a center portion of the prism face 39 between the paths 17 and 18. It serves to maintain the planar facial surface portion 39 of the prism substantially in parallel with the inside planar surface portion 51 of the mirror base 23 at the other end 41 of the housing, and thus also in parallel with the mirror surfaces 21 and 22.

Generally intermediate the opposite side walls 32 and 33 and located adjacent end wall 35, the housing is internally equipped with an upright rigid mounting block 42 for the base component 23 for the mirrors. Block 42 is integrally formed with the bottom wall of the housing and has a transversely extending vertical slot 43 in which the base component 23 is fixed. As thus fixed, the mirror surfaces 21 and 22 that form and define the end terminals 19 and 20 are laterally offset from the mount 42 and arranged in the light paths 17 and 18.

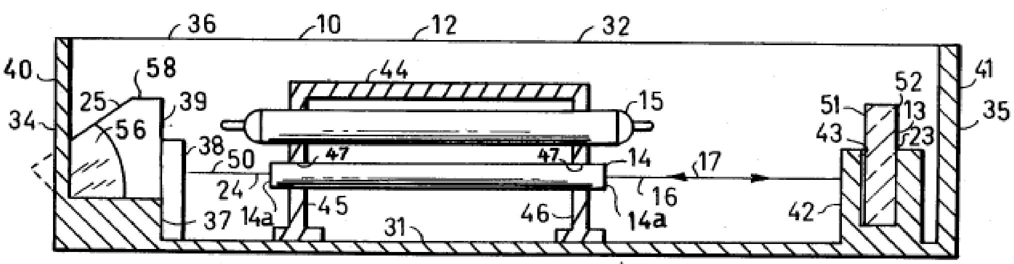


FIG. 2

The flashlamp 15 and laser rod 14 are mounted on an inverted rigid U-shaped support 44 that is fixed to the bottom wall 31 and located adjacent side wall 32. Support 44 has spaced apart upright legs 45 and 46 with appropriate horizontally aligned apertures for their mounted positions. These components 15 and 16 of the device are vertically spaced apart on support 44 and horizontally arranged in parallel as seen in FIG. 2. The laser beam 50, under such circumstances, passes through the aligned leg apertures 47 for rod 14 as it traverses the path 17 through the rod.

The mirror base component 23 of the resonator is generally rectangular in the illustrated embodiment and preferably made of fused quartz material because of its low temperature coefficient of expansion as well as the desire, in the illustrated embodiment, for transparency to facilitate the transmission of the laser output 11. The oppositely facing surface portions 51 and 52 of the flat base component 23 are plane parallel surfaces and the mirror surfaces and the mirror surfaces 21 and 22 that form and define the end terminals of the cavity are embodied and fixed on the inside facing planar surface portion 51 so as to provide a coplaner arrangement of the mirror surfaces and facilitate a generally parallel arrangement with the face 39 of prism 25. The mirror surfaces 21 and 22 may be formed from any suitable coating material providing the desired reflectivity. Coating 21a may be formed from conventional dielectric coating materials that provide a maximum reflectance and coating 22a may be formed from conventional dielectric material providing a lesser reflectance at surface 22 so that a portion of the light incident to the latter surface 22 may be transmitted through the base as the output beam 11. Typically, the coating 22a may provide 60% reflectance of the incident light at surface 22 so that a portion of the incident light impinging on the surface 22 passes through the quartz base component and then through the aligned aperture 53 in end wall 35 to provide the laser output beam 11.

The mirror surfaces 21 and 22 on the quartz structure 23 are spaced apart and face in a common direction toward the prism face so that incident beam light impinging on each surface is reflected 180° and thus back along the path of incidence at the terminal mirror.

The corner prism 25 in the illustrated embodiment is formed from a cylindrical quartz component 58 that is provided with three orthagonally arranged reflective surfaces 54, 55, and 56. The components 58 is truncated and, as seen in FIG. 3, has a flat surface 59 that is normal to the facial surface 39 and in parallel with the axis 48 through the apex 49 of the component, the arrangement being provided to facilitate the mounting of the prism in mount 37. As thus arranged in the resonator, the axis 48 of the prism is generally normal to the flat face 51 of the base component 23 so that surfaces 39 and 51 of the resonator components 25 and 23 are generally parallel. However, substantial deviation in the parallel arrangement can be tolerated because of the optical nature of the prism and which translates and reflects the incident light along parallel paths.

In normal operation of the laser device 10, the flashlamp 15 is initially energized so as to provide a means for pumping energy into the lasing medium of rod 14. When an electron population inversion is attained, a lasing action transpires and the photon or light beams produced in the medium along the rod axis 24 are propagated back and forth between the end terminals 19 and 20. At end terminal 19 the incident beam light along path 17 is normal to the plane surface 51 and upon impinging upon surface 21 is reflected back along the path 17 of incidence thereto. At the opposite ends of rod 14, the rod is equipped with planar end surface portions 14a that are normal to the path 17 to avoid light refraction in the illustrated embodiment. However, to avoid the resulting etalon effect at the rod ends, conventional wedging practices may be followed as will be apparent to those skilled in the art. In transversing the rod along path 17, the reflected beam light further stimulates photon beam emission as is well known. At the prism end 26 of path 17, the incident light beam 50 passes through the prism face 39 and encounters the orthogonally arranged reflective surface 54 of prism 25 and is thereby reflected along the path 57 of translation between paths 17 and 18 as best seen in FIGS. 1 and 3. In traversing the path 57, the light reflected by surface 54 thereafter impinges upon the orthogonal surfaces 55 and 56. At surface 56 the translated beam light is reflected into path 18 and emerges from the prism 25 through the prism face 39. The end surfaces of components 29 and 28 are normal to the path 18 to avoid nonlinearity in path 18 and after traversing the pockets cell 29 and polarizer 28, the beam light impinges upon mirror surface 22. Here a portion of the beam light incident to the surface 22 is reflected back along the path 18 while the balance of the incident light passes through the coating 22a and component 23 and thence, through aperture 53 to provide the laser output 11. The beam light reflected by the terminal forming surface 22, of course, then retraces the paths 18, 57, and 17 to the other terminal end 19 of the cavity and is again reflected so that further photon beam emission is stimulated during each traverse of the rod 14.

The Q-switching function of the Pockets cell 29 is deemed obvious to those skilled in the art. Briefly, however, the cell 29 is subjected to a pulsating D-C voltage that successively activates the cell so that the beam propagation is periodically interrupted when the cell is activated. During the activated period, pumping continues and the inversion builds up to be released during the intervals of voltage removal from the cell so that the output is concentrated in short pulsating burts of coherent light. (Col. 4-7, Line 38-68, 1-68, 1-68, 1-8 Resp. of OD1)

OD1 also discloses in FIGS. 5-8 and wherein the invention is seen as embodied in a laser device 60 of the type having a continuous beam output 61. The device 60 is quite similar in structure to the device illustrated in the previous embodiment with provisions, however, being made for a generally lateral and continuous beam output 61. Again, the device includes an elongated generally rectangular housing 62 for the optical resonator 63. The resonator 63 utilizes an elongated cylindrical YAG rod 64 as a source of lasing medium and an elongated cylindrical krypton lamp 65 as the means for pumping energy into the lasing medium.

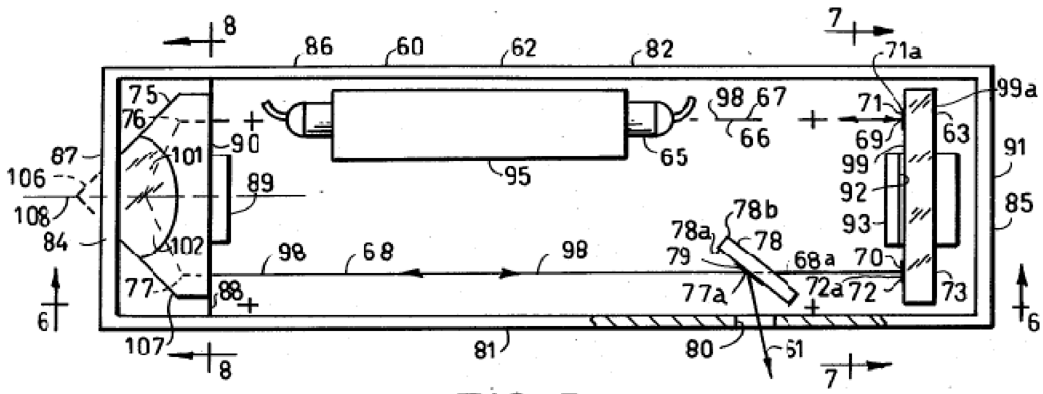


FIG. 5

The resonator path or optical cavity 66 again has horizontally extending linear light paths 67 and 68a which terminate at the end terminals 69 and 70 and are parallel and laterally offset as seen in the drawings. The end terminals 69 and 70 of the cavity 66 are formed and defined by mirror surfaces 71 and 72 that are embodied in another rigid unitary quartz component 73 that forms the base structure for mirror coatings 71a and 72a. The longitudinal axis 74 of the laser rod 64 is coaxially arranged with light path 67 to again facilitate propagation of the photon beams which are produced in the medium along the rod axis. The beam 98 developed by the lasing action is translated and reflected between parallel light paths 67 and 68a by means of another corner prism 75 which is structurally identical to that described in the previous embodiment and by means of a quartz component 78 that serves as the base for the pick-off mirror coating 79. Prism 75 is arranged at the prism ends 76 and 77 of the paths 67 and 68. The opposite ends of the path 67 are designated at 76 and 69, whereas the opposite ends of the path 68 are designated at 77 and 77a respectively.

At path end 77a, the laser device is provided with a flat, transparent and rectangular quartz component 78 that serves as a mount providing a surface 78a for a suitable dielectric coating 79 which laterally reflects a portion of the light through an aperture 80 in the housing side wall 81 to thus provide the output beam 61. The balance of the light incident to the coated surface 78a is transmitted by the transparent component 78 and due to refraction is translated to emerge from component 78 at the opposite surface 78b along the path 68a. Path 68a is offset from path 68 but nevertheless parallel to both paths 67 and 68.

As in the arrangement shown in the previous embodiment, the housing 62 has opposite side walls 81 and 82, opposite end walls 84 and 85, and an open top wall 86 in addition to the bottom wall 83 of the structure. At one end 87 of the housing, the housing is internally equipped adjacent end wall 84 with a form fitting mount 88 for the corner prism 75. Mount 88 includes an upright section 89 that confronts a center portion of the plane facial surface portion 90 of the prism and which is located between the parallel light paths 67 and 68 for purposes of maintaining a substantially parallel arrangement of the prism face 90 with the inside planar surface portion 99 of the mirror base 73 at the other end 91 of the housing. The laser beam along paths 67 and 68 is accordingly normal to the prism face 90 upon emergence and entry of the prism.

The terminal mirror base component 73 is mounted in a transversely arranged slot 92 in a rigid block 93 and which is formed integral with the bottom wall and generally located adjacent to end wall 85 and intermediate the opposite side walls 81 and 82. The rigid rectangular base component 73 is fixed in the slot 92 and arranged with the end terminal forming and defining mirror surfaces 71 and 72 laterally offset from the block and in the light paths 67 and 68a at the end terminals 69 and 70 of the cavity.

The lamp 65 and rod 64 are mounted on another inverted rigid U-shaped component 95 that is fixed to the bottom wall and located adjacent side wall 82. The legs 96 and 97 of the support 95 are spaced apart and are provided with horizontally aligned apertures for receiving the opposite ends of the laser rod and flashlamp in their mounted positions. These components 64 and 65 are also vertically spaced apart and horizontally arranged in parallel as seen in FIG. 6, the arrangement being such that the laser beam 98 passes through the aligned leg apertures 104 in traversing the light path 67 through rod 64. The opposite end plane surface portions 64a of rod 64, are normal to path 67 in the illustration so as to avoid refraction and simplify the structural requirements. Again however, conventional wedging practices may be used to avoid the etalon effects if desired.

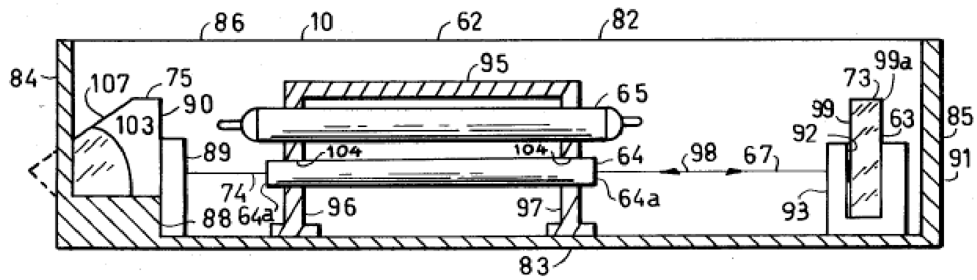


FIG. 6

The base component 73 is generally rectangular as seen in the drawings, and may be made, in this embodiment, from any suitable opaque or transparent material providing the desired rigidity for the structure. A fused quartz glass material is entirely suitable and preferred however, because of its low temperature coefficient of expansion. The inside facing surface portion 99 of the outer surface 99a of the base 73 is a plane surface, and the mirror surfaces 71 and 72 that define and form the end terminals of the cavity are provided by reflective coatings 71a and 72a that are fixed to the flat surface 99. These coatings may be formed by conventional dielectric coating materials and which, in this embodiment, provide a maximum reflectance at both mirror surfaces 71 and 72. These surfaces 71 and 72 may of course, be provided by a continuous noninterrupted coating that covers the entire surface 99 if desired. The mirror surfaces 71 and 72 face in a common direction toward the prism face, and as such, the incident beam light that falls on the surfaces 71 and 72 is reflected by each surface back along its path of incidence thereto and toward the prism face.

The corner prism 75, like the corner prism in the previous embodiment is made from a cylindrical quartz component 107 that is provided with orthogonally arranged flat plane light reflective surfaces 100, 102 and 103. The component is truncated as seen in the drawings, and also has a flat surface 105 which is parallel with the prism axis through the apex 108 to facilitate the mounting of the structure in the housing. The face 90 of the prism is, of course, perpendicular to the axis 106 and in mounting the component 73, the face 99 of the component is arranged generally normal to the prism axis 106 so that the mirror surfaces 71 and 72 are generally parallel with the face 90 of the prism 75.

When the laser device 60 is rendered operational, the lamp 65 is energized to provide the means for pumping energy into the lasing medium of the rod 64. As the population inversion is attained, the photon or light beams produced in the medium along the rod axis 74 are again propagated back and forth between the end terminals 69 and 70 of the cavity. At terminal 69, the path 67 for the incident beam light is normal to surface 99 and mirror surface 71 so that it is reflected back along the path 67 and through the rod 64 to further stimulate photo beam emission. At the prism end 76 of path 67, the beam enters the face 90 of prism 75 and encounters the reflective surface 100 of the corner prism 75. Here the incident light in path 67 is reflected along the path 101 for translating the beam between paths 67 and 68 as seen in FIGS. 5 and 8. Along this path 101, the beam light impinges upon orthogonally arranged surfaces 102 and 103 and from surface 103 is reflected along the linear light path 68 to emerge through the prism face 90. At end 77a of path 68, a portion of the beam light is laterally reflected as the output 61 by the coating 79. The balance of the light passes through component 78 and is refracted to emerge at surface 78b along path 68a. The translated beam light thereafter impinges upon mirror surface 72. Here, the path 68a is normal to the base surface 99 and surface 72 and hence, the incident light is again reflected back along the path 68a and thereafter retraces the paths 68, 101 and 67 to the other end terminal 69. Again, as the light passes along the path 67 through rod 64, further stimulated emission is, of course, developed.

In this embodiment, the corner prism 75 and component 78 reflect and translate the beam between the offset and parallel paths 67 and 68a that terminate at the planar surface and the base, and the surfaces 71 and 72 of the coatings are arranged to reflect the incident light at the terminal ends 69 and 72 back along the respective paths 67 and 68a.(Col. 7-9, Line 10-68, 1-68, 1-35 Resp. of OD1)

OD1 further discloses in FIG. 10 schematically illustrates a laser device embodying principles of the invention and in which a solid state laser rod constitutes the unitary base structure for the cavity and terminal mirrors.

The device 10 has a resonator 161 which includes an elongated cylindrical YAG rod 162 that provides the source of lasing material. It also includes an elongated cylindrical krypton lamp 163 that provides the means for pumping energy into the lasing medium. The laser beam 164 is developed along the axis 165 of the rod and resonates and is propagated back and forth between the end terminals 166 and 167 of the resonator cavity or light path 168.

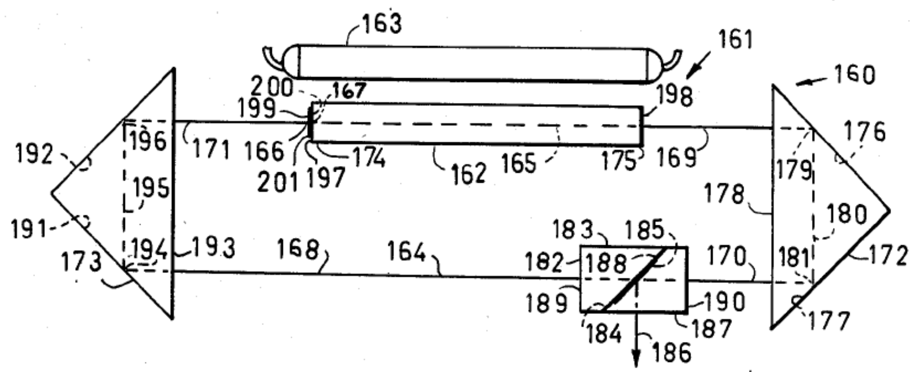


FIG. 10

The beam path 168 includes parallel linear light paths 169 and 170 and a linear light path 171 which is coaxial with path 169 and the rod axis 165 and also laterally offset from path 170. The beam is translated and reflected between the paths 171 and 169 that terminate at the cavity terminals 166 and 167 by means of a pair of porro, or roof top prisms which are designated at 172 and 173. These prisms, as seen in the drawings, are spaced apart from the opposite ends 174 and 175 of the laser rod.

Porro prism 172 has a pair of orthogonally arranged planar light reflective surfaces 176 and 177 and a flat planar facial surface portion 178 in the isosceles arrangement. The facial surface 178 is arranged perpendicular to the light path 169 and to the axis of the rod so that beam light along path 169, which is incident to the face 178 enters the prism and at the end 179 of path 159 impinges on and is reflected by the orthogonal surface 176 along a linear light path 180 in the prism. Path 180 is parallel to the prism face 178 and light incident to the prism surface 177 at the end 181 of path 180 is reflected along path 170 and in parallel with the light in path 169.

The base component of the pick-off mirror for the resonator is shown in the form of a wedge member that is designated at 183. It has a flat planar surface 184 which is inclined to the linear path 170 and provided with a suitable dielectric coating that is fixed to the surface 184 and serves to laterally reflect a portion of the beam light as the laser beam output 186. The wedge 183 of the pick-off mirror is transparent and preferably formed from a suitable quartz or other light transmitting material. To avoid beam refraction and non-linearity in the path 170 traversed between the prisms 173 and 172, a compensating wedge 187 made of like transparent material is provided. Wedge 187 has an inclined surface 188 that confronts the inclined surface 184 of member 183 in the assembled arrangement and is contiguous with the coating on surface 184. At the opposite ends of the wedge assembly, the wedge members 183 and 187 have flat plane surface portions 189 and 190. These surfaces are normal or perpendicular to the light path 170 so that refraction of light at the surfaces 189 and 190 is avoided and light reflected by the prism 172 along path 170 traverses a linear route to prism 173.

Prism 173 is also a porro prism and has orthogonally arranged planar light reflective surfaces 191 and 192, as well as a flat planar facial surface portion 193 in the isosceles arrangement. The face 193 of prism 173 is perpendicular to path 170 and parallel to the face 178 of prism 172. Beam light along path 170 that is incident to the normally arranged face 193 of the prism enters the prism and, at the end 194 of path 170, is reflected along the linear path 195 through the prism 173. At the other end 196 of path 195, light incident to the orthogonally arranged surface 192 is reflected toward the rod 162 along path 171 and, after emerging from the prism face 193, is reflected at the cavity end terminal 166 to again traverse the paths 171, 195, 170, 180 and 169 back to the other end terminal 167.

At the opposite ends 174 and 175 of the rod, the rod 162 is equipped with planar exterior surface portions 197 and 198. These surfaces are parallel to each other and to the faces 178 and 193 of the prisms, and hence are normal to the coaxial paths 171 and 169. The arrangement at end 175 permits the beam light along path 169 to enter or exit the end 175 without refraction. This rod end 175 can, of course, be provided with an inclined surface and a compensating wedge component if avoidance of the etalon effect is desired.

The end terminals 166 and 167 in this embodiment are formed by oppositely facing reflective or mirror surfaces 199 and 200 that are provided by a coating 201 of suitable light reflective material that is applied and fixed to the end surface 197 of rod 162. In this arrangement of the coating, surface 200 confronts the planar end surface 199 of the rod and the surfaces 199 and 200 are also normal to the light paths 171 and 169. The paths 171 and 169 accordingly extend in opposite directions from the end surface portion 201 of rod 162 with the beam light generated along the rod axis and incident to surface 200 being reflected toward prism 172 along the path 169 through the rod 162 while beam light incident to surface 199 is reflected back along path 171.

In this arrangement, the laser rod provides the rigid unitary structure for the coating that forms and defines the end terminals and has the advantage that proper orientation of the rod in the resonator arrangement serves to automatically arrange the terminal mirrors in the laser device.

FIG. 11 schematically illustrates an arrangement in a laser device and in which the envelope for a fluid lasing medium constitutes the rigid unitary base structure for the cavity end terminal mirrors.

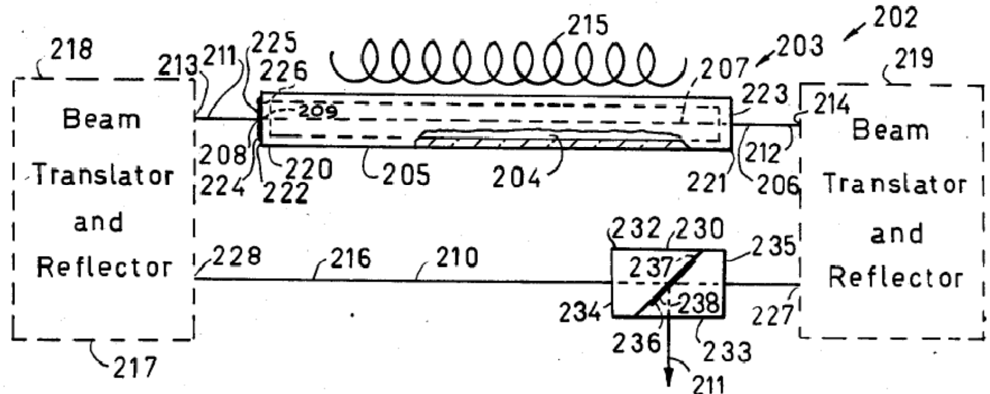


FIG. 11

The lasing device 202 shown in FIG. 11 has a resonator 203 which includes a fluid lasing medium 204 that is shown in the form of a He-Ne gas lasing medium. The medium 204 is housed in an elongated hollow envelope 205 made from transparent material, such as a suitable quartz glass. The means for pumping energy into the medium is shown in the form of an R-F coil 215 that serves, when energized, to establish the population inversion that causes the lasing action. The lasing action develops a beam 206 along the axis 207 of the envelope and which resonates back and forth between the opposite end terminals 208 and 209 of the resonator cavity or light path 210.

The cavity 210 includes coaxial linear light paths 211 and 212 which terminate at the terminals 208 and 209. At the other ends 213 and 214 of the paths 211 and 212, suitable means 217 is provided for translating and reflecting the beam light along a linear light path 216 which is laterally offset from and in parallel with the light paths 211 and 212 that terminate at the end surface 222 of the envelope.

The translating and reflecting means 217 may be formed by any suitable optical system such as a pair of mirror clusters or prisms having appropriately arranged reflective surfaces. In the illustration depicted, the means 217 is shown as having spaced apart translator and reflector components 217 and 218. Each of these components may be formed by a corner prism or by three orthogonally arranged mirrors in a mirror cluster. Component 218 serves to translate and reflect the laser beam between offset and parallel light paths 211 and 216 while component 219 serves to translate the beam between paths 212 and 216.

The housing envelope 205 for the gas lasing medium 204 has opposite ends 220 and 221, and the envelope is equipped with planar exterior surface portions 222 and 223 at these opposite ends 220 and 221. Surface 223 is normal to path 212 so that refraction is avoided during the light passage through the surface. Surface 222 is parallel to the surface 223 and hence, normal to the light paths that terminate at the end surface 222. The envelope 205 has a uniform thickness at its opposite ends 221 to provide interior end surfaces in the envelope that are normal to path 212 and to thus avoid refraction as the light passes between the medium and end walls at the interior of the envelope.

The end terminals are formed by a mirror surface forming coating 224 that is fixed to the planar end surface 222 of envelope 205. The coating may be formed by any suitable material, such as by one or more of the dielectric coating materials commonly used in laser applications for such purposes. The coating 224 provides oppositely facing mirror surfaces 225 and 226 that respectively define and form the end terminals 208 and 209, and, in the arrangement surface 226 confronts the planar end surface 222 of the envelope.

Paths 211 and 212 extend in opposite directions that are normal to the end surface 222 of the envelope, and in operation, beam light produced along the axis 207 of the envelope 205 which is incident to the mirror surface 226 is reflected back from the cavity terminal 209 and along the path 212 through the lasing medium. At the end 214 of the path, the beam light is translated and reflected by component 219 into path 216. As the light passes from one end 227 of path 216 to the other end 228, it encounters the output beam pick-off assembly 230 and a portion of the beam is laterally reflected as the laser rod output beam 231.

Assembly 230 is like that described in the previous embodiment, and has a pair of transparent wedge members 232 and 233 that are made from like materials and respectively provided with planar facial surface portions 234 and 235. These surface portions are arranged normal to the light path 216 to avoid refraction. The wedges 232 and 233 have confronting planar surface portions 236 and 237 that are inclined to the light path 216, and wedge 232 has a suitable reflective coating 238 that is fixed to surface 236. This coating 238 serves to laterally reflect a portion of the incident light as the laser output and pass the balance of the light along the path 216 to the translating and reflecting component 218.

At the end 228 of path 216, component 218 serves to translate and reflect the light incident to the component into path 211. This light is transmitted along the path to surface 225 and at the cavity terminal 208 is reflected by the surface back along the path 211. The light incident to component 218 at the path end 213 is again translated and traverses paths 216 and 212 through the opposite end terminal 209. As the beam traverses the path 212 through the medium, further emission is, of course, stimulated.

In this arrangement, the laser envelope provides the rigid unitary structure for the coating that forms and defines the end terminals and again has the advantage that proper orientation of the laser envelope in the resonator arrangement serves to automatically arrange the terminal mirror without the need for separate means for facilitating the adjustments and maintenance of the proper orientations. (Col. 11-14, Line 21-68, 1-68, 1-22 Resp. of OD1)

OD1 also discloses FIG. 12 illustrates an arrangement in which the rigid base component for the terminal mirrors is provided in an assembly that establishes offset and parallel light paths at the cavity terminals and also provides the output beam for the laser device.

The laser device 240 has a resonator 244 which includes an elongated cylindrical YAG rod 241. Rod 241 provides a source of lasing medium, and the pumping of the medium is accomplished by energizing an elongated krypton lamp 242. The beam 245 developed by the lasing action is propagated along the rod axis 243 and resonates back and forth between the end terminals 246 and 247 of the resonator cavity or light path 248.

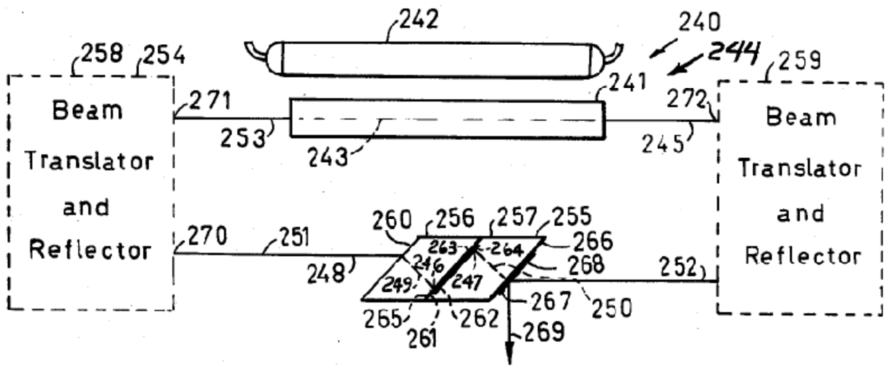


FIG. 12

The cavity path 248 includes parallel linear light paths 249 and 250 in the terminal forming and light pick-off assembly 255. It also includes parallel linear light paths 251 and 252 and a linear light path 253 which is offset and parallel with paths 251 and 252. Path 253 extends through the laser rod 241 and is coaxial with the axis of the rod.

The means 254 for translating and reflecting the beam 245 between the light paths 249 and 250 that terminate at the cavity terminals includes an assembly 255 of transparent wedge members 256 and 257 and a pair of beam translating and reflecting components 258 and 259. Component 258 serves to translate and reflect the laser beam 245 between linear light paths 251 and 253. It may take the form of any suitable optical system providing the desired translation. A corner or porro prism that is appropriately arranged may be used as well as a mirror cluster having a reflective surface arrangement that is comparable to either of the aforementioned prisms. Component 259 serves to translate and reflect the laser beam 254 between linear light paths 252 and 245 and may also take the form of one of the arrangements contemplated for component 258.

The wedge assembly 255 includes transparent wedge members 256 and 257. In this embodiment, wedge member 255 consititutes the rigid unitary base component for the end terminal forming mirror coating and it has oppositely facing planar exterior end surface portions 260 and 261. These surfaces 260 and 261 are parallel and inclined to light path 251 so that the light is refracted in passing between paths 251 and 249. Surface 261 has a coating 262 of suitable dielectric material that forms the oppositely facing planar light reflective or mirror surfaces 263 and 264 that form and define the end terminals 246 and 247. As the coating 262 is fixed to the member 256, surface 263 confronts the end surface 261. The other wedge member 257 of the assembly 255 also has oppositely facing planar exterior end surface portions 265 and 266. These surfaces 255 and 266 are parallel to each other and are arranged in parallel with surfaces 260 and 261 in the assembly 255. Surface 265 confronts the coated surface 261, and surface 266 is inclined to the light path 252 so that the light is refracted in passing between paths 250 and 252. Member 257 is fixed to member 256 and provides the base for the beam pick-off mirror. Member 257 is provided with a suitable dielectric coating 267 that is fixed to the end surface 266 and the coating serves to laterally reflect a portion of the light incident to the surface 268 as the output beam 269 while passing the balance of the light through the surface 266 and along path 250. (Col. 14-15, Line 23-68, 1-18 Resp. of OD1)

Document OD2 discloses in FIG. 7 Twin Side Sawing (TSS) 28 is an assembly with a provision to place 6-6 dies on both the sides having two sensor—one is sensing forward direction 24 and another is sensing backward direction 25. This assembly is also provided with limit switches with screw adjustment for precise setting of 180 degree for double side sawing.

TSS Fixture 29 is to Move TSS 28 upto 180 degree by software command with the help of fixture's motor. Laser head 4 is the most important component to produce the laser light. This head 4 consists rod and lamp. Rod is made of Nd:YAG and it works as a pumping source to produce more photons. These photons fall on lamp of Krypton which ultimately produce laser light. Two mirrors 1 & 7 are placed at each end of laser chamber—FIG. 5 to amplify the laser light by feedback mechanism. Power supply controls the intensity of beam. Beam expander 13 reduces the divergence and improves directionality of the beam, making the beam thin and parallel. Q-switch 5 produces a powerful pulse from the continuous beam. An aperture 3 & 6 restricts the light amplification along the axis of laser chamber and thus provides sharp frequency band. Beam coming out from the laser source is bended at 90 degree to reach to the diamond. Then through focusing lens 14, beam gets focused on the diamond. Through computer card, movement of the axes can be controlled. In case of power failure a safety shutter blocks the laser beam.

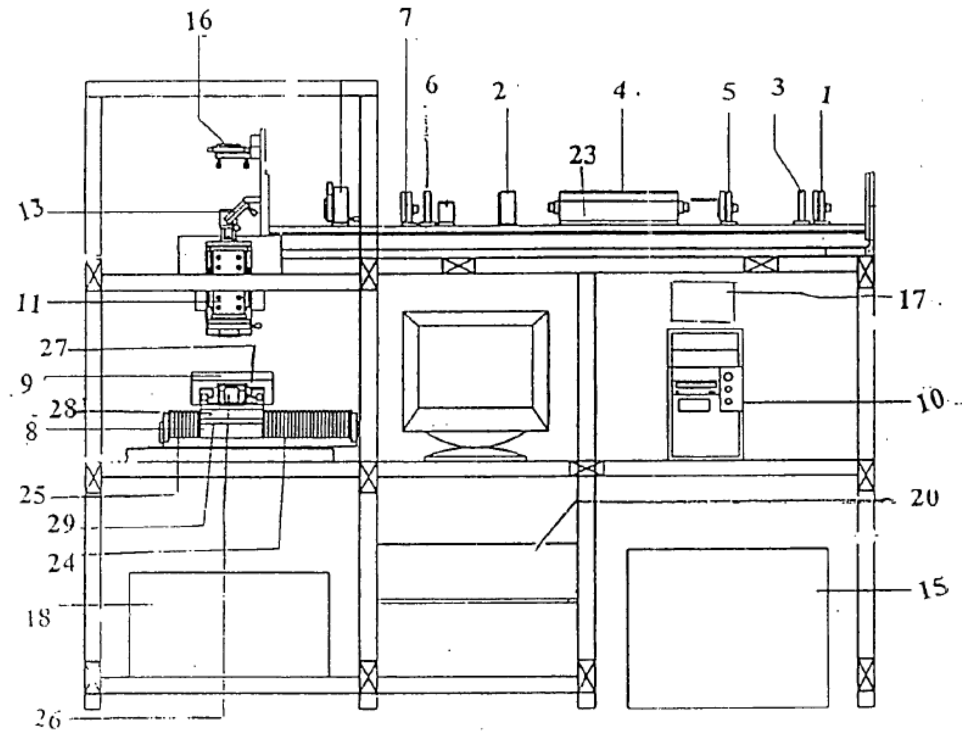


Fig. 1

In cooling unit 31 is a switch, 32 is start switch, 33 is flow switch, 34 is low water level switch, 35,36,37 & 38 are temperature setting switches and 39 is alarm switch.

In RF Q Switch driver 40 is mode switch, 41 is enter switch, 42 is power switch and 43 is start switch.

When TSS 28 filled with dies with 12 mm distance between each die is placed on the fixture and the machine is switched on first computer, starts with “Shortcut to Multi sawing” icon. When this icon is double clicked, on screen, “set diamond data” is seen containing options like: center point, start point, end point, focus point, size of diamond, step size, saw width, minimum width and start at. After entering all the relative data and then clicking on “start sawing” all the data are displayed on the screen. If any particular diamond is to skip then parameters are set for the next diamond. To stop the sawing process press “escape”.

Speed setting, extra setting, axes setting, fixture setting, key direction, step size, ramping, shutter on/off etc. are done by selection from appropriate advance setup. (Para 34-39 of OD2)

OD2 also discloses Laser source unit/resonator has a laser head 4, a Q-switch 5, two apertures 3 & 6, front mirror 1 & back mirror 7, a safety Shutter 2, and a beam expander. Laser head 4 is the crucial part to generate the laser light. Front and back mirror 1 & 7 amplifies the laser light by providing the feedback. Q-switch 5 is used to store the laser light energy to emit as a burst of high peak power. Shutter 2 block the laser beam in case of electrical failure and hence it is called as a safety shutter. An aperture 3 & 6 controls the light amplification along the off-axis of the resonator FIG. 5 to provide the sharp frequency band. As per the name indicates, beam expander 13 expands the laser beam to minimize its divergence.

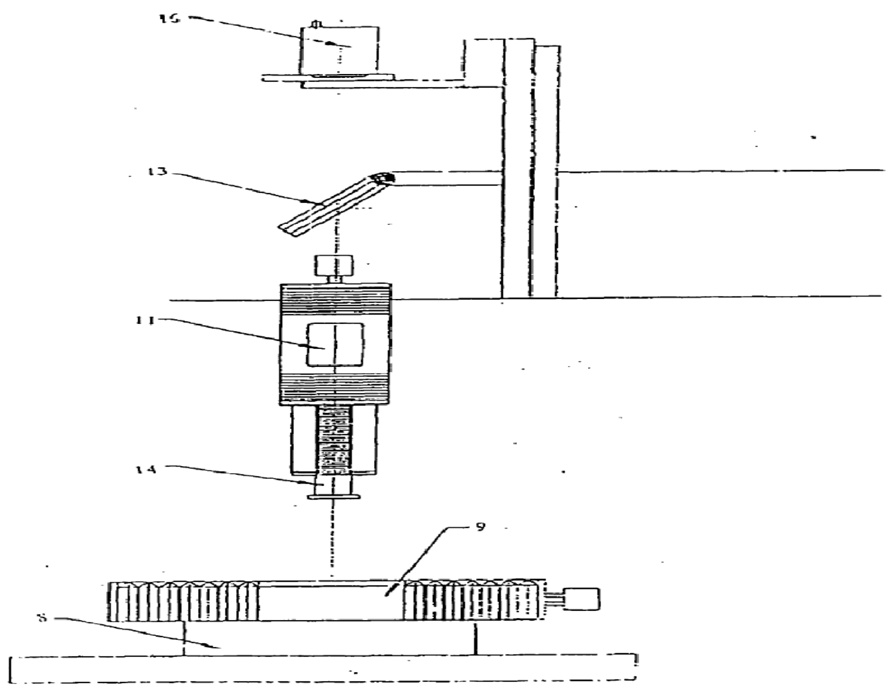


Fig. 2

CNC Interface consists of X 8 or Y 9 or Z 11 axis and the computer unit 10. For this purpose, inside the computer 10, a control card is placed which is connected to the rear portion of the accupos 18 having a 37-pin connector/parallel port. A beam attenuator—safety shutter 2 must be provided which will enable user to terminate lasing without turning off the main power switch 12. The safety shutter 2 is located inside the laser head assembly 4 and is actuated by the toggle switch 19. The shutter 2 terminates lasing by blocking the laser beam path and preventing emission of laser radiation out of the head assembly 4.

Beam delivery system consists a beam bender 13 and a focusing lens 14. The laser beam coming from the beam expander of the laser source is to be sent to the work-surface. Beam bender 13 bends the beam at 90° which is then focused by the focusing lens 14. By changing the focal length of focusing lens 14, power density and depth of the focus can be altered. The alignment of the focus is very important because if the beam center does not co-inside with center of the lens then the beam after the lens will not be straight and therefore the cutting efficiency drastically decreased.

RF Q-Switch driver to get the pulsed output with high peak power, the laser is operated in Q-switched mode 5. To get the radio frequency RF generator 20 is used. Due to this high frequency it is also cooled by chilled water by chilling unit 21.

Chiller unit is used for two purpose;

(1) three phase chiller system which is used for providing the chilled water to the laser head 4 and Q-switch 5.

(2) Pump system 22 which is mainly used for circulating the water from chiller to the laser head via water to water heat exchanger 15.

Inside laser cavity 23 both Nd:YAG rod and the lamp are immersed in flowing cold water. The De-ionized water is used as it has high transparency and low electrical conductivity. Water temperature is regulated by means of a solenoid 30 CCD camera 16 gives 75 times magnification for on-line viewing the process. And this process can be seen on CCTV 17 to avoid errors.

Power supply unit ignites and controls the intensity of the laser light emitted by the laser lamp. This is the main power supply unit which controls the laser output. In many application laser is not used continuously, therefore the power supply is provided with a special feature of standby mode. This arrangement is very much useful in increasing the operational life of lamp and also that of power supply.

Servo Stabilizer prevents the whole machine from the variations of the electricity supply.(Para 24-33 of OD2)

Document D3 discloses in FIG. 2, three mirror configuration of the present invention, which also comprises primary mirror M1, secondary mirror M2 and tertiary mirror M3, is quite distinct from the prior art configuration of FIG. 1. More specifically, it will be seen in FIG. 2 that the three mirrors all share a common axis and that furthermore, the primary mirror M1 and the tertiary mirror M3 share a common vertex. It will be seen hereinafter that in addition to sharing a common vertex, primary mirror M1 and tertiary mirror M3 are fabricated on a common substrate, thereby fixing their relative positions to one another during fabrication and thus obviating the requirement for alignment upon assembly of the optical system.

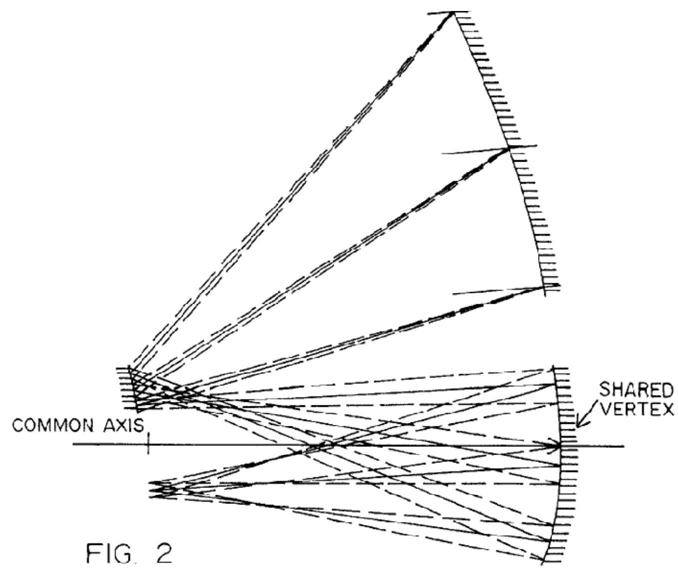
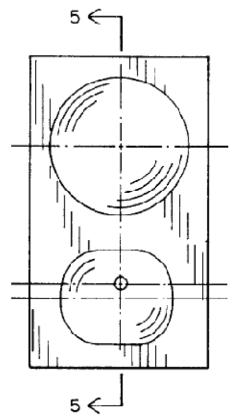


FIG. 2

The meaning of a common axis and a shared vertex may be better understood by reference to FIG. 3, wherein it will be seen that each mirror M1, M2 and M3 may be characterized as a selected portion of a curved surface. The surfaces of M1 and M2 are spherical and the surface of M3 is an ellipsoid. Each such surface is associated with an axis, and as shown in FIG. 3, all three such surfaces are configured to have a common unitary axis. Furthermore, the spherical surface of M1 and the ellipsoid surface of M3 are positioned to share a common vertex as shown in the right-hand portion of FIG. 3. An additional feature of the present invention, the most significant one thereof from the standpoint of manufacturability, is the shared common substrate of both M1 and M3, as seen best in FIGS. 4 and 5. FIGS. 4 and 5 are the front view and side view respectively, of a primary and tertiary mirror of the present invention fabricated on a common substrate and representing an actual reduction to practice of the invention herein disclosed.



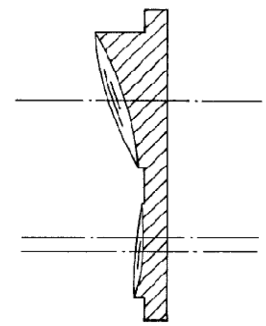


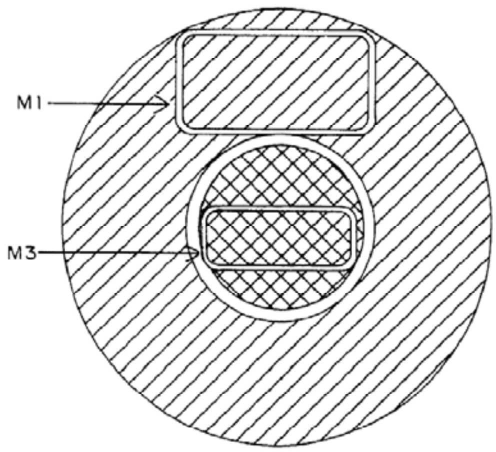
FIG. 5

FIG. 4

In the configuration illustrated in FIGS. 4 and 5, the primary mirror M1 is substantially circular in shape, having a vertically projected diameter of 6.25 inches, a vertex radius of 20 inches and a conic constant of -0.771. The tertiary mirror M3 is substantially rectangular, but having rounded corners with a radius of about 0.75 inches, a vertical length of 4.245 inches and a horizontal width of 5.186 inches. The distance between the center lines of the primary mirror M1 and the tertiary mirror M3 is 6.726 inches and the common optical axis line is 0.691 inches above the center line of the tertiary mirror M3. Tertiary mirror M3 has a vertex radius of 8.456 inches and a conic constant of -0.124. The substrate material may, by way of example, be aluminum, beryllium, silicon carbide or SXA. (Col. 4-5, Line 36-67,1-13 Resp. of D3)

D3 also discloses FIG. 7, it will be seen that in the present invention there is no overlap between the machined regions of the primary and tertiary mirrors M1 and M3 respectively, and in fact as shown in FIG. 7, there is a gap or clearance annulus represented by the unshaded area in FIG. 7 between the outer fabrication circle of tertiary mirror M3 and the inner fabrication circle of primary mirror M1. More specifically, in FIG. 7, the cross-hatched area represents the machined region of the tertiary mirror M3 and the shaded area represents the machined region of the primary mirror M1. The machining of M3 is accomplished by moving the diamond turning tool radially from the center vertex point at the center of the circles of FIG. 7, outward in a radial direction. The same is true for the fabrication of M1.

FIG. 7



However, the radial travel of the cutting tool for fabrication of M3 is entirely distinct from and non-overlapping with the radial travel of the cutting tool for fabrication of M1. (Col. 5-6, Line 65-67, 1-14 Resp. of D3)

Document OD3 discloses in FIG. 1 shows the laser 1 having a housing 2 surrounding the resonator or discharge volume 5 and enclosing the electrode system 10-14. The two endfaces 8 and 9 of the housing serve mostly to hold the mirrors 17-21. The system of electrodes 10-14 has an external voltage supply lead and consists of the central electrode 11 located on the longitudinal axis of the housing 2 and having an outer contour that defines two oppositely directed discharge surfaces 12 and 13, each of which cooperates with an associated opposite electrode 10 and 14 located inside the housing along the longitudinal wall, with discharge surfaces 3 and 4, respectively.

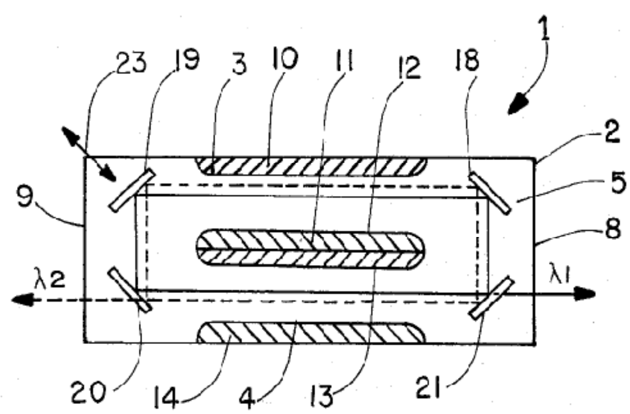


Fig. 1

The three totally reflecting elements 18-20, for example, mirrors, and the partially transmissive optical element 21, possibly another, suitably constructed mirror, are disposed at the end faces 8 and 9 at the level of the free spaces between the electrodes, all for the case of a beam of wavelength λ1 as shown in solid lines. The surfaces of the mirrors face one another and make an angle of 45° with the beam path. When the gas in the resonator chamber is excited, the emissions constitute a ring laser whose radiation is coupled out through the partially transmitting mirror 21. If a ring laser with two wavelengths λ1 and λ2 is used, another totally reflecting mirror, for example mirror 20, must be replaced by a partially transmitting mirror. An example of a laser with four different extractable wavelengths λ1 and λ4 is illustrated in FIG. 3. In this case, transmission is set at 85% and reflection at 15%. Of course, these percentages of transmission and reflection can be changed for other embodiments and could even be different for any of the four optical elements of the example shown. (Col. 4, Line 8-40 of OD3)

Document OD3 also discloses in FIG. 2 the mirrors 19' and 20', including their associated gratings, are rotatable in the direction of the double arrows. As shown, the mirror 19' has been turned by approx. 45° so that the mirrors 19' and 20' now only reflect along parallel lines, in the longitudinal direction of the housing 2, toward the associated transparent or partially transparent mirrors 18' and 21' which may be moved in the direction of the double arrows and can replace the wall at this location.

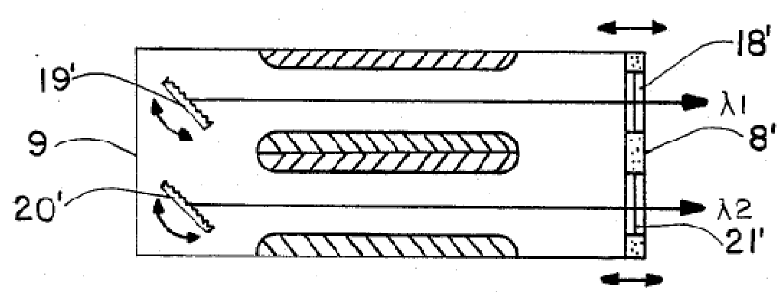


Fig. 2

This construction permits an adjustment of the length of the laser and operation of the laser with two synchronous pulses of wavelengths λ1 and λ2, extracted separately by mirrors 18' and 21', respectively. Other wavelength-selective optical elements, for example, prisms, could be used instead of the gratings. The grating constants corresponding to the mirrors associated with different wavelengths can be different. The displacement of the optical elements and/or the sidewall on which they are mounted takes place with the aid of the piezoelectric drive 23, in each case perpendicular to the plane of these elements or sides.

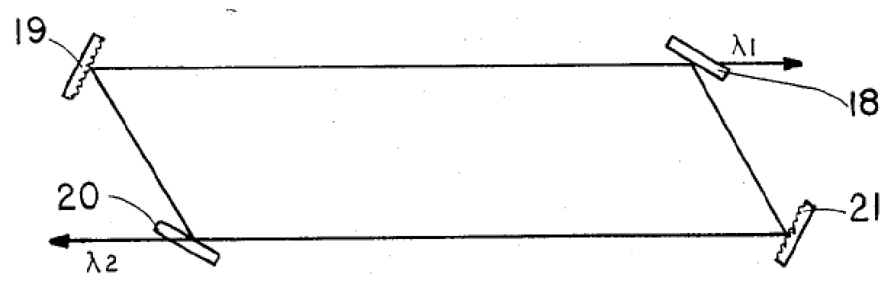


Fig. 4

In the embodiment of FIG. 4, the beam path forms a parallelogram. This is due to the fact that only diagonally opposite mirrors 18 and 20 on the one hand, and 19 and 21 on the other hand, or their gratings, subtend the same angle of the beam. In this instance, two beams with different wavelengths λ1 and λ2 are coupled out by 80%-transmitting mirrors 18 and 20.

FIGS. 5a and 5b show the endwalls 8 and 9 separately. They may be made of glass, glass-ceramic material, quartz, plastic, germanium, CdTe or zinc selenide. In the present example, the two mirrors 18' and 21' are fixed in their mutual relationship of surfaces. The mirror 18' is totally reflecting while the mirror 21' has an outer, partially transmitting region and a fully transparent center created by the hole 7'. Depending on the type of laser used, from 10 to 90% of the surface may be taken up by the opening. In another embodiment, not shown in the drawing, there is no hole; in that case, the "mirror" must be thought of as being transparent, with only low absorption. It would also be possible to make the entire endwall of transparent material and only cause total reflection at the desired location, for example, by vapor deposit of a layer of gold. The totally reflecting mirrors and the partially transmissive layers could also be imbedded in the wall. A plate so constructed may be used as a mode selector.

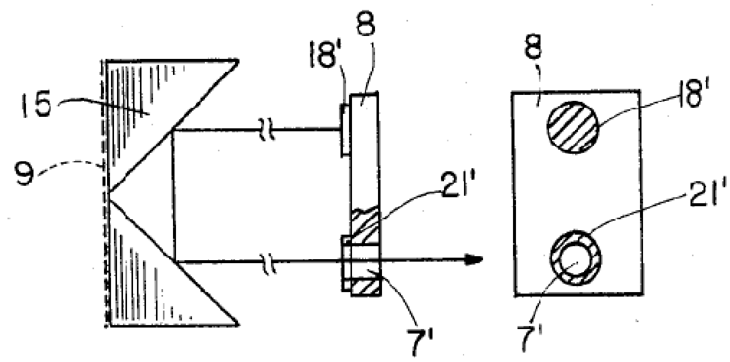


Fig. 5a Fig. 5b

In another embodiment, shown in FIG. 5a, the totally reflecting mirrors of the wall 9 may be replaced by a prism block 15 or, as shown in FIG. 6, by a triple mirror 16. The latter should be so placed in the beam that only its surface areas 16' are optically active, but not its ridges 16". (Col. 4-5, Line 41-68, 1-25 Resp. of OD3)

Document OD3 discloses in FIG. 8, the beam can be guided and shaped while being folded outside of the housing. As shown in dashed lines, this processing can also take place within the housing.

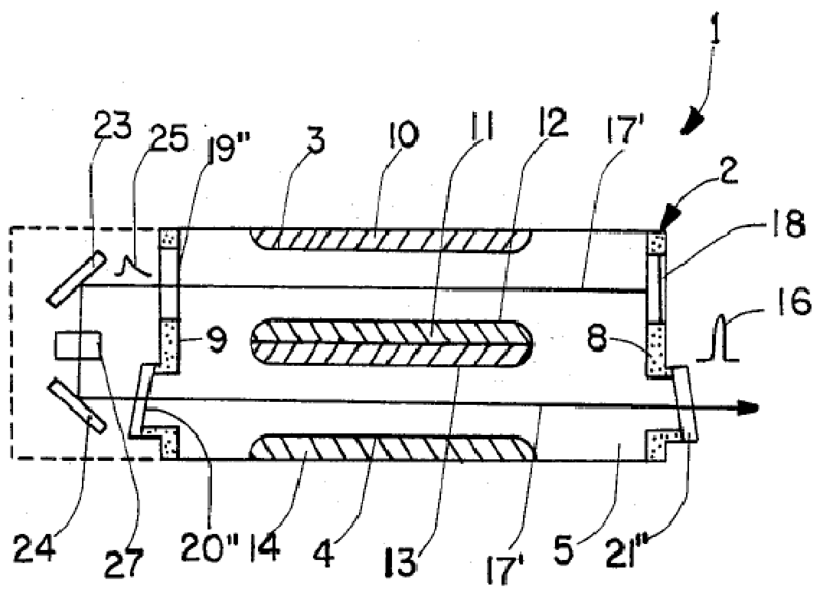


Fig. 8

In this example, only a totally reflecting element, 18, for example a mirror, is fastened to, or inserted in the wall 8, while part of the wall 9 is replaced by an at least partially transmissive optical element 19", for example another suitably constructed mirror, or the wall is made transparent to the laser radiation at this location. Brewster angle windows 20" and 21" are inserted into the walls 8 and 9 between the electrodes 11 and 14.

In this arrangement, the laser beam 17' is fully reflected at the mirror 18 and then passes through the discharge channel formed by the electrodes 10 and 11, e.g., a laser oscillator. It is then coupled out at the other side and deviated by 90° at the mirror 23 which is positioned at a 45° angle with respect to the beam. The beam then enters the element 27 that processes the beam temporally or spatially. This is the preferred position for the element 27 but, in principle, it may be located anywhere in the beam path.

If it is necessary to incorporate an element 27 that influences the time behavior of the beam, also called a mode-locking element, that element may be an active or passive Q-switch. The active switch may have, as effective component, an electro-optical crystal of CdTe or an acousto-optical crystal, while the passive switch can contain a saturable absorber of Ge, SF6 or hot CO2. In the latter case, the crystal itself has the property of acting as an optical switch due to saturation absorption, while this effect is created by optical triggering in the former case. A laser spark gap may be used to trigger the electro-optical switch in order to change the transmission. If it is necessary to alter the spatial properties of the pulse, that means the laser pulse must be made wider or changed from a narrow to a broad shape. The beam can also be rotated or polarized or its phase fronts may be changed by adaptive optics. The deviating elements may also be adaptive mirrors.

After exiting from the element 27, the laser beam is again deviated by 90°, into the opposite direction of its original direction, by the mirror 24, also set at 45° relative to the beam. It passes through the Brewster angle window 20" in the end wall 9 into the channel formed by the electrodes 11 and 14, serving as an amplifier in the present example. At the other end, the laser beam is then extracted through the Brewster angle window 21" in the end wall 8, in the direction of the arrow.

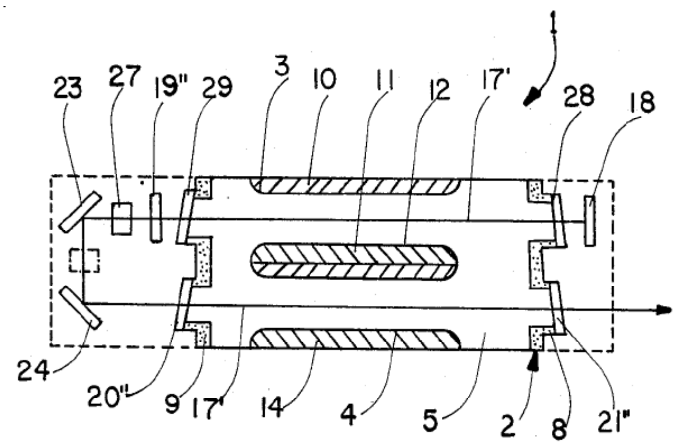


Fig.9

FIG. 9 differs from FIG. 8 mainly only in that the optical elements 18 and 19" in the side walls 8 and 9 are replaced by the Brewster angle windows 28 and 29. The optical elements 18 and 19" are disposed, in this example, outside of the housing 2, in each case directly adjacent the associated Brewster angle window 28, 29. (Col. 5-6, Line 31-68, 1-17 Resp. of OD3)

Therefore, it is not inventive and it would have been “obvious to person skill in the art” at the time the invention was made to modify laser cutting apparatus includes a first laser unit, second laser unit, and a cooling system, first laser beam unit includes a first reflecting mirror and the first focusing lens assembly to form a first laser beam for irradiating the substrate and the second laser unit includes a second laser beam unit includes a second reflecting mirror and the second focus lens assembly to form a second laser beam to focus on the surface of the substrate and the first laser beam is a carbon dioxide laser beam, the second laser beam is a laser beam of ultraviolet wavelength wherein the first laser beam through a first reflection mirror, after being reflected on the first focusing lens assembly, to irradiate the substrate in a non-focus method in a non-focus position of the first focus lens assembly and second laser beam through the second reflecting mirror, is reflected to the second focus lens assembly is focused on the substrate in a focus system to the focus position of the second focus lens assembly along with cooling system is a single liquid, mixture or mixtures of one or more gas and liquid in the single gas and a single liquid of D2, D1 with features as high-power laser oscillator having surface roughness of an outer circumferential section except a section in the vicinity of the center is made coarse in at least one of reflecting mirrors for a laser resonator in which an enclosure, in which a laser medium is encapsulated, OD1 with technical features as laser device includes an elongated generally rectangular box-type housing for an optical resonator that utilizes an elongated cylindrical ruby rod as the lasing medium source and also includes a means for pumping energy into the lasing material and which is shown in the form of an elongated xenon flashlamp, optical cavity or resonator light path includes horizontally extending parallel linear light paths and that are laterally offset and interconnected by a light path within the prism component of the resonator along with opposite end terminals of the cavity are formed and defined by flat planar mirror surfaces that are formed by means of coatings which are fixed to the exterior surface of a rigid unitary component that provides the base support structure for the mirror coatings and laser rod is mounted with its longitudinal axis in a coaxial arrangement with light path so that the photon beams produced along the rod axis be propagated in the cavity and laser beam produced by the lasing action is translated and reflected between the light paths by means of a corner prism that is arranged at the prisms ends of the light paths and path ends are opposite the respective terminal ends 19 and of the cavity, OD2 with technical features as Twin Side Sawing is an assembly with a provision to place dies on both the sides having two sensor—one is sensing forward direction and another is sensing backward direction and Beam coming out from the laser source is bended at 90 degree to reach to the diamond, focusing lens , beam gets focused on the diamond, D3 with technical features as three mirror configuration of comprises primary mirror, secondary mirror and tertiary mirror, and three mirrors all share a common axis and that furthermore, the primary mirror and the tertiary mirror share a common vertex and OD3 with technical features as laser having a housing surrounding the resonator or discharge volume and enclosing the electrode system and two endfaces of the housing serve mostly to hold the mirrors and system of electrodes has an external voltage supply lead and consists of the central electrode located on the longitudinal axis of the housing and having an outer contour that defines two oppositely directed discharge surfaces, each of which cooperates with an associated opposite electrode located inside the housing along the longitudinal wall, with discharge surfaces along with surfaces of the mirrors face one another and make an angle of 45° with the beam path, the mirrors including their associated gratings, are rotatable in the direction of the double arrows, mirror has been turned by approx. 45° so that the mirrors now only reflect along parallel lines, in the longitudinal direction of the housing, toward the associated transparent or partially transparent mirrors to have gemstone processing machine of present alleged invention with characterized technical features as said first reflective member is inline with said laser source, and positioned on a first side of said laser source, wherein said first reflective member reflects back said incident laser beam to a second side of said laser source through said first aperture; said second reflective member is offset from said laser source, and positioned on said first side of said laser source; and said laser resonator comprises: at least a first beam bender is placed inline with said laser source, and positioned on said second side of said laser source to reflect said laser beam incident from said first reflective member, at a first angle of reflection being 45°; and at least a second beam bender is placed offset from said laser source, and positioned on said second side to reflect said laser beam reflected by said first beam bender to said second reflective member through said second aperture, at a second angle of reflection being 45°.

Considering scientific and technical analysis of documents **D1:** JPS60217678A, **D2:** JP2007152958A, **D3:** US5862726A, **OD1:** US4677639, OD2**:** US20040262274 and **OD3:** US4499582 in combination, present application for patent lacks of inventive step still stands as the applicant fails to persuade the same. Features of current amended principle claim is not inventive over cited documents as above and are not allowable u/s 2(1) (ja) of the Act.

Hence present alleged invention cannot be considered as inventive as it has not made any significant technical advancement in the field over the cited documents as above.

Response/ arguments made under other para and other submissions of written submission have been fully considered accordingly.

Pre-grant opposition filed u/s 25(1) of the Patents Act, 1970 (as amended) by TAPAN SHAH:

The documents filed under Pre-grant opposition filed u/s 25(1) of the Patents Act, 1970 (as amended) by **TAPAN SHAH** has been fully considered along with Response/ arguments made under other para and other submissions of written submission.

The patent application No. 1643/MUM/2008 decided as per Rule 55 (5) of the Patents Rule, 2003 (as amended).

Conclusion:

Based on above, I am of opinion that the present amended claims are not allowed. Therefore, I hereby accept the Pre-grant opposition filed u/s 25(1) and refuse the instant application 1643/MUM/2008 u/s 15 of the Patents Act, 1970 (as amended).

Dated: 25/09/2019

Mangesh Mokashi
Asst. Controller of Patents and Designs

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