

SPECIFICATION

Collimated light beam source

The invention relates to an optical system which provides a collimated light beam, comprising a tubular holder, a semiconductor laser in the holder, and a system of lenses in the holder, the focus of which coincides with a laser element incorporated in the semiconductor laser.

An optical system of the above-mentioned kind is disclosed in Netherlands Patent Application 7608561, in particular Figure 16. The semiconductor laser emits a strongly diverging beam of rays, in contrast, with for example a HeNe laser. In order to obtain a parallel beam of rays when a semiconductor laser is used, the system of lenses must be positioned very accurately with respect to the semiconductor laser element, in which the focus of the system of lenses must be adjusted so as to be accurate within $1\mu\text{m}$ with respect to the laser element. The said Netherlands Patent Application shows an arrangement in principle but does not give any indication how to obtain accurate adjustment or of a suitable construction of the optical system.

It is an object of the invention to provide an optical system of the kind mentioned in the opening paragraph which comprises means which enable accurate adjustment in a comparatively simple manner and which system is also suitable for mass production. The invention provides an optical system which provides a collimated light beam, comprising a tubular holder, a semiconductor laser positioned against an abutment in the axial direction in the holder, a system of lenses incorporated in the holder on the side of said abutment remote from said laser, a resilient element placed between the system of lenses and the abutment, and on the side of the system of lenses remote from the resilient element, a locking element which, after axial adjustment in the holder, is fixed in such a place that the system of lenses, after being moved in the axial direction against the pressure of the resilient element, is in the position in which its focus coincides with a laser element in the semiconductor laser.

The semiconductor laser is moved in the holder until against the abutment and is fixed in that position, the resilient element and then the system of lenses and the locking element are inserted in the holder. This assembly is then placed in an aligning apparatus, the locking element for the system of lenses is moved in the direction of the laser against spring action and when it is established in the aligning apparatus that the optical system provides a collimated light beam, i.e. that the emanating rays are in parallel, the locking element is fixed in the holder, the system of lenses being simultaneously adjusted accurately.

Such an optical system can be mass produced and has wide possibilities of application. For example, it is suitable for use in video disc players, in digital optical recording, in optical displacement

transducers based on the interferometric principle, and for many other applications.

In a favourable embodiment of the optical system in accordance with the invention the tubular holder comprises on its inner surface at least three ribs the tops of which are situated accurately on the surface of a circular cylinder for accurate radial positioning of at least the system of lenses. Thus, the system of lenses and possibly other components of the optical system are positioned very accurately in the holder additionally in a radial direction.

In a further embodiment of the optical system in which a cylinder lens is also present which is situated on the side of the system of lenses remote from the semiconductor laser, according to the invention the locking element is of metal and has lugs engaging about circumferential parts of the cylinder lens in such manner that upon rotating the locking element the cylinder lens is adjustable tangentially.

By using a cylinder lens the astigmatism of the laser can be corrected. By rotating the cylinder lens into the correct position, the oval beam of rays changes into a circular beam. The locking element with the lugs is a handy means to adjust the cylinder lens.

The locking element can be fixed with respect to the holder in various manners. It has proved to be particularly favourable to construct the locking element as a metal ring and the holder as a metal tube, the holder, at the location where the locking element is present, comprising at least three blind holes of which the part of material still present is melted by heating with a laser pulse and after solidification forms a joint between the holder and the locking element. As a result of this a permanent fixation is obtained of a very rigid quality, the position being previously adjustable very accurately.

After adjusting the locking element, the system of lenses and the semiconductor laser can be spaced extremely accurately by means of the pressure which is exerted by the resilient element. It may be advantageous to adjust said position permanently and not to let it depend on a permanent good action of the spring pressure and not to let it be influenced by external forces. For this purpose, according to an embodiment of the invention, an annular metal element may be provided between the system of lenses and the semiconductor laser, the holder in the location where the annular element is present, comprising at least three blind holes of which the part of material still present is melted by heating with a laser pulse and after solidification forms a joint between the holder and the annular metal element.

Although the holder, the locking element and the annular element may be formed from any material, these parts preferably consist of a metal, such as aluminium. It is then ensured that the optical system, once adjusted, will accurately remain in said position, that no mutual stresses occur in the case of temperature variations, and

that the material has sufficient rigidity to prevent variation of the mutual position.

Embodiments of the invention will be described in greater detail, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows a first embodiment of the optical system to obtain a collimated beam,

Figure 2 is a side elevation of the holder,

Figure 3 shows a cylinder lens and an associated locking element, and

Figure 4 shows a second embodiment of the optical system.

Figure 1 shows a first embodiment of an optical system which provides a collimated light beam. A holder 1 preferably of aluminium has an abutment 2. A semiconductor laser 3 comprises a flange 4; said flange engages with its upper surface the abutment 2 and with its side face the inner wall of holder 1. The semiconductor laser 3 is fixed in the holder by means of bent-over lugs 5 which are formed from material of an end portion of the holder.

The holder furthermore comprises a system of lenses 6, as well as a cylinder lens 7. A locking element 8 is provided at the laser-remote end of the holder, while an annular element 9 is present between the laser and the system of lenses and an annular element 10 is present between the system of lenses 6 and the cylinder lens. Furthermore, a resilient element in the form of a helical compression spring 11 is present between the abutment 2 and the annular element 9.

The inner surface of the holder 1 preferably comprises three longitudinal ribs 12, as shown in Figure 2. The tops of the ribs are machined accurately by means of a calibrating tool to provide parts of the surface of a circular cylinder. The lenses 6 and 7 are thus positioned radially very accurately. At the area of the locking element 8 three blind holes 13 are provided in the holder (see also Figure 2), while at the area of the annular element 9 three further blind holes 14 are present in the holder. The locking element 8 comprises two lugs 15 which engage around flattened sides 16 of cylinder lens 7, see Figure 3.

In order to obtain an emanating light beam having parallel rays, the focus of the system of lenses 6 must coincide very accurately with the light-emitting laser element 17 of the *p-n* laser 3. For this purpose, after providing the indicated components in the holder 1, the locking element 8 is moved in the direction of the semiconductor laser 3. During this movement, cylinder lens 7, annular element 10, system of lenses 6 and annular element 9 also move so that spring 11 is compressed. When it is established on an aligning apparatus that the emanating beam of rays is parallel, the locking element 8 is fixed. Although there exist several possibilities for this purpose, the fixation is preferably obtained by heating the material in the blind holes 13 by means of a laser pulse. Only a very local heating is obtained in which some material melts both from the holder and from the locking element 8 and after

solidification a permanent position of the locking element 8 is obtained. The resulting joint is referenced 18. In this position the system of lenses 6 is very accurately adjusted, the accuracy of adjustment of the focus relative to the laser element 17 being better than $1\mu\text{m}$.

In order not to be permanently dependent on the quality of spring 11 to accurately maintain the distance between laser element 17 and lens 6 when the optical system described is used, annular element 9 may also be connected permanently to holder 1. In this case also, a joint *via* melting of material in hole 14 by heating with a laser pulse is to be preferred.

The holder and elements 8, 9 and 10 are preferably manufactured from aluminium.

The cylinder lens 7 serves to correct for the astigmatism of the laser. Rotating the lens 7 causes the emanating beam of rays to change from an oval shape into a circular shape. Rotating the cylindrical lens is carried out by rotating locking element 8, the lugs 15 engaging on the flattened sides of 16 of lens 7 cause a simultaneous rotation of the cylinder lens. The connection of the locking element 8 to the holder takes place after adjusting the system of lenses 6 and the cylinder lens 7.

Figure 4 shows a simplified construction of an optical system to obtain a collimated light beam.

A semiconductor laser 23 is placed in a holder 21 having an abutment 22. A spring 25 is present between a flange 24 of the semiconductor laser and a ring 29. A lens 26 and a locking ring 28 complete the optical system. The lens 26 is preferably a known bi-aspherical lens. It can be manufactured, for example from synthetic resin.

In this case also, lens 26 is moved relative to the laser device against the pressure of spring 25 by means of the adjustment of locking ring 28. When the focus of the lens has been adjusted accurately with respect to the laser element not shown, locking ring 28 is connected, preferably again by heating by means of a laser pulse, as described with reference to Figure 1. If desired, ring 29 may also be fixed in this manner. The device shown in Figure 4 may be used in situations where the correction for astigmatism of the semiconductor laser is not necessary.

CLAIMS

1. An optical system which provides a collimated light beam, comprising a tubular holder, a semiconductor laser positioned against an abutment in the axial direction in the holder, a system of lenses incorporated in the holder on the side of said abutment remote from said laser, a resilient element placed between the system of lenses and the abutment, and on the side of the system of lenses remote from the resilient element, a locking element which, after axial adjustment in the holder, is fixed in such a place that the system of lenses, after being moved in the axial direction against the pressure of the resilient element, is in the position in which its focus coincides with a laser element in the



that the material has sufficient rigidity to prevent variation of the mutual position.

Embodiments of the invention will be described in greater detail, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows a first embodiment of the optical system to obtain a collimated beam,

Figure 2 is a side elevation of the holder,

Figure 3 shows a cylinder lens and an associated locking element, and

Figure 4 shows a second embodiment of the optical system.

Figure 1 shows a first embodiment of an optical system which provides a collimated light beam. A holder 1 preferably of aluminium has an abutment 2. A semiconductor laser 3 comprises a flange 4; said flange engages with its upper surface the abutment 2 and with its side face the inner wall of holder 1. The semiconductor laser 3 is fixed in the holder by means of bent-over lugs 5 which are formed from material of an end portion of the holder.

The holder furthermore comprises a system of lenses 6, as well as a cylinder lens 7. A locking element 8 is provided at the laser-remote end of the holder, while an annular element 9 is present between the laser and the system of lenses and an annular element 10 is present between the system of lenses 6 and the cylinder lens. Furthermore, a resilient element in the form of a helical compression spring 11 is present between the abutment 2 and the annular element 9.

The inner surface of the holder 1 preferably comprises three longitudinal ribs 12, as shown in Figure 2. The tops of the ribs are machined accurately by means of a calibrating tool to provide parts of the surface of a circular cylinder. The lenses 6 and 7 are thus positioned radially very accurately. At the area of the locking element 8 three blind holes 13 are provided in the holder (see also Figure 2), while at the area of the annular element 9 three further blind holes 14 are present in the holder. The locking element 8 comprises two lugs 15 which engage around flattened sides 16 of cylinder lens 7, see Figure 3.

In order to obtain an emanating light beam having parallel rays, the focus of the system of lenses 6 must coincide very accurately with the light-emitting laser element 17 of the *p-n* laser 3. For this purpose, after providing the indicated components in the holder 1, the locking element 8 is moved in the direction of the semiconductor laser 3. During this movement, cylinder lens 7, annular element 10, system of lenses 6 and annular element 9 also move so that spring 11 is compressed. When it is established on an aligning apparatus that the emanating beam of rays is parallel, the locking element 8 is fixed. Although there exist several possibilities for this purpose, the fixation is preferably obtained by heating the material in the blind holes 13 by means of a laser pulse. Only a very local heating is obtained in which some material melts both from the holder and from the locking element 8 and after

solidification a permanent position of the locking element 8 is obtained. The resulting joint is referenced 18. In this position the system of lenses 6 is very accurately adjusted, the accuracy of adjustment of the focus relative to the laser element 17 being better than $1\mu\text{m}$.

In order not to be permanently dependent on the quality of spring 11 to accurately maintain the distance between laser element 17 and lens 6 when the optical system described is used, annular element 9 may also be connected permanently to holder 1. In this case also, a joint *via* melting of material in hole 14 by heating with a laser pulse is to be preferred.

The holder and elements 8, 9 and 10 are preferably manufactured from aluminium.

The cylinder lens 7 serves to correct for the astigmatism of the laser. Rotating the lens 7 causes the emanating beam of rays to change from an oval shape into a circular shape. Rotating the cylindrical lens is carried out by rotating locking element 8, the lugs 15 engaging on the flattened sides of 16 of lens 7 cause a simultaneous rotation of the cylinder lens. The connection of the locking element 8 to the holder takes place after adjusting the system of lenses 6 and the cylinder lens 7.

Figure 4 shows a simplified construction of an optical system to obtain a collimated light beam.

A semiconductor laser 23 is placed in a holder 21 having an abutment 22. A spring 25 is present between a flange 24 of the semiconductor laser and a ring 29. A lens 26 and a locking ring 28 complete the optical system. The lens 26 is preferably a known bi-aspherical lens. It can be manufactured, for example from synthetic resin.

In this case also, lens 26 is moved relative to the laser device against the pressure of spring 25 by means of the adjustment of locking ring 28. When the focus of the lens has been adjusted accurately with respect to the laser element not shown, locking ring 28 is connected, preferably again by heating by means of a laser pulse, as described with reference to Figure 1. If desired, ring 29 may also be fixed in this manner. The device shown in Figure 4 may be used in situations where the correction for astigmatism of the semiconductor laser is not necessary.

CLAIMS

1. An optical system which provides a collimated light beam, comprising a tubular holder, a semiconductor laser positioned against an abutment in the axial direction in the holder, a system of lenses incorporated in the holder on the side of said abutment remote from said laser, a resilient element placed between the system of lenses and the abutment, and on the side of the system of lenses remote from the resilient element, a locking element which, after axial adjustment in the holder, is fixed in such a place that the system of lenses, after being moved in the axial direction against the pressure of the resilient element, is in the position in which its focus coincides with a laser element in the



semiconductor laser.

2. An optical system as claimed in Claim 1, wherein on its inner surface, the tubular holder has at least three longitudinal ribs the tops of which are situated accurately on the surface of a circular cylinder for the accurate radial positioning of at least the system of lenses.
3. An optical system as claimed in any of the Claims 1 or 2, which also has a cylinder lens which is present on the side of the system of lenses remote from the semiconductor laser, the locking element being of metal and having lugs engaging around circumferential parts of the cylinder lens in such manner that upon rotating the locking element the cylinder lens is adjustable tangentially.
4. An optical system as claimed in any of the Claims 1 to 3, wherein the locking element consists of a metal ring and the holder consists of a metal tube, the holder in the place where the locking element is present comprising at least three blind holes of which the part of material still present is melted by means of heating by a laser

pulse and after solidification forms a joint between the holder and the locking element.

5. An optical system as claimed in any of the Claims 1 to 4, wherein between the system of lenses and the semiconductor laser, an annular metal element is provided, and wherein the holder, in the place where the annular element is present, has at least three blind holes, the part of material of which still present being melted by means of heating by a laser pulse so that after solidification it forms a joint between the holder and the annular metal element.

6. A device as claimed in any of the preceding Claims, wherein the holder, the locking element and the annular metal element are of aluminium.

7. An optical system which provides a collimated light beam substantially as described with reference to Figures 1, 2 and 3 of the accompanying drawings.

8. An optical system which provides a collimated light beam substantially as described with reference to Figure 4 of the accompanying drawings.

The text of the specification has been reproduced by photocopying. The original typescript may be inspected on the premises of the Patent Office

17

RECEIVED
GENERAL INVESTIGATIVE
DIVISION
FBI
JAN 12 1961
WASHINGTON, D.C.