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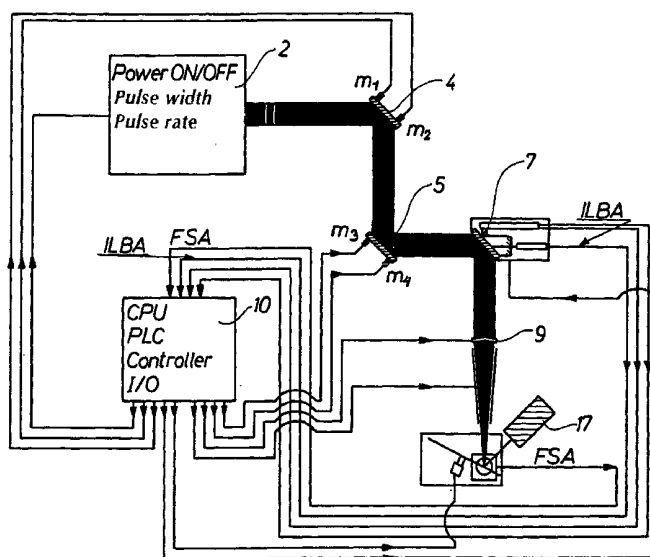
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- (71) Applicant (for all designated States except US): **INSTITUTTET FOR PRODUKTUDVIKLING** [DK/DK]; DTU, Bygning 425, Produktionstorvet, DK-2800 Kgs. Lyngby (DK).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **BAGGER, Claus** [DK/DK]; 4 Grøndalsvænge, DK-3460 Birkerød (DK). **OLSEN, Flemming, Ove** [DK/DK]; Egevangs Alle 23, DK-4180 Sorø (DK).
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(54) Title: DEVICE FOR ANALYSING AN INFRARED LASER BEAM AND A LASER PROCESSING SYSTEM OF WHICH THE DEVICE FORMS PART



(57) Abstract: Device for analysing an infrared laser beam and comprising means for providing a two-dimensional image of the laser beam and means for scanning successive lines of images and for generating a time-varying output signal of an amplitude being proportional to the light intensity in each of the points of the scanned lines. The device further comprises means for digitalising the output signal to allow storage of data representing an image of the energy distribution in the laser beam, and means for signal processing the data and analysing each image. According to the invention the infrared beam illuminates a surface or a screen (15) converting the incident infrared light into visible light which may be recorded by means of an inexpensive CCD camera (13).



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Device for analysing an infrared laser beam and a laser processing system of which the device forms part.

Technical Field

The invention relates to a device for analysing an infrared laser beam and comprising
5 means for providing a two-dimensional image of the laser beam, means for scanning successive lines of images and for generating a time-varying output signal of an amplitude being proportional to the light intensity in each of the points of the scanned lines, means for digitalising the output signal to allow storage of data representing an image of the energy distribution in the laser beam, and means for signal processing
10 the data and analysing each image.

Background Art

A known device of this type for analysing the energy distribution of a laser beam from a CO₂ laser emitting a beam of infrared light at a wavelength of about 10.6 μm is comparatively expensive, as an IR camera costing about DK 300,000 is needed.

15 Brief Description of the Invention

The object of the invention is thus to provide a more simple device for analysing the energy distribution of an infrared laser beam.

According to the invention a device of the above type is characterised in that the infrared laser beam or a suitable portion thereof is adapted to illuminate a surface and
20 a screen, which is able to convert the incident infrared light into visible light which may be recorded by an inexpensive CCD camera, whereby the use of a fairly expensive infrared camera is avoided.

Moreover according to the invention the surface or screen to be illuminated may be a phosphorus surface or screen optionally bias illuminated for instance by means of ultraviolet light.

In another embodiment the surface to be illuminated may be a metal surface emitting
5 visible light when heated.

The invention also relates to a laser processing system for processing a workpiece by means of an infrared laser beam comprising a device according to the invention for analysing the laser beam.

Brief Description of the Drawings

10 The invention is explained in greater detail below with reference to the accompanying drawings, in which

Fig. 1 illustrates a system for processing a workpiece by means of a CO₂ laser beam and which comprises sensors for characterising the laser beam,

Fig. 2 illustrates a first sensor in form of an integrated low-cost beam analyser,

15 Fig. 3 illustrates a second sensor in form of a focal spot analyser, and

Fig. 4 is a perspective view of the sensor shown in Fig. 3.

Best Modes for Carrying Out the Invention

The system shown in Fig. 1 for processing a material by means of a CO₂ laser beam comprises a device for characterising the laser beam. This device is formed of two
20 sensors. These sensors are able to determine different laser beam parameter values

such as the energy distribution, the centring, etc. The processing system further comprises a power supply supplying power to a CO₂ laser 2. The CO₂ laser 2 emits an infrared laser beam reaching an area of the material to be processed subsequent to reflection from two adjustable deflection mirrors 4, 5 and a fixed and partly translucent mirror 15 and focusing by means of a lens 9. Fig. 1 furthermore illustrates portions of a circuit for controlling the various units of the processing system. This control circuit comprises a CNC controller 10 including a CPU and the associated equipment. The CNC controller 10 communicates with the sensors via an internal bus and receives signals therefrom.

- 10 The sensors consist of an integrated low-cost beam analyser ILBA and a focal spot analyser FSA. The former sensor is able to carry out measurements on the system in operation, while the latter sensor may only be used according to need and remains passive during most of the operation time. Control signals are initiated and transmitted to the sensors ILBA and FSA through separate channels communicating
15 with the CNC controller 10.

Each sensor further generates signals transmitted to the CNC controller 10 for signal analysis.

- The signals from the sensor ILBA serve to centre the laser beam in relation to the desired beam direction. The centring is performed by adjusting the two deflection
20 mirrors 4, 5 by means of electromotors m_1 , m_2 , m_3 m_4 controlled by means of control signals from the CNC controller 10. The signals from the sensor ILBA are also used to determine the geometry and propagation of the raw laser beam including its diameter and the focal point position.

- The signals from the sensor FSA is used to determine the focal point of the focused
25 laser beam with a view to calibration thereof.

Fig. 2 illustrates the sensor ILBA arranged in a box located behind a deflection mirror 7 transmitting in the range of 1% of the infrared laser light.

The sensor ILBA illustrated in Fig. 2 may be arranged behind a movable mirror to allow measurement of the raw basic beam in several different positions in relation to the processing area.

The sensor ILBA comprises a phosphorus screen 15. An ultraviolet light source 11 bias illuminates the phosphorus screen 15 causing it to shine. When hit by an infrared laser beam, the bias illuminated screen 15 becomes dark at the spot hit by the beam allowing an identification of the position thereof.

10 The phosphorus screen 15 may be placed on a transparent glass substrate and may be observed from the rear by means of a CCD camera 13 adapted to perform a successive scanning of an image and generating a time-varying output signal of an amplitude being proportional to the light intensity in each of the points of the scanned lines. The signals from the CCD camera 13 are digitized and the position and the
15 diameter of the raw laser beam are determined by a digital signal processing of the digitized image signals.

The phosphorus screen 15 may be provided with different sensitivities. It may be necessary to use several different phosphorus screens depending on how large a variation in the output of the laser is to be measured. Usually lasers in the power
20 range of 1-4 kW are used. A chopper mechanism may further be incorporated, whereby a protective shield is either inserted in front of the phosphorus screen 15 or removed from the laser beam, when measurements are not performed.

The output signals from the sensor ILBA are transmitted to the controller 10 and form the basis of the calculation of the diameter of the laser beam and of the
25 weighted centre position of the raw laser beam.

The focal spot analyser FSA is shown in Fig. 3 and comprises a rotary chopper disk 14 transmitting an amount of energy to a material through a slot in the disk 14, said material for instance being an absorbing surface subsequently emitting light when subjected to heating or excitation. A CCD camera 16 is arranged such that it records
5 images of the luminous spot on the absorbing surface. The recorded image(s) is/are transmitted to the controller 10, in which a simple image processing procedure may be used for determining the diameter and position of the laser beam. Such an image processing procedure may for instance consist of determining where the spot begins and where it ends by performing a horizontal scanning of the circular spot and setting
10 a threshold value. Several horizontal scanings are then carried out at different levels. The centre, which is the centre of the spot, is found at the scanning showing the largest distance between the points of intersections. The software needed for this procedure may be programmed on a software platform such as Delphi or C⁺⁺. The communication between the camera 16 and the controller 10 may for instance take
15 place using the UBS Standard. The calculations may be based on the calculation principles determined in the ISO standard No 1114. The systems may, however, not necessarily be able to provide sufficiently detailed data so as to obtain the necessary accuracy in the results stated in the said standard for the measurements to comply with the standard.

20 The focal spot analyser FSA may be arranged in a corner of the working area of the laser processing system.

At suitable intervals the control circuit may place the processing optics 9 of the processing system to a position over the focal spot analyser FSA to allow the focal spot analyser to measure the laser beam. The relative distance between the lens 9 and
25 the focal spot analyser FSA may be varied by means of the height control of a cutting machine. At the same time successive images of the spot of the laser beam may be recorded using the FSA such that the diameter and position of the laser beam may be determined at a number of levels. As a result information about the propagation, the

focusing, the beam quality and the alignment of the laser beam through the cutting machine may be determined.

This information may be used for diagnosing the laser and the lens 9 and optionally to finely align the laser beam for instance by means of the mirrors 4 and 5.

- 5 Another use of a FSA is to mount it in a suitable manner under the focusing optics of the laser processing system such that it may follow the optics through the system. As a result the FSA may be used to analyse different points in the working area of the system as part of an extensive measuring of the processing system.

The sensitivity is controlled in various focal point positions and at different power
10 levels by the following measures:

Controlling the rotational speed of the chopper disk 14, changing the width of the slot in the rotary disk 14 and displacing the disk 14 in the horizontal direction.

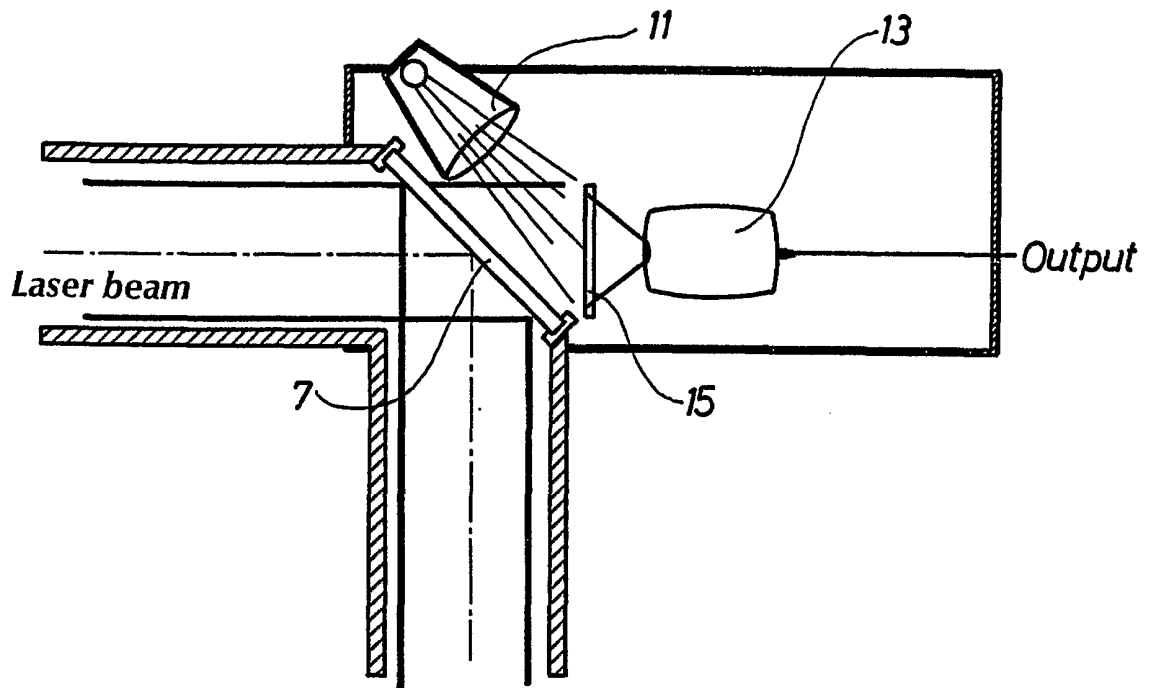
- For each focal point position the output signals from the focal spot analyser FSA may
15 be used to calculate the beam diameter and the weighted centre position of the raw beam.

The unused energy reflected by the chopper disk 14 is transmitted to an energy absorber 17 optionally being water-cooled.

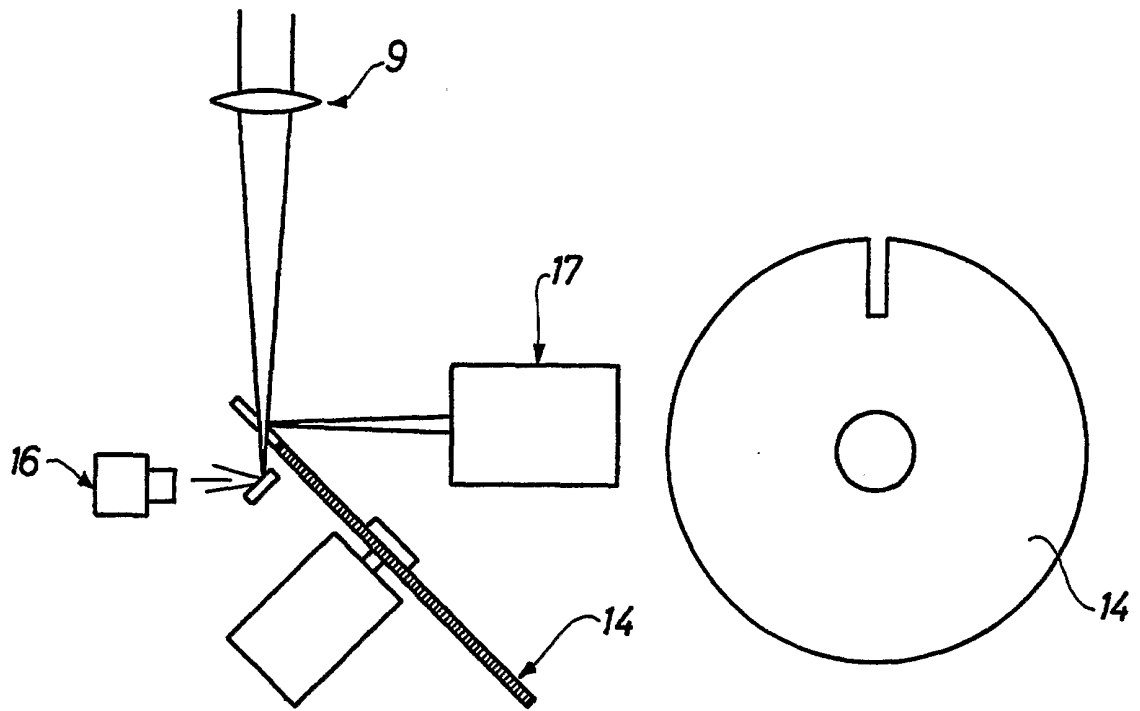
Claims

1. Device for analysing an infrared laser beam and comprising means for providing a two-dimensional image of the laser beam, means for scanning successive lines of images and for generating a time-varying output signal of an amplitude being
5 proportional to the light intensity in each of the points of the scanned lines, means for digitalising the output signal to allow storage of data representing an image of the energy distribution in the laser beam, and means for signal processing the data and analysing each image, c h a r a c t e r i s e d in that the infrared laser beam or a suitable portion thereof is adapted to illuminate a surface and a screen (15) which is
10 able to convert the incident infrared light into visible light which may be recorded by a CCD camera (13) or the like.
2. Device according to claim 1, c h a r a c t e r i s e d in that the screen to be illuminated is a phosphorus screen (15) which optionally is bias illuminated.
3. Device according to claim 1, c h a r a c t e r i s e d in that the phosphorus screen
15 (15) is bias illuminated by means of ultraviolet light (11).
4. Device according to claim 1, c h a r a c t e r i s e d in that the surface to be illuminated is a metal surface.
5. Device according to claim 4, c h a r a c t e r i s e d in that the metal surface is made of anodized aluminium.
- 20 6. Device according to claim 4, c h a r a c t e r i s e d in that metal surface is made of chromium-plated steel.
7. Device according one or more of the preceding claims, c h a r a c t e r i s e d in that a chopper, eg in form of a slotted rotary dish (14), is inserted in the beam channel.

8. Laser processing system for processing a workpiece by means of an infrared laser beam comprising a device according to claim 1 for analysing the laser beam.
9. Laser processing system according to claim 8 comprising a first sensor in form of a low-cost beam analyser ILBA and a second sensor in form of a focal spot
5 analyser FSA.

*Fig. 2*

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**Fig. 3**

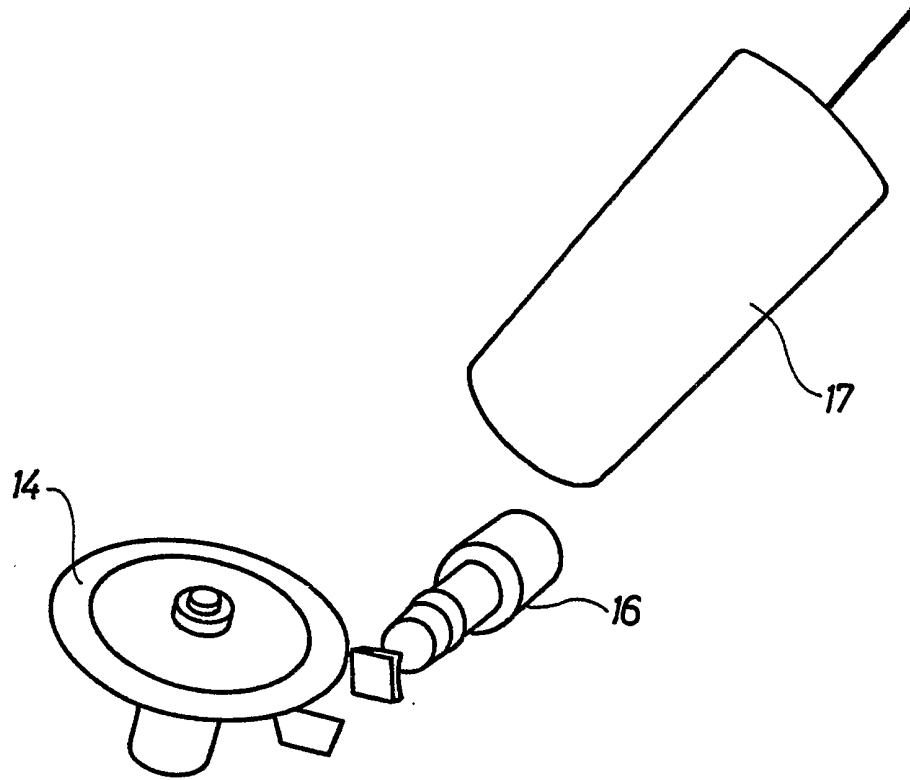


Fig. 4