PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G01B 11/24	A1	(11) International Publication Number: WO 93/08447
		(43) International Publication Date: 29 April 1993 (29.04.93)

(21) International Application Number: PCT/FI92/00281

(22) International Filing Date: 20 October 1992 (20.10.92)

(30) Priority data:
914959 22 October 1991 (22.10.91) FI

(71) Applicant *(for all designated States except US)*: TAMGLASS ENGINEERING OY [FI/FI]; Vehmaistenkatu 5, Sf-33730 Tampere (FI).

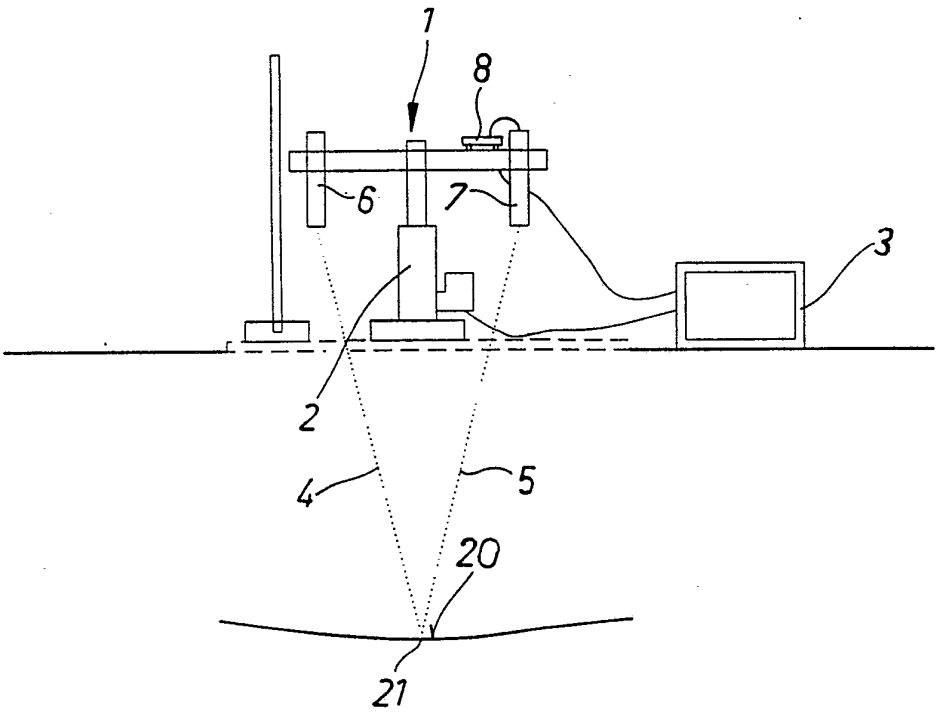
(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : HÄYRINEN, Ville [FI/FI]; Väinölänkatu 6 C 55, SF-33100 Tampere (FI).

(74) Agent: LEITZINGER OY; Ruoholahdenkatu 8, SF-00180 Helsinki (FI).

(81) Designated States: JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, SE).

Published
With international search report.

(54) Title: METHOD AND DEVICE FOR MEASURING THE DEGREE OF BENDING IN A GLASS SHEET



(57) Abstract

The invention relates to a method and a device for measuring the degree of bending in a glass sheet. An optical measuring unit (1) is used for emitting an illuminating ray (4) and for receiving a measuring ray (5). The optical components for rays (4, 5) are directed in a manner that the rays cross each other. When a glass sheet surface (20) is located exactly at the crossing point of these two rays, the light reflects from illuminating ray to measuring ray, the latter being monitored by means of electrical measuring elements (3) which also serve as control elements for a manipulating mechanism (2), whereby said optical measuring unit (1) is manipulated up and down in vertical direction.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria
AU	Australia
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CS	Czechoslovakia
CZ	Czech Republic
DE	Germany
DK	Denmark
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IT	Italy
JP	Japan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
LI	Liechtenstein
LK	Sri Lanka
LU	Luxembourg
MC	Monaco
MG	Madagascar
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SK	Slovak Republic
SN	Senegal
SU	Soviet Union
TD	Chad
TG	Togo
UA	Ukraine
US	United States of America
VN	Viet Nam

Method and device for measuring the degree of bending in a glass sheet

The present invention relates to a method for measuring the degree of bending in a glass sheet by using an optical measuring unit for directing to the surface of a glass sheet on the one hand an illuminating ray and on the other hand a measuring ray crossing the illuminating ray. The invention relates also to a device for measuring the degree of bending in a glass sheet, said device including an optical measuring unit provided with first optical elements for emitting an illuminating ray and second optical elements for receiving a measuring ray crossing the illuminating ray and for focusing it on a light detector.

This type of laser-assisted bending-degree measuring method and device have been disclosed in the Applicant's earlier Finnish Patent application 912871. It proposes the use of a per se known measuring device, based on COD camera technique in a manner that the stationarily positioned device can be used for monitoring the bending degree of glass. However, a measuring device based on COD camera technique is relatively expensive as it requires a large number of sensitive light detectors. The installation of such a device for various applications also requires strict accuracy.

An object of the invention is to provide an improved method and device, which are based on a more simple and inexpensive design construction and which can thus be preferably used both for measuring the deflection and for control measuring after bending and possible tempering.

The object of the invention is achieved on the basis of the characterizing features set forth in the annexed claims.

One embodiment of the invention will now be described in more detail with reference made to the accompanying drawings, in which

fig. 1 shows the general design of a measuring device of the invention schematically in a side view;

fig. 2 shows schematically the construction of an optical measuring head included in the device;

fig. 3 shows a cross-section of optical elements for emitting an illuminating ray 4 (e.g. a laser beam);

fig. 4 shows a cross-section of optical elements for receiving a measuring ray 5; and

fig. 5 shows in a larger scale the use of a delimiter 16 provided with a rectangular slot 17 in front of a photodiode 15.

The device consists of three main components, which include an optical measuring unit 1, a measuring-unit manipulation mechanism 2, and operation controlling electronic measuring and control elements 3.

The degree of bending or deflection of a glass sheet surface 20 is monitored by measuring its distance by means of two mutually crossing optical rays 4 and 5. One of the rays is an illuminating ray 4, which is generated by means of laser and optics 6 and which produces on the glass surface a small illuminated spot having a diameter of

300 - 500 µm. Criss-crossing with said illuminating ray 4 at a point 21 and at a fixed pre-selected angle is a measuring ray 5 for collecting the light reflected from the target on a detector, which in the present case comprises a photodiode 15 contained in an optical tube 7 (see fig. 4). Optics 7 and detector 15 together produce or define said measuring ray 5. Thus, the measuring ray 15 can be determined to be such a volume, wherein a detector 15 associated with optics 7 is capable of detecting a light source (point 21) only and solely if the light source (point 21) is included in said volume. It is obvious that a photodiode is not the only plausible detector and that one and the same device can inlude a plurality of detectors. The measuring ray 5 is restricted by means of a rectangular slot 17 included in a delimiter 16 so as to produce on the target surface 20 a rectangle, having dimensions of e.g. 0.3 x 5 mm^2. A rectangular form is capable of providing a good measuring accuracy while avoiding alignment problems which would result from focusing two small rays on a single spot. The delimitation of a ray can be effected by a variety of methods and the form need not be rectangular but it can be generally elongated. Alternatively, the illuminating ray 4 can be delimited to have an elongated form. The delimitation relaxes the manufacturing tolerances and application of the device but is not essential in view of the operation and accuracy of the device.

Measuring the distance of target surface 20 is based on the fact that the reflection of light from illuminating ray 4 to measuring ray 5 is only possible if the object to be measured is located precisely at the crossing point 21 of these two rays 4, 5. Thus, the question is about an optical triangulation method, wherein crossing point 21 of the rays and said optical elements 6 and 7 provide a

measuring triangle.

As shown in fig. 3, lenses 11 and 12 included in laser optics 6 are fastened to a tubular member 13, which is also provided with a laser 10.

According to fig. 4, a delimiter 16, a lens 18 and a filter 19 included in photodiode optics 7 are fastened to a tube 14, which is also provided with a photodiode 15 behind said delimiter 16.

As shown in fig. 2, both tubular optical elements 6 and 7 are secured to a member 9 so as to provide an optical measuring head 1 that can be manipulated as a single unit. The distance between the outset points of measuring rays 4 and 5 can be e.g. 30 cm. That distance, however, as well as the angle between rays 4 and 5, can be preset at a certain fixed value.

Generally speaking, a method of the invention is based on the fact that the position of optical measuring head 1 transmits data about the bending degree of a glass sheet and a manipulating mechanism 2 or the operator of a measuring device seeks to maintain said optical measuring head 1 at a constant distance or nearly at a constant distance from glass sheet 20 by means of said optical triangulation.

The photodiode 15 is linked through the intermediary of an amplification electronic component 8 with measuring and control elements 3 for controlling said mechanism 2, capable of manipulating the optical measuring unit up and down in vertical direction. Thus, on the one hand, said measuring and control elements 3 serve to control manipulating mechanism 2 and, on the other hand, to

monitor an electric signal coming from photodiode 15. One possible solution for measuring and control elements is a programmable logic, which includes analogical inputs and outputs and in which it is possible to program an access strategy required for searching said target 20.

The manipulating means 2 may comprise primarily direct-current or stepping-motor based linear motors. In principle, both are just as well suitable for the purpose but direct-current linear motors fitted with an attitude- or position-measuring potentiometer are more simple to control and more economical in terms of price. Thus, the measuring and control elements 3 are in possession of data about the position or travelling distance of optical measuring unit 1 in relation to a preset value, which is selected e.g. in a manner that said crossing point 21 is located in alignment with the surface 20 of a glass sheet bent to a desired degree. Thus, this data about the position or travelling distance can be transmitted from a sensor associated with manipulating means 2 or it can be obtained directly from control commands issued by control elements 3 (e.g. when using a stepping motor). The degree of bending can hence be monitored constantly as the glass is bending by lowering said optical measuring unit 1 so that the crossing point 21 of the rays follows the glass surface 20. The measuring result is reported as a plus/minus deviation from a predetermined target value. In control measurements, it is sufficient to report whether the measuring result lies within an acceptable range.

Claims

1. A method for measuring the degree of bending in a glass sheet by using an optical measuring unit for focusing on a glass sheet surface (20) on the one hand an illuminating ray (4) and, on the other hand, a measuring ray (5) which crosses the illuminating ray and whose light detector (15) includes electrical measuring elements (3) for providing data as to when the glass surface (20) is located exactly at a crossing point (21) between these two rays (4, 5), c h a r a c t e r i z e d in that by the manipulation of an optical measuring unit (1) said crossing point (21) is caused to coincide with glass surface (20) and the degree of glass bending is determined on the basis of the manipulating distance or position of said optical measuring unit (1).

2. A method for measuring the degree of bending in a glass sheet by using optical triangulation, wherein a glass sheet surface (20) is on the one hand exposed to an illuminating ray (4) and, on the other hand, a measuring ray (5) crossing the illuminating ray, whereby optical elements (6, 7) for said rays are included in an optical measuring head (1) at a distance from each other, a crossing point (21) for rays (4, 5) and said optical elements (6, 7) providing a measuring triangle, c h a r a c t e r i z e d in that the location of optical measuring head (1) transmits data about the bending degree of a glass sheet and that a manipulating mechanism (2) or a measuring device operator strives to maintain said optical measuring head (1) at a constant distance or nearly at a constant distance from glass sheet (20) by means of optical triangulation.

3. A method as set forth in claim 1 or 2, c h a r a c -

t e r i z e d in that said manipulating mechanism (2) for optical measuring unit (1) is controlled by means of electrical measuring and control elements (3), which simultaneously monitor an electric signal coming from a light detector (15).

4. A method as set forth in claim 1, 2 or 3, c h a r - a c t e r i z e d in that said illuminating ray (4) comprises a laser ray.

5. A device for measuring the degree of bending in a glass sheet, said device comprising an optical measuring unit (1) provided with first optical elements (6) for emitting an illuminating ray (4) and second optical elements (7) for receiving a measuring ray crossing said illuminating ray and for focusing it on a light detector (15), c h a r a c t e r i z e d in that said optical measuring unit (1) is adapted to be manipulated by means of a manipulating mechanism (2), which is controlled by means of electrical control elements (3) which are in possession of data about the manipulating distance or position of measuring unit (1) and which control elements (3) also monitor an electric signal coming from a light detector (15).

6. A device as set forth in claim 5, c h a r a c t e r - i z e d in that said first or second optical elements (6 or 7) are provided with a delimiter (16), whereby said illuminating ray (4) or measuring ray (5) is given an elongated, e.g. rectangular cross-section.

7. A device as set forth in claim 5 or 6, c h a r a c - t e r i z e d in that said light detector (15) is a photodiode.

8. A device as set forth in claim 5 or 6, c h a r a c - t e r i z e d in that said optical measuring unit (1) can be linearly manipulated up and down in vertical direction.

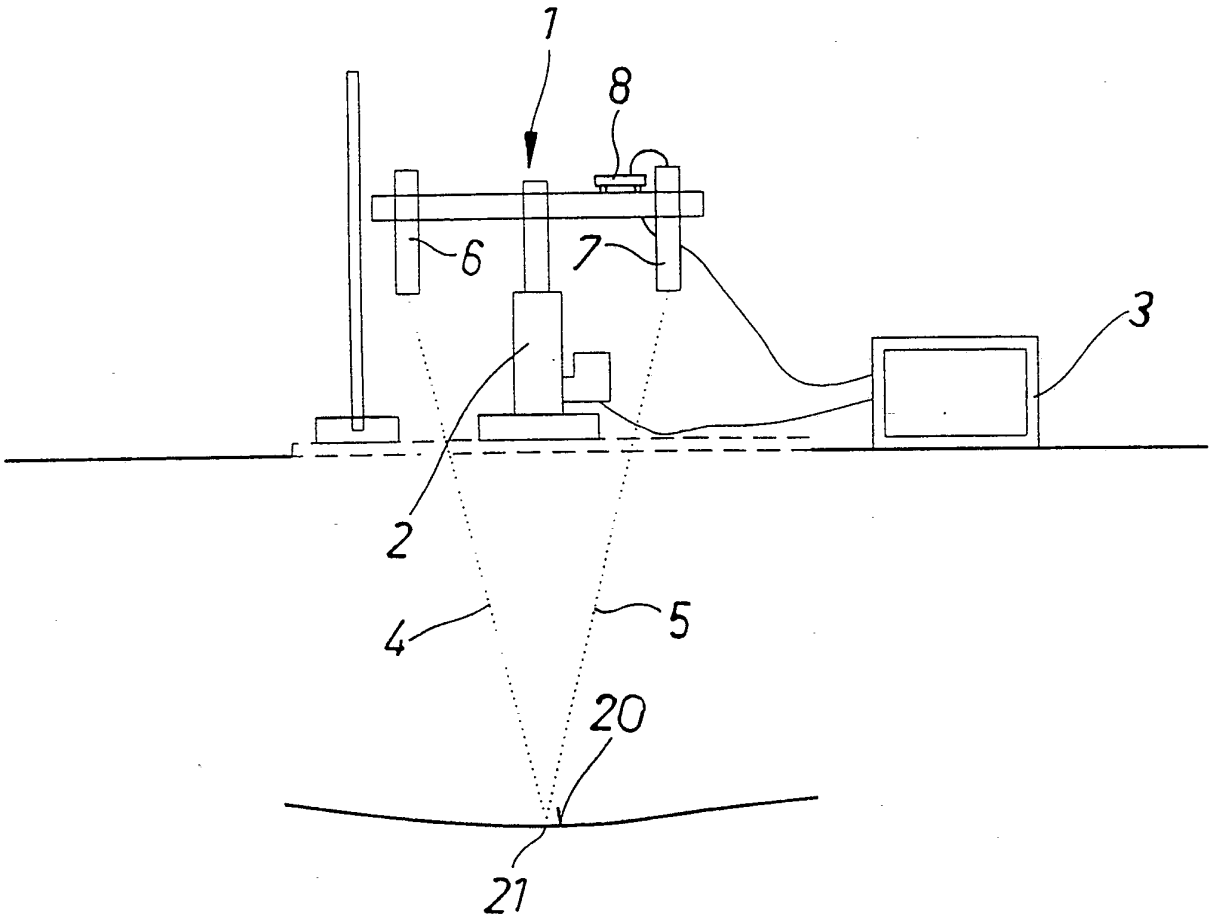


Fig. 1

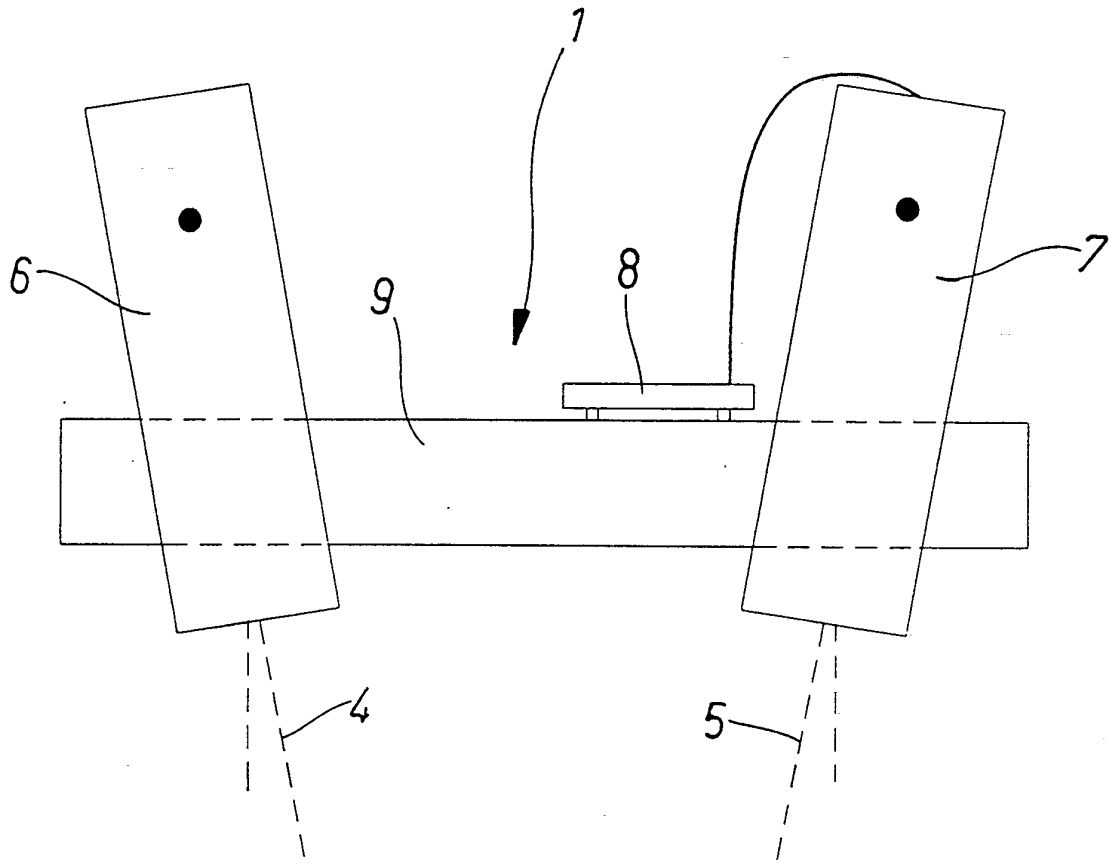


Fig. 2

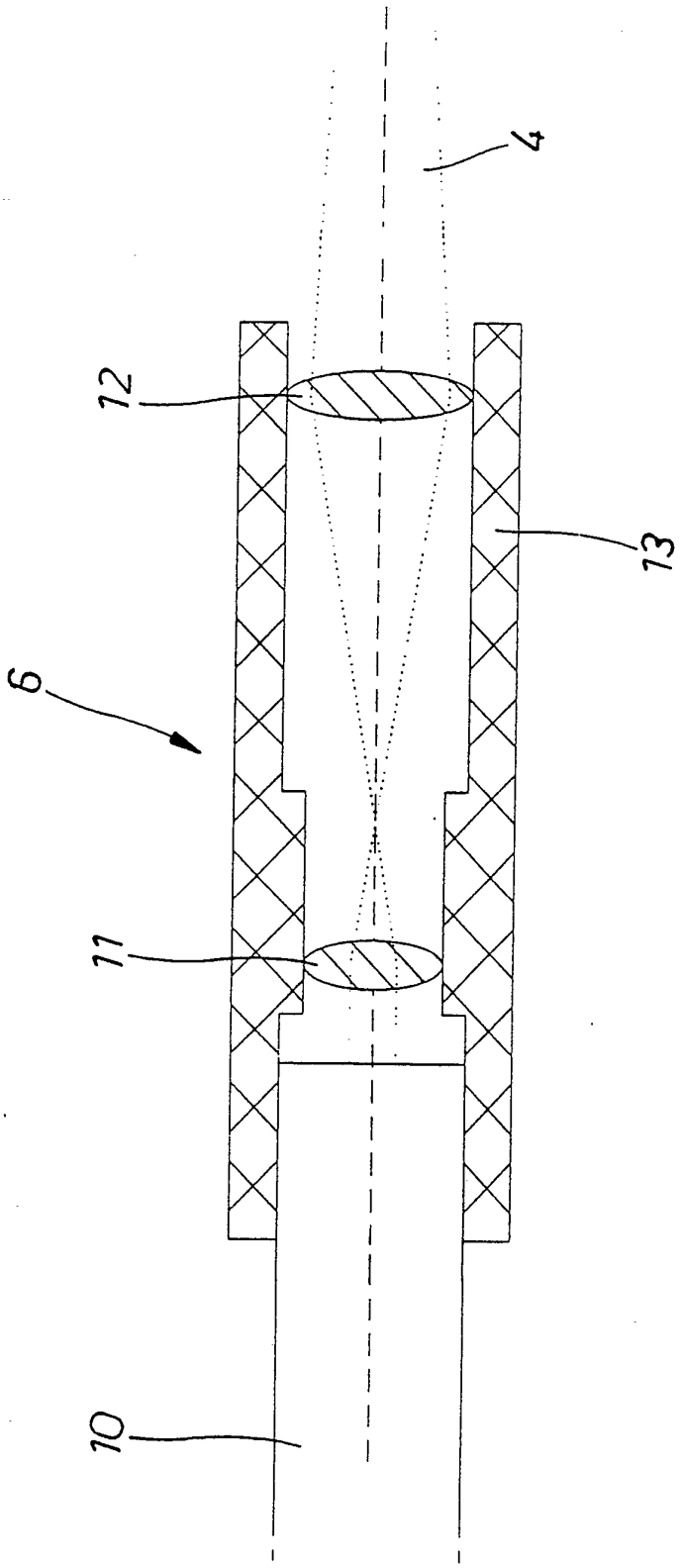


Fig. 3

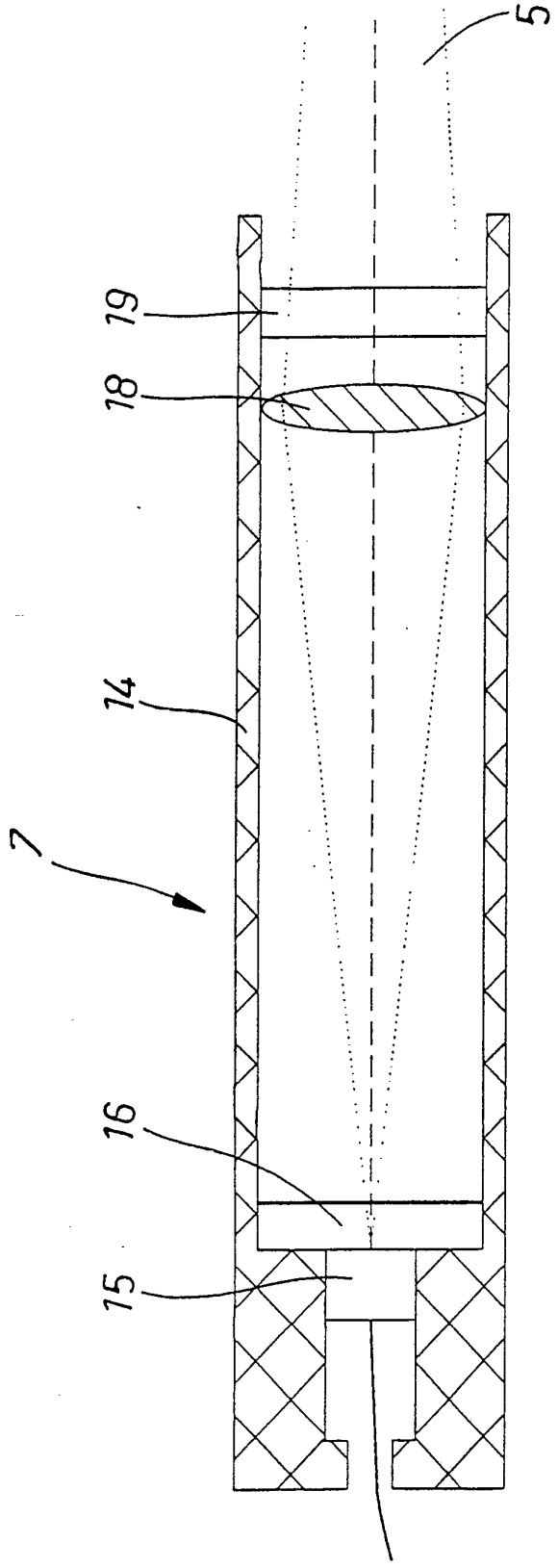


Fig. 4

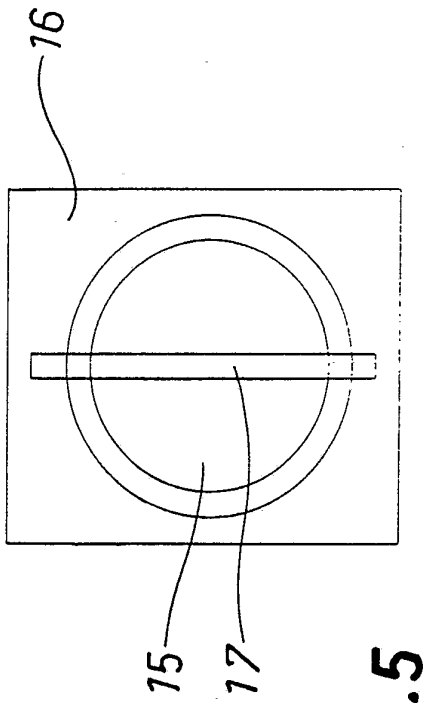


Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No PCT/FI 92/00281

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: G 01 B 11/24

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	G 01 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	US, A, 4660970 (FERRANO) 28 April 1987, see the whole document --	1,4
X	GB, A, 2205640 (JANUSZ ANDREW VELTZE) 14 December 1988, see the whole document --	1,4

---

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
21st January 1993	28 -01- 1993
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	INGEMAR JOSEFSSON

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.PCT/FI 92/00281

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the Swedish Patent Office EDP file on 08/01/93
The Swedish Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A- 4660970	87-04-28	CA-A-	1232444	88-02-09
		DE-A-	3342675	85-06-05
		DE-A-	3472166	88-07-21
		EP-A-B-	0145957	85-06-26
		JP-A-	60185108	85-09-20
GB-A- 2205640	88-12-14	NONE		