



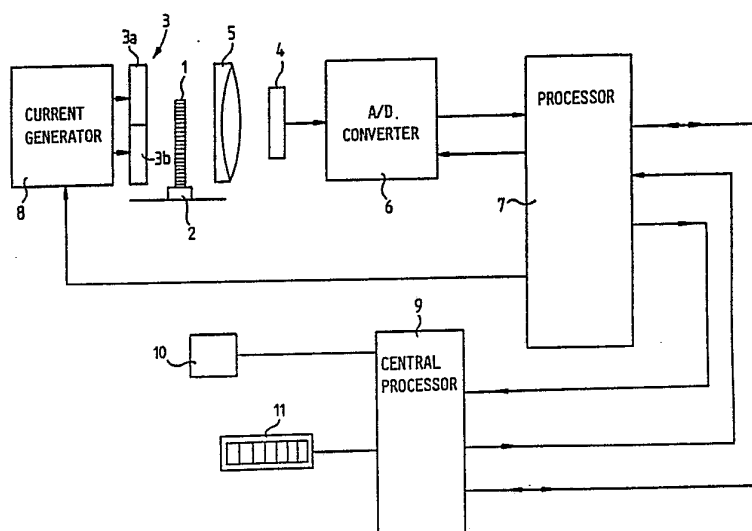
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification <sup>4</sup> : G07D 5/02, G07F 3/02 // G01B 11/08</p>	<p>A1</p>	<p>(11) International Publication Number: WO 88/ 07731 (43) International Publication Date: 6 October 1988 (06.10.88)</p>
<p>(21) International Application Number: PCT/FI88/00046 (22) International Filing Date: 30 March 1988 (30.03.88) (31) Priority Application Number: 871403 (32) Priority Date: 31 March 1987 (31.03.87) (33) Priority Country: FI</p> <p>(71) Applicant (for all designated States except US): INTER MARKETING OY [FI/FI]; Tietäjantie 10-12, SF-02130 Espoo 13 (FI).</p> <p>(72) Inventors; and (75) Inventors/Applicants (for US only) : SAARINEN, Tapani [FI/FI]; Hämeentie 48 A 43, SF-00500 Helsinki (FI). RÄSÄNEN, Jaakko, Antero [FI/FI]; Juuritie 10, SF-02720 Espoo (FI).</p>		<p>(74) Agent: OY KOLSTER AB; Iso Roobertinkatu 23, P.O. Box 148, SF-00121 Helsinki (FI).</p> <p>(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK, FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), NO, SE (European patent), US.</p> <p>Published With international search report.</p>

(54) Title: A DEVICE FOR IDENTIFYING COINS OR THE LIKE

## (57) Abstract

The invention relates to a device for identifying coins or the like on the basis of the diameter thereof, comprising a coin path (2) for feeding coins or the like (1); a light source (3) for illuminating the coin or the like (1) on the path (2) in a direction essentially perpendicular to the plane of the path (2); and a photosensitive sensor (4) for converting the light gone past the coin or the like (1) into an electric signal dependent on the diameter of the coin or the like. The light receiver has previously been formed by accurately positioned optical fibres, whereby, however, it is necessary to ascertain that the coin or the like makes contact with the path at the measuring moment; on the other hand, information is obtained on the size class of the coin only. These drawbacks are eliminated by means of the device according to the invention, which is characterized in that the light source (3) is column-like; that a lens assembly (5) is arranged in front of the photosensitive sensor (4), behind the coin path (2), for projecting an image of the light source (3) on to the sensor (4); and that the sensor is a sensor (4) measuring the amount of light for converting the light amount of a light column sent by the column-like light source (3) and gone past the coin into an electric signal depending on the diameter of the coin.



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A device for identifying coins or the like

This invention relates to a device for identifying coins or the like on the basis of the diameter thereof, comprising

5                   - a coin path for feeding coins or the like;  
                  - a light source for illuminating the coin or the like on the path in a direction essentially perpendicular to the plane of the path; and

10                   - a photosensitive sensor for converting the light gone past the coin or the like into an electric signal dependent on the diameter of the coin or the like.

In coin identification devices of the above type the light receivers are formed either by optic fibres the ends of which are arranged at suitable heights in accordance with the diameters of the different coin types or by columns consisting of photodiodes or some other photosensitive elements. This kind of devices for determining the diameter of a coin or the like are known e.g. from British Patent Applications 2 115 547 and 2 176 038 and U.S. Patent Specifications 1 379 473 and 4 249 648. The use of a sensor according to British Patent Application 2 176 038 requires that the coin is in contact with the path when it passes the sensor. On the other hand, this kind of sensor arrangement merely enables the different coin types to be separated from each other, whereas foreign coins, for instance, which fall between these coin types are included in the group of the next smallest coin type, and it is not possible to exclude them from the counting. Further, when this kind of device is modified so as to be operative with an other country's coins, a new basic adjustment is required, i.e. the fibres have to be arranged at suitable heights through

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experimentation. The devices disclosed in British Patent Application 2 115 547 and U.S. Patent Specifications 1 379 473 and 4 249 648 utilize photodiode rows by means of which the size of a coin or some other object can be determined on the basis of the number of photodiodes shadowed by the coin. The sorting accuracy of devices of the above type could possibly be improved by increasing the number of the fibres or photodiodes, whereby, in theory, it would be possible to determine the diameter very accurately; in practice, however, the formation of a measuring sensor consisting of a great number of fibre ends or photodiodes is difficult and in any case causes considerable costs on account of the complicated structure as well as the detector to be attached to each fibre or photodiode.

Swedish Patent Specification 397 420, in turn, discloses identification of coins or the like on the basis of the area thereof. In a device according to this publication the light receiver consists of a large-area sensor formed by four solar cells, by means of which sensor the area of the coin can be determined on the basis of the total amount of light gone past the measuring point at the measuring moment. For obtaining a correct measuring result, there must not be more than one coin at a time within the measuring area, which, on the other hand, retards considerably the operation of the device and, in addition, it has to be provided with means for preventing more than one coin entering the measuring area. In addition, the calibration of the responses of the different parts of the large-area sensor is also difficult if not impossible.

The object of the present invention is to provide a new device for the determination of the dia-

meter of coins or the like with an accuracy such that coins or the like having a different diameter can be removed from the coin path. More precisely, the object of the invention is to provide a measuring device sufficiently accurate in view of the coin manufacturing tolerances and other factors affecting the coin diameter so that it enables an accurate determination of the diameter of coins or the like. A further object is to solve the problems which have occurred in connection with prior optically operating devices for the determination of coin diameters and devices derived therefrom in view of the costs, reliability, and complicated structure.

The above objects are achieved by means of a device according to the invention, which is characterized in that the light source is column-like; that a lens assembly is arranged in front of the photo-sensitive sensor, behind the coin path, for projecting an image of the light source on to the sensor; and that the sensor is a sensor measuring the amount of light for converting the light amount of a light column sent by the column-like light source and gone past the coin into an electric signal depending on the diameter of the coin. Thus the diameter of the coin or the like is determined as the difference between a value measured to an empty path by the sensor measuring the amount of light and a minimum value measured during the passage of a coin or the like. When this kind of measuring principle is used, the coins need not be in contact with the coin path, but the measurement is based only on the amount of light which is able to go past them when they pass the measuring point.

By using a lens assembly in front of the sensor measuring the amount of light for projecting the image

of the light source on to the sensor, the sensor may be smaller than the light source and thus more advantageous in price; on the other hand, the lens assembly protects the sensor against dust, which is significant as dust formation is a major problem with optic fibres.

In the device according to the invention, variations in the luminosity of the light source due to ageing or voltage variation, for instance, are compensated by the column-like light source which comprises two superposed column elements which are equal in size and the light amount of which is separately adjustable for the calibration of the readings given by the sensor measuring the total amount of light. Thus it is always possible to standardize the measuring situation irrespective of possible variation in the sensitivity of the sensor or a slight dust formation on the lens assembly.

In the following the device according to the invention and its operating principle will be described in more detail with reference to the attached drawing, in which the figure shows the operating scheme of the device according to the invention.

The figure shows generally the structure of the device according to the invention. The measuring arrangement thereof comprises a coin path 2 on which a coin 1 is shown; a light source 3 positioned on one side of the coin; and a lens assembly 5 and a photo-sensitive sensor 4 opposite to the light source and behind the coin. As the column-like light source 3 is positioned in an upright position in front of the coin path 2 and an image of the light source is projected through a slit and the lens assembly 5 to the sensor 4 measuring the total amount of light on the other side of the coin path, the light source is covered by the

coin when it passes along the path in an amount corresponding, in a maximum case, to the diameter of the coin, and the difference between the maximum and minimum amount of light corresponds to the diameter of the coin. That portion of the light column which is covered by the coin is independent of the vertical position of the coin on the path, so the coin need not be in contact with the path 2 at the measuring moment. The coin 1 is illuminated in a direction essentially perpendicular to the plane of the coin path, i.e. the plane of the coin 1. The function of the coin path 2 is to feed the coins essentially in the desired plane and separately from each other to the measuring means. Thus the coins need not be passed one by one on to the path, which would result in too low a counting rate. In the device according to the invention the only thing to be done is to ascertain that the coins are not positioned side by side on the path, which is relatively easy to effect mechanically, whereby collisions along the path can be regarded to belong to the normal operation of the device. Such collisions may have as a result that the coin is off the surface of the path at the measuring point, which, however, does not affect the measuring accuracy due to the operating principle of the device according to the invention.

The use of the lens assembly 5 enables the light column 3 to be projected to the photosensitive sensor 4 in a smaller size, whereby the sensor may be e.g. a PIN diode. A signal proportional to the total amount of light from the light column 3 is converted into an electric signal and passed from the photosensitive sensor to an A/D converter 6 for converting the measuring value to a digital value. The converter 6 may be e.g. an 8-bit A/D converter. From the converter 6 the digital measuring values are transferred to a

processor 7 which carries out the calculations with the measuring values and calibrates the measuring arrangement. When the amount of light at the sensor 4 exceeds a predetermined level for a certain period of time, the processor 7 detects that the path 2 is free and compares the voltage level of the sensor 4 to a level set at the manufacturing stage of the device and corrects a current generator 8 of the light source 3 in a corresponding way. The correction to be carried out at one time is so small that the sawing effect caused by the adjustment does not cause an error in the end result but it merges into the disturbances and noise occurring in the system in any case. Thus the correction can be made parallelly with the normal calculation process; in practice, correction is carried out continuously between the coins, being interrupted only for the time of the proper measuring.

The column-like light source 3 comprises two separate column elements, such as two LED columns 3a and 3b. It is also possible that due to the manufacturing scattering thereof, different amounts of light are obtained from the different LED columns with the same current, and the amount of light does not necessarily change in the same way with the ageing of the LEDs. Even though the columns could be made equally luminous at the manufacturing stage of the device, the situation does not necessarily remain unchanged when the device ages.

Since the junction point of the LED columns 3a and 3b is positioned in the middle of the centre of the lens assembly 5, the image formed to the photosensitive sensor 4 by both the columns is equally large; the light amount of the LED columns 3a and 3b can be adjusted to the same value simply by extinguishing the columns by turns and by defining the difference be-

tween the set values of the columns, the difference being then maintained during normal measuring. This kind of balancing of the light amounts of the LED columns is preferably carried out each time the current  
5 to the device is switched on. After the balancing, the light amount of the bottom, i.e. the empty path is set to a certain predetermined value, which is again carried out by means of the current generator 8. In this way one calibration point of the measuring device  
10 can be calibrated. The other calibration point is obtained by thereafter extinguishing the lower column, so that an artificial measuring situation is obtained which corresponds to a coin 1 passing along the coin path 2 and having a diameter equalling in size with  
15 the lower LED column 3b, and by comparing the light amount thus obtained to a value stored in the permanent memory at the calibration stage of the device. If this comparison reveals an essential difference between these values, the operation of the device is  
20 faulty. In this way the device itself is able to detect even a relatively small malfunction of the measuring system.

The processor 7 carries out the calculation of a numerical value representing the diameter of the  
25 coin or the like. When the amount of light from the sensor 4 falls below a predetermined level, the processor 7 starts to form a moving average from the last 16 samples, simultaneously storing samples in the memory for later examining. The moving average is de-  
30 termined in two parts, the first part being formed by the first eight samples and the second part by the last eight samples in this group of sixteen samples. When the average value of the group of the first eight samples becomes smaller than the average value of the  
35 group of the last eight samples, the amount of light

has reached the minimum thereof and starts to grow again. The last sample of the group of the first eight samples is thus nearest to the maximum diameter of the coin or the like. In order to improve the sorting accuracy of the measuring arrangement, the sum of a number of samples, in practice 30 to 40 samples, taken before the sample representing the maximum diameter, said sample included, is calculated and the sum so obtained is divided by a figure depending on the number of the samples. In this way it is possible to eliminate the dependence of the obtained value on the path velocity of the coins or the like. In practice, a sorting capability of 0.05 mm is obtained when the 8-bit A/D converter 6 is used. This can be regarded as fully sufficient, taking into consideration the manufacturing tolerances of the coins and the diameter variations occurring therein in use. The sampling interval may be e.g. 200 microseconds. Thereby the moving average is determined for a time of 3.2 milliseconds. Accordingly, the point representing the maximum diameter of the coin is available 1.6 milliseconds after the middle point of the coin has gone past the measuring point. When the time required for the treating of the values in the processor, e.g. 4.4 milliseconds, is added thereto, the device knows the diameter of the coin six milliseconds after the middle point of the coin has gone past the sensor 4. Since the number of the samples obtained from each coin also depends on the path velocity of the coin, the moment when the coin is positioned by a sorting/rejecting unit 10 of the path can be determined by means of the path velocity. Thus a coin can be removed reliably from the path if it is detected that its diameter deviates from that of the coins for which the device has been calibrated. So it is easy to remove foreign

coins from the counting process. The sorting/rejecting unit 10 is controlled by a central processor 9 which receives information from the processor 7 on the diameters and velocities of the coins detected on the path. The central processor 9 then either sorts out the coin to an acceptable coin type on the basis of the diameter data and adds the monetary value of this coin to the sum shown on a display 11, or controls the sorting/rejecting unit 10 so as to remove from the path a coin which does not belong to any one of the acceptable coin types.

Since the operation of the device according to the invention is based on the measurement of the amount of light and, on the other hand, on typical measuring values determined for each coin type by means of this kind of measurements, there is no problem in modifying the counter so that it suits the species of coin of different countries. When the monetary values of the coins of a new country are taught to the device, the number of the coins and the corresponding values are first programmed in the device, whereafter a calibration run is carried out, in which a certain number of each coin type is passed through the device. The device forms coin groups the average value of which is calculated and the upper and lower acceptable limits are determined for each type by giving the mechanical tolerances of the coins of the country in question.

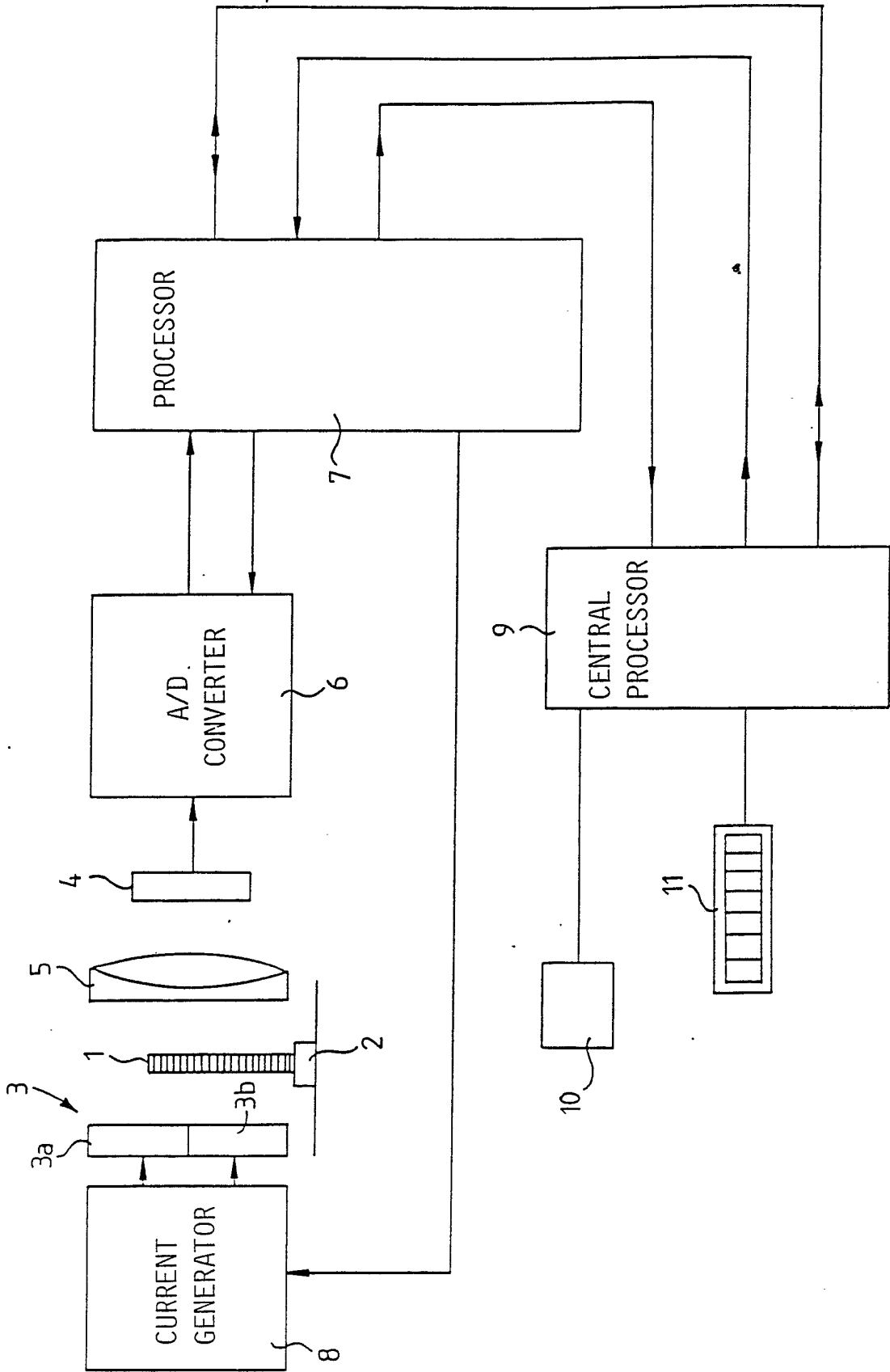
The device according to the invention has been described above only on the basis of one specific embodiment, and it is to be understood that it is possible to modify the structure of the device as well as the ways of calculating the measuring values dependent on the coin diameter without, however, deviating from the scope of protection defined in the attached

claims. Since the device according to the present invention is based on the identification of coins or the like exclusively on the basis of the diameter thereof, it is obvious that it does give fully reliable information on whether all the coins fed into the device are genuine. This can be ascertained by additional units provided in front of or behind the device, the operation of which devices may be based on the determination of the thickness, for instance, or on the determination of the material of the coin by means of an inductive method. Accordingly, by combining the device according to the invention to units previously known from coin sorting a device can be obtained which both identifies the genuineness of the coins and calculates the value thereof extremely reliably.

## Claims:

1. A device for the identification of coins or the like on the basis of the diameter thereof, comprising
- 5           - a coin path (2) for feeding coins or the like (1);
- a light source (3) for illuminating the coin or the like (1) on the path (2) in a direction essentially perpendicular to the plane of the path (2); and
- 10           - a photosensitive sensor (4) for converting the light gone past the coin or the like (1) into an electric signal dependent on the diameter of the coin or the like, characterized in that the
- 15           light source (3) is column-like; that a lens assembly (5) is arranged in front of the photosensitive sensor (4), behind the coin path (2), for projecting an image of the light source (3) on to the sensor (4); and that the sensor is a sensor (4) measuring the amount of
- 20           light for converting the light amount of a light column sent by the column-like light source (3) and gone past the coin into an electric signal depending on the diameter of the coin.
2. A device according to claim 1, characterized in that the column-like light source (3) comprises two superposed column elements (3a, 3b) equal in size, the light amount of the column elements being separately adjustable for the calibration of the readings given by the sensor (4) measuring the amount
- 25           of light.
3. A device according to claim 2, characterized in that the column elements of the light source are LED columns.
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4. A device according to claim 1, characterized in that the photosensitive sensor (4) is a PIN diode.



# INTERNATIONAL SEARCH REPORT

International Application No PCT/FI88/00046

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC <sup>4</sup>		
G 07 D 5/02, G 07 F 3/02 // G 01 B 11/08		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
<b>Classification System</b>	<b>Classification Symbols</b>	
IPC 4	G 07 D 5/00,/02; G 07 F 3/02; G 01 B 11/08	
US C1	194:4, 317, 328, 334, 338; 250:223R	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
SE, NO, DK, FI classes as above		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>9</sup></b>		
<b>Category <sup>10</sup></b>	<b>Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup></b>	<b>Relevant to Claim No. <sup>13</sup></b>
A	DE, A1, 2 724 868 (WALTER HANKE MECHANISCHE WERKSTÄTTE) 14 December 1978 See paragraph bridging pages 5 and 6	1, 2
A	DE, A1, 3 304 395 (NATIONAL REJECTORS INC GMBH) 16 August 1984 See paragraph bridging pages 8 and 9	1
A	US, A, 4 676 358 (WARREN G ROSENDAHL JR) 30 June 1987 See column 4, lines 39-48	1
A, P	US, A, 4 585 936 (SELLIER CHRISTIAN) 29 April 1986 See column 5, lines 19-39	1
A	US, A, 4 217 491 (DUFFORD JR ET AL) 12 August 1980 See column 2, lines 26-47	3, 4
	.../...	
<p><sup>10</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"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</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"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.</p> <p>"Δ" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
1988-05-24	1988 -06- 28	
International Searching Authority	Signature of Authorized Officer	
Swedish Patent Office	Hans Bandelin	

## III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
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A,P	Technisches Messen tm, 54. Jahrgang, Heft 5/1987 (München), G Klotz, "Hochgenaues Messen von rotationssymmetrischen Bauteilen in Fertigung und Qualitätssicherung" Teil 1: Messverfahren für Aussendurchmesser, see pages 173-179; especially chapter 5.3	1
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