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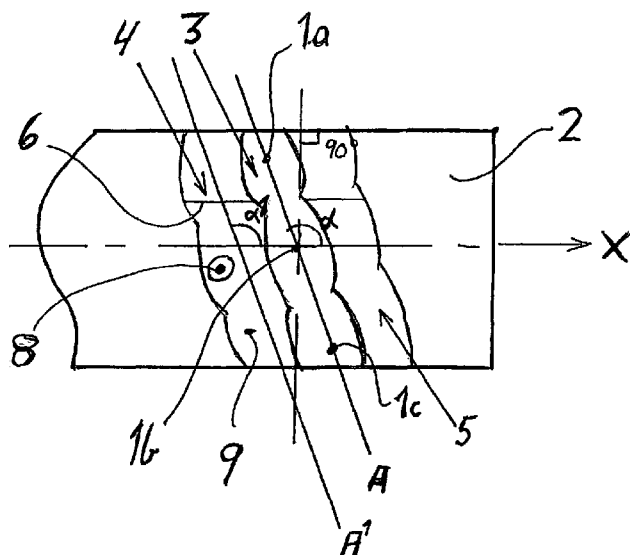
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(54) Title: METHOD AND APPARATUS FOR INSPECTION OF SURFACES

**Fig. 1**

(57) Abstract: A method and an apparatus for inspection of at least one surface of an object (2) having an elongated shape in a direction (X) where an illuminating device (ID), that may comprise at least two illuminators (1a, 1b) or a non-discrete light array, is arranged in the vicinity of the object. At least one image digitization device (20) is arranged for capturing images of said surface. The illuminating device is further aligned in a manner with regard to the direction (X), thereby illuminating a part of the surface of said object (2) at an angle (α , α') in a dark field and/or bright field condition, whereby defects in the said surface can be visualized and imaged. In particular 3D defects, pressure lines, dents, dielines etc. in extruded products can be detected. An image processing unit can compare captured data with stored threshold data for quality inspection and grading. If rejection is necessary, a manipulator can be controlled in accordance to this and remove rejected objects. The object and/or apparatus can be arranged for movement along direction (X).

Method and apparatus for inspection of surfaces

5 The present invention relates to a method and an apparatus for inspection of surfaces.
One embodiment of the invention relates to inspection of elongated objects with defects
that are likely to be oriented in its elongated direction. In one other embodiment of the
invention it relates to inspection of moving surfaces with elongated defects that are likely
to be oriented in its direction of movement. The invention may also be used to detect
10 overall shape of an object and also to give a quantification of cross section curvature.

Surface quality control of products, such as extruded products are commonly done by
visual inspection. For instance, such control can be performed on profiles leaving an
extruding machine, to assure that the extruding process is operated within certain
15 tolerances. Further, control can be made of extruded and also surface treated products
before packing and shipping to a customer destination.

For many manufacturing applications such as for instance, when producing extruded
products to building appliances, the visual surface quality of the delivered products is very
20 often of great importance. In some appliances, most sides of the products may, in its final
installation, be visually arranged together with other components in the final assembly.
However, in some other appliances at least one side of the product will be hidden.

Visual inspection is time consuming and it is also difficult to inspect all sides of a moving
25 product at a time. Further, by manual inspection there might be some variations with
regard to the quality tolerances set that may be introduced by varying lighting conditions,
the individuals making the inspection may judge surface defects differently, etc.

Therefore, it is of importance to provide an automated method and an apparatus that can
30 perform surface inspection of rapidly moving objects, and from all sides thereof.

The working principle of the present invention is primary based upon dark field illumination
of the surface to be inspected. However, the corresponding bright field and the grey field
(near bright field area, somewhere between the bright field and the dark field areas) can
35 also give valuable information of the object's surface. An image digitization device
(camera) is applied to make images of the dark field, grey field and bright field illuminated
surface. The dark field information is analyzed by means of a computer or the like, where

the purpose of the analysis is to evaluate whether there are surface defects of a type and severity that leads to rejection of the product or simply to assign a quality grade of the object. Bright field information captured by a camera can be applied to get information related to the overall geometry of the object in the same sense as above, or to
5 identify/recognize the type of the object to be analysed.

US 6,327,374 B1 discloses a method and an arrangement for automatic inspection of the surface of a moving object, in which a region of the object's surface is illuminated from at least two different illumination directions. The object's illuminated surface region is imaged
10 with a camera to provide image information for analysis. The light sources illuminate the object's surface from the different illumination directions at different times, and the camera is a line scan camera. The arrangement further comprises a timing controller for synchronous pulsing of the light sources and the at least one line scan camera. The pulsing frequencies of the light sources should be above 1 kHz. Thus the pulsing
15 frequency of the camera must be of a multitude higher, corresponding to the number of light sources.

EP 0 898 163 B1 discloses a method and an apparatus for automatic inspection of moving surfaces, such as steel strips, wood, leather or tiles. In a preferred embodiment the
20 solution comprises at least three different illumination/observation channels. The solution is based upon photometric stereo. Information on reflectivity, colour, glossiness and profile of the inspected surface is captured, e.g. by an apparatus comprising a colour line scan camera and at least three spatially separated light sources with different spectral characteristics. The results of the image acquisition are registered images, e.g. R-, G-, B-
25 images, basically corresponding to the channels of illumination. The images are processed in several steps comprising estimation of surface anomalies, feature extraction and classification. The purpose of this system seems to be that by using three light sources of different spectral characteristics the camera can capture three different images of the surface simultaneously, which can improve capacity and accuracy of the inspection.
30 Alternatively one light source can be applied together with a plurality of sensor devices (cameras).

DE 195 11 534 A1 relates to a method and an apparatus for detecting 3D-defects, such as dents and steps in a flat surface, in applications for automatic surface inspection,
35 following the idea of photometric stereo. The surface under inspection is simultaneously illuminated with at least two lamps from different directions under dark field conditions,

where the light from the lamps has different colours. A colour line scan camera is used for image acquisition and 3D-defects are detected by analyzing the measured colour values.

When using one image capturing device together with a plurality of illuminators, there is disclosed in the above mentioned prior art to light up the illuminators individually at a frequency that in total corresponds to the capture frequency of the image grabber. Under such circumstances the capture frequency of the image grabber must be relatively high, at least when inspecting moving objects, to secure sufficient input data from the surface.

Further, it is also known from the above mentioned prior art to take images simultaneously at various observation/illumination channels, which will reduce the need for that high capture frequency of the image grabber.

In accordance with the present invention it is possible to inspect visual surfaces of a moving object, or by mutual movement between the apparatus and object, where in one embodiment all visual sides of the object can be inspected simultaneously. This requires a sufficient amount of cameras.

The capacity and capability of the inspecting apparatus allows the object to be inspected at all visual sides thereof at a relatively high speed.

The invention is in particular suited for inspection of elongated products in continuously or semi-continuously manner, and is well suited for inspection of extruded products, treated on its surface or not. It is advantageous that the surface have a certain directional reflecting property, preferably of a glossy character, depending of the illuminating source.

In particular, the invention is well suited for detecting surface defects on products produced by extrusion, continuous or semi-continuous casting, rolling or other continuous or semi-continuous processes.

In accordance with the present invention, the processing of images and the composition of information there from can be done at high speed and in a simplified manner.

Moreover it represents benefits with regard to a quantitative inspection of manufactured goods.

These and further advantages can be achieved with the invention as defined in the accompanying claims.

In the following, the invention shall be further described by examples and figures where:

5

Fig. 1 discloses a principal set up of one embodiment in accordance with the present invention, seen from above,

10

Fig. 2 discloses the principal set up as shown in Fig. 1, seen from the side and further disclosing an image digitization device,

Fig. 3 discloses a second embodiment of the invention, comprising an arrangement that illuminates more than one side of the object to be inspected,

15

Fig. 4 discloses a third embodiment of the invention, similar to that of Fig. 3, but with one helix shaped, non discrete illuminator.

20

Fig. 5 discloses a sketch of the apparatus including image processing and rejecting device,

Fig. 6 discloses an image of a surface having blisters as surface defects,

Fig. 7 discloses an image of a surface having dielines (longitudinal defect) as surface defect.

25

Fig. 8 discloses an image of a surface having colour streaks as defects,

Fig. 9 discloses an image of a surface having one dent as defect,

30

Fig. 10 discloses an image of a surface having a wave as defect.

35

As shown in Fig. 1 and 2, one object 2 has an elongated shape in direction X, and is further arranged for movement along this axis X. The object is illuminated by an illuminating device (ID) that in this embodiment comprises three illuminators 1a, 1b and 1c. Such illuminators can be of LED type, ordinary light bulbs or the similar. The wavelength of the emitted light should preferably be as short as possible to be able to detect small defects (for instance, 5-6 μm or less).

The movement of the object can be performed by the production process itself, by motorized rollers 21, 22, 23 or the similar. The illuminators are arranged above the surface of the object 2 and are aligned along one axis A (Fig. 1) that is inclined with an angle α with regard to the axis of movement X. Consequently, a bright field area 3 will be seen at a corresponding angle with regard to said axis X, however depending on the topology of the surface 2. At the peripheral regions of said bright field area, the object 2 will be illuminated under dark field conditions in areas 4, 5. Between the two mentioned dark field areas and the said bright field area there will be transition areas named grey field areas.

In principle, the angle α can be somewhere between 0° and 360° with regard to the axis of movement X, depending on features related to the object to be analyzed and its surface defects. In practical modifications, this angle can deviate somewhat from a perpendicular to the axis of movement. In the example shown in Fig. 1, the angle α is approx. 110° .

In this set up, the dark field area 4 will be of particular interest. However the dark field area denoted reference numeral 5, can be applied as well. This depends on practical arrangement of the set up. An image digitization device 20 (camera or the similar, see Fig. 2) is arranged at a level above the object 2 and preferably perpendicular to the horizontal plane. In the images taken by the image digitization device the information from the dark field area 4 is identified for further processing by an image processing system (will be described later). For instance, images can be captured from a part of the dark field area with good dark field illumination, and further represented by an intensity profile with basis in the line A'. Line A' is preferably oriented at the similar angle as line A, namely at angle α' . There may be a deviation between these two angles due to the topography or geometry of the surface to be inspected, and it may be arranged slightly non parallel to line A to avoid disturbances from the bright field area.

Further, in this set up the bright field area can first of all be determined to define what part of the dark field area that should be applied to find information regarding the surface analysis, for instance where to apply the intensity profile scan that is performed in the dark field area.

The bright field area will be apparent as a "snake" of reflected light. The shape of the snake (curved or linear) contains information of the global surface deviation from a correct shape.

The type of object to be inspected and its shape, for instance an extruded profile with a defined cross sectional shape, could be determined with a camera or the similar connected to a computer that images and analyses the end area of the profile to define the type of profile. The result of the analysis can be compared with a set of predefined profile types initially stored in the computer. Then, in the following surface analysis the result of the image analysis can be compared with the predefined values to determine if any deviation of the surface is within preset tolerances or not.

When analysing extruded objects, it should be understood that information regarding for instance pressure lines can be retrieved in the bright field area where this type of defect may cause a deviation in the shape of the "snake". Other defect such as blisters or dents with an extension along the X-axis may be found by an analysis of the bright field, grey field and/or dark field area.

The distance between the lines A and A' in this embodiment (Fig. 1) is chosen in accordance to do the inspection of the surface at optimum dark field conditions, and at a certain distance from the bright field illuminated area to avoid light disturbances from this field.

In the shown set up defects indicated with reference numerals 6, 8 and 9 can be detected by the image digitization device in the dark field illuminated area. These defects can be local defects such as scratches running along the objects length axis, as indicated by 6 or it could be continuous or semi continuous defects generated in the production process of the object, such as valleys, pressure lines and ridges. With regard to extruded product this can be represented by a defect commonly known as dielines. Other variants of defects with regard to extrusion processes could be dents 8, pits or for instance blisters 9 that have no particular direction of extension.

The present invention is in particular appropriate for detecting defects that may occur in certain extrusion processes in particular aluminium extrusion processes, but not limited to these types of processes.

In this set up there is shown three illuminators. However, the principles of the present invention can alternatively be exploited by an illuminating device ID comprising two illuminators arranged along an axis inclined with respect to the objects axis of movement.

A main advantage with the set up shown here is that all the illuminators may be activated simultaneously and continuously due to the arrangement of illuminators along an inclined axis with respect to the axis of the objects movement. Thus, a part of its surface will be illuminated under a dark field conditions from which the image digitization device, preferably an area scan camera, collects information. As the object moves, a surface following the extension direction of the object can be illuminated, imaged and analyzed.

It is the mutual relative movement between the set up and the object that makes the visual inspection of the surface of the object in its total length possible in accordance with this embodiment. Alternatively, the object could be stationary and the set up could be arranged for movement (not shown).

In Figure 3 there is disclosed an apparatus that makes it possible to inspect in principle all visual sides of a moving object 2'. As in the previous example the object 2' is arranged for movement in direction X, which is here in the horizontal plane. The set up in this embodiment includes a ring 30 through which the object 2' passes. At the periphery of the circumferential or surrounding ring there is attached an illuminating device ID that is represented by depicted illuminators, 1'a – 1'q arranged in a manner where they completely surrounds the object 2' in the sense of illuminating it. The plane of the ring in this embodiment is arranged at an inclined angle with respect to the perpendiculars of the objects axis of motion, to produce dark field illuminated areas at least at some surfaces of the moving object. In this set up, the main axis A', B' of the ring 30 are inclined at angles α' , β' respectively with regard to a plane perpendicular to axis X.

In the embodiment shown, the main directions of the optimum dark field areas allocated along lines A', B' are inclined at angle α' (surface 2'a) and simultaneously at an angle β' (surface 2'b). Said angles may be different with regard to the angles α' , β' of the illuminating device ID, due to the actual surface geometry of the object.

In one other preferred embodiment the plane of the ring 30 can be arranged perpendicular to the objects axis of movement X, but then the depicted illuminators 1'a-1'q are preferably arranged in positions in the ring following a helix, i.e. the ring is formed as a cylinder shell where the illuminators are arranged in a continuous, even thread line pattern (helix). In one tested embodiment, illuminators were installed in an equally spaced helix pattern in a ring with radius 500mm. The axial distance between the first and the last illuminator of the ring in direction X was 200mm.

It should be understood that the number of illuminators may differ from what has been presented above, and can be optimized with regard to the actual task.

This preferred solution makes it possible to illuminate all visible (non-occluded) surfaces of the object in dark field conditions, where inspection can be carried out without bright field disturbances from neighbouring illuminating sources. This embodiment is not shown as such, but the illuminating set up will in principle be similar to the embodiment shown in Fig. 4, apart from that the embodiment of Fig. 4 discloses a non-discrete illuminating device.

In Fig. 4 there is shown a set up similar to that disclosed in Fig. 3, where an object 2'' is surrounded by an illuminating device comprising one illuminator 1'' that can be a non-discrete light array, fibre based illuminator or the similar. In the Figure there are shown two image capturing units or image digitization devices 40, 41. The light array is clearly arranged in a substantial helix path around the object to be inspected. In theory one could substitute this continuous light array with a similar helical structure, such as a helix shaped band or the like, having discrete illuminators attached to it.

In the example shown in Fig. 4, the angles of illumination of the surfaces of the object corresponding to α' , β' as shown in Fig. 3, will be determined by the helix angle with regard to its axis.

In the above mentioned embodiments, one or more image digitization devices can be arranged at appropriate positions. For instance, four image digitization devices can be arranged to capture images at four principal axis that are mutually perpendicular at each other. In one embodiment (see Fig. 3), one first image digitization device can be arranged perpendicular to the surface 2'a and one second perpendicular to surface 2b', while the other two image digitization devices are arranged similarly with respect to the other two surfaces 2'c, 2'd (not shown).

Preferably six cameras or image digitization devices can be applied, and arranged substantially along the periphery of a circle in a plane perpendicular to the objects axis of movement, possibly with a minor mutual adjustment in the X-direction. Preferably, the centre of the said circle coincides with the centre of the object's cross section. The sectors between the cameras are preferably 60°. Even more cameras can be applied, due to the complexity of the surface of the object to be inspected. However, this is also a cost issue.

The above mentioned embodiments relating to a helix configuration of the illuminating device may be denoted as a full helix darkfield (FHDF).

5 In an extrusion process a number of fine longitudinal lines can be created in the objects surface. Small lines are normally acceptable while larger ones constitute die lines or 'sharp hill' defects. Groups of fine lines may constitute colour streaks that in certain appliances can not be accepted.

10 The types of defects mentioned are particularly challenging due to fact that the defects are in the exact same direction as the extrusion and that the illumination should cover a large number of different shapes of profiles. Usually a dark field illuminator needs to be built and optimized for a specific shape, but in a case where a large number of various profiles are to be inspected, the light and consequently the apparatus must have built-in flexibility. This flexibility may be achieved with a full darkfield helix as described
15 above.

It should be understood that in embodiments relating to Fig. 3, there is mentioned an arrangement of the illuminators in a cylinder shell arrangement with or without the positioning following a helix path, but other arrangement of the illuminators can be
20 possible within the scope of the invention. The main issue is to generate a dark field illuminated area at selected parts of the moving object that can be exploited for image capturing and analysis of surface quality, where disturbances from the bright field area are avoided.

25 For instance, the illuminators can also be arranged in a substantial quadratic or rectangular frame more or less surrounding the object, where all sides are inclined at an angle α , β etc. with respect to the perpendiculars of the axis of movement, thus creating a darkfield illuminated area angled at corresponding angles α' , β' etc. on the surface of the object. This will in particular be suitable for objects having a quadratic or rectangular
30 cross-section.

In Fig. 5 it is disclosed a sketch of the apparatus including image processing and rejecting device of a moving object.

35 Captured images from the camera(-s) can be transferred to an image processing unit here called sensor PC(-s) communicating with a Master PC. This unit can process images and extract data significant for the actual surface geometry and quality. Data deriving from the

image processing unit are compared with stored threshold data representative for set values of accepted surface quality. A PLC assisted manipulator can be controlled by signals from the processing unit and further be arranged to remove objects with rejected surface quality from the main transport path of objects (not shown). A strobe controller is
5 arranged to synchronize the illuminator(-s) and the camera(-s). A front end camera (not shown) can be used to determine the type of object to be inspected. The velocity of the object can be determined by use of appropriate equipment such as an encoder.

Figs. 6 discloses blister defects imaged at the surface of an extruded object. The bright
10 field area can be seen from left to the right somewhat in the middle of the image, and one blister is seen as a bright bridging part having one dark spot above and one below itself. Immediately above and below said blister, another two blisters can be seen as somewhat bright spots.

In Figure 7 there is disclosed one image of an extruded surface showing defects of the type dieline. The two round spots in the image and one partly shown at the right edge of the image are led illuminators arranged in a helix configuration (slightly slanted in the image). These illuminators illuminate the opposite side of the object. In the central part of the image there is shown the illuminated part of the object, where the bright field area is
20 the part of the surface which is clearly visible. The bright field illuminated area is slightly slanted upwards to the right with regard to the elongated axis of the object. At the upper and the lower part of the bright field illuminated area, both in the grey field areas and the dark fields areas there is clearly visible lines, in particular in the right quarter of the image. These lines are dielines introduced in the surface during extruding the object.

In Fig. 8 there is disclosed so called colour streaks that can be seen as a vertical band extending in the middle of the image of the object, and being visible in both dark field areas, grey field areas and the bright field area. These defects can occur due to a change of the texture in the surface. Outside the object itself, there are shown three led
30 illuminators and one forth in part that illuminates the opposite sides of the object.

Fig. 9 discloses one dent in the surface of an object. This defect can be seen above the traversing bright field area, and partly "depressing" the bright field "snake" in the left part of it. Above the depression, there is shown a dark spot. Such defects can be introduced
35 under transport when the product leaves the extrusion press.

Fig. 10 discloses a wave shaped defect in one object, and is situated above the bright field area. Outside the object at the right side, there is shown one led illuminator that illuminates the opposite side of the object.

- 5 It should be understood that information from a bright field area can also be collected and analyzed. In particular, 3D defects, pressure lines, dents, etc. in extruded products can be detected in this area.

- It should further be understood that the present invention can have a lot of applications.
10 For instance inspection of products related to extruding processes, rolling processes (sheet, blanks of metal) and casting processes e.g. ingot or billet casting can be performed by the use of present invention.

- The invention can be used for inspection of objects of various materials and surface
15 treatments. For instance metals (steel, aluminium and aluminium alloys that can be surface treated, polished, painted or non-treated on its surface i.e highly reflective), plastics, etc.

- The invention may be used in combination with other illumination set ups such as
20 arrangements that may create an axial darkfield and/or tangential darkfield on the surface of the object. In this type of set up the capture frequency of the image grabbers and the on-off frequency of the various types of illuminators have to be synchronized to have an optimum result. Further, the image processing has to be coordinated in accordance to the various image sources.

Claims

1. A method for inspection of at least one surface of an object (2) preferably having
5 an elongated direction (X) where an illuminating device (ID) is arranged in the vicinity of the object, the method further includes capturing images of said surface by at least one image digitization device (20),

characterised in that

the illuminating device (ID) is further aligned with regard to the direction (X) of the
10 object (2) in a manner where it illuminates a part of the surface of said object (2) at an angle (α , α') with regard to the direction (X) in an illuminated condition such as dark field and/or bright field, whereby defects in the said surface can be visualized and imaged.

- 15 2. A method in accordance with claim 1,

characterised in that

the surface of the object (2) is illuminated in a dark field condition in its total width and where corresponding images are covering said width.

- 20 3. A method in accordance with claim 1,

characterised in that

the illuminating device (ID) is positioned in a manner where it surrounds the object (2) partly or totally, and that image digitization devices are similarly covering the illuminated area.

- 25 4. A method in accordance with claim 1,

characterised in that

the illuminating device (ID) is arranged in a manner where it is substantially aligned in a helix shaped path.

- 30 5. A method in accordance with claim 1,

characterised in that

the axis of the helix is substantially parallel with the elongated direction (X) of the object.

- 35 6. A method in accordance with claim 1,

characterised in that

the illuminating device (ID) comprises several illuminators that are activated simultaneously.

7. A method in accordance with claim 1,

characterised in that

the object is arranged for movement in its direction (X).

8. Apparatus for inspection of at least one surface of an object (2) preferably being extended in a direction (X) where an illuminating device (ID) is arranged in the vicinity of the object, at least one image digitization device (20) is arranged for capturing images of said surface,

characterised in that

the illuminating device (ID) is further aligned in a manner with regard to the direction (X) of the object, where it illuminates a part of the surface of said object (2) an angle (α , α') with regard to the direction (X) in an illuminated condition, such as dark field and/or bright field whereby defects in the said surface can be visualized and imaged.

9. Apparatus in accordance with claim 8,

characterised in that

the illuminating device (ID) is positioned in accordance with a surrounding or circumferential frame with regard to the object (2).

10. Apparatus in accordance with claim 8,

characterised in that

the illuminating device (ID) is substantially arranged in accordance with a helix shaped curve.

11. Apparatus in accordance with claim 8,

characterised in that

the illuminating device (ID) comprises several illuminators that are preferably of LED (light emitting diodes) type.

12. Apparatus in accordance with claim 8,

characterised in that

the illuminating device (ID) is represented by a non-discrete light array arrangement.

13. Apparatus in accordance with claim 8,

characterised in that

there are several image digitization devices (20) or cameras positioned above the surface to be imaged.

14. Apparatus in accordance with claim 13,

characterised in that

there are preferably six image digitization devices (20) arranged in a manner where they surrounds the object and are further arranged with a mutual angular distance of 60°.

15. Apparatus in accordance with claim 8,

characterised in that

the captured images are transferred to an image processing unit.

16. Apparatus in accordance with claim 15,

characterised in that

datas deriving from the image processing unit are compared with stored threshold data representative for set values of accepted surface quality.

17. Apparatus in accordance with claim 15,

characterised in that

a manipulator is receiving signals from said image processing unit and is further arranged to remove objects with rejected surface quality.

18. Apparatus in accordance with claim 8,

characterised in that

the object and/or apparatus is arranged for movement along the direction (X).

19. Apparatus in accordance with claim 8,

characterised in that

the object is made out of aluminium or an aluminium alloy.

20. Apparatus in accordance with claim 8,

characterised in that

the object is made out of a plastic material.

21. Apparatus in accordance with claim 8,
characterised in that
the object is made by an extrusion process.

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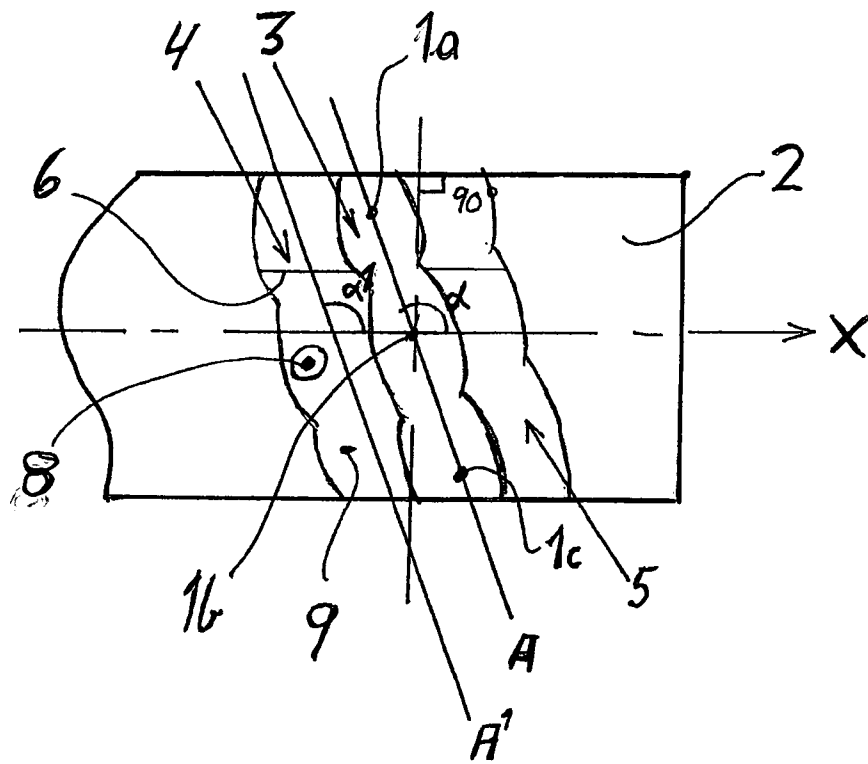


Fig. 1

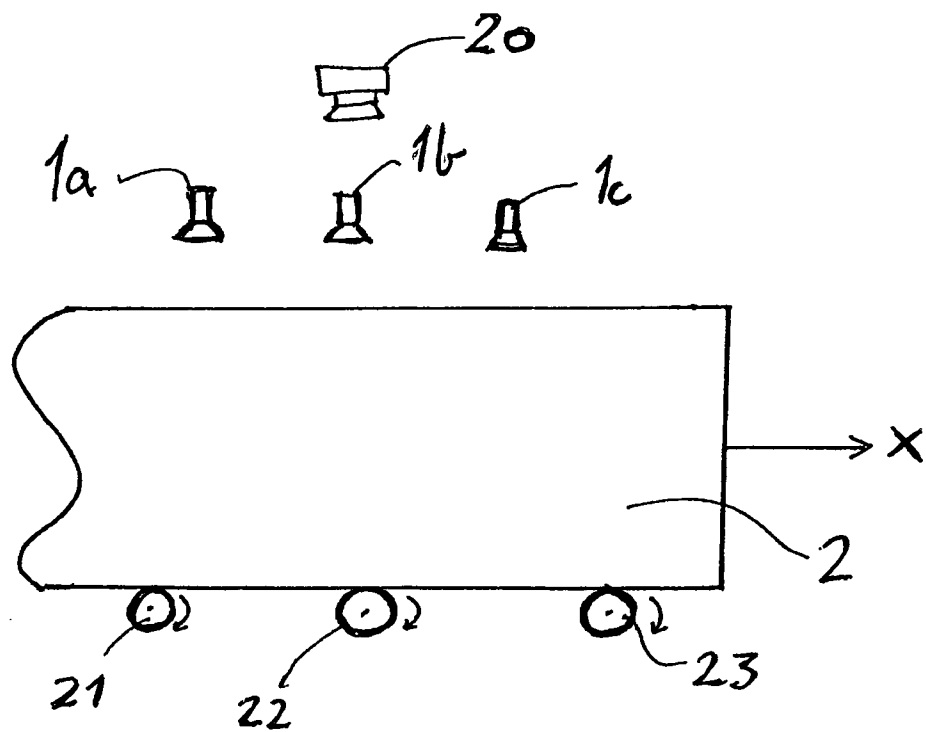
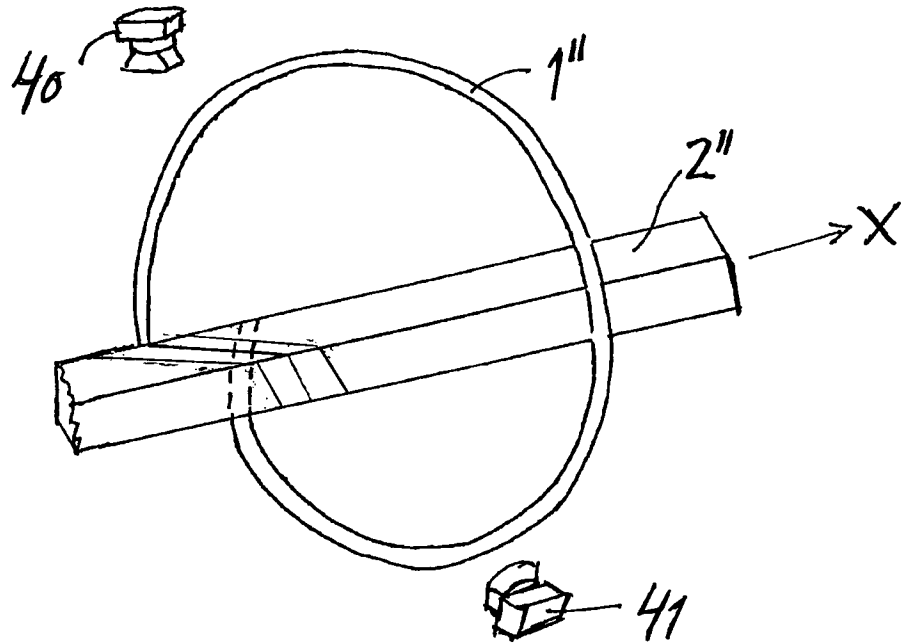


Fig. 2

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**Fig. 4**

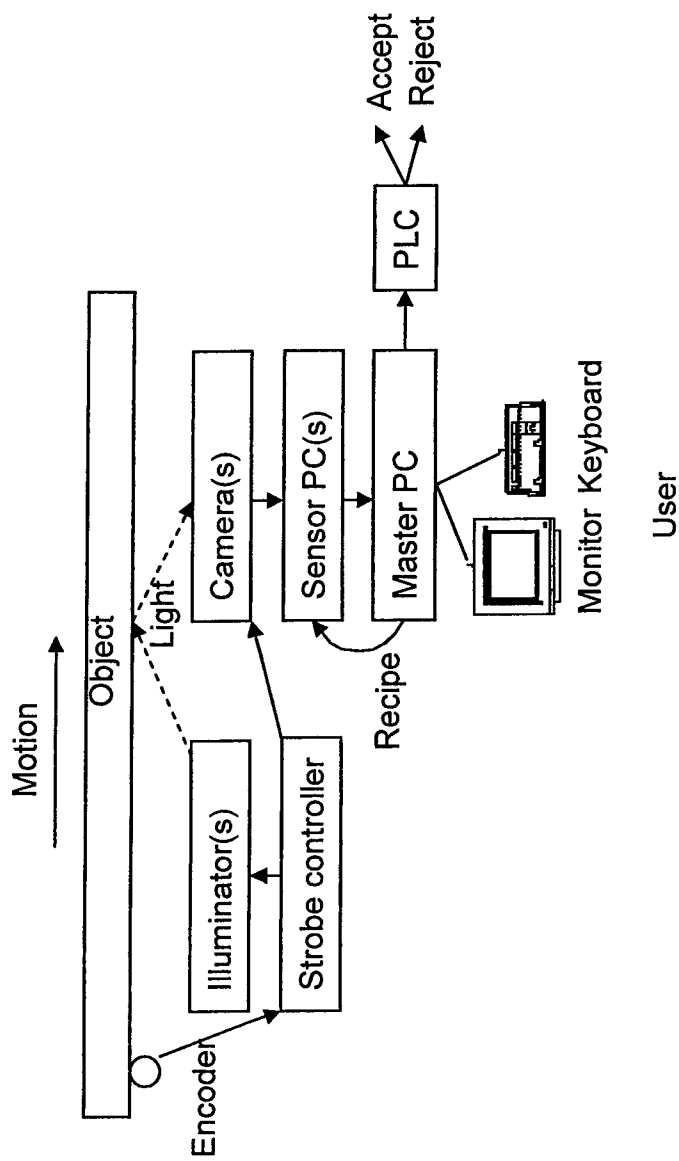


Fig. 5

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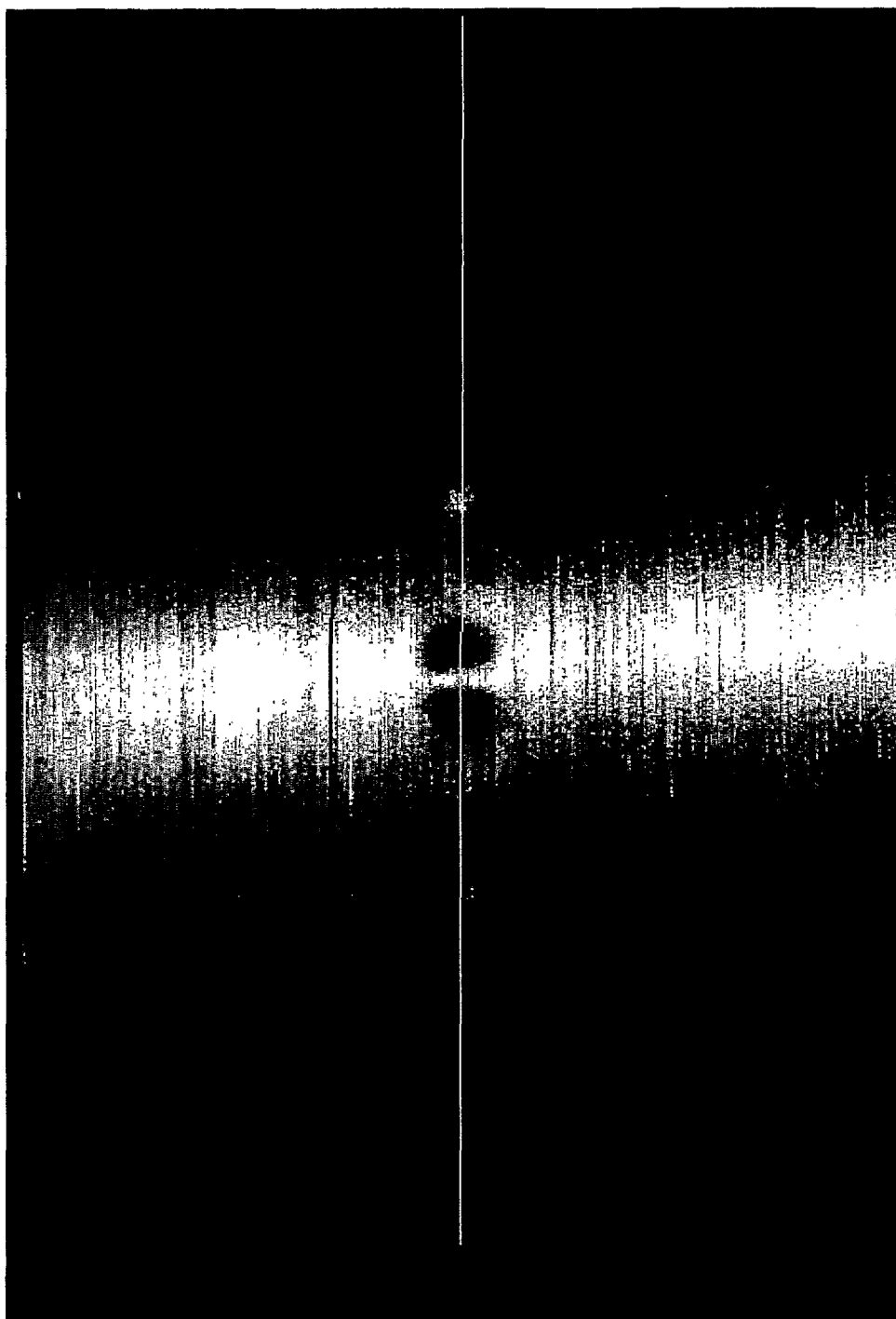


Fig. 6

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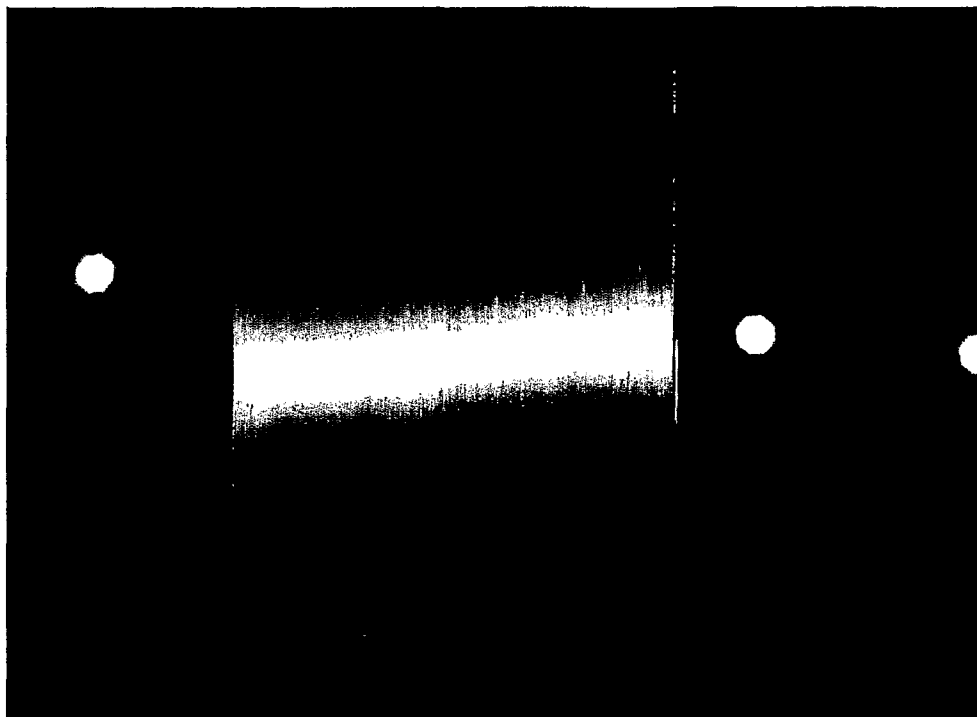


Fig. 7

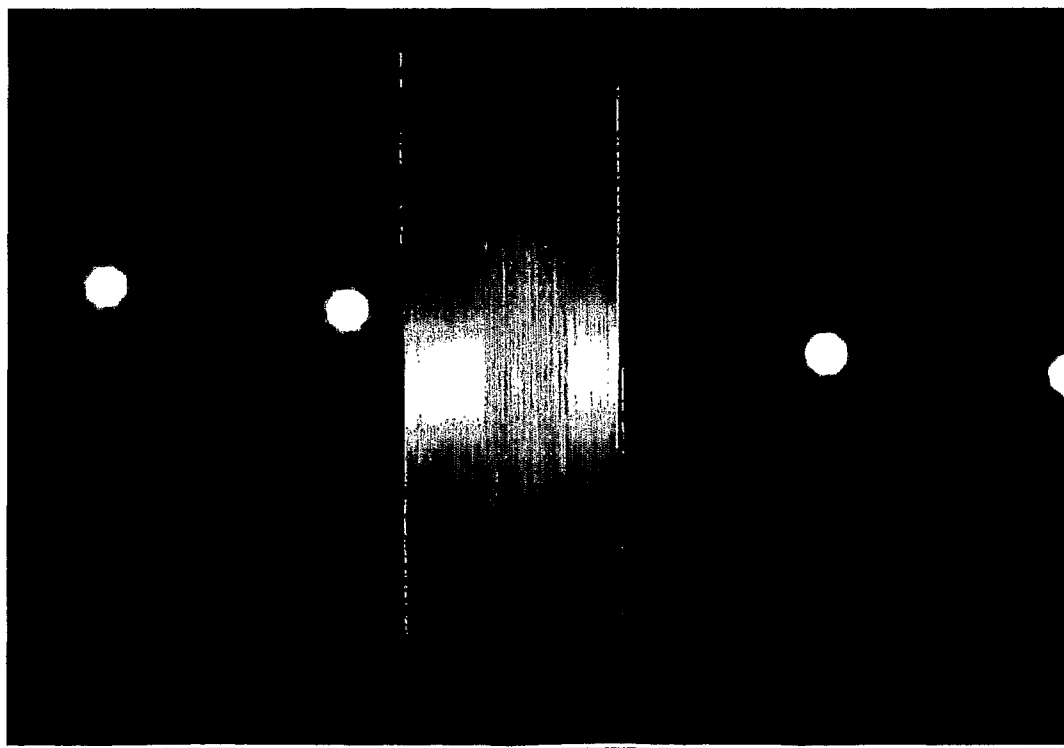


Fig. 8

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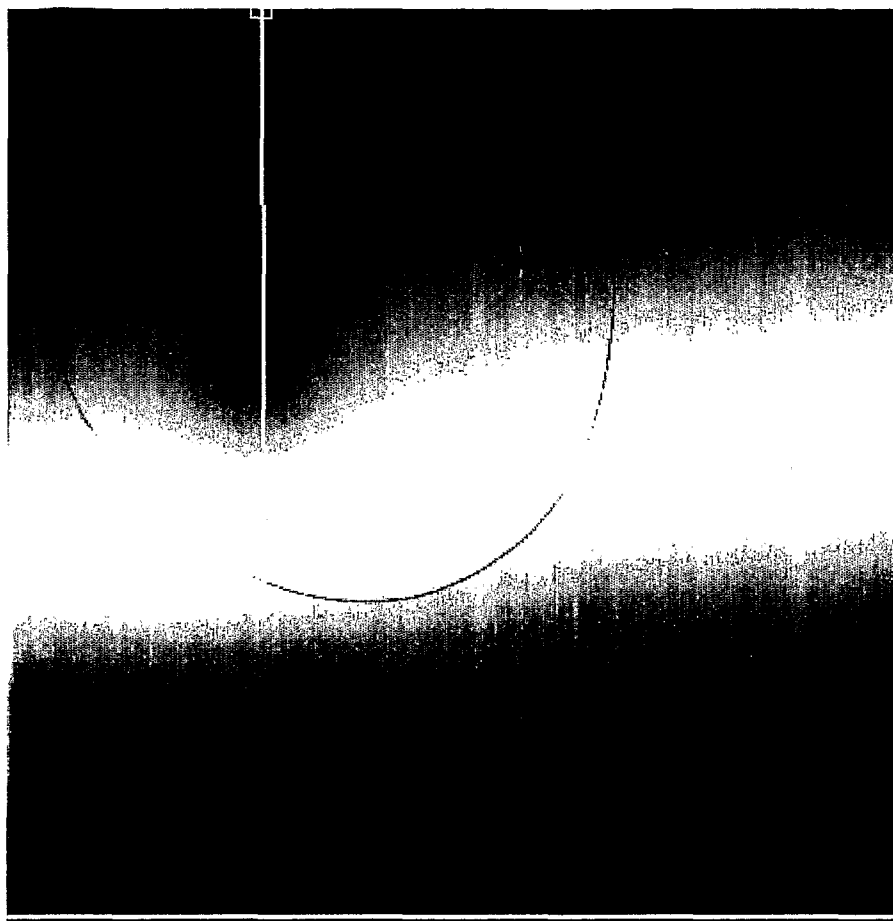


Fig. 9

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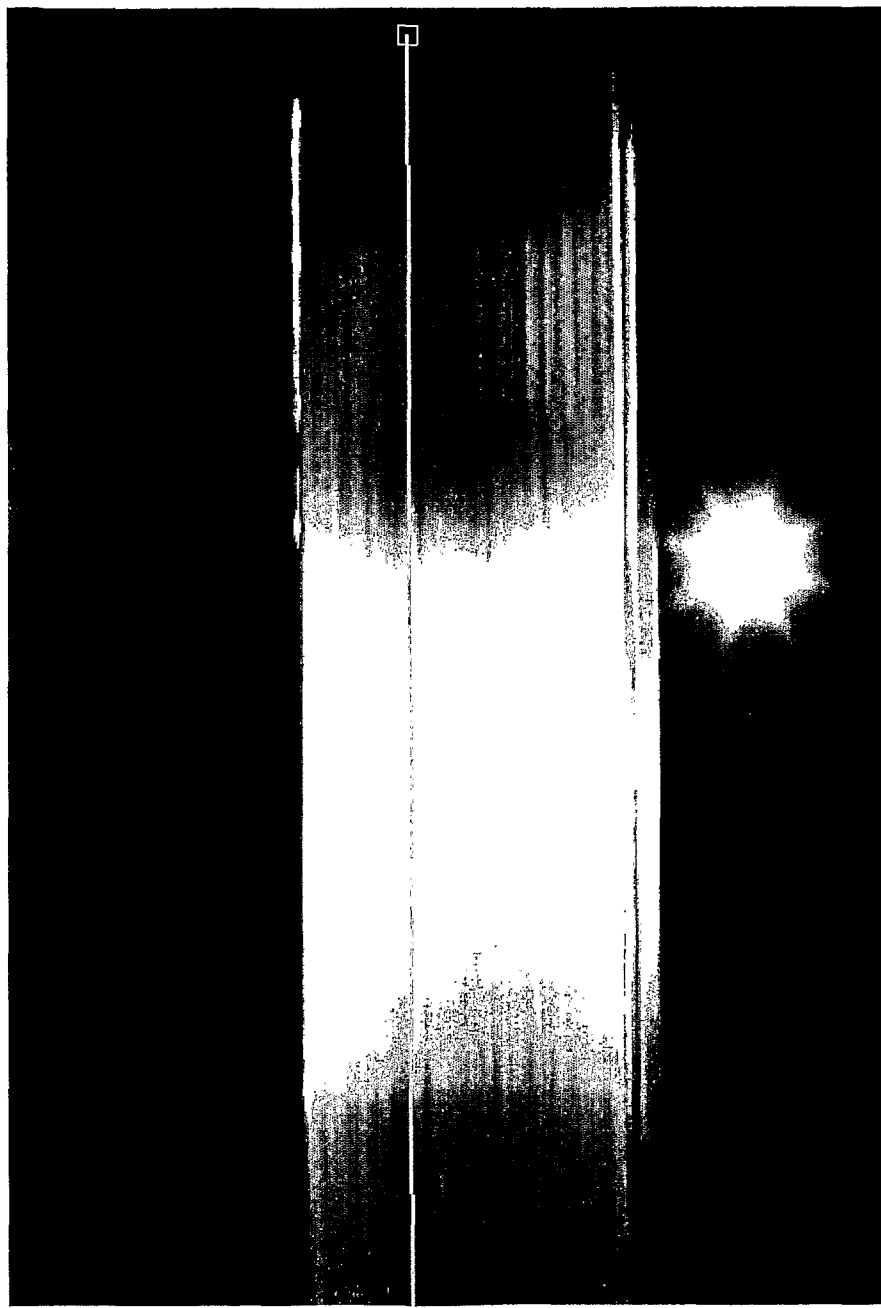


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO2010/000264

A. CLASSIFICATION OF SUBJECT MATTER

G01N21/892 (2006.01), G01N21/89 (2006.01), G01N21/88 (2006.01), G01N33/20 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NO, DK, FI, SE: Classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI, FULL TEXT DATABASES, PATGRANSK

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0898163 A1 (FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, SPECTRA PHYSICS VISIONTECH OY, VTT ELECTRONICS), 1999.02.24 Abstract, [0019-0020]	(1-21)
A	GB 1407409 A (FERRANTI LTD), 1975.09.24 Fig. 3	(1-21)



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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

"E" earlier application or patent 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 when the document is taken alone

"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

Date of the actual completion of the international search
27/08/2010Date of mailing of the international search report
03/09/2010Name and mailing address of the ISA/
Nordic Patent Institute
Helgeshøj Allé 81, 2630 Taastrup, DenmarkAuthorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/NO2010/000264

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