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INCLINATION GAUGE**

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**(56) Prior Art Documents
AU 610751 40404/89 G01C 9/06 9/32 9/36
AU 35362/89 G01C 9/06 9/24 9/36
AU 20064/88 G01C 9/06 9/12**

(57) Claim

1. Inclination gauge comprising a reservoir, containing a clear liquid and a gas bubble, light emitting and light detecting means arranged at opposed positions with regard to said reservoir, the refractory index of the liquid, of the gas and of the tube material being chosen such that light going through the reservoir completely filled with liquid follows a trajectory substantially differing from the trajectory followed by light traversing the reservoir at least partially filled with gas, wherein on the center line in the path from the light emitting means and detecting means near the point of egress of light from the reservoir a shield is provided, arranged such that rectilinear transmittal of light from the light emitting means to the light detecting means through the gas bubble is substantially completely blocked.

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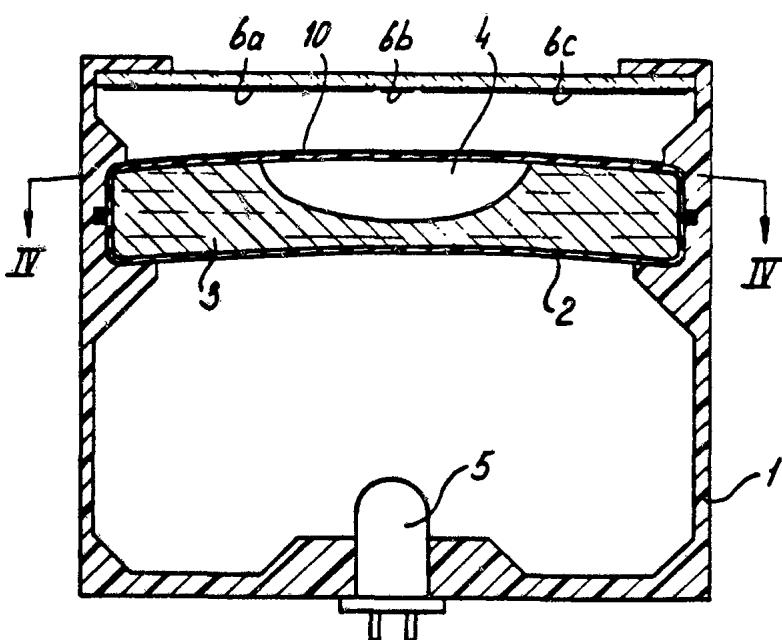
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(54) Title: INCLINATION GAUGE



(57) Abstract

Inclination gauge having a reservoir filled with liquid and containing a gas bubble. The position of the gas bubble is detected by light detecting means in that light going through the completely filled tube gives another convergent nature than light going through tube partially filled with liquid and partially filled with gas. On the centerline light emitting - light detecting means between the reservoir and the light detecting means a shield is provided.

BUBBLE INCLINATION GAUGE INCLUDING A CENTRAL SHIELD
FOR LIGHT-EMITTING AND LIGHT-DETECTING MEANS

BACKGROUND OF THE INVENTION:

The invention relates to an inclination gauge comprising a reservoir containing a clear liquid and a gas bubble and light emitting and light detecting means arranged at opposed positions with regard to said reservoir. It is intended to convert the movement of the gas bubble in the reservoir to an electric signal. By this it is no longer necessary to monitor directly the gas bubble in the reservoir. Also it is possible to provide self-adjusting devices.

From U.S. Patent No. 4,625,423 it is known to direct a beam of light through a tubular reservoir containing either liquid or a gas volume. When light is transmitted through the liquid a converging effect is obtained. When light traverses to the gas volume a non converging beam leaving the reservoir is realized. By monitoring the change in light intensity at the spot of the light dependent resistance, information can be obtained with regard to the position of the gas volume in the reservoir. However, the transition from converging to parallel and diverging is a continuous process. This means that only by considerable amplification of the light dependent resistance can an exact prediction can be obtained about the position of the inclination gauge. However, if there are slight changes in the light emitting source and/or the transparency of the reservoir and/or its contents, the results of the measurements will be affected. This means that this device is not reliable in long term.

SUMMARY OF THE INVENTION:

It is the main purpose of the invention to obviate this problem. This is realized with an inclination gauge comprising a reservoir containing a clear liquid and a gas bubble, light emitting and light detecting means arranged at opposite positions with regard to said reservoir, the refractory index of the liquid, of the gas and of the tube material being chosen such that the light going through the



reservoir completely filled with liquid follows a trajectory substantially differing from the trajectory followed by light traversing the reservoir at least partially filled with gas, characterized in that on the center line from the light emitting and detecting means near the point of egress of the light from the reservoir a shield is provided.

If e.g. the light is converging as with the U.S. Patent No. 4,625,423 device when completely filled with liquid, despite of the shield provided the light detecting means will receive a strong focussed light beam. However, as soon as the beams emitting from the reservoir are parallel or diverging no light at all will be incident at the light detecting means. This means that because of the shield provided by the invention a kind of on/off effect is obtained for the light impinging the light detecting means. Even if the light source and/or the light properties of the reservoir and/or the contents slightly change during production or use, this has no effect on this on/off effect. This means that it is always guaranteed that optimum detection is obtained. Also it is always guaranteed that optimum detection is obtained. Also it is not longer necessary to considerably amplify the signal obtained from the light detecting means. Preferably the surface area of the shield is at least as large as the effective surface area of said light detecting means.

If the inclination gauge comprises a reservoir in which the gas bubble in the balanced position does not completely fill the cross section of the reservoir, problems might arise if one or two LDR's (Light Dependent Resistors) are used. These LDR's only measure the surface area lightened. If the reservoir according to the invention with a gas bubble not completely filling the cross section of the reservoir is tilted to one side the LDR on that side will first register complete darkness or light. However, after further tilting the reservoir gas will accumulate near one end and fill the cross section of the reservoir completely by which the length of the gas bubble decreases and so an error signal can be obtained. To obviate this problem according to a further embodiment of the invention said light detecting members comprise at least



three light sensitive means arranged in line, wherein the outermost ones have a relatively large extent and the center one has a relatively smaller extent. The extent of the outermost light sensitive members preferably substantially 5 equals the length of the gas bubble in the balance position. By having an intermediate light detecting means with a relative small dimension the problem described above is obviated. The signal obtained from the light detecting means can be processed in any known way to display a signal or to provide an 10 acoustical signal or both. The acoustical means can be devised such that when moving from one extremity of the inclination gauge to the other, first a first signal is produced having a first frequency with first constant intervals between signal 15 periods, after which a second signal is produced having the first frequency and second variable intervals between signal periods, said intervals decreasing towards the third signal, said third signal being continuous and having said first or a second frequency, after which a fourth signal is produced having a second frequency and third variable intervals between 20 signal periods, said intervals increasing towards the fifth signal, said fifth signal having the second frequency and fourth constant intervals between signal periods.

The invention also relates to a device for measuring the movement of an object comprising the inclination gauge as 25 described herein. This can e.g. be an acceleration gauge.

The invention will be described in further detail with reference to the drawing in which a preferred embodiment is shown and wherein:

FIG. 1 shows a trajectory of light followed according 30 to the prior art with a completely liquid filled reservoir,

FIG. 2 shows the device according to FIG. 1, with a partly liquid filled reservoir;

FIG. 3 shows schematically the device according to the invention:

35 FIG. 4 shows a cross section according to line IV-IV in FIG. 3,

FIG. 5 shows schematically the trajectory of light with a completely liquid filled tube according to the invention



along line V-V of FIG. 4, and

FIG. 6 shows a trajectory of light with a partially liquid filled tube according to the invention along line VI-VI of FIG. 4.

5 In FIG. 1 schematically the path followed by the light according to the prior art is shown. 7 indicates incident light, 2 a tube like reservoir, 3 the liquid contained in this reservoir, 8 exiting light and 6 light detecting means. In FIG. 2 the same is shown except that the tube is not 10 completely filled with liquid 3 but also comprises a gas bubble 4. Because of the different refractive index of gas relative to the liquid used, as shown in the figure, the parallel incident light beam will diverge. This means that in the FIG. 1 case a strong signal is obtained on light detecting means 6 whilst in the FIG. 2 situation a less intense signal is obtained. However, there is still light incident on light detecting means 6, which means that the light detecting means 6 must be able to discriminate between more and less light. This means that when during production or use variations occur 20 affecting the quantity of light detected by light detecting means 6 corresponding adaptions have to be made. The invention provides a solution for this problem and a preferred embodiment of it is schematically shown in FIG. 3. This embodiment comprises a frame 1 in which a tube-like element 2 is mounted. 25 Also light emitting diode 5 is arranged in the frame 1 as well as light detecting means 6a, 6b, and 6c. As shown in the cross section of FIG. 4 tube 2 is provided at its upper side with a dark line or shield 10. From FIGS. 5 and 6, being cross sections through the FIG. 4 tube 2, it is clear what effect 30 will be obtained from displacing gas bubble 4 through tube 2. Comparing FIG. 5 and FIG. 1 there will not be a large difference except that the light following the center line is blocked in the embodiment of FIG. 5.

35 However, comparing FIG. 2 and FIG. 6 indicates that because of the shield 10, no light at all will reach light detecting means 6. Because of this an on/off configuration is obtained being less sensitive for variations occurring during use or production. The reason that three light detecting means



are used is based on the fact that the light detecting means which are used are so called light dependent resistors. These resistors only measure the quantity of light incident. If it is e.g. given that a balance situation is obtained if half of 5 LDR 6a is radiated, during tilting of tube 2 clockwise this balance position will be disrupted. However, as soon as gas bubble 4 hits the left extremity of tube 2 its length will decrease by increasing its cross sectional area. An air chamber will be formed at the left side and it is possible that 10 the length of the air bubble substantially corresponds with the balanced position of LDR 6a. To prevent this, much smaller LDR 6b is provided such that in this error situation there is a signal from LDR 6b, which is not the case if there is a balanced position. This LDR 6b can also be used for 15 automatically switching to another tube 2 being arranged perpendicular with regard to tube 2 shown. This permits horizontal - vertical use of the inclination gauge.

Although the embodiment shown in the drawing is preferred at the time being, many amendments can be made 20 without leaving the scope of protection as defined by the appended claims.



THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Inclination gauge comprising a reservoir, containing a clear liquid and a gas bubble, light emitting and light detecting means arranged at opposed positions with regard to 5 said reservoir, the refractory index of the liquid, of the gas and of the tube material being chosen such that light going through the reservoir completely filled with liquid follows a trajectory substantially differing from the trajectory followed by light traversing the reservoir at least partially filled 10 with gas, wherein on the center line in the path from the light emitting means and detecting means near the point of egress of light from the reservoir a shield is provided, arranged such that rectilinear transmittal of light from the light emitting means to the light detecting means through the gas bubble is 15 substantially completely blocked.

2. Inclination gauge according to claim 1, wherein the surface area of said shield is at least as large as the effective surface area of said light detecting means.

3. Inclination gauge according to claim 1, wherein said 20 light detecting means comprises at least three light sensitive members arranged in line, two outermost ones having a larger extent than a center one.

4. Inclination gauge according to claim 3, wherein the extent of at least one of the outermost light sensitive members 25 substantially equals the length of the gas bubble in the balanced position of the inclination gauge.

5. Inclination gauge according to claim 1, wherein the reservoir comprises a tube-like body, of which in the position of use an upper part is internally curved.

30 6. Inclination gauge according to claim 1, wherein said means for emitting light comprises a light emitting diode.



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7. Inclination gauge according to claim 1, wherein said means for detecting of light are connected with a measuring device.

Dated this 22nd day of July 1992.

5 SOPHA BODEWES-TUNHAU
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Fellows Institute of Patent
Attorneys of Australia.



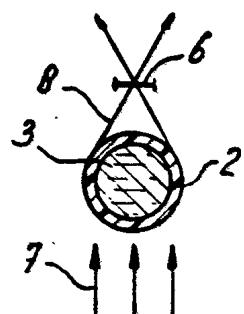
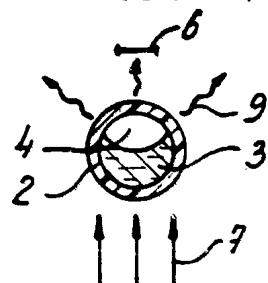
fig-1
PRIOR ARTfig-2
PRIOR ART

fig-4

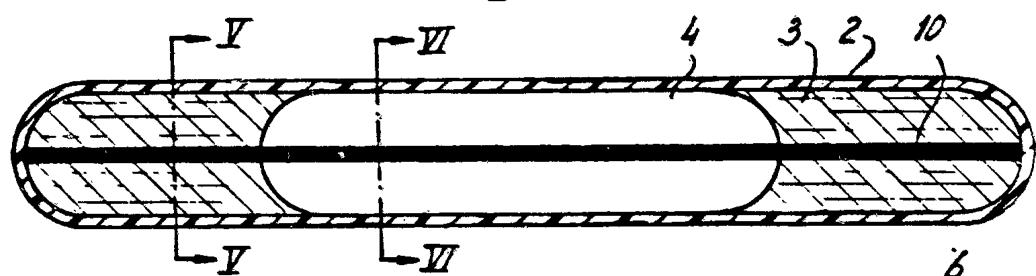


fig-5

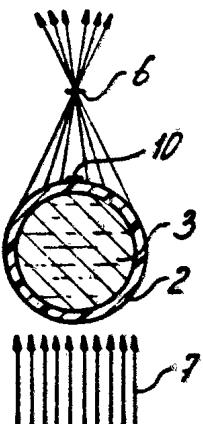
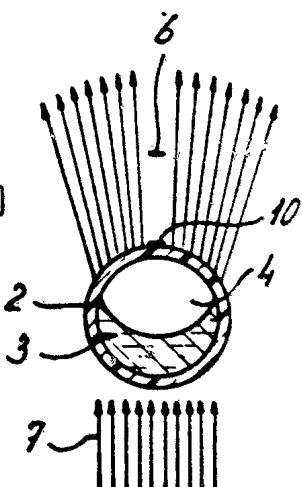


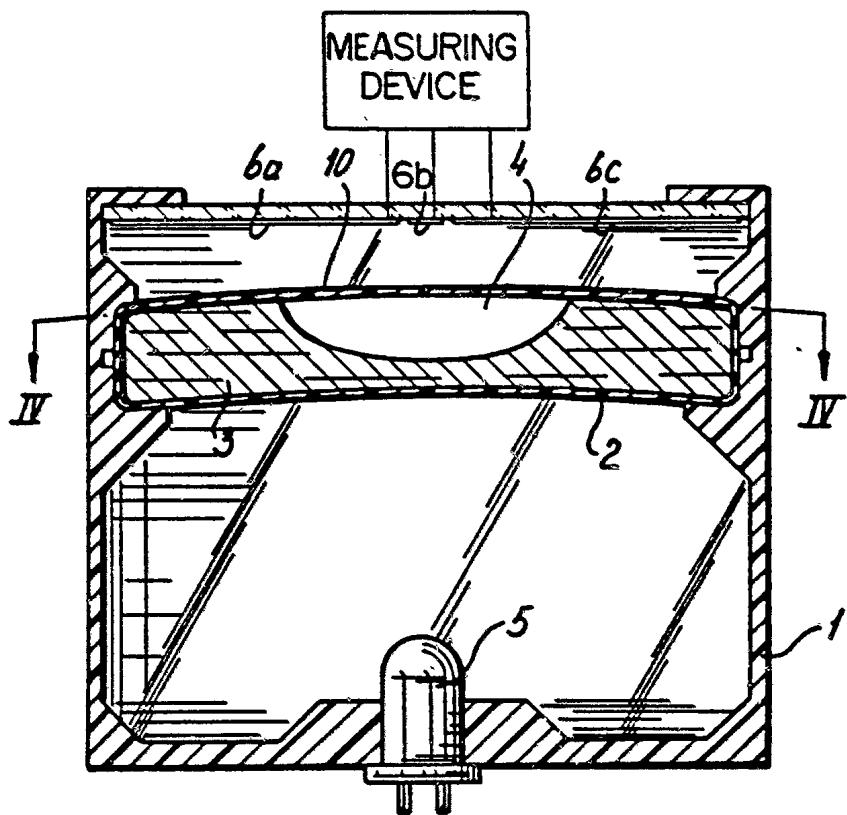
fig-6



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Fig-3



INTERNATIONAL SEARCH REPORT

International Application No

PCT/NL 89/00052

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁴

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

IPC ⁴ G 01 C 9/34, G 01 C 9/06

II. FIELDS SEARCHED

Minimum Documentation Searched ⁵

Classification System	Classification Symbols
IPC ⁴	G 01 C

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in the Fields Searched ⁶

III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁷

Category ⁸	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	US, A, 4625423 (R.R. SACKETT) 2 December 1986, see abstract; column 5, lines 39-68; figures 6,7,8A	1,5,6,7, 8,10
A	EP, A, 0168150 (TECHNICAL DESIGNS INC.) 15 January 1986, see page 7, lines 9-18; figure 3; page 8, lines 1-9; page 12, lines 26-29	1,5,6,7,8,10
A	Patent Abstracts of Japan, vol. 10, no. 127 (P-455)(2184), 13 May 1986; & JP, A, 60252215 (SABUROU SUGAWARA) 12 December 1985, see the abstract	1

⁴ Special categories of cited documents:
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 "O" document referring to an oral disclosure, use, exhibition or other means
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⁵ "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.
 "A" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search
22nd September 1989

Date of Mailing of this International Search Report

27 OCT 1989

International Searching Authority

EUROPEAN PATENT OFFICE

Signature of Authorized Officer

T.K. WILLIS

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.

NL 8900052
SA 29487

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 European Patent Office EDI file on 18/10/89. The European 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- 4625423	02-12-86	None	
EP-A- 0168150	15-01-86	US-A- 4590680 CA-A- 1229976	27-05-86 08-12-87