A moisture sensor is optically coupled to the inside surface (13) of a windscreen (2) in order to measure the presence of moisture on its outside surface (4). An infrared beam produced by an infrared diode (1) of the moisture sensor enters a window (5) at right angles to an emitter surface (11), undergoes total internal reflection at a side surface of the moisture sensor located perpendicular to the inside surface (13), when dry, the beam undergoes total internal reflection at the outside surface (4) and exits at right angles to a sensor surface (6) to be detected by a sensor (3). When the outside surface (4) is wet a portion of the infrared beam (21) travels through the outside surface (4) and the sensor receives a diminished signal. The inside surface (13) and the front surface (12) of the moisture sensor are optically coupled by a clear adhesive (7).
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Codels used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

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"A MOISTURE SENSOR"

BACKGROUND ART

There are instances when it is necessary to determine moisture levels on a surface such as the windscreen of a vehicle.

In the case of the windcreens of road vehicles, there has been a number of attempts in the past to determine the need to wipe the windscreen by determining the current level of rainfall or the current level of water on the windscreen. Some of these attempts, such as is described in USA patent 4 355 271 (Noack), have used devices which emit radiant energy from the inside of the windscreen, and direct it at the outside windscreen surface at an angle such that it will be substantially totally internally reflected from a dry screen but allowed to substantially entirely pass through a wet screen. By suitably positioning a detector that will respond to the radiant energy, it can be determined whether or not the screen is wet. However, typical examples of such devices are inefficient due to reflective losses incurred when the radiant energy beam enters and leaves the windscreen at the inside air/screen interface at a similar angle. USA patent 4 620 141 (McCumber et al) discloses a sensor unit of this general type but further including a light conducting rod for each emitter and detector and may overcome the problem of reflective losses. Such devices tend to be less than straightforward to manufacture and assemble. Furthermore, the required physical dimensions of the prior art devices are inconveniently large in order to obtain the required relative location of the sensor and emitter.

DISCLOSURE OF THE INVENTION

The present invention seeks to overcome the disadvantages in the prior art by providing a device which will be more easily manufactured and assembled and of
compact size.

The invention provides a device to be optically coupled to the inside of a windscreen and which utilizes a radiant energy path within a transparent window, the path initially entering and finally leaving the window perpendicularly to surfaces provided for that purpose, and the proportion of radiant energy being internally reflected from the outside windscreen surface being indicative of its degree of dryness. When the outside surface is wet substantial radiant energy is transmitted through the surface and the detected signal reduced; when dry substantially total internal reflection occurs. Accordingly, throughout this specification, the terms wet and dry indicate the presence or absence of water, ice, or the like substance that will change the optical path of the radiant energy at that outside surface.

Accordingly, in one broad form, the present invention provides a window means for a moisture sensor adapted to be positioned behind an inside surface of a windscreen so as to provide radiant energy which will be internally reflected by the outside surface of the windscreen to a degree proportional to the dryness of said outside surface, the window means being composed of materials substantially transparent to said radiant energy and comprising:

front surface means adapted to be optically coupled to said inside surface of the windscreen;

an emitter surface;

and a sensor surface,

and wherein the emitter and sensor surfaces are each angled relative to the front surface means such that said front surface means is adapted to be optically coupled to said windscreen so that radiant energy entering said window substantially perpendicularly through said emitter surface will follow a path to exit a portion of the front
surface means and, if internally reflected by the outside surface of the window, will re-enter a second portion of the front surface means and continue to and exit substantially perpendicularly through said sensor surface. Preferably the window means is a one piece window and the front surface means is a continuous front surface.

Preferably the emitter is an infra-red diode. Preferably the window includes a further surface positioned along the radiant energy path and providing a surface of total internal reflection to the radiant energy. It is further preferred that this further surface be intermediate the emitter surface and the front surface.

It is preferred that the radiant energy path is such that the angle of incidence with the front surface is pre-selected within an angle range being dependent upon the frequency of radiant energy to be used and the refractive index of the material in which the window is produced such that the radiant energy will be totally internally reflected by the front surface when the outside front surface interfaces with air, i.e. the surface is dry.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a cross-sectional view of an embodiment of the invention attached operatively to the inside of a vehicle windscreen; and

Figure 2 is a cross-sectional view of a disassembled moisture sensor in accordance with the invention.

BEST MODE OF CARRYING OUT INVENTION

Figure 1 shows a typical installation for use in a car, or other road vehicle. However, the installation could equally well be incorporated in any other type of vehicle which includes a windscreen and a windscreen wiping system similar of those commonly found on road vehicles.

The device includes a general housing 8 wholly composed of plastics material having a front opening
covered by a window 5 which is substantially transparent to infrared energy to form an integral part of the housing 8. The window 5 is fixed to the inside surface 13 of a vehicle windscreen 2 by a clear layer of adhesive 7, or similar, and may form a permanently contiguous bond such that the window 5 and windscreen 2 become effectively an integral structure. The clear adhesive 7 acts to optically couple the window 5 to the windscreen 2. The entire surface adhered to the windscreen is transparent which reduces the obviousness of the device to an outside observer.

An internal body 9 anchors at least one infra-red emitting diode 1, a corresponding at least one sensor 3 and a circuit board 15 providing electronic support.

For operational purposes the adhesive layer 7 may be replaced by any non-adhesive optical coupling layer, such as petroleum jelly, and some alternative means provided in order to fix the device in position relative to the windscreen 2.

The window 5 may be produced in two parts, separated along a line between the portions 18 and 19 being the exit and entry portions of the radiant energy however the one piece construction illustrated is preferable.

The window 5 includes an emitter surface 11 proximate to the emitter 1 and a side surface 10 approximately perpendicular to a front surface 12 of the window 5. Proximate the sensor 3 is a sensor surface 6 lying parallel to the emitter surface 11. The emitter 1 and sensor 3 are positioned perpendicular to their respective surfaces 11 and 6.

It should be noted that operatively, the relative angles of the surfaces 6, 10, 11 and 12 may be altered but it is preferred that the surfaces 11 and 6 are angled to the same side of a perpendicular to the front surface, as discussed later, and the radiant energy path remains
primarily as described further in this specification. The general arrangement illustrated and described in detail provides a physically compact device which is easily assembled.

The electrical hardware supporting the device is held on circuit board 15 and includes an electrical supply for the infra-red emitting diode 1 and signal receiving circuits connected to the infra-red sensor 3. It is connected to other vehicle electrics by wires not shown in the drawings.

In operation infra-red energy emitted from emitter 1 passes perpendicularly through the emitter surface 11 and is totally internally reflected from the side surface 10 thence passes substantially straight through the optically coupled interface between the front surface 12 at portion 18 and into the windscreen 2. At the outside surface 4 of the windscreen 2, total internal reflection of the infra-red energy will occur if the surface 4 is substantially dry. If the surface 4 is partially wet by water drops 20 then the infra-red energy will be proportionately transmitted through the outside surface 4 as energy 21 and the sensor 3 will receive a proportionately diminished signal.

The totally internally reflected portion of infra-red beam passes through the optically coupled interface between the window 5 and the windscreen 2 at portion 19, finally leaving the window 5 perpendicularly through the sensor surface 6 so as to strike and affect the sensor 3. The sensor 3 is used to produce a signal detected and processed by the connected electronics proportional to the dryness of the windscreen 2.

The optical coupling of the window 5 and windscreen 2 and the infra-red energy entering and leaving perpendicularly to the sensor and emitter surfaces allows the device to operate in a most efficient manner in that
there can be virtually no losses of radiant energy due to significant unwanted reflection. Furthermore, the emitter and sensor devices can be positioned close to one another and in parallel alignment so as to provide a compact assembly.

Figure 2 shows the moisture sensor device in a disassembled state.

The circuit board 15 includes the emitter 1 and sensor 3 soldered into place and preangled so as to coincide with their intended operational directions. The board 15 is then positioned behind the body 9, on the side opposite the side which will be adjacent the window 5. As the board 15 is brought up into position relative to the body 9 the emitter 1 and sensor 3 will align with and enter their respective holes 16 which will finally anchor those components in position. Finally, the board 15 enters the attachments 17 to hold the board 15 in place.

Next, the sub-assembly comprising the board 15, the body 9, the emitter 1 and the sensor 3, is slid into the hollow interior of the housing 8 which itself already includes the transparent window 5. With the angle of the emitter surface 11 and the sensor surface 6 being both on the same side of a perpendicular to the front face 12, that is they are in a common 90° arc drawn from the front surface 12, the body 9 easily self aligns and positions within the hollow relative to the rear surface of the window 5 being finally held in position by detents 14.

Thus the major components can all be injection molded and are very easily assembled so as to be inexpensively produced. Further, as the electrical components attached to the board 15 can be quickly detached from the housing 8 which is adhered via the window 5 to the windscreen 2, an electrical fault or a broken windscreen can easily be remedied without necessitating the replacement of the
operational part of the sensor. Also, as the body 9 is slid into the housing 8 in a direction parallel to the front face 12, it is very easily inserted into the housing 8, after it has been fixed to a windscreen 2 and installed in a vehicle, from above with gravity then assisting to maintain the components in their correct place and the length of the electrical wiring being minimal.
CLAIMS

1. A window means for a moisture sensor adapted to be positioned behind an inside surface of a windscreen so as to provide radiant energy which will be internally reflected by the outside surface of the windscreen to a degree proportional to the dryness of said outside surface, the window means being composed of materials substantially transparent to said radiant energy and comprising:

   - front surface means adapted to be optically coupled to said inside surface of the windscreen;
   - an emitter surface;
   - and a sensor surface,

and wherein the emitter and sensor surfaces are each angled relative to the front surface means such that said front surface means can be optically coupled to said windscreen so that radiant energy entering said window substantially perpendicularly through said emitter surface will follow a path to exit a portion of the front surface means and, if internally reflected by the outside surface of the window, will re-enter a second portion of the front surface means and continue to and exit substantially perpendicularly through said sensor surface.

2. A window means as defined in claim 1 wherein the window means is a single piece window and the front surface means is a continuous surface.

3. A window means as defined in claim 1 or 2 further including at least one side surface intersecting said path and providing a surface of internal reflection to said radiant energy.

4. A window means as defined in claim 1, 2 or 3 wherein said emitter surface is parallel to said sensor surface.

5. A window means as defined in any one of the claim 1-4 wherein said front surface means is adhered and optically coupled to the inside surface of a windscreen by adhesive
substantially transparent to the radiant energy.

6. A window as defined in any one of the claims 1-5 further including a housing extending from the window and defining a hollow interior adjacent said emitter and sensor surfaces and an open end for inserting and releasably holding a correspondingly shaped body means therein.

7. A window means composed substantially entirely of plastics material transparent to radiant energy and including a front surface means, mutually parallel sensor and emitter surfaces being angled to said front surface means at between $30^\circ$ and $60^\circ$, and a side surface substantially perpendicular to said front surface means, and said emitter surface, sensor surface, side surface and front surface means all being substantially perpendicular to a common imaginary optical path plane and further said side surface being intersected by an imaginary line extending substantially perpendicularly from one of the sensor and emitter surfaces.

8. A window means as defined in claim 7 wherein said sensor and emitter surfaces are angled at about $45^\circ$ to said front surface.

9. A moisture sensor comprising:
   - a radiant energy emitter;
   - a sensor corresponding to the emitter;
   - a window means composed of material transparent to the radiant energy and having at least one front surface adapted to be optically coupled to an inside surface of a windscreen, an emitter surface and a sensor surface;
   - and a body means positioning the emitter proximate and aligned with said emitter surface to provide radiant energy directed substantially perpendicularly into the window means through said emitter surface and positioning the sensor proximate and aligned with said sensor surface to receive radiant energy directed substantially
perpendicularly out through said sensor surface,
said window means being configured to provide a
radiant energy path, when optically coupled to the inside
surface of a windscreen, from said emitter to the outside
surface of the windscreen to be internally reflected at
the outside surface of the windscreen, to a degree
proportional to the dryness of said outside surface, and
the reflected portion of the radiant energy to proceed to
and exit said window substantially perpendicularly through
said sensor surface.
10. A moisture sensor as defined in claim 9 wherein said
body means includes an electronic board including
electronic circuitry supporting the operation of the
emitter and the sensor.
11. A moisture sensor as defined in claim 9 or 10 and
said window means further comprising a side surface
positioned along the radiant energy path and providing a
surface of internal reflection to the radiant energy.
12. A moisture sensor as defined in claim 11 wherein said
side surface is intermediate the front surface and a
surface selected from the group comprising the emitter
surface and the sensor surface.
13. A moisture sensor as defined in any one of the claims
9-12 being adapted to be adhered by transparent material
at said front surface to said inside surface of the
windscreen.
14. A moisture sensor as defined in any one of the claims
9-13 wherein the emitter is an infra-red emitting diode.
15. A moisture sensor as defined in any one of the claims
9-14 wherein said sensor surface and said emitter surface
are substantially parallel.
16. A moisture sensor as defined in any one of the claims
9-15 further including a housing incorporating said window
and wherein said body means is substantially opaque to
said radiant energy and is a sliding fit in a direction
parallel to said front surface into said housing.

17. A moisture sensor as defined in claim 16 wherein said emitter and said sensor will self align with said emitter surface and said sensor surface respectively during said sliding fit of the body means into said housing.

18. A moisture sensor as defined in claim 17 further including a circuit board to which said emitter and said sensor are fixed and wherein said circuit board is positioned and held alongside said body means, on a side of said body means opposite said window, and which includes holes for locating said emitter and said sensor and during positioning said circuit board to be held alongside said body means said emitter and said sensor will self align with and enter their respective holes.

19. A moisture sensor comprising:
   a radiant energy emitter;
   a sensor corresponding to the emitter;
   a window means composed of material transparent to the radiant energy and having at least one front surface adapted to be optically coupled to an inside surface of a windscreen, an emitter surface and a sensor surface parallel to the emitter surface;
   a housing incorporating said window;
   and a body means substantially opaque to said radiant energy and being a sliding fit in a direction parallel to said front surface into said housing positioning the emitter proximate and aligned with said emitter surface to provide radiant energy directed into the window means through said emitter surface and positioning the sensor proximate and aligned with said sensor surface to receive radiant energy directed out through said sensor surface, said window means being configured to provide a radiant energy path, when optically coupled to the inside surface of a windscreen, from said emitter to the outside surface of the windscreen to be internally reflected at
the outside surface of the windscreen, to a degree proportional to the dryness of said outside surface, and the reflected portion of the radiant energy to proceed to and exit said window through said sensor surface.
INTERNATIONAL SEARCH REPORT

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

According to International Patent classification (IPC) or to both National Classification and IPC
Int. Cl.® G01N 21/47, B60S 1/02, 1/08

II. FIELDS SEARCHED

Minimum Documentation Searched

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

AU : IPC as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>DE,C, 3823300 (KOSTAL L GMBH) 17 August 1989 (17.08.89) See whole document</td>
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<tr>
<td>P, X</td>
<td>EP,A, 444520 (KOSTAL L GMBH) 4 September 1991 (04.09.91) See abstract</td>
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* 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 document but published on or after the international filing date
- "L" document which may throw doubts on priority claims(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 document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step 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

X Document containing an inventive step or, in the case of a group of claims, a substantial part of the subject matter of each claim of the group

Y Document defining the general state of the art which is considered to be of particular relevance

& Document published prior to the international filing date or priority date

IV. CERTIFICATION

Date of the Actual Completion of the International Search 29 July 1992 (29.07.92)

Date of Mailing of this International Search Report 10 Aug 1992 (10.08.92)

International Searching Authority AUSTRALIAN PATENT OFFICE

Signature of Authorized Officer MARK HAYNES

Form PCT/IPS/210/ second sheet (January 1988)
### FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

| X | USA, 4973844 (O'FARRELL et al), 27 November 1990 (27.11.90)  
See page 5 lines 34-51, page 7 line 5 - page 12 line 46, figures 1, 3, 15  
1, 6, 9, 10, 14, 16, 17-19 |
| X | Patent Abstracts of Japan, P327, page 152,  
JP,A, 59-159053 (NIPPON DENSO K.K.),  
See abstract  
1-3, 5, 6, 9, 11, 12, 14 |
| A | EP 311005 (KARL GEHRAD) 12 April 1989 (12.04.89),  
See whole document.  
7 |

### V.  OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claim numbers, because they relate to subject matter not required to be searched by this Authority, namely:

2. Claim numbers, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claim numbers, because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4a

### VI. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

This International Searching Authority found multiple inventions in this international application as follows:

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest:

- The additional search fees were accompanied by applicant’s protest.
- No protest accompanied the payment of additional search fees.
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