Abstract:
A gait and stance analysis involving the use of a time-of-flight or other distance measuring devices comprising making a measurement of the distance between an underside of a foot and the upper side of a surface, preferably without corresponding pressure measurements.
METHOD AND DEVICE FOR EVALUATING A CONTACT AREA BETWEEN A FOOT AND A SURFACE

Technical Field

The present invention relates to a device and a method for evaluating the footprint of an object on a surface.

Background

Stance and gait analysis are important tools in the fields of podiatry, shoe manufacture, orthotics, prosthetics and related fields.

The more common form of gait analysis relies on measuring the pressure of the foot relative to a surface, often with the use of piezoelectric, or other, pressure sensors. Such sensors are expensive, difficult to maintain and cumbersome to transport.

It is also known to use image information to analyse gate. For example, "4D Measurement and Analysis of Plantar Deformation During Walking and Running"; Masaaki Moehimaru and Makiko Kouchi; Footwear Science, vol. 3, no. supl, pp. S109-S112, 2011 discloses the use of a camera for capturing images of the underside of a foot onto which light is projected, and basing a gait analysis on the captured images. The disadvantage of this system is that the information provided by such images is not detailed enough for a reliable analysis of the gait.

It is also known to use image information to analyse stance. A classical apparatus used in stance analysis comprises a transparent surface, such as a plane of glass, mounted over an angled mirror. A patient stands on a surface and a diagnostician views the patient's stance in the mirror.

Summary of the Invention

According to a first aspect, the invention provides a device for evaluating a contact region between a foot and a surface, the device comprising:

a camera for capturing spatial information relating to the surface and the foot,
a processing device for collating the spatial information and for characterising
said contact region on the basis of the image information and the spatial
information,
wherein said camera is adapted to capture spatial information relating to a
distance between said surface and a plurality of points on an underside of said foot.

It is to be realised that the camera may be any device capable of determining spatial
information of the foot. In certain embodiments, this comprises distance information
between the foot and the surface, or distance information of the location of the foot in
the space surrounding the surface.

The camera may a frame rate of more than 20Hz. Preferably more than 30 Hz and, in
an embodiment, of about 40 Hz. In an embodiment, the camera has a resolution
greater than 100 x 50. Preferably, greater than 150 x 100 and, in an embodiment
176x144. Preferably, each of the elements from which the resolution is comprised
includes distance information. The distance information may have an accuracy greater
than 2 mm, preferably greater than 1 mm, and in an embodiment of about 0,5 mm.

The camera may be a time of flight camera. Alternatively, or in addition, the camera
may be a structured light camera or a stereographic camera.

The camera may be orientated on an underside of the surface. The camera may
capture distance information relating to the orientation of a foot relative to the surface
and relating to a distance between an underside of the foot and the upper side of the
surface.

The foot may contact an upper side of said surface.

The device may further comprise two or more cameras.

The device may comprise three time of flight cameras wherein a first camera is
arranged on an underside of the surface; a second camera is arranged on a first lateral
side relative to the contact region; and a third camera is arranged on a second lateral
side relate to the contact region.

The surface may be translucent or transparent.
The surface may not include force or pressure sensors.

The spatial information may comprise three dimensional information.

A method of characterising a contact region between a foot and a surface, the method comprising:

- capturing spatial information relating to the surface and the foot,
- characterising said contact region on the basis of the spatial information,

wherein said spatial information relates to a distance between said surface and a plurality of points on an underside of said foot.

The method may further comprise determining the spatial information for a plurality of points on an underside of the foot.

The spatial information may comprise a shortest perpendicular distance between the underside of the foot and the surface.

The spatial information may be processed by determining information relating to said contact region and designating a footprint, dividing the footprint into plural masks and determining one or more properties of each mask.

The method may comprise dividing the footprint lengthwise in three and width wise in two, thereby forming six masks, and for each mask calculating:

- contact duration (% stance phase);
- contact area (cm²);
- mean squashing.

The contact duration may be calculated as a percentage of the stance phase. The "squashing" may be calculated on the basis of the minimum distance between the foot and the surface, along a line perpendicular to the surface.

The method may further comprise analysing a gait associated with said foot by analysing plural sets of said spatial information, each set corresponding to a different position of the foot relative to the surface over time.

The camera may be a time of flight camera.
The camera may be orientated to view an underside of the surface.

The method may include bringing a foot into contact with an upper side of said surface.

The method may further comprise capturing spatial information from two or more cameras.

The method may comprise capturing spatial information from three time of flight cameras wherein a first camera is arranged on an underside of the surface; a second camera is arranged on a first lateral side relative to the contact region; and a third camera is arranged on a second lateral side relate to the contact region.

The surface may be translucent or transparent.

The surface may not include force or pressure sensors.

The spatial information may comprise three dimensional information. The spatial information may comprise distance information.

A further aspect of the invention relates to a method for evaluating the footprint of an object on a surface, the method comprising the steps of:

- providing a sequence of three dimensional representations depicting said object entering and leaving contact with said surface;
- computing footprint information comprising contact area and contact intensity of said object on said surface, for at least a portion of said object, based on information comprised in said sequence. In this embodiment, the contact intensity may be related to the distance between the underside of the foot and the upper side of the surface.

A further aspect of the invention relates to a system for analysing a dynamic footprint. The system comprises a scanner for digitizing the 3D foot shape during stance phase. In an embodiment, for each frame, a footprint is extracted to this foot shape following all the points one centimetre over the ground. Although the term "ground" is used here, it will be understood that this is a reference to the surface on which the contact region with the foot is analysed.
Brief Description of the Drawings

Aspects of the present invention will now be further described, by way of example only, with reference to the accompanying figures, in which:

Figure 1 is a schematic illustration of a device according to an embodiment of the invention;

Figure 2 is a photograph of a device according to an embodiment of the invention in use;

Figure 3 illustrates various aspects of measuring a footprint according to an embodiment of the invention;

Figure 4 illustrates further aspects of measuring a footprint according to an embodiment of the invention;

Figure 5 illustrates various aspects of measuring a footprint according to a further embodiment of the invention;

Figure 6 illustrates further aspects of measuring a footprint according to a further embodiment of the invention; and

Figure 7 illustrates a footprint divided up into different masks to aid in the analysis.

Detailed Description

Figure 1 illustrates a device 10 according to an embodiment of the invention. The device 10 includes a glass plate 12 which comprises the surface with which a foot is brought into contact and the contact region is evaluated in the manner described below.

Embodiments of the invention are described with reference to evaluating the stance and gait of a human. Therefore, references to a 'foot' are references to a human foot. However, it is to be realised that embodiments of the invention are not necessarily limited in this respect. In further embodiments, the stance and gait of an animal or mechanically moveable object may be evaluated. In further embodiments, the static or
dynamic weight distribution of an object may be evaluated. In such embodiments, the
terms "foot" and "footprint" will be evaluated accordingly.

The device 10 further comprises three time of flight cameras 16, 18 and 20. Cameras
16, 18 and 20 are of a known type and collect distance information of the foot (not
shown in Figure 1). The foot will contact the glass plate at region 14 and it is in region
14 that the foot will produce a footprint. This region 14 is therefore a contact region
between the surface 12 and the foot. It is to be realised that the region 14 is illustrated
in a schematic manner in Figure 1. In embodiments of the invention, the region of
contact will vary depending on the time during a gait when the measurement is made,
and on the shape of the foot being considered. Furthermore, although the region 14 is
illustrated as a flat area in Figure 1, in embodiments of the invention, this is a three
dimensional volume, as described in more detail below.

Camera 20 is orientated below the glass plate 12, camera 16 is orientated on a lateral
side of region 14 and camera 18 is orientated on the other lateral side of region 14. In
Figure 1, dashed line 22 demarcates the medial line, but this may be an arbitrary line.
Important for certain embodiments of the invention is that the distance information
collected about the foot includes most sides of the foot. It has been found that the
arrangement of three cameras with one camera below, and two to either side, of the
foot strikes a reasonable balance between collecting as much distance information as
possible and the cost of the camera concerned. In use the two laterally placed
.cameras will collect distance information corresponding to a lateral and medial aspect
of a foot.

In further embodiments of the invention, particular where cost is an issue, a single
camera located below the region of the contact between the surface and the foot, may
be used.

Figure 2 is a photograph of a device according to an embodiment of the invention. The
device illustrated in Figure 2 has the same arrangement as the device 10 of Figure 1
and therefore similar reference numerals have been used to illustrate similar features,
where visible. As shown in Figure 2, a foot 24 is in contact with the surface 12.

A method of evaluating the contact region between the foot and the surface will now be
described with reference to Figures 3 and 4.
Figure 3 illustrates the manner in which the contact region is converted into a metric for characterisation and comparison. In embodiments of the invention, the metric is referred to as a "Dynamic Least Height Distance" (DLHD). Figure 3a illustrates a 3D foot shape (at 30% of the stance phase) which comprises the distance information collected from the three cameras (16, 18 and 20, Figure 1). Figure 3b illustrates how this information is limited by considering a region of height 15 mm only (the remaining distance information is discarded in this embodiment), and for these points only the positions in an x-y plane have been considered. In Figure 3c, pixel values have been defined by the vertical coordinates of the corresponding lowest point (in other words, the height of the closest surface of the foot to the glass plate, or surface on which the contact region is being evaluated). This is the LHD (or "Least Height Distance") - for further detail regarding this measurement, refer to the Moehimaru and Kouchi article referenced above. Embodiments of this invention differ from this as described above and in that the dynamic, or change, in these metrics are considered.

The closest surface of the foot is considered by considering a perpendicular line between the glass plate and the foot 24.

Figure 3d illustrates 3D foot shape and corresponding DLHD at different instants of the stance phase of the gait of the foot.

In this embodiment, the contact region is evaluated on the basis of a height of 15 mm. However, in further embodiments, the height may vary. In certain embodiments, the height may depend on the size of the foot.

Figure 7 illustrates the manner in which a footprint 100 may be divided up into masks so that different footprints representative of different times in a gait may be compared to one another. It is to be realised that for embodiments of the invention concerned with stance analysis, such a subdivision may not be necessary.

Figure 7 illustrates a footprint 100 divided into six different masks. The six masks are designated as follows:

102: medial rear-foot;
104: lateral rear-foot;
106: medial mid-foot,
108: lateral mid-foot;
110: medial fore-foot; and
112: lateral fore-foot.

Figure 4 illustrates mean curves and standard deviation of mask contact intensity (mean DLHD in millimetres) and contact area (in square centimetres). Corresponding to each of the six masks illustrated in Figure 7. The data is expressed in percentage of stance phase with the following designations:

Contact intensity (measured as a function of the distance between the foot and the surface):
Line 50: medial rear-foot 102;
Line 52: lateral rear-foot 104;
Line 58: medial mid-foot 106,
Line 60: lateral mid-foot 108;
Line 66: medial fore-foot 110; and
Line 68: lateral fore-foot 112.

Contact area (measured as the area where the distance between the foot and the surface is zero):
Line 54: medial rear-foot 102;
Line 56: lateral rear-foot 104;
Line 64: medial mid-foot 106,
Line 62: lateral mid-foot 108;
Line 70: medial fore-foot 110; and
Line 72: lateral fore-foot 112.

The manner in which the evaluation is carried out will now be described, with reference to Figures 3 and 4.
The right foot of ten healthy subjects (26.2± 4.1 years, 1.73 ± 0.07m, 70.5 ± 6.9 kg) was recorded during five gait trials at self-selected speed on a device similar to that illustrated in Figures 1 and 2. The three time-of-flight cameras used have a frequency (frame rate) of 40Hz and a resolution of 176x144 for 3D data acquisition with an accuracy close to 0.5mm. The cameras digitize the foot during gait from the medial, lateral and plantar (with the camera under the glass plate) sides of the foot. An alignment of all 3D data obtained from the three cameras is performed to reconstruct the 3D foot shape.

From the 3D foot shape (Figure 3a), DLHD was computed as the vertical distances between the points of the 2D sole shape and the glass plate (i.e. surface-to-surface distance). The maximal surface-to-surface distance for including points was arbitrarily set to 15 mm (Figure 3b). These distances were then represented and mapped using a colour scale (Figs. 3c-d). Using a known method, DLHD was rotated according to the centroid and the major foot axis calculated from the "maximum DLHD", i.e. the LHD². An oriented bounding box area was computed around the LHD (i.e. minimum rectangle containing all maximum DLHD pixels). Finally, DLHD was divided equally lengthwise in three parts and width wise in two parts to obtain the six masks illustrated in Figure 7 and described above. Contact intensity (i.e., instantaneous DLHD) and contact area were calculated on each ROI (mean curve of the ten subjects mean curves) for each frame of the entire foot rollover.

Figure 4 shows the subjects’ mean curves of the masks’ mean contact intensity and contact area. The contact intensity of the medial and lateral sides evolved almost similarly for the rear-foot and the fore-foot while the contact intensity of the lateral mid-foot was displayed more negative values (i.e. higher DLHD value) than the medial mid-foot. In contrast to contact intensity, the contact area was higher for the medial rear-foot and fore-foot while the contact areas of the medial and lateral mid-foot were quite similar.

DLHD data were not comparable to traditional plantar pressure data regarding mean intensity and contact area. This difference between both DLHD and plantar pressure data were mainly explained by the specificity of each physical quantity. A relation does not necessarily exist between DLHD and pressure: different pressure quantities could
be recorded with the same DLHD quantity, and vice versa. For this reason, the interest of plantar sole DLHD analysis is to provide new information about foot rollover evolution to complement, and not to necessarily substitute, plantar pressure examination. However, it is to be realised that for certain purposes, such as gait anomaly diagnosis, the DLHD analysis as described above can be just as characteristic of anomalies as plantar pressure information and therefore, in certain situations, the current method may indeed replace the known devices and methods.

The foot plantar aspect has a non-homogeneous design. The current plantar sole DLHD method provides an indirect assessment of the mechanical properties of the different foot segments, like heel pad deformation. Some plantar foot segments, as the medial mid-foot, are close to the ground during stance phase; nevertheless the contact is light or absent (in case of normal foot arch). Compared with plantar pressure data coming from the contact surface, DLHD assesses foot deformation over the contact surface. Plantar arch height variation or the windlass mechanism can also be analysed with methods of the invention, even in the case of subjects with high arch. Using a DFS system and studying plantar sole DLHD also enable to analyse simultaneously 3D foot shape and 2D plantar sole deformations with the same system.

Figures 5 and 6 illustrate a method of evaluating the contact region between the foot and the surface in a difference manner. Figure 5 illustrates the evolution of the contact region over time and is similar to Figure 4. Figure 6 illustrates the data collected by a device with the arrangement illustrated in Figures 1 and 2, and described above. The solid lines of the graph represent data collected by the device as illustrated in Figures 1 and 2 (referred to as a 'scanner in the Figures and in the text below). The dashed lines of the graph represent data collected by a known plantar pressure gait measuring device of the type described above, in this instance a plantar pressure plate (200Hz, Footscan®, RSscan, Olen, Belgium) was used in a walkway.

As illustrated in Figure 7, the footprint is again divided into six masks and the data for each mask evaluated individually for both contact area and contact intensity. It should be noted that for contact intensity, it was assumed that the LHD was analogous to pressure for the sake of this comparison. The following lines represent the corresponding masks:

Contact area information (graphs a, b and c):
medial rear-foot 102 scanner data;
medial rear-foot 102 pressure data;
lateral rear-foot 104 scanner data;
lateral rear-foot 104 pressure data;
medial mid-foot 106 scanner data;
lateral mid-foot 108 scanner data;
lateral mid-foot 108 pressure data;
medial mid-foot 106 pressure data;
medial fore-foot 110 scanner data;
lateral fore-foot 112 scanner data;
lateral fore-foot 112 pressure data;
medial fore-foot 110 pressure data.

Contact intensity information (graphs c, d and e):
medial rear-foot 102 scanner data;
medial rear-foot 102 pressure data;
lateral rear-foot 104 scanner data;
lateral rear-foot 104 pressure data;
lateral mid-foot 108 scanner data;
lateral mid-foot 108 pressure data;
medial mid-foot 106 scanner data;
lateral fore-foot 112 pressure data;
medial mid-foot 106 pressure data;
medial fore-foot 110 scanner data;
lateral fore-foot 112 scanner data;
lateral fore-foot 110 scanner data.

Seven healthy realized four gait trials at self-selected speed on each system, randomly. In the discussion below, the term “foot squashing” is used. It is to be realised that this is the same as the DLHD defined above.

Foot squashing was only defined using all the points of the 3D foot shape one centimetre over the ground (Figure 5). Both footprints, i.e. squashing and plantar pressure, were divided lengthwise in three parts and width-wise in two parts in order to obtain six masks, as described. For each mask, several parameters were defined as follows:

• contact duration (percentage of stance phase) for both methods;
• contact area (cm²) for both methods;
• contact intensity, mean squashing (millimetres, for the method according to the invention) and mean pressure (kilopascal, for the plantar pressure method).

Figure 6 shows a comparison between the squashing and pressure parameters for contact area and intensity. Contact durations were relatively similar (difference lesser than 3% of the stance phase) for both squashing and pressure methods with a maximum difference for the medial mid-foot (80% and 74% of the stance phase for squashing and pressure, respectively). Concerning contact areas (Figures 6 a-c), the values were higher with squashing than pressure. The curves evolved similarly around the rear-foot. Relatively, contact areas of mid-foot and forefoot were higher with squashing than pressure during the first part of the stance phase. Finally, contact intensities revealed some similar curve patterns, even if "kilopascal" and "millimetres" cannot be compared (Figures 6 d-f). The most important differences were noted around the fore-foot with high intensity during the first part of the stance phase for squashing, and during the last part of the stance phase for pressure.

Embodiments of the current invention concern a new approach to analysing dynamic footprint, i.e. gait. Importantly, the comparison shows that useful results are obtainable by the method of this invention. In general, duration, contact area and intensity evolved similarly with both methods. The most important differences were noted around the mid-foot, especially for the medial part. In this embodiment, information for a contact region having a height of one centimetre over the ground compared with plantar pressure distribution (which only uses the contact) was used (although the height may be varied).

References


It will be appreciated by the person skilled in the art that various modifications may be made to the above described embodiments without departing from the scope of the present invention.
CLAIMS

1. A device for evaluating a contact region between a foot and a surface, the device comprising:
   a camera for capturing spatial information relating to the surface and the foot,
   a processing device for collating the spatial information and for characterising said contact region on the basis of the image information and the spatial information,
   wherein said camera is adapted to capture spatial information relating to a distance between said surface and a plurality of points on an underside of said foot.

2. The device according to claim 1 wherein the camera is a time of flight camera.

3. The device according to claim 2 wherein the camera is orientated on an underside of the surface.

4. The device according to claim 3 wherein the foot contacts an upper side of said surface.

5. The device according to any preceding claim further comprising two or more cameras.

6. The device according to claim 5 comprising three time of flight cameras wherein a first camera is arranged on an underside of the surface; a second camera is arranged on a first lateral side relative to the contact region; and a third camera is arranged on a second lateral side relative to the contact region.

7. The device according to any preceding claim wherein the surface is translucent or transparent.

8. The device according to any preceding claim wherein the surface does not include force or pressure sensors.
9. The device according to any preceding claim wherein the spatial information comprises three dimensional information.

10. A method of characterising a contact region between a foot and a surface, the method comprising:
    capturing spatial information relating to the surface and the foot,
    characterising said contact region on the basis of the spatial information,
    wherein said spatial information relates to a distance between said surface and a plurality of points on an underside of said foot.

11. The method according to claim 10 further comprising determining the spatial information for a plurality of points on an underside of the foot.

12. The method according to claim 11 wherein the spatial information comprises a shortest perpendicular distance between the underside of the foot and the surface.

13. The method according to claim 11 or claim 12 wherein the spatial information is processed by determining information relating to said contact region and designating a footprint, dividing the footprint into plural masks and determining one or more properties of each mask.

14. The method according to claim 13 further comprising dividing the footprint lengthwise in three and width wise in two, thereby forming six masks, and for each mask calculating:
    contact duration;
    contact area; and
    mean squashing.

15. The method according to any of claims 10 to 14 wherein the method further comprises analysing a gait associated with said foot by analysing plural sets of said spatial information, each set corresponding to a different position of the foot relative to the surface over time.
16. A method for evaluating the footprint of an object on a surface, the method comprising the steps of:
providing a sequence of three dimensional representations depicting said object entering and leaving contact with said surface;
computing footprint information comprising contact area and contact intensity of said object on said surface, for at least a portion of said object, based on information comprised in said sequence.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. A61B5/103 A61B5/11

ADD.

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):

A61B

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

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

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 5 800 364 A (GLENN EI KENNETH DONALD [GB] ET AL) 1 September 1998 (1998-09-01) abstract</td>
<td>1-12, 15</td>
</tr>
<tr>
<td></td>
<td>col umn 8, l ine 11 - col umn 13, l ine 42 figures 2-6</td>
<td>14</td>
</tr>
<tr>
<td>Y</td>
<td>BETTS R P ET AL: &quot;Stati c and dynami c foot-pressure measurements in clinical orthopaedi cs&quot;, MEDICAL AND BIOLOGICAL ENGINEERING AND COMPUTING, SPRINGER, HEIDELBERG, DE, vol. 18, no. 5, 1 September 1980 (1980-09-01), pages 674-684, XP002121536, ISSN: 0140-0118 page 674 - page 677; figures 1,2</td>
<td>13, 16</td>
</tr>
</tbody>
</table>

**X** Further documents are listed in the continuation of Box C. **X** 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 o n or after the international filing date
  - "L" document which may throw doubts on priority claim(s) one of 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
  - "Z" document member of the same patent family

Date of the actual completion of the international search: 20 March 2013

Date of mailing of the international search report: 02/04/2013

Name and mailing address of the ISA:
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016

Authorized officer: Arti kis, T
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>US 4 267 728 A (MANLEY MICHAEL T ET AL) 19 May 1981 (1981-05-19) abstract column 2, line 42 - column 4, line 13 figures 1, 3, 4</td>
<td>1-16</td>
</tr>
<tr>
<td>A</td>
<td>US 4 600 016 A (BOYD TIMOTHY L [US] ET AL) 15 July 1986 (1986-07-15) abstract column 4, line 33 - column 6, line 11; figures 1, 2</td>
<td>1-16</td>
</tr>
<tr>
<td>Patent document cited in search report</td>
<td>Publication date</td>
<td>Patent family member(s)</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>-----------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>US 5800364 A</td>
<td>01-09-1998</td>
<td>AU 6113994 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA 2157370 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 0688181 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5800364 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 9420020 A1</td>
</tr>
<tr>
<td>US 6205230 B1</td>
<td>20-03-2001</td>
<td>NONE</td>
</tr>
<tr>
<td>US 4267728 A</td>
<td>19-05-1981</td>
<td>NONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 4600016 A</td>
</tr>
</tbody>
</table>