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(54) Title: STIFFENED ROTOR HAT WITH CORRUGATED SHAPE

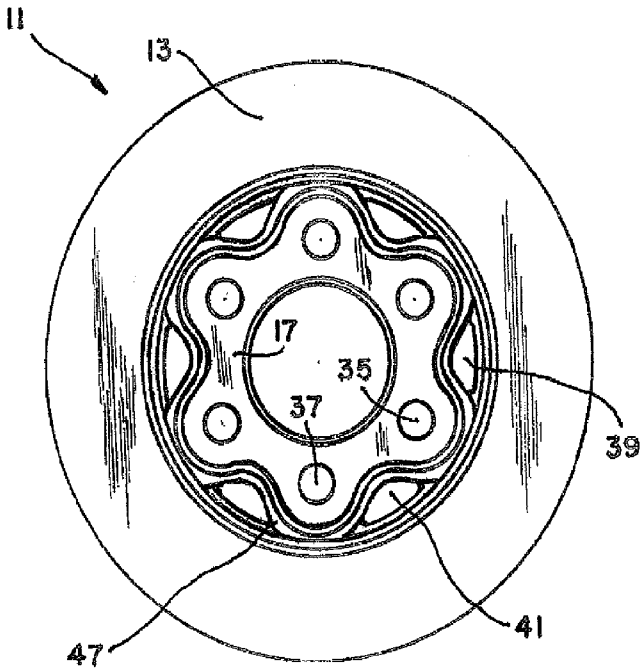

FIG. 1

(57) Abstract: A vehicle wheel assembly includes a vehicle wheel and a rotable hub rigidly coupled together for co-rotation about a common axis. A disc brake rotor (11) including an annular disc (45) and a hollow hat (55) with a corrugated sidewall (21) coupling the disc and hub. The radial distance between the hat sidewall and the axis varies as a function of rotational angle. The hat end (47) is joined with the disc in a plurality of discrete regions interspersed with openings (39,41) allowing air flow through the rotor. The hat sidewall is fluted having a number of lobes (23,25,27,29,31,33) interleaved with a like number of valleys (43,67,69) and the rotable hub includes a mounting flange (51) having a like number of interleaved lobes and valleys received within the hollow hat. Each flange lobe has a wheel mounting lug (61,63) extending therefrom passing through a like number of aligned apertures (35,37) in both the hat and wall portion and the wheel.

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STIFFENED ROTOR HAT WITH CORRUGATED SHAPE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention.

[0002] The present invention relates to disc brake assemblies and more particularly to an improved disc brake rotor.

[0003] 2. Description of the related art.

[0004] Many motor vehicles include disc brake systems having a circular metal disc brake rotor with opposed braking surfaces that are clamped by brake pads carried by a brake caliper to exert a braking effect. The wheel hub incorporates an anti-friction wheel bearing assembly in which one race of the bearing is coupled to the vehicle suspension and the other rotationally mounts the brake rotor and wheel. Ordinarily the rotating components of the rotor, wheel and hub assembly are manufactured separately and assembled together by a plurality of bolts and lug nuts which clamp the wheel to the hub flange with a so-called hat or mounting flange portion of the rotor clamped therebetween. In order to enhance performance of the braking system it is desired to carefully and accurately control the dimensional characteristics of the rotor braking surfaces as the rotor rotates. The thickness variation of the disc and the lateral run-out or lateral deflection of the surfaces as they rotate needs to be held to minimum tolerances. The desire to control lateral run-out of braking surfaces of a disc rotor are well known and rotor manufacturing techniques have been improved to reduce such run-out.

[0005] For example, U.S. Patent 6,988,598 attempts to solve this problem by allowing the rotor to slide axially during brake application assuming a new axial location not dictated by the wheel face after release of the braking pressure. This patent suggests a disc brake rotor mounting system that enables self-alignment of the rotor without the need for a precision mounting surface on the wheel.

[0006] U.S. Patent 5,988,761 teaches a wheel end hub assembly for a motor

vehicle incorporating mechanical retention features which accurately and positively orient the motor vehicle brake component, such as a disc brake rotor or brake drum with respect to its wheel hub. With this approach, the machining operations for the brake component braking surfaces can be accurately based from a datum surface of the hub. The assembly incorporates a retention nut threaded onto the wheel mounting bolts which exerts a clamping force on the brake component, e,g., a rotor mounting flange, and further establishes the relative positions of the hub and brake component. In this patented arrangement, the wheel is fixed to the hub with lug nuts engaging the mounting bolts and clamping the wheel against the braking component.

[0007] A recent salutary advance provides solutions to these problems by fixing the rotor to the hub flange outside the wheel-to-hub flange bolted joint to reduce mounted rotor distortion induced by wheel clamp load.

[0008] Another recent and noteworthy advance concerned primarily with thermally induced distortions suggests a vented rotor having inboard and outboard brake plates and a generally cylindrical hat with a one end attachable to the vehicle wheel and a sidewall terminating in a plurality of brake plate attachment ribs some of which (typically alternate ones) couple the hat to the inboard plate and others of which couple it to the outboard plate.

[0009] In spite of these significant advances, brake roughness warranty remains one of the top problems that plague many vehicle platforms. High levels of lateral runout (LRO) have been shown to increase the likelihood of brake roughness that occurs over time and usage of the vehicle. Mounting a wheel to a rotor usually increases (sometimes substantially) the LRO of the rotor. Therefore, by providing a means to reduce this increase in LRO, the likelihood of brake roughness is reduced.

[0010] The current configuration of the rotor hat section is characterized by a cylinder that extends from the wheel mounting surface to one of the brake plates. It has been demonstrated through analysis that elongated hat sections

reduce distortions that increase LRO. Therefore, it follows that improving the stiffness of the hat section reduces distortions. The goal of this invention is to improve the hat stiffness in an alternate way.

[0011] The rotor braking surface is characterized dimensionally by measuring the lateral runout (LRO) with respect the axis of part rotation. When a wheel is mounted to the vehicle, the rotor which is sandwiched between the wheel and hub distorts thereby increasing the LRO. LRO can be converted to thickness variation (TV) between plates or braking surfaces over time through off brake contact with the brake linings. Thickness variation directly relates to the generation of brake torque variation during braking. Brake torque variation excites a vehicle into brake roughness. Therefore, low LRO is desired to minimize the potential for brake roughness.

[0012] Most front brake applications today have very limited packaging space. Typically, the package limits the length of the hat section such that the benefit a long hat cannot be realized. The intent of the invention is to increase the stiffness of the hat section without significantly affecting the axial package.

[0013] It is desirable to provide a means to stiffen the rotor hat section to reduce the transmission of strain energy from the wheel mounting surface to the brake plates, that is, to reduce distortions.

SUMMARY OF THE INVENTION

[0014] The present invention provides a solution to the distortion problem by modifying the hat shape to incorporate corrugations around the periphery of the hat thereby increasing the hat stiffness. Furthermore, the hub flange to which this rotor mounts can be modified to have lobes that nest within the hat shape so that overall package is not significantly compromised..

[0015] The invention comprises, in one form thereof, a disc brake rotor for a vehicle wheel assembly having an annular disc with opposed friction braking surfaces and a hollow hat for coupling the disc to a vehicle wheel. The hat has

a generally planar free end wall for attachment to the wheel and a fluted sidewall formed as a number of generally uniformly spaced lobes interleaved with a like number of valleys coupling the free end wall to the disc. The hat includes an edge opposite the free end which is joined with the disc in a plurality of discrete regions interspersed with openings allowing air flow through the rotor. The sidewall is of a generally uniform non-circular cross-sectional configuration exhibiting a generally serpentine pattern which extends between the free end and the disc.

[0016] An advantage of the present invention is that no significant change to the packaging of a brake within an application is required as the improvement lies entirely within the hub and rotor.

[0017] Another advantage is that windows can be added to the area that connects the hat section with the brake plates providing for improved brake cooling by allowing airflow to the brake plate inner diameter from the inboard and outboard sides of the rotor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Fig. 1 is an inboard elevation view of a rotor illustrating the invention in one form;

[0019] Fig. 2 is an inboard isometric view of the rotor of Fig. 1;

[0020] Fig. 3 is an outboard isometric view of the rotor of Fig. 1;

[0021] Fig. 4 is an outboard elevation view of a vehicle hub adapted to the rotor of Fig. 1;

[0022] Fig. 5 is a side elevation view of the hub of Fig. 4 from the right side thereof;

[0023] Fig. 6 is a cross-sectional view of a wheel assembly along the lines 6-6 of Fig. 4 additionally showing the rotor of Figs. 1-3 and a portion of a vehicle wheel; and

[0024] Fig. 7 is a cross-sectional view similar to Fig. 6, but taken along the

lines 7-7 of Fig. 4.

[0025] Corresponding reference characters indicate corresponding parts throughout the several drawing views.

DETAILED DESCRIPTION OF THE INVENTION

[0026] Referring now to the drawings and particularly to Figs.1-3, there is shown a disc brake rotor 11 having an inboard friction braking surface 15 and an outboard friction braking surface 13. The annular disc 45 is illustrated as two plates joined by multiple ribs. The rotor further includes a hollow hat 55 having a planar free end wall 17 which provides a wheel mounting surface 19 and sidewall 21 having a corrugated or fluted configuration including a plurality of generally uniformly spaced lobes 23, 25, 27, 29, 31 and 33 interleaved with a like number of valleys or grooves such as 43, 67 and 69. These corrugations enhance the sidewall rigidity. The inboard hat edge 47 is joined to the annular disc 45 at a plurality of discrete regions leaving multiple gaps or openings such as 39 and 41 which allow air flow through the rotor. Axially between where the edge 47 is joined to the disc 45 and the end wall 17, the fluted hat sidewall is of a uniform or constant non-circular cross-sectional configuration. End wall 17 includes a number of wheel mounting bolt apertures such as 35 and 37 which align with similar wheel apertures for rigidly coupling the wheel and rotor with a vehicle hub 49 as illustrated in Figs. 4-7.

[0027] In Figs. 4 and 5, the hub 49 is seen to have a generally planar mounting flange 51 having a generally serpentine configured periphery 53 including a number of lobes such as 57 and 59 interleaved with intervening valleys shaped to nest within the hollow hat 55 of Figs. 1-3. Each flange lobe has a wheel mounting lug such as 61 and 63 extending therefrom and spaced to pass through a like number of aligned apertures such as 35 and 37 in both the hat end wall portion 17 and the wheel 65 (Figs. 6 and 7). The hub 49 has a protruding shoulder or circular post 71 matable with corresponding central

apertures in both the wheel and the rotor. A barrel 73 extends from the flange 51 to be suitably journalled for rotation about an axis 75.

[0028] Fig. 6 shows the hub 49 in cross-section along the line 6-6 of Fig, 4, but with the rotor 11 and an illustrative wheel portion 65 assembled thereto. Lug nuts such as 77 and 79 cooperate with corresponding lugs to rigidly couple the hub 49 and wheel 65 for rotation about their common axis 75. The rotor 11 has the end 17 captured or sandwiched between the flange 51 and wheel 65. Fig 6 illustrates the diametrically opposed lobes 29 and 23 of Fig. 3. The radial distance between the axis 75 and the inner surface of the hat sidewall 21 is shown as R1 measuring the radial distance from the axis to the lobe 23.

[0029] Fig. 7 is a cross-sectional view similar to Fig. 6, but taken along the line 7-7 of Fig. 4. Line 7-7 is angularly oriented 30 degrees from line 6-6 to illustrate the angular spacing between diametrically opposed troughs 67 and 69. Now the radial distance between the axis 75 and the inner surface of the hat sidewall 21 is shown as R2 measuring the radial distance from the axis to the inside of the trough 69. Considering the symmetry of the sidewall, a cross-section taken another 30 degrees from line 7-7 would yield a view essentially identical to Fig. 6. Further 30 degree rotations of the section line would alternately provide views matching Figs. 6 and 7, thus R1 shows the maximum distance between the axis 75 and sidewall 21 while R2 shows the minimum distance. In view of the smooth serpentine configuration of the sidewall 21 as best seen in Fig. 1, there is a continuous variation in the radial distance between the maximum and minimum values. Hence, as the wheel, rotor and axle rotate about the axis 75, the radial distance to the hat sidewall (taken in some reference direction) varies periodically as a function the angle of wheel rotation repeating every 60 degrees.

[0030] Thus, while a preferred embodiment has been disclosed, numerous modifications will occur to those of ordinary skill in this art. Accordingly, the scope of the present invention is to be measured by the scope of the claims which follow.

What is claimed is:

1. A disc brake rotor for a vehicle wheel assembly, comprising:

an annular disc having opposed friction braking surfaces; and

a hollow hat for coupling the disc to a vehicle wheel, the hat including a generally planar free end wall for attachment to the wheel and a fluted sidewall coupling the free end wall to the disc.

2. The brake rotor of claim 1, wherein the hat includes an edge opposite the free end joined with the disc in a plurality of discrete regions.

3. The brake rotor of claim 2, wherein the discrete regions are interspersed with openings allowing air flow through the rotor.

4. The brake rotor of claim 1, wherein the fluted sidewall is formed as a number of generally uniformly spaced lobes interleaved with a like number of valleys.

5. The brake rotor of claim 1, wherein the fluted sidewall is of a generally uniform cross-sectional configuration between the free end and the disc.

6. A brake rotor for a vehicle wheel assembly, comprising:

an annular disc having opposed friction braking surfaces; and

a hollow hat for coupling the disc to a vehicle wheel, the hat including a generally planar free end for attaching to the wheel and a sidewall having a generally uniform non-circular cross-sectional configuration extending between the free end and the disc.

7. The brake rotor of claim 6, wherein the sidewall cross-section exhibits a generally serpentine pattern.

8. The brake rotor of claim 6, wherein the hat sidewall is joined with the disc in a plurality of discrete regions.

9. The brake rotor of claim 8, wherein the discrete regions are interspersed with openings allowing air flow through the rotor.

10. The brake rotor of claim 7, wherein the sidewall is formed as a number of

generally uniformly spaced lobes interleaved with a like number of valleys.

11. A vehicle wheel assembly, comprising;

a vehicle wheel;

a rotatable hub rigidly coupled with the wheel for co-rotation about a common axis; and

a disc brake rotor having an annular disc, and a hollow hat including a sidewall portion coupling the disc and hub, and an end wall portion captured between the wheel and hub, the radial distance between the hat sidewall and the axis varying as a function of rotational angle.

12. The vehicle wheel assembly of claim 11, wherein the functional relationship between rotational angle and radial distance is a periodic function.

13. A vehicle wheel assembly of claim 11, wherein the sidewall portion is corrugated including a number of lobes interleaved with a like number of valleys.

14. The brake rotor of claim 11, wherein the hat includes an end opposite the end wall portion joined with the disc in a plurality of discrete regions.

15. The brake rotor of claim 14, wherein the discrete regions are interspersed with openings allowing air flow through the rotor.

16. The vehicle wheel assembly of claim 11, wherein the rotatable hub includes a generally planar mounting flange having a generally serpentine peripheral configuration nesting within the hollow hat.

17. The vehicle wheel assembly of claim 16, wherein the sidewall portion is fluted including a number of lobes interleaved with a like number of valleys, and the rotatable hub includes a generally planar mounting flange having a like number of interleaved lobes and valleys received within the hollow hat.

18. The vehicle wheel assembly of claim 17, wherein each flange lobe has a wheel mounting lug extending therefrom passing through a like number of aligned apertures in both the hat end wall portion and the wheel.

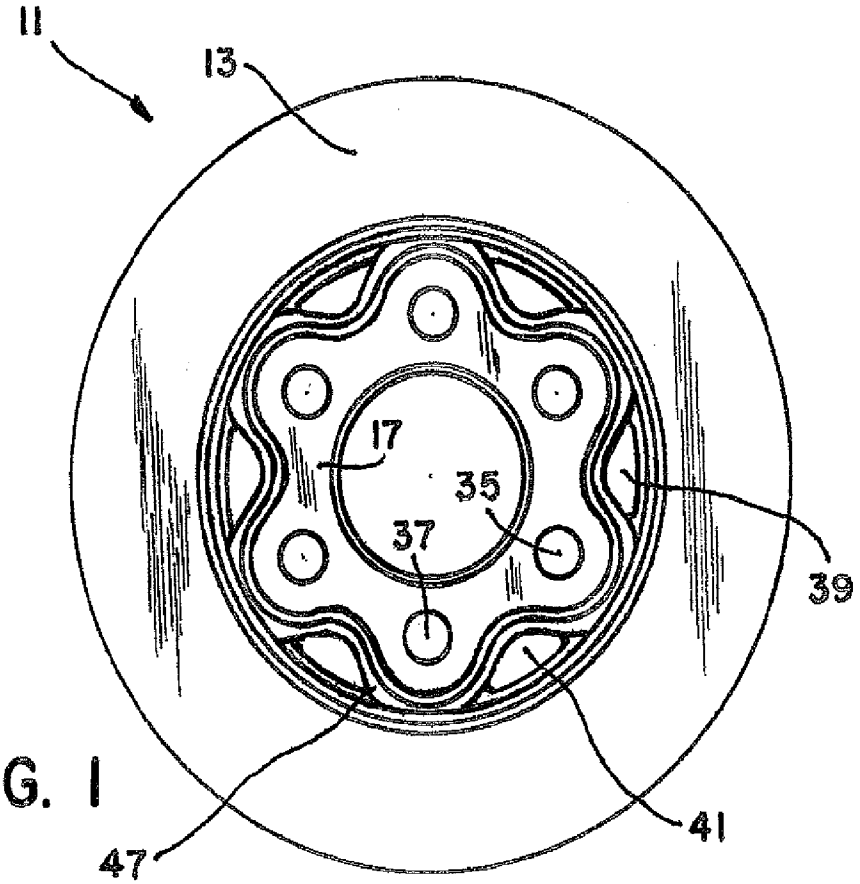

FIG. 1

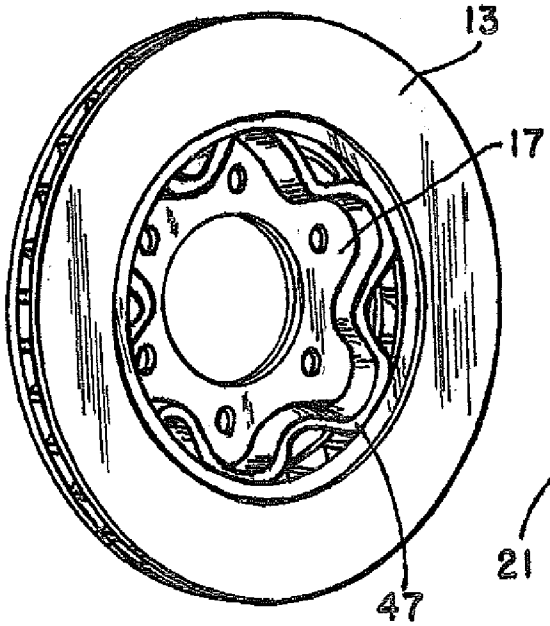

FIG. 2

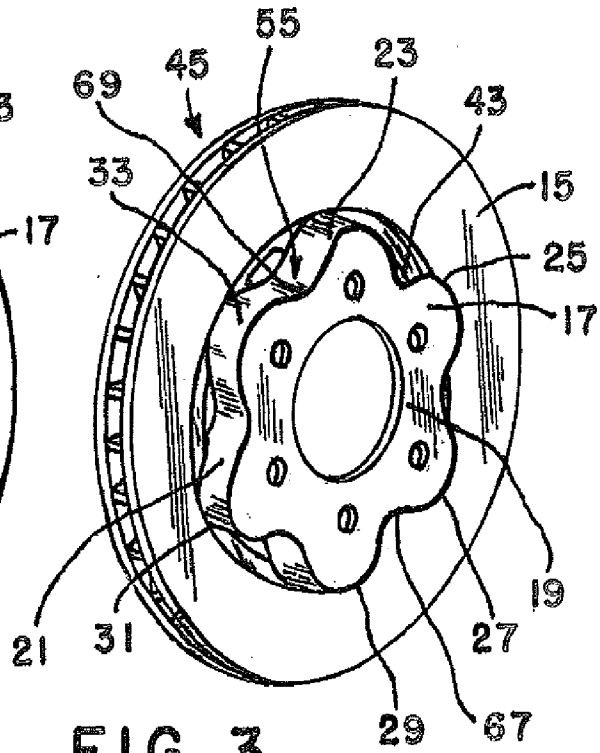

FIG. 3

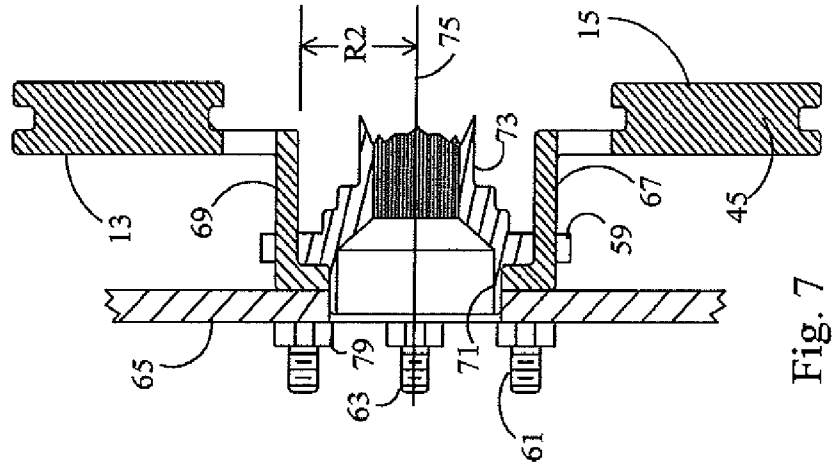

Fig. 7

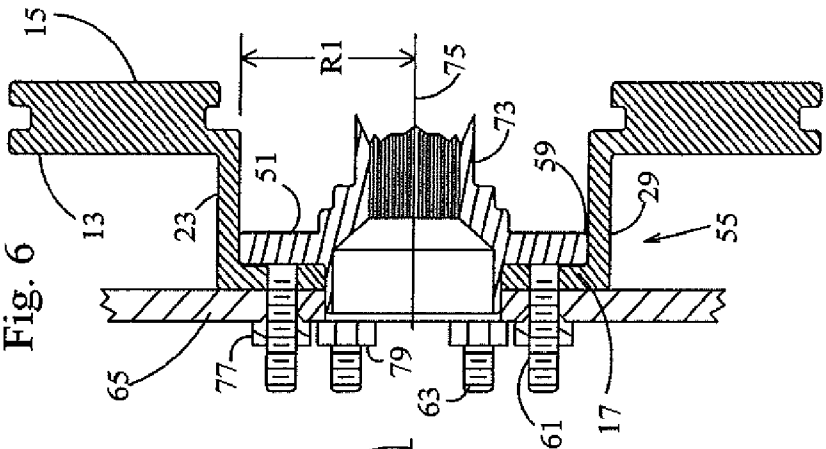

Fig. 6

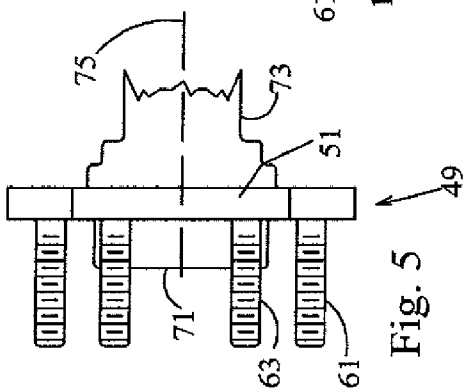

Fig. 5

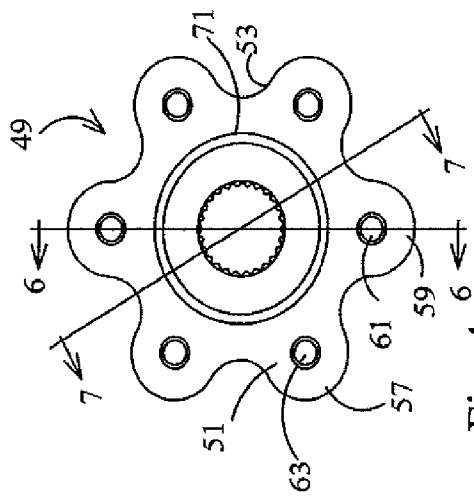

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2009/045334

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16D65/12

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)
F16D

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 practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1 333 561 A (GIRLING LTD) 10 October 1973 (1973-10-10) page 2, line 4 - line 38; figures 2,3	1-18
X	US 2005/126870 A1 (DOPPLING HORST [DE] ET AL) 16 June 2005 (2005-06-16) figures 2,5	1-18
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
6 August 2009	13/08/2009

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

INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

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