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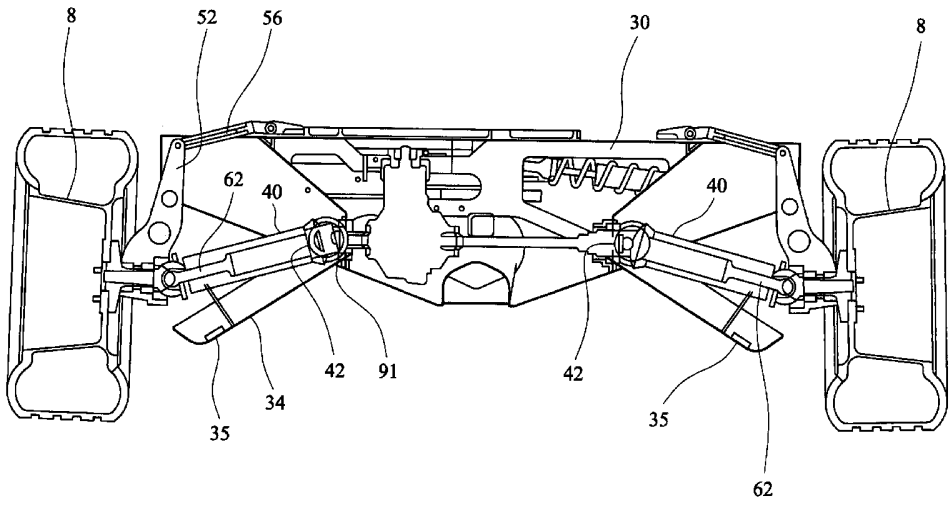
(54) **Title:** AMPHIBIOUS VEHICLES WITH RETRACTABLE WHEELS



(57) **Abstract:** Amphibious vehicle (2, fig. 1) has road wheels (8) which are retractable to allow planing. Each wheel suspension has a gap (80) in the planing surface (20) of the hull. To reduce hydrodynamic drag and improve marine handling, covers (34) are provided which cover gaps (80) when the wheels are retracted. These covers may be hinged parallel to a longitudinal, or to a transverse, axis of the vehicle. The covers may be hung from suspension arms (40) or otherwise connected to hull (16). The covers may leave gaps (90); to cover these, a second embodiment comprises "barn door" double covers (92, 94, fig. 5). A third embodiment has a mechanical linkage (182, fig. 7), which biases cover (180) to overlay gap (90) on wheel retraction. The covers cover a small gap in the hull through which the suspension is retracted and are designed to reduce flutter or chattering of the cover when in the water at speed but not the wheels.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

AMPHIBIOUS VEHICLES WITH RETRACTABLE WHEELS

The present invention relates to amphibious vehicles, and particularly to hull fairings for recesses in the hull.

In our co-pending Patent Application No. PCT/GB/04/002156, a planing amphibious vehicle hull is shown with recesses in the areas where retractable wheels and their suspensions move during suspension retraction and protraction. Because the suspensions are assembled from below during manufacture, the recesses intrude considerably into the planing surfaces of the hull. In order to reduce this intrusion, plates are fixed across part of each recess after assembly of the suspension. These plates are currently glued into position, although they could be bolted. As will be seen from Figure 1 of the above prior application, it is clear that particularly the front wheel recesses are very much open at the bottom. As a result of the openings in the bottom of the hull, there can be problems with drag on the hull when the vehicle tramps through rough water. This is particularly problematic for vehicles smaller and lighter than that shown in the prior application.

A further known solution to this problem of reducing drag on water is disclosed in US 4,958,584, to Williamson. In this patent, a single sliding cover 18 (Figure 5) for front and back wheel wells 42 on one side of the vehicle is powered fore and aft by a double acting hydraulic cylinder 148. This arrangement appears to be a very simple and elegant solution, but has considerable practical drawbacks.

First, the slide channels will be susceptible to damage or seizure due to ingress of sand or silt. Second, the cover runs parallel to the hull for most of its length; so any grounding or collision damage which distorts either the hull or the cover would be liable to cause the two parts to jam together, preventing protraction of the wheels and stranding the vehicle on water.

Third, the use of a single actuator to move such a large and complex sliding panel is liable to lead at the least to uneven panel movement, and at the most to complete seizure, especially as wear and play build up as the vehicle ages. Finally, a single cover as shown, which overlaps the hull between front and rear arches even when closed, would project below the hull at the front, at least, of each wheel arch, disturbing the smooth flow of water along the vehicle's planing surface. Clearly, fresh thinking is needed.

Several other proposals have been published to cover a retractable wheel on marine craft or amphibians. In US 2,781,529 (Moody), a boat is shown with a pair of retractable wheels which when protracted enable the boat to be towed as a trailer on land. Each wheel has a suspension pivotal about a transverse axis and is retractable through an interruption in the bottom. Each interruption is arranged to be covered by a pair of covers hinged about a longitudinal axis. To retract the wheels, a lever attached to the suspension is moved forward. Attached to the lever are cables which pull the covers shut. The adjustment of the cables relative to the lever and covers is clearly critical since if too short the covers will tend to jam on the suspension and if too long the covers will not close properly. To avoid jamming the tendency

will be for the cables to be set too long and this may be extended as the cables stretch and slacken off. The result will be an imprecise closure of the interruption and a tendency when in the water for the covers to flutter. This would slow the boat and could be noisy.

JP 4,349,009 A (Inoue Nobuaki - Isuzu) describes and shows a cover arrangement for an amphibious retractable wheel. The wheel cover hinges about a longitudinal axis. Again a cable arrangement is used to pull the cover shut but by some undisclosed means. Torsion bars are used to open the cover. Therefore considerable force will be needed to shut the covers and this will tend to stretch the cover closing cables. Again the problem of imperfect closure and hence cover flutter will probably occur.

A more direct cover closure arrangement is incompletely shown in US 5,690,046 (Grzech) where a longitudinally hinged cover is linked in an undisclosed way by a pair of links to a retractable wheel suspension member which pivots about a transverse axis. Again the problem of Moody's arrangement occurs where the covers when closing must be carefully arranged not to jam against the wheel as it is pulled into its housing. Yet again the indirect connection between cover and suspension is likely to cause imperfect cover closure. A further problem is that the relative movement enabled by what could be the linkage between cover and wheel is limited so that the cover when open extends well below the wheel axle and therefore the cover could hit the ground and become deformed or even be torn off. The failure in Grzech's patent to disclose how his linkage worked may indicate that it was not reduced to practice.

An object of the invention is, therefore, to further reduce drag on an amphibious vehicle when in water.

According to the invention, there is provided an amphibious vehicle having retractable road wheels each mounted by means of a wheel suspension to a vehicle body, the body having a planing bottom, wherein the bottom has for each suspension an interruption in the bottom through which at least a part of the suspension can move during retraction or protraction of its said road wheel, wherein the interruption is arranged to be substantially covered by a cover bracketed to the part of the wheel suspension, the cover so arranged that the cover at least partially opens on wheel protraction and wherein the said road wheel is outboard of the cover.

The fixture of the cover to the suspension ensures that its cover pivots about the pivotal axis of the suspension so that the wheel cannot jam on the cover. Preferably, the cover and suspension pivot about a longitudinal axis of the vehicle. The longitudinal axis is in the fore and aft direction.

According to a further aspect of the invention there is provided an amphibious vehicle having road wheels arranged to be raised from a first position where they are road usable to a second position where they are above the water-line of the vehicle, the road wheels being each mounted by means of a wheel suspension to a vehicle body, the body having a planing bottom, wherein the body has for each suspension an interruption in the bottom through which at least a part of the suspension can move during retraction or

protraction of its said road wheel to or from the second position in which said road wheel is outside the interruption, wherein the interruption is arranged to be substantially covered by a cover connected to the part of the suspension, the cover being so arranged so that the cover at least partially opens on wheel protraction.

The arrangement whereby only the at least part of the suspension retracts through the interruption in the bottom of the vehicle whilst leaving the road wheels mainly or completely outside the vehicle reduces the size of the interruption. This also avoids any problem of road wheels and covers jamming. It also ensures a minimum intrusion into the bottom of the vehicle by parts of the vehicle used in road mode.

Preferably the part of the suspension which is retractable into the bottom of the vehicle is a lower suspension member which extends at least mainly in a transverse direction of the vehicle. This limits the longitudinal dimension of the interruption and hence reduces any tendency of the cover to flutter.

Limitation of cover size and extent of the interruption makes it possible to provide an indirect connection between the suspension and cover so that the cover or covers can be hinged to the vehicle body about a different axis or different axes to an axis about which the road wheel is retractable.

In a preferred arrangement, the cover is connected to a lower suspension member, so that when protracting the

wheels, the lower suspension member carries the cover down with it. The bracketed connection between the suspension member and cover may be slightly extensible but the extensibility is only against a strong spring, so that when retracting the wheels, the suspension member may retract into the interruption in the hull; while the cover is constrained to remain flush with the hull surface. Flutter is reduced in this arrangement.

The cover(s) may be hollow bodies, which provide buoyancy to the vehicle on water. In this case, the cover(s) may be made of blow moulded plastic. Alternatively, they may have buoyancy foam attached. The cover(s) may also be profiled to match the hull planing surface, with features like strakes continued across the cover surfaces. The cover(s) may have drains so that on protraction water collected by the cover(s) can drain off. This is applicable to a shaped cover.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 is a diagrammatic side elevation view of an amphibious vehicle according to the invention;

Figure 2 is a transverse cross section through plane II-II of the vehicle of Figure 1 according to a first embodiment of the invention, with the wheels retracted;

Figure 3 is a transverse cross section through plane II-II of the vehicle of Figure 1 according to a first embodiment of the invention, with the wheels protracted;

Figure 4 is a view from below the vehicle of Figure 1 with the wheels retracted;

Figure 5 is a transverse cross section through plane II-II of the vehicle of Figure 1 according to a second embodiment of the invention, with the wheels retracted;

Figure 6 is a view from below the vehicle of Figure 5 with the wheels retracted; and

Figure 7 is a transverse cross section through plane II-II of the vehicle of Figure 1 according to a third embodiment of the invention, also with the wheels retracted.

Amphibious vehicle 2 has a prime mover 4 driving a pump jet 6 through a marine transmission. Locomotion on road is provided by wheels 8, which are driven through a road transmission. The wheels are shielded by wheel arches 12. The vehicle body comprises an upper body 14 and a hull 16, which are formed separately and joined at split line 18. A chassis is also provided, as is described below. If this chassis is bonded to the bodywork, it may be regarded as part of the overall body structure. The hull has a planing surface 20. A driver's seat 22 is provided with one or more passenger seats 24 astern of the driver's seat. The seating axis is on the longitudinal axis of the vehicle, or parallel thereto. The axis of the prime mover is also along, or parallel to, the longitudinal axis of the vehicle. Driver

controls are provided, in this case handlebars 26. A windscreen 28 is provided for weather and spray protection.

Figures 2 and 3 show a pair of rear wheels 8 mounted on hubs 54. The hubs are driven by intermediate shafts 62 and layshafts 60, which are driven from the prime mover 4. The intermediate shafts are supported inside lower suspension members 40 respectively which are each in the form of a tube. The tubelike members 40 are pivotally mounted at their inner ends on bearings 42. The outer ends of members 40 are connected to upright members 52, which carry hubs 54. Upper suspension members 56 connect between vehicle chassis 30 and upright members 52.

As can be seen in Figure 4, hull 16 has a planing bottom 20, in which there are gaps 80 forming interruptions in the bottom through which lower suspension members 40 can move, from a retracted position of the wheels as shown in figure 2, to a protracted or wheels down position as shown in Figure 3.

Fixed to lower suspension members 40 are covers 34, which are fixed by means of inner and outer brackets 36 and 38 (Figure 3) to members 40, so that the covers pivot about bearings 42. Gaps 80 are defined by body edges 84, 86, and 88. Covers 34 when closed substantially fill gaps 80, only leaving small clearance gaps 90 necessitated by the need to distance the outer faces of the covers from the centres of bearings 42. One way drains 35 are provided in the covers. The gaps 90 may be eliminated by the provision of flexible material. The brackets 36 and 38 may be made slightly extendable against a strong spring to allow for driftwood or

other flotsam catching between one of the covers and the bottom. The spring should be strong enough to prevent flutter.

In order to achieve complete filling of clearance gaps 90, a second proposal has a pair of covers 92 and 94 for each interruption in the hull surface, which are hinged at 96 and 98 on one side and at 100 and 102 on the other side of the planing surface 20. This is shown in Figures 5 and 6. Door 92 is shown figuratively in an open position here, although the suspension is retracted; on the right hand side of the Figure, a dashed outline of the corresponding door is shown.

Each cover 92, 94 of each pair hinges about a transverse axis of the vehicle so as to fill half of each gap 80. The covers are split into pairs in "barn door" style to reduce downward protrusion below the hull surface 20 when the covers are open. The covers may be made flexible to avoid breakage on striking rocks, etc. They may also protect the wheel suspensions from impact damage, e.g. scratching of anti-corrosive coatings. The simplest and most foolproof means of opening these covers is to arrange for them to be held shut by springs 110 and 112 (Figure 5) when wheels are retracted, and pushed open by the suspension as the wheels protract. Alternatively, mechanical linkages to the wheel suspensions may be arranged. Such linkages could be designed to impart a translating movement to the covers, so that they move transversely across the vehicle before or during deployment.

It may be found that the travel of hull gap covers attached to suspension members is preferred to be less than that of

the retractable suspension. Particularly where a narrow hull is combined with a large vee angle, as seen in the Figures, it will be necessary for the wheels to be tipped up at a large angle to the road position to keep them above the water line when cornering on water. In this case, if the covers are constrained to move through the same angles as the lower suspension members, covers which are flush with the hull when the wheels are retracted may hit the ground when the wheels are protracted; conversely, covers which as shown in figure 3, clear the ground adequately in road mode, will be drawn up above the hull line when the wheels are retracted.

This mechanical contradiction may be averted by breaking the fixed mechanical link between the covers and the suspension members. Figure 7 shows such an arrangement with the wheels retracted. Cover 180 on the right hand side of the Figure (left hand side of the vehicle) is shown retracted, as it would be with the wheels retracted; but cover 180 on the left hand side of the Figure (right hand side of the vehicle) is shown figuratively in a protracted position, to show linkage 182.

When the suspension is protracted, covers 180 are pushed down below planing surface 20 by stops 194 mounted on the lower suspension members. In this position, covers 180 are stabilized by linkages 182. When the suspension is retracted, pins 194 also retract; and covers 180 are pulled up towards surface 20 by tension springs 192, which are tethered above surface 20. The suspension members will be pulled up inside the hull as far as is required to fully retract the wheels; but the covers will be held in place

flush against the hull by tabs 104, which are moulded into the hull for this purpose. Alternatively, tabs 104 may be moulded into the covers. Linkages 182 collapse for storage, as shown on the right hand side of the Figure.

It will be appreciated that further modifications to the suspension layout described above may be made as required without departing from the spirit and scope of the invention. For example, the covers described may be applied to a non-driven, and/or a steered, axle. Rather than the lower suspension members being tubular, they may be solid, or wishbones.

CLAIMS

1. An amphibious vehicle having retractable road wheels each mounted by means of a wheel suspension to a vehicle body, the body having a planing bottom, wherein the bottom has for each suspension an interruption in the bottom through which at least a part of the suspension can move during retraction or protraction of its said road wheel, characterised in that the interruption is arranged to be substantially covered by a cover bracketed to the part of the wheel suspension, the cover so arranged that the cover at least partially opens on wheel protraction and wherein the said road wheel is outboard of the cover.

2. An amphibious vehicle according to claim 1, where the cover is fixed to the suspension so as to be at least partly rotatable about an axis parallel to the vehicle's longitudinal axis.

3. An amphibious vehicle according to claim 1 or 2 wherein the suspension has an upper and a lower suspension member fixed to the body so as to enable movement of the suspension about an axis parallel to the vehicle's longitudinal axis.

4. An amphibious vehicle according to any of the above claims, where the cover is bracketed to a lower suspension member.

5. An amphibious vehicle having road wheels arranged to be raised from a first position where they are road usable to a second position where they are above the water-line of the vehicle, the road wheels being each mounted by means of a

wheel suspension to a vehicle body, the body having a planing bottom, wherein the body has for each suspension an interruption in the bottom through which at least a part of the suspension can move during retraction or protraction of its said road wheel to or from the second position in which said road wheel is outside the interruption, wherein the interruption is arranged to be substantially covered by a cover connected to the part of the suspension, the cover being so arranged so that the cover at least partially opens on wheel protraction.

6. An amphibious vehicle as claimed in claim 5 where the part of the suspension which is retractable into the bottom of the vehicle is a lower suspension member which extends at least mainly in a transverse direction of the vehicle.

7. An amphibious vehicle according to claim 5 or 6, where the fixture of the cover to the body of the vehicle is hinged by means of a hinge or hinges, with hinge axes parallel to the vehicle's transverse axis.

8. An amphibious vehicle according to any one of claims 5 to 7, where the cover is movably connected to the body by a linkage.

9. An amphibious vehicle according to any one of claims 5 to 8, where the cover is connected to the body by an extensible sprung connection, and constrained to not pass within the hull by tabs projecting from said cover, which abut against the hull as the suspension is retracted.

10. An amphibious vehicle according to any one of claims 1 to 9, where the cover is constrained to be prevented from passing through the interruption into the hull by an overlap of the bottom around the interruption or by an overlap of the cover around the interruption.

11. An amphibious vehicle according to claim 10 wherein the overlap comprises several tabs.

12. An amphibious vehicle according to any one of the preceding claims wherein flexible material is provided between the bottom of the vehicle and the cover at the inboard end of the cover.

13. An amphibious vehicle according to any one of the preceding claims wherein the cover has a drain therethrough.

14. An amphibious vehicle according to any of the above claims, where the cover is formed as a buoyant body.

15. An amphibious vehicle according to claim 14, where the cover is formed as a hollow body.

16. An amphibious vehicle as herein described and as illustrated in any one or more of Figures 1 to 7.

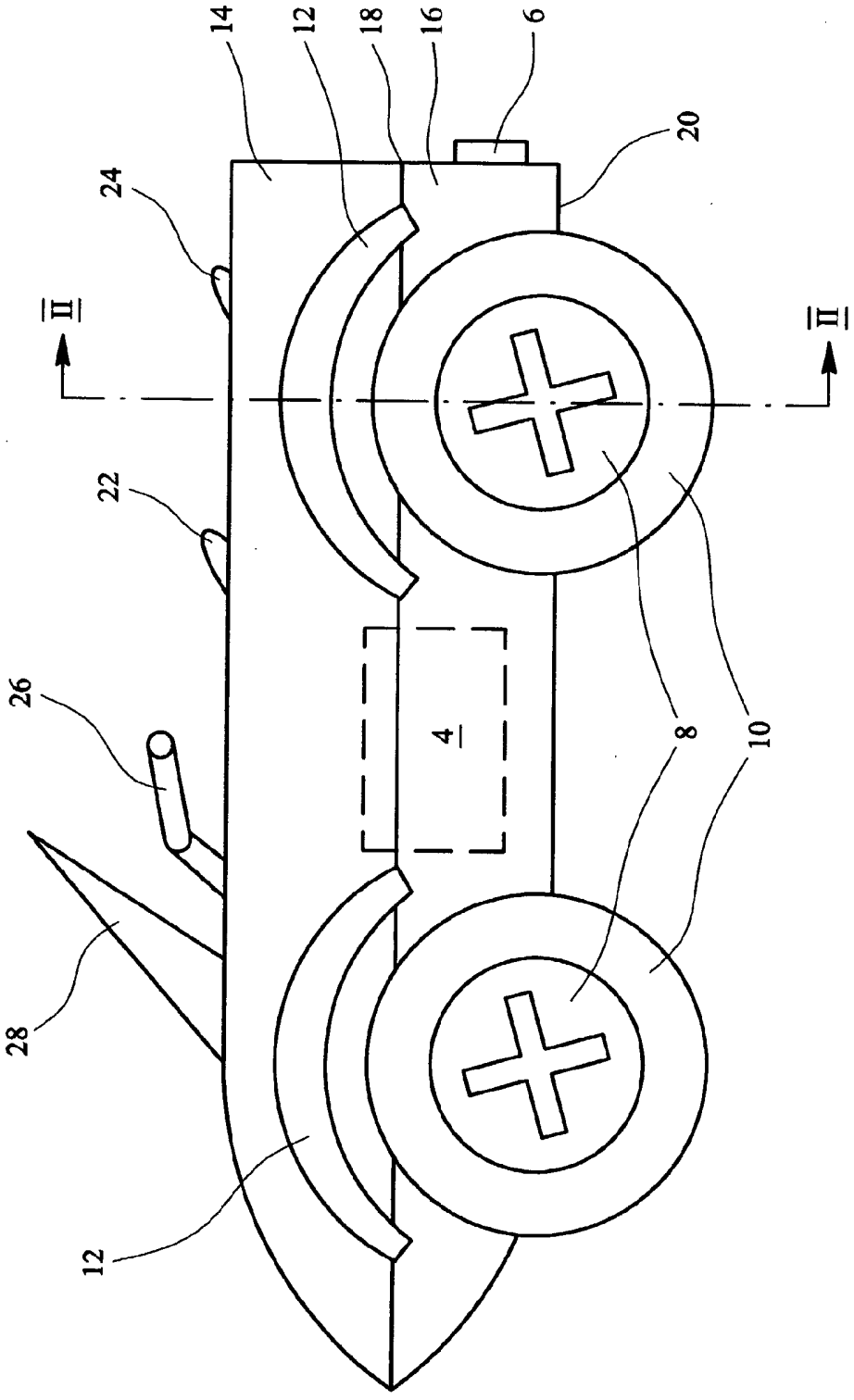

FIG. 1

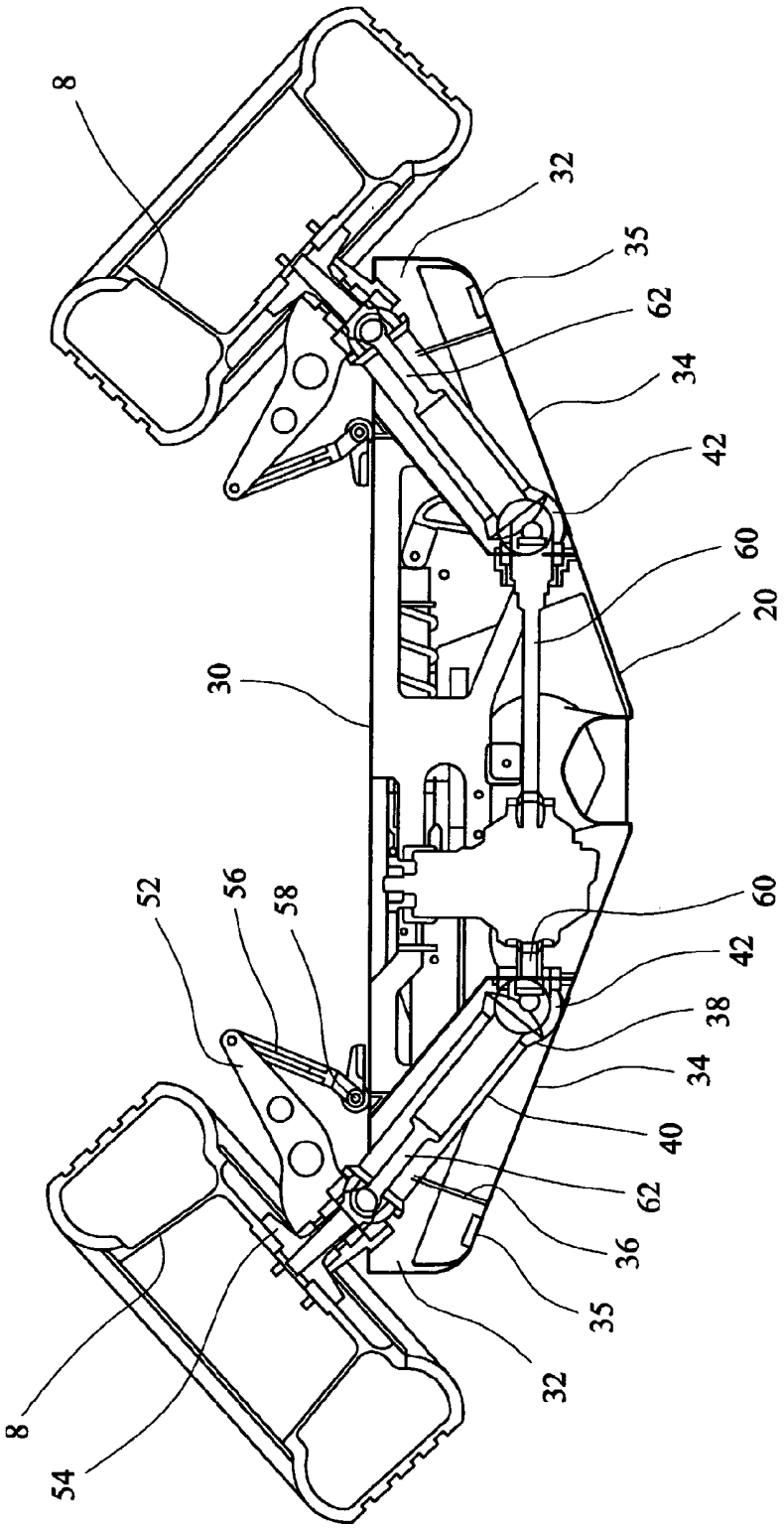

FIG. 2

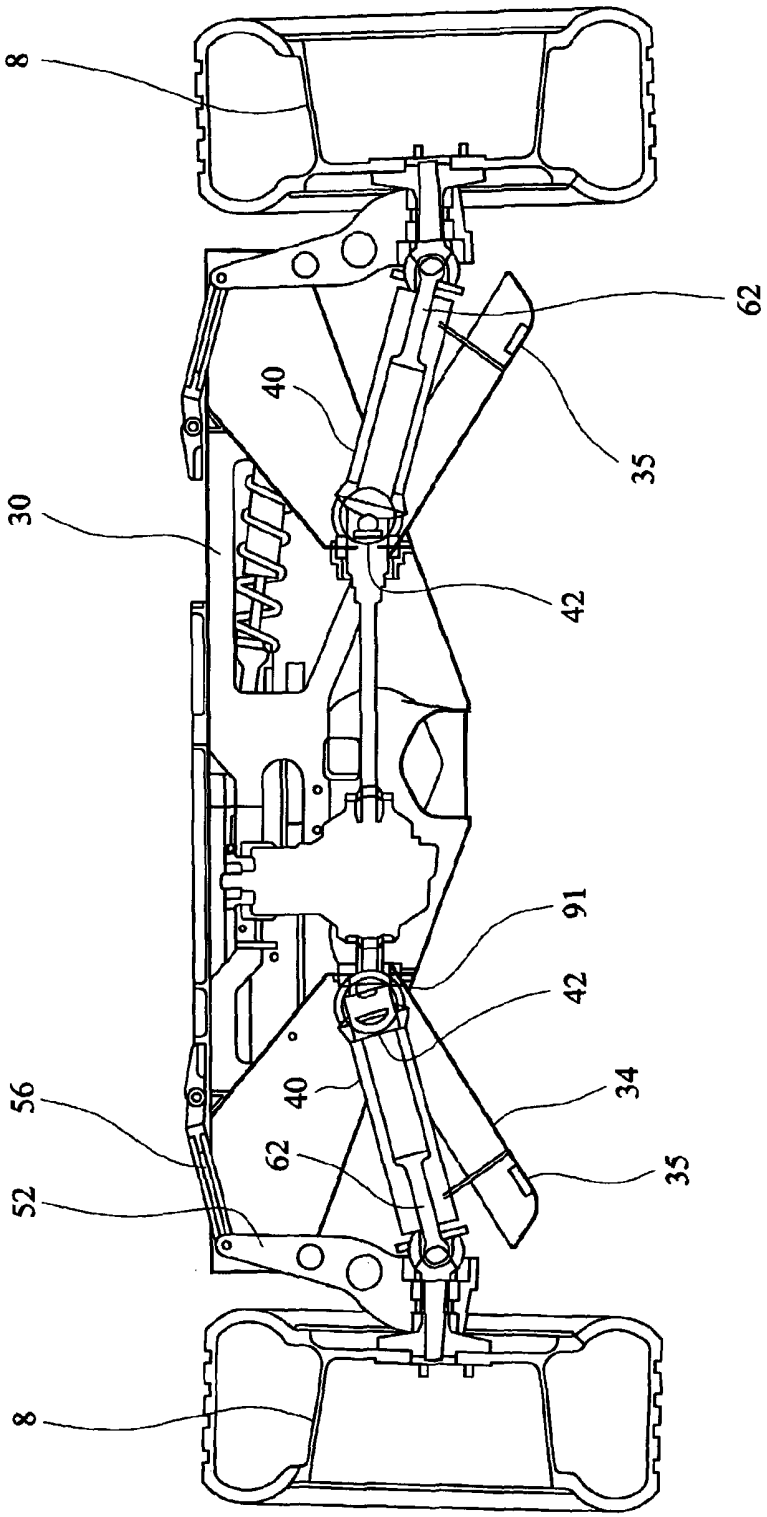

FIG. 3

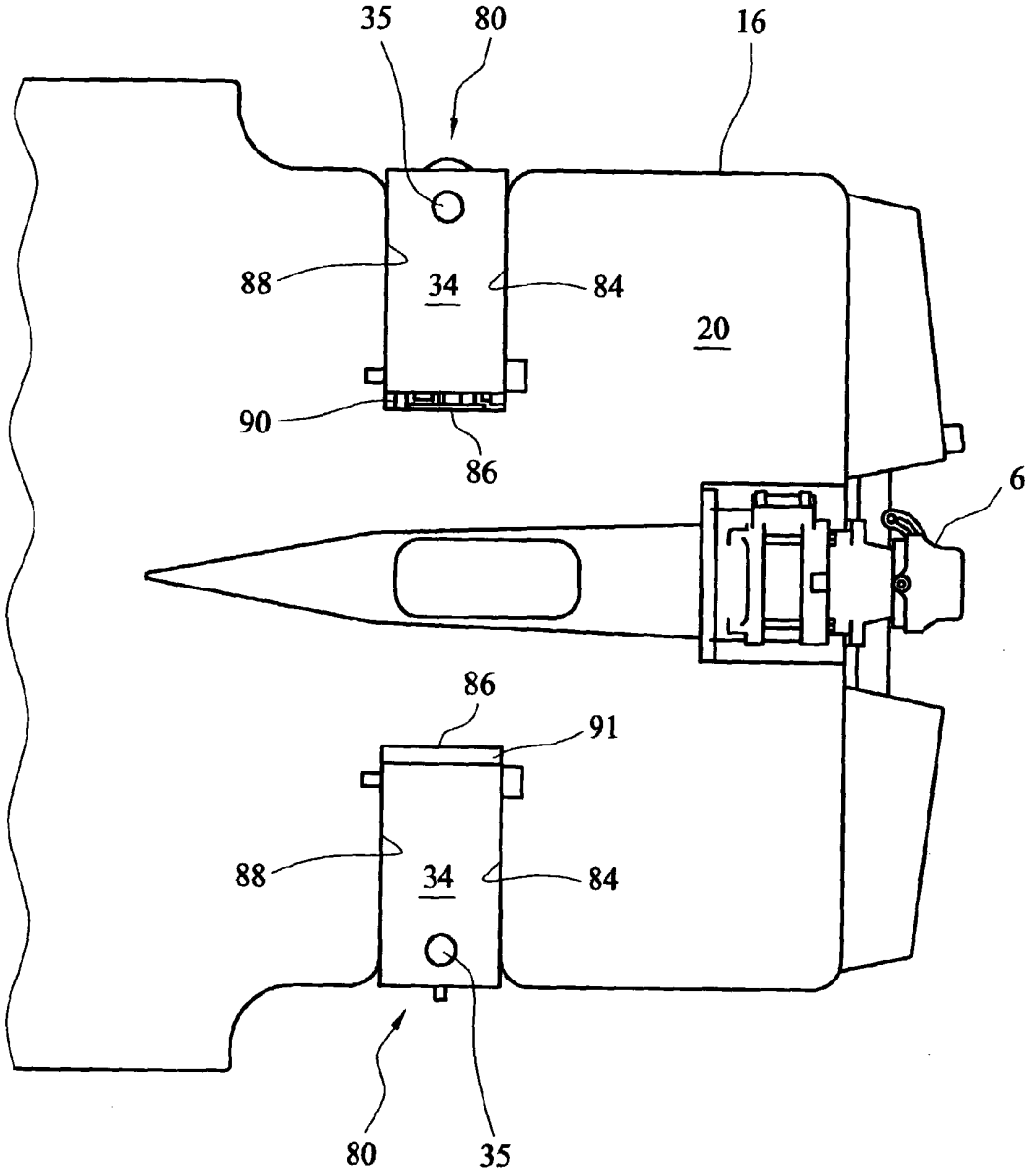

FIG. 4

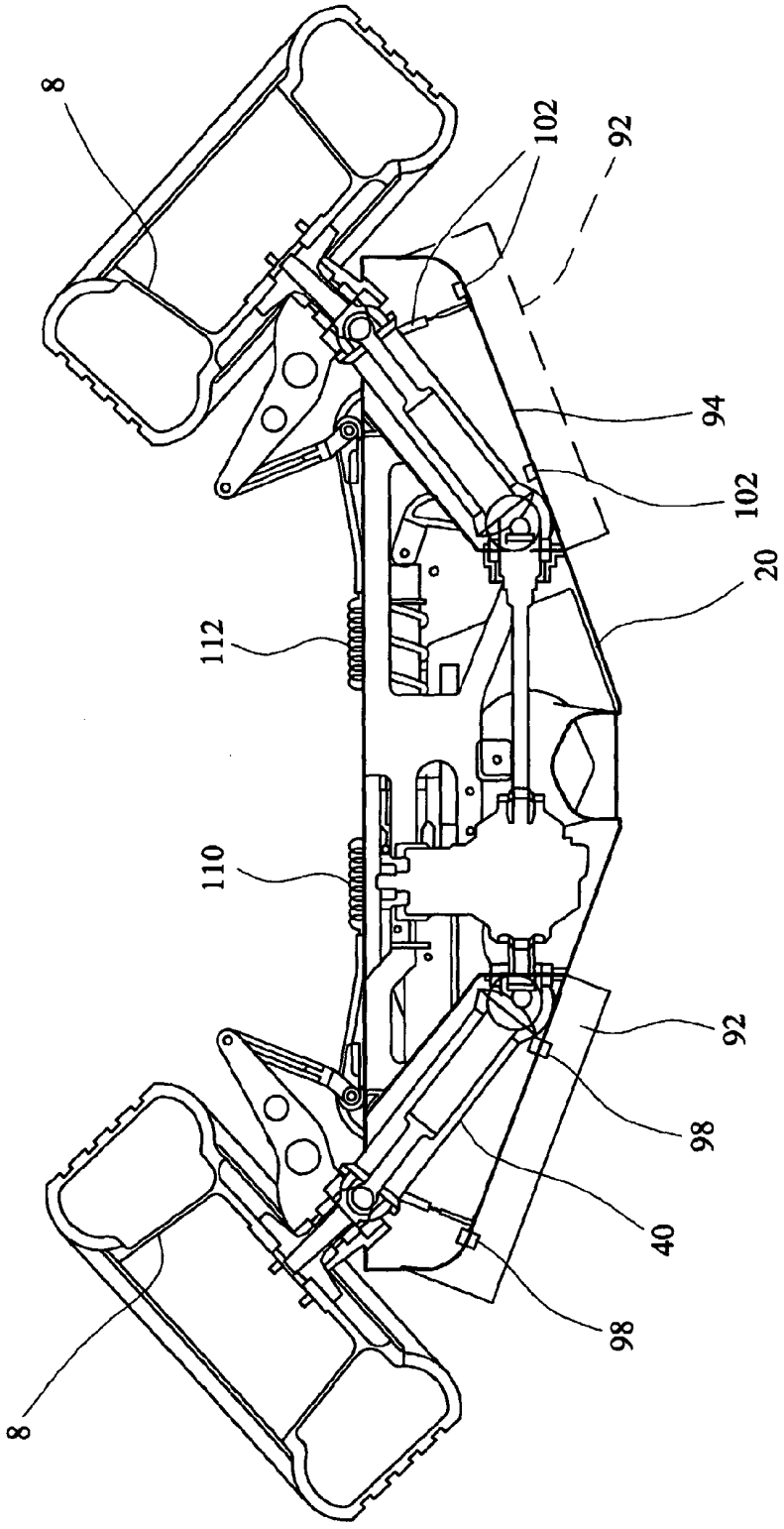

FIG. 5

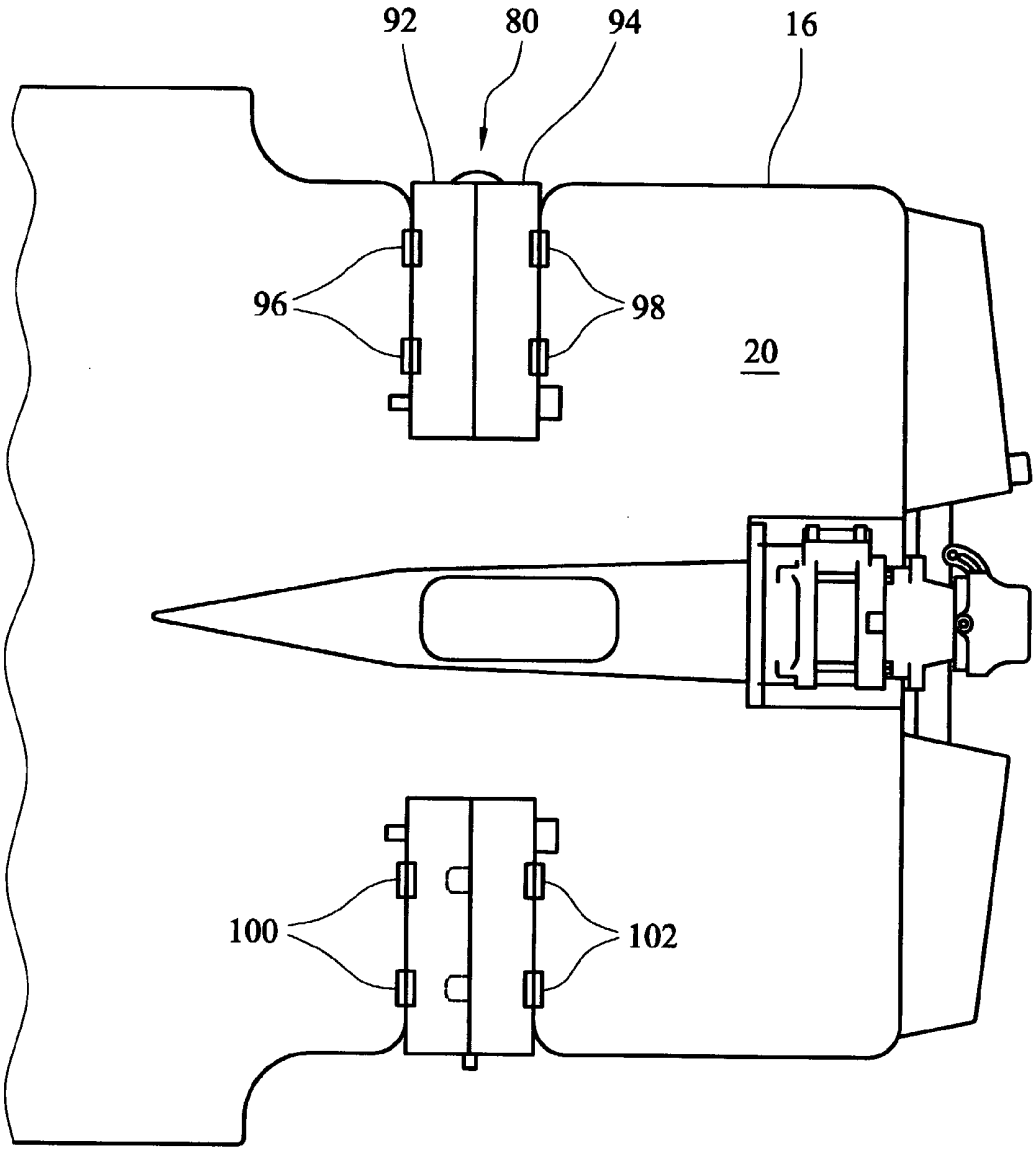

FIG. 6

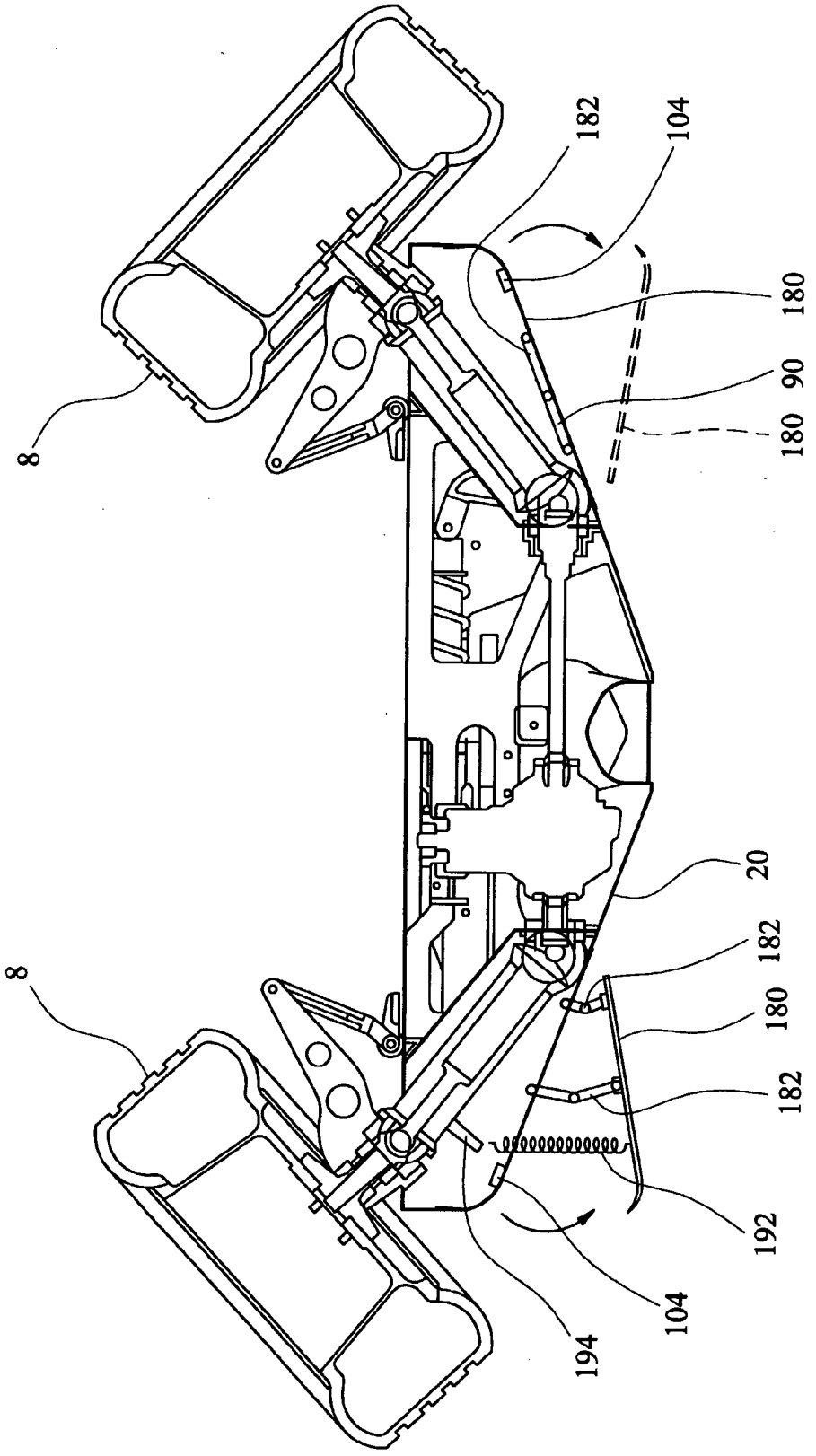

FIG. 7

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB2005/003999

A. CLASSIFICATION OF SUBJECT MATTER
B60F3/00

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)
B60F B63C B62D

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, PAJ, WPI Data

C. 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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X	US 5 690 046 A (GRZECH, JR. ET AL) 25 November 1997 (1997-11-25) cited in the application column 11, line 51 - column 12, line 17; figures 8,11-13	1,2,5,7, 8,10
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
28 December 2005	05/01/2006

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, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Untermann, N

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INTERNATIONAL SEARCH REPORT

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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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Information on patent family members

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