United States Patent [19]

Rapson

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[54] **SKIRTS OF GAS CUSHION VEHICLES**

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[73] Assignee: **Hovercraft Development Limited,** London, England

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[30] **Foreign Application Priority Data**

June 6, 1972 United Kingdom..... 26324/72

[52] **U.S. Cl.**..... **180/117;** 180/127; 244/23 R

[51] **Int. Cl.**..... **B60v 1/00**

[58] **Field of Search** ..... 180/116, 117, 127, 124, 180/128, 126, 120, 121, 123, 122; 114/67 A; 244/23 R

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Assistant Examiner—Galen L. Barefoot
Attorney, Agent, or Firm—Cameron, Kerkam, Sutton, Stowell & Stowell

[57] **ABSTRACT**

Pitch, roll or heave control of a gas cushion vehicle is effected by the provision of a skirt comprising upper and lower parts of flexible sheet material at least the lower part being formed by a succession of wall members each presenting a concavity to the cushion and having inwardly extending side portions connected to the vehicle by ties. Adjusting members to act to cause or allow swinging movement of the ties in a substantially horizontal plane to produce movement of the wall members towards or away from the vehicle periphery. The adjusting members preferably comprise ties extending substantially at right-angles to, and connected to the ties of, the side portions. The skirt may be divided into any desired number of sections arranged for adjustment in unison or individually.

10 Claims, 15 Drawing Figures

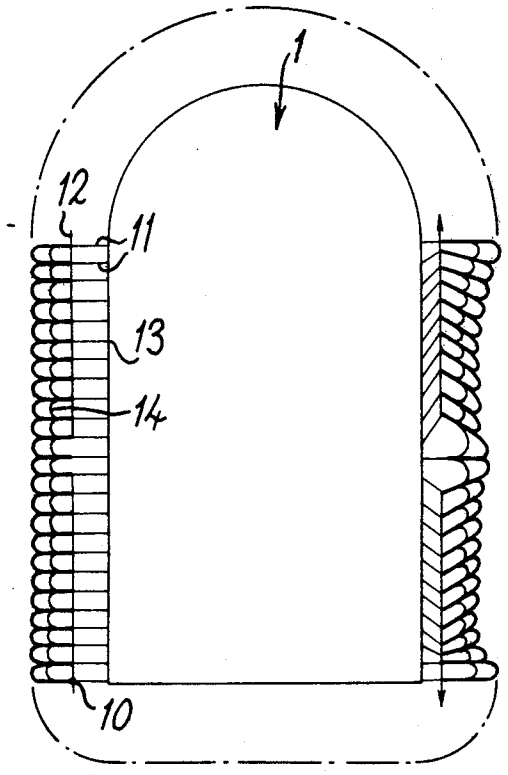


Fig. 1.

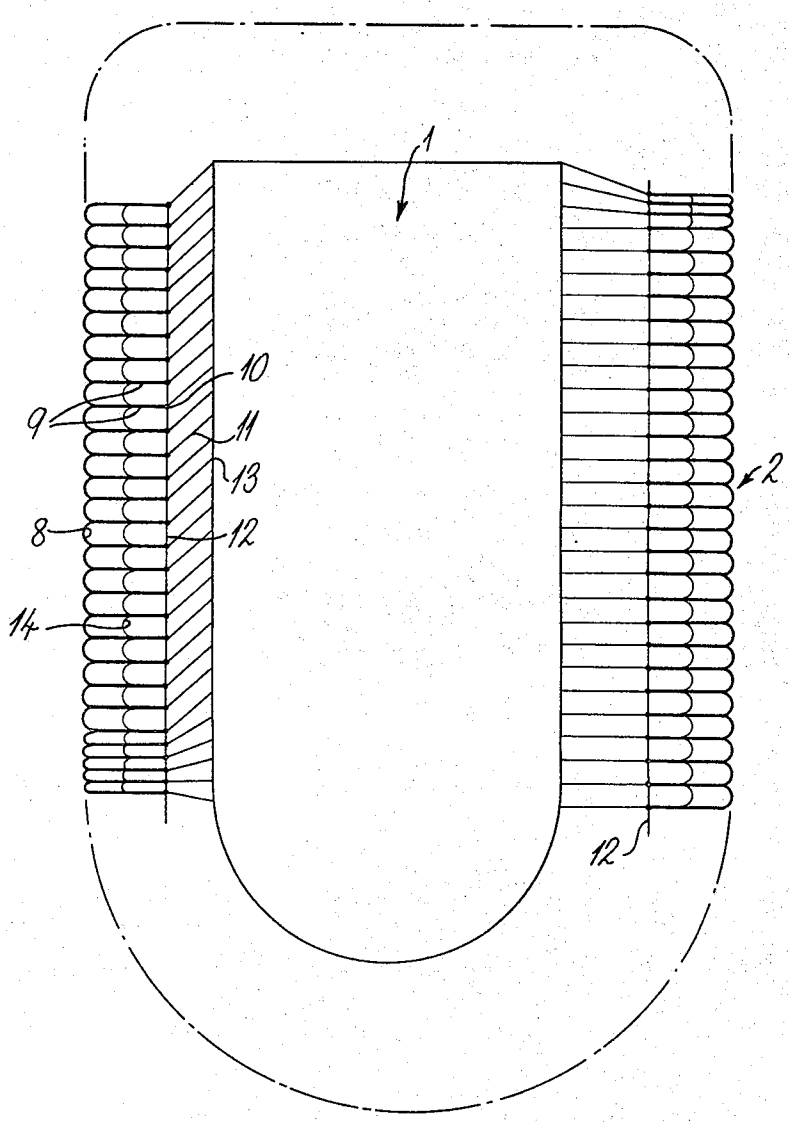
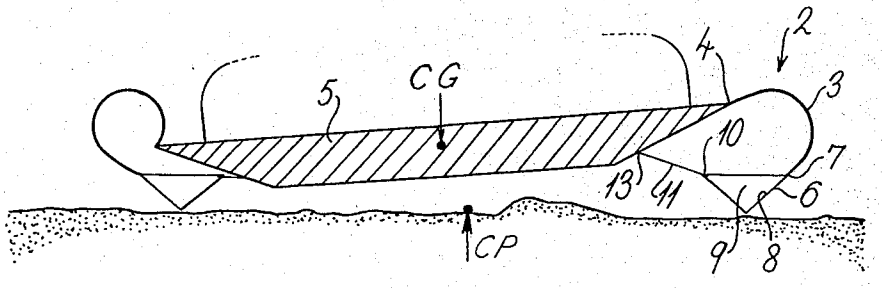
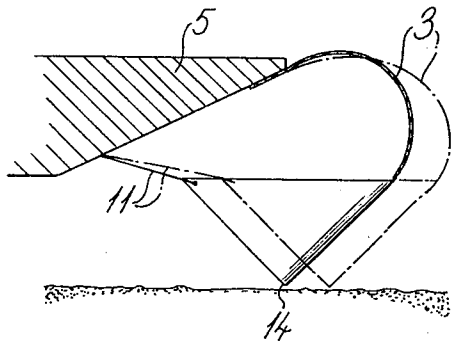


Fig. 2





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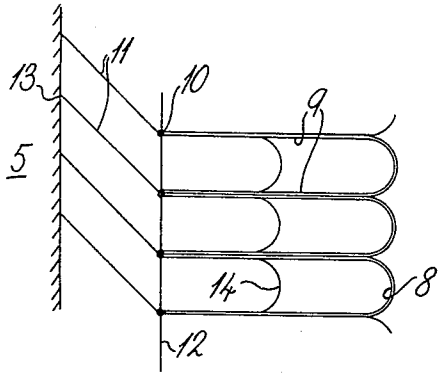


Fig. 4.

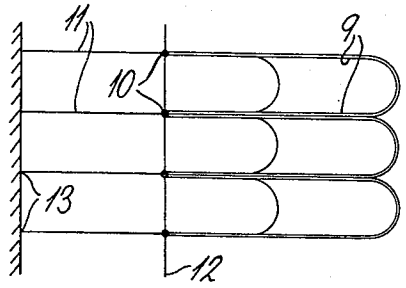


Fig. 5

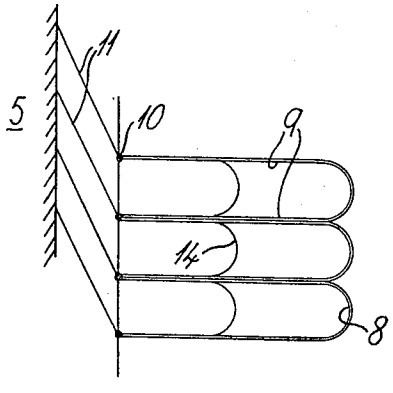
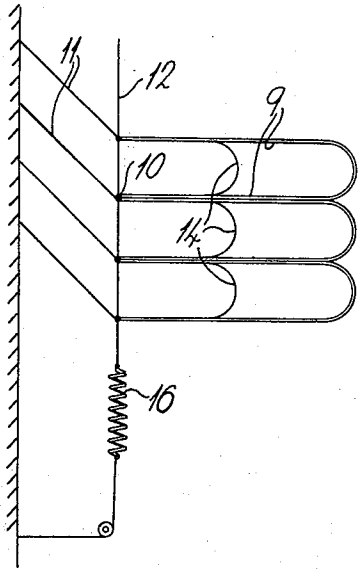


Fig. 6.

Fig. 7.



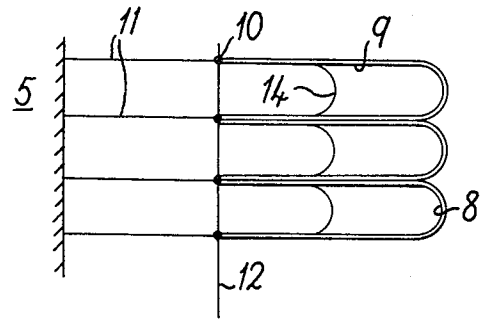


Fig. 8

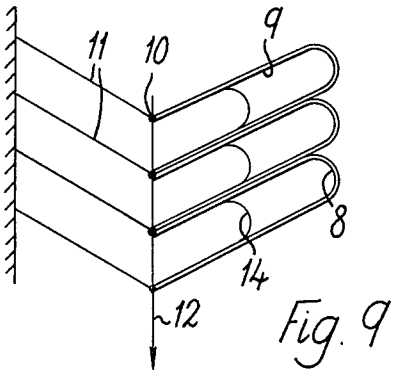


Fig. 9

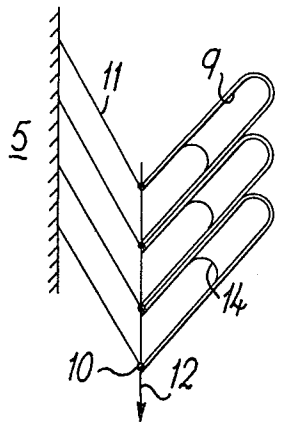


Fig. 10

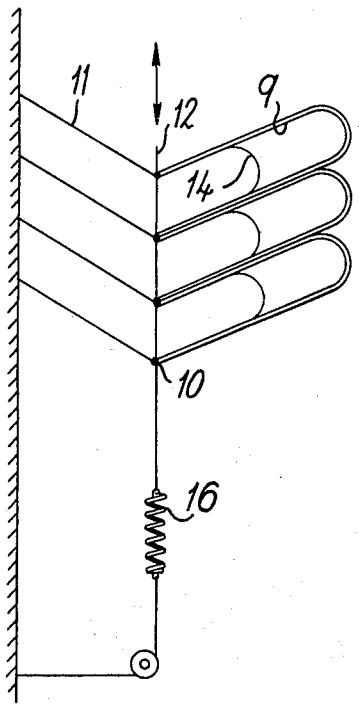


Fig. 11

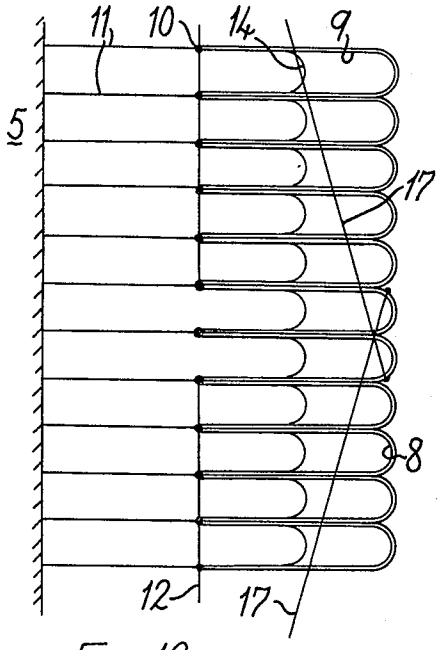


Fig 12

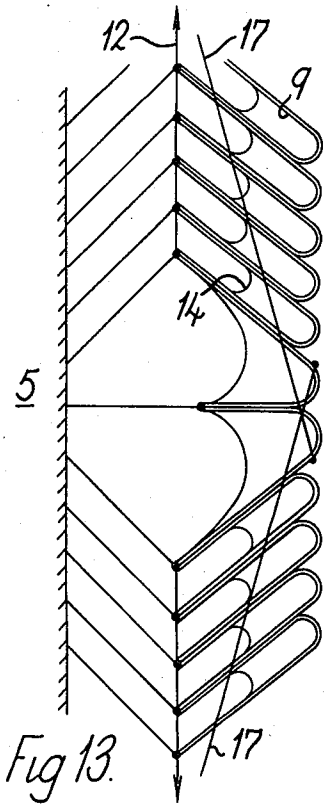
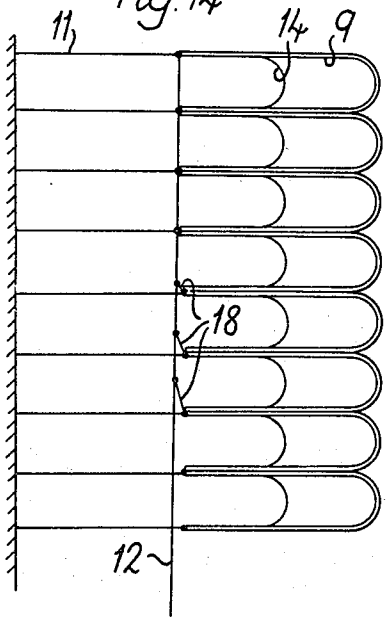


Fig 13.

Fig. 14



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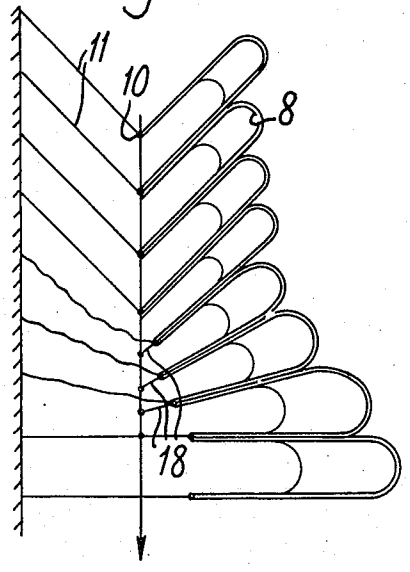
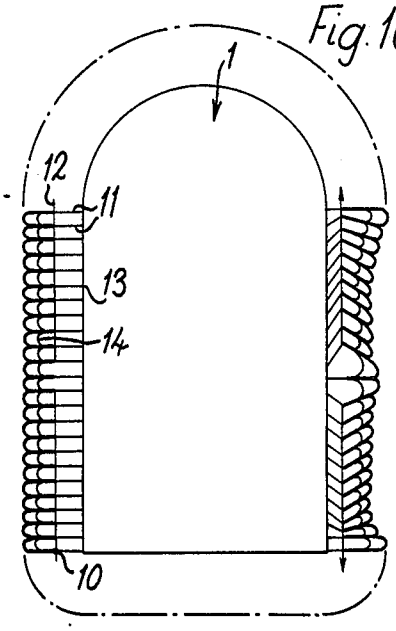


Fig. 16



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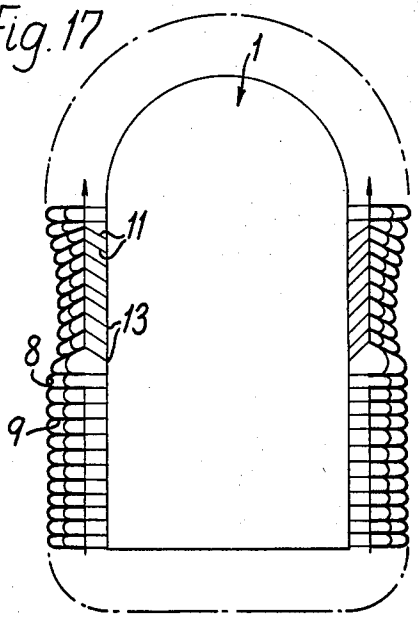


Fig. 18

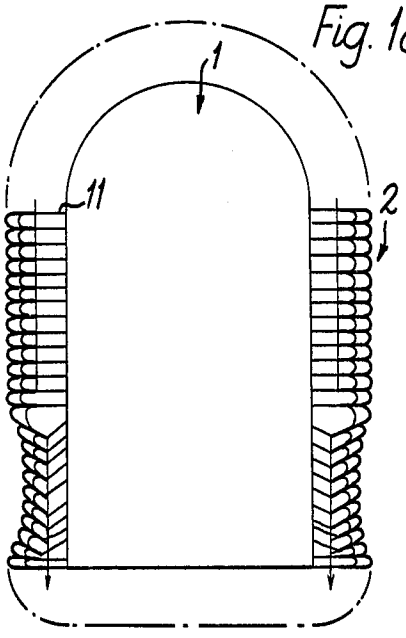
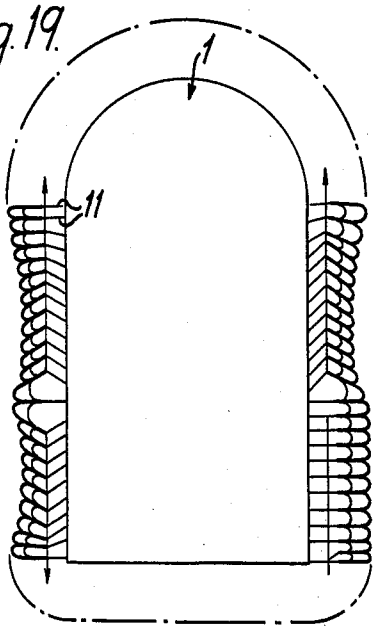


Fig. 19



SKIRTS OF GAS CUSHION VEHICLES

This invention relates to cushion containing skirts of gas cushion vehicles and more particularly to means whereby lateral adjustment of such skirts may be effected at will or be arranged to occur automatically so as to occasion a shift in the position of the centre of pressure of the gas cushion contained thereby in relation to the centre of gravity of the vehicle, or to alleviate pressure fluctuations in the cushion.

According to one aspect of this invention a skirt for a gas cushion vehicle comprises upper and lower parts of flexible sheet material, the upper part being connected to the vehicle body so as to be deflectable relative thereto, at least the lower part comprising a contiguous succession of independently deflectable flexible wall members each having an outer portion which faces the gas cushion and a pair of inwardly extending side portions, the side portions being connected to the vehicle body by tie means, in which means are provided to cause or allow the tie means to swing in a substantially horizontal plane about their attachments to the vehicle and thereby result in the outer portions of the wall members being moved laterally relative to the vehicle body.

Conveniently the tie means may comprise substantially inextensible cords, ropes, wires or the like and the means for causing or allowing the same to swing in a substantially horizontal plane about their attachments to the vehicle may comprise one or more further cords, ropes or ties extending substantially at right angles to the side portions of the wall members being connected to each of the same either directly or indirectly e.g. via the tie means. The further tie means is conveniently arranged to hold the side portions of the wall members at the desired spacing. Longitudinal movement of the further tie means will then cause the inner extremities of the individual side portions of the wall members to describe an arcuate path about the attachment points of their ties to the vehicle, to occasion a lateral adjustment of the position of the wall members in relation to the vehicle.

It will be appreciated that lateral adjustment of a skirt, i.e. towards and away from the vehicle periphery, can thereby be achieved to combat roll, pitch and heave of a vehicle in an analogous manner to that proposed to be achieved by other skirt adjusting means, such as the means disclosed in Moore U.S. Pat. No. 3,420,329, but the mechanism in accordance with the present invention has the advantage of greater simplicity than known means.

According to another aspect of the invention, to improve the ride of the gas cushion vehicle resilient means are incorporated in or associated with the tie means or the skirt adjusting means so as to allow lateral adjustment of the skirts in dependence upon the cushion pressure.

The invention is further described below with reference to the accompanying drawings in which:

FIG. 1 is a diagrammatic plan view of a gas cushion vehicle fitted with a skirt in accordance with the invention;

FIG. 2 is a transverse section of the vehicle of FIG. 1;

FIG. 3 is a transverse section through the skirt of the vehicle of FIGS. 1 and 2;

FIGS. 4, 5 and 6 are diagrammatic plan views of the skirt indicating the manner in which lateral adjustment thereof is achieved;

FIG. 7 is a view similar to FIGS. 4–6 showing a modification thereof to render it responsive to variation in cushion pressure;

FIGS. 8 to 11 correspond to FIGS. 4 to 7 showing a modification of the skirt thereof;

FIGS. 12 and 13 are further diagrammatic plan views of a skirt in accordance with FIGS. 8 to 10, in which separate sections of the skirt are arranged for independent adjustment, as well as in unison;

FIGS. 14 and 15 are still further diagrammatic plan views showing how movement of the wall members forming the skirts in accordance with FIGS. 12 and 13 may be phased out at the extremities of a skirt section, and

FIGS. 16 to 19 are diagrammatic plan views of a vehicle fitted with a skirt in accordance with FIGS. 12 and 13 indicating various ways in which the skirt sections may be operated.

Referring to FIGS. 1–3, a gas cushion vehicle 1 is provided with a skirt 2 comprising upper and lower parts formed of flexible sheet material, the upper part 3 comprising a simple sheet having a first edge 4 which is attached to the periphery of the vehicle body 5, and a second edge 7 to which the lower part 6 is connected. The lower part 6 comprises a contiguous succession of independently deflectable wall members of the kind described in British Pat. No: 1,043,351, each comprising, as best seen from FIGS. 4–7, an outer portion 8 and a pair of side portions 9, the inner extremities 10 of which are connected to the vehicle body 5 by ties 11.

Referring now to FIGS. 4–6, a further or adjusting tie 12 is provided extending substantially at right angles to the side portions 9 of the wall members and parallel to the associated side of the vehicle body, to which the inner extremities 10 of the side portions are connected at the desired predetermined spacing or pitch interval. As will readily be understood from FIGS. 4–6, by pulling on the tie 12 the inner extremities of the side portions 9 will be caused to describe an arcuate path about the attachment points 13 of their associated ties 11 to the vehicle body 5 and thus occasion lateral adjustment of the wall members in relation to the vehicle. In consequence the seal point of the lowest extremity 14 of the segments will be moved substantially horizontally inwards (as well as forwards or backwards as the case may be) so as to occasion a shift in the centre of pressure of the vehicle supporting gas cushion in relation to the centre of gravity of the vehicle. FIGS. 1 and 2, of course, illustrate the case of skirts provided at the sides of a vehicle which may be laterally adjusted to produce a transverse shift of the centre of pressure of the cushion in relation to the centre of gravity of the vehicle in order to combat roll or to bank a craft in an appropriate manner when effecting turns.

In order to provide for lateral movement of the skirts both towards and away from the centre line of the vehicle the normal or datum position of the ties 11 which constrain the skirt against outward deflection by the pressure of the cushion it contains, may be set at an angle to the lateral axis of the craft as indicated in FIG. 4. Then by releasing the tension in the tie 12 outward movement of the skirt will be allowed to take place under the influence of the outwardly directed forces exerted thereon by the pressure of the cushion, and

conversely by pulling on the tie **12** inward movement of the skirt can be occasioned against the said forces.

The movement of the wall members as depicted in FIGS. **4** to **6** assumes that the upper part of the skirt does not impose any constraint, within the limits concerned, upon their ability to move longitudinally. Hence upon adjustment the wall members, or more particularly their side portions, are shown as remaining normal to the longitudinal axis of the vehicle. If it was desired that the side portions of the wall members should at all times extend substantially normal to the longitudinal axis of the vehicle, and the material of the upper part of the skirt was incapable in itself of sufficient longitudinal stretching, then additional material could be provided in the upper part of the skirt in, for example, the form of corrugations. Conveniently, the additional material of the upper part of the skirt could be provided at each end of an operative section of skirt and would be fitted with an appropriate number of wall members.

The longitudinal movements of the wall members, i.e. their movement parallel to the adjacent parts of the vehicle body, which will occur upon operation of the adjusting ties **12,** will tend to cause bunching of the wall members at one end of an operative length of skirt. This bunching will of course be more pronounced in the case in which an additional length of upper skirt fitted with wall members is provided. If found necessary, longitudinal movement of the side portions of the last few wall members at the ends of a section of skirt may be phased out by the use of suitable elastic ties.

A modification of the skirt system described above which will contribute towards an improved ride of the vehicle is indicated in FIG. **7.** Thus resilient means such as a spring **16** is incorporated in each longitudinally extending tie **12** so as to allow longitudinal movement thereof in dependence upon fluctuations in cushion pressure. Starting with the skirt and ties in the datum position indicated, an increase in the cushion pressure which will increase the tension in the tie **12** will occasion extension of the spring **16** to allow the skirt to "pay out." A subsequent reduction in the cushion pressure to its standard value will allow the spring **16** to take charge to return the skirt to its initial position.

Such lateral adjustment of the skirt will allow the skirt contained volume to increase as cushion pressure rises and to return to its normal value when the cushion pressure falls to its standard value, so as to reduce the forcing on the craft, since part of the energy normally responsible for the heave acceleration otherwise experienced by the vehicle, due for example to the passage of waves through the cushion, will be dissipated by deforming the skirt laterally. Naturally the degree of stretch of the skirt should be limited so that its geometry does not become distorted beyond its normal operating range, but even the ability to accommodate changes of a few percent of cushion volume should attenuate fluctuating forces in heave and thus improve the ride experienced by passengers.

Plainly the tension in the spring and its rate can be adjusted as desired to cater as required for automatic lateral skirt adjustments in response to variation in cushion pressure both above and below a standard value and also to cater for variations in the standard value depending upon the load carried by the vehicle.

The ties **12** may be rendered resilient in any desired manner other than by springs **16** as described in order to allow automatic lateral adjustment of the skirt in response to fluctuations in cushion pressure. Alternatively or in addition the ties **11** may be rendered resilient to achieve the same end. Although by virtue of their simplicity it is thought desirable that the ties **11** and **12** should comprise flexible cords, ropes, wires or the like, plainly this is not essential. Thus for example, both sets of ties could comprise rigid bars appropriately pivotted to the vehicle or side portions of the wall members as the case may be. If the ties **11** were rigid then their angular adjustment could be effected other than by the longitudinally extending ties **12** (which might indeed be dispensed with) and separate means may be provided to move the ties **11** in the required manner. It will also be appreciated that it is not essential for the ties **12,** in whatever form they might take, to be connected to the inner extremities of the side portions of the wall members as illustrated. The ties **12** could indeed be connected to the ties **11** at any desired point intermediate their connections to the wall members and the vehicle.

Referring now to FIGS. **8** to **10** a modification of the skirt in accordance with FIGS. **4** to **6** is illustrated in which the basic construction of the skirt is the same as that of FIGS. **4** to **6,** and the parts thereof are identified by the same reference numerals as therein, but it is arranged to prevent or at least to restrict longitudinal movement of the wall members making up the skirt, that is to say movement in a direction parallel to the periphery of the skirt, upon operation of the adjusting ties **12.** This arrangement has the advantage that lateral movement of the skirt for a given movement of the adjusting ties **12** is increased compared with the arrangement of FIGS. **4** to **6.** Upon operation of an adjusting tie **12** the upper edges of the outer portions **8** of the wall members associated therewith will be moved along a substantially horizontal path in a vertical plane at right-angles to the longitudinal axis of the vehicle, and the side portions **9** of the wall members will be raked forwards or backwards depending upon the direction of movement of the tie **12,** as indicated in FIGS. **9** and **10.** Otherwise the operation of the skirt in accordance with FIGS. **9** to **10** will be directly comparable to that of FIGS. **4** to **6.**

In FIG. **11** a skirt in accordance with FIGS. **8** to **10** is illustrated incorporating the modification of FIG. **7.**

Referring now to FIGS. **12** and **13,** two sections of skirt in accordance with FIGS. **8** to **10** are shown as being provided along one side of a vehicle. A separate adjusting tie **12** is associated with each skirt section, one arranged to be moved in one direction to effect lateral adjustments of its associated skirt section, and the other being arranged to be moved in the opposite direction to effect a comparable movement of its associated skirt section. When both ties **12** are operated together the longitudinal forces which would tend to shear the wall members of the skirt, i.e. cause longitudinal movement of the wall members forwards in respect of a front section, and rearwards in respect of a rear section, are balanced out. If, however, it is desired to operate any one section independently, it is necessary to provide additional restraining ties **17.**

It will be noted that the side portions of the wall members which abut at the junction between the skirt sections are not connected to the adjusting ties **12** associated therewith. The restraining ties **17** are passed through the space provided by the upper part **3** of the

skirt above the side portions **9** of the wall members forming the lower part of the skirt, from a convenient attachment point to the vehicle body at one end to a point at or adjacent the outer portion of the wall member at the inner end of the distal skirt section. Thus in the event of the operation of the adjusting tie **12** of only one skirt section, the relevant restraining tie **17** sympathetic movement of the other skirt section on the same side.

Whether or not the adjusting ties **12** are operated individually or in unison the innermost wall member of the skirt section with which they are associated will be splayed as illustrated in FIG. **13.** By virtue of the fact that the innermost side portion of the inner wall member of each skirt section is not connected to the associated adjusting tie **12,** it is ensured that a seal is maintained between the skirt sections. The forces exerted on the wall members by the cushion pressure of course at all times acts inter alia to urge the adjacent side portions of neighbouring wall members together to effect seals between them.

To phase out movement of the wall members towards the front and rear of the craft to which the skirt they comprise is attached, provision may be made as illustrated in FIGS. **14** and **15.** As will be seen therefrom the adjusting ties **12** may not be connected to the side portions or ties **11** of the outer one or more wall members of a skirt section, and the side portions of a selected number of the wall members adjacent the outer end of the skirt section may be additionally connected to the adjusting ties by further connections **18.** Upon operation of the associated tie **12** the tensile forces previously taken by the ties **11** of those wall members will then be taken by the additional connections **18,** as indicated in FIG. **15.**

Examples of selective operation of sections of skirt in accordance with FIGS. **12** and **13** are illustrated in FIGS. **16** to **18.** Thus in FIG. **16** operation of the adjusting ties **12** of the two sections of skirt on the starboard side of a craft is shown, to induce roll of the craft to starboard. In FIG. **17** operation of the two front sections of skirt on either side of the craft is shown, to effect a bow-down attitude. FIG. **18** shows the converse, i.e. the operation of the two rear sections on the two sides of the craft to effect a stern-down attitude, and FIG. **19** indicates the operation of the two port and forward starboard skirt sections to induce a roll to port and a bow-down attitude. This last effect may equally be achieved by operation of the forward port section of the skirt only.

While the invention has primarily been described and illustrated in relation to lateral adjustment of skirts at the sides of a gas cushion vehicle or craft, to provide a facility to shift the centre of pressure of the vehicle supporting gas cushion relative to the centre of gravity of the vehicle, comparable provision can equally be made for skirts at the bow or stern of a vehicle. Indeed as already indicated any desired length of section of a skirt may be rendered adjustable in the ways described for selective operation at will or in an automatic manner. The skirts or skirt sections may of course be operated not only to effect movements of the centre of pressure of a gas cushion in relation to the centre of gravity of a vehicle to counteract rolling or pitching of the vehicle, but may equally be operated to induce such movements of the vehicle as required. For example, it may be found desirable to induce a rolling movement of a vehicle to facilitate or promote a turn. In addition adjustment of a skirt may be effected in a manner to increase or decrease the effective area of the cushion contained thereby, without causing a shift in the centre of pressure thereof, in order to counteract heaving of the vehicle.

Differential lateral adjustment of wall members along the given length of sections of a skirt may also be effected to vary the plan form of the cushion contained thereby, so that the plan form of the cushion could, for example, be tapered towards the bow of a vehicle. Such adjustment may be made by providing successive groups of wall members with separate adjusting ties **12** or, alternatively, by arranging for the ties to be moved other than in a direction at right-angles to the intended direction of adjusting movement of the skirt. In the case of a skirt length extending along the side of a vehicle, the adjusting ties would, for example, be arranged to extend at an angle to the longitudinal axis of the vehicle. Graded movement of successive wall members along a given length or section of skirt controlled by a single adjusting tie may also be promoted by employing a tie having selected stretch properties. Stretching of the tie when under load may then be arranged to produce progressively increasing movements of successive wall members the nearer they are to the end of the tie which is pulled.

Generally, although as mentioned in connection with the embodiment of FIGS. **4** to **6,** a skirt or a skirt section may normally be maintained in a datum position from which it may be adjusted both towards and away from the periphery of a vehicle, it is thought it may be more practical to arrange for the normal operating position of a skirt to be that of their maximum extension, so that only positive inward adjusting movements thereof are arranged to be effected. Approximately the same degree of shift of the centre of pressure of a cushion can be achieved with such an arrangement, and under normal operating conditions it has the possible advantage that the longitudinal ties **12** are not constantly maintained under tension. Furthermore with such an arrangement it may not be necessary to have the adjusting ties **12** secured to the tie means **11** of the side portions of the wall members to hold them at the desired spacing, it could suffice to arrange for operative interconnection between the tie means **12** and **11** only upon movement of the tie means to effect inward lateral adjustment of skirt. If, however, resiliency is incorporated in the skirt system, as described in connection with FIGS. **7** and **11,** then it is necessary normally to maintain the skirts in an intermediate datum position.

I claim:

1. A skirt for a gas cushion vehicle comprising upper and lower parts of flexible sheet material, the upper part being connected to the vehicle body so as to be deflectable relative thereto, at least the lower part comprising a contiguous succession of independently deflectable flexible wall members each having an outer portion which faces the gas cushion and a pair of inwardly extending side portions, tie means connecting the side portions to the vehicle body, and adjusting means for causing angular movement of at least inner portions of the tie means in a substantially horizontal plane about substantially vertical axes passing through their attachments to the vehicle, and thereby result in the outer portions of the wall members being moved

laterally in a direction towards or away from the vehicle body.

2. A skirt for a gas cushion vehicle comprising upper and lower parts of flexible sheet material, the upper part being connected to the vehicle body so as to be deflectable relative thereto, at least the lower part comprising a contiguous succession of independently deflectable flexible wall members each having an outer portion which faces the gas cushion and a pair of inwardly extending side portions, tie means connecting the side portions to the vehicle body, and adjusting means for causing the tie means to swing in a substantially horizontal plane about their attachments to the vehicle, and thereby result in the outer portions of the wall members being moved laterally relative to the vehicle body, the adjusting means comprising further tie means extending substantially at right-angles to the side portions of the wall members and operatively connected to the tie means thereof, and means operative to effect linear movement of the further tie means to cause the inner extremities of the side portions of the wall members to describe an arcuate path about the attachment points of their tie means to the vehicle to occasion a lateral adjustment of the position of the wall members in a direction towards or away from the vehicle body.

3. A skirt as claimed in claim 2 including means for restricting movement of the wall members in a direction parallel to that of the further tie means upon adjusting movement thereof.

4. A skirt as claimed in claim 3 in which the skirt is divided into sections, each section being provided with a separate adjusting tie means, the tie means of adjacent sections being arranged for movement in opposite directions.

5. A skirt as claimed in claim 4 including additional restraining tie means associated with each skirt section to prevent sympathetic movement of that section upon individual adjustment of an associated adjacent skirt section.

6. A skirt as claimed in claim 1 in which the adjusting means normally maintain the skirt in a datum position from which it may be moved either towards or away from the periphery of the vehicle by appropriate movement of the adjusting means.

7. A skirt as claimed in claim 6 in which resilient means are associated with the adjusting means to allow lateral movement of the skirt in dependence upon the pressure of the cushion contained thereby.

8. A gas cushion vehicle in which the cushion is contained at least in part by a skirt, comprising a skirt having upper and lower parts of flexible sheet material, the upper part being connected to the vehicle body so as to be deflectable relative thereto, at least the lower part comprising a contiguous succession of independently deflectable flexible wall members each having an outer portion which faces the gas cushion and a pair of inwardly extending side portions, tie means connecting the side portions to the vehicle body, and adjusting means operative to cause the tie means to swing fore and aft in a substantially horizontal plane about their attachments to the vehicle body so as to vary the distance between the inner extremities of the side portions of the wall members and the adjacent part of the vehicle body, whereby the boundary of the gas cushion defined by the outer portions of the wall members is moved horizontally in a direction substantially at right-angles to the (periphery) said adjacent part of the vehicle body.

9. In a gas cushion vehicle comprising a skirt having upper and lower parts of flexible sheet material for containing the cushion at least in part, the upper part being connected to the vehicle body so as to be deflectable relative thereto, at least the lower part comprising a contiguous succession of independently deflectable flexible wall members each having an outer portion which faces the gas cushion and a pair of inwardly extending side portions, tie means connecting the side portions to the vehicle body, means for controlling the vehicle in heave, pitch or roll comprising means operative to effect angular movement fore and aft of the tie means of the side portions of at least a selected number of the wall members in a substantially horizontal plane and about substantially vertical axes passing through their attachments to the vehicle body, so as to move the outer portions of the wall members horizontally in a direction substantially at right-angles to that part of the vehicle periphery to which they are attached.

10. Means for horizontally adjusting the boundary of the cushion of a gas cushion vehicle in a direction towards or away from the vehicle periphery comprising a skirt having upper and lower parts of flexible sheet material for containing the cushion at least in part, the upper part being connected to the vehicle body so as to be deflectable relative thereto, at least the lower part comprising a contiguous succession of independently deflectable flexible wall members each having an outer portion which faces the gas cushion and a pair of inwardly extending side portions, means for constraining the inner extremities of the side portions of the wall members for movement in a horizontal arcuate path, and means to cause swinging movement of the said extremities in a fore and aft direction in a substantially horizontal plane so as to cause the boundary of the gas cushion defined by the outer portions of the wall members to be moved towards or away from the vehicle periphery at selected localities.

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