July 12, 1966 H. A. MACKIE 3,260,322

MULTIPLE PAD AIR CUSHION SUPPORT

Filed Jan. 10, 1962 2 Sheets-Sheet 1

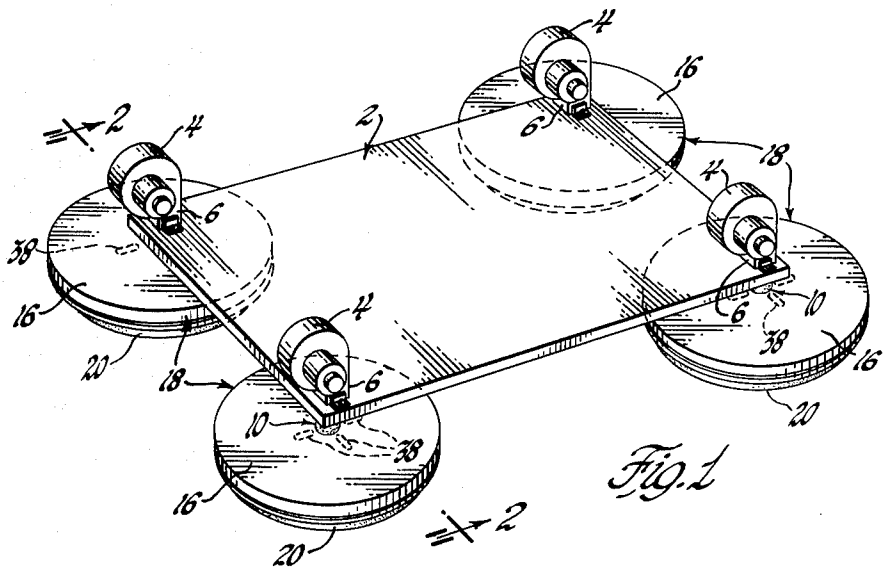

Fig. 1

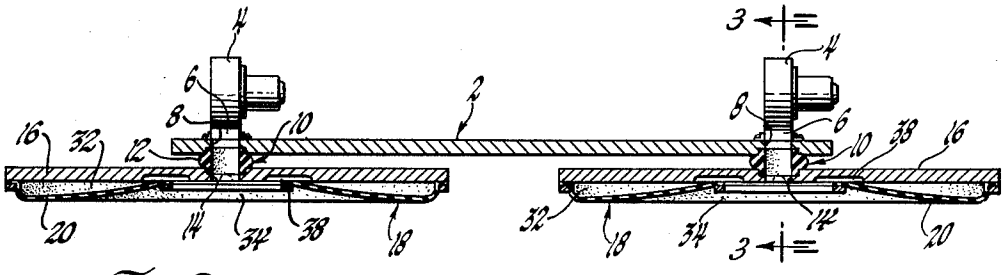

Fig. 2

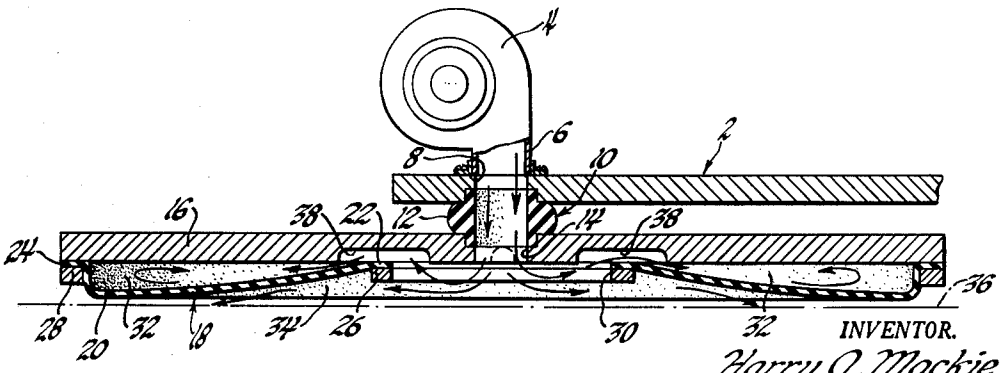

Fig. 3

INVENTOR.
Harry A. Mackie
BY
W. F. Wagner
ATTORNEY

July 12, 1966 H. A. MACKIE 3,260,322

MULTIPLE PAD AIR CUSHION SUPPORT

Filed Jan. 10, 1962 2 Sheets-Sheet 2

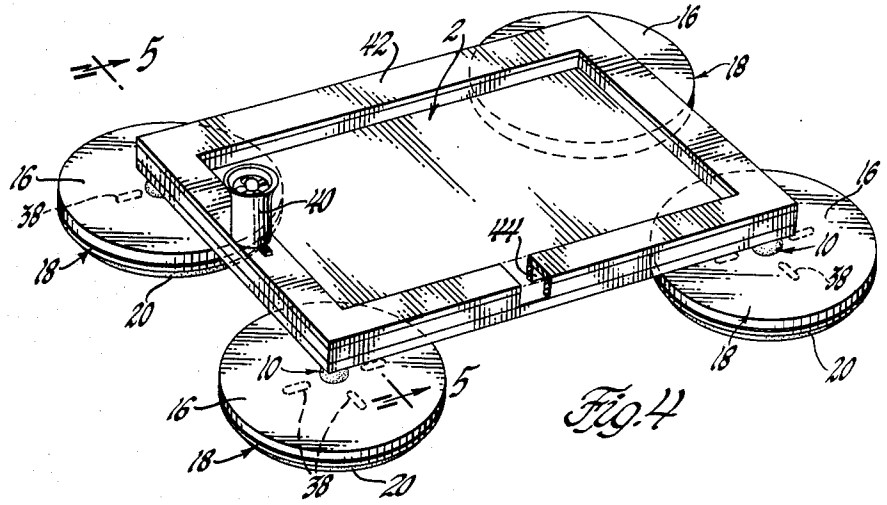

Fig. 4

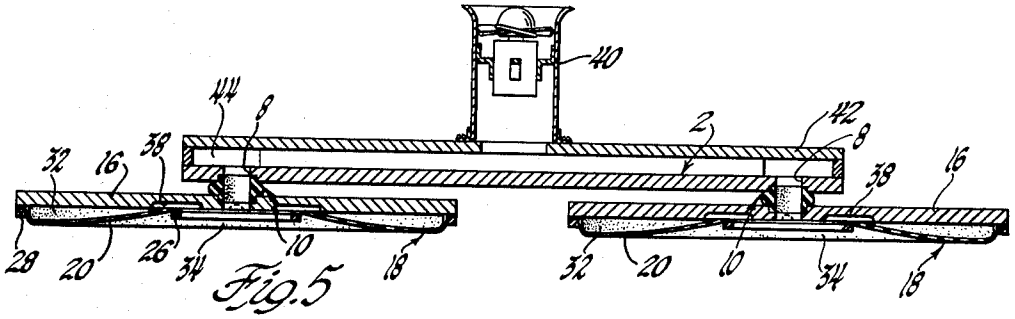

Fig. 5

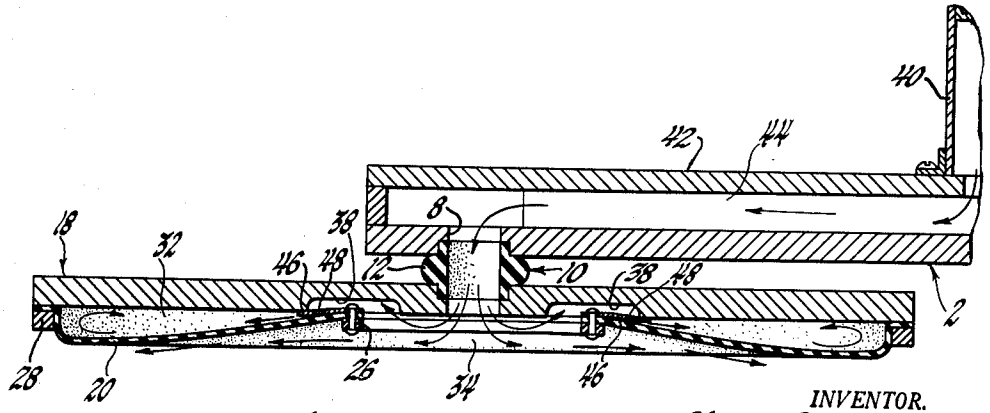

Fig. 6

INVENTOR.
Harry A. Mackie
BY
W. F. Wagner
ATTORNEY

United States Patent Office

3,260,322

Patented July 12, 1966

3,260,322

MULTIPLE PAD AIR CUSHION SUPPORT

Harry A. Mackie, Birmingham, Mich., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Filed Jan. 10, 1962, Ser. No. 165,417
9 Claims. (Cl. 180—7)

This invention relates to wheelless load supporting devices and more particularly to devices of the type supported relative to the ground solely by means of a low pressure free air cushion.

The present invention is directed to improvements in air cushion vehicles of the type shown in copending application Serial No. 4,465, Mackie et al., assigned to General Motors Corporation.

In the indicated copending application, a substantially flat centrally apertured rigid platform has disposed thereunder and secured to the perimeter thereof a flexible diaphragm having a central aperture aligned with and maintained in vertically spaced relation with the platform aperture. The diaphragm and platform form an annular cavity which is subjected to air pressure from a source connected to the aperture in the platform, causing the diaphragm to bulge downwardly and form a plenum cavity between the diaphragm and the ground. The plenum communicates with the annular cavity so that the pressure within the annular cavity is equal to the pressure within the plenum which forms the "ground cushion." Among the various capabilities of this device is an inherent pitch and roll stability which is significantly in excess of conventional plenum chamber and air bearing type cushion devices. However, in practical utilization of the diaphragm type supporting device, it has been found that extreme maldistribution of load may occur which would cause one side of the vehicle to ground out and thereby significantly impair the efficiency of operation thereof.

An object of the present invention is to provide a flexible plenum chamber type air cushion vehicle having an extended range of stability in pitch and roll.

Another object is to provide a device of the stated character in which a rigid load supporting platform is disposed over a plurality of air cushion devices which are preferably located at the lateral and longitudinal extremities of the platform.

A still further object is to provide an arrangement of the stated character wherein the individual air cushion devices are secured to the platform in a manner permitting limited universal angular movement of each with reference to the plane of the platform.

A yet further object is to provide a construction of the type described wherein each of the cushions are provided with operating pressure from a single source and the platform inconporates conduit means for distributing the air to the individual units.

A still further object is to provide in a structure of the type having a common source of air, means for preventing diaphragm pulsation, whereby load shift on the platform does not cause pressure transfer from one cushion to the other.

These and other objects, advantages and features of the invention will become more fully apparent as reference is had to the accompanying specification and drawings wherein:

FIGURE 1 is a schematic perspective view of a multiple cushion load supporting platform in accordance with one embodiment of the invention;

FIGURE 2 is a view looking in the direction of arrows 2—2 of FIGURE 1;

FIGURE 3 is an enlarged sectional elevational view looking in the direction of arrows 3—3 of FIGURE 2;

FIGURE 4 is a schematic perspective view of another embodiment of the invention;

FIGURE 5 is a sectional elevational view looking in the direction of arrows 5—5 of FIGURE 4; and

FIGURE 6 is an enlarged fragmentary sectional elevational view of a portion of the structure shown in FIGURE 5.

Referring now to the drawings and particularly FIGURES 1, 2 and 3, there is shown a load supporting structure in which the reference numeral 2 designates a substantially flat horizontal load supporting platform. At each of its four corners, platform 2 has mounted thereon identical electric motor driven blowers 4, the discharge ends 6 of which are secured to the upper surface of platform 2 in axial alignment with identical apertures 8 extending through platform 2 at the four corners thereof. At their lower ends, each of the apertures 8 receives the upper end of a tubular rubber element 10, each of which is formed with a vertically intermediate radially outwardly extending flange portion 12 of semi-circular cross section. The lower extremity of each rubber element 10 in turn extends downwardly into a central aperture 14 formed in each of four identical rigid circular disks 16 forming the base of air cushion assemblies 18. Extending beneath each disk 16 is a flexible annular diaphragm 20. As seen best in FIG. 3, the inner and outer peripheries 22 and 24 of diaphragm 20 are secured to the undersurface of disk 16 adjacent the inner and outer periphery thereof by an inner clamp ring 26 and an outer clamp ring 28. The large diameter central aperture 30 defined by the inner periphery 22 and ring 26 is axially aligned with the central aperture 14 of disk 16. To facilitate movement of air into both the annular cavity 32 formed between disk 16 and diaphragm 20 as well as into the frusto-conical plenum cavity 34 formed between diaphragm 20 and the ground surface 36, the lower surface of disk 16 is formed with a plurality of circumferentially spaced radially extending upwardly deformed channels 38 which provides communication between cavity 32 and plenum 34, yet permits the ring 26 and inner periphery 22 of diaphragm 26 to be secured directly to the underside of disk 16. Therefore, air entering aperture 14 from blower 4 simultaneously flows into annular cavity 32 and plenum 34 so that the annular cavity 32 inflates and elevates the disk 16 while the plenum fills to provide a plurality of air cushions or pads which maintain the platform 2 in frictionless spaced relation with the ground 36.

According to one feature of the present invention, the areas over which air bearing or cushion support is provided for the load carried on platform 2 are not only evenly distributed with respect to the platform, but additionally extend horizontally well beyond the lateral and longitudinal extremities of the load supporting platform. Since the physical limits of platform 2 are substantially inboard of the effective area of support provided by the cushions 18, there is little tendency for one or more of the cushions to ground out due to maldistribution of load on platform 2. In addition, in accordance with another feature of the invention, to the extent that inclination of the platform may be induced by maldistribution of load, such inclination is transmitted to the geometric center of the effected pads only as an increase in load without forcing a corresponding inclination of the associated rigid disk 16. As a result, the individual disks remain parallel to the ground and the air bearing effect continues to function with optimum efficiency. This is accomplished in the embodiment shown by utilizing the flexible yielding character of the tubular members 10 to provide a limited universal motion for each disk, the degree of relative inclination between the individual disks and the platform being determined by the radius of curvature of the intermediate bulged flange 12 of the tubular members.

In FIGURE 4, there is shown a modified form of the invention in which the multiple pad construction is utilized in connection with a single source of air pressure in the form of an axial type blower **40**. Blower **40** is mounted on a supporting platform having a rectangular tubular frame **42**. The interior cavity **44** of frame **42** serves as a common conduit to direct air under pressure from blower **40** to each of the individual air pads which are mounted thereto in the same manner described with reference to the embodiment of FIGURE 1. However, while reducing the number of air sources required, the utilization of a common source of air pressure renders the device susceptible to "pumping" or pressure transfer from the annular cavity **32** of one pad **18** to the corresponding cavity of another as a result of load misalignment. Therefore, the radial channels **38** providing communication between cavity **32** and plenum **34** are provided with check valves which readily allow entrance of air into the cavities **32** but inhibit reverse flow of air pressure therein. Hence, pumping of air in one cavity **32** back through the rectangular frame into another cavity **32** subjected to a lighter load is resisted. As seen best in FIGURE 6, this is accomplished by a reed valve **46** which overlaps the outboard portion of each channel **38** and is anchored to the upper surface of inner ring **26**. Reed valve **46** is highly yieldable in the direction of air flow into the cavity **32** and preferably provides an imperfect seal to back flow of air so that the annular cavities will slowly deflate when the blower **40** is inoperative and allow the entire device to come to rest on the outer rings **28** of each cushion. In the illustrated embodiment, this is accomplished by providing a leakdown aperture **48** in the reed valves **46**.

While two embodiments of the invention have been shown and described, it will be apparent that other changes and modifications may be made therein. It is, therefore, to be understood that it is not intended to limit the invention to the embodiment shown, but only by the scope of the claims which follow.

I claim:

1. A ground proximity air cushion supported vehicle comprising a load supporting superstructure having a plurality of apertures formed adjacent the perimeter thereof, a plurality of rigid platforms underlying said superstructure, each platform having a central aperture aligned with one of said apertures in said superstructure, a flexible tubular element connecting said aligned apertures, means forming a radially outwardly deformed flange on said tubular element between and in contact with the undersurface of said superstructure and upper surface of said platform acting to maintain said platform and superstructure in vertically spaced relation, air bearing means formed on the underside of said platform, and blower means mounted on said superstructure connected in communicating relation with said plurality of apertures in said superstructure for introducing air under pressure into said air bearing means.

2. A ground proximity air cushion supported vehicle comprising a load supporting superstructure having a plurality of apertures formed adjacent the perimeter thereof, a plurality of rigid platforms underlying said superstructure, each platform having a central aperture aligned with one of said apertures in said superstructure, a flexible tubular element connecting said aligned apertures, means forming a radially outwardly deformed flange of generally semi-circular cross section on said tubular element between and in contact with the undersurface of said superstructure and upper surface of said platform acting to maintain said platform superstructure in vertically spaced relation and allowing limited universal movement therebetween, a flexible diaphragm hermetically secured centrally and peripherally to the underside of said platform forming an annular cavity between said platform and diaphragm and a frusto-conical plenum cavity between said diaphragm and the ground, means providing communication between said central aperture, annular cavity and plenum cavity, and air flow generating means mounted on said superstructure connected in communicating relation with said plurality of apertures in said superstructure for introducing air under pressure into said annular cavity and plenum cavity.

3. The structure set forth in claim **2** wherein said air flow generating means comprises a separate blower assembly mounted on said superstructure adjacent each aperture formed in the latter.

4. The structure set forth in claim **2** wherein said superstructure includes a hollow frame providing common communication with each of said apertures formed therein and said air flow generating means comprises a single blower mounted in communicating relation with said hollow frame remote from said apertures.

5. A ground proximity air cushion supported vehicle comprising a load supporting superstructure having a hollow boundary frame formed with a plurality of perimetrically spaced apertures, a plurality of rigid platforms underlying said superstructure, each platform having a central aperture aligned with one of said perimetrically spaced apertures, a flexible tubular element connecting said aligned apertures, means forming a radially outwardly bulged flange on said tubular element between and in contact with the undersurface of said superstructure and upper surface of said platform acting to maintain said platform superstructure in vertically spaced relation, a generally horizontal flexible annular diaphragm disposed below said platform concentric with said central aperture, means securing the inner and outer periphery of said diaphragm to the underside of said platform providing an annular cavity between said platform and diaphragm and a generally frusto-conical plenum cavity between said diaphragm and the ground, passage means formed in said platform connecting said annular cavity and said plenum cavity, and blower means mounted on said superstructure connected in communicating relation with the interior of said hollow boundary frame for introducing air under pressure into said annular cavity and plenum cavity.

6. A ground proximity air cushion supported vehicle comprising a load supporting superstructure having a hollow boundary frame formed with a plurality of perimetrically spaced apertures, a plurality of rigid platforms underlying said superstructure, each platform having a central aperture aligned with one of said perimetrically spaced apertures, a flexible tubular element connecting said aligned apertures, means forming a radially outwardly bulged flange on said tubular element between and in contact with the undersurface of said superstructure and upper surface of said platform acting to maintain said platform superstructure in vertically spaced relation, a generally horizontal flexible diaphragm annularly disposed below said platform, means hermetically connecting the inner and outer periphery of said diaphragm to the underside of said platform providing an annular cavity between said platform and diaphragm and a frusto-conical plenum cavity between said diaphragm and the ground communicating with said central aperture, passage means formed in said platform bridging the connection between the inner periphery of said diaphragm and said platform, and blower means mounted on said superstructure connected in communicating relation with the interior of said hollow boundary frame for introducing air under pressure into said annular cavity and plenum cavity.

7. The structure set forth in claim **6** wherein said passage means comprises at least one radially directed upwardly deformed channel formed in said platform.

8. The structure set forth in claim **7** including check valve means associated with said channel providing substantially one-way communication between said annular cavity and plenum cavity.

9. The structure set forth in claim **8** wherein said check

valve means comprises a reed valve arranged with reference to said channel to provide substantially free air flow from said plenum cavity to said annular cavity, and means formed in said reed valve providing substantially restricted flow from said annular cavity to said plenum cavity.

References Cited by the Examiner

UNITED STATES PATENTS

2,893,722	7/1959	Beck	248—22 X
3,051,512	8/1962	Cranston	285—235 X
3,052,483	9/1962	Petersen	180—7
3,182,739	5/1965	Cockerell	180—7
3,185,238	5/1965	Coates	180—7

FOREIGN PATENTS

1,238,499	7/1960	France.
924,834	5/1963	Great Britain.

A. HARRY LEVY, *Primary Examiner.*