United States Patent

[11] 3,613,821

[72] Inventors **John Kerr**
Cambuslang, Glasgow, Scotland;
Ian Lasbrey, Belfast, Northern Ireland

[21] Appl. No. **802,840**
[22] Filed **Feb. 27, 1969**
[45] Patented **Oct. 19, 1971**

[73] Assignee **National Research Development Corporation**
London, England

[32] Priority **Mar. 2, 1968**
[33] **Great Britain**
[31] **10268/68**

[54] **LOAD-SUPPORTING DEVICE**
9 Claims, 10 Drawing Figs.

[52] **U.S. Cl.** ..... **180/125,** 94/7, 104/23 FS
[51] **Int. Cl.** **B60v 1/00**
[50] **Field of Search** ..... 180/124, 125, 116; 214/1 AB; 94/7; 244/114

[56] **References Cited**

UNITED STATES PATENTS

1,874,689	8/1932	Allaro	94/7 UX
2,832,986	5/1958	Seck	180/116 UX
2,990,939	7/1961	Kelly	214/1 AB X
3,104,496	9/1963	Macks	180/125 X
3,232,366	2/1966	Cockerell	180/124
3,416,626	12/1968	Nagamatsu	180/124
3,022,712	2/1962	Cousino et al.	94/7
2,912,952	11/1959	Simmons	244/114 X
3,261,418	7/1966	Bertin	180/116 X
3,513,934	5/1970	Crowley	180/124

Primary Examiner—A. Harry Levy
Attorney—Cameron, Kerkam & Sutton

ABSTRACT: A load-supporting device comprising at least one air cushion lifting pad in combination with a compliant ground-effect surface provided by elastomeric material, and means for supplying pressurized fluid to each pad to form a fluid cushion between each pad and the compliant surface.

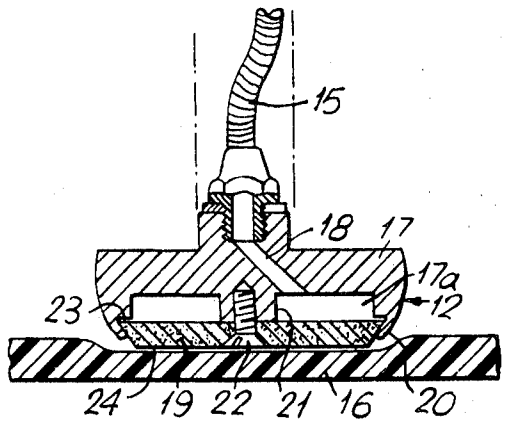


FIG. 1.

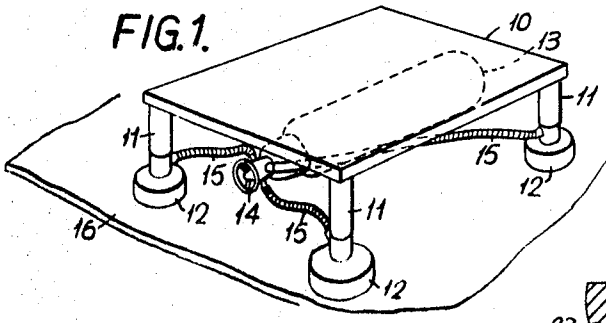
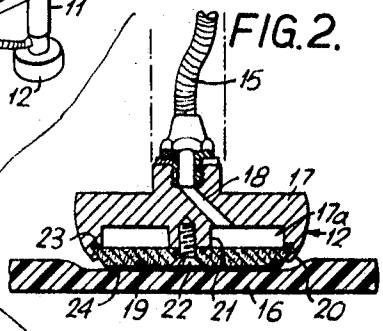


FIG. 2.



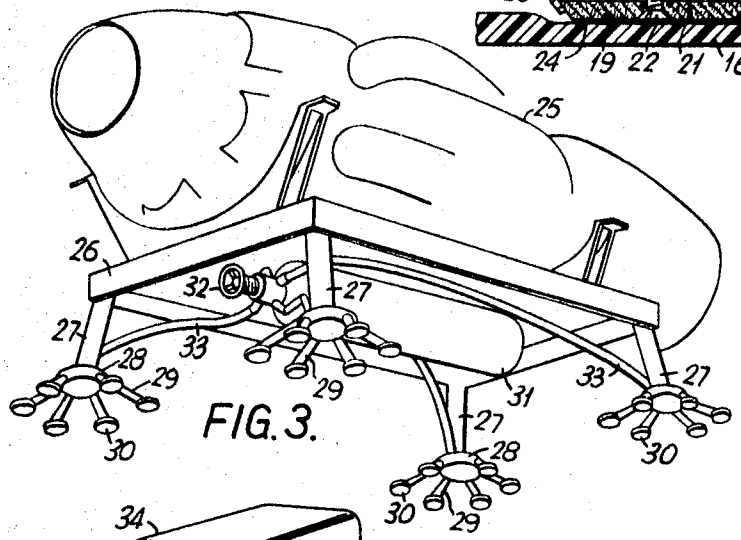


FIG. 3.

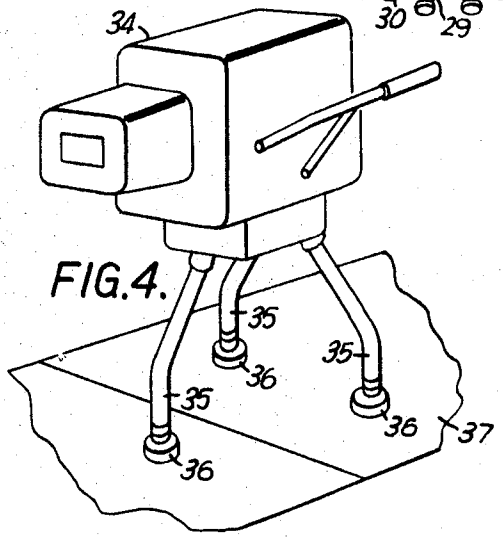


FIG. 4.

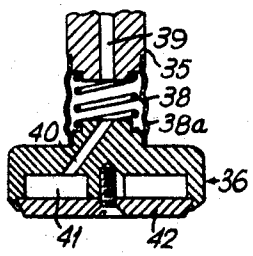


FIG. 5.

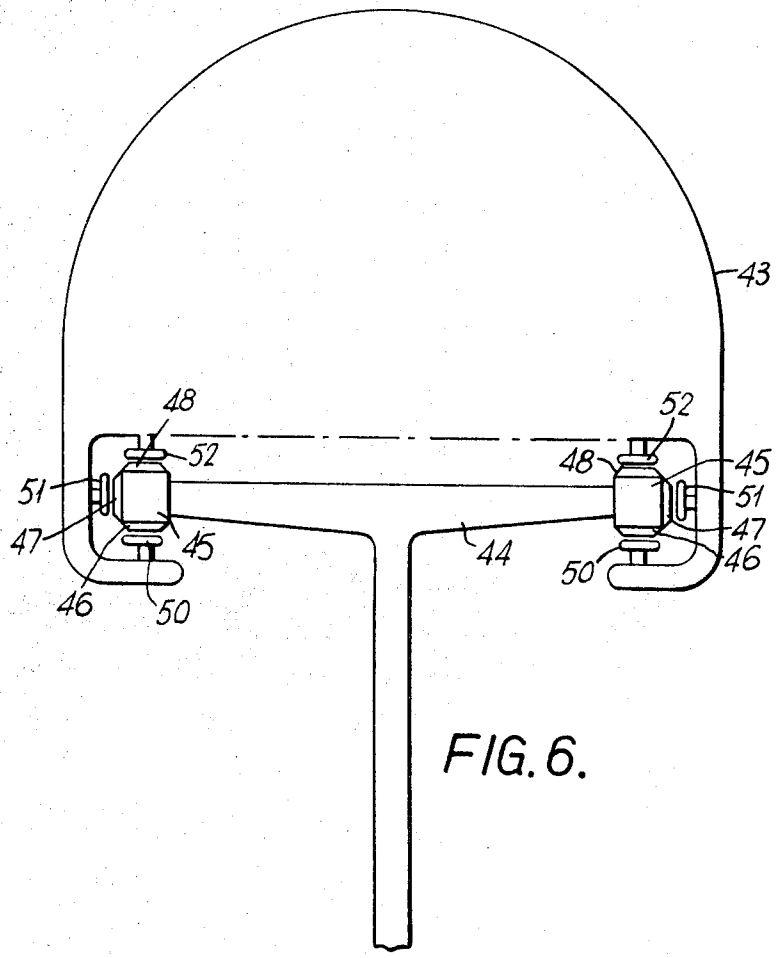


FIG. 6.

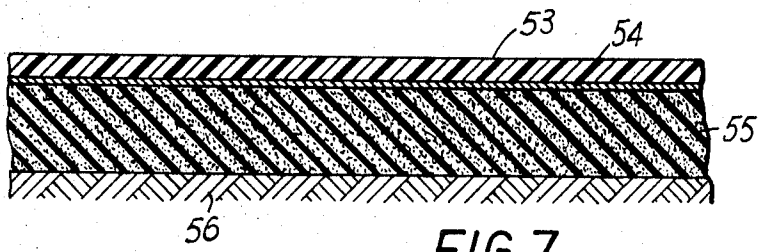


FIG. 7.

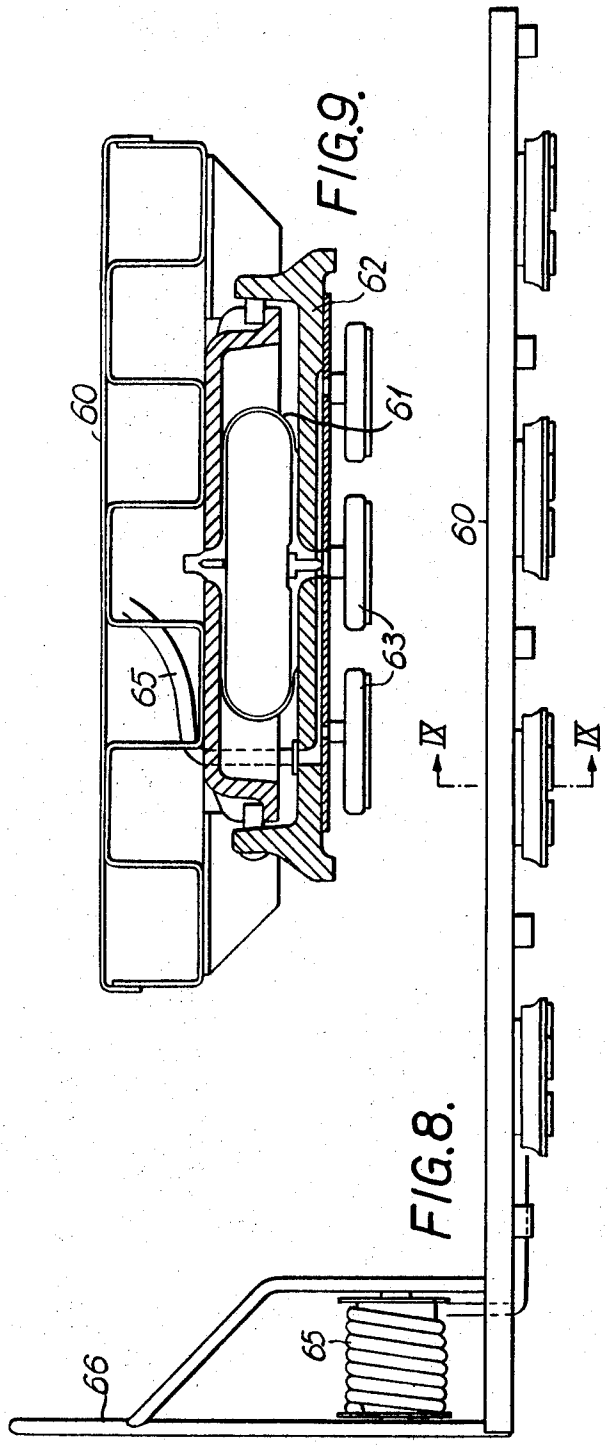


FIG.8.

FIG.9.

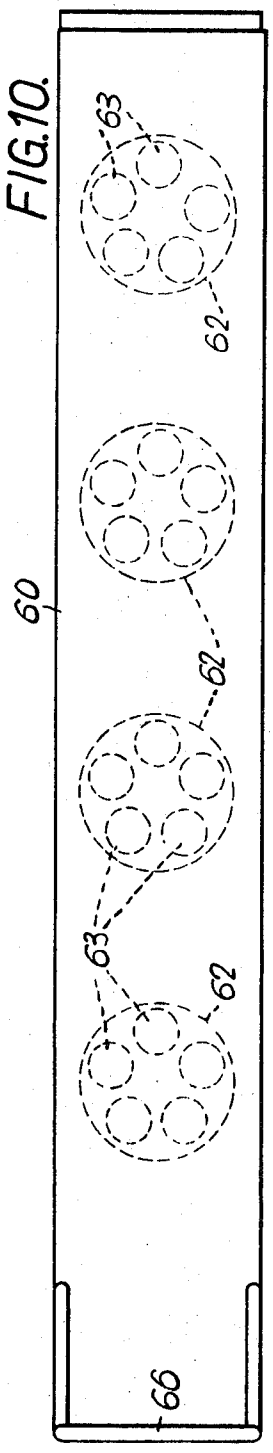


FIG.10.

LOAD-SUPPORTING DEVICE

This invention relates to a load-supporting device.

It is known to use small air cushions both of the plenum chamber type and the air curtain contained type, on such devices. It has also been proposed to use a pad of porous material as an air-cushion device. Such devices are limited in the load they can support. If Ws is the specific load and Ps is the supply pressure, then Ws/Ps, for a normal ground surface, is not usually higher than 0.2 to 0.4.

It has now been found that if an air cushion is used with a compliant surface, then a very much higher ratio of Ws/Ps can be obtained, and if a porous air-cushion pad is employed, then the ratio is higher than can be obtained with plenum chambers. Air curtain contained cushions operate at very low specific loads, for example $Ws = 10$ p.s.i., compared with these systems.

Accordingly, the present invention provides a load-supporting device which comprises a fluid-cushion lifting pad in combination with a compliant surface, the device including means to supply fluid, preferably air under pressure, to the lifting pad, so that a cushion of air or a thin layer of air is formed between the under surface of the pad and the compliant surface.

Preferably the lifting pad is of the porous pad type rather than an open plenum chamber or air-curtain type.

Preferably the device includes a number of separate porous pads or discs. The pads or discs may, for example, be supported at the ends of resilient legs, or they may be supported individually by springs. The springs may be mechanical or they may be pneumatic or hydraulic.

The porous material may, for example, be sintered metal, compacted into a disc, such as sintered stainless steel or brass.

Materials which are sufficiently compliant for the purposes of the invention can be found among elastomeric materials such as synthetic rubbers, of which "Neoprene" (registered trade mark) is a particularly suitable example, silicone rubbers, and so on, including nonrubber-based materials. Materials used satisfactorily with an air bearing according to the invention have had a hardness between 30° and 90° shore hardness and preferably between 50° and 60°.

The degree of compliancy has been found to depend on the applied specific loading, and this is also related to the shear modulus. In practice the ratio of specific load to shear modulus should lie in the range 0.05 to 1.0 or, more generally speaking, the specific load in pounds per square inch should be equal to the shear modulus in the same units, as a first approximation in choosing a compliant material.

The choice of a suitable compliant surface enables Ws/Ps ratios as high as 1.0 to be obtained but in practice the ratio will usually be in the range 0.5 to 0.85.

One advantage of using this type of supporting device with a compliant surface is that the porous pads will travel over small gaps between adjacent section of the compliant surface.

Use of sheets of the compliant material enable heavy loads to be moved across ground which would otherwise be too uneven, or too hard, to provide the necessary combination of compliance and smoothness to support the load with reasonably economical use of power.

Where the material is laid over a particularly rough floor the compliant material, say in quarter-inch-thick sheets, may be laid over a thin sheet of a stiffer material such as plastic or metal, in turn laid on a soft material such as foamed rubber or other foamed material. The thin metal spreads the load.

While use of the invention will normally be such that the pad moves relative to a stationary compliant surface, this is not necessarily the case. Movement of the surface relative to the pad would be relevant to application in a conveyor system, for example, with a web having a compliant surface movable over and around a sequence of pads. Similarly, a load-carrying pallet having a compliant undersurface can be moved over a floor fitted with a regular array of lifting pads.

Also it might be noted that while it will be found convenient in many cases to locate the relevant source of pressurized fluid for movement with the pad or pads the latter can be arranged for movement relative to a fixed source to which they are connected by way of a flexible air line or the like.

In any event, for a clearer understanding of the practical application of the invention, reference will now be made, by way of example, to the accompanying drawings in which:

FIG. 1 shows an industrial pallet incorporating the invention;

FIG. 2 is an enlarged section through one of the porous pads employed in both FIGS. 1 and 3;

FIG. 3 shows a cradle for transporting a gas turbine engine, the cradle embodying the invention;

FIG. 4 shows a television camera modified in accordance with the present invention;

FIG. 5 shows one of the porous supporting pads used at the lower ends of the legs of the television camera;

FIG. 6 shows a tracked hovercraft in which the track and the hovercraft are modified to embody the invention;

FIG. 7 shows, in section, an alternative form of load-supporting compliant surface for use with the invention;

FIG. 8 is a side view of a trolley-type pallet embodying the invention;

FIG. 9 is a sectional view of the pallet shown in FIG. 8, taken on the line IX—IX in the latter figure; and

FIG. 10 is a plan view of the pallet shown in FIG. 8.

In FIG. 1 is shown a pallet 10 which is supported at its four corners by legs 11. At the lower end of each leg is an air-cushion pad 12 supplied with air from a bottle 13 controlled by a valve 14. The air is supplied to each of the four pads 12 through flexible pipes 15 and the pallet rests on a compliant surface made of quarter-inch-thick "Neoprene" sheeting 16.

The form of each of the pads is shown in FIG. 2. Each pad 12 consists of a housing 17 to which the pipe 15 is attached so that air can be supplied through passage 18 to an annular chamber 17*a* within the housing. The lower end of the pad 12 is closed by a thin disc 19 of sintered stainless steel and the outer edge of the housing 17 is peened over at 20 to seal the edge and to make a smooth rounded edge to the pad. Added support for the disc 19 is provided by a central lug 21 to which the disc is held by a screw 22. In addition the disc is attached to the adjacent inner surfaces of the housing, such as 23, by "Araldite" (registered trademark). Air passes through the pipe 15 via passage 18 to the annular chamber 17*a* and then through porous sintered metal disc 19 to form an air layer 24 between the lower face of the disc and the compliant surface of the sheet 16.

In FIG. 3 the invention is shown applied to a lifting and transporting cradle for a jet engine 25. The engine rests on the cradle 26 which has four legs 27 terminating in respective feet 28 from each of which extend six resilient fingers 29, and at the end of each of which fingers is a pad 30. Each of the pads 30 is similar in construction to the one shown in section in FIG. 2, while each of the fingers 29 may be similar in construction to the pad-supporting means shown in FIG. 5.

The air supply for the pads is provided by a bottle 31 and controlled by a valve 32, the air passing through pipes 33 to each of the sets of pads 30.

Again, in use, the cradle is moved across a compliant surface such as 16 in FIG. 1. The compliant material can be laid permanently or it can be put down in strips as required.

In FIG. 4 is shown a television camera 34 which has tripod legs 35 terminating in support pads 36 resting on a compliant surface 37 formed of sheets of silicone rubber. As will be apparent from the drawing, the gaps between adjacent sections of the compliant surface 37 are small in relation to the dimensions of the pads 36.

Each of the pads 36 is of the form shown in FIG. 5 and is supported at the end of the leg 35 by means of a spring 38 and a flexible casing 38*a* therearound. The casing 38*a* is airtight so that air passing down through a passage 39 in the leg 35 will enter a further passage 40 leading to an annular chamber 41. The pad 36 is closed by a disc 42 of sintered brass.

This arrangement not only enables the camera 34 to be moved quickly and easily across a television studio floor, but also results in extremely quiet operation which is essential in such a studio, particularly if the studio is laid with a continuous compliant surface with no joints.

In FIG. 6 the invention is shown as applied to a tracked ground-effect vehicle. The vehicle 43 is shown supported on a track 44. The ends of the track arms terminate in rectangular section members 45 carrying strips 46, 47 and 48 of compliant material such as "Neoprene."

The vehicle is supported by means of pads 50, 51 and 52, each pad being of the form shown in FIG. 2. The pads 50 and 52 provide vertical movements and the pads 51 restrain sideways movement.

There may be, say 25 pads 52 on each side of the craft and a corresponding number of pads 50 and 51, the pads being about 10 inches in diameter.

This arrangement enables the track construction to be very cheap compared with previous proposals, since the strips 48 etc. need only be about a foot wide which means that the concrete rectangular section members 45 can be as little as a foot wide which reduces cost compared with the large and wide tracks proposed previously.

In FIG. 7 is shown an alternative form of compliant surface. A sheet 53 of "Neoprene" about a quarter-inch thick is laid on top of a sheet 54 of nonporous, stiffer material, such as a thin metal sheet or plastic sheet, aluminum being a possible material. The aluminum sheet 54 rests on a 3-inch-thick layer of foamed rubber 55, which in turn is laid on the uneven ground 56.

With this arrangement the layer 53 provides the compliant surface, the aluminum sheet 54 spreads the load and the foamed rubber 55 smooths out unevenness in the ground surface.

In FIGS. 8, 9 and 10 is shown an industrial-type pallet modified in accordance with this invention.

The pallet is in the form of a trolley which has a platform 60 supported through a number of bellows-type springs 61, each spring being attached to a supporting device 62 in the form of a circular member carrying a group of five symmetrically spaced porous pads 63, supplied from a common air supply.

There are four groups of the porous pads spaced along the length of the trolley. The air supply can be through a flexible airhose reel 65. The trolley has an end handle 66 for manual manipulation.

The trolley can either be used to support objects spaced on the platform 60, or, for example, two trolleys can be used, one being positioned under each end of a larger platform or any other large object which has to be moved.

While in the above embodiments reference has been made to the use of air, other gases and also liquids can be employed. In the case of liquids there is an advantage that very much higher values of P_s can be obtained economically, for example values of several thousand p.s.i. The use of liquid will, though, require use of compliant materials having correspondingly higher shear modulus values, materials suitable for this purpose being textile or wire-reinforced elastomers, for example, such as are used in conveyor belts, etc., preferably with substantially homogeneous reinforcement.

We claim:

1. A load-supporting system comprising at least one fluid-cushion lifting pad in combination with a layer of compliant elastomeric material providing a ground-effect surface, the lifting pad including a housing having a fluid chamber therein, means for supplying fluid under pressure to said chamber, and a rigid porous member forming the outlet of said chamber through which said fluid passes to form a fluid cushion between the pad and the compliant surface, the ratio of the specific load applied to said compliant surface by said pad compared to the shear modulus of the elastomeric material being in the range 0.05 to 1.0.

2. A system according to claim 1 wherein said porous member is made of compacted sintered metal.

3. A system according to claim 1 wherein the elastomeric material has a hardness in the range 30° to 90° shore hardness.

4. A system according to claim 3 wherein said hardness is in the range 50° to 60° shore hardness.

5. A system according to claim 1 wherein said compliant surface is formed of a plurality of sections of said elastomeric material laid over an existing surface with gaps between adjacent sections which are small in relation to the dimensions of the lifting pad.

6. A system according to claim 1 wherein said compliant material forms a ground-effect surface on a track for a tracked ground-effect vehicle.

7. A load-supporting system comprising at least one fluid-cushion lifting pad in combination with a compliant laminated ground-covering structure comprising a layer of elastomeric material providing a ground-effect surface, said layer of elastomeric material overlaying a sheet of stiff material which, in turn, overlays a layer of resilient material softer and thicker than the layer of elastomeric material, and means for supplying fluid under pressure to the pad so that a cushion of fluid is formed between the pad the compliant surface.

8. A system according to claim 7 wherein said stiff material is metal and said resilient material is foamed rubber.

9. A load-transporting system comprising a load-carrying body, a plurality of lifting-pad housings having chambers therein closed at their lower ends by respective porous members, resilient means connecting said pads to depend from said body, a layer of compliant elastomeric material providing a ground-effect surface for said pads, and means for supplying fluid under pressure to said chambers to form a fluid cushion between each of said pads and said surface, the ratio of the specific load applied to said compliant surface by each of said pads compared to the shear modulus of the elastomeric material being in the range 0.05 to 1.0.