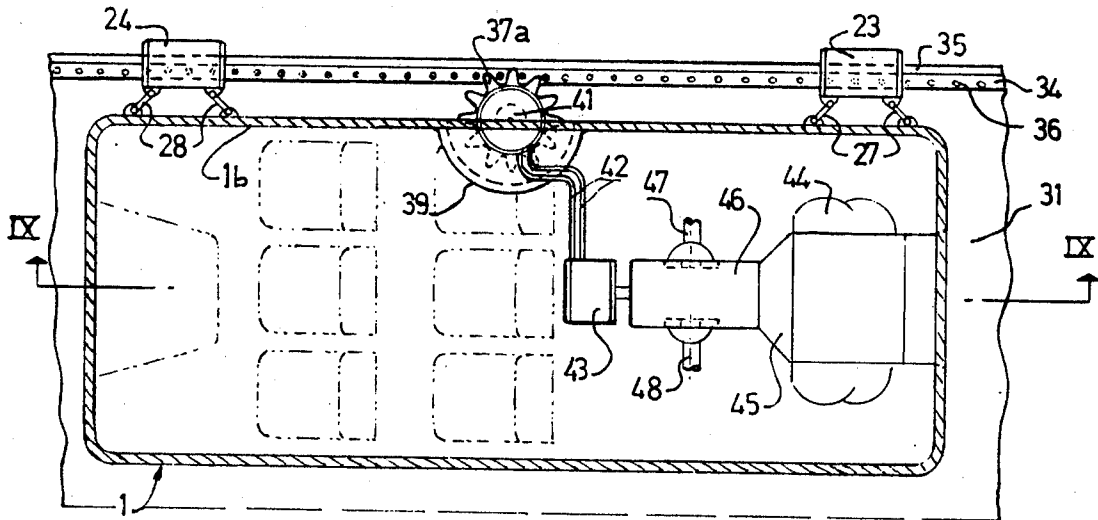


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 [33] **France**  
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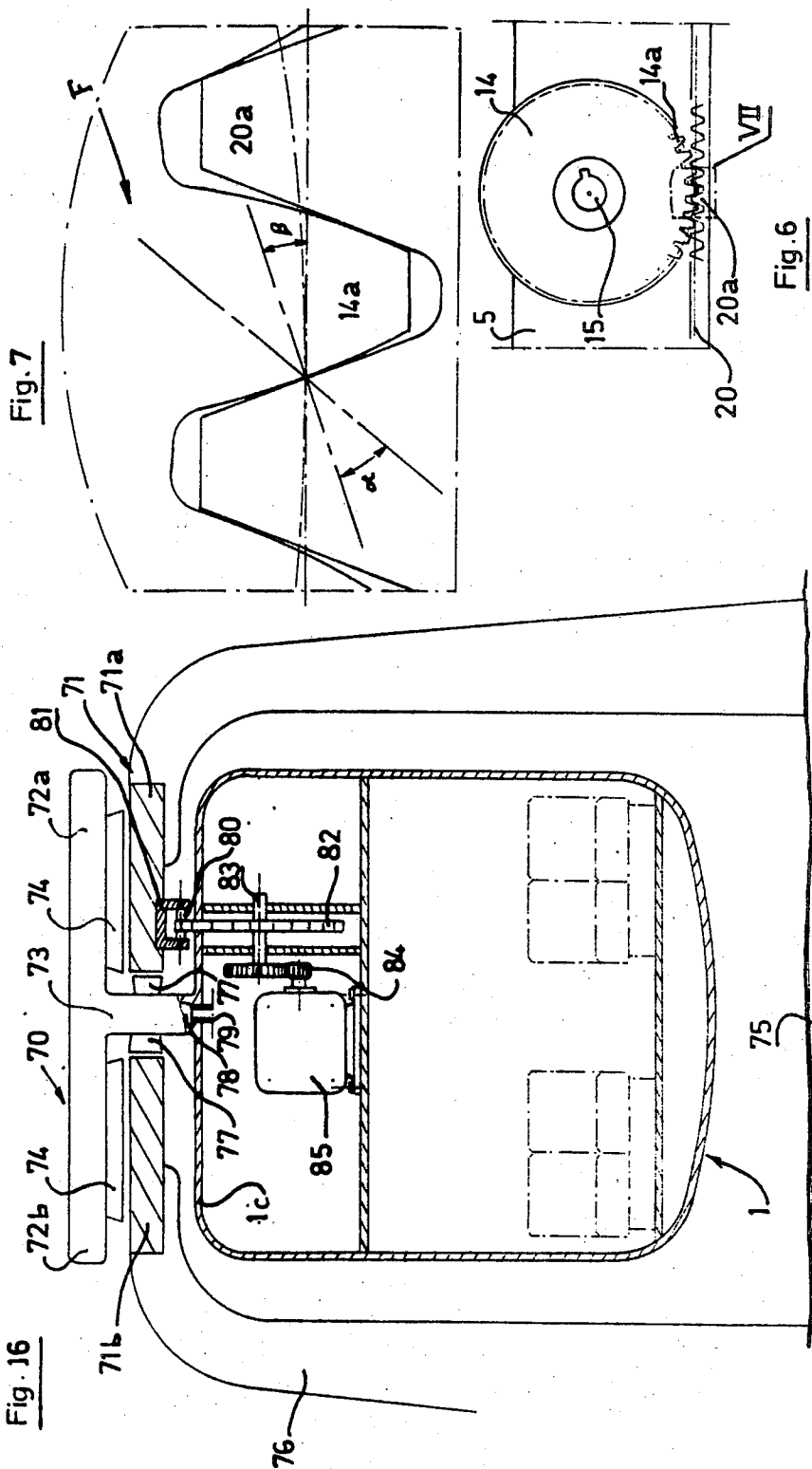
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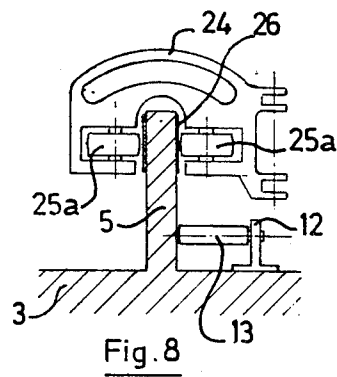
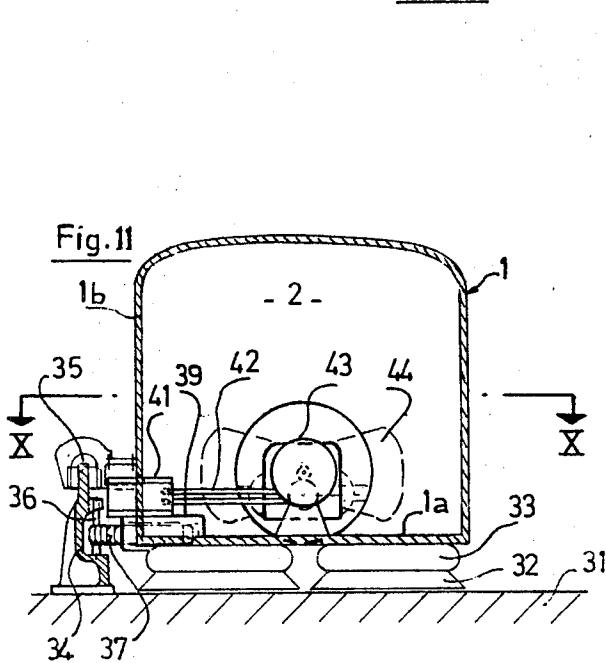
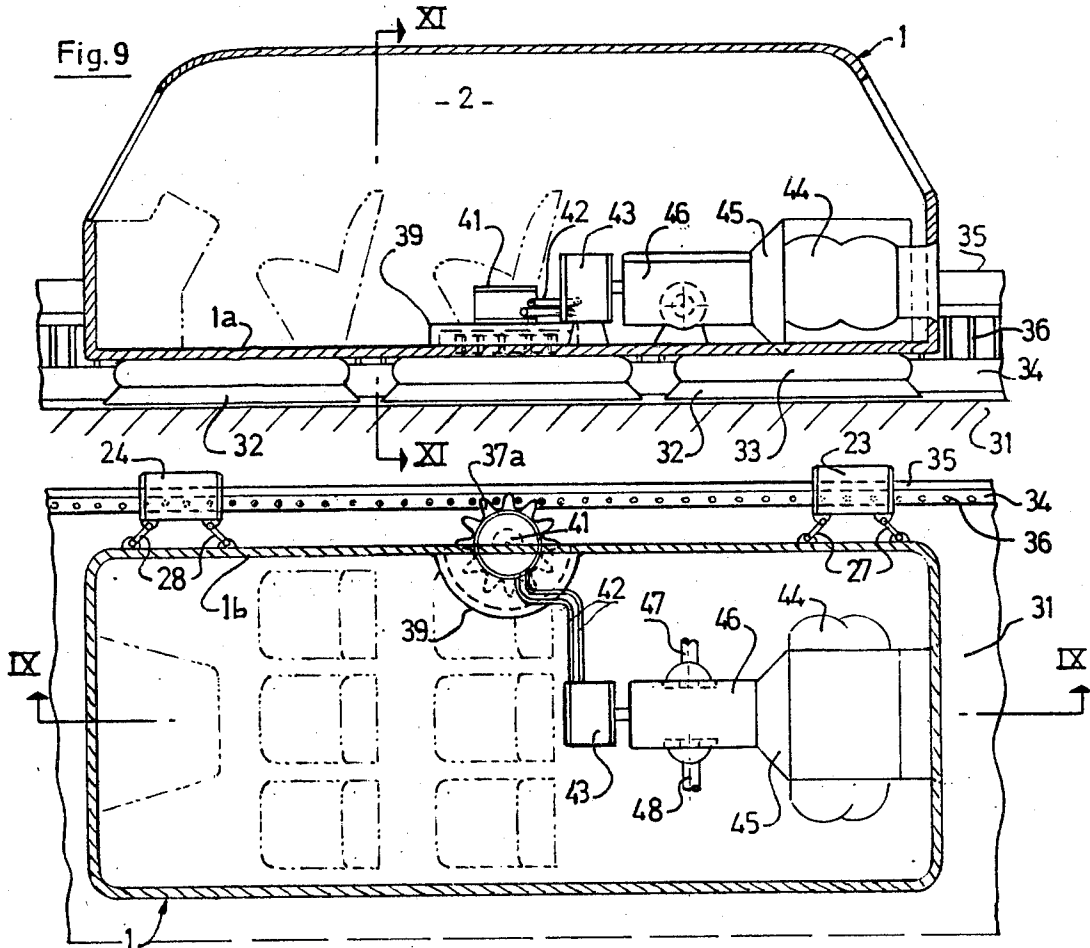
[54] **GROUND-EFFECT TRANSPORTATION SYSTEM**  
**4 Claims, 17 Drawing Figs.**  
 [52] U.S. Cl. .... **104/23FS,**  
                     104/23R, 104/134, 105/29, 74/422  
 [51] Int. Cl. .... **B61b13/08,**  
                     F16h 1/04, B61c 11/04  
 [50] Field of Search ..... 104/23, 23  
                             FS, 134, 148, 147; 105/29; 74/422, 461, 462

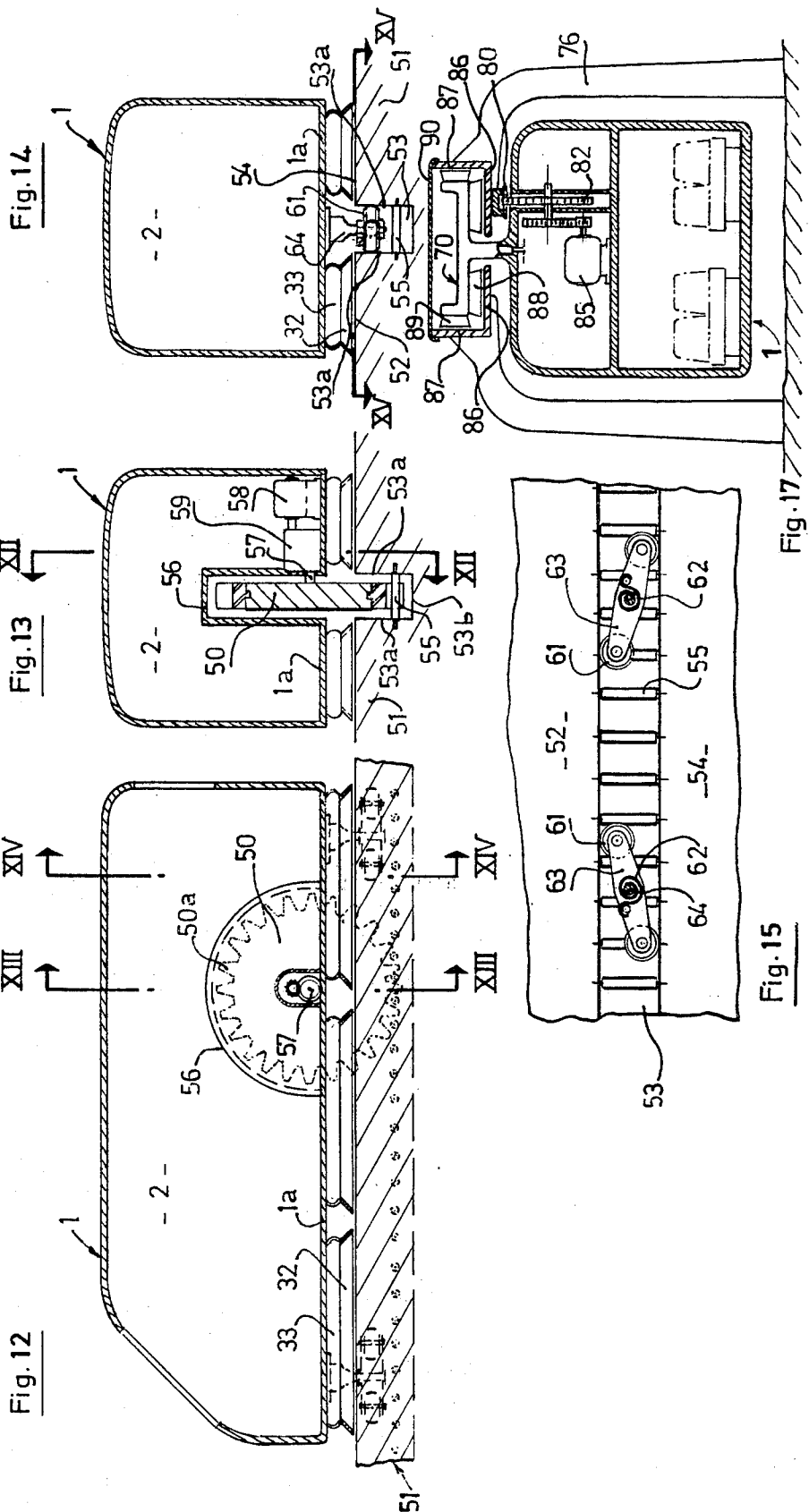
**ABSTRACT:** A transportation system comprising a prepared track, a ground-effect machine movable therealong with the interposition of at least one pressure-fluid cushion, and means for propelling the machine, said means comprising at least two toothed members—namely one gearwheel and one member reacting with the gearwheel teeth—borne the one by the machine and the other by the track and drive means for rotating the gearwheel, the toothed members having tooth systems which mesh with one another, at least one of the tooth systems being at least partly formed by a rubberlike resilient material.











## GROUND-EFFECT TRANSPORTATION SYSTEM

This invention relates to a transportation system comprising a prepared track, a ground-effect machine moveable therealong with the interposition of at least one pressure-fluid cushion, and means for propelling the machine.

It is an object of the invention to provide a system wherein the propelling forces are entirely disassociated from the forces which bear and/or guide the machine.

Another object of the invention is to enable the machine to be propelled along paths comprising variable and steep gradients.

Another object of the invention is to provide a flexible and quiet drive for the machine.

According to the invention, therefore, a transportation system comprises means for propelling the machine, said means comprising at least two toothed members—namely one gearwheel and one member reacting with the gearwheel teeth—borne the one by the machine and the other by the track, the toothed members having tooth systems which mesh with one another, at least one of the tooth systems being at least partly formed by a rubberlike resilient material or elastomer.

Preferably, the gearwheel and the means for rotating the same are mounted on the machine, whereas the reaction member, which is advantageously of the rack kind, is mounted on the track with the interposition of bearing means. If required, however, the rack or similar device can be mounted on the machine and the gearwheels can be mounted on the track.

According to a feature of the invention, the means bearing the reaction member can also be used to guide the machine, for instance by friction, by wheels or by hydrodynamic or by hydrostatic cushions.

The reaction member can be a rack with which the wheel cooperates, in which event the rack and tooth have involute tooth systems which are carefully constructed and which preferably are of large module. The wheel can then be readily positioned in the rack, the coefficient of friction  $C_f = \tan \alpha$  between the materials used, and the pressure angle  $\beta$  of the wheel teeth on the rack teeth, preferably being such that  $C_f = \tan \alpha > G$  ( $G$  DENOTING THE FRICTION ANGLE)

More simply, the reaction member can be an openwork rack comprising rods which extend substantially parallel to the gearwheel axis and which are disposed at a regular spacing from one another, each tooth of the wheel being adapted to penetrate between two consecutive rods and cooperate with one of them.

The gearwheel axis can extend substantially perpendicularly to a longitudinal plane of the machine of substantially perpendicularly to the surface on which the machine is mounted. The machine can be devised to move beside, above or below the reaction member.

The following description, taken together with the accompanying exemplary nonlimitative drawings, will show clearly how the invention can be carried into effect.

In the drawings:

FIG. 1 is a sectioned view on the line I-I of FIG. 2 of a first embodiment of this invention;

FIG. 2 is a sectioned view on the line II-II of FIG. 1;

FIG. 3 is a sectioned view on the line III-III of FIG. 2;

FIG. 4 is a partly sectioned view to an enlarged scale on the line IV-IV of FIG. 2;

FIG. 5 is a partly sectioned view to an enlarged scale on the line V-V of FIG. 2;

FIG. 6 is a view similar to FIG. 4 of another feature of the invention;

FIG. 7 is a diagrammatic view showing to an enlarged scale the detail VII of FIG. 6;

FIG. 8 is a view similar to FIG. 9 of another feature of the invention;

FIG. 9 is a sectioned view on the line IX-IX of FIG. 10 of a second embodiment of this invention;

FIG. 10 is a sectioned view on the line X-X of FIG. 11;

FIG. 11 is a sectioned view on the line XI-XI of FIG. 9;

FIG. 12 is a sectioned view on the line XII-XII of FIG. 13 of a third embodiment of the invention;

FIG. 13 is a sectioned view on the line XIII-XIII of FIG. 12; FIG. 14 is a sectioned view on the line XIV-XIV of FIG. 12; FIG. 15 is a partly sectioned view to an enlarged scale on the line XV-XV of FIG. 14;

FIG. 16 is an elevation in cross section of a fourth embodiment of the invention, and

FIG. 17 is a view similar to FIG. 16 but to a reduced scale of another feature of the invention.

Referring to FIGS. 1—3, which show a first embodiment of the invention, a ground-effect machine 1 comprising a cockpit or driving cab or the like 2 cooperates with a track 3 comprising a bearing part 4 and a lateral extension 5 which in this embodiment is disposed on one side of the bearing part 4. Nozzles 6a which are with advantage oriented in the direction of movement of the machine 1 are provided in the central part of the surface 4, and nozzles 6b which in this embodiment are substantially perpendicular to the surface 4 are provided on each side of the central zone of the surface 4. The nozzles 6a, 6b are connected to capacities 7 which are supplied with pressure fluid by means (not shown) and which are disposed in consecutive relationship along the track 3 and which are normally closed by flaps 8a, 8b opening as the machine passes by.

Lift is provided by pressure-fluid cushions 9 which are, with advantage, limited by preferably flexible skirts 10 secured to the structure 1a. Cushions 9 are supplied with pressure fluid via nozzles 6b. Of course, nozzles 6b oriented in the direction of movement of the machine 1 can be provided, such nozzles then cooperating with reaction members, such as blades (not shown) rigidly secured to the machine structure, in which event the rear skirt of the cushion 9 is raised.

Extending parallel to extension 5 along track 3 is a bearing or support member 12 which is secured to track 3 between the nozzle zone of the surface 4 and the extension 5 near the same and which is preferably smaller than the extension 5. Rods 13 which are at a regular spacing from one another and which extend substantially perpendicularly to the side surfaces of the extension 5 at an appropriate distance from the surface 4 are secured to the extension 5 and support member 12 to form an openwork rack.

Near the machine sidewall 1b which is on the same side as the extension 5, and opposite the rods 13, at least one wheel 14 having teeth 14a of appropriate length is rotated by a shaft 15 perpendicular to a longitudinal plane of the machine 1 passing through the wall 1b so that each tooth 14a can penetrate between two consecutive rods 13 and bear on one of them. The space between two consecutive rods 13 is at least equal to the maximum width of one tooth 14a; The teeth 14a and/or rods 13 are at least partly formed by a rubberlike resilient substance or elastomer.

A fairing 18 receives a turbine 16 comprising a shaft 17 which is, with advantage, parallel to the shaft 15 and which is rigidly secured to a rotor 16a having blades 16b adapted to cooperate with the nozzles 6a. Shaft 17 is connected to shaft 15 of gearwheel 14 by way of means 19 providing a demultiplication and reversal of the direction of rotation (for instance, in the form of two cooperating gearwheels of different diameters), a clutch 21 and a gearbox 22.

In the example described, members for guiding the machine are borne by structure 23, 24 disposed near the ends of the machine 1 and cooperate with the side surfaces of extension 5 near the free terminal edge thereof. Each structure 23, 24 has at least two low-friction runners 25 disposed one on either side of the side surfaces of extension 5 and adapted to slide along the latter surfaces. The latter surfaces can be provided with thin strips 26 of a material having a low coefficient of friction with the runners. The structures 23, 24 are connected to machine wall 1b by arms 27, 28; the same are secured to wall 1b by way of articulations 27a, 28a and to the structures 23, 24 by way of articulations 27b, 28b. The arms 27, 28 can be telescopic.

In the embodiment shown in FIG. 8, the runners 25 are replaced by wheels or rollers 25a which are mounted on the structures 23, 24 and which cooperate with the extension 5 to guide the machine.

The operation of the propelling system is clear from the description just given. As the machine moves along, fluid jets from the nozzles 6a impinge on the blades 16b driving the turbine. The same rotates the gearwheel 14 whose teeth 14a bear on the rods 13 to advance the machine. Minor variations in the position of the gearwheel 14 relatively to the rods 13 do not impair propulsion, the teeth 14a penetrating between the rods 13 to some extent.

In the embodiment shown in FIGS. 6 and 7, the gearwheel 14 cooperates with a rack 20. As in the embodiment shown in FIGS. 1—5, the gearwheel 14 and/or rack 20 are formed at least partly by a resilient deformable rubberlike or elastomeric material and have respective involute tooth systems 14a, 20a which are carefully devised and of large modules; the wheel 14 can readily be positioned in the rack 20, the coefficient of friction  $C_f = \tan \alpha$  between the materials used for the rack 20 and the wheel 14, and the pressure angle  $\beta$  of the teeth 14a on the teeth 20a, preferably being such that  $C_f \tan \alpha > \tan \beta$ ,  $\alpha$  denoting the friction angle. An arrow F in FIG. 7 indicates the direction of rotation of wheel 14.

The feature of a gearwheel cooperating with a rack is of use in all the other embodiments to be described hereinafter. The machine can of course be guided by a central extension of the track without for that reason departing from the scope of the invention.

In a second embodiment of the invention, shown in FIGS. 9—11, a machine 1 having a cabin 2 cooperates with a bearing or supporting track 31 by way of pressure-fluid cushions 32 connected by suspension members 33 to the cabin structure 1a. The cushions 32 are supplied with pressure-fluid in known manner from onboard pressure-fluid sources, e.g. fans (not shown). The machine 1 moves along a support 34 which is rigidly secured to the track 31; an extension 35 thereof has side surfaces substantially parallel to a longitudinal plane of the machine 1, the support 34 having rods 36 which are substantially perpendicular to surfaces 31 and which are disposed at a regular spacing from one another.

At least one gearwheel 37 which is identical to the gearwheel of the first embodiment and whose axis extends substantially perpendicular to surface 31 is received in a recessed part 39 of machine sidewall 1b, some of wheel 37 extending outside wall 1b to near the support 34 opposite rods 36. Teeth 37a of wheel 37 can therefore cooperate with rods 36. Gearwheel 37 is rotated by a hydraulic motor 41 connected by lines 42 to a hydraulic pump 43 which is connected to a motor 44 via a clutch 45 and gearbox 46. All these drive means are mounted on the machine 1. As in the previous embodiments, the teeth of the wheel 37 and/or the rods 36 are made at least partly of a resiliently deformable rubberlike or elastomeric material.

Motor 44 could also be used to drive fans (not shown) supplying the cushions 32 with pressure fluid, such fans being connected, for instance, to outputs 47, 48 of gearbox 46.

As in the first embodiment, the machine is guided by runners 25 mounted on structures 23, 24 cooperating with the side surfaces of extension 35, the structures 23, 24, being connected to the machine by articulated arms 27, 28. Of course, the machine 1 can be guided by a central extension of the track without departure from the scope of the invention.

In a third embodiment of the invention, shown in FIGS. 12—15, the machine 1 cooperates with a track 51 comprising bearing portions 52, 54 and a U-shaped substantially central groove or trough or the like 53 bounded by two sidewalls 53a and a base 53b. Rods 55 substantially perpendicular to the track longitudinal center plane are secured to the walls 53a near the base 53b. Lift cushions 32 which have suspension members 33 and which, as in the second embodiment, are supplied with fluid from the machine cooperate with the track portions 52, 54. A gearwheel 50 whose axis is substantially parallel to the rods 55 can rotate in a recessed part 56 of the machine wall 1a the part 56 being substantially symmetrical of the machine longitudinal center plane and being disposed opposite the groove 53. Some of wheel 50 extends outside the

machine 1 and into the trough 53 to near the rods 55. The teeth of 50a can therefore cooperate with the rods 55 to propel the machine.

In this example, a motor 58 mounted on the machine drives shaft 57 of wheel 50 via a demultiplication member 59. As in the previous embodiment, the wheel 50 and/or the rods 55 are at least partly made of a resiliently deformable rubberlike or elastomeric material.

Advantageously, the machine can be guided by runners or wheels 61 which are mounted in pairs in structures 63 and which bear near the bearing surface of the track on the side surfaces 53a of trough 53 by way of a spiral spring 62, the structures 63 each being articulated to an extension 64 of the machine structure 1a. In the example shown, the machine has two pairs of wheels 61 positioned substantially at its ends.

Without departure from the scope of the invention, the groove 53 can be disposed other than in the machine longitudinal center plane, the machine possibly even being adapted to move alongside the trough.

In the embodiment shown in FIG. 16, the machine 1 is suspended from a track 71 borne by pylons 76 above a surface 75. The track 71 comprises two supports 71a, 71b with which an extension 70 of the machine wall 1c, extension 70 having two bearing arms 72a, 72b and a central guiding part 73 can cooperate by way of pressure-fluid cushions 74, 77 providing lift and guidance respectively for the machine. Cushions 74, 77 receive pressure fluid from capacities, as 78, which are disposed in extension 70 and which are connected to an onboard pressure-fluid source (not shown) via lines as 79.

Rods 80 which are substantially perpendicular to the machine longitudinal center plane and which are disposed near the machine wall 1c and which are disposed at a regular spacing from one another are connected, for instance, to support 71a by a structure 81.

A gearwheel 82 which is identical to the gearwheels of the previous embodiments and whose axis 83 extends substantially parallel to the axis of the rods 80 is mounted on the machine and extends through the wall 1c to near the rods 80. The shaft of wheel 82 is connected to a motor 85 via a demultiplication member 84.

Gearwheel 82 cooperates with rods 80 to propel the machine 1. As in the previous embodiments, the gearwheel 82 and/or the rods 80 are at least partly made of a resilient rubberlike or elastomeric material.

Of course, the suspended track can, without departure from the scope of the invention, be devised differently from what is shown in FIG. 16. More particularly, and as FIG. 17 shows, the track can be concave with the concavity uppermost and comprise two bearing parts 86 and two lateral guiding extensions 87 substantially perpendicular to the parts 86. In such a case the extension 70 is devised correspondingly and cooperates with the bearing parts 86 via pressure-fluid cushions 88 and with the guiding extensions 87 by way of pressure-fluid cushions 89. A protective roof 90 over the track is secured to the free ends of the lateral extensions 87.

In all the previous embodiments described, the machine could of course be guided, just as in the final embodiment, by means of fluid cushions.

The invention is not of course limited to the embodiments described in detail and covers embodiments which can be devised by the use of equivalent technical means.

I claim:

1. A transportation system comprising a track, a ground effect machine guided along said track and conjugate means fitted respectively on said track and on said machine for driving said machine relatively to said track, said conjugate means comprising a rack component and a pinion component in mesh with each other,

- i. at least one of said components being at least partly formed of a resilient elastomeric material, and
- ii. said components having a mutual gear design of such friction angle  $\alpha$  and pressure angle  $\beta$  that  $\tan \alpha > \tan \beta$ .

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2. A transportation system as claimed in claim 1, wherein said rack component comprises a grating of uniformly spaced rods forming an openwork lattice.

3. A transportation system as claimed in claim 1, wherein said track is an elevated track having an undersurface, one of said components is fitted on said undersurface, said machine is suspended underneath said undersurface and lifted by ground effect towards the same, and the other of said components is

fitted at the top of said machine, whereby said components are urged into mesh with each other by said lifting ground effect.

4. A transportation system as claimed in claim 3, wherein said track comprises a top upwardly exposed bearing surface, and said machine comprises an overtopping flanged carrier structure overlapping said bearing surface with the interposition of a pressure fluid cushion.

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