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CONTROL DEVICE FOR A GROUND EFFECT MACHINE

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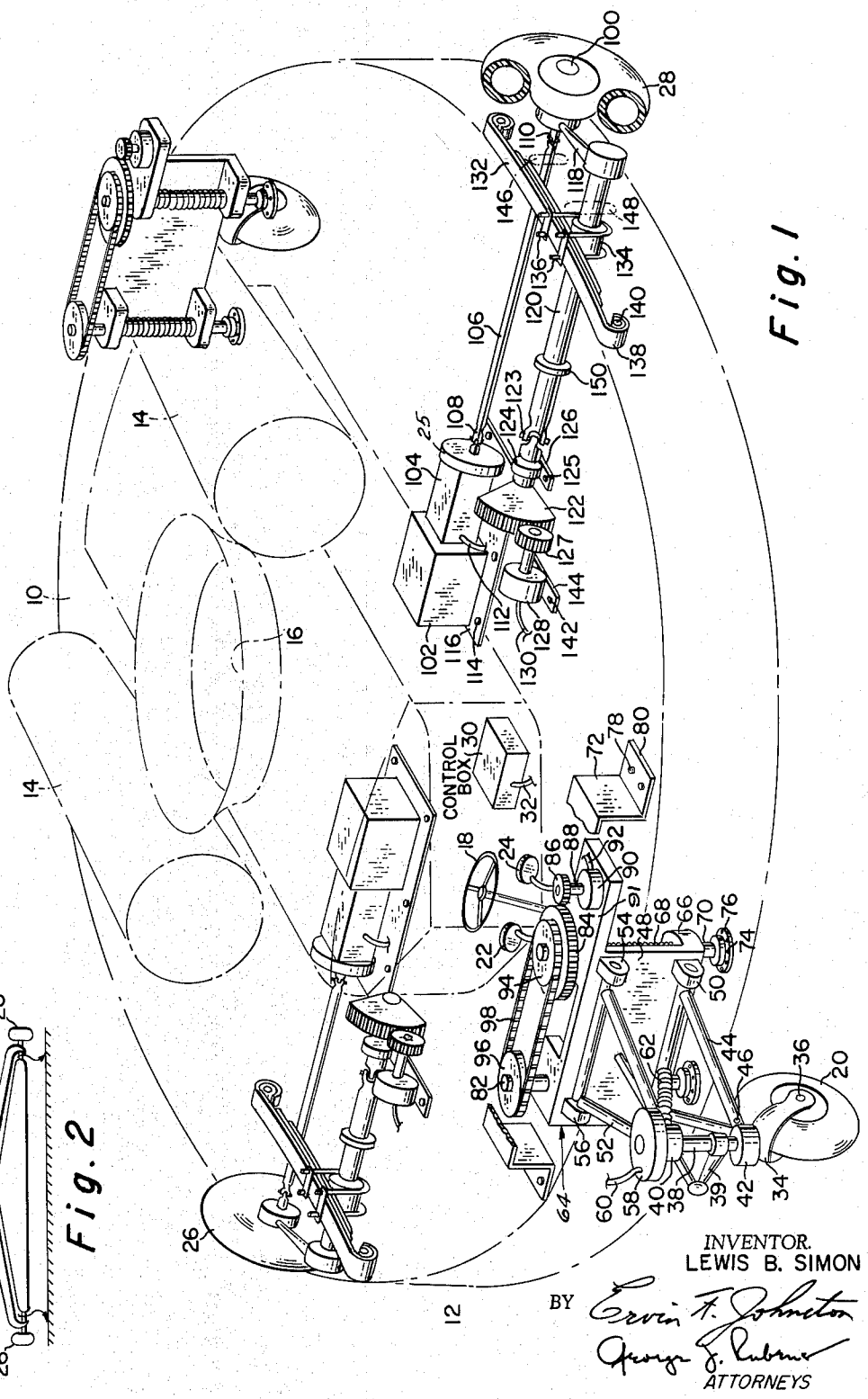

Fig. 1

Fig. 2

INVENTOR.
LEWIS B. SIMON

BY Erwin F. Johnston
George J. Lubner
ATTORNEYS

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CONTROL DEVICE FOR A GROUND EFFECT MACHINE

Lewis B. Simon, 1333 Fern Oaks Drive, Santa Paula, Calif.

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The present invention relates to a control device for a ground effect machine and more particularly to a control device for maneuvering the machine over terrain which is sloping or rough and for manipulating turns, starts or stops.

The operational capability of presently existing ground effect machines (GEM's) has been seriously curtailed because of the inherent disadvantages of the floating action of the machine over the surface of the ground. Operational restrictions have been placed upon presently existing GEM's because of their tendency to slide sideways on sloping surfaces and their susceptability to complete destruction upon meeting steep slopes, ramps or obstacles along the surface of the ground. Further, the operational capability of presently existing GEM's has been seriously curtailed by their inability to make quick starts, stops or turns over the surface of the ground. There has been no means, presently existing, which has enabled a GEM to negotiate a hump in the ground merely a few feet high. In order for presently existing GEM's to climb grades the machine has been tilted to obtain the required upward force component. Tilting the vehicle is limited by the ground, is dangerous at high speed, and the directional component is relatively small. This method of climbing grades is wasteful of power and at present the maximum grade of climb which can be negotiated is 20%. In order to prevent presently existing GEM's from sliding sideways on sloping surfaces side jets or propellers have been employed as support or differential pitch of propellers or fan pressure has been used, however, the control of such equipment has been very difficult. In order for presently existing GEM's to make starts, stops or turns jets or propellers have been used for the proper force component, however, this results in a lack of responsiveness and such equipment is also difficult to control. All of these characteristics would seriously hamper the GEM's capability to traverse rough and undeveloped terrain as well as marshy soft ground. The present methods of control are so ineffective that operator fatigue is a serious problem and is presently planned to be alleviated by expensive and heavy gyroscopic and other sensing devices coupled to complex servos to maintain some sort of automatic control over the above mentioned apparatus. The present invention overcomes these difficulties by adding running gear to the GEM such as wheels, inflated balls and the like. A main feature of the invention is to employ a wheel at the front end of the machine to meet humps or abrupt inclines in the ground thereby preventing any possibility of collision of the machine therewith. Another feature is to employ means for selectively retracting any of the wheels with respect to the GEM so that they can be extended when needed to make a predetermined pressure contact with the ground surface and retracted when control is not required. In one embodiment the invention employs a wheel located at the forward end, the after end and each of the sides of the GEM with the side wheels separately driven and braked and with the forward wheel capable of being steered. With such an embodiment the contact

of the wheels will prevent the GEM from sliding sideways on sloping surfaces and will carry the GEM over any slope, ramp or obstacle along the surface of the ground. Further, the power given to the side wheels will enable the GEM to make quick starts, the side wheels will enable the GEM to negotiate a turn rapidly upon braking a selected side wheel and/or the forward wheel can be steered to facilitate turning maneuvers and the braking of both side wheels enables the GEM to be stopped quickly.

An object of the present invention is to provide a device for controlling a ground effect machine.

Another object is to provide a device for improving the maneuverability of a ground effect machine.

A further object is to provide a device for preventing a ground effect machine from sliding sideways on sloping surfaces.

Still another object is to provide a device for enabling a ground effect machine to efficiently climb steep sloping surfaces.

Yet another object is to prevent collision between an obstacle or abrupt grade with a ground effect machine.

A still further object is to provide a device for enabling a ground effect machine to quickly accelerate.

Still another object is to provide a device for enabling a ground effect machine to quickly decelerate.

Yet another object is to provide a device for enabling a ground effect machine to responsively turn corners.

A still further object is to provide a device which will enable a ground effect machine to more efficiently climb slopes, negotiate rough terrain, quickly accelerate or decelerate and/or responsively negotiate turns.

Other objects and many of the attendant advantages will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawing in which like reference numerals designate like parts throughout the figures thereof and wherein:

FIG. 1 shows an isometric view of a preferred embodiment of the invention with a portion of the exterior of the ground effect machine cut away.

FIG. 2 illustrates a schematic view of a cross section of the ground effect machine to show the relationship of the propeller with respect to the control device.

Referring now to the drawings wherein like reference numerals designate like or corresponding parts throughout the separate views there is shown in FIG. 1 a ground effect machine having a top surface **10** and a peripheral skirt **12** supported by a frame (not shown), the top **10** in turn supporting a pair of jets **14** capable of propelling the GEM in a forward direction. Below an intake opening **16** within the top **10** of the GEM is a propeller **17** (shown in FIG. 2) for providing the cushion of air. Located at a driver's position within the GEM is a steering wheel **18** for steering a wheel **20** mounted on the forward end of the GEM, a pair of pedals **22** and **24** for independently braking wheels **26** and **28**, through operation of braking means such as brake drums **25**, located at the side of the GEM and a control box **30** for controlling other functions of the wheels, the control box **30** having a lead **32** which connects with hardware controlling the various wheels.

The wheel **20** is rotatably mounted on a support **34** by an axle **36**, the support **34** being fixedly mounted to a steering arm **38**. Fixedly atached to the steering arm **38** is a steering mechanism **39** which connects up with the steering wheel **18**. The steering arm **38** is rotatably mounted in bearings **40** and **42** so that the wheel **20** will have a castoring action. The bearing **42** is rotatably mounted to a triangular control arm **44** by a pin **46**, the triangular control bar **44** in turn being rotatably mounted to a support plate **48** by a bearing **50** and rotatably mounted to another bearing opposite thereof which is

identical thereto but not shown. The bearing 40 is rotatably mounted to a triangular control bar 52 in an identical manner as the mounting of the bearing 42 to the triangular control bar 44, the triangular control bar 52 in turn being rotatably mounted to the support plate 48 by bearings 54 and 56. The steering arm 38 extends into a hydraulic brake mechanism 58, this brake mechanism 58 having hydraulic lines 60 which go to the control panel 30 via the lead 32. A spring shock absorber 62 is mounted at one end to the bearing 40 and at an opposite end to the control rod 44 so as to act as a shock absorber for the wheel 20. A rear side of the support plate 48 has bosses 64 and 66 which are threaded to engage a screw shaft 68, the screw shaft 68 being rotatably mounted to the GEM by a lower bearing support 70 and an upper bearing support 72 which has been cut away. The lower bearing support 70 is fixedly attached to the GEM by bolts 74 which pass through a flange plate 76 and the upper bearing support 72 is fixedly attached to the top 10 of the GEM by bolts 78 passing through pads 80. On an opposite side of the support plate 48 is another screw shaft 82 which is mounted in an identical manner as to the mounting of the shaft 68. Fixedly attached to the shaft 68 is a spur gear 84 which meshes with a smaller spur gear 86, the smaller spur gear 86 being fixedly mounted to an output shaft 88 of a servo motor 90. The servo motor 90 is fixedly attached to a plate 91 which is an extension of the boss 64 and has a lead 92 which goes to the control panel 30 via the lead 32 for control purposes. Fixedly mounted to the shafts 68 and 82 are sprockets 94 and 96 respectively, the sprockets 94 and 96 engaging a chain 98 so that the shaft 82 will be rotated in a like manner as shaft 68 upon the operation of the servo motor 90. The length of the control arms 44 and 52 are such that the wheel 20 is capable of contacting the ground forward of the forward end of the GEM. Located at the after end of the GEM is another wheel which is mounted in an identical manner to the GEM as the forward wheel 20 with the exception that the after wheel is facing in a reverse direction and does not include the mechanism for steering purposes.

The wheel 28 is fixedly mounted to a short axle 100, the short axle in turn being driven by a motor 102 via a transmission 104 and a swing axle 106, the axle 106 being connected to the transmission 104 by a universal joint 108 and connected to the short axle 100 by a universal joint 110. The transmission 104 has a line 112 which goes to the control box 30 via the lead 32 for control purposes. The motor 102 and the transmission 104 are mounted to the GEM by bolts 114 which pass through a plate 116. The short axle 100 is rigidly connected to a trailing arm 118, the arm 118 in turn being rigidly connected to a torsion rod 120. The torsion rod 120 is connected to a sector gear 122 via a universal joint 123. The sector gear 122 being rotatably mounted in a bearing 124 which is fixedly mounted to the GEM by a bolt 125 passing through a bracket 126 and another bolt (not shown) passing through another side (not shown) of the bracket 126. The sector gear 122 in turn engages a spur gear 127 which is rigidly attached to an output shaft of a servo motor 128. The servo motor 128 has a lead 130 which goes to the control box 30 via the lead 32 for control purposes. The torsion rod 120 is spring mounted to the GEM by a spring 132, the rod 120 being rotatably supported by a bearing 134 which is fixedly attached to the spring by brackets 136 and the spring 132 being supported at one end 138 to the GEM by a pin 140 and the other end of the spring being supported in a like manner. The servo motor 128 is fixed to the GEM by a bolt 142 which passes through a bracket 144 and by another bolt passing through the same bracket on the other side of the motor. The skirt 12 of the GEM is slotted at 146 so that upon operation of the motor 128 by the operator of the control box 30 the wheel 28 can be raised or lowered with respect to the GEM. Further, the skirt 12 is slotted at 148 to allow for movement of the torsion rod 120 upon springing action. The torsion rod 120 has a torsion coupling 150 for taking the load off of sector gear 122 upon shock being exerted at the wheel 28. The wheel 26 which is located on the opposite side of the GEM is mounted, controlled and operated in an identical manner as the wheel 28.

In FIG. 2 is a schematic illustration showing that the propeller 17 is located above the control device described herein. As shown in FIG. 1 the control device including the side wheels 26 and 28 and the forward wheel 20 and the corresponding mechanism for each is located forward of the propeller 11 so that there is no interference with the control device and the operation of the propeller 17.

In the operation of the control device the operator can selectively operate the wheel to perform many desirable functions in the maneuverability of the GEM such as:

(1) When the GEM is to operate on a sloping surface the wheels 26, 28 and/or 20 are lowered by the operator until they make a desired pressure contact with the ground so that the GEM will be prevented from sliding sideways from the sloping surface by the friction between the wheels 26 and 28 with the ground and/or the maintenance of steerage of the wheel 20;

(2) for negotiating terrain which has local humps or otherwise has projections that would extend above the height of the air cushion of the GEM the forward wheel 20 and the after wheel are lowered to a position where they will meet these humps and carry the GEM's over the humps so as to prevent damage to the GEM. Under this arrangement the forward wheel 20 and the rear wheel need not contact the ground while the GEM is in operation but merely need to be in position to negotiate the humps. In most instances the wheel 20 need only be positioned slightly below the skirt 12 of the GEM and at slow speeds with sufficient pressure in the wheel 20 one inch would be adequate. It is to be noted that upon the forward wheel 20 engaging a hump the GEM will be tilted upward at its forward end which will cause the after end of the GEM to be immediately supported by the after wheel as well as an upward force due to the decrease in the cushion depth at the after end of the GEM;

(3) for quick acceleration the wheels 26 and 28 are lowered to make ground contact and are quickly rotated by the motors cooperating therewith;

(4) for making quick stops once again the wheels 26 and 28 are lowered to make ground contact and both are braked;

(5) for making quick turns once again the side wheels 26 and 28 are lowered to make desired pressure contact with the ground and are independently braked by the pedals 22 and 24 and/or the steering wheel 18 can be employed to selectively turn the wheel 20 so as to facilitate turns; and

(6) for climbing slopes the side wheels 26 and 28 are again lowered to engage the ground and are motor operated to swiftly carry the GEM up the sloping surface.

The forward acting jets 14 are not necessary in the operation of the GEM, however, they can be used for facilitating forward movement of the GEM over the ground. It is to be noted that when the operator desires to perform any of the functions of raising or lowering any one of the wheels or braking any one of the wheels he will use the control panel 30.

Further, it is to be noted that the teaching above suggests many other embodiments of the invention. For instance, the forward wheel 20 could be used alone for negotiating humps in the ground. Further, a plurality of wheels similar to wheel 20 could be used along the

forward edge of the GEM to insure that it will negotiate any humps that it may encounter thereacross. Also, the side wheels **26** and **28** could be used alone with merely the feature of retractability for preventing the GEM's from sliding sideways on sloping surfaces and then being retracted for flat ground operation.

It is now readily apparent that the present invention provides many advantages over the presently existing ground effect machines by providing a control device which will greatly increase the maneuverability thereof. By employing this control device in ground effect machines the operational capability of the machine is greatly enhanced.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. In combination with a ground effect machine which is capable of riding on a cushion of air over the ground in a forward direction, a control device comprising:

(a) a plurality of wheels including at least two side wheels and one wheel mounted at a forward end and another wheel mounted at an after end of said machine with each side wheel fixed facing in a forward direction and said forward wheel capable of contacting the ground forward of said forward end; and

(b) means for selectively positioning each of said wheels vertically below said machine so that upon operation of the machine both wheels can be extended to contact the ground so as to prevent the machine from sliding sidewise on sloping surfaces and upon operation over ground having humps which project above the height of the air cushion, both wheels can be retracted to slightly extend below said machine so as to ride the machine over the humps and prevent a collision between said humps and said machine.

2. In combination with a ground effect machine having a forward end, an after end and sides therebetween and capable of riding on a cushion of air over the ground in a forward direction, a control device comprising:

(a) a plurality of wheels with one wheel mounted at the forward end, another wheel mounted at the after end and a wheel mounted at each of the sides said machine with the forward wheel capable of contacting the ground forward of said forward end;

(b) means for selectively positioning each of said wheels vertically below said machine so that while the machine is in operation the wheels can be extended to make pressure contact with the ground and can be retracted to be spaced from the ground, whereby upon operating the machine in the forward direction said wheels can be extended to contact the ground to prevent the machine from sliding sidewise on sloping ground surfaces or can be retracted to allow the machine to travel solely on its air cushion;

(c) means for steering the forward wheel so that when the forward wheel is in contact with the ground the forward wheel can be steered to facilitate turning maneuvers or can be steered to prevent sidewise movement of the machine when it is operating over said sloping ground surface;

(d) means for independently braking each of the side wheels so that when the side wheels are in contact with the ground a selected side wheel can be braked to facilitate turning maneuvers or both wheels can be braked to facilitate stopping forward motion of the machine; and

(e) means for driving said side wheels so that when the side wheels are in contact with the ground the side wheels can be driven to facilitate forward motion of the machine.

3. In combination with a gorund effect machine having a forward end, an after end and sides therebetween and capable of riding on a cushion of air over the ground in a forward direction, a control device comprising:

a forward wheel and an aft wheel each capable of castoring;

said forward and aft wheels mounted on frames which are movable vertically;

at least two side wheels one each positioned at the sides of said machine;

each of said wheels movable downwardly to a position where they extend below the skirt of said machine so as to space said machine above the surface of the ground;

a motor for driving each of said side wheels; and braking means for braking each of said side wheels,

whereby the forward and aft wheels may both support and steer said machine and said side wheels may support, brake and drive said machine, said wheels serving to maintain said machine in a level attitude over sloping ground and to space said machine above ridges, humps and similar obstructions in its path of travel.

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BENJAMIN HERSH, *Primary Examiner.*

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