

Sept. 14 , 1926.

1,600,154

J. D. VAN VLIET

RUNNING GEAR

Filed August 9, 1924

3 Sheets-Sheet 1

Fig. 1.

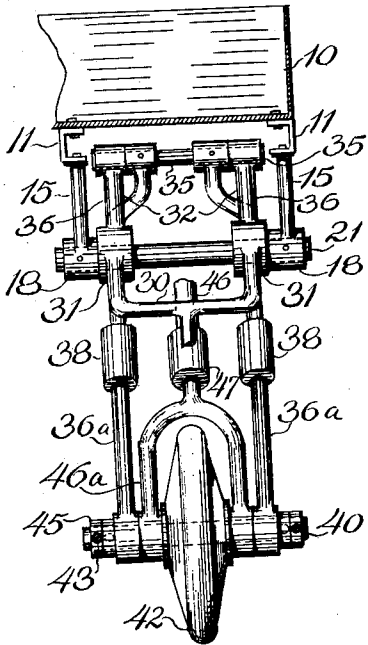
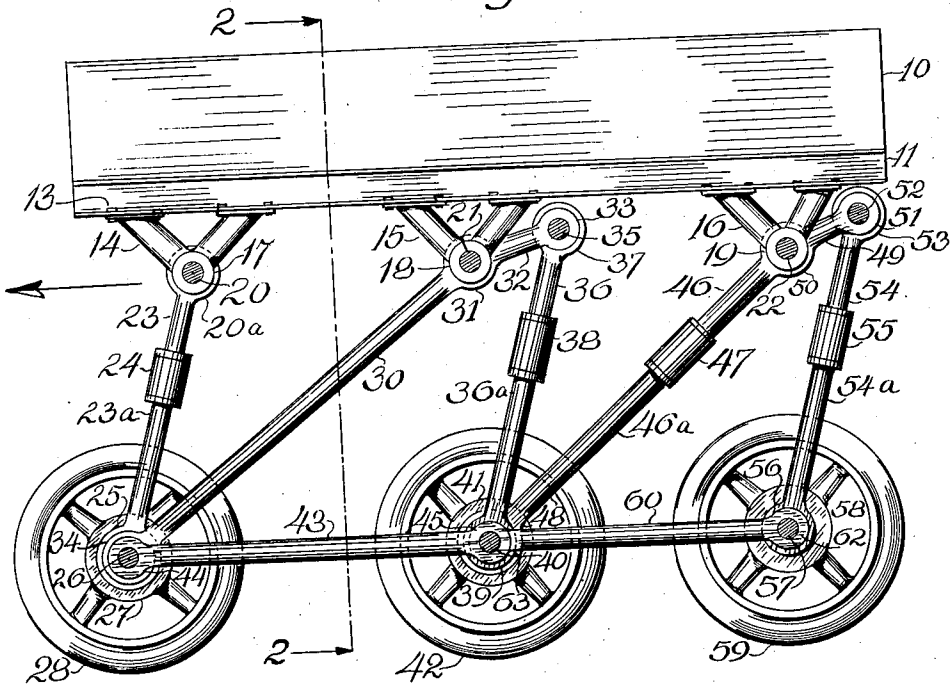


Fig. 2.

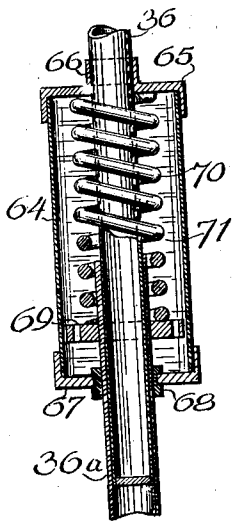


Fig. 3.

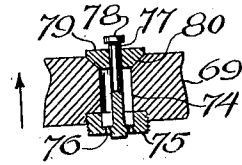
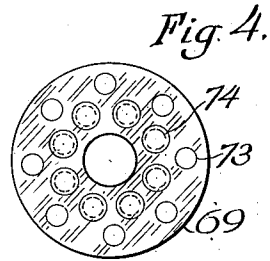


Fig. 5.

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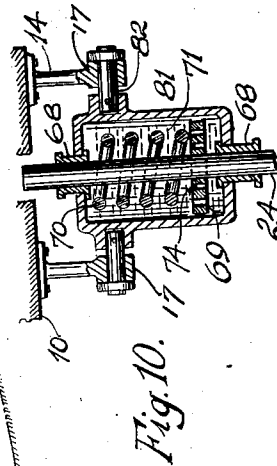
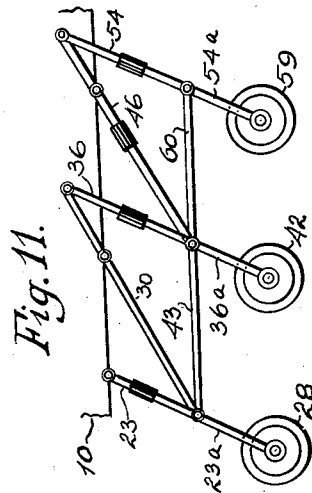
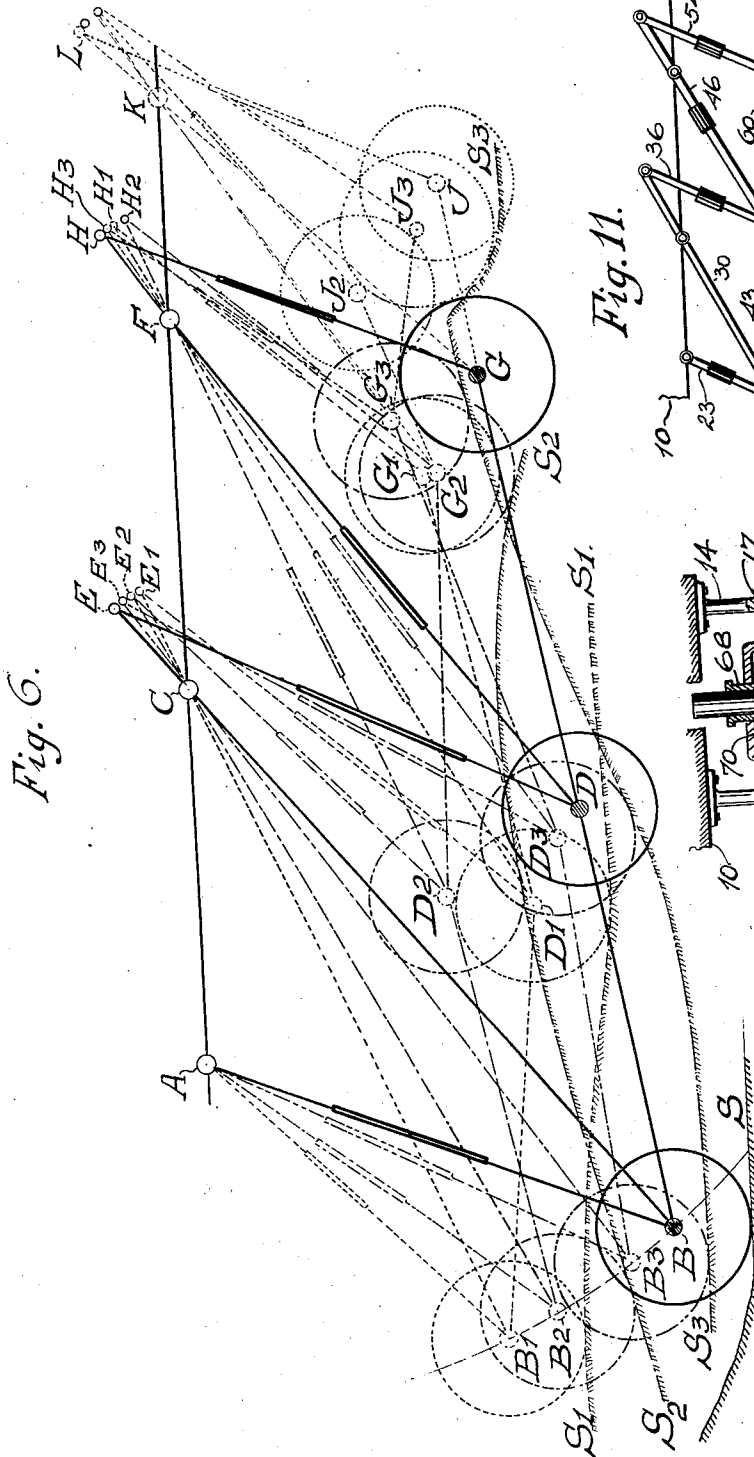
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Sept. 14, 1926.

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3 Sheets-Sheet 2



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Sept. 14 , 1926.

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RUNNING GEAR

Filed August 9, 1924

1,600,154

3 Sheets-Sheet 3

Fig. 7.

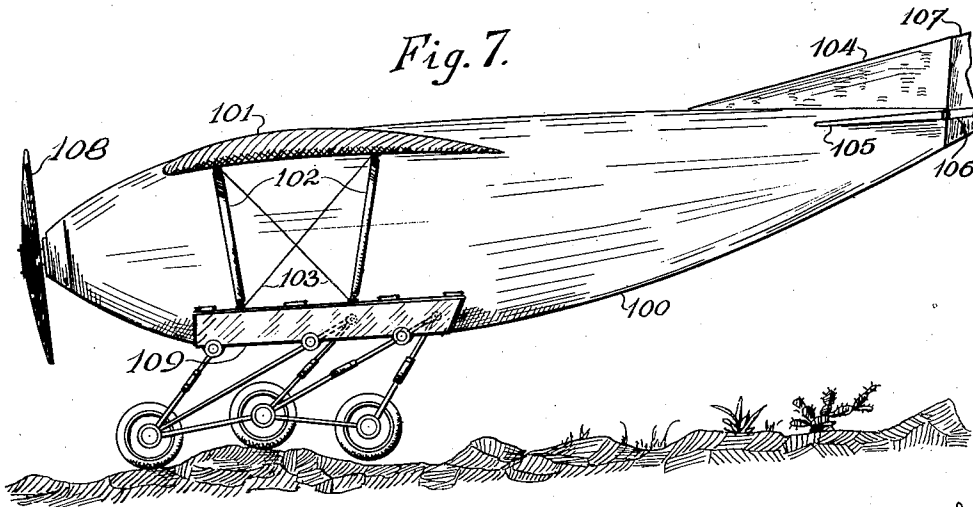


Fig. 8.

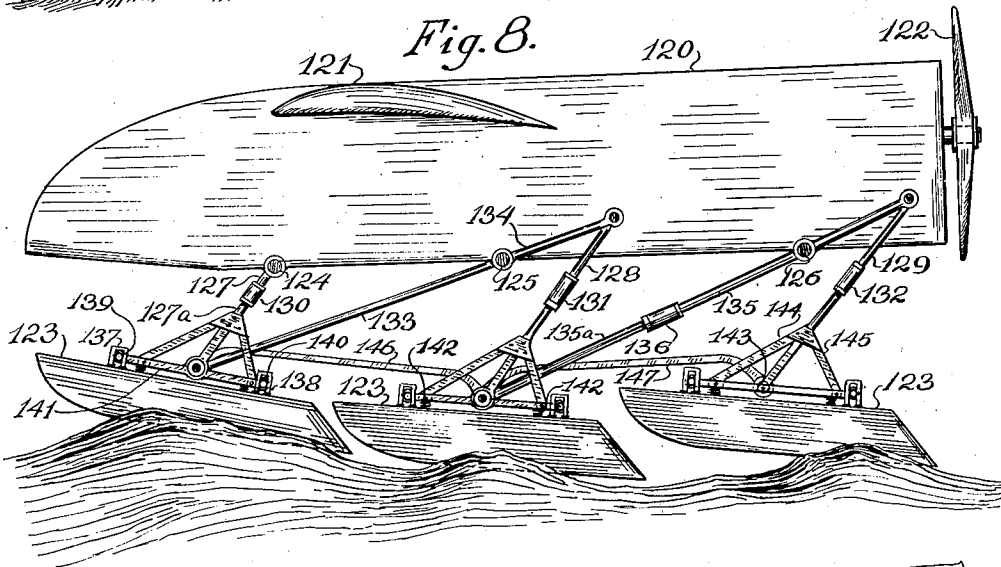
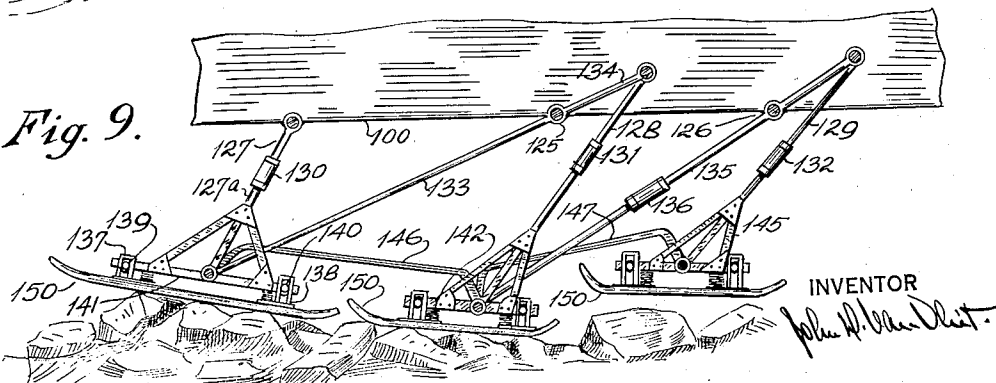


Fig. 9.



Patented Sept. 14, 1926.

1,600,154

UNITED STATES PATENT OFFICE.

JOHN DUMANS VAN VLIET, OF SAN FRANCISCO, CALIFORNIA.

RUNNING GEAR.

Application filed August 9, 1924. Serial No. 731,221.

The invention relates to a running gear in which the means for locomotion, by which name I designate wheels, skids, floats, caterpillar tractors or any other appliances suited to the particular nature of the surface on which the vehicle is to travel, are placed in a fore-and-aft sequence and slidingly and resiliently connected with the body of the vehicle in such a manner that the shocks incidental to the encountering of irregularities of the surface are transmitted from one means for locomotion to the others and in doing so, are absorbed by and distributed over all structural members of the running gear and its attachments to the body of the vehicle.

One of the objects of the invention is to provide means whereby the shock imparted to one of the means for locomotion by the encountering of an irregularity of the surface, causes all the means for locomotion, as a collective entity, to conform themselves to said irregularity, the general action of the collective means for locomotion being that of automatically yielding to and folding itself over the obstacle or irregularity encountered.

Another object of the invention is to provide means whereby the shock imparted to any one of the means for locomotion causes all the means for locomotion to change their respective positions with reference to each other, as well as with reference to the body of the vehicle, in a vertical as well as in a horizontal direction.

Still another object of the invention is to provide means whereby the individual means for locomotion are successively brought into accelerated contact with the irregularities encountered.

Still another and most important object of my invention is to provide a running gear especially adaptable to heavier- and lighter-than-air flying machines, enabling these machines to start from, alight on, and travel over rough and broken ground, rough water, snowfields and expanses of pack-ice and other peculiar and unusually constituted surfaces, such as a flying machine may have to cope with in the course of extended cross-country and trans-aquatic flights, without subjecting the machine to excessive shocks and vibrations, and obviating the possibility of nosing over, whenever in the run over the surface a considerable obstacle is encountered.

With these and other objects in view the invention comprises certain arrangements and combinations which are fully described in the annexed specification and more particularly pointed out in the appended claims.

I wish it to be understood that I do not limit myself to the particular construction and embodiments hereinafter described, since such construction and embodiments are amenable to considerable modifications as may be required by amplifications of design, without however exceeding the scope or affecting the spirit of the invention.

Reference is to be had to the following drawings, in which—

Fig. 1 is a side-elevation of the running gear in one of its embodiments, the means for locomotion being represented by wheels.

Fig. 2 is a section of Fig. 1.

Fig. 3 illustrates a preferred embodiment of the shock-absorber used in various members of the running-gear.

Fig. 4 is a plan view of the plunger used in the shock-absorber shown in Fig. 3.

Fig. 5 is a detailed view of a check-valve, in one of its embodiments, a number of which are used in the plunger.

Fig. 6 is a diagram illustrating the action of the running gear under various conditions fully described in the specification.

Fig. 7 shows the running gear attached to an airplane in the act of landing.

Fig. 8 shows the running gear provided with floats as means for locomotion and illustrates its action when progressing over rough water.

Fig. 9 shows the running gear provided with skids and illustrates its action when progressing over a surface of broken pack-ice.

Fig. 10 shows a modification in the construction of the running gear, relating to the location of the shock-absorber.

Fig. 11 illustrates a variation in the arrangements of the strut members, referred to in the text of the specification.

The running gear can be adapted to any kind of vehicle. In the following description special attention has been paid to its application to aerial vehicles, which often have to take off from and alight on rough and broken surfaces at a comparatively high speed. In such cases it is of the greatest importance that the shocks occasioned by the impact be as much as possible distributed over the entire chassis and also that these

shocks be partially absorbed before being transmitted to the body-structure of the flying machine. It is also of great importance that the rebound be reduced to a minimum.

5 With these ends in view the running gear comprises certain arrangements and combinations of which Fig. 1, shows a simple embodiment.

10 The brackets 14, 15 and 16, attached in a suitable manner to the vehicle-body 10, have the bearings 17, 18 and 19 respectively, carrying the fixed axles 20, 21 and 22. Piv-
15 otally attached to the axle 20 by the bearings 20^a are the upper struts 23, slidingly and resiliently engaging by means of the shock-absorber 24 with the lower struts 23^a which at their lower extremity are provided with the journals 25 carrying the wheel-
20 axle 26 around which rotates the wheel hub 27 integral with the wheel 28.

The direction of forward motion of the vehicle, as indicated by the arrow, makes the axle 20 the front body-axle and the wheel 28 the front wheel.

25 The rigid diagonal strut 30 is pivotally attached by the journals 34 at its lower extremity to the front wheel-axle 26 and pivotally attached by the journal 31 to the body-axle 18. The diagonal strut 30 has
30 the extension 32, forming an integral part with it, which is provided at its extremity with the journal 33 carrying the axle 35.

Pivotally attached to the axle 35 by the journal 37 is the strut 36 slidingly and re-
35 siliently engaging by means of the shock-absorber 38 with the lower strut 36^a which is provided at its lower extremity with the journal 39 carrying the wheel-axle 40 around which revolves the wheel-hub 41
40 integral with the wheel 42.

The horizontal struts 43 connect the wheel-axes 26 and 40, being pivotally attached to them by means of the bearing
45 journals 44 and 45 respectively.

Pivotally attached to the body-axle 22 by the journal 50 is the diagonal strut 46, slid-
45 ingly and resiliently engaging by means of the shock-absorber 47 with the lower diagonal strut 46^a which by means of the journal
50 48 is pivotally attached to the wheel-axle 40.

Integral with the strut 46 is the extension 49 having the journal 51 at its upper ex-
55 tremity carrying the axle 52.

Pivotally attached to the axle 52 by means of the journal 53 is the strut 54 slidingly
55 and resiliently engaging by means of the shock-absorber 55 with the lower strut 54^a which at its lower extremity has the journal 56 carrying the wheel-axle 57 around which
60 revolves the hub 58 integral with the wheel 59.

The horizontal struts 60 connect the wheel-axes 40 and 57 to which they are
65 pivotally attached by means of the journals 63 and 62 respectively.

Referring to Fig. 2 it is seen that the run-
ning gear is placed at one side of the body 10, which is depicted as broken off, and that the brackets carrying the body-axes
70 are attached by means of bolts to the body-frame girders 11. It is understood that the vehicle is provided with a separate running gear at either side and that these individual
75 running gears may be interconnected laterally in any suitable manner, provided these connections do not interfere with the indi-
vidual action of each running gear.

It is also understood that the vehicle may be provided with a combination of individ-
80 ual running gears arranged in any manner deemed expedient; for instance, the vehicle may be provided with an individual run-
ning gear at either side of the body and another one medianly disposed in advance or
85 back of the other two, or there may be an equal plurality of individual running gears at each side of the vehicle-body. This combination again may be complemented by an
90 individual running gear, in advance or back of the others, medianly disposed with re-
spect to the vehicle body.

Since all members of the running gear are pivotally inter-connected, the means for locomotion are enabled to jointly swing back
95 and forth in the manner more fully described hereinafter. It is of the greatest importance that the running gear should not be able to swing sideways, that is, in a direction transverse to the line of forward motion
100 of the vehicle and with this end in view the brackets 14—14, 15—15 and 16—16 have been spaced far apart in a lateral sense to allow the use of long body-
105 axes, thus providing a broad supporting base for the struts leading from these axles to the means for locomotion.

From an examination of Fig. 1 it is evident that the struts composing the connect-
110 ing members of the running gear can be differentiated into vertical struts, diagonal struts and horizontal struts and they will be referred to as such hereinafter. It is hereby pointed out that these appellations serve
115 merely as an approximate indication of their general position with respect to the vehicle and that the terms "horizontal" and "vertical" are not to be taken literally since a considerable deviation from the implied
120 direction may in many instances be found expedient.

In Fig. 2 the strut 46^a is represented as
125 forked at the lower end to enable it to receive the wheel-hub. This construction need not necessarily be adhered to throughout the running gear. The struts may be
130 either forked at their extremities or else may run in duplicate pairs as is the case with the struts 36 and 36^a. Suitable combinations of single forked struts and duplicate parallel struts may also be employed.

If necessary each pair of duplicate parallel struts may be braced together laterally, to insure an equal and simultaneous action of the shock-absorbers. It is understood that, if a pair of duplicate parallel struts is used in place of a single forked strut containing a shock-absorber, both struts of the pair will be provided with a shock-absorber. If transverse bracing of the struts is resorted to, this must be effected in such a way that the resilient and telescoping action of the struts is not interfered with.

The running gear need not necessarily be placed underneath the body of the vehicle. It can be slung on outrigger axles carried in suitably constructed brackets at the side of the vehicle-body at any desired height. The body-axes may also be contained inside the body, allowing its sides to come down over the running gear, which will thus be partially concealed. It is desirable to have at least one longitudinal frame-member for each side of the running gear, since one of the functions of the running gear is the distribution of shocks over the body-frame. This particular construction need however not be strictly adhered to and any other suitable design of body-frame may be adopted.

The vertical struts 23, 36 and 54 are and the diagonal strut 46 are shown in the drawing as consisting of two sections each: an upper section slidingly and resiliently engaging with a lower section bearing the same numeral with the index "a" appended.

The way in which the two sections engage is shown in Fig. 3. The upper strut-section 36, preferably consisting of hollow metal tubing, fits slidably inside the lower strut-section 36^a. The cylinder 64 partially encloses the extremities of both the upper and the lower section, being securely fastened to the upper strut-section by the collar 66 of the cylinder-head 65 forming an integral part of the cylinder 64. The cylinder bottom-plate 67, also an integral part of the cylinder, is provided with the packing-gland 68 which fits slidingly around the lower strut-section 36^a. The plunger 69, fitting slidingly inside the cylinder 64, is securely fastened around the strut-section 36^a. The coil-spring 70, encompassing both struts, is compressedly interposed between the plunger and the cylinder-head 65. The cylinder is entirely filled with an incompressible and preferably viscous fluid, 71, such as oil.

Fig. 4 shows the plunger 69 provided with the perforations 73 and the check-valves 74, which are depicted in detail in Fig. 5, in which the valve cage 75 in threaded engagement with the plunger has the openings 76, the valve-stem 77 with the stop-collar 78, the valve-head 79 fitting into the seat 80 formed by the flaring out of the perforation 74. The arrow indicates the direction in which

the fluid contained in the cylinder is able to pass through the valve, by lifting the valve-head 79 until stopped by the valve-stop 78. I do not limit myself to this particular device and any other device giving similar functional results may be employed.

The action of the running gear has been diagrammatically represented in Fig. 6, in which the body-axes are designated by the letters A, C and F, respectively, the wheel-axes by the letters B, D and G, respectively and the diagonal strut-extension axes by the letters E and H. The indices 1, 2 and 3 appended to the above characters designate the successive positions of the axes and, consequently, of the struts which connect them. For the purpose of illustration it has been assumed that the running gear serves as the landing gear of an airplane and the means for locomotion are represented by wheels, the centers of which, when the landing gear is hanging free, are situated in a straight line sloping rearwardly upward, forming an acute angle with the horizontal line through the centers of the body-axes; the foremost wheel thus being lowest with reference to the body of the machine.

The full lines represent the running gear in its normal position when no load is being applied to the wheels, as would be the case when the airplane is clear of the ground. The airplane is assumed to be in the act of landing on rather rough ground and the front wheel B meets with a protruding unevenness of the surface, such as a hillock or a rock.

The impact produces an axial load in the strut AB, the shock being partially absorbed by the shock-absorber with which the strut is provided, causing the strut to be shortened. Referring to Fig. 3 it is obvious that the lower strut will be pushed upward, sliding sleeve-wise over the upper strut and carrying with it the plunger 69. The cylinder being securely fastened to the upper strut will retain its position and the lower strut is slidingly forced through the packing-gland 68. The incompressible fluid contained within the cylinder will be forced through the holes 73 of the plunger and at the same time the coil spring will be compressed. One of the purposes of the shock-absorber is to absorb the shock at a comparatively slow rate so that part of the load can be instantly transmitted to the other members of the running gear. The perforated plunger serves as a means to retard the action of the coil-spring thus insuring the distribution of the load through the entire running gear.

The diagonal strut BC, being pivoted at C, compels the wheel-axle B to move in a circular path of the radius BC, no other motion being possible. For the purpose of illustration it has been assumed that the

strut AB has been shortened to the length AB^1 and the position of the wheel-axle B will then be B^1 . This new position of the strut AB and the corresponding position of all the other members of the running gear have been represented by short-dash lines.

Since at the moment of landing, due to the sloping position of the running gear, the wheel G has not yet touched the ground, there will be no load on the strut DE, which therefore retains its original length. As the angle of the strut BC with reference to the body has been changed, the point E of the extension CE has been lowered, as has also, in consequence, the point D. At the same time this point has been pulled forward by the horizontal connecting strut BD. Therefore the resultant position of D is now D^1 . To make this position possible, the diagonal strut DF had to be lengthened. The shock-absorber in this strut will therefore, in this instance, act in a direction opposite to the one in the front strut and for this reason the coil springs in the cylinder are introduced on assembling under a slight initial compression, so that the lengthening of one strut may not interfere with the shortening of the others.

The angle of the strut DF with reference to the body will be changed and consequently the point H at the end of the extension FH will be lowered. The wheel G has not touched the ground as yet and therefore, there being no axial load on the strut GH, this strut will retain its original length. The wheel G however, will move forward by reason of its being connected to the wheel D by the strut DG, and at the same time it will rotate in a circular arc of the radius HG. The new position of the point G is now G^1 .

The shaded line S represents the surface at the moment the front wheel touches the ground and shows the irregularity this wheel is about to encounter. The shaded line S^1 represents the surface after the front wheel has come into contact with the irregularity. An examination of the diagram reveals plainly how the front wheel has been raised to the top of the obstacle while the center wheel has been lowered behind it. The rear wheel, it is seen, has not yet come in contact with the surface. All the wheels have been raised with respect to the body and also have shifted their position, with respect to the body, in a forward direction.

With respect to each other however, the front and rear wheel are now relatively higher than the center wheel. The vehicle-body then has settled down on the running gear and the shock has been mainly absorbed by the front strut shock-absorber, and at the same time the reaction has caused the next wheel to lower itself behind the irregularity of the surface. The weight imposed on the

front wheel has thus caused the entire running gear to change its conformation to the exclusion of any appreciable rebound.

The center wheel will next come in contact with the irregularity and there will be an axial load on the strut DE. The shock is partially absorbed by the shock-absorber in this member which will be correspondingly shortened. Since the greater part of the weight is now taken by the center wheel, having been removed from the front wheel, the front strut actuated by the coil spring of its shock-absorber, will tend to lengthen itself, while still in contact with ground, but now on the forward slope of the irregularity. For the purpose of illustration it has been assumed that the wheel D has been forced upward to the position D^2 , the length of the strut DE being now D^2E^2 . The position of the front wheel B is determined by the non-variable lengths BE and BD, making B^2 the corresponding new position. The relative positions of the elements of the running gear for this second case are indicated by the dot-and-dash lines.

At the moment the wheel D reaches the obstacle there is still no load on the rear wheel G and the strut GH therefore retains its original length. The strut length D^1F has been shortened and its angle with respect to the vehicle body has been greatly reduced, bringing the point H^1 to the position H^2 and the corresponding position for the wheel G is now G^2 .

With respect to the vehicle-body, the wheel D has again been raised whereas the front- and rear-wheels have each been lowered. The wheels B and D are now each in contact with the ground and the rear wheel G is about to come in contact. The position of the wheels relative to each other has been modified so that the center wheel is now higher than either the front or the rear wheel.

The shaded line S^2 represents the surface of the ground, showing plainly how the front wheel is now in contact with the forward slope of the irregularity, the center wheel on the apex of the same and the rear wheel about to establish contact with the surface. The body of the vehicle is noticeably nearer to the wheels, which indicates that the body has again settled, the brunt of the shock being absorbed by the shock-absorber in the strut DE, while the shock is also partially transmitted to the front shock-absorber, but in a reverse direction. The rebound is therefore transmitted from one shock-absorber to the other.

As the vehicle moves forward, the wheel G will next come in contact with the irregularity of the surface and the resulting axial load in the member GH will cause this member to be shortened while the shock is partially absorbed by the shock-absorber in this

member. Most of the load has now been transferred from the wheel D to the wheel G and since in addition the member DH acts as a lever with the point F as a fulcrum the strut D^2E^2 will be lengthened, partly as a result of the action of the coil spring in its shock-absorber and partly through the down pull of the strut DH, while the wheel D will be kept in contact with the ground.

The front wheel B will be likewise brought down and the new positions of the wheels are now B^3 , D^3 and G^3 . The position of the struts is indicated on the diagram by the dot-dot-dash lines. The shaded line S^3 represents the ground surface and it is seen that the rear wheel is now at the top of the irregularity, while both the center and front wheels are in contact with the ground on the forward slope of the irregularity. With reference to the body the rear wheel is now higher than the other wheels, but with reference to each other all these wheels are nearly in a straight line and the struts BA and DE have nearly regained their original lengths and positions.

From a study of the diagram, as described above, it is obvious that the general action of the running gear is such as to progressively conform itself to the irregularities of the surface and that the shock of landing is progressively absorbed by and transmitted to the other members of the running-gear and, consequently, to the vehicle body, the lever-like action of the pivoted diagonal members controlling the reactionary movement of those wheels which are not subjected to shock, their motion being always opposite in direction to that of the wheel which is momentarily subjected to the greatest load. In the particular embodiment described and illustrated in Fig. 6, the controlling member of the running gear is the front diagonal strut BC with its extension CE. It is of importance that this member be absolutely rigid since its oscillations control the forward movement of all the means for locomotion with reference to the body. By reason of this forward buffer-like motion the means for locomotion to the rear of the one subjected to shock will meet the obstacle half way and at the same time the angles of the "vertical" struts with respect to the body will be modified to the extent of insuring the greatest axial load at the moment of coming in contact with the surface, and therefore the greatest possible action of the shock-absorbers.

As has already been explained, the forcing upward of the wheel B will result in a downward motion of the wheel D. In the above description it has been assumed that as there is no load on the strut D^1E , this strut will retain its original length. This however, is not strictly so, for a lengthening of the strut DF is essential in order to per-

mit the forward motion of the wheel D, with the result of causing a slight axial load in the member DF, which will, as a consequence, be slightly shortened. As it is desirable to make the up-and-down motion of the wheels as pronounced as possible, this slight disadvantage can be neutralized by making the extension CE sufficiently long to insure an adequate arc of travel for the point E.

In Fig. 1 the diagonal strut extensions have been shown as being at a slight angle to the diagonals to which they appertain. This construction is preferable to the straight extensions since the up-and-down movement of the points E and F will thereby be accentuated. The straight extensions shown in Fig. 6 however illustrate the action with sufficient clearness.

A fourth wheel J has been shown in light dotted lines in addition to the other three wheels, the positions J^2 and J^3 corresponding with B^2 , D^2 and G^2 , and B^3 , D^3 and G^3 respectively.

It is apparent that the movement of the wheel J with reference to the wheel G is similar to that of the wheel G with reference to the wheel D. Any number of wheels can be employed in a fore-and-aft sequence and I do not limit myself to the number shown in the drawings. Two wheels may be used as well as three or five or more. In each case however the controlling member is the rigid diagonal strut, for reasons already stated.

It is important that the struts, as soon as the axial load upon them is diminished or removed, should be able to quickly lengthen themselves again, so that the struts from which the load is being removed do not interfere with the action of those struts which are in order of being compressed. The shock-absorber should therefore act comparatively slowly under a compression load and respond much more readily to a tensional force demanding a lengthening of the struts. This has been achieved by providing the plungers with the check-valves already described, which automatically provide a greater number of passages for the oil to flow through on the downward stroke, thus diminishing the retarding action of the perforated plunger. The check-valve employed for this purpose need not necessarily be of the type shown in the drawing; a ball check-valve or any other device answering the purpose may be substituted with equal results. It is imperative that the shock-absorber cylinders be entirely filled with oil or a similarly viscous fluid to prevent a sudden acceleration in the shortening of the struts under load, which would occur, for instance, when the top of the plunger were to emerge from the oil; moreover, the inclined position of the struts demands a completely filled cylinder in order to obviate any slantwise partial immersion of

the plunger. A certain amount of leakage through the packing-gland is liable to occur, and it is understood, although not shown on the drawings, that the shock-absorber is provided with proper means to keep the cylinders entirely filled, such as for instance, a gravity tank with adequately connected conduits to the cylinder.

Means for filling the cylinders and other accessories hereby are implied, although not shown on the drawing, and it is understood that when telescoping strut-members are employed suitable provision is made to prevent leakage of oil down into the struts. It is also implied that provision is made to obviate any compression of air inside the tubular struts which might interfere with the working of the shock absorber, and suitable air valves or perforations in the struts are understood to be employed.

Certain variations may be introduced in the arrangement of the principal elements of the running gear. In Fig. 1 the shock-absorber 24 is shown as placed intermediate the body-axle 20 and the wheel-axle 26. The required action of the strut 23 can however also be obtained by placing the shock-absorber in the body-axle and making it part thereof. This arrangement is shown in Fig. 10. The strut 24, provided with the perforated plunger 69, which has the check-valves 74, slides inside the oil-filled cylinder 81 to which the axles 82 are securely fastened. These axles turn in the bearings 17 of the brackets 14 which are fastened in a suitable manner to the body 10. The cylinder has the packing glands 68 at the top and bottom, allowing the strut to slide up and down. The coil-spring 70 is interposed between the plunger and the cylinder head. This arrangement obviates the necessity of making the strut in two sections which are in sliding engagement with each other. The construction of the cylinder however will be somewhat heavier than would otherwise be the case.

The above described construction can also be applied to the other vertical struts, in which case the shock-absorber-axes would pivotally engage with the extremities of the diagonal strut-extensions; and can equally be applied to any of the diagonal struts in which shock-absorbers are required.

Fig. 7 shows a three-wheeled running gear applied to an airplane including the fuselage 100, the wings 101 with the struts 102 and the crosswires 103, the tailfin 104, the stabilizer 105, the elevators 106 and the rudder 107. The fuselage is provided with the tractor airscrew 108, the powerplant being inside the fuselage and not shown. The airplane is thus of the usual type and it is understood that the collective landing gear consists of two units, one at either side of the fuselage and each one like the running gear shown in

the drawing. The individual units can be interconnected laterally by any suitable means, provided each unit retains its complete liberty of action.

In Fig. 7 the center-wheel has just come in contact with an irregularity of the surface, the front wheel having already passed the same and has descended to meet the forward slope of the obstacle. The rear wheel is shown in the act of descending, in consequence of the forcing upward of the center-wheel. The diagonal strut-extensions of the running gear are shown as being inside the frame 109, the fulcrums being just at the bottom of the frame. They can also be placed higher up inside the fuselage and the location of the running gear may be so arranged that only the wheels protrude outside the body, an arrangement which has the advantage of reducing the air-resistance offered by the members of the running gear. Another modification would be attaching the running gear to suitably braced outriggers at either side of the fuselage, the upper portion of the gear being protected by a streamlined cowl.

It is obvious that inasmuch as there is a great variety of designs for airplanes, a particular design may directly affect the location of the running gear. The units may have to be placed a considerable distance away from the fuselage and may have to be directly attached to the wing-structure, which in that case will then be provided with special bracing to take care of the landing stresses. The number of running-gear units is of course by no means restricted to two, but may vary from two to any number required by the design of the airplane. The number of means for locomotion in each running-gear unit may also vary from two to any number compatible with the design of the airplane.

It may in some instances be desirable to remove the entire running gear as a unit from the body of the vehicle or from parts pertaining thereto, in which case the strut members will be attached to a special member removably attached to a rigid portion of the vehicle and I purposely differentiate between means for locomotion attached to the vehicle in the manner described and means for locomotion similarly attached to a member removably attached to a rigid portion of the vehicle, the latter arrangement constituting a removable running gear.

Fig. 8 represents a combination of an airplane with a hydroglider, including the body 120, the wings 121 attached to the body and the pusher-screw 122, connected to the powerplant inside the body. The balancing and steering surfaces are not shown in the drawing, but it is understood that the machine possesses all the elements constituting it an operative whole.

The machine is provided with a running gear in which watertight floats serve as means for locomotion enabling it to rest on land or skim along and take off from the surface of the water.

The floats 123 are placed in a fore-and-aft sequence and possess a flat or V-shaped hydroplaning bottom, curving upward at the front, and meeting the forwardly slantwise truncated rear end of the pontoon.

The structural elements of the hydrorunning gear and their interrelation are similar to those of the land-running gear already described, comprising the body-axes 124, 125 and 126, the so-called "vertical" struts 127, 128 and 129 provided with the shock-absorbers 130, 131 and 132 respectively, which resiliently and in sliding relation connect the lower sections of the struts with the upper sections, being on the drawing differentiated from them by the same respective numerals with the index added thereto, the rigid front diagonal strut 133 with the extension 134 and the rear diagonal strut 135 slidingly and resiliently engaging with the lower section 135^a by means of the shock-absorber 136. The floats are attached to the vertical struts in the following manner:

To the top surface or deck of the float are fixed the vertically slotted guides 137 and 138 slidingly engaging with the horizontal transverse pins 139 and 140, respectively, of the horizontal strut or brace 141. The springs 142 attached to the deck of the float and the brace 141 keep the last two named elements in resilient relation. At the point of intersection of the lower vertical strut with the brace 141 is fixed the lower axle 143. The diagonal braces 144 and 145 are rigidly attached to the brace 141 and to the lower vertical strut. The same mode of attachment applies to the other floats, the horizontal struts 146 and 147 pivotally interconnecting the lower axles. This running gear differs from the one previously described in that the lower struts are provided with a rigid longitudinally extended base permitting a stable attachment for the elongated floats. In all other essentials the arrangement of the elements conforms with that of the land running gear. The action of the floats is as follows:

When the hydro-vehicle is driven along the surface of rough water, it will be subjected to a series of shocks equalling and often surpassing in intensity those experienced by a land-vehicle riding over broken ground. If the disturbances in the surface of the water are inconsiderable the rate of progress and the longitudinal stability of the vehicle are not greatly affected. If the waves however, attain considerable proportions, the pontoons or floats with which the hydro-vehicle is provided, will have a tendency to nose into the waves since the great speed of

the machine does not allow of an easy riding over them as would be the case with a boat. Especially in the case of a flying machine trying to effect a landing on rough water there will be considerable danger of a sudden check in speed with an attendant possibility of the entire machine nosing over and coming to grief, which can only be avoided by the exercise of considerable skill on the part of the pilot.

To meet these adverse contingencies, the float or pontoon, instead of being made in one continuous piece, as is the usual practice, has been divided lengthwise into several units, each unit constituting a float by itself, movable with respect to the body of the vehicle and to each other.

The floating means, constituting also the means for locomotion, are attached to the body of the hydro-vehicle in the manner already fully described.

Referring to Fig. 6, it has been explained that when the shock is taken by the front "vertical" strut, this strut by reason of its pivotal connection with the front diagonal strut will swing forward, thereby diminishing its angle with respect to the body of the machine. The front float, being attached to this strut in the manner described, will consequently alter the angle of its planing surface with respect to the horizontal in a like degree and will make it conform to a certain extent with the slope of the wave which it meets. The center float is simultaneously lowered and swung forward with an attendant increased forwardly upward inclination, its planing surface thus meeting the surface of the water at an angle of incidence adapted to the slope of the wave. This prevents the float from nosing into the wave and to a great extent obviates shock and retardation of forward motion. The same action applies to the rear float. When the center float is on the crest of the wave, the front and rear floats will present a lesser angle to the horizontal than the center float and at the same time be lower than the center float with reference to the body of the vehicle. The collective floating means, therefore conforms itself to the surface of the water and bends itself over the waves in the same manner as the wheels of the land-running-gear follow the irregularities of the ground. The initial position of the floats is preferably such that when the running gear is hanging free, the floats are pointing slightly downward, so that when the floats are resting on or running over the water with all struts taking the load in equal proportion, the floats will be in line horizontally. The springs interposed between the deck of the floats and the horizontal braces in conjunction with the vertically slotted guides and guide pins, allow the floats to adjust themselves to minor disturbances in the surface of the water and

in the slopes of the waves. The horizontal connecting struts shown in Fig. 8 are curved downward at their extremities, thus raising these struts and thus allowing the nose of the floats to clear them even in extreme positions. A variation of this mode of connecting is shown in Fig. 11.

The position of the pontoons in a fore-and-aft sequence depends largely on the size and the design of the hydro-vehicle. They can be placed at considerable intervals or as close together as their movement will allow. In either case the result is the same: the collective means for locomotion conform themselves to the irregularities of the surface and at the same time any danger of their nosing into the waves is obviated by the automatically increased angle of incidence of their planing surfaces.

Should the pontoons be placed far apart, it may be found expedient to substitute a succession of toggle-like means in the place of the diagonal single lever-means described.

The running gear in which floats serve as means for locomotion can be applied to a hydro-glider as well as to an airplane and it is understood that Fig. 8 serves as an illustration for both cases.

Fig. 9 shows the running gear provided with the skids 150 which are attached to the vertical struts in substantially the same manner as the floats in the preceding case and the action of the skids as regards their relative movement is in all respects similar to that of the floats. The skids are employed when a landing on or a take-off from a rough and slippery surface is required, such as is the case, for instance on snow fields and expanses of broken pack-ice. The skids are curved upward at their front end to obviate any chance of their catching in the irregularities of the surface.

Another type of means for locomotion more especially adapted to running over loose sandy soil or soft marshy ground where a broad tread is required to prevent the vehicle from sinking in, as the caterpillar tractor. In this case the running gear in all its essential features will be the same as the one provided with floats or skids; the caterpillar belt runs over two wheels or pulleys the axles of which are connected by a brace which is either rigidly or pivotally attached to the vertical strut, as is the case with the braces 141 described in the float attachment. The entire running gear unit will then present a series of caterpillar tractors in a fore and aft sequence in the same fashion as the hydro-gear presents a series of floats.

From the above description it is evident that the running-gear with its various modifications can be applied to any kind of vehicle. As already pointed out it is especially useful in flying machines. Although especial stress has been laid on its application to air-

planes, it is understood that other aerial vehicles are also included, such as helicopters and dirigible balloons, and that in all these applications the disposition and attachment of the running gear units may be such as found expedient and compatible with the general design of the vehicle. The term hydro-vehicle is meant to imply any vehicle designed to permanently, temporarily or intermittently progress on the surface of the water by artificial or natural means, and the means for locomotion may constitute the floating means as well as the means for hydro-planing over the surface, or a combination of both.

I wish it to be understood that the term "running gear" does not necessarily imply a running gear in supporting relation to the vehicle body and that the term in its broader sense includes any arrangement tending to facilitate and lessen the friction of a vehicle progressing along a surface in vertical, lateral or other relation thereto and depending on this surface for guidance, and I have accordingly differentiated these conditions in the appended claims.

Having thus fully described my invention, I claim:—

1. In a vehicle, the combination with a rigid portion of the vehicle, of a plurality of means for locomotion disposed in a fore-and-aft sequence, and means attachingly connecting said means for locomotion with one another and with said rigid portion of the vehicle, said means comprising a plurality of struts disposed at substantially right angles to the fore-and-aft axis of the vehicle, each of said struts being respectively attached to each of said means for locomotion at its extremity remote from the vehicle, and one of said struts being attached at its opposite extremity to said rigid portion of the vehicle, a plurality of fore-and-aft struts attached to and interconnecting said normally disposed struts, and a plurality of diagonal struts attachingly connecting each of said normally disposed struts, with the extremity nearest the vehicle of the next normally disposed strut, each of said diagonal struts being attached at a point intermediate its extremities to said rigid portion of the vehicle.

2. In a vehicle, the combination with a rigid portion of the vehicle, of a plurality of means for locomotion disposed in a fore-and-aft sequence, and means attachingly connecting said means for locomotion with one another and with said rigid portion of the vehicle in supporting relation thereto, said means comprising a plurality of substantially vertical struts, each of said struts being respectively attached at its lower extremity to each of said means for locomotion and one of said vertical struts being attached at its upper extremity to said rigid portion of the vehicle, a plurality of substantially horizon-

tal fore-and-aft struts interconnecting said vertical struts, and a plurality of diagonal struts attachingly connecting each of said vertical struts, with the upper extremity of the next vertical strut, each of said diagonal struts being attached at a point intermediate its extremities to said rigid portion of the vehicle.

3. In a vehicle, the combination with a 10 rigid portion of the vehicle, of a running gear comprising a rigid frame-like member removably attached to said rigid portion of the vehicle, a plurality of means for loco-
15 motion disposed in a fore-and-aft sequence, a plurality of struts substantially normally disposed to said rigid frame-like member, each of said normally disposed struts being
20 respectively attached at its extremity remote from the vehicle to each of said means for locomotion, and one of said normally dis-
posed struts being attached at its opposite extremity to said rigid frame-like member, a
25 plurality of fore-and-aft struts, substantially parallel to said rigid frame-like member, attached to and interconnecting said nor-
mally disposed struts, and a plurality of di-
agonal struts attachingly connecting each of
30 said normally disposed struts, with the innermost extremity of the next normal strut, each of said diagonal struts being attached
at a point intermediate its extremities to
said rigid frame-like member.

4. In a vehicle, the combination with a 35 rigid portion of the vehicle, of a running gear comprising a rigid frame-like member removably attached to said rigid portion of the vehicle, a plurality of means for loco-
40 motion disposed in a fore-and-aft sequence, and means attachingly connecting said means for locomotion with one another
and with said rigid frame-like member in
supporting relation to the vehicle, said means
45 comprising a plurality of substantially vertical struts, each of which being respectively
attached at its lower extremity to each of
said means for locomotion, and one of said
vertical struts being attached at its upper
50 extremity to said rigid frame-like member, a plurality of substantially horizontal fore-
and-aft struts attached to and interconnect-
ing said vertical struts, and a plurality of
diagonal struts attachingly connecting each
55 of said vertical struts, with the upper ex-
tremities of the next following vertical
struts, each of said diagonal struts being at-
tached at a point intermediate its extremi-
ties to said rigid frame-like member.

5. In a vehicle, the combination with a 60 rigid portion of the vehicle, of a plurality of means for locomotion disposed in a fore-
and-aft sequence, and means pivotally and
swingingly attaching and resiliently con-
necting said means for locomotion to and
with one another and to and with said rigid
portion of the vehicle, said means comprising

a plurality of struts provided with shock-ab-
sorbing means, disposed substantially nor-
mally to the fore-and-aft-axis of the vehicle,
each of said normally disposed struts being
70 pivotally attached at its extremity remote
from the vehicle to each of said means for
locomotion respectively, and one of said nor-
mally disposed struts being pivotally attached
at its opposite extremity to said rigid portion
75 of the vehicle in resilient relation thereto,
a plurality of fore-and-aft struts pivotally
attached to and interconnecting said normal-
ly disposed struts, and a plurality of di-
agonal struts, provided with shock-absorb-
80 ing means, pivotally, attachingly and resil-
iently connecting each of said normally dis-
posed struts, with the extremity nearest the
vehicle of the next normally disposed strut,
each of said diagonal struts being pivotally
85 attached at a point intermediate its extremi-
ties to said rigid portion of the vehicle.

6. In a vehicle, the combination with a
rigid portion of the vehicle, of a plurality
of means for locomotion disposed in a
fore-and-aft sequence, and means pivotally 90
and swingingly attaching and resiliently
connecting said means for locomotion to
and with one another and to and with said
rigid portion of the vehicle in resilient sup-
95 porting relation thereto, said means com-
prising a plurality of substantially vertical-
ly disposed struts provided with shock-ab-
sorbing means, each of said vertically dis-
posed struts being pivotally attached at its
100 lower extremity to each of said means for
locomotion, and one of said struts being piv-
otally attached at its upper extremity to said
rigid portion of the vehicle in resilient re-
lation thereto, a plurality of substantially
105 horizontal fore-and-aft struts pivotally at-
tached to and interconnecting said vertical
struts, and a plurality of diagonal struts,
provided with shock-absorbing means, piv-
otally, resiliently and attachingly connect-
110 ing each of said vertical struts, with the
upper extremity of the next vertical strut,
each of said diagonal struts being pivotally
attached at a point intermediate its extremi-
ties to said rigid portion of the vehicle.

7. In a vehicle, the combination with a 115 rigid portion of the vehicle, of a running
gear comprising a rigid frame-like member
removably attached to said rigid portion of
the vehicle, a plurality of means for loco-
120 motion disposed in a fore-and-aft sequence,
a plurality of struts, provided with shock-
absorbing means, normally disposed to said
rigid frame-like member, each of said nor-
mally disposed struts being pivotally at-
125 tached at its extremity remote from the
vehicle to each of said means for loco-
motion respectively, and one of said nor-
mally disposed struts being pivotally at-
tached at its opposite extremity to said
130 rigid frame-like member in resilient re-

lation thereto, a plurality of fore-and-aft struts, substantially parallel to said rigid frame-like member, pivotally attached to and interconnecting said normally disposed struts, and a plurality of diagonal struts, provided with shock-absorbing means, pivotally attached to and resiliently connecting each of said normally disposed struts, with the innermost extremity of the next normally disposed struts, each of said diagonal struts being pivotally attached at a point intermediate its extremities to said rigid frame-like member.

8. In a vehicle, the combination with the rigid portion of the vehicle, of a running gear in resilient supporting relation thereto, said running gear comprising a rigid frame-like member removably attached to said rigid portion of the vehicle, a plurality of means for locomotion disposed in a fore-and-aft sequence, a plurality of substantially vertical struts provided with shock-absorbing means, each of said vertical struts being pivotally attached at its lower extremity to each of said means for locomotion respectively, and one of said vertical struts being pivotally attached at its upper extremity to said rigid frame-like member in resilient relation thereto, a plurality of substantially horizontal fore-and-aft struts pivotally attached to and interconnecting said vertical struts, and a plurality of diagonal struts provided with shock-absorbing means pivotally attached to and resiliently connecting each of said vertical struts with the upper extremity of the next vertical strut, each of said diagonal struts being pivotally attached at a point intermediate its extremities to said rigid frame-like member.

9. In a vehicle, the combination with a rigid portion of the vehicle, of two means for locomotion disposed in a fore and aft sequence and means attachingly connecting said means for locomotion with one another and with said rigid portion of the vehicle in supporting relation thereto, said means comprising two substantially vertical struts, each of which being attached at its lower extremity to one of said means for locomotion respectively, one of said vertical struts being attached at its upper extremity to said rigid portion of the vehicle, a substantially horizontal fore and aft strut interconnecting said vertical struts, and a diagonal strut attachingly connecting one of said vertical struts, with the upper extremity of the other vertical strut, said diagonal strut being attached at a point intermediate its extremities to said rigid portion of the vehicle.

10. In a vehicle, the combination with a rigid portion of the vehicle, of a running gear comprising a rigid frame-like member removably attached to said rigid portion of the vehicle, two means for locomotion disposed in a fore and aft sequence, two struts

substantially normally disposed to said rigid frame-like member, each of said normally disposed struts being respectively attached at its extremity remote from the vehicle-body to one of said means for locomotion, one of said normally disposed struts being attached at its upper extremity to said rigid frame-like member, a fore and aft strut substantially parallel to said rigid frame-like member attached to and interconnecting said normally disposed struts, and a diagonal strut attachingly connecting one of said normally disposed struts, with the innermost extremity of the other normally disposed strut, said diagonal strut being attached at a point intermediate its extremities to said rigid frame-like member.

11. In a vehicle, the combination with the rigid portion of the vehicle, of a running gear comprising a rigid frame-like member removably attached to said rigid portion of the vehicle, two means for locomotion disposed in a fore and aft sequence and means attachingly connecting said means for locomotion with one another and with said rigid frame like member in supporting relation to the rigid portion of the vehicle, said means comprising two substantially vertical struts, each of which being respectively attached to each of said means for locomotion, one of said vertical struts being attached at its upper extremity to said rigid frame-like member, a substantially horizontal fore and aft strut attached to and interconnecting said vertical struts, and a diagonal strut attachingly connecting one of said vertical struts, with the upper extremity of the other vertical strut, said diagonal strut being attached at a point intermediate its extremities to said rigid frame-like member.

12. In a vehicle, the combination with a rigid portion of the vehicle, of two means for locomotion, disposed in a fore and aft sequence, and means pivotally, and swingingly attaching and resiliently connecting said means for locomotion to and with one another and to and with said rigid portion of the vehicle, said means comprising two struts provided with shock-absorbing means, disposed substantially normally to the fore and aft axis of the vehicle each of said normally disposed struts being pivotally attached at its extremity remote from the vehicle to each of said means for locomotion respectively, one of said normally disposed struts being pivotally attached at its opposite extremity to said rigid portion of the vehicle in resilient relation thereto, a fore and aft strut pivotally attached to and interconnecting said normally disposed struts, a diagonal strut pivotally attaching and resiliently connecting one of said normally disposed struts, with the extremity nearest the vehicle of the other normally disposed strut, said diagonal strut being pivotally at-

tached at a point intermediate its extremities to said rigid portion of the vehicle.

13. In a vehicle, the combination with the rigid portion of the vehicle, of two means for locomotion disposed in a fore and aft sequence, and means pivotally and swingingly attaching and resiliently connecting said means for locomotion to and with one another and to and with said rigid portion of the vehicle in resilient supporting relation thereto, said means comprising two substantially vertical struts provided with shock-absorbing means, each of said vertical struts being pivotally attached at its lower extremity to each of said means for locomotion respectively, one of said vertically disposed struts being pivotally attached at its upper extremity to said rigid portion of the vehicle in resilient relation thereto, a substantially horizontal fore and aft strut pivotally attached to and interconnecting said vertical struts, and a diagonal strut pivotally and attachingly connecting one of said vertical struts, with the upper extremity of the other vertical strut, said diagonal strut being pivotally attached at a point intermediate its extremities to said rigid portion of the vehicle.

14. In a vehicle the combination with a rigid portion of the vehicle, of a running gear comprising a rigid frame-like member removably attached to said rigid portion of the vehicle, two means for locomotion disposed in a fore and aft sequence, two struts provided with shock-absorbing means, normally disposed to said rigid frame-like member, each of said normally disposed struts being pivotally attached at its extremity remote from the vehicle to each of said means for locomotion respectively one of said normally disposed struts being pivotally attached at its upper extremity to said rigid frame-like member in resilient relation thereto, a fore and aft strut substantially parallel to said rigid frame-like member pivotally attached to and interconnecting said normally disposed struts and a diagonal strut pivotally and attachingly connecting one of said normally disposed struts, with the innermost extremity of the other normally disposed strut, said diagonal strut being pivotally attached at a point intermediate its extremities to said rigid frame-like member.

15. In a vehicle the combination with a rigid portion of the vehicle, of a running gear in resilient supporting relation thereto, said running gear comprising a rigid frame-like member removably attached to said rigid portion of the vehicle, two means for locomotion disposed in a fore and aft sequence, two substantially vertical struts provided with shock-absorbing means, each of said vertical struts being pivotally attached at its lower extremity to each of

said means for locomotion respectively, one of said vertical struts being pivotally attached at its upper extremity to said rigid frame-like member in resilient relation thereto, a substantially horizontal fore and aft strut pivotally attached to and interconnecting said vertical struts and a diagonal strut pivotally attached to and resiliently connecting one of said vertical struts with the upper extremity of the other vertical strut, said diagonal strut being pivotally attached at a point intermediate its extremities to said rigid frame-like member.

16. In a vehicle the combination with the rigid portion of the vehicle, of a running gear in resilient supporting relation thereto, said running gear comprising a rigid frame-like member removably attached to said rigid portion of the vehicle, three means for locomotion disposed in a fore and aft sequence, three substantially vertical struts provided with shock-absorbing means, each of said vertical struts being attached at its lower extremity to each of said means for locomotion respectively, one of said vertical struts being pivotally attached at its upper extremity to said rigid frame like member in resilient supporting relation thereto, substantially horizontal fore and aft struts pivotally attached to and interconnecting said vertical struts and diagonal struts pivotally attached to and interconnecting each of said vertical struts, with the upper extremity of the next following vertical strut, said diagonal struts being pivotally attached at a point intermediate its extremities to said rigid frame-like member, and being also in resilient relation to said vertical struts.

17. In a vehicle, the combination with a rigid portion of the vehicle, of a running gear comprising a rigid frame like member removably attached to said rigid portion of the vehicle, three means for locomotion disposed in a fore and aft sequence mounted on substantially vertical pivotally and swingingly interconnected strut members in pivotal and swinging supporting relation to said rigid frame like member, lever-connections between each consecutive pair of said vertical strut members, pivotally attached to said rigid frame-like member, and resilient means keeping all of said strut members in swingingly movable relation.

18. In a vehicle running gear including pivotally and relatively movably interconnected strutmembers associated with means for locomotion in resilient relation to a rigid portion of the vehicle and lever connections pivotally attached to said rigid portion of the vehicle associated with said strutmembers, the combination of a strutmember, two other elements movably connected by said strutmember, and acceleratingly expanding and retardingly compressing resilient shock-absorbing means keeping said

strutmember and said elements in resiliently movable, shock-absorbing and shock-transmitting relation, said means comprising a receptacle connected to one of said elements, a body of preferably viscous incompressible fluid confined within said receptacle, a piston slidingly received within said receptacle and connected to said strutmember, valve means in said piston automatically and alternately restricting and facilitating the movement of said piston in said incompressible fluid, and resilient shock-absorbing means associated with said elements.

19. In a vehicle running gear in swingingly movable, shock-absorbing, shock-transmitting supporting relation to a rigid portion of the vehicle, the combination of two wheels disposed in a fore-and-aft sequence, mounted on the lower extremity respectively of substantially vertical strutmembers, the foremost of said strutmembers being pivotally and swingingly in a fore-and-aft sense connected to said rigid portion of the vehicle or to members pertaining thereto in a manner excluding sideways swinging motion, retardingly compressing and acceleratingly expanding resilient shock-absorbing means associated with and tending to keep said foremost vertical strutmember in resiliently movable, shock-absorbing and shock-transmitting relation to said rigid portion of the vehicle, a substantially horizontal strut-like member pivotally attached to and spacingly connecting said vertical strutmembers, lever means connecting said vertical strutmembers in compensatingly movable relation, said lever means comprising a diagonal strutmember pivotally attached at a point intermediate its extremities to said rigid portion of the vehicle or to members pertaining thereto, said diagonal strutmember being pivotally attached at its lower extremity to said foremost vertical strutmember preferably at or near the point of attachment of said horizontal strutmember, and pivotally connected at its upper extremity with the upper extremity of the rear vertical strutmember, and retardingly compressing and acceleratingly expanding resilient shock-absorbing means associated with and tending to keep said rear vertical strutmember in resiliently movable, shock-absorbing and shock-transmitting relation with said lever means and with the rigid portion of the vehicle, said combination having for its object the adaption of the means for locomotion as a collective entity to the inequalities of the surface with an attendant neutralization of the rebound produced by shocks, said adaption being achieved by allowing the front-wheel to swing upward and forward in a circular arc around the pivotal center of said diagonal lever means, the shock of the impact being absorbed by the resilient means associated with the foremost strutmember,

the pivoting lever bringing the rear wheel down behind the obstacle while at the same time said rear wheel is pulled forward by the horizontal strutmember in bufferlike relation to the approaching obstacle, the rebound from the impact on the front wheel being thus instantly taken up by the shock-absorbing device associated with the rear strutmember. The frontwheel having passed over the obstacle, the rear wheel will then be subjected to impact and the process of transmitting the shock and absorbing the rebound take place in the reverse direction, the acceleratingly expanding shock-absorbing means enabling the struts to quickly regain their original length the moment the excess load due to impact is removed from them, substantially as described in the specification.

20. In a vehicle, the combination with the rigid portion thereof, of a running gear comprising three wheels disposed in a fore-and-aft sequence, substantially vertical strut-like members on which said wheels are mounted, the fore-most of said vertical members being pivotally and swingingly in a fore-and-aft sense connected to the rigid portion of the vehicle in a manner excluding lateral motion, resilient shock-absorbing means associated with and tending to keep said foremost vertical strut-member in resiliently movable, shock-absorbing and shock-transmitting relation to the rigid portion of the vehicle, members pivotally attached to and spacingly interconnecting each consecutive pair of vertical members, lever-means interconnecting each consecutive pair of vertical members in compensatingly movable relation to one another, said lever-means comprising a rigid diagonal member pivotally attached intermediate its extremities to the rigid portion of the vehicle or to members pertaining thereto, said rigid diagonal member being at its lower extremity attached to the fore-most vertical member, and at its upper extremity to the upper extremity of the intermediate vertical member, a second diagonal member pivotally attached intermediate its extremities to the rigid portion of the vehicle, said second diagonal member being at its lower extremity pivotally attached to the intermediate vertical member and at its upper extremity to the upper extremity of the rear-most vertical member, resilient shock-absorbing means associated with and tending to keep said second diagonal member in resiliently movable, shock-absorbing and shock-transmitting relation with the rigid portion of the vehicle and the intermediate vertical member, and resilient shock-absorbing means associated with and tending to keep said intermediate and rear-most vertical members in shock-absorbing, resiliently movable relation with the elements which they connect.

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