Dec. 28, 1943. J. LLOYD 2,338,046

LANDING GEAR OF AIRPLANES

Filed April 25, 1940 2 Sheets-Sheet 1

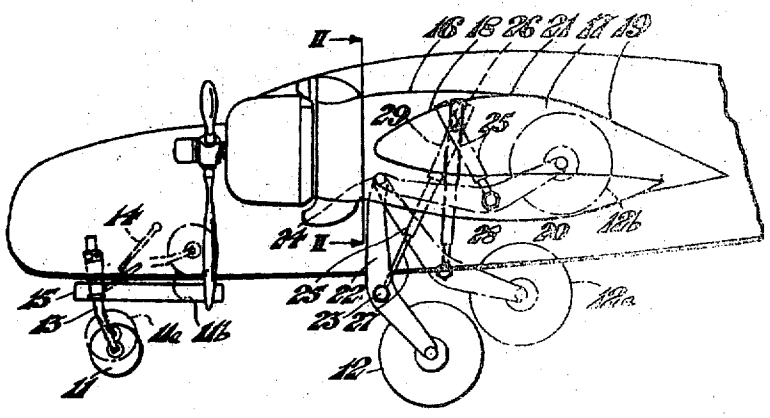


Fig. 1.

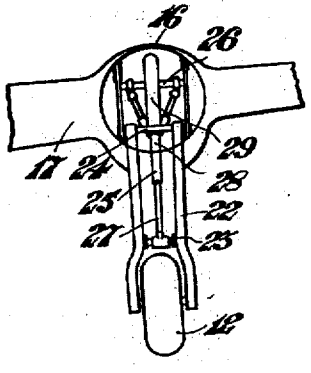


Fig. 2.

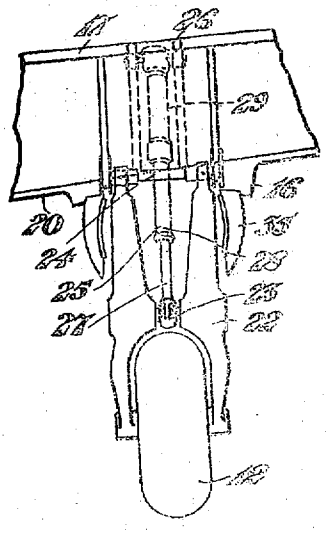


Fig. 4.

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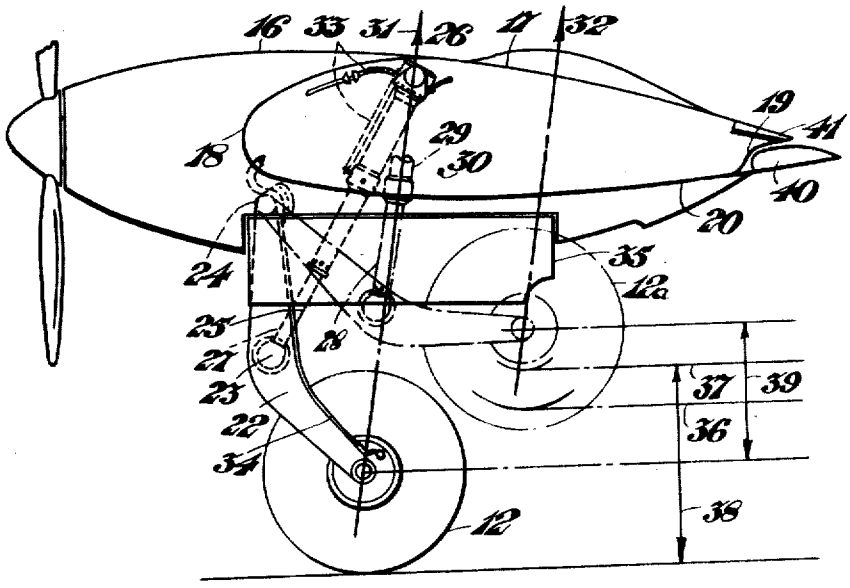


Fig. 3.

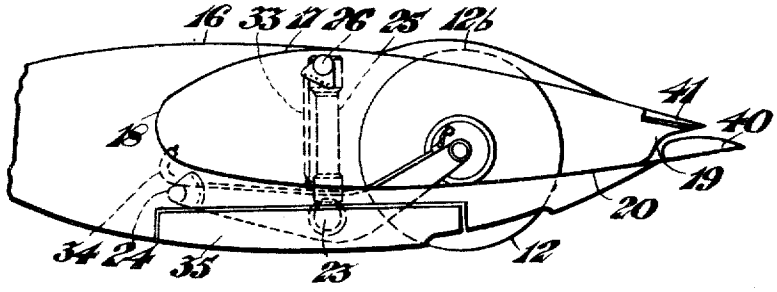


Fig. 5.

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LANDING GEAR OF AIRPLANES

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Application April 25, 1940, Serial No. 331,526
In Great Britain June 10, 1939

5 Claims. (Cl. 244—102)

The main object of the present invention is to provide an improved landing-gear, for an airplane, which will have advantages over present forms of landing gear.

According to the present invention, the airplane has a landing-gear disposed so that the initial reaction thrust of the landing surface on the main portion of the landing-gear is just forwardly of the centre of gravity of the machine when landing, and the main portion is adapted so that while receiving the landing shock the reaction thrust will be transferred to be well rearwardly of the centre of gravity of the machine.

In a preferred arrangement, a landing wheel or equivalent part is supported by a rigid member pivotally mounted upon the airplane (for example, on one of the wings) and pivoted intermediate its ends to means including an oleo-leg which is in turn pivotally mounted upon the airplane, the main portion of the said member being substantially vertical when in the landing position and the oleo-leg behind it and inclined from it to the rear. The said member is preferably downwardly and rearwardly cranked from the pivotal connection with the oleo-leg so that the wheel is trailing, and the oleo-leg preferably pivoted higher up on the machine than the member.

In this way it is easily possible to arrange for the vertical movement of the wheel hub or equivalent part to be approximately twice the shock-absorbing movement of the oleo-leg, dependent upon the position of the pivotal connection of the oleo-leg to the rigid member, the arrangement preferably being such that the downwardly and rearwardly cranked portion of the member will be substantially horizontal after the oleo-leg movement has been completed. Naturally further movement can occur between the machine and the landing surface, in the case of a pneumatically-tyred wheel, while the pneumatic tyre on the wheel is being flattened.

In carrying out the invention, the landing-gear is preferably one of the tricycle type, the two rear wheels or equivalent parts being adapted according to the invention while the forward wheel or equivalent part conforms with normal practice. If the initial reaction thrust on the two rear wheels is rearwardly of the centre of gravity, as is the case at the present time, the load on the single front wheel becomes excessive, and in particular, in the case of a landing-gear adapted in the manner of the specification of co-pending application Serial No. 331,525, filed April 25, 1940 (so as to have a considerably greater shock-absorbing movement between the centre of gravity of the machine and the landing surface than is at present considered to be advisable), the movement which would have to be allowed for in the single front landing wheel would be excessive.

In the accompanying diagrammatic drawings—

Figure 1 is a fragmentary side elevation of an airplane arranged according to the invention, the rear portion of the fuselage and tail being omitted. The figure shows in full lines a tricycle type of landing gear in the landing position before impact with the ground, and in chain lines the position occupied by the landing gear after landing, whilst in other chain lines the landing gear is shown fully retracted.

Figure 2 is a front elevation of one of the rear wheels of the landing gear, being a section mainly on the line II—II of Figure 1;

Figure 3 shows, to a larger scale, an elevation of an alternative form of wing-mounted engine casing incorporating one of the rear wheels of a tricycle type of landing gear according to the invention;

Figure 4 is a front view of the landing wheel of this modified form of landing gear; and

Figure 5 is a view similar to that of Figure 3 but with the landing wheel fully retracted.

Referring to the drawings, the outline representation of Figures 1 and 2 is of a twin-engined monoplane having a tricycle type of landing gear with a relatively-small forward wheel 11 and two larger rear wheels 12. The forward wheel 11, which is arranged according to normal practice, is carried by a known form of oleo-leg 13 supported in the underside of the front end of the fuselage and stayed by a jack 14. The chain lines 11a represent the position of the forward landing wheel after the oleo-leg has telescoped on landing, and the lines 11b the position of the landing wheel when it and the oleo-leg have been retracted by the jack in known manner into the interior of the fuselage, after which the cover 15 can be closed.

In like manner 12a and 12b represent the position of one of the rear landing wheels 12 after landing and when retracted, respectively.

It will be observed that, when in the landing position, the rear wheel 12 is at a materially-lower level than the front wheel 11.

In Figures 1 and 2 an engine egg or casing 16 is supported on a wing 17 of which 18 represents the leading edge, 19 the trailing edge, 20 the line of contact of the undersurface of the

wing with the engine casing, and 21 the wing tip. The aileron and flap or flaps are not shown on the wing for the sake of simplicity.

The rear landing gear structure comprises a fork 22 which is built up of two light-alloy castings or other rigid members united to one another intermediate their ends by a cross-pin 23. The lower portion of the fork is rearwardly cranked, as shown in Figure 1, and the landing wheel 12 is journalled therein. The landing wheel carries a pneumatic tyre and is provided with an hydraulic or other brake (not shown). The fork 22 is pivotally mounted at 24 on the stationary framework, the upper portion of the fork being vertical when the landing wheel is in the landing position prior to impact with the ground, as shown in full lines in Figure 1.

Pivotally connected to the cross-pin is one end of a known form of combined oleo-leg and two-stage jack 25 the other end of which is pivotally mounted at 26 upon the stationary framework. The jack includes an inner rod 27 which telescopes into an intermediate tube 28 when taking the landing shock. When the landing gear is to be fully retracted the inner member 27 and the intermediate tube 28 are both retracted into the outer tube 29 as shown in Figure 1.

As will be best understood from a consideration of the description in connection with Figures 3 to 5, the initial upward landing thrust on the rear wheels is arranged to be forwardly of the centre of gravity of the machine, the final upward landing thrust (when the landing gear is in the loaded position) being well to the rear thereof. The landing gear is, moreover, one which is capable of allowing a very much greater vertical movement than has been allowed for up to the present time.

In the construction of Figures 3 to 5, where the same reference characters are used as far as possible as are used in connection with Figures 1 and 2, a slightly-different form of engine casing 16 is shown. The section of the wing 17 is indicated in full lines in Figures 3 and 5, and 30 in Figure 3 represents the approximate position of the centre of gravity of the machine. At the moment of impact the upward landing thrust is along the chain line 31 which, it will be observed, is forwardly of the centre of gravity of the machine. (Naturally the position of this line 31 will vary slightly according as to whether landing takes place with the wheel brakes on or off.) When the landing gear has telescoped under the landing shock, however, the landing thrust acts along the chain line 32 which, it will be observed, is well to the rear of the centre of gravity.

In general the construction of Figures 3 to 5 is substantially the same as that of Figures 1 and 2, the rear wheel landing gear including a built-up fork 22 with a rearwardly-cranked portion, the two members of the fork being united to one another by a cross-pin 23 in the vicinity of where the lower end of the two-stage jack 25 is connected to it. In these figures there are shown pipes 33 for supplying hydraulic fluid to the jack, and a further pipe 34 for supplying hydraulic fluid to the brake. Furthermore, 35 represents hinged doors which can be closed after the landing gear has been fully retracted, as shown in Figure 5, when the machine is in flight. The fork is pivotally mounted at 24 just inside the engine casing, and the jack at 25 near the top of the engine casing. The jack moves to a substantially vertical position as the cranked portion of the fork becomes horizontal— see Figure 3.

The horizontal line 36 represents the ground relatively to the wheel 12 when the machine has landed and the tyres are partially flattened under the load. The horizontal line 37 represents the ground when the tyres are fully squashed during the action of taking the full landing shock. The vertical distance represented by the line 38 is therefore the measure of the vertical travel provided by the landing gear between the centre of gravity of the machine and the ground, taking into consideration both the travel allowed for by the oleo-leg and the flattening of the tyres. The vertical line 39 represents the actual travel allowed for by the oleo-leg alone.

In practice its travel is arranged, as stated, to be very much greater than is the case with previously-known machines. (For a high-powered, medium-size machine as shown the distance 38 may be 193 centimetres and the distance 39 may be 135 centimetres.)

In landing an airplane according to the invention the following procedure is adopted. The airplane is allowed to glide, with downwardly-extending flaps to give lift, at a relatively low speed (approximately twenty per cent above the stalling speed) directly on to the landing ground, or with only a slight flattening out. Figures 3 and 5 of the drawings show at 40 an appropriate flap which can be turned downwardly for the purpose. When the main landing wheels 12 engage the ground the landing thrust, as stated, is forwardly of the centre of gravity, along the line 31, and in this way the imposition of an excessive load on the front landing wheel 11 is avoided. As the main landing gear collapses, however, the line of thrust passes to the rear of the centre of gravity, as shown at 32, and the forward wheel therefore then comes into action in the ordinary way. Immediately upon impact occurring the downwardly-extending flaps 40 can be "replaced" by upwardly-extending flaps, and for this purpose the drawings show such a flap at 41. In this way the lift is reduced and the wheel brakes are rendered effective to the maximum degree.

The landing gear illustrated both in Figures 1 and 2 and in Figures 3 to 5 is one which is capable of dealing with a vertical velocity of approximately twenty-five feet per second, and such a landing velocity may be required to be dealt with if the machine is being crashed as aforesaid— i. e., being landed without any flattening out. If the machine is just momentarily flattened out, however, almost coincident with the occurrence of the landing impact, the vertical velocity can be immediately reduced below the twenty-five feet per second without a very much larger landing ground being necessary.

It is preferred to make use of an oleo-leg which has approximately twice the shock-absorbing ability of an ordinary oleo-leg, i. e., which will carrying twice the normal load and have twice the usual movement. With the construction shown it is also possible to arrange for the vertical extent of the wheel hub movement to be approximately twice the shock-absorbing movement of the oleo-leg, dependent upon the position of the pivotal connection of the oleo-leg to the rigid member. In this way the vertical movement allowed to the centre of gravity of the machine during the landing impact is approximately four times that ordinarily allowed—the vertical movement necessary being dependent upon the square of the vertical velocity and, as stated, the landing gear is pref-

erably one which can deal with a vertical velocity approximately twice the normal.

What I claim as my invention and desire to secure by Letters Patent of the United States is:

1. In an airplane, a landing gear comprising a single front landing wheel and two laterally spaced rear landing wheels, rigid vertically extending arms having their upper ends pivotally connected to the airplane structure and their other ends connected to said wheels, and telescopic means including a double-stage hydraulic jack, one stage of which serves as an oleo-leg and the other stage for retracting purposes, said means having two ends pivotally connected to the middle of said arm and to the airplane structure, respectively, the pivotal connections of said arms being so positioned on the airplane structure that the line of the initial landing thrust acting on said rear wheels passes in front of said center of gravity.

2. In an airplane, a landing gear comprising a single front landing wheel and two laterally spaced rear landing wheels, rigid vertically extending arms having their upper ends pivotally connected to the airplane structure and their other ends connected to said wheels, and telescopic means including a double-stage hydraulic jack, one stage of which serves as an oleo-leg and the other stage for retracting purposes, said means having two ends pivotally connected to the middle of said arm and to the airplane structure respectively, said arm and said telescoping means being disposed, when in landing position, that the line of initial landing thrust acting on said rear landing wheels passes in front of the center of gravity of the airplane.

3. In an airplane, a landing gear comprising a single front landing wheel and two laterally spaced rear landing wheels, rigid vertically extending arms having their upper ends pivotally connected to the airplane structure and their other ends connected to said wheels, and telescopic means including a double-stage hydraulic jack, one stage of which serves as an oleo-leg and the other stage for retracting purposes, said means having two ends pivotally connected to the middle of said arm and to the airplane structure respectively, said arm and said telescoping means being disposed, when in landing position, in front of the center of gravity of the airplane and being further adapted to be moved by the force of the landing impact into a position in which the rotating moment on the airplane produced by the impact force changes its direction between the time said rear wheels touch the ground and the time said arm comes into said position.

4. In an airplane, a landing gear of the tricycle type comprising a single front landing wheel and two laterally spaced rear landing wheels, rigid vertically extending arms having their upper ends pivotally connected to the airplane structure and their lower ends connected to said wheels, yielding means tending to maintain said arms extending downwardly while landing, said arms being so positioned with respect to the center of gravity of the airplane that the line of the initial landing thrust applied by the rear wheels passes at the moment of landing forwardly of said center of gravity.

5. In an airplane, a landing gear of the tricycle type comprising a single front landing wheel and two laterally spaced rear landing wheels, ridid vertically extending arms having their upper ends pivotally connected to the airplane structure and their lower ends connected to said wheels, yielding means tending to maintain said arms extending downwardly while landing, said arms being so positioned with respect to the center of gravity of the airplane that the line of the initial landing thrust applied by the rear wheels passes at the moment of landing forwardly of said center of gravity, but as said arms move toward their retracted position under the action of the landing thrust, the line of said thrust moves to the rear of said center of gravity.

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