Jan. 2, 1934. A. BOGGIO 1,942,235

METHOD AND RELATIVE DEVICE FOR APPLYING BRAKES TO AEROPLANE WHEELS

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Fig. 1

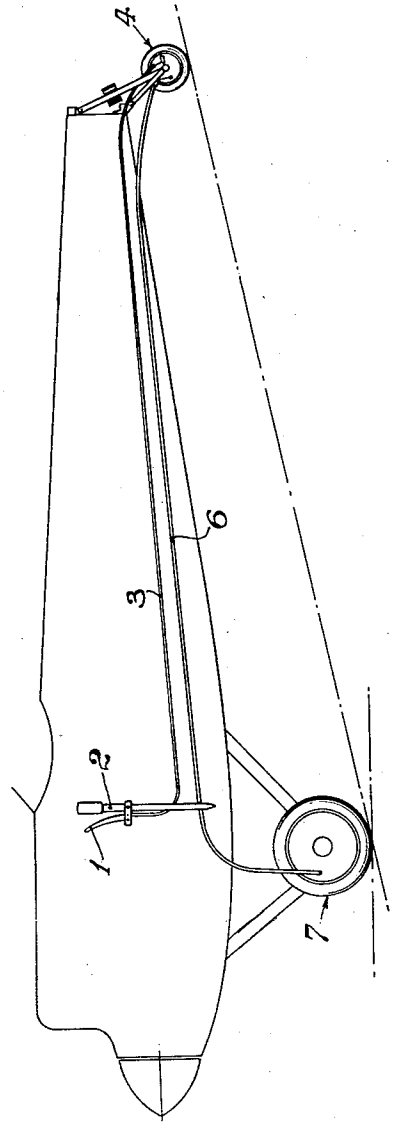


Fig. 4

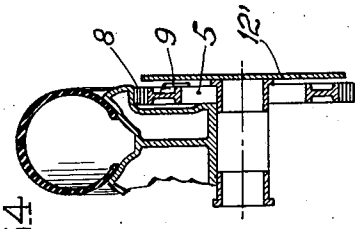


Fig. 3

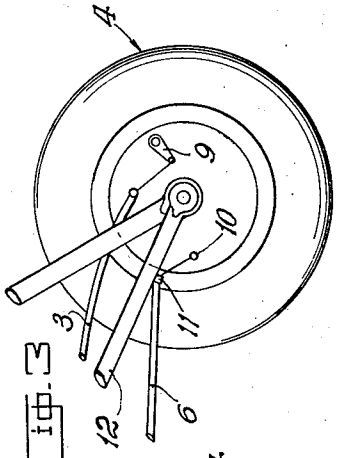
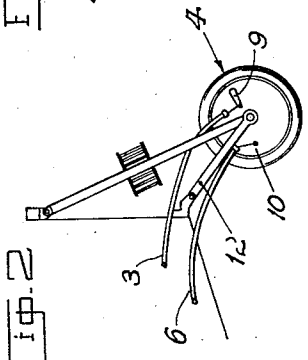


Fig. 2



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METHOD AND RELATIVE DEVICE FOR APPLYING BRAKES TO AEROPLANE WHEELS

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Fig. 5

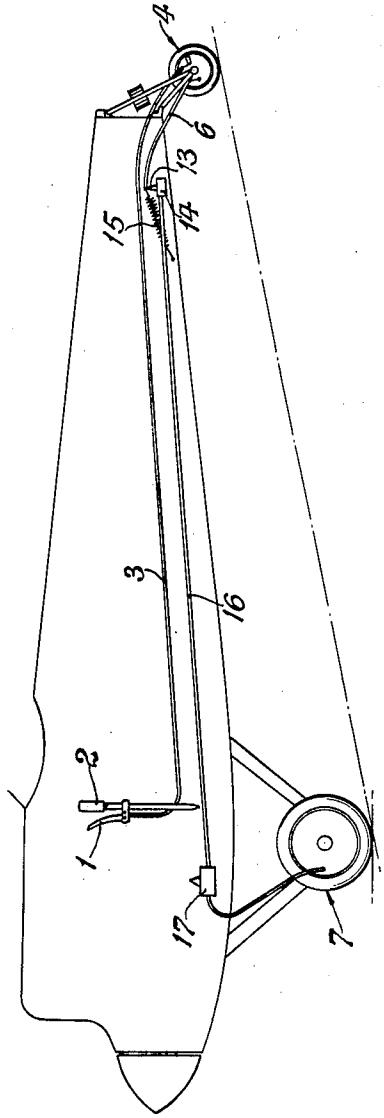


Fig. 7

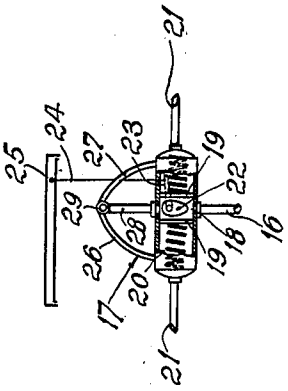
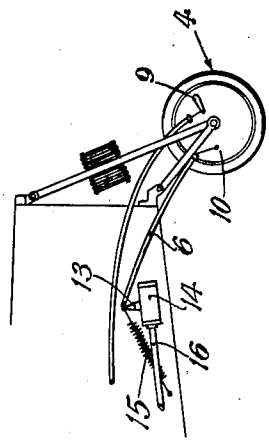


Fig. 6



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METHOD AND RELATIVE DEVICE FOR APPLYING BRAKES TO AEROPLANE WHEELS

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Fig. 8

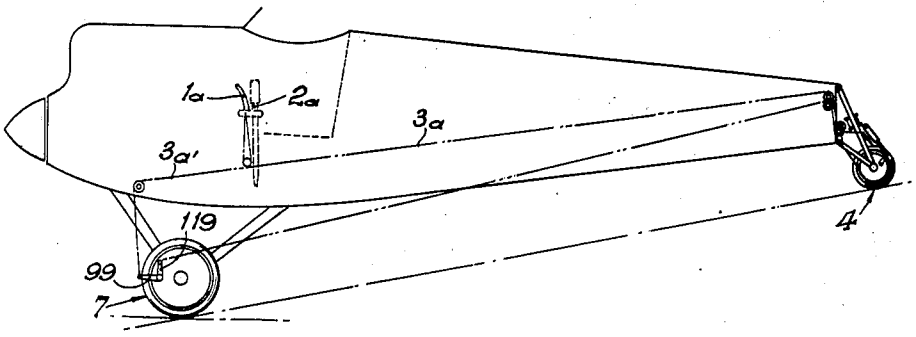


Fig. 9

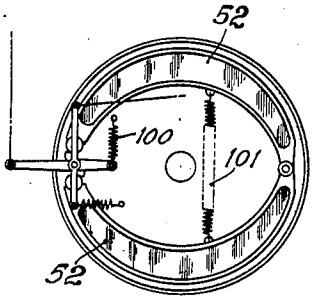


Fig. 10

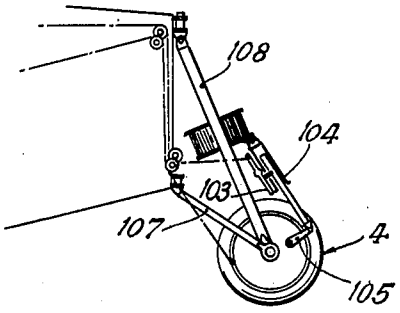


Fig. 11

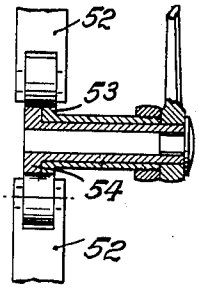


Fig. 12

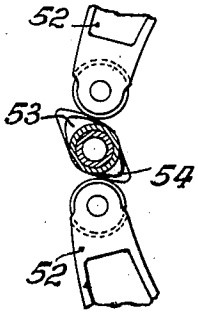


Fig. 13

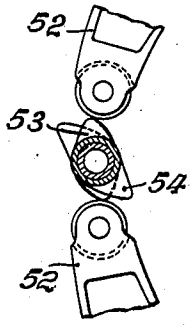
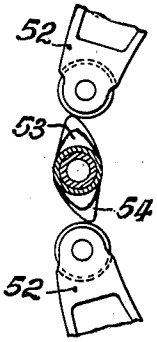


Fig. 14



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METHOD AND RELATIVE DEVICE FOR APPLYING BRAKES TO AEROPLANE WHEELS

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Fig. 15

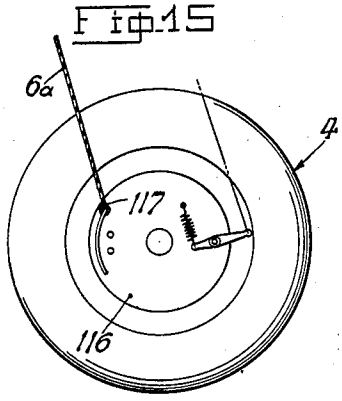


Fig. 16

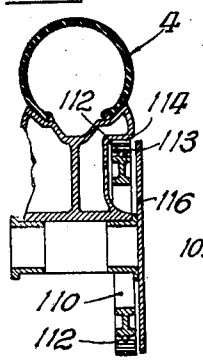


Fig. 17

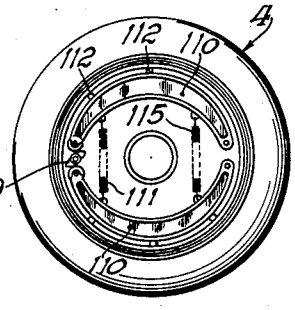


Fig. 18

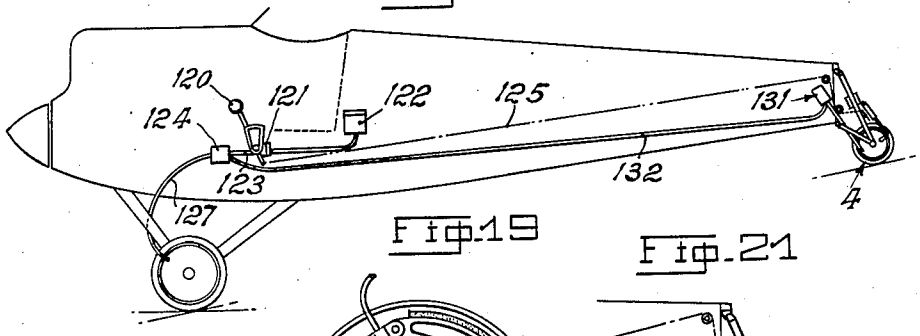


Fig. 19

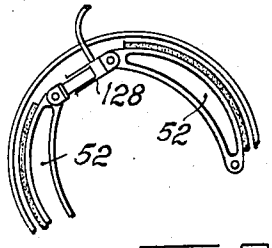


Fig. 20

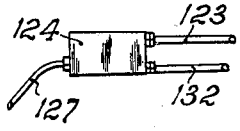


Fig. 21

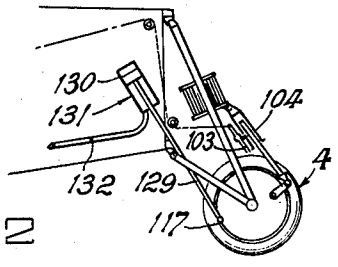
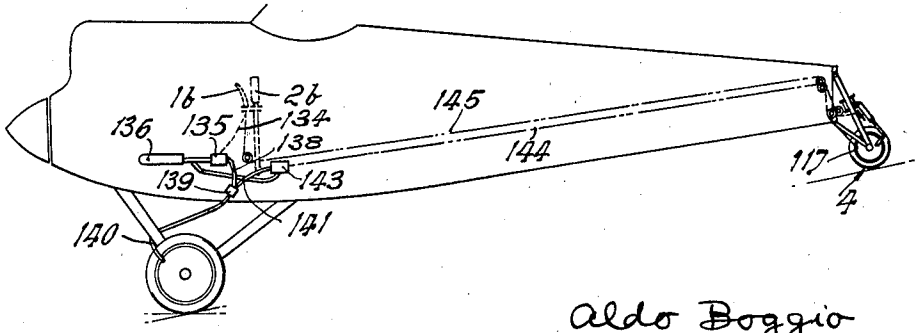


Fig. 22



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Patented Jan. 2, 1934 1,942,235

UNITED STATES PATENT OFFICE

1,942,235

METHOD AND RELATIVE DEVICE FOR APPLYING BRAKES TO AEROPLANE WHEELS

Aldo Boggio, Milan, Italy

Application July 7, 1933, Serial No. 679,419, and in Italy May 19, 1932

15 Claims. (Cl. 244—2)

The object of the present invention is to provide improved means for applying brakes to aeroplane wheels.

The invention is characterized essentially by the fact that the braking effect on the main body wheels of an aeroplane is obtained through a rear tail wheel when the latter contacts the ground, the arrangement being such that the braking force developed can be manually regulated by the pilot. One of the salient features of the invention includes the utilization of the rotative movement of the rear wheel to develop the desired braking effect. Another feature involves an arrangement such that the amount of braking force applied to the main wheels may be readily regulated or modified and selectively applied to either wheel by the pilot without in any degree interfering with his operation of the main aeroplane controls.

In its practical application the invention may be carried out through the utilization of either mechanical or hydraulic actuating means. In some embodiments the controls are such that the pilot merely regulates the braking force developed by the rear wheel. In other embodiments such force may be both regulated by the pilot and supplemented by additional braking force developed at another source. The invention involves various detailed features of construction, and these together with an explanation of the various basic features and adaptations will be discussed.

The invention will now be described, referring to the attached drawings which show, merely by way of example but without limiting effect, some forms of executing the invention.

Fig. 1 represents diagrammatically, an aeroplane furnished with the braking system in question, the forces applied being mechanically transmitted by cords or inextensible wires.

Fig. 2 represents in detail the tail device, with mechanical means for transmitting the applied forces.

Fig. 3 is a side plan view of the tail wheel.

Fig. 4 represents a transverse section through a tail wheel, showing particularly the means through which the rotative movement of the wheel develops the braking force.

Fig. 5 represents diagrammatically an aeroplane furnished with the brake system wherein the applied forces are transmitted hydraulically.

Fig. 6 represents in detail the tail wheel construction according to the invention as applied to the system shown in Fig. 5.

Fig. 7 represents a detail of the differential distributor for the liquid under pressure which may be employed under control of the rudder bar to enable the selective application of the braking forces to the several main wheels.

Fig. 8 represents diagrammatically an aeroplane furnished with a braking device employing a different tail wheel construction and wherein the applied forces are mechanically transmitted by cords or wires; and further showing an arrangement whereby the braking forces developed are supplemented by an additional force manually applied by the pilot.

Fig. 9 shows, in detail, one of the front wheel brakes as employed in the system of Fig. 8.

Fig. 10 represents in detail the tail wheel construction as shown in Fig. 8.

Fig. 11 represents in detail for the control of the brake shoes of the front wheels according to the embodiment of Fig. 8.

Fig. 12 represents the front wheel brake actuating cams at the beginning of the first phase of braking as applied by the pilot.

Fig. 13 shows the same cams at the end of this first phase.

Fig. 14 shows the cams in the last phase of braking when the forces developed by the rear wheel are applied.

Fig. 15 is a plan view of a modified tail wheel.

Fig. 16 represents a partial transverse section of the same.

Fig. 17 represents a view of the internal members of the same.

Fig. 18 represents diagrammatically an aeroplane furnished with still another variation of the brake device in question, with hydraulic means for transmitting the applied forces, and including means for applying a supplemental braking force.

Fig. 19 represents the internal members of a front wheel brake, as employed in the embodiment of Fig. 18.

Fig. 20 represents in detail the collecting tank for the liquid under pressure used in this embodiment.

Fig. 21 represents a tail wheel similar to Fig. 10 but with hydraulic control for the braking system.

Fig. 22 represents an aeroplane furnished with a further variation of the device generally similar to the system of Fig. 18 but in which the braking forces are applied pneumatically.

In the form shown in Figs. 1 to 4 the braking device includes a small lever 1 mounted on the control-bar 2 or the steering wheel of the aeroplane. Pressing lever 1 gives tension to a wire

3 which spreads out brake-cheek 8 attached to and rotatable with a disc 5 of the tail wheel 4. This cheek-carrying disc 5, being mounted loose on the axle of the wheel, is, therefore, dragged around by the rotation of the wheel when the wheel contacts.

In its rotation the cheek-carrying disc pulls a wire 6 which controls the braking of the body front wheels 7. This braking force may be selectively reinforced or augmented on one or on the other wheels at the will of the pilot, to facilitate steering when on the ground as will hereinafter be explained. Cheeks 8 are controlled by means of small lever 9; 10 is the point where the end of the brake cord is attached to the disc 5 whilst 11 is where the outer Bowden cable ends on the tail wheel supporting fork 12. The disc 5 and its associated parts as shown in Fig. 4, may be covered by a protecting casing 12'.

The characteristic action of the device according to the invention is easily seen. If lever 1 is not operated everything is at rest and tail wheel 4 rolls freely. If the pilot wishes the characteristic braking action to come into play, he need only operate lever 1, so as to cause the braking cheeks to press against the tail wheel, with adjustable intensity. If the wheel is lifted off the ground nothing happens; if however it touches the ground, it tends to rotate the cheek-carrying disc with an intensity proportional to the friction of the cheeks against the tail wheel drum, such intensity being regulatable through lever 1 at the will of the pilot and proportional to the rotative force of the tail-wheel as it contacts the ground. A pull is induced by this action on cord 6 controlling the front-wheel brakes. If the pilot wants to reduce or take off the brake, he has only to loosen or set free lever 1.

In the variation shown in Figs. 5, 6, 7, illustrating braking by hydraulic transmission, the small lever 1 is the same and also cable 3 and the tail-wheel construction is as in Figs. 3 and 4, but in this case cable 6 connects with and actuates lever 13 of the hydraulic pump 14, situated in the fuselage, against the action of spring 15, or other elastic means. By means of tube 16 the oil under pressure developed by the pump 14 is carried to the center portion of a collecting tank 17 formed (see Fig. 7) of a double pump-barrel. The forces of the oil presses out the two opposing pistons 19 overcoming springs 20 (if adopted) and sends the oil under pressure to each of the two wheel brakes through their respective connecting tubes 21. In practice tube 16 may be eliminated, combining the pump and collecting tank in one unit.

A cam 22 connected by lever 23 and rod 24 to rudder-bar 25 is contained in the collecting tank. If the pilot, for example, presses his right foot on the rudder bar 25, the cam displaces the piston to the right and causes in the corresponding space, a pressure which controls the brake of the right body wheel, even when the tail wheel pump is not acting; in this manner the pilot may, independently of the control from the tail wheel, use either one or the other brakes to facilitate steering the aeroplane when on the ground. This differential action comes into play even if the brake control device of the tail wheel is functioning. In such a case, an increase of braking pressure on the one and a decrease on the other wheel is obtained. For recharging the oil in the whole group of members, use is made of three tubes 26, 27, 28 and of a four-way valve 29 through which it is possible to recharge separately each of the three spaces into which the whole device is divided and the lines 16 and 21.

When small lever 1 is not operated everything is at rest and the tail wheel rolls freely without developing any braking force. If the pilot wishes to apply the brake to the two wheels in motion or stationary he has only to operate the aforesaid small lever. By this he obliges the brake cheeks to grind against the tail wheel with an adjustable intensity. If the tail wheel is off the ground, nothing happens, if however this is rolling on the ground, it tends to draw with it the disc carrying the brake cheeks, with an intensity proportional to the control force applied and to the friction between the brake cheeks and the tail wheel as it rolls along the ground; a tension on the cord is thereby induced with consequential action of the brakes on the body wheels. If the pilot wishes to reduce or to take off the brake he has only to loosen or free lever 1. If by a too intense braking or some other force tending to cause the plane to somersault the contact of the tail wheel with the ground diminishes or ceases, the brake comes off instantly and automatically, partially or totally, though the pilot continues to apply the brake, since, either, the spring or other elastic means of the pressure generator or the other springs inserted in the circuit, will induce (when the tail is lightened or raised) a gradual or instantaneous decrease in pressure in the control lines.

The system as described might also be operated pneumatically by substituting, for the hydraulic pressure generator, an air pressure pump, or arranging for the tail device to control a valve emitting air from an air receiver to the brake circuit. Also if it is desired, the differential collecting tank of the hydraulic control may be applied on the common circuit of the front wheel brake with hydraulic control directly operated by the pilot.

In the above described systems there is the advantage that, since the braking force on the main wheels is produced automatically, the force which the pilot need use to initiate the braking action is very limited, thus permitting it to be applied by an ordinary small lever of a minimum strength, attached to either the control lever or wheel, whichever is used. It further has the advantage that the pilot himself may continue to keep control over the trim of the aircraft even whilst braking, and the cause of from the actual arrangement and function of the brake mechanism, he need not be preoccupied with the danger of the braking force increasing to a point where it might tend to cause the plane to overturn, since the braking force is automatically limited or interrupted as soon as the tail lightens and rises from the ground. As another advantage it may be pointed out that the means employed in connection with the tail wheel to develop a braking force for the front wheels is such as to function as a brake for the tail wheel and thus further aids in slowing down or stopping the aircraft.

In Figs. 8 to 17 showing another variation of the device having mechanical control the two main front landing wheels are furnished with a brake having expanding brake-cheeks 52 controlled by a special system of double cams 53—54 arranged side by side (whereas the usual type of cams are single).

The pilot has a brake control lever 1*a* mounted, for example, on the main control lever (joystick) 2*a*; on pressing this lever wires 3*a'* and 3*a* tighten, the first leading to lever 99 controlling the small

cam 53, this lever being returned by a spring 100 whilst the brake cheeks are closed by another spring 10. By this arrangement the pilot can directly apply an initial braking force to the wheels.

Wire 3*a* turns lever 103 which locks the two parts of the telescopic rod 104 attached to lever 105 of the tail wheel 4 as best shown in Fig. 10. This latter is mounted on two forks 107 and 108 the second one being flexible. Lever 105 is in one piece with cam 109 which, by turning, separates brake cheeks 110, overcoming spring 111.

These cheeks do not, as is usually the case, carry directly on them the facing of high frictional material (Ex. Ferodo) but, through a series of balls 112 compel the expansion of the steel band 113 which is cut at one point, which carries the facing 114 of friction material and is retained closed or unexpanded by spring 115. The steel band is rigidly attached to a pin 117 projecting through disc 116 and carrying a cord 6*a* controlling lever 119 of the main wheels which lever is in one piece with the large cam 54. Pin 117 is returned to its normal position by a spring when the cheeks are released.

Let us examine the action of the arrangement. When the pilot, after the wheels touch the ground, wishes to apply the brake in order to reduce the landing run, he operates lever 1*a* and through cord 3*a*', lever 99 operates cam 53 expanding the brake cheeks thereby inducing a moderate initial braking action (Figs. 12, 13).

When, following the diminished velocity of the apparatus the tail drops, the tail wheel runs on the ground gradually increasing its pressure on it. In this manner the flexible fork 108 is lowered and since, by the action of lever 103 and its catch the telescopic rod 104 is locked, this rod moves lever 105 consequently spreading out the brake cheeks 110, causing the spreading of ring 113 which, by its friction material, engages the wheel 4. Ring 113 is drawn round on balls 112 whereas the drum carrying the brake cheeks remains fixed, the said ring drags with it cord 6*a* which acts on lever 119 and large cam 54 (Fig. 14) which further spreads out the brake cheeks, rendering the braking of the main wheels more positive as the pressure of the tail wheel on the ground increases. In this way the aim of the device is attained, which is to allow of an action of braking progressive with the greater braking pressure when the tail upon the ground without danger of the forcible drag on the front wheels causing the plane to somersault, because, if the tail wheel rises from the ground, the strain on cord 6*a* lessens and large cam 54 reduces or ceases its braking action.

In other words, there is strong braking action only when there is an accompanying pressure of the tail on the ground and rolling of the tail wheel; that is, when conditions are against somersaulting.

Braking action, therefore, is proportional to the condition of the apparatus being in the best trim for landing.

When the pilot wishes to release the brake he has only to release lever 1*a* and by doing this he annuls the rigidity of the telescopic rod 104 and thus the action of the tail wheel whilst the cams 53 and 54 return to the position of rest by action of the return spring.

The cords or inextensible wires can be so arranged that the movement of the rudder bar induces different braking actions on the two wheels, to facilitate land manoevers of the plane.

A hydraulic control arrangement such as shown in Figs. 18 and 21 may be utilized in the previously described system of Fig. 8 wherein an initial braking action is applied by the pilot before the tail wheel becomes operative. In such case a lever 120 similar to lever 1*a* actuates a pump 121 to force oil from a tank 122 through tube 123 to a distributing chamber 124. From the chamber 124 the oil is forced under the pressure developed by the pump through tubes 127 to the front wheels, which are provided with brakes 52 (Fig. 19) actuatable by a hydraulic ram 128 with which the tube 127 connects.

The lever 120 additionally actuates a cord 125, as in the preceding case, which cord connects with catch 103 serving to lock telescopic rod 104 (Fig. 21) and, as in the preceding case, causes braking of the tail wheel which is arranged as indicated in Figs. 15, 16, 17. Here however, pin 117 draws rod 129 which ends in a small piston 130, sliding in a pump barrel 131 from which leads off a tube 132 connecting with collecting tank 124 with which as previously stated also connects tube 123 and pump 121. The pump may be at the tail as shown in the figure, or may be at the center controlled by a flexible transmission.

The arrangement functions as follows: When the pilot wishes to apply the brakes, he operates lever 120 and, by means of brake pump 121, transmits a certain pressure to collecting tank 124, which pressure is then transmitted to the brakes by tube 127. This pressure is kept moderate by means of an appropriate adjustment of the brake pump so as to obtain a moderate initial braking action similar to that obtained in the case of the small cam 53 which is utilized in the system shown in Figs. 8 to 14.

The lever besides producing a moderate braking force through the pump 121 simultaneously actuates cord 125 to bring the tail wheel mechanism into operation when such wheel contacts the ground. A consequential additional braking force is developed by displacement of disc 116 which through pin 117 and rod 129 actuates pump 130. The braking pressure developed by the pump, transmitted through tube 132 and collecting tank 124, augments the pressure initially developed in tubes 127 by pump 121 and results in the application of a greater braking force to the front wheels. If the tail tends to rise, the rolling of the wheel diminishes or stops and then piston 131 tends to rise again causing the pressure in the collecting tank, and consequently the brake, to diminish.

By inserting a distributing valve, such as previously discussed (Fig. 7), between collecting tank 124 and the several wheel tubes 127 and connected with the rudder bar, it is possible to obtain different braking action on the two wheels to facilitate manœuvering on the ground as in the preceding case.

The front wheel brakes and the brake pump may be of any type known and used for brakes controlled hydraulically or of any other type.

It is also possible to arrange matters so as to avoid the use of the double pump, that is having one only pump controlled, in the first instance, by the pilot through a Bowden cable, and afterwards by transmission coming from the tail wheel.

In the variation illustrated in Fig. 22 is shown a realization of a pneumatic control. The whole arrangement comprises: a compressed air receiver 136 and two outlet valves 135 and 143, the first directly controlled by small lever 1*b* mounted on the main control-lever, and the second

by the lever actuated cord or wire 144, moved and tail wheel mechanism which is constructed in a manner identical with that already described in the preceding cases (Figs. 3 and 10).

Tubes 138 and 141 leading from the valve connect the several valves 135 and 143 with a collector 139 having connected thereto a tube 140 delivering pressure to the front brakes controlled pneumatically by, for example, the Palmer or some other suitable system.

The arrangement works as follows: when the pilot wishes to apply the brake, he operates small lever 1*b* which, through a Bowden cable 134 opens valve 135, air then passes through tube 138 to collector 139 from thence, through tubes 140, to the brakes.

At the same time, lever 1*b* pulls cord or wire 145 which as in the preceding cases, operates catch 103 locking telescopic rod 104 and causing, always as in the preceding cases, the development of a braking action by the tail wheel.

Pin 117 pulls cord or wire 144 when the tail wheel contacts the ground and the wheel turns opening valve 143 which, through tube 141 will send air under pressure from air receiver 136 to collector 139 increasing the pressure and consequently reinforcing the braking action. Such reinforcement ceases if the pressure of the tail on the ground ceases, and consequently, if the rolling of the tail wheel ceases. Also, here, as in the preceding case, by inserting between collector 139 and tubes 140 a distributing valve, connected with the rudder bar, different braking effects on the two wheels may be obtained to facilitate manoeuvering the apparatus on the ground.

The invention has, amongst others, the following advantages, especially in the execution forms shown in Figs. 5, 6 and 7:—

(*a*) the brake control over the two wheels 7 can be operated with the same hand which is holding the wheel;

(*b*) the brake control over one wheel is obtained by movement of the feet only;

(*c*) it is possible to use also the rudder-bar 28 with the brake in action, and by this obtain differential braking;

(*d*) braking is progressive because its intensity depends on the tail wheel contacting and rotating on the ground; besides, the pilot can always graduate or completely annul the braking effect.

(*e*) the pilot can apply the brake firmly even when running (taxying) rapidly, because the aeroplane graduates the braking action with relation to its trim.

(*f*) if from uneven ground, or from other cause, the tail tends to rise, thus rendering braking dangerous, the brake is released automatically, even if the pilot continues to apply it.

It is understood that the embodiments of the invention illustrated and described shall only be explanatory and shall not limit the scope of the invention. In practice other variations may be thought of or variations and additions added to the forms shown, without departing from the scope of the invention.

Having now described my invention and how the same is to be carried out, what I claim as my invention is:

1. A braking system for an aircraft having front landing wheels and a tail wheel, brakes for the front wheels, and means actuatable by rotative movement of the tail wheel for applying said brakes.

2. A braking system according to claim 1 characterized by the fact that the brake actuating means is operable independently of any relative movement between the tail wheel mounting and the aircraft.

3. A braking system according to claim 1 characterized by the fact that the brake actuating means is operable independently of any variation in the degree of contact made by the tail wheel with the ground and that the operation of said means is dependent solely on the ground contact being sufficient to cause rotation of said wheel.

4. A braking system for an aircraft having front landing wheels and a tail wheel, brakes for the front wheels, and means frictionally engageable with the tail wheel and actuatable by rotation thereof to apply said front wheel brakes.

5. A braking system according to claim 4 characterized by the fact that the front wheel brake actuating means in frictionally engaging the tail wheel applies a braking force to the tail wheel.

6. A braking apparatus for an aircraft comprising in combination with front and rear landing wheels, brakes for each of said wheels, manually controlled means for applying braking action to said rear wheel, and means connecting the front and rear wheel brakes and actuatable by movement of said rear wheel brake for applying the front wheel brakes.

7. A braking system for an aircraft having front landing wheels and a tail wheel, brakes for the front wheels, means actuatable by the rotative movement of the tail wheel for applying a braking force to said front wheel brakes, and means controllable by the pilot connecting with said brake operating means to vary the braking force applied.

8. In an aircraft having front landing wheels and a tail wheel, means for applying a braking force to the front wheels actuatable by rotative movement of the tail wheel, and a lever controllable by the aircraft pilot for graduating the braking force developed.

9. In a braking system for airships having front landing wheels and a tail wheel, brakes for the front wheels, and actuating means for said front wheel brakes including movably mounted means supported adjacent the tail wheel having a friction surface engageable with the tail wheel and adapted upon rotation of the tail wheel as the same rolls along the ground to be actuated thereby, together with means responsive to movement of said tail wheel engaging means to transmit a braking force to the front wheel brakes.

10. In a braking system for airships having front landing wheels provided with brakes and a tail wheel, bands having frictional surfaces adapted to be expanded into engagement with a surface of the tail wheel and a support for the bands permitting limited rotative movement of bands with the tail wheel as said wheel rolls along the ground, means controllable by the aircraft pilot for expanding the brake bands and means actuatable under rotative movement of the bands for applying a braking force to the front wheel brakes.

11. A braking system for an aircraft having front landing wheels and a tail wheel, brakes for the front wheels, manually controlled means for directly applying a braking force to the front wheel brakes, means for developing and applying to said brakes an additional braking force, said additional means being actuatable by rotative movement of the tail wheel as the same makes rolling contact with the ground to augment the braking force developed by the first means, and

control means for regulating the amount of braking force developed by the tail wheel.

12. A braking system for an aircraft having front landing wheels and a tail wheel, brakes for the front wheels, means for directly applying a braking force to the front wheel brakes, adjustable means actuatable by rotative movement of the tail wheel and operable when said wheel makes rolling contact with the ground to apply an additional braking force to the front wheel brakes, and a control lever operable to actuate the first braking means and simultaneously to render the tail wheel operative to apply an additional braking force.

13. A braking system for an aircraft having front landing wheels and a tail wheel, brakes for the front wheels, a control lever, means operable by said lever to apply an initial braking force to the front wheel brakes, additional means actuatable by rotative movement of the tail wheel to apply an additional braking force to the front wheel brakes, and means connecting said control lever and tail wheel mechanism and actuatable by the lever as the lever is moved to produce the initial braking force to render the tail wheel mechanism operative to produce said additional braking force.

14. A braking system for an aircraft having front landing wheels and a tail wheel, brakes for the front wheels, a control lever, actuating means connecting the control lever with said brakes and operative on movement of the lever to apply a braking force to the brakes, additional brake applying means engageable with the tail wheel and actuatable by movement of said wheel to apply an additional force to both the front wheel brakes, and means connecting with the said control lever and actuatable thereby to bring the additional brake applying means into engagement with the tail wheel.

15. A braking system for an aircraft having front landing wheels and a tail wheel, brakes for the front wheels, a control lever, actuating means connecting the control lever to said brakes and operative on movement of said lever to apply a braking force to said brakes, and additional braking mechanism regulatable by said control lever including, means operative by the tail wheel connecting with the front wheel brakes and actuatable by movement of the tail wheel as it contacts the ground to apply an additional braking force to said brakes, and means connecting the control lever and tail wheel brake actuating means and operative on movement of the control lever to regulate the additional braking mechanism.

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