

PUBLISHED
MAY 25, 1943.
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AUTOMATIC PILOTING OF MARINE
OR AERIAL VEHICLES
Filed April 11, 1941

Serial No.
388,039

Fig. 1.

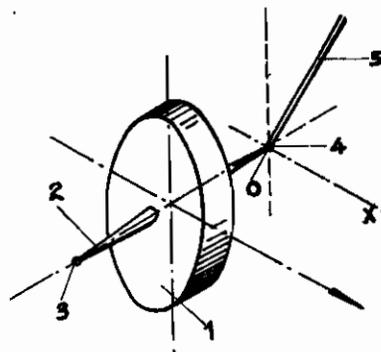


Fig. 2.

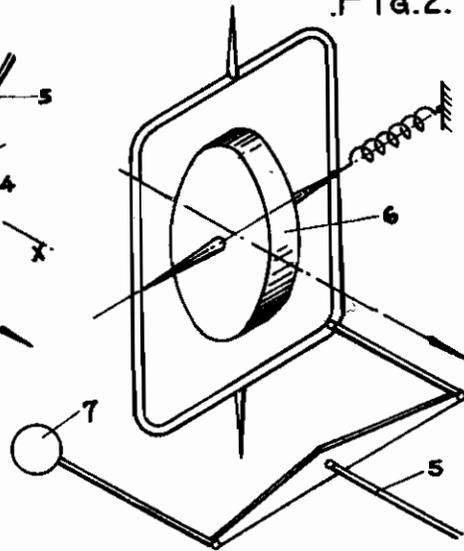


Fig. 3.

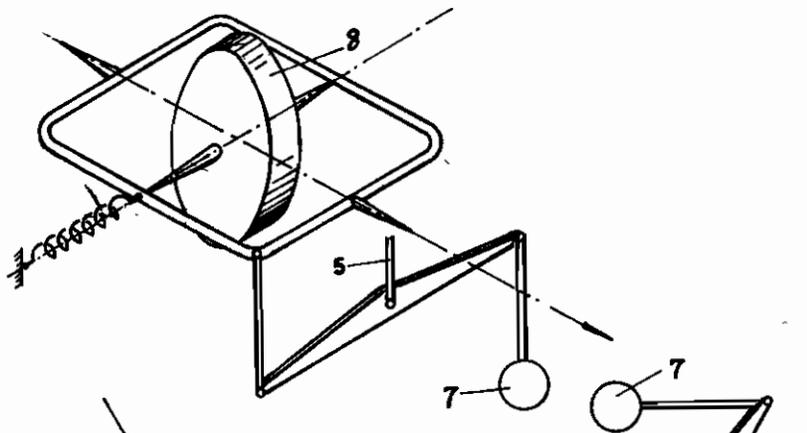
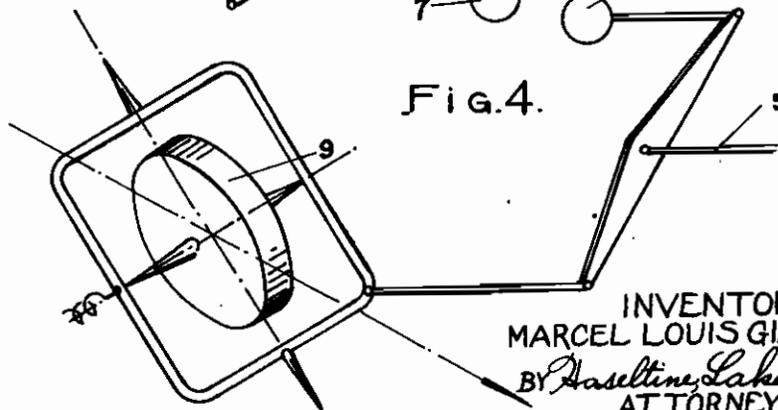


Fig. 4.



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ALIEN PROPERTY CUSTODIAN

AUTOMATIC PILOTING OF MARINE OR AERIAL VEHICLES

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Application filed April 11, 1941

The present invention has for object certain improvements in the automatic piloting of marine or aerial vehicles. These improvements are mainly intended to considerably simplify automatic piloting systems.

A first part of the invention concerns vehicles such as aeroplanes which are so devised that any transverse inclination relatively to apparent gravity causes a turning towards said inclination with a speed which is proportional thereto. This property can be imparted to the aeroplane, either by the forms, arrangements and proportions of the empennage and aerofoil, or by sliding detectors acting on the steering rudder, such as weathercocks, differential pressure-gauges, lateral pendulums, or autopter units described in the French Patent No. 825,922, dated 30th November 1936. In this case, the invention consists in arranging on the vehicle in question a steering detector (and in particular of the yawing speeds), which can comprise a precession gyroscope, and in causing said detector to act not on yawing rudders, but on rolling rudders, or in other words, on transverse inclination rudders.

In an aeroplane (or other marine or aerial vehicle) thus improved, the automatic piloting apparatus is considerably simplified. In fact, since the aeroplane has the property of effecting yawing movements so as to rapidly come back, damped, to the same initial sliding value (for instance null) when it has departed therefrom, any transverse inclination of the aeroplane is instantaneously translated by a speed of yawing rotation proportional to said transverse inclination, so that it becomes possible to pilot and steer the aeroplane by means of its warping rudders and ailerons, without the addition of a supplementary mechanism on the steering control.

The simplification is considerable since it includes the complete elimination of any control of the steering rudder, the adjustment of the latter remaining locked in the position corresponding, for instance, to null sliding, either because it presents the autopter function as described in the French Patent No. 825,922 dated 30th November 1936 and that its adjustment is maintained at zero, or because it directly or indirectly obeys a sliding weathercock or a transverse pendulum the control linkwork of which has been definitely adjusted.

The automatic piloting mechanism of the warping can then be presented in various forms, some of which are described hereinafter by way of examples.

According to the technics of the use of free

gyroscopes, a single gyroscope 1 having an axis 2 (Fig. 1) can be arranged at right angles to the plane of symmetry of the aeroplane; if it is assumed that the end 3 of said axis is mounted as a spherical joint and that the end 4 controls the warping rudders and ailerons, it can be imagined that the rod 5 adapted to transmit the orders is located in the plane X02 parallel to the plane of symmetry. In the case of said Figure 1, it will be seen that the order transmitted is the same whether the aeroplane turns to the right, or whether it inclines to the right; if in both cases said order is intended to incline the aeroplane to the left, it will also overcome a rolling disturbance and a yawing disturbance.

This simple mechanism ensures the return to rectilinear flying in the case of stoppage of a side engine for instance, since the yawing speed is proportional to the rolling divergence. As this yawing speed is compulsorily annulled by the detection of divergence increasing in the direction given by the gyroscope, equilibrium is established at the rolling inclination which creates, by sliding, a yawing torque balancing the lack of balance due to the stoppage of the engine. The addition on the linkwork 5 of a compensation slowly modifying the length of the warping linkwork until the divergence of the gyroscope according to OX is annulled, will also have for effect to bring back the steering to the initial head, the aeroplane flying correctly inclined, the stopped engine being at the top.

On the other hand, automatic piloting apparatus have already been proposed in which the steering rudder is controlled by its detectors and by rolling detectors. But the present invention concerns, in the embodiment which will be described, an arrangement according to which it is the warping rudder which alone is controlled, and not only by the steering detectors as in the case previously described, not only by the rolling detectors, which corresponds to the usual arrangement, but by a coupling in parallel of these two kinds of detectors, which is only possible on an aeroplane having the property previously defined.

In this case, and according to the technics of precession gyroscopes coupled to an instrument, a single gyroscope 6 (Fig. 2) can be arranged, set as the preceding one and responsive to rolling speeds, coupled to a compass 7 detecting the direction. The gyroscope 6 will damp the rolling disturbances, the aeroplane always coming back transversely to the horizontal by the action of the

compass 7 which inclines it, in order to bring back the aeroplane to the initial course.

It will also be advantageous to provide the gyroscope in such a manner that it is responsive to yawing speeds and always coupled to the compass (fig. 3). The gyroscope 8 will damp the rolling disturbances because they instantaneously give rise to yawing speeds, and in addition it will energetically damp the yawing disturbances. As in the case of fig. 1, the stoppage of a side engine will give rise to a yawing speed and to a rolling inclination, equilibrium being finally established by a certain divergence from the head, a certain transverse inclination of the aeroplane and further rectilinear flying; if a compensation mechanism has been added, the initial head will moreover be re-established, the aeroplane flying correctly inclined, the stopped engine being at the top.

It has finally been proposed to use, for controlling a single rudder, a detector simultaneously responsive to two reference axes: it is thus that automatic piloting apparatus are known in which the steering rudder is controlled by a free gyroscope or precession gyroscope the axis of which is inclined in such a manner that it is simultaneously responsive to rolling and yawing rotations. But, according to the invention it is the warping rudder which alone is controlled, and by a detector responsive both to rolling and to yawing, which is only possible on an aeroplane having the property previously defined.

Fig. 4 gives, for instance, a solution corresponding to the known means in which the gyroscope 9 is simultaneously responsive to yawing and to rolling, so that, with the same results as those of fig. 3, the rolling disturbances are also immediately piloted, by avoiding the delay caused by the use of the yawing movement determined by the steering rudder following a rolling disturbance.

Another part of the invention relates to the case of an aeroplane provided with stabilizing devices adapted to maintain constant, relatively to the air, the incidence detected at the rear of the centre of gravity of the aeroplane. This aeroplane thereby presents the property of effecting pitching movements so as to rapidly return, damped, as set forth in the French Patent No.

839,030, of the 29th November 1937, to its initial incidence when it has departed therefrom. It then becomes possible to simplify most of the automatic piloting and pitching devices. In fact, the latter, since they must instantaneously overcome the variations of the inclination relatively to the horizontal or the variations of speed, have a considerable action on the setting of the elevator, and from this important action might result in certain cases, the appearance of slow pitching oscillations, slightly damped or even amplified. That is why, for instance, certain mechanisms having a free gyroscope adapted to maintain constant the inclination relatively to the horizon, are provided with a longitudinal pendulum applied to the gyroscope, which thus supplies, by precession, an order proportional to the derivative of the inclination relatively to the horizon, which ensures the damping of the oscillations. Other anemometer mechanisms adapted to maintain the constancy of the speed, are provided with a precession gyroscope adapted to damp the oscillations which the anemometer piloting alone would allow to pass and would amplify. The same would be true if the anemometer was replaced by a longitudinal pendulum. In these various cases, the property imparted to the aeroplane by the stabilizing devices adapted to ensure the damping of the pitching oscillations will allow of using a free gyroscope without a coupled damping pendulum or an anemometer alone, or a pendulum alone. In all these cases, the action of the instrument on the setting of the rudder can be so much the more reduced as said instrument supplies orders the more delayed relatively to the disturbances to which the aeroplane is subjected, either in the case of the gyroscope it still pilots a great deal during the instantaneous disturbances and ensures, in addition, the slow modification of the length of the linkwork, the constancy of the inclination relatively to the horizon notwithstanding the permanent equilibrium disturbances; or, in the case of the anemometer it pilots but slightly during the instantaneous disturbances, its effect being in particular to slowly modify the length of the linkwork to maintain the speed constant.

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