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TURN INDICATOR.

By A. de Gramont de Guiche.

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In foggy weather or nocturnal flights the pilot needs two indicators, an altimeter and an instrument that will indicate immediately any change in the direction of flight. If we assume the drift to be zero, or at least that its value is known, it is still necessary to see that the airplane does not deviate from its rectilinear path. The indications furnished by the compass are too slow. Hence the need of a "turn indicator."

For this kind of instrument, the gyroscopic effect of some rapidly revolving body is generally utilized. If the axis of such a revolving body is deflected from its direction in the plane P, it exerts, in a plane perpendicular to P, a reaction couple equal to the product of the kinetic moment of the revolving body times its angular velocity of disorientation. If we call

I the moment of inertia of the revolving body with reference to its axis of rotation,

ω the angular speed of the revolving body, and

$d\Phi/dt$ its angular velocity of disorientation, we obtain for the value of the gyroscopic couple,

$$c = I\,\omega\,\frac{d\Phi}{dt}$$

Note that in the second member I is defined by construction. The angular speed of the gyroscope can be kept practically

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constant. The gyroscopic reaction couple is consequently proportional to the angular velocity of disorientation and the gyroscopic turn indicator can give quantitative results.

This being the case, let us consider the conditions to be fulfilled by such an instrument.

1. It must be able to give useful indications from the moment of "taking off;"

2. The indications must be instantaneous and must be brought to the attention of the pilot without any exertion on his part;

3. The indicator must be sensitive only to changes of orientation in the horizontal plane. In particular, it must not be affected by longitudinal changes in level and this appears to be one of the most difficult conditions to fulfill.

1. Rapid start.- The turn indicator must begin to function as soon as the airplane leaves the ground. On the Paris-London line, for example, the departure from the English station of Croyden, often takes place in a fog and it is during the first moments of flight that the indicator is most useful.

On certain foreign airplanes, a propeller set in motion by the relative wind drives a dynamo whose current serves to revolve the gyroscope placed in front of the pilot and whose indications are rendered visible by means of a pointer.

Another solution consists in driving the gyroscope by means of the suction of a Venturi tube.

It is obvious that such devices require some time to start and cannot function properly at the moment the airplane leaves

the ground.

It seemed simpler therefore to me to employ a propeller driven by the relative wind, and to make a gyroscope of it.

2. Description and operation.- The indicator consists essentially of a small propeller whose blades end in a fly-rim for increasing the momentum of the propeller. The propeller axis AB (Fig. 1) can oscillate about an axis O, perpendicular to the plane of the figure, which is parallel to the plane of symmetry of the airplane.

The point B is subjected to the constant pull of the spring R, the opposite end of which is attached to the fixed point C. It is therefore the movements of the point B, that must be transmitted to the pilot. For this purpose, I have invented two devices in collaboration with Mr. Robert Alkan.

The first is hydraulic. Two drums D and E (Fig. 2), filled with some non-congealable liquid, are disposed at either side of the axis. In each drum, one of the diaphragms is fixed, while the other is subject to displacements communicated to it by two connecting-rods. Each drum is connected by a tube to a receiving drum. The two tubes G and H, connecting the transmitting to the receiving drums, are of like capacity.

Each assemblage is completely filled with liquid. The two receiving drums I and J, are mounted in opposition and move the pointer K in front of the scale L. The drums have practically no reaction of their own. Hence it follows that, for every displacement α of the transmitting system, there is a corresponding displacement in the drums E and D, thus producing a movement of

the liquid in both tubes and a corresponding displacement of the diaphragms in I and J. The pointer moves in front of the scale, the amplitude of its motions being simply a function of α and consequently of $\frac{d\Phi}{dt}$, on the assumption that ω is constant (the speed of the airplane being constant).

This device is independent of the temperature of the surrounding air, since any change in temperature would produce like results in both tubes and could cause no displacement of the pointer. On the other hand, the inertia of the liquid in the tubes would have the effect of damping the oscillations of the gyroscopic device.

The second device transmits the indications by optical means. We sought certain advantages unobtainable with the customary dials. The turn indicator is placed on the hood of the airplane, in front of the wind shield, in the field of vision of the pilot, who can observe it without accommodation of his eyes, since the indications are projected to infinity. The pilot therefore utilizes these indications, without ceasing to regard the horizon. He can thus profit from a fugitive opening in the clouds for finding a landmark.

At B (Fig. 3) there is a transparent screen, perpendicular to the plane of the figure, which moves in front of a horizontal slot in accord with the oscillations of A O B. A small electric bulb G and the lens H illuminate the screen, whose image seen through the slot, is collimated by the lens L.

The transparent screen is divided into two regions, colored respectively green and red and separated by a narrow white strip. The change of color shows at the first glance the direction of the turn. Furthermore, the screen is marked with parabolic curves, small sections of which appear through the slot and give an indication of the angle of disorientation.

The latter device, tried with a blower, gave good results. Experiments are being tried on an airplane.

3. Influence of the relative wind on the instrument.- The two forms of the turn indicator just described must be considered only as tentative results of a study that has perhaps only just begun. It is not certain that the type of instrument we have tried to perfect can always solve the problem satisfactorily. A rotating body rigidly attached to an airplane and subjected to the relative wind is necessarily attacked by the latter at variable angles. These changes in the angle of attack must be without effect on the gyroscope, or at least not result in the production of any force in the vertical plane passing through the axis of rotation outside of the axis itself.

It is difficult to foresee whether it will be so. Experience alone can show whether the displacements of the center of thrust on the rotating body are negligible or not.

Translated by the National Advisory Committee for Aeronautics.

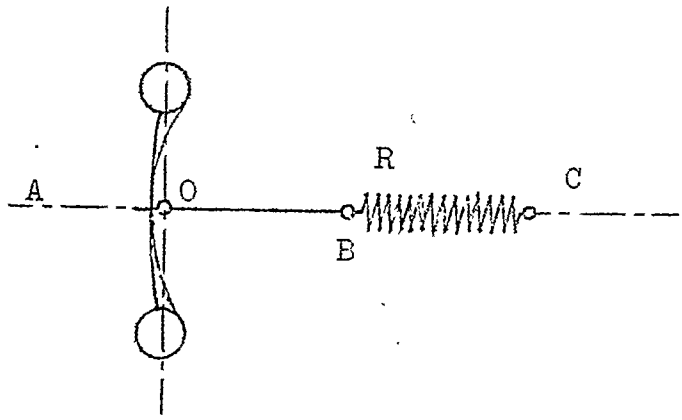

Fig. 1.

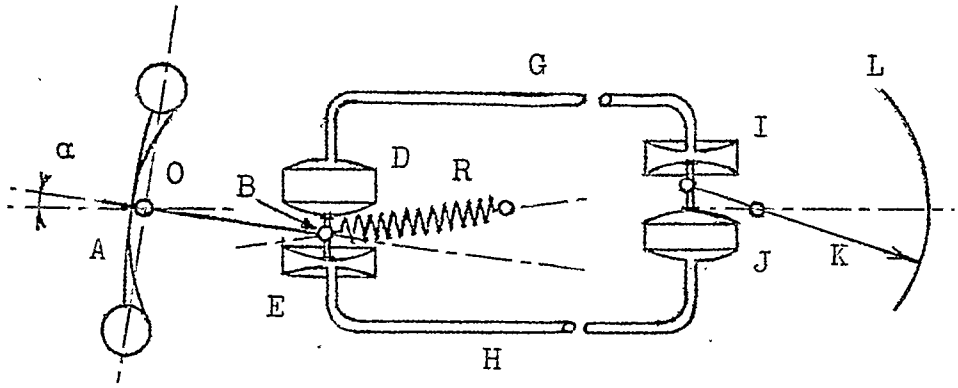

Fig. 2.

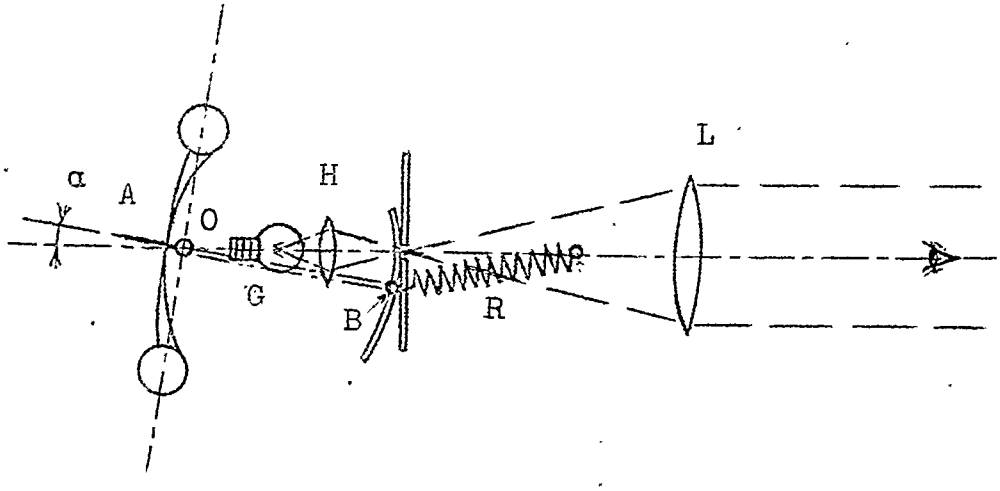

Fig. 3.