Sperry Attitude Gyro

Unrestricted Artificial Horizon and Pitch Meridian : An Instrument Which Indicates Attitude at All Times

The instrument is completely self-contained in a neat small case.

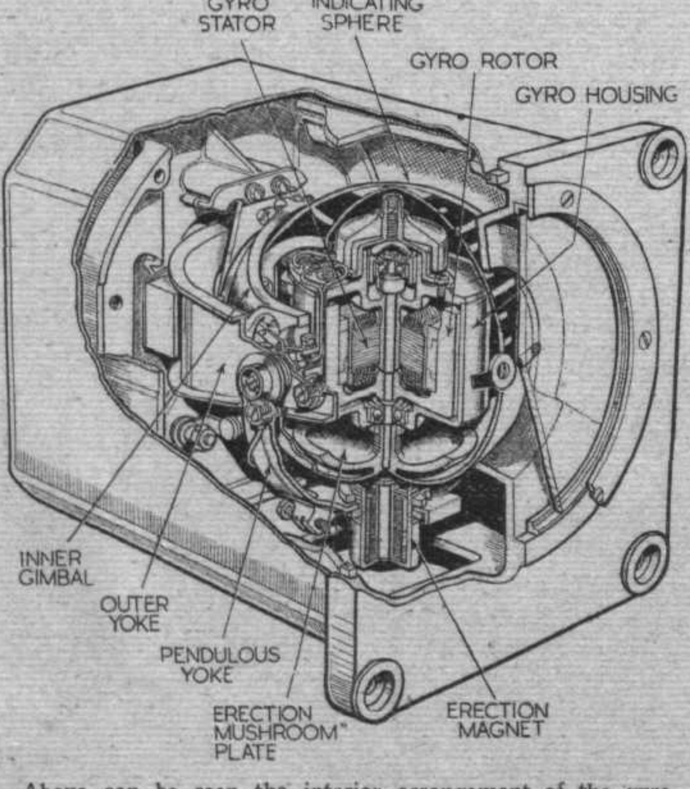
WHEN a pilot is flying blind, for example through cloud, and there is absolutely nothing he can see outside by which to orient himself, then in order to ascertain and maintain the attitude of his aircraft he is forced to fly "on instruments."

The six instruments which make up the standard British blind-flying panel are the air speed indicator, artificial horizon, rate of climb indicator, altimeter, directional gyro, and turn and bank indicator. These six indicators each perform a given function and by the correlation and interpretation of the several readings given, the pilot is able to tell what his aircraft is doing. However, there is a limiting factor to the ease of blind flying imposed by the necessity for interpreting and correlating the various readings, and although when flying blind normally the slight deviations in attitude are corrected immediately and almost subconsciously by a good "instrument" pilot, there always exists the possibility that at some time or other, in the violent viscera of cloud, for instance, the aircraft might be so thrown about that it would be a period of quite some few seconds before the pilot was able to straighten out his machine according to the readings vouchsafed by the instruments. Again, there is the possibility that in certain circumstances the aircraft might run out of height before the pilot had sorted out from his dials what was happening and had been able to apply the requisite correction.

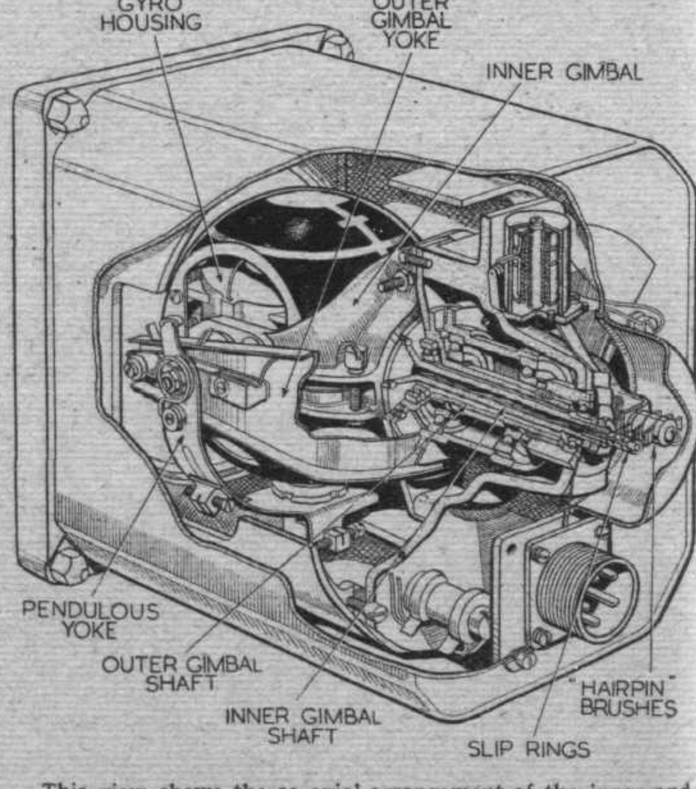
These circumstances are, of course, remote as to likelihood, but they are nevertheless possible and, furthermore, always ready to come forward and administer a salutary lesson to the but human pilot. Normally, it goes without saying, one can fly on instruments safely, accurately and happily—apart from the fatigue question—and never have a sticky moment; but there are definite limitations imposed by the complex readings of flight instruments, which prevent a pilot being able to tell—literally at a glance—what his aircraft is doing. An instrument which *will* tell the pilot at a glance exactly what his aircraft is doing is something for which we have been waiting ever since aircraft were first flown, and at last we have something which approaches it very closely.

Supersession of Artificial Horizon

The famous instrument concern, the Sperry Gyroscope Company, have devised a gyro-stabilised instrument which, without restriction of any kind, enables one to tell exactly in what position the aircraft is poised relative to the earth;



Above can be seen the interior arrangement of the gyro mechanism, erection mechanism and the relationship of gyro to sphere.



This view shows the co-axial arrangement of the inner and outer gimbal shafts together with the brush and slip ring assembly for power feed.

this having been achieved by virtue of surmounting an obstacle which, hitherto, has been one of the chief bugbears, that is, providing the gyro element with unrestricted 360 deg. movement in two planes perpendicular to each other.

It must not be thought that the new attitude gyro makes the normal flying instruments redundant. They are equally as necessary now as they ever have been, for it is only by their means that accurate blind flying can be achieved. However, the attitude gyro does supersede the normal artificial horizon owing to the fact that the range of indication is unrestricted as opposed to the approximate 60 deg. in pitch and 100 deg. in roll limits of the artificial horizon.

The attitude gyro is a departure from normal practice in two respects, (i) in its unrestricted movement, and (ii) in that the indication given is of pattern form as distinct from the "pointer and line" form in general use.

Representation

Through a circular window in the instrument case the pilot sees a portion of a sphere, the upper half of which is dark in colour whilst the lower half is light. Across the centre of the window is an alternately light and dark dotted lubber line which appears to the pilot as being in line with the sphere's equator when in level flight. In the centre of the lubber line is a circular "bull's-eye" which is used as a pitch index in steep turns or rolls.

A meridian line passing through both polar positions bisects the sphere vertically, and at right angles to it latitude circles are spaced at each 30 deg. above and below the equator with short horizontal lines across the meridian at each 10 deg. between the latitude circles. The 90 deg. references are solid circles at each end of the polar axis. All these markings are in contrasting colour to the hemisphere on which they lie so that it is equally as easy to read one half of the sphere as the other; additionally, the pattern appears the same under ultraviolet fluorescent lighting by night as it does by natural daylight.

Around the upper half of the window frame are marked radial reference lines at each 30 degs. Thus, in a 30 deg. bank to port, for example, the equator and meridian line of the sphere will each bisect the lubber line's central bull's-eye, but the upper limit of the meridian will be aligned with the 30 deg. division to the right on the window frame, whilst the left extremity of the equator will be lined-up with the 60 deg. division on the left of the window frame. The accompanying diagrams illustrate a series of indications and pilot's views for various manœuvres.

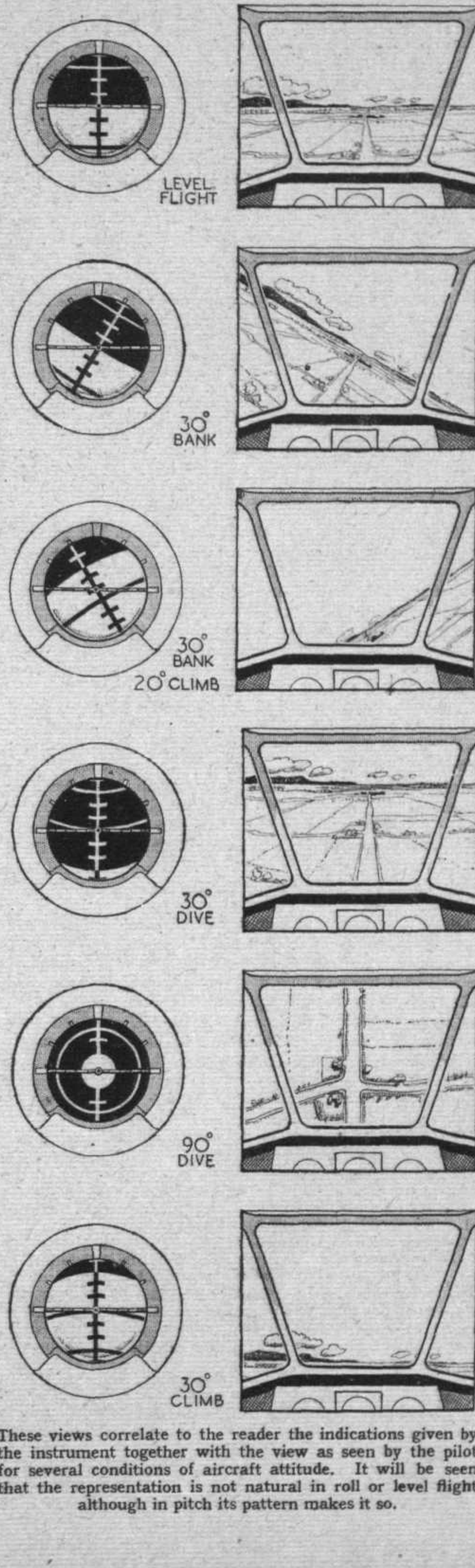
Construction of the attitude gyro is neat and compact, the whole being enclosed within a case 5in. square by 7⅝in. long and weighing but 4½ lb.

Structure

The gyro unit comprises the rotor (squirrel-cage) of a three-phase induction motor which spins around the stator on bearings at top and bottom of the enclosing housing. Around the housing is fitted the indicating sphere, the sides of which are cut away to accommodate the bearings in which the gyro housing is pivoted. These bearings are carried in the horn tips of the inner gimbal yoke which itself is mounted on the end of a shaft running in bearings at the rear of the instrument case, thus the indicating sphere can rotate through 360 deg. about the transverse axis and the gimbal yoke supporting the sphere can rotate through 360 deg. about the fore and aft axis. By this means unrestricted movement of the sphere in two planes perpendicular to each other is achieved.

Electrical current is supplied to the gyro by three "hairpin" contacts which act as brushes to three slip rings on the end of the inner gimbal shaft. Leads from slip rings to rotor are carried along inside the shaft and branch to each arm of the gimbal yoke to effect contact at the bearings.

Beneath the rotor housing, yet within the sphere, is an "inverted mushroom" spherical segment erection plate mounted on an extension of the rotor shaft and spinning with it. Immediately beneath the erection plate and sup-



These views correlate to the reader the indications given by the instrument together with the view as seen by the pilot for several conditions of aircraft attitude. It will be seen that the representation is not natural in roll or level flight although in pitch its pattern makes it so.

SPERRY ATTITUDE GYRO

ported in a U-bracket swung from the outer gimbal yoke is the erection magnet, this, of course being outside the indicating sphere.

The outer gimbal yoke is supported in two ball-bearings co-axial about the inner gimbal shaft and has limited swing to 23 deg. either side about the fore and aft axis. Likewise the U-bracket carrying the erection magnet can swing 30 deg. back and forth in its bearings on the transverse axis. It may thus be seen that the erection magnet can swing within limits about both the roll and pitch axes, but as it is pendulous it always seeks the vertical unless accelerated in the horizontal plane; for example, during a turn.

Bearing friction and slight unbalance, neither of which can be completely eliminated, impose on the gyro forces which tend to make the spin axis deviate from the vertical. Additionally, since a gyro maintains a fixed attitude in space it appears to drift relative to the earth. It is, therefore, to overcome the effect of these three factors that the erection system is incorporated, its function being to maintain the gyro axis vertical in order to establish a fiducial flight reference.

Erection Mechanism

The erection plate, as stated, spins with the gyro rotor and is suspended over the pendulous erection magnet which always (normally) seeks the vertical. Magnetic flux emanating from the magnet induces electro-motive forces in the body of the rotating erection plate, and, consequently, eddy currents and a magnetic field, but as this is symmetrical and the erection plate is normally rotating on an axis on which the magnet is suspended, the magnetic forces can be considered as in a state of balance. However, when the plate is displaced relative to the magnet, the flux emanation from the latter is no longer symmetrical about the plate. This displacement breaks down the state of balance in the induced electro-motive forces which causes a drag to be produced on the erection plate tending to return it to the symmetrical (co-axial) disposition once more. In such a manner the erection system governs the gyro by overcoming the forces which cause the gyro to drift.

Instrument Presentation

There is a fairly full field of endeavour waiting to be explored on the subject of flight instrument representation.

The writer remembers thinking when he first came across the artificial horizon that it seemed a pity that the instrument horizon bar moved against a stationary aircraft lubber image instead of vice versa. Of course, reversed presentation means added complication in design and construction of the instrument. There is, too, the consideration that pilots are familiar with one type of presentation and they would need to forget what they had learned in order to cope with reversed indication. In the writer's opinion, however, the reversed presentation is intrinsically the better and would be found easier to fly on with greater accuracy because the sensing of the indications would be natural.

Pilot's Conservatism

Other factors enter into the general problem, and one of these, which, perhaps, is sometimes overlooked, is the tendency of many pilots to fly largely by one, or possibly, two instruments. One is taught to fly on instruments with the precept that the various readings should be correlated, and the aircraft should be flown on the interpretation of the correlated readings. What in fact actually happens is that a pilot finds that he can fly fairly reliably on the artificial horizon and directional gyro, or on the turn and bank indicator and d.g. and, of course, he does so. It should not be imagined that all pilots react in this way, for such is not the case; but there are, nevertheless, many pilots who do fall into this category. Probably the chief danger of concentration on perhaps two instruments to the exclusion of the other four is that when something sticky does happen, the pilot takes some little while before he can sort out from his clocks what the aircraft is doing—were he normally to fly by *all* his instruments, that sorting out period might be drastically reduced—and the time factor for corrective action can easily be vital; that is, vital to life.

Pictures to Reduce Fatigue

This problem of instrumentation might be simplified by arranging that each instrument shows the pilot a pictorial representation the sense of which is natural. Were this done effectively the pilot's reaction to any given indication would be naturally instinctive, automatic and virtually instantaneous. The attitude gyro is a good attempt at pictorial representation apart from its quality as a flight instrument but, nevertheless, the sensing of the indications given is not natural, it is but an elaboration of the normal artificial horizon. The whole business of instrument flying is complex and difficult of analysis. Certainly, however, with the post-war airlines giving night sleeper services and sub-stratosphere routes there must be a drastic simplification of instrument presentation. Fatigue is a deadly foe of the pilot, and instruments get proportionally more difficult to interpret with increase in fatigue.

It seems clear that the goal to be aimed at is graphic pictorial representation which eliminates the necessity for interpretation.

BODY SNATCHING

THE idea of being whipped smartly off the ground at the end of a nylon rope trailed by a low-flying aircraft may not strike everyone as the ideal way of boarding the said aircraft, but the exigencies of war often impose upon the individual some degree of physical (and/or mental) discomfort in the interests of operational efficiency.

Patently there can be occasions—such as the retrieving of an agent from hostile territory, or an airman stranded inaccessibly—when an aircraft wishes to collect a passenger in circumstances which make a landing inadvisable or even impossible, and it was with this thought in mind that the U.S.A.A.F. decided to explore the possibilities of applying the pick-up method already proved to be quite practical with mail bags and even laden gliders.

Experiments were therefore undertaken by the U.S. Air Technical Service Command, all their tests being made at the Clinton Country Army Air Base in Wilmington, Ohio, which is actually a glider field. In the first test a Stinson Reliant was used, and its pick-up equipment differed only in small details from the normal pick-up gear. An electric winch with automatic delayed-action brakes accommodated 185ft. of half-inch nylon rope, the business end of which carried a hook and was attached to a 10ft. wooden guide pole trailed beneath the aircraft. Total weight of this gear was 2,000 lb. The ground equipment comprised a nylon loop hung between two poles and attached to the "guinea-pig's" special harness. Considerable time, incidentally, was spent on evolving a suitable modification of normal parachute harness and sundry other details, in order to ensure a good safety factor. Nevertheless it was as well that they tried it out on a sheep before risking a human passenger, because the first sheep was killed when the harness twisted and strangled it. Further modification, however, overcame this defect and the next sheep—an easy animal to kill—lived to "baa" the tale.

But this in no way detracts from the cool courage of Paratrooper 1st Lt. Alexis Doster, who volunteered to be the first human passenger to be picked up, for the risk was still pretty great. In fact, Doster wore a parachute and carried a sharp hunting knife to cut himself free if there proved to be any serious trouble about the final operation of getting him safely into the aircraft. He reported, in fact, that his harness and the "prop wash" did make it difficult, but said that the actual pick-up was perfectly smooth and quite free from any jerking effect. Experiments are continuing.