THE ASKANIA AIRCRAFT COMPASSES

General Observations on Aircraft Compasses.

The aircraft compass is a development of the ship's compass. We have years of experience in the construction of ship's compasses, and it was natural that we should apply the same principles to the construction of aircraft compasses. As a result, the time required for the development of this new instrument was materially shortened, and from the very outset we have had aircraft compasses theoretically correct in design.

Although the principles underlying all compasses are the same, the special requirements on board ship and in the air differ to such an extent that a mere adaption of a ship's compass to aircraft requirements can never give satisfactory results. It is not sufficient merely to modify the ship's compass in regard to weight, size, and ease of reading. These superficial changes are obvious, but until the special conditions under which the aircraft compass has to work are investigated and adequately provided for, the instrument cannot be expected to function accurately.

Aircraft travel through space at speeds many times greater than those of ships. The accelerating and retarding forces present are likewise very much more considerable. An entirely new factor which has to be reckoned with is the power of rapid travel along a curved line, which is practically negligible in ordinary marine navigation. The flight velocity factor, during curved flight, frequently assumes such dimensions that the resultant of all the accelerating forces at work may assume almost any angle to the line of the gravitational pull. Under quite ordinary flying conditions the line of gravitation may easily deviate 50 to 60 degrees from the normal when describing a curve. In contrast to the ship's compass, the axis of the aircraft compass, even though suspended on gimbal rings, may deviate to this extent from the perpendicular. In such positions the influence of the vertical component of the earth's magnetic field on the compass is inevitable. Every aircraft compass is more or less deflected on a curve, quite apart from the purely dynamic disturbance of the magnet system and of the card.

A very simple experiment will illustrate the nature of this disturbance. An arrow is drawn on a sheet of paper roughly representing the compass card, and this sheet of paper is held horizontally with the arrow pointing in a fixed direction in front of the observer. Then imagine, as an extreme case, a curve involving a bank of 90 degrees. Raise the paper on end to represent this; suppose that in this position a turn of 180 degrees is carried out. Now the aircraft is flying straight ahead again. On bringing the paper back to the horizontal, we find the arrow pointing in the opposite direction. In this instance the card would have been deviated 180 degrees by purely dynamic forces.

In addition to this, there is the deflection of the system brought about by the influence of curved motion in the compass filling: dragging. Owing to the far greater cornering speed possible with an aeroplane as compared with a ship, the deviation caused by dragging is of particular importance in connection with aircraft compasses.

From all the foregoing it is clear that on every curve some deviation of the compass is bound to take place and cannot be avoided.

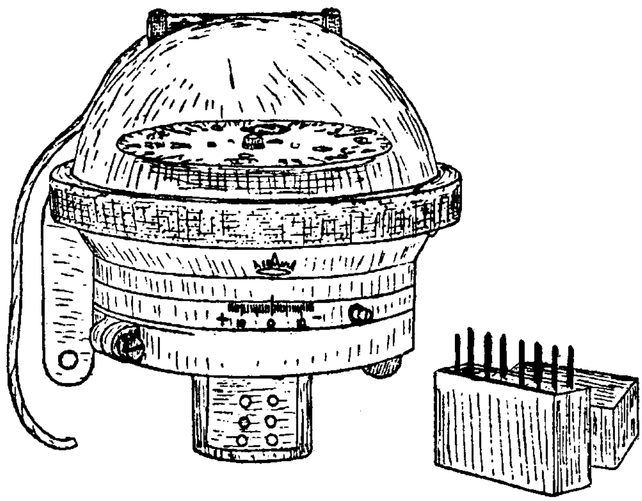
That compass, therefore, which most rapidly comes to rest again after a deviation will give the safest and most accurate indications. Consequently, the main principle to be striven for in all aircraft compasses is a short period of oscillation and correct adjustment of the damping. The short period of oscillation is secured by increasing the magnetic moment and reducing the moment of inertia of the system. By dint of years of systematic work, we have succeeded, as regards our aircraft compasses, in bringing to a maximum the value represented by the fraction $\frac{\text{magnetic moment}}{\text{moment of inertia}}$.

For ship's compasses the considerations which hold good are different. Disturbances of the compass due to searoll are rhythmic and occur at regular intervals, and there is always the risk that the period of oscillation of the compass may coincide with that of the disturbing impulses. In such a case resonance leads to the ordinary oscillation being magnified by the disturbing impulses. As it has proved impossible, so far, to keep the period of oscillation of the ship's compass below that of the ship's roll, the only practical solution found so far has been to prolong the period of oscillation artificially, by increasing the moment of inertia. A compass that oscillates slowly may, under favourable conditions, show steadier readings than one in which the oscillation frequency coincides with the rolling due to the waves. Disturbances due to flying energy and dynamic influence can be disregarded. Dragging, in ordinary marine navigation, is of quite secondary importance. It has to be remembered that dragging in a compass is broadly speaking governed by the damping. A strongly damped compass will have a correspondingly pronounced drag. All the attempts so far made to attain complete aperiodic damping of the magnet system of the aircraft compass have led to failure. Where the oscillation is slow the pilot, being obliged to take his readings quickly, is inclined to assume that the compass has already settled down, whereas in point of fact, it is still more or less deflected and is creeping back asymptotically to its normal position. The damping of our compasses is achieved almost exclusively by the formation of eddies between the system and the filling. Coupling with the compass housing is obviated by keeping it at a sufficient distance and by selecting an appropriate design for the housing.

The Askania "Franz" Aircraft Compass.

The "Franz" Aircraft Compass is superior by reason of its large magnetic moment, the thoroughness with which all oscillations are damped out, the small extent to which it is disturbed by shocks and when changing course, and the rapidity with which it settles down again into the position of rest. It offers great resistance to all external disturbing forces.

The card, which can be read from any position, from above down to and including an almost horizontal direction, renders this compass specially serviceable as an observation compass. It helps the pilot to find his bearings quickly in an emergency as the graduations on the card are not altered by parallax.



The optical effect of the glass dome is to give the card an apparent diameter of about 90 m/m (3.5 ins.) and to make it look as though it were inclined towards the observer, whatever the direction of view. This apparent inclination makes it possible to read the card even when viewed almost end-on, and the effect is strikingly noticeable if the card is looked at from various positions whilst the instrument is supported at eye level. The white card shows up clearly against a dead black background. The lubber line is extra large, so that it does not need to be looked for. The whole card system is so mounted that even when turned upside down nothing can be dislogded.

Results of tests made at a horizontal intensity of 1.85 thousand Gauss Units and at a temperature of 18° C. (64°-F.):

Continuance of oscillations after provoking a deviation of 90 degrees until the compass comes back to rest	10 Sec.
Continuance of oscillations after a deviation of 45 degrees until the compass comes back to rest	9.5 Sec.
Duration of a simple oscillation	6 Sec.
Damping, expressed in percentage of the arc of oscillation	78-81 %
Angle of tilt of card	25 degrees
Drag during a circular movement of 3 minutes duration	0.4 —
— — — 2 — —	0.5 —
— — — 1 — —	1.3 —
— — — ½ — —	1.9 —

The illuminant consists of a 14 volt lamp with a blue screen, supported on a bracket attached to the compass bowl. An adjustable mask regulates the intensity of the light. The 14 volt lamp may be connected without any intermediate resistance to the current supply on board if it is between 4 and 14 volts.

The compass body, together with the compensating device, rests rotatably on a flanged ring provided with a locking device. Around this ring is rotatably fitted a second narrow ring with a clamping screw. This second ring is marked with divisions reading from 0 to 12 degrees to either side, so that the lubber line can be set parallel to the axis of the aeroplane body.

The compass can be fixed either to one of the transverse walls or to one of the lateral walls. It is advisable for this purpose to jack up the plane into the normal flying position. The compass having been attached, the big clamping screw is loosened and the compass box turned until the lubber line is in the forward position so far as can be judged by the eye. The screw must then be tightened up again. Next, the small clamping screw near the graduation is loosened, and the ring so placed that the zero under the index mark comes into position under the crown. The screw is then tightened up again. The final setting of the lubber line parallel to the axis of the aeroplane is done at the time of compensating.

The compensating device has 6 apertures on its right hand side and another 6 on its rear side for the insertion of magnetic needles. 1 or 2 of these are required for each aperture. These apertures are spaced out in sets of 3 at short distances above each other. By this means the magnetic action of the needles upon the magnet system of the compass card can be graduated, and deviation is more easily eliminated. The compensating magnets are aged and can be supplied singly. They cannot de-magnetise each other after compensation, because each needle has its own setting. The black magnets have a large, the white ones a smaller magnetic moment.

The magnets to be inserted on the right are to correct deviation either on a North or South course, and those inserted on the rear side are for on East and West courses.

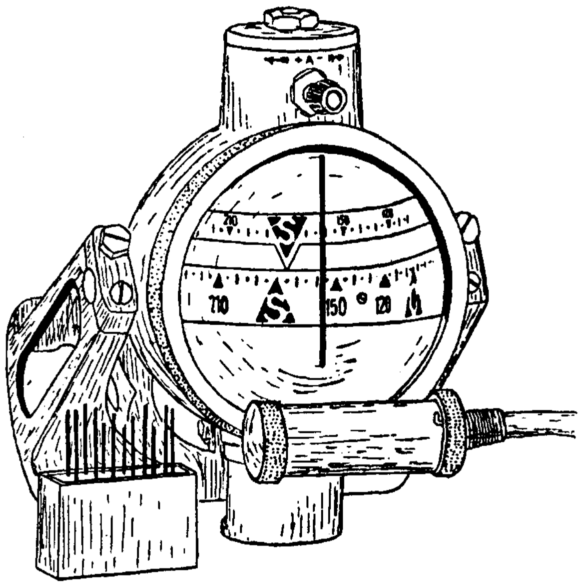
A retaining sheath prevents the magnets from falling out. After compensating, the sheath is turned round until the retaining spring clicks into its notch.

The weight of the instrument is 1,5 kilos (3 lb. 5 oz.) and the outside measurements are :- height, 126 m/m (4.96 ins.); width, 120 m/m (4.72 ins.); depth, 123 m/m (4.84 ins.).

The Askania "Emil" Aircraft Compass.

This compass with its upright steering card is specially well adapted to the needs of the aircraft pilot. The best place to fit it is somewhere near the line of forward observation. The 10-graduation card is very conspicuously marked.

The course-setting scale which is uppermost facilitates steering very considerably. It is set by means of the upper milled-head nut. The need for mental work during flight is eliminated. The right hand clamping screw on the stirrup serves for the horizontal setting of the compass. The needle compensating device is underneath.



Results of tests made at a horizontal intensity of 1.85 thousand G. U. and at a temperature of 18° C (64° F.):

Continuance of oscillations after provoking a deviation of 90 degrees until the compass comes back to rest	19	Sec.
Continuance of oscillations after a deviation of 45 degrees until the compass comes back to rest	18	Sec.
Duration of a single oscillation	7.7	Sec.
Damping, expressed in percentage of the arc of oscillation	74 %	
Angle of tilt of card	25	degrees
Drag during a circular movement of 3 minutes duration	0.4°	
— — — 2 — —	0.6°	
— — — 1 — —	1.6°	
— — — ½ — —	3.8°	

The illumination and the compensating device are similar to those used in the "Franz" compass.

After loosening the bearing clamp screws this compass can be fixed either upright, suspended, or in any desired position intermediate between the two. The instrument having been fixed, the aeroplane is jacked into the normal flying position, the compass is rotated round the clamping pivots until the course-setting scale is horizontal in relation to the steering scale beneath it, and the clamping screws are tightened up again.

The final setting of the lubber line is done at the time of compensating. It is effected by turning the red lubber line by means of the hexagonal nut of the head of the compass according to the plus or minus sign found at the side of it.

Steering.

The red lubber line stands out clearly against the white card and the dead black background. The course to be steered is set by turning the milled-head above the course-setting scale until the required point on the scale coincides with the lubber line. There will always then be one or two principal lines clearly visible with their elongated downward pointing extremities.

The aircraft will be flying on its right course whenever the corresponding and clearly marked principal lines of the course-setter and of the steering card coincide with one another, *e. g.* S with S. The course at starting is usually ascertainable from conspicuous landmarks in the neighbourhood of the aerodrome. If the course is set and held by reference to such a line, it is only necessary, by turning the milled head, to bring the course setter into agreement with the steering card, and the right course, corrected for deviation, aberration and drift is thereby set without any calculation being necessary. The good or bad alignment of the two strokes facing each other will show at a glance whether the right course is being held. Any deviation from the course strikes the eye at once. It is not even necessary to note or to memorize the details of the course, but, if wanted, these are easily read off against the lubber line.

The weight of the instrument is about 1,5 kilos (3.3 lb.) and the outside measurements are :- height 160 m/m (6.3 ins.); width 126 m/m (5 ins.); depth 94 m/m (3.7 ins.).