ABSTRACTS.

The Aeroplane in Curvilinear Flight.

The article describes an investigation into the attitude taken up by an aeroplane in curvilinear flight. It is admittedly only a very approximate method, assumptions being made in order to simplify the mathematics. When an aeroplane turns, it banks, and if the banking is excessive the machine side-slips inwards, the opposite being the case if the angle bank β is not large enough. First of all the author examines the relation between β and other quantities, defining the machine and the motion.

If ρ be the radius of curvature of the path, V the velocity, then the angle of bank β is given by $\tan\beta = V^2/\rho g$, assuming the sine law for the resistance of the planes.

A few remarks are made on the gyroscopic effect of the airscrew either in assisting or opposing the banking movement, together with a consideration of the difference in the lifts on the two wings due to the circular motion.

The effect of the angle of the rudder is next examined, and an expression is derived for the radius of curvature of the path. If F_s be the area of the rudder, and α the initial value ($t=0$) of the angle through which the rudder is turned, then the component forces acting on the rudder parallel and perpendicular to the longitudinal axis of the machine are respectively—

$$R_s = v^2 F_s \sin^2\alpha\psi\gamma/g,$$
$$A_s = v^2 F_s \sin\alpha\cos\alpha\psi\gamma/g,$$

γ = the density of the air and ψ a constant coefficient. The latter force produces a moment about the vertical axis through the C.G. and if the average be l, M can be written in the form

$$M = C\sin 2\alpha,$$

C being assumed constant and equal to $\psi\gamma l v^2 F_s/2g$, and the moment produced by R_s neglected in comparison with M. Further neglecting the opposing moments due to difference of the relative speeds of the outer and inner wings the equation

$$\frac{d^2\phi}{dt^2} = \frac{C\sin 2\alpha}{J}$$

is obtained where ϕ is the angle between the original rectilinear flight path and the axis of the machine at time t, and J the moment of inertia about the vertical axis through the centre of gravity.

On integration this gives the angular velocity

$$w = \frac{C\sin 2\alpha}{J}t$$

and the angular displacement $\phi = C\sin 2\alpha t^2/2J$, and since $\phi = vt/\rho$,

$$\rho = 2vJ/C\sin 2\alpha t.$$

In actual flying the banking of the machine due to difference in the speed of inner and outer wings will cause the machine to "take the curve" and the centrifugal force will balance the lateral force so as to do away with side-slipping.

It is admitted that the above formula for ρ is only a rough approximation, assuming as it does the constancy of α and v. At large values of β, M is usually small; for the extreme case $\beta = 90°$, it vanishes. J also ceases to be a principal moment of inertia for values of β other than 0° or 90°. Still it is claimed that the approximation is good for the values of β up to about 25°.

Further

$$\tan \beta = \frac{v^3 F_s \,.\, t \sin 2\alpha}{4gJ}$$

Finally a few calculated values of β are given for $\alpha = 5°$ and 10° and for values of t varying between $t = l$ and 20 seconds, and the personal element introduced into the control of the machine is discussed. ("Schweiz Aero Club Bulletin," Nos. 8 and 9.)

Influence of Wave Formation upon Aerodynamic Resistance.

The square law of resistance of a body moving in air applies only up to 240 m.sec. At this velocity the resistance co-efficient, obtained by dividing the resistance w by v^2—where v is the velocity of the body relative to the air, increases rapidly until at 480 m.sec. it reaches a maximum about three times its original value. The coefficient then gradually decreases with speed. A. Sommerfeld sought an explanation from an analogy between the waves from a solid sphere moving with a velocity greater than sound and electrons moving quicker than the velocity of light.

For motion of a body through the air with a velocity greater than that of sound, the ratio w/v^2 was taken to be of the form

$$\frac{w}{v^2} = y = K + A\,\frac{1 - e^2/v^2}{v^2}$$

where c is the velocity of sound (340 m./sec.) and K and A are constants.

For cases where v is less than c it was considered that compressibility affected the density according to the law

$$\mu = \mu_0 \frac{c \,.\, f(v)}{c \,.\, f(v) - v}$$

where μ is the normal density and $f(v)$ a function of the velocity taken to be of the form

$$f(v) = a + bv.$$

The law for the curve y against v then took the form

$$y = \frac{w}{v^2} = B\,\frac{\mu_0 f(v)\, c}{f(v) \,.\, c - v}$$

v being $< c$.

The constants were chosen to fit a given case. (Dr. Alfred Lechner, "Osterreichische Flug-Zeitschrift," Aug., 1918.)

Limit Performances of Aeroplanes.

The article commences with a discussion of the utility and futility of helicopters, and concludes from aerodynamic and stability considerations that the introduction of such a new type of dynamic aircraft is neither advantageous nor desirable. Proceeding to an analysis of the limiting range of an aeroplane the writer commences with a consideration of certain properties of wings, and points out the desirability of an accurate definition of what is meant by the chord of an aerofoil, and consequently also by the angle of incidence. He supports the view that the latter should always be measured from a position of zero lift, because only thus is a sensible comparison between the properties of different aerofoils possible. The problem of maximum flight endurance or of the greatest distance which an aeroplane can fly without re-fuelling is shown to depend ultimately on the efficiency of propellers, the L/D of the machine, the fuel consumption per horse-power, the ratio of useful load to total weight. The following conclusions are then drawn:—

(1) The maximum distance which an aeroplane may cover in the near future without re-fuelling may be estimated at 4,500 km., sufficient for crossing the Atlantic from Newfoundland to Ireland.

(2) The rational solution of the trans-Atlantic flight is furnished by the single-screw multi-engine aeroplane, which has the great advantage over all other existing types of being characterised by a decrease in drag and specific weight with an increase in size. With such an aeroplane the Atlantic could be crossed within 30 hours.

(3) The development of a propeller endowed with high efficiency and means for absorbing variable power is an additional important factor. (G. de Bothezat, "Aviation," Oct. 1, 1918.)

German Hannoveraner C.L. II.

This machine is a light two-seater for general use. Precise details have been lacking for some time; it first made its appearance in January of 1918.

The principal dimensions are as follows:—

Upper wing span	39.2 ft.
Lower wing span	36.7 ft.
Total length	25.6 ft.
Height	9.4 ft.
Lifting surface	347 sq. ft.
Total weight	2,545 lb.

The wings are unequal in span and chord. There is a dihedral of 1-1/2° on the upper and 2-1/2° on the lower plane, and the lower wings are swept back 1-1/4°. The ailerons are of steel tube framework and balanced; they are operated by cables in the interior of the lower plane.

There is a central plane to which the upper wings are attached. In the thickness of this central plane are a honeycomb radiator and a petrol tank. The amount of cooling surface of the radiator in action is adjustable by means of a pivoted metal plate, and there is a level indicator on the petrol tank. The central plane is covered with 3-ply.

The wing struts, of which there is one pair on each side of the body, are of steel tubes in a faired sheath. They do not follow the stagger of the planes, and slope outwards laterally from base to top.

The cabane is divergent and consists of three tubes of N-form on each side of the fuselage. The points of attachment of these tubes to the body are very far apart, and the method of attachment does not appear to be very successful. It has been proved that after a very short time the bolts show wear.

The tail is a small biplane, segmental in plan form, with elevators top and bottom. A single strut on each side of the fuselage is fitted between the planes. The whole consists of a framework of steel covered with fabric. The lower tail-plane is divided by the fuselage and the fixed fin and the rudder extend as far as the top plane.

The fuselage is entirely of wood, and ends in a vertical knife edge forming the rudder post. The front portion is very deep and nearly fills the gap between the wings. The two cockpits are separated by 22 cm. only.

The motor is a 200 h.p. new model Opel, with six cylinders in line.

The Hannoveraner C.L. II. can fly for 2-2½ hours, and its ceiling is 19,700 ft., which it reaches in about 45 minutes. Its speed is 100 m.p.h. at 6,500 ft., and 90 m.p.h. at 13,000 ft.

In the opinion of pilots who have flown it, the machine is very sensitive to the controls.

The Hannoveraner C.L. III. preserves the general characteristics of the C.L. type II. In it the cross bracing between the tailplanes is replaced by two small flattened tubes, each extending from the base of the fixer fin to the top of an inter-plane strut. (" L'Aérophile," Oct. 1-15, 1918.)

Meteorological Conditions and Flying.

The author suggests that the chief conditions that increase the risks of flying are (1) gales, (2) squalls, (3) bumps and eddies, (4) clouds, (5) rain, hail and snow, (6) fog, (7) lightning. While strong winds are not now as formidable as heretofore, danger is to be anticipated when these arise with great suddenness. The author remarks in illustration that at Farnborough an anemometer 140 ft. above ground-level registered a velocity of 80 miles per hour, when only a quarter of an hour previously the air had been quite calm. Considerable damage was done on that occasion to hangars and tents. But in general a gale may be forecasted many hours in advance, from the weather map for the day. Squalls, on the other hand, which are usually associated with thunderstorms, are frequently a much graver danger since they are often preceded by very light winds or even complete calm, and within a minute from their onset may be blowing 60-80 miles per hour.

A particularly dangerous form is that known as the line squall; this extends usually only a few miles across, but may be several hundred miles long, and advances across the country broadside on at 20-40 miles per hour. Besides the blast of wind in front of the squall there are great up-currents in front, and down-currents near the middle, with violent eddying between. It is suggested that warnings of the approach of these dangers could be carried through by telegraphic communication from aerodromes to a central office.

Bumps are mostly due to rising currents of air over surfaces of the ground that are of different temperatures, and to eddy motion due to the wind blowing over irregularities of surface. They are also associated with cumulus clouds. The cumulo-nimbus clouds being associated with heavy rain and possible hail, or with snow in winter, may prove extremely dangerous; they usually constitute a sea of very rapidly ascending currents.

Low sheets of clouds may prove a hindrance to work with aeroplanes, and if they are exceptionally low, may cause difficulties for a pilot in returning to an aerodrome or even in landing. (C. J. P. Cave, " Aerial Age Weekly," Sept., 1918.)

Determining Direction and Velocity of Wind by Sound.

The method was originally invented solely for artillery purposes, but it will become, in the opinion of the author, General Bourgois, one of the best methods for the investigation of meteorological problems, and is applicable in cloudy weather. Before the war, meteorologists considered the determination of the velocity and direction of the winds at high altitudes very important with a view to forecasting the weather conditions. During the war this knowledge became of paramount importance with relation to the flight of aeroplanes and for the calculation of the range of shells, which at the summit of their trajectory come under the influence of currents hitherto unknown. The knowledge is necessary at night, and in foggy or cloudy weather, as well as during daylight, when the movement of clouds is observable. The new method known as " sound-ranging " was brought into use by the military meteorological office in 1917.

The method consists in allowing a balloon filled with hydrogen to rise freely, and be carried by the various currents of the atmosphere. This balloon carries small shells, which burst at regular intervals. Certain apparatus register the explosions, and these enable the position of the balloon to be accurately determined. These points are then plotted, and the trajectory or course of the balloon is traced. The sum of the projections on a horizontal plane of the positions at which the explosions took place, and the knowledge of the time intervals between these explosions enable the velocity and the mean direction of the wind to be determined between certain altitudes.

The balloons used are 1 m. to 1.30 m. diameter, and the shells are charged with melinite, the weight of a shell being about 200 gr. In spite of the smallness of the shells the explosions can be heard at distances up to 15 kilometers, even with a contrary wind having a velocity of over 10 m. per sec. The results obtained will be published completely by the geographical department of the army, and will be compared with those obtained at the German observatory of Lindenberg, where captive balloons and kites were employed. Sound-ranging has been possible every day, whereas a captive balloon could only be used on 91 days in the year at Lindenberg.

The balloon and kite method is rarely available at heights exceeding 5,000 m., and the record for a balloon is 7,058 m., these heights are readily attained by the sound-ranging balloons, and heights of 8,000 to 10,000 m. have been reached experimentally. The little hydrogen balloons can be used in winds having a velocity of 35 m. per sec., whereas this is quite impossible with either the captive balloon or kite. Teisserenc de Bort divided the atmosphere into two parts, the troposphere and the stratosphere. The former, which has a mean depth of 10 to 12 km., should be the region of vertical currents and the phenomena which control the climate in our countries. Sound-ranging gives for the first time a means of exploring completely this most important part of the atmosphere. ("Comptes Rendus," Nov. 25, 1918.)

Dopes, Doping and Ventilation.

The principal feature of this article is the description of the system of drying in cabinets, as invented by the writer. In order to prevent "blushing" of the doped surfaces during the drying process, it is necessary to keep the relative humidity of the drying-room below 50° F., blushing being due to condensation of moisture on the film of dope. The employment of cabinets for drying obviates the need for a high temperature work-room which would be trying for the workers. The cabinet system is much less expensive than the system sometimes employed of combined cooling and heating ventilation of the dope-room. The drying chambers or cabinets are steam-heated to a temperature of 105° F. under ordinary weather conditions. Gratings in the floor carry off the heavy fumes. About five changes of air per hour are necessary for the cabinet. Partitions forming the cabinets may be simply framed and covered with close mesh muslin and given two coats of calcimine to make them airtight. (F. A. Leedy, "Aviation," Nov. 15, 1918.)

Production Problems of Aircraft Bolts, Screws and Nuts.

Superintendent Sheahan gives an account of the special difficulties which attend the manufacture of such small aircraft parts as bolts, screws, and nuts. The average bolt and nut maker, who turns out his products, the bolts by the heading process with rolled threads, and the nuts by the punched method, is warned that he is absolutely unfitted to undertake contracts for small aircraft parts.

A number of the difficulties arise from the fact that the 3-3½ per cent. nickel steel, commonly used in the aeronautical industry, is undoubtedly one of the hardest steels to machine properly, and it is of vital importance that no ring scores circle the bolt, stud, or turnbuckle shank.

Aeroplane constructors generally specify heat treatment of the nickel steel, which increases the tensile strength from 50 to 100 per cent., followed by die sizing of the threaded portions to a basic pitch diameter with a tolerance of 0.002 in. The precautions to be taken in die sizing after heat treatment are mentioned. But the writer does not see why the pieces should not be threaded to the required tolerance before the heat treatment, which, if carried out in the proper manner, can be done without the formation of any scale on the thread, and without any appreciable change in the dimensions of the piece. If this practice were adopted threads of greater strength would be obtained, and there would be a considerable economy in manufacture.

Attention is drawn to the enormous difference in the cost of manufacture of parts made of alloy steel of high tensile strength, and those made of the ordinary carbon steel. Col. R. K. Bagnall Wild's estimate of five times for alloy steel as against carbon steel is quoted, together with the statement that for alloy steel several operations are necessary which are quite overlooked by the manufacturer with experience of only carbon steel, and that the cost of various operations, such as " burring " heads of bolts after machining, is additional to Col. Bagnall Wild's estimate.

Although not simple, the manufacture of bolt nuts is not attended by so many difficulties as in the case of bolts. The tapped size should in no case exceed the basic pitch diameter by more than 0.002 in. in the larger sizes, while 0,005 in. is a liberal enough tolerance for the smallest nuts. The size of tap drill should be chosen so as to give a thread about 75 per cent. of the full depth. This gives a margin of safety of about two to one in favour of the nut not stripping as against the breaking of the bolt. Even a 50 per cent. thread will break the bolt before the thread will strip.

The commercial taps on the market are generally not made to tap to the fine tolerances required, and manufacturers consequently generally make their own taps. Some information on this point is given. Castellation of the nuts may be done by means of a special attachment on the automatics, but it is more quickly done as another operation on other machines.

The methods of gauging bolts and nuts are given; manufacturers are recommended to gauge their bolts on production by " snap " limit gauges, in which the bolt is applied to the gauge and not *vice versa*. The weight of the bolt then decides if it is a " go " or a " not go." (" Aviation," Oct. 15, 1918.)

Sheet Metal Aeroplane Fittings.

Aeroplanes require a large number of metal fittings entailing considerable work. Many are built up of combinations of sheet metal stampings, or of forgings and stampings.

Oxy-acetylene is employed largely for welding the parts together, but some fittings are brazed. A socket for the front upper end of the landing gear strut is shown, consisting of three sheet metal parts, welded together, and a more complicated piece comprising one of the horns that go on top of the wing. A much larger piece is the nosepiece that goes at the front of the fuselage; this is formed out of sheet metal with a large number of openings, the edges of which are bent inwards, and finally the whole sheet is folded in a very complicated manner. The flanging is at present done by hand, but it can be easily seen from the illustrations that the use of dies for bending would reduce the cost if the demand became great enough. (" American Machinist," Oct. 19, 1918.)

Aerial Postal Service.

A trans-Adriatic aerial postal service has been established between Venice and Ancona, and Trieste, Fiume, Porenzo, Zara and Pola. A service will shortly be established between Brindisi and Dalmatia. (" Giornale d'Italia," Nov. 20, 1918.)