PRACTICE AND THEORY OF AVIATION.—IV.*

THE LEADING AEROPLANES.

BY GROVER CLEVELAND LOENING, A.M.

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11. THE BLÉRIOT XII. MONOPLANE.

M. BLÉRIOT has also designed a passenger-carrying type of monoplane, the No. XII, which differs in structure from the No. XI. A type similar in form to the No. XII. is the small No. XIII., with which M. Blériot attained high speed at Rheims in 1909.

On June 12th, 1909, the first flight of an aeroplane carrying three passengers was accomplished by M. Blériot on his large No. XII. The machine has since then become almost as popular as the No. XI., and more than thirty aeroplanes of this type are now in use.

The Frame.—The long central frame of wood braced in every panel by cross wires is very deep at the front and tapers gracefully to a point at the rear.

The Supporting Plane.—On the upper deck of the central frame at the front is placed the main plane, which is continuous and perfectly horizontal. The plane is braced by wires from the frame and its structure is similar to that of the Blériot No. XI. The spread is 30.2 feet, the depth is 7.6 feet, and the surface area is 228 square feet.

The Direction Rudder.—A single surface placed at the rear extremity of the vertical keel is used as the direction rudder. Its area is 9 square feet and it is operated by a foot lever as in No. XI.

The Elevation Rudder.—The elevation rudder consists of a single surface, placed at the extreme rear and 20 square feet in area. It is operated by the front and back motion of the "bell-crank."

Transverse Control.—To preserve the lateral balance the main surfaces are warped inversely by the side to side motion of the "bell-crank," exactly as in No. XI. A small surface under the seat also aids in lateral balancing.

Keels.—A horizontal keel of 21 square feet area is placed on the framework at the rear but somewhat in front of the elevation rudder.

Propulsion.—A 60 horse-power 8-cylinder E. N. V. motor is placed in the frame under the main plane. This motor drives by a chain transmission a single 2-bladed Chauviere propeller, the axis of which is placed on the edge of the main plane. This propeller is 8.8 feet in diameter and 9 feet pitch, and turns at 600 r.p.m.

The Seat or bench for three is placed in the frame under the main plane and back of the motor.

The Mounting is similar to that on No. XI.

The total weight is from 1,150 to 1,300 pounds. The speed is 48 miles per hour; 21 pounds are lifted per horse-power and 5.3 pounds per square foot of surface. The aspect ratio is 4 to 1.

References.—Aerophile, v. 17, pp. 319, 488; Sci. American Supp., v. 68, p. 136; Encyl. Av., v. 1, pp. 72, 92; Flug. Motor

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N° 11
Blériot XII
Monoplane

Scale, of feet

N° 12

Grade Monoplane

Scale $\frac{1}{8}'' = 1'$

Front Elevation

Side Elevation

Plan

Tech., No. 20, p. 18; No. 22, p. 10; La Vie Auto, v. 9, p. 729; Locomocion Aerea, v. 1, p. 28; Aeronautics (Brit.), v. 2, p. 117; L'Automobile, v. 7, p. 520; Genie Civil, v. 55, p. 344.

12. THE GRADE MONOPLANE.

Herr Grade has the distinction of being one of the first German aviators to design and successfully fly an aeroplane. In the fall of 1909 he began flights on his interesting monoplane, and on October 30th, 1909, won the \$10,000 Lantz prize for a German-built machine. Since then Herr Grade has made many excellent flights, and in the recent race meetings at Heliopolis he took a notable part. His machine is simple and flies easily. Many duplicates of this type have already been sold.

The Frame.—The frame consists essentially of a

main metal tube chassis at the front, from which a long thick piece supporting the rudders is run out to the rear.

It is remarkable for its simplicity.

The Supporting Plane.—The main surface is made of Metzeler rubber fabric stretched over a bamboo frame. The surface is very flexible and the two ends are slightly turned up from the center. The curvature is almost the arc of a circle and the surface is very thin. The spread is 30 feet, the depth 7 feet, and the area 208 square feet.

The Direction Rudder.—The direction rudder consists of a single flexible surface of about 16 square feet area, carried at the rear and controlled by a lever operated by the aviator. The surface is not hinged, but is merely bent by the controlling wires in the desired way.

The Elevation Rudder.—The elevation rudder consists also of a single flexible surface placed at the rear. Its area is about 20 square feet and it is operated by a large lever universally pivoted on the frame above the aviator. To rise, this lever is pulled up, and to descend, it is pushed down, thus respectively bending up and bending down the rear horizontal surface.

Transverse Control.—The transverse control is effected by warping the main surfaces. This is accomplished through wires leading from the large lever. Side to side motion of this lever warps the surfaces inversely. Thus if the machine tips down on the right, the lever is moved over to the left, thus raising the depressed side and depressing the elevated side.

Keels.—The tapering ends of both the direction and elevation rudders can be considered as keels. An additional vertical keel is placed in front, both above and below the main surface.

Propulsion.—A 4-cylinder 24 horse-power V-shaped motor is placed at the front edge of the plane. It drives direct at 1,000 r.p.m. a 2-bladed metal propeller 6 feet in diameter and 4 feet pitch.

The Seat is placed under the plane, and consists of a hammock-like piece of cloth which gives great comfort and little weight.

The Mounting is on two wheels at the front and one smaller one at the rear. There are no springs provided whatsoever on the chassis. The front wheels are fitted with a brake to bring the machine to a stop shortly after landing.

The total weight is from 350 to 450 pounds. The speed is approximately 44 miles per hour; 17 pounds are lifted per horse-power and 1.9 pounds per square foot of surface. The aspect ratio is 3.2 to 1.

References.—SCI. AMERICAN, v. 101, p. 292; Aerophile, v. 17, pp. 439, 508; Zeit. für Luftschiff, v. 13, pp. 802, 957;

The Mounting is mainly on a large single wheel with an oleo-pneumatic spring in the center at the front and a smaller one in the same center line at the rear. When first starting the aeroplane is inclined, resting on one end of the plane, on each end of which also a wheel is placed.

This aeroplane is a distinct departure from all other monoplanes in the placing of the motor, aviator, and rudders, and in the comparatively simple and efficient method of transverse control by sliding surfaces, applied here for the first time.

The Frame.—The framework is largely a combination of numerous king-post trusses with spruce compression members and wire tension members. The framework is open throughout, thus enabling quick inspection and easy repairs. The chassis at the center is mainly of steel tubing.

The Supporting Plane.—The main supporting plane at a 5-deg. dihedral angle consists of two main beams across which are placed spruce ribs. The surface is made of Baldwin vulcanized silk, of jet black color, tacked to the top of the ribs and laced to the frame. The curvature of the surface is slight and is designed for high speed. The spread is 31 feet, the depth 6 feet, and the surface area 186 square feet.

The Direction Rudder.—The direction rudder, a rectangular surface, is placed at the front and has an area of 6 square feet. It is operated by wires leading to the bracket underneath the controlling column. By turning this column to either side the aeroplane turns to that side.

The Elevation Rudder.—The elevation rudder consists of a single surface 17 square feet in area placed also at the front. It is operated by wires leading to the lever at the side of the controlling column. By moving this column forward or backward, the elevation rudder is caused to turn down and turn up respectively.

Transverse Control.—The framework of the main surface is carried out 30 inches on either end of the surface, and affords a place for the rail upon which the auxiliary sliding surfaces move. These sliding surfaces, or "equalizers" are each $12\frac{1}{2}$ square feet in area, and when normal project 15 inches beyond the end of the surface on either side. They are connected by a wire to each other, and a long cable running to each end through a pulley connects them to the steering wheel. The control is then as follows: If the right end of the aeroplane is tipped down the wheel supported on the controlling column is turned away from the lowered side. This causes the equalizer on the raised end to be pulled in under the main surface, while at the same time the one on the other end is pulled out. This action merely decreases the supporting surface on the raised end and increases that on the lowered end, thus righting the machine.

Keels.—A horizontal surface placed at the rear acts as a longitudinal stabilizer. It is 10.5 square feet in area, and is fixed firmly to the supporting framework, 10 feet in the rear of the main surface.

Propulsion.—A 25 horse-power Curtiss 4-cylinder motor is placed on the framework above the plane and at the rear of it. The motor drives direct a 2-bladed wooden propeller 6 feet in diameter and 4.5 feet pitch at 1,200 r.p.m. The propeller is of original design and said to be very efficient.

N° 13

Pelterie Monoplane

Aero, v. 1, p. 405; Motor Car Jour., v. 2, p. 794; La Vie Auto, v. 9, p. 711; Zeit. Ver. Deut. Ing., v. 53, p. 1762.

13. THE PELTERIE MONOPLANE.

The Pelterie monoplane is considered by many to be one of the most perfect types of aeroplanes. Great finish is exhibited in its construction and form, but due probably to motor troubles it has never been flown for any great length of time. M. Pelterie, the designer, is one of the foremost aviation scientists abroad, and previous to his experience with this machine he conducted a series of gliding experiments of great interest. M. Guffroy, as well as M. Pelterie, has flown this type several times.

The Frame.—The central frame, somewhat similar in shape to a bird's body, is made largely of steel tubing, and is quite short. All exposed parts are covered with Continental cloth.

The Supporting Plane.—The main surface is particularly strong and solid, and is made of steel tubing carrying wooden ribs covered with Continental cloth. The curvature is very similar to that of a bird's wing, and transversely the surface curves downward dihedrally from the center. There is very little bracing necessary. The spread is 35 feet, the depth 6.1 feet, and the area 214 square feet.

The Direction Rudder.—The rudder for steering from side to side consists of a vertical rectangular surface of 8 square feet area, placed below the central frame at the rear. It is operated by the side to side motion of the lever at the aviator's right hand. To turn to any side the lever is inclined to that side.

The Elevation Control.—There is no elevation rudder in the Pelterie monoplane, the elevation of the machine being regulated by changing the incidence of the main plane itself. To ascend, for example, the aviator pulls the lever in his left hand toward him. This increases the incident angle of the plane and the consequent increase of lift causes the machine to rise.

Transverse Control.—Each half of the main plane is warpage about its base, and transverse equilibrium is obtained by an inverse warping of the plane. The side to side motion of the left-hand lever controls the warping. If the machine is tipped down on the right end the lever is moved to the left and the machine brought back to an even keel. In turning to either side both the left-hand lever controlling the warping and the right-hand lever controlling the direction rudder are simultaneously moved to that side. This is a very effective controlling system.

Keels.—Vertical and horizontal keels, consisting of gradually tapering surfaces, are fixed to the frame and aid in preserving stability. The rear horizontal keel, shaped like a bird's tail, has an area of 20 square feet.

Propulsion.—A 7-cylinder 35 horse-power R.E.P. motor, placed at the front, drives direct a four-bladed aluminium and steel propeller at 900 r.p.m. The diameter of the propeller is 6.6 feet, and the pitch 5 feet.

The Seat is placed in the frame, and protected on all sides. The aviator's shoulders are flush with the surface.

The total weight is from 900 to 970 pounds. The speed is 39 miles per hour; 27 pounds are lifted per horse-power, and 4.4 pounds carried per square foot of surface. The aspect ratio is 5.75 to 1.

References.—Soc. des Ing. Civ., v. 2 (1908), p. 13; Boll. Soc. Aer. Ital., v. 6, pp. 67, 288; Aerophile, v. 15, p. 331; v. 16, p. 226; v. 17, p. 33; Flight, v. 1, pp. 19, 360; Aeronautical Jour., v. 13, p. 64; Zeit. für Luftschiff, v. 12, p. 458; Aeronautics, v. 4, p. 21; La France Aérienne, v. 14, Nos. 7, 9; Zeit. Ver. Deut. Ing., v. 53, p. 1760; Genie Civil, v. 55, p. 346.

14. THE PFITZNER MONOPLANE.

In the early part of January, 1910, the remarkable monoplane designed by Mr. A. L. Pfitzner and built at the Curtiss aeroplane factory at Hammondsport, N. Y., was completed and flown. The first flights were short, due largely to the inexperience of the aviator, Mr. Pfitzner, but the monoplane is considered by many to be a very promising type.

N° 14

Pfitzner Monoplane

The *Seat* for the aviator is placed out in front of the main plane and directly in the center line.

The *Mounting* is on four small rubber-tired wheels, placed at the lower ends of the four main vertical posts of the chassis. The wheels are not mounted on springs.

They are spaced by steel tubing and are fitted with brakes.

The total weight in flight is from 560 to 600 pounds. The speed is estimated at 42 miles per hour; 24 pounds are lifted per horse-power, and 3.2 pounds car-

ried per square foot of surface. The aspect ratio is 5.17 to 1.

References.—Aeronautics, v. 6, p. 53, February, 1910; v. 6, p. 82, March, 1910.

(To be continued.)

HIGH-FREQUENCY MEASUREMENTS.

APPARATUS FOR DETERMINATION OF CONSTANTS.

THE periods and wave-lengths of the electrical circuits employed in wireless telegraphy are usually determined by measuring the maximum deflection of a galvanometer needle. Zero methods are preferred for most physical determinations, as they are generally more sensitive and exact than methods which require the actual measurement of deflections. Braun and his pupils endeavored, long ago, to apply the zero method to high-frequency measurements. In a recent issue of the *Physikalische Zeitschrift*, L. Kann describes an apparatus devised for the determination of the constants of oscillatory electric circuits by the zero method. Fig. 1 shows an exterior view of the apparatus.

In order to understand the principle of its operation, it must be recalled that in the case of resonance or unison of a primary and a secondary circuit (Fig. 2) there is a difference of phase, amounting to $\pi/2$, or one-quarter period, between the inducing and induced currents. In these conditions, if the primary current is represented by the formula $a = A \sin nt$, where n is the frequency, t the time, and A the amplitude, or maximum value of the primary current, the induced current may be represented by the formula $b = B \cos nt$, where B is the amplitude of the induced current, and the sum of the two currents may be represented

A, B, C, p , and n are constants, and the equation is true for all values of t . By putting nt equal successively to 0 and to $\pi/2$, we find, $C \sin p = B$, and $C \cos p = A$. Hence $C^2 = A^2 + B^2$.

Now, the heating effect of an undulatory current is

FIG. 2.

proportional to the square of its amplitude. Hence the equation $C^2 = A^2 + B^2$ expresses the fact that in the case of resonance the aggregate heating effect of the primary current and its induced current is the same, whether the two currents flow together through a coil of given resistance, R , or separately through two coils, each of resistance R .

Conversely, the equality of the heating effects proves that the two currents differ in phase by one-quarter period and, consequently, that the two circuits have exactly equal periods of oscillation.

In the apparatus here described, the heating effects are produced, not by the currents of the two open condenser circuits which are to be compared, but by currents which are induced by these in two closed aperiodic circuits, and which are proportional respectively to the amplitudes of the currents of the primary and secondary condenser circuits.

Thus, the current J_1 of the primary condenser circuit (Fig. 3) which induces the current J_2 in the secondary condenser circuit, simultaneously induces the current i_1 in the closed circuit I_1 and the current J_2 induces the current i_2 in the closed circuit I_2 .

The closed circuits I_1 and I_2 are connected with four similar heating coils in such a manner that the first coil receives the sum of the currents, $i_1 + i_2$, the second coil the current i_1 , and the third coil the current i_2 , while no current flows through the fourth coil, which is added only for symmetry.

The first and fourth coils are inclosed in one bulb

K_1 , the second and third coils in the other bulb K_2 , of a differential air thermometer. The bulbs are connected by the capillary tube k , which has at its ends two small bulbs SS , which are connected by a tube provided with a stop-cock H , for the purpose of equalizing the air pressure in the two large bulbs. The bent capillary tube contains a short thread of mercury or other liquid a , which serves as an index, and stands exactly in the middle of the tube when the temperature of the air in the two bulbs is the same. As one bulb is heated by the currents i_1 and i_2 , acting separately, and the other by their sum, $i_1 + i_2$, flowing through a single coil, the equality of temperature indicates that the square of the sum of the amplitudes of these currents is equal to the sum of their squares. A similar relation exists between the amplitudes of the currents in the two condenser circuits and, therefore, these circuits have the same period of oscillation.

In using the apparatus, the circuit of which the period is to be measured is made the primary circuit. The secondary circuit is provided with an adjustable condenser, and its period is known for every value of

FIG. 3.

its capacity, which is altered until the index of the thermometer is brought to the zero mark. The apparatus can also be employed for the measurement of self-induction, capacity, and damping of oscillations.—Prometheus.

THE ULTRA-RAPID CINEMATOGRAPH.

By C. V. BOYS.

A RECENT number of *La Nature* contains a very interesting account of the latest work of the Marey Institute. By means of the new instrument, the ultra-rapid cinematograph invented by M. Bull, sharp stereoscopic cinematograph views may be obtained of such extremely rapid movements as, for instance, the flight of a fly or the breaking of a soap bubble. With the ordinary cinematograph the photographic film moves discontinuously, being arrested at the moment of each exposure. While this is simple enough at moderate speeds, it would be quite impossible where the exposures are at the rate of 2,000 a second, and the mean speed of the film 4,000 centimeters (1,575 inches) a second. These are the figures that are necessary for the study of insect flight, and these are attained in the new instrument. With such a speed the movement of the film must be continuous, and a sharp image is possible only if the exposure does not exceed 1/400,000 second, and for this the electric spark gives a light of sufficiently short duration.

The apparatus is shown diagrammatically in the figure. R is a wheel 34.5 centimeters (13.6 inches) in diameter, which may be turned at a high speed by means of an electric motor. It carries two long strips of photographic film to receive the stereoscopic images. On the same axis, but outside the octagonal light-proof case, is fastened an interrupter, I , of fifty-four strips of copper, which serve to make and break the primary circuit of an induction coil fifty-four times every turn, or 2,000 times a second. The secondary of the induction coil is connected with a pair of spark-gaps, E , arranged in series, the electrodes being of magnesium to increase the light. The arrangement of the two gaps and their relation to the optical system are shown in plan (left for right) in the upper left-hand corner of the figure. A condenser, L , is connected to the wires leading to the spark-gaps. The optical system is made

clear by the figure, but the lenses are made of quartz and Iceland spar instead of glass, so as to be transparent to the actinic rays of short wave-length for which glass is opaque. A mirror, M , throws the pair of images on a ground-glass screen, N , or, on being turned up out of the way, it leaves a clear passage for them to be formed on the films. In order to prevent the photographs from being spoiled by multiple exposure, two shutters of thin steel, actuated by springs, are released electromagnetically one after the other, the interval being the duration of one turn of the wheel.

The movements photographed are determined as to time by fine wire prolongations of the prongs of a tuning-fork of 50 waves a second, which are photographed at each successive exposure, and as to distance by a divided glass scale, which equally appears in every picture. It is, of course, necessary to insure

THE ULTRA-RAPID CINEMATOGRAPH.

that the fly or other insect shall traverse the field of view just at the time that exposure is made. There is no difficulty in causing the creature to fly in the right direction, as a window is sufficient to determine the line of flight. One method by which M. Bull releases the fly at the right moment is by holding it in electromagnetically-operated forceps, which are relaxed by the same current which starts the first shutter. This works well enough with ordinary flies, but hymen-

optera and some other insects hesitate and only make their flight after the exposure is completed. For such cases, M. Bull incloses them in a glass tube with a very light mica door, which is moved by the insect in its flight, and which, making a contact, sets the shutter mechanism in action.

In order to study the movements represented on the films, which in nature are far too rapid to be followed by the eye, it is merely necessary to pass them through an ordinary cinematograph, making some fifteen exposures a second instead of the 1,500 or 2,000 a second employed in taking the photograph, and then the movement, 100 or more times as slow, will be seen, and in many cases easily followed. Where a still greater slowing is required, M. Bull arranges to make the film appear stationary for a much larger proportion of the whole interval than is usual, and then only two or three views a second are sufficient to give an apparently continuous movement.—Nature.

E. Stephan describes in *Beton u. Eisen* an investigation of the cause of failure of the concrete covering of some sewage tanks. Although in the sewage-water a strong smell of hydrogen sulphide was perceptible, no trace of this compound could be detected in the atmosphere of the sewage tanks, which was also free from sulphur trioxide, but contained carbon dioxide. The outer layers of the defective concrete were so soft that they could readily be removed by a powerful jet of water; the firm concrete beneath was of a brownish tint. A considerable portion of the lime in the decomposed concrete was in the form of calcium sulphate, but small quantities of calcium hydrogen sulphide were also present, indicating that the decomposition was caused by hydrogen sulphide, the calcium sulphide formed at first becoming ultimately converted into sulphate. Stephan recommends the application of a coating of tar to the concrete after the latter has hardened to some extent and is thoroughly dry.