TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 724

THE 1933 CONTEST FOR THE DEUTSCH DE LA MEURTHE TROPHY

AIRPLANES PARTICIPATING IN THE CONTEST

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L'Aéronautique, July and August 1933

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AIRPLANES PARTICIPATING IN THE 1933 CONTEST FOR THE DEUTSCH DE LA MEURTHE TROPHY

By Pierre Léglise

The essential regulations of the 1933 Deutsch de la Meurthe contest were: a maximum piston displacement of 8 liters (488 cubic inches); length of course, 2,000 kilometers (1,242.7 miles); obligatory stop of 1 hour 30 minutes after 1,000 kilometers (621.4 miles); stops permitted, but length of stops not to be deducted in calculating the mean speed. These broad limits and the liberty allowed the designers led to very happy results. New airplanes and engines were elaborated in less than a year or even six months in some cases.

The time seemed to be too short for putting on the finishing touches in certain cases, thus making the contest less severe for the remaining airplanes. Only the productions of Potez-Potez and Caudron-Renault remained, which were well adapted to the purpose and led to methodical investigations in a direction that is rather new in France.

INTRODUCTION

The airplanes were made of wood (excepting, of course, the fittings, engine bearers, landing gears, etc.). There was one notable exception, the "Kellner-Béchereau," which was all metal and which constituted a study for a pursuit airplane. Preference was given wood for airplanes to be made quickly in small lots. The wings were cantilever (except the "Farman-Renault," which was braced externally) with plywood coverings. Their relative thickness at the root was small, being only 12.8 percent of the chord in the "Caudron 360."

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*L'Aéronautique, July (pp. 150-158), and August (pp. 175-184), 1933.

Structural drag was largely eliminated. The landing gears received particular attention. There were retractable landing gears (Potez and Kellner-Béchereau); landing gears with only one wheel, retractable or fixed, and wing skids (Farman); and a landing gear with only one very thin streamline strut (Caudron).

Other parts were also visibly refined: inside controls, enclosed cockpits, streamline windshields, engine cowlings with minimum louvers, and wing connections developed from wind-tunnel tests (Potez, Kellner-Béchereau). The desirable reduction in the wing area led certain contestants to seek high lift by means of flaps (Caudron) or ailerons (Potez). The following descriptions will indicate the new features of each airplane.

The take-offs were generally difficult, sometimes even agonizing. This was doubtless due more to the poor functioning of the propellers, adapted to speeds of 300 km/h (186.4 mi./hr.) or more, than to the reduction in the wing area. Moreover, in our opinion, the necessity of using wheels of small diameter which alone can find room enough in wings of 3 to 4 m^2 (32.3 to 43.1 sq.ft.) (the wheels of the Béchereau, for example, would have been obliged to lodge in the connections at the leading edge of the fuselage) did not facilitate the take-offs.

Deutsch Trophy Airplanes of the Future

Where can improvements be made for future Deutsch de la Meurthe contests? We think they will be made first in the retractable landing gear and then in the variable-pitch propeller, preferably automatic. The search must next be directed to high-lift systems.

Let us assume that, due to reduction in the weight of the engines, the speed range can be raised to 4 on the average, and that a maximum speed of 500 km/h (310 mi./hr.) will soon be attained at the price of a landing speed of only about 120 km/h (75 mi./hr.). If the problem of the high-lift airplane has been thus far avoided, it will come up again at higher speeds. The nature of the contest will necessarily lead to airplanes of variable polar. Here the three fields of investigation will reappear: camber, angle of attack, area.

For the present we will say nothing of the area. Previous tests are doubtless rather deceptive, because the increases in the area have been small or even insignificant. At present only the variation in the camber, by means of flaps has been utilized. It appears that the Zap and Fowler systems here have new possibilities, still but little known to us.

The variable angle of attack, by rotation of the engine group, coordinated, automatically or not, with the adjustment of the stabilizer, would seem to have a future and not be very complicated mechanically. In this connection a number of patents have already been taken out. The ones by Caudron and Levasseur, in particular, have been analyzed in this magazine. It has been studied by the Italian engineer Pegna and the Bernard firm. Moreover, nothing prevents requiring of the propeller a direct lift component and a buffer effect of the oblique air current during the whole take-off. This assumes, of course, the use of a controllable-pitch propeller capable of producing a considerable thrust at low speed. Such a system would involve the running of risks in landing in case of engine failure.

Thus there probably exist, in the matter of speed, some untried ways whose exploration may lead to useful results. It is gratifying to see our institutions of research taking up their investigation.

THE POTEZ 53, WINNER OF THE CONTEST

Aerodynamics

The Potez 53 was the object of very thorough wind-tunnel investigation with the almost complete elimination of interferences (figs. 1, 2, and 3). The drags were estimated as follows:

Wing,	34 percent
Fuselage with cowled engine,	39 "
Tail surfaces,	9 "
Misc. (oil radiator, interstices, roughnesses, etc.,	6 "

Increase due to slipstream, 12 percent

The complete airplane, in the wind tunnel, had a $C_{x\ min}$ of 2.15. It is obtained by transformal conformation and conserves interesting characteristics for all the relative thicknesses between 6 and 22 percent. (See polars.) The wing is tapered. The profile at the root is the P.9 with a relative thickness of 18 percent and the same profile at the tip reduced to the relative thickness of 5 percent. The angle of setting is uniform throughout the span.

Construction

The low cantilever wing consists of two half-wings joined to a central part integral with the fuselage. The half-wings are attached by special fittings with conical nuts which eliminate all play and do not project beyond the surface. Box spars, spruce ribs, and plywood covering. The wing-fuselage junction is filleted. The fillets, of which two different kinds were used on the contesting airplanes, increased the lift 12 percent as compared with wings without fillets. Fuselage of circular section in front and ovoid at the rear; spruce frame with plywood covering; retractable landing gear, increasing the speed about 40 km/h (about 25 mi./hr.).

The engine is a Potez 9 B 310 hp. with supercharger and annular cowl; a single fuel tank of 320 liters (84.5 gallons); oil tank forward in a special, well-ventilated compartment.

The Potez 53 of Détré won the trophy at the speed of 322.8 km/h (200.6 mi./hr.). Lemoine lost sight of the course for an instant, due to projections of oil, and went astray. After recovering it, he made one lap at the very high speed of 356 km/h (221.21 mi./hr.), but the rupture of an oil pipe compelled him to drop out during the fifth lap.

The attack of Potez on the double problem of the airplane and the engine group attained well-merited success. The perfectly designed Potez 53 lifted with relative ease the load of fuel required for the first 1,000 km (621.4 miles). The course was flown with great regularity by Détré, who gave the impression of sparing his airplane.

Legends with Detailed Descriptions

FIGURE 1.- The Potez 53 airplane. (Note: The position of the landing gear, as sketched by the writer, may not be exact.)

Characteristics

Span	6.65 m	21.82 ft.
Length	5.40 "	17.72 "
Height	1.80 "	5.91 "
Wing area	7.20 m^2	77.50 sq.ft.
Weight without fuel	600 kg	1,322.77 lb.
Gross weight	900 "	1,984.16 "

FIGURE 2.- Three-quarter front view of the Potez 53 with 310 hp. Potez 9B engine.

FIGURE 3.- Three-quarter rear view of the Potez 53.

FIGURE 4.- Longitudinal section of the Potez 53 airplane. P, air inlet of supercharger; R, oil radiator; r, wheels on which are wound the cables which raise the landing gear; L, mechanism which, operated by wheel V, simultaneously deflects the ailerons in the same direction; M, control stick; P, instrument board; p, parachute. All controls are rigid and no part projects beyond the covering. Pilot's cockpit is behind wing. The windshield is prolonged forward and can be detached to enable use of parachute, which is also facilitated by a handle on the fuselage.

FIGURE 5.- Tests of complete models differently equipped.

FIGURE 6.- Characteristic curves, for aspect ratio 5, of Potez P9 wing section.

The effect of the various combinations of the factors defined on the left is indicated on the right.

Drag Elements of Airplane	Test Results (fig. 5)	
a, landing gear retracted	----------	induced polar.
b, landing gear let down	– – – –	wing alone.
c, with wing-fuselage fillet	————	solution A (a,c,e,g).
d, without wing-fuselage fillet	—— - ——	" B (b,c,f,g).
e, pilot's cockpit covered	—— -- ——	" C (a,d,e,g).
f, pilot's cockpit open	○	" D (a,c,f,g).
g, with inner fairing of wheel	△	" E (a,c,e,h).
h, without inner fairing of wheel	▽	" F (a,d,f,g).

Solution A (i.e., landing gear retracted, wing joined to fuselage by fillet, cockpit covered and wheels faired) was chosen for the Potez 53. The gain in the $C_{x\,min}$ over solution B, which differs from A by the landing gear being down and the cockpit uncovered, is more than 4 percent. The increase in $C_{z\,max}$ with respect to solution C, which differs from solution A only by the absence of wing-fuselage fillet, is about 12 percent.

FIGURE 6, which gives the polar, the fineness ratio, and the C_m curves for two relative thicknesses (12 and 20 percent) of the wing section P9, shows that $C_{z\,max}$ decreases simultaneously with the relative thickness e, and that the fineness ratio increases when e decreases.

FIGURE 7.- Aileron control.

<u>Operated as ailerons</u>.- If the wheel V is not touched, the articulations a are fixed with respect to the case C, and the motions of the stick act directly on the case and consequently on the whole control system.

Operation as flaps.- The wheel V operates a pair of bevel gears c by means of a long shaft inside the tube, at the ends of which are mounted the control stick and the case C. The rotation of V moves a nut e, on a screw v. The rods T, going to the ailerons, are attached at a to a sort of deformable quadrangle, the sides of which (b and T') are, respectively, hinged to the case C and to the nut e. When, for example, e is raised toward the top of the case by the distance AB, b and T' approach each other, and the joints a are thrust outward by the distance l, thus simultaneously deflecting both ailerons in the same direction.

FIGURE 8.- Landing gear of Potez 53 in various phases of retraction.

It is seen that when the landing gear is retracted, the inner fairings of the wheels form two quite large bosses on the lower side of the wing. According to tests made by the Potez Company, such bosses on the lower side of the wing have but little effect. This fact is confirmed, moreover, by what is known of certain American airplanes whose landing gears are not entirely concealed in the wings (notably the Boeing "Monomail").

At Étampes-Mondésir, before the designer of the airplane, we expressed the opinion that the retracting parts on the landing-gear struts might increase the take-off time, as they present a very large angle of attack to the relative wind.

Since then, the Potez Company has called our attention to the fact that the take-off distance is essentially a function of the propeller thrust and hence of the propeller diameter. It was noted, in fact, that Détré, with his Potez 53 No. 10, equipped with a propeller of larger diameter than the No. 12, took off each time with a full load of fuel just as well as, if not better than, the other contestants, who carried only half a load of fuel.

FIGURE 9.- One of the two kinds of joints between the wing and fuselage on the Potez 53.

FIGURE 10.- Left, articulation of landing gear; right, air inlet and oil radiator.

FIGURE 11.- Retractable landing gear of Potez 53 with Messier shock absorbers. Upper left: diagram of extended

landing gear as seen from the front. Upper right: front and plan views of landing gear folded in the wing. Middle left: diagram showing forward displacement of wheel in lowering. Bottom: details of socket C and of lug O for attaching cable c.

The retractable landing gear of the Potez 53 is installed in such a way that, in the extended position, the center of each wheel advances a distance d with respect to its position in the wing. The retracting mechanism adds only about 6 kg (13.2 lb.) to the weight of the landing gear.

The strut J, which carries the fork and the Messier shock absorber, is hinged by means of a lug C to a sleeve B. This sleeve can itself slide and turn on a fixed tube T mounted behind the front spar. Around B there turns a ring a, on which a lug O serves as attachment for the operating cable c, The latter is actuated by the gears R, controlled by the pilot. J is held by a V-strut, the apex of which is hinged to J by a sort of universal joint A and the opposite ends to the bottom of the fuselage following an axis XX. The projections of XX form the angles α and β with the horizontal and vertical, respectively, in such a way that all the axes converge toward the rear and diverge toward the front. It is these inclinations that make it possible to advance the wheels sufficiently, when lowered, with respect to the center of gravity, while insuring their proper lodgment between the two spars, when retracted.

THE "CAUDRON 360", WINNER OF SECOND PLACE
(figs. 12, 13, and 14)

Aerodynamics

A low-wing monoplane; tapered wing with rounded tips; aspect ratio, 6.6; taper, 40 percent. Symmetrical biconvex profile set at +2°; top of wing, straight. The profile undergoes a triple evolution along the span: reduction of the chord from 1.5 m (4.92 ft.) at the root to 0.6 m (1.97 ft.) at the tip; reduction of the relative thickness from 12.8 percent at the root to 6.4 percent at the tip; relative increase in the radius of curvature of the leading edge toward the tip. Mr. Riffard thinks the third artifice contributes greatly to the fineness of the wing.

100 $C_{x\,min}$ of wing alone (model), 0.8; 100 C_x of the landing gear (model), 0.4; 100 $C_{x\,min}$ of airplane complete (model), 1.77; drag (calculated) due to cooling of engine, 100 C_x = 0.43. Total drag of airplane used in calculating its performances, 100 C_x = 2.2. The transverse position of the wing opposite the fuselage with faces parallel at the line of junction eliminates the interference between the wing and fuselage. The wing had trailing-edge flaps with a chord equal to 30 percent of the wing chord. These flaps made it possible to increase the $C_{z\,max}$ about 30 percent. A double flap could have raised the increase to 37 percent, but the device, after being tested in the wind tunnel, was not retained, due to complication of the construction for a relative benefit which was considered inadequate. The control of the flaps was combined with that of the stabilizer. (See description of "Superphalène", L'Aéronautique, no. 163, p. 380, December 1932.)

Construction

Wing.- A single-piece box spar with laminated spruce flanges and birch plywood webs. All the calculations were made on the basis of the single spar, but the auxiliary spar to which the ailerons are hinged nearly doubles the strength. Wooden ribs with plain webs every 15 cm (about 5.9 in.); 2 mm (0.08 in.) birch plywood covering, covered with glued fabric and well varnished. (Doubtless 3 mm (0.12 in.) okoumé plywood would be preferable. It has the same weight and greater strength.) The ailerons, balanced both statically and dynamically, are mounted on ball bearings. The total wing area of the "Caudron 360" is only 7 m² (75.3 sq.ft.). If the portion concealed in the fuselage, 1.06 m² (11.4 sq.ft.), is deducted, the useful area is found to be only 2.97 m² (32 sq.ft.) for each half-wing. If the Caudron bureau of research were to rebuild the airplane, we believe it would reduce the wing setting by a fraction of a degree (C_x varies but little in the vicinity of $C_{x\,min}$) and would offset the corresponding reduction of C_z by an increase in the wing area. Take-off and landing would thus be facilitated.

Fuselage.- Straight sides, circular top and elliptical bottom. The side girders each consists of a wooden lattice enclosing two plywood webs. The assemblage of these girders at the sternpost suffices to give them the correct contour. They are hollow at the bottom to receive the wing spar which is attached to each of them by two strong bolts.

The three "Caudron 360" airplanes made for the contest were to be equipped with Regnier 210 hp. 6-cylinder engines ("Caudron 366"), but, for lack of time, 165 hp. Renault Bengali engines ("Caudron 362") were installed without modifying the airplanes. As a result, the airplanes were a little too bulky and heavy for their power. It would have been possible to save about 40 kg (88.2 lb.) and increase the speed by a better adaptation of the airplane to the engine used. The engine bed, in particular, was longer than necessary for the four cylinders of the Bengali.

The first "Caudron 362" (figs. 20 and 21) was destroyed in a fatal accident (fluttering of throttle valves due to loosening of bolt in control system). The spring, which was designed to keep these valves open in case of failure of the control lever (it being always possible to stop the engine by means of the magneto contacts) failed to function, probably because insecurely attached by a careless mechanic. The second "Caudron 362" broke its landing gear in taking off during a test.

Only Delmotte's airplane was able to participate in the contest. The average speed for the 2,000 km (1,243 mi.), deducting stops (Delmotte refueled every 500 km (311 mi.), was 317.04 km/h (197 mi./hr.); actual mean speed, 291.5 km/h (181.14 mi./hr.). The average speed was lower in the second half than in the first, the last 800 km (497 mi.) being flown with 225 r.p.m. less of the engine (magneto and valve spring), i.e., at 125 instead of 165 hp. Normally the pilot would have been able to increase the speed to 340 km/h (211.3 mi./hr.) during the last 1,000 km (621.4 mi.). The landing was as fine as the take-off; no projection of oil nor trace of the exhaust tarnished its surface.

The performance of the "Caudron 360" was very remarkable. This airplane, equipped with an engine of some 200 hp., should easily attain 400 km/h (about 248.5 mi./hr.). It would then have a gross weight of 755 kg (1,664.5 lb.), a weight empty of 475 kg (1,047.2 lb.) and a power loading of 3.5 kg/hp (7.7 lb./hp.).

The Caudron Company intends to install a wing of 9 m^2

(about 96.88 sq.ft.), with a lifting section about 20 percent better than the one used in the contest on one of its "C.360". Equipped with a Renault Bengali, with a compression ratio of 10, underfed on the ground, the airplane will try to beat the altitude record for monoplanes of less than 450 kg (992 lb.) weight empty. It should reach 10,500 m (about 34,450 ft.).

Intercity records of 300 km/h (186 mi./hr.) will be attempted with the second airplane equipped with a Ratier automatic variable-pitch propeller, which will increase the thrust 90 percent in taking off. With this propeller and trailing-edge flaps, of which Delmotte made no use in the contest take-offs, it should be possible to carry sufficient fuel for a flight of about 2,500 km (about 1,550 miles).

FIGURE 12, "Caudron 360".- Note the single landing-gear struts. It would seem impossible to conceive of a landing gear with less head resistance.

Characteristics

Span	6.80	m	22.31	ft.
Length	6.87	"	22.54	"
Height	1.88	"	6.17	"
Wing area	7	m^2	75.35	sq.ft.
Weight empty	405	kg	892.87	lb.
Grossweight	695	"	1,532.21	"

Legends with Detailed Descriptions

FIGURE 13.- Delmotte's "Caudron 360" in line of flight.

FIGURE 14.- Delmotte's "Caudron 360" refueling.

FIGURE 15.- Elements of landing gear for "Caudron 360" designed by Charlestop Company in collaboration with Caudron Company. The shock-absorbing struts end at top in a cardan attachment and at the bottom in a disk which is

bolted to the fork. The square sleeves are held at the top between fittings integral with the spar. Charlestop balloon tires 500 by 150 mm (19.68 by 5.90 in.) with magnesium fairings.

FIGURE 16.- Attachment of spar to fuselage in "C.360". At left, section parallel to plane of symmetry of airplane; in center, transverse view; at right, plan view. The spar penetrates grooves made in bottom of each side of fuselage. At the right of the attachments, it is first encircled by a distribution band of duralumin 1.25 mm (.05 in.) thick secured by wood screws 3 by 16 mm (.12 by .63 in.). Since the spar flanges are not parallel, walnut blocks are interposed between them and the band. (See central figure.) On the front and rear surfaces of the spar, and therefore above the band, there are secured, by wood screws 4 by 20 mm (.16 by .79 in.) two strong plates F of 3.2 mm (.126 in.) duralumin. These plates are reinforced by riveted strips B and drilled to receive the bolts b. The wing is joined to the fuselage by the four bolts b, each ending in a socket O, in which the nut can be turned. Threaded duralumin rods T of 6 mm, join the fittings F in pairs through strong transverse frames. They absorb the small eccentric moment which is exerted on the strips B. Of course the holes in the sides of the fuselage are reinforced by fittings, F' above and f below, the latter being cross-braced after the spar is mounted. On the plan view it is seen that the thickness of the webs decreasees toward the interior of the fuselage. This is natural, since the fixation is situated in the plane of the lateral girders. This method of attaching the spar to the fuselage is entirely new. It has the following advantages: elimination of the exterior fittings (which might dispense with all connection fairing) and direct transmission of the stresses, without eccentricity, in the median plane of the elements which must absorb them.

FIGURE 17.- Controls of the "Caudron 360".

Flap control.- This control is represented by fine lines, chiefly in the upper part of the drawing. The wheel V turns the screw v which rotates the shaft A. The rods T (only one being visible on the longitudinal view) actuate the rods ending at R, the flaps being controlled directly from R at the end of their axis of articulation. The axis of the wing passes through the center of R, the section being symmetrically beconvex. The axis of the flap is on the line of zero lift. The actuation of A by v occurs very near the right-hand end of this shaft. The portion of A involved in the control of the right-hand flap is therefore very small and there is therefore no torsional effect. On the contrary, the remaining portion, which covers practically the whole width of the fuselage, acquires considerable torsion, resulting in a slight retardation in the deflection of the left-hand flap, with respect to the right-hand flap. It is found that this difference automatically offsets the engine moment, thus making it possible to mount the fin exactly in the plane of symmetry of the airplane. As in the "Superphalène", the stabilizer is adjusted to the deflection of the flaps, thus increasing the stability. The sleeve m makes it possible to throw out of gear the rods connecting the stabilizer to the wheel V. The control c makes it possible, by milled nuts, to give the stabilizer the desired initial adjustment.

Elevator control.- This is perfectly rigid and is indicated on the diagram by dot hatching.

Aileron control.- Rigid in fuselage; transmission by piano wires in wing. The small diagram, corresponding to a transverse view, shows exactly to point of attachment of a piano wire. (See also internal aileron control in figure 18.) Motion of sleeve, ±25 percent.

Rudder control.- Rudder bar P actuates, by 2.5 mm (.098 in.) double piano wires passing under the fuselage, a vertical shaft A_d mounted on the rear side of a fuselage frame. This shaft transmits the rotation to a pair of 2.5 mm piano wires, doubled, situated in the upper part of the fuselage.

FIGURE 18.- Structural details of the "Caudron 360".

In the center.- Landing-gear strut or leg and transmission of controls (at bottom).

Left-hand, top to bottom.- Middle part of fuselage, inside aileron control, and details of attachment of landing-gear strut to spar.

Right-hand, top to bottom.- Wing structure (one flange of spar cut to show laminae) and rear end of fuselage (inverted). The skid is recalled by a sandow and its travel is limited by two straps.

FIGURE 19.- Mounting of landing-gear legs on spar in "Caudron 360".

Spar structure in vicinity of landing gear.- 1, 1 mm (.039 in.) veneer glued to spruce 2; 2, spruce board 10 mm (.394 in.) thick; 3, birch plywood 3 mm (.118 in.) thick; 4, duralumin strip screwed to web (the veneer 1 prevents spruce 2 from splitting under the action of the screws); 5, supporting surface (shown in section) of rear fitting F. The two fittings F are joined by four 12 mm (.472 in.) bolts B, passing through spruce cross blocks 50 by 50 mm (1.97 by 1.97 in.), capable of withstanding a compressive force of 10,000 kg (22,046 lb.).

Mounting of leg.- The Charlestop shock absorber engages in a practically square piece, the two symmetrical sides of which are assembled along the two ribs N. This piece, which serves to guide the leg, is indicated in the figure by dot hatching. It is encased between the two wings f, in the fitting in front of F, and is secured by five bolts. The four bolts a and the bolt A absorb the moment, while two washers are adjusted in the orifices O of 35 mm (1.38 in.) diameter. To the bolt A is attached the cardan joint (shown in the two detail sketches), which holds the end of the shock absorber. It is only necessary to raise A to cause the latter to drop. The hole below A makes it possible to remove the brake valve. As can be verified by a few measurements, with the use of the scale, this mounting is very strong and elegant. The guiding case of the leg, for example, has a frontal width of only 48 mm (1.89 in.)

FIGURE 20.- Side view of the "Caudron 362".

FIGURE 21.- Front view of the "Caudron 362".

THE "FARMAN-RENAULT"
(figs. 22 and 23)

The Farman Company had designed two wooden airplanes: one, with a thin braced wing, equipped with a 400 hp. inverted Farman engine; the other, with a cantilever wing, equipped with a 165 hp. Renault Bengali engine.

The single-wheel landing gear, which was the essential novelty of the Farman airplanes, had not proved disappointing, at least in its principle; the take-offs and landings not being so difficult as was feared. The airplanes quickly acquired lateral stability on their single wing. Nevertheless, the finishing of the Farman-Renault landing gear suffered for lack of time.

The wing section was derived from that of the "Farman 230." Two tapered wings attached to the fuselage: on top, by embedded bolts (as in the "Farman 230"); on the bottom, by multiple fittings. Covering of 3 mm (0.12 in.) plywood. Factor of safety, 17.5; each wing weighing, however, only 24 kg (53 lb.) for 3 m² (32.3 sq.ft.) of area. Enclosed cockpit with sliding panels. Propeller of 1.9 m (6.23 ft.) diameter.

Arnoux on the "Farman-Renault," May 22, 1933, raised the speed record for 100 km (62.14 miles) to 303.387 km/h (188.52 mi./hr.), but this record was beaten the same day by Delmotte on the "Caudron 360" with a speed of 333.765 km/h (207.39 mi./hr.).

In taking off for the Deutsch contest with fuel for only 500 km (310.7 miles), the landing gear gave way and the propeller was damaged.

THE "FARMAN-FARMAN"
(figs. 24 and 25)

Wing of 7 percent relative thickness and dihedral of 2 degrees 30 minutes; no longitudinal dihedral; covering of okoumé plywood, 3 mm (0.12 in.) thick. Held by brace wires, the lower wires being attached to the base of the wheel box. Constant profile set at 0°; ailerons of 25 cm (9.84 in.) chord throughout span.

In the contest Salel seemed to take off more easily than the other contestants. He had taken on board, however, 350 kg (771.6 lb.) of fuel and oil and 31 liters (8.2 gallons) of water. The pilot seemed to be master of the controls, and the airplane turned quickly. The first laps were flown at a mean speed of 300 km/h (186.4 mi./hr.). Unfortunately, a leak in the oil radiator resulted in the melting of the front bearing of the propeller. The emergency radiator, installed in place of the normal radiator, which was damaged two days before the contest, was inadequate, whence the failure.

Due to this regrettable incident, the airplane could not do its best. The Farman 12 brs engine of 90 mm (3.54 in.) bore and 100 mm (3.94 in.) stroke, had a compression ratio of 7.2, a supercharging ratio of 1.45 (supercharger not disconnectible) and developed 430 hp. at 4,000 r.p.m. (reduction $\frac{1}{2}$, propeller diameter 2.4 m (7.87 ft.), but it was run only at 3,700 r.p.m., developing 270 hp. The empty weight of 257 kg (566.6 lb.) was of interest for the power obtained.

FIGURE 22.- "Farman-Renault" 165 hp. airplane.

Characteristics

Span	5.98 m	19.62 ft.
Length	5.50 "	18.04 "
Height	1.35 "	4.43 "
Wing area	6.26 m²	67.38 sq.ft.
Weight empty	350 kg	771.62 lb.
Fuel	170 "	374.79 "
Oil	20 "	44.09 "
Pilot	75 "	165.34 "
Gross weight	615 "	1,355.84 "

AA, line of attachment of box tip.

FIGURE 24.- "Farman-Farman" 400 hp. airplane.

Characteristics

Span	8.10 m	26.57 ft.
Length	6.91 "	22.67 "
Height	1.53 "	4.99 "
Wing area	9.31 m²	100.21 sq.ft.
Weight empty	650 kg	1,433.00 lb.

Fuel and oil	350 kg	771.62 lb.
Water radiators and water	53 "	116.84 "
Air radiator	8 "	17.64 "
Gross weight	1,150 "	2,535.30 "

A, air radiator; H, oil radiator-tank; E, water radiators. The three main tanks, of 83, 203, and 115 liters (32, 54, and 30 gallons) emptied into the 33-liter (8.7-gallon) tank behind the wheel box, from which the fuel was pumped.

FIGURE 23.- Farman airplane with 165 hp. Renault engine.

FIGURE 25.- Farman airplane with 400 hp. Farman engine.

FIGURES 23 and 25.- Each Farman airplane had a single-wheel Messier landing gear (with brake in the Farman-Farman and without brake in the Farman-Renault) and retractable skids under the wing tips. The wheel of the "Farman-Renault" was also retractable. (See fig. 27.)

FIGURE 26.- Wing sections of "Farman Renault" and "Farman-Farman" airplanes.

FIGURE 27.- "Farman-Farman" 400 hp. airplane. The fuselage, of 650 by 750 mm (25.59 by 29.53 in.) maximum section, excluding wheel fairing, had, in the middle, two strong boxes C and C' over the wing spars. The fin is integral with the headrest and fuselage. Safety factor, 10. Engine bearer B consists essentially of two duralumin girders integral with fuselage. The water radiators were originally situated on the sides of the fuselage, on both sides of the pilot's seat, but, for the contest, Lamblin radiators were substituted at E. "Aivaz" air radiator at A on the engine cowling; Aivaz oil radiator at H forming the rounding in front of the box under the fuselage. F, frame carrying the wheel; P, pulley; e, air inlet.

FIGURE 28.- Wing of "Farman-Farman" 400 hp. airplane. At the right, section and plan of wing assembly; below, sections of the two spars. The box spars each consisted of two strong flanges and two 3 mm (0.12 in.) plywood webs. At the attachment to the fuselage the front spar is suitably reinforced by wooden blocks which increase the width

of the upper flange. There are regularly spaced ribs and solid cross beams between the flanges at the attachment of the brace wires.

FIGURE 29.- Fuel system of "Farman-Renault" 165 hp. airplane. The three tanks empty into a 3-liter tank, from which it is drawn by two pumps P.

FIGURE 30.- Landing gear of "Farman-Renault" 165 hp. airplane. C, fairing of fork F, hinged at O to the front spar; M, jaws blocking the stop a; S, sandow (elastic cable); c, double ratchet functioning in both directions; o, attachment of lifting chain to top of F; p and p', pulleys.

Operation.- The landing gear being down, the pilot turns a cogwheel, over which passes a chain, by means of a double ratchet c. The chain, in passing around the pulleys p and p' pulls on the point o and makes it descend, thus raising the wheel between the two spars. In the lowered position, the fork is held elastically by the sandow S, the traction of which is supported, by means of the stop a, by the jaws M. Of course the pilot must liberate a by opening M before he can raise the landing gear. The lack of elasticity of the fork in the vertical direction, is probably responsible for the four descents of the wheel noted during the tests and contest. On encountering an obstacle greater than the capacity of the tire to absorb, the additional shock absorption can be furnished only by the rearward yielding of the wheel. If, for any reason, this yielding were limited, it is obvious that the fork, or its connections, would have to yield. It is very remarkable, moreover, that, for each landing "on the belly," only the structures were damaged (propeller bent, cowling dented, exhaust pipe flattened). In the "Farman-Renault," the trailing edge of the wing is only 45 cm (17.7 in.) from the ground, which makes capsizing practically impossible.

FIGURES 31 to 33.- Structural details of "Farman-Farman" 400 hp.

FIGURE 31.- Tail surfaces and rear end of fuselage. Upper left-hand drawing shows attachment of brace wires to wing. Drawing below latter shows attachment of same wires to fuselage. (These two wires were afterwards replaced by a single wire.)

FIGURE 32.- Elevator hinge without projections.

FIGURE 33, left to right.- Elastic mount of landing wheel in its box and engine mount. Arrow points at detail of engine bearer

THE "KELLNER-BÉCHEREAU 28 V.D." WITH 350 HP. DELAGE ENGINE (figs. 34 and 35)

This airplane was not able to participate in the contest. On May 14, Captain Vernhol, suddenly enveloped and blinded in flight by a cloud of vapor, was forced to land precipitately, shattering the airplane.

The 28 V.D. had been finished only a fortnight before the contest. Since the propeller, an adjustable-pitch Ratier, braked the engine too much, its pitch was reduced some five divisions the day of the accident. The pilot having thrown the throttle wide open, the speed mounted to 4,400 r.p.m., instead of 4,000. The excess power developed may have caused the rupture of some connection or the obstruction of a pipe.

The airplane had been the object of thorough investigation in the wind tunnel, and its unusual plan form was doubtless suitable for speed. It could receive, without modification, a 650 hp. engine for which it was really designed.

FIGURE 34.- "Kellner-Béchereau 28 V.D."

Characteristics

Span	6.65 m	21.82 ft.
Length	7.16 "	23.49 "
Height	2.64 "	8.66 "
Wing area	10.60 m^2	114.10 sq.ft.
Airplane without engine	304 kg	670.20 lb.
Engine, empty	391 "	862.00 "

Engine accessories	260 kg	573.20 lb.
Tanks, empty	47 "	103.62 "
Fuel	400 "	881.85 "
Oil	25 "	55.12 "
Pilot and tools	88 "	194.00 "
Total weight in flight	1,600 "	3,527.39 "

For the contest, the airplane would have had a wing loading of 150 kg/m² (30.72 lb./sq.ft.) and its speed should have been of the order of 400 km/h (248.6 mi./hr.). The fuselage had a center section of 0.58 m² (6.24 sq.ft.). The track had a width of 1.48 m (4.86 ft.). The area of each aileron was 0.66 m² (7.1 sq.ft.).

FIGURE 35.- View of the "Kellner-Béchereau 28 V.D."

FIGURE 36.- Polars of "Kellner-Béchereau 28 V.D."

FIGURE 37.- Arrangement of tanks and landing gear in wing of "Kellner-Béchereau 28 V.D." At top, plan view of wing and wing section through XX; at bottom, vertical section through YY. Plan view shows the three tanks. Hatching shows portion of bottom of one of them which forms the wing covering. Landing gear is partially included in this tank. Rear spar is bent, but a prolongation connects its oblique portion to the fuselage. E, 12 mm (0.47 in.) depression in bottom of tanks; R, helicoidal groove in which moves the upper end r of the leg J; R_f, tank in fuselage; S, siphon with regulating plug; T and T', tubes 20 by 22 mm (0.787 by 0.866 in.) conducting fuel to R_f; U, landing-gear box; V, dump valve; p, compressed-air intake for forward dump valve; r, pivot; t, air vents; v, screw for attaching wing radiators (see detail). In order to comprehend the complexity of the wing structure, it is necessary to imagine the superposing of the water system in the above plan, while bearing in mind that the relative thickness of the wing does not exceed 12 percent. This airplane is the first, we believe, to have tanks and radiators both in the wing.

FIGURE 38.- Water circulation in fuselage of the "Kellner-Béchereau 28 V.D." The three drawings are all on the

same scale as in figure 39 and bear the same references: T, equilibrium tube connecting the two inlets E_p from water pump; T', equilibrium tube from water tank; t, thermometers. T and T' and tube connecting A_1 and A_2 to the tank all have cross sections of 36 by 38 mm (1.42 by 1.50 in.).

FIGURE 39.- Water circulation in wing of K.-B. 28 V.D.

Arrangement of radiators.- The radiators cover the whole top of the wing to the rear spar, and the bottom of the wing over a width of 1.1 m (3.61 ft.). The remainder of the lower surface could be easily utilized, due to the landing gear and dump valve. The figure shows the tubes of only one of the radiators on top of wing, but all three are shown on the bottom of the wing. The two front radiators encircle the leading edge and cover the top of the wing. (See section XX.)

Water circulation in wing.- Water from tank enters A by two tubes: A_1 along rear spar; A_2, in leading edge. These tubes empty into the radiator-inlet tubes: C_a, for the radiators on top of wing, and C_a', for those on the bottom. The cooled water flows into the return tubes (C_r, for the top radiators and C_r' for the bottom ones) and through a single tube R, along the front spar, to the pump. The arrows indicate the general direction of flow. Of course the water follows the interior channels and it is only intended, by means of the arrows, to indicate the communications between the corresponding C_a and C_r.

Diameters of tubes.- (In order to find references, follow the tubes.)

1. A_1 and A_2. From 1 to 2 and 2', tubes 33 by 35 mm (1.3 by 1.38 in.); from 2 to 3 and from 2' to 3', tubes 28 by 30 mm (1.1 by 1.18 in.); beyond 3 and 3', tubes 24 by 26 mm (0.945 by 1.024 in.). All tubes are aluminum. The connections between radiator and collector are tubes of 24 by 26 mm.

FIGURE 40.- Oil radiator. Above, from left to right, lateral rear view and front views of oil radiator tank in K.-B. 28 V.D. A, oil intake; C, attachment collar on nose of engine; C_i, lower collectors; C_s, upper collector; R, return to pumps; V, drain (and filling) valve; b, band of 0.6 mm copper riveted and soldered to radiator for attaching to covering; s, air vent.

FIGURE 41.- Engine bed of K.-B. 28 V.D. Above, front view. On the right, elevation and plan views. The engine bed consists mainly of two sheet-metal structures, riveted to the fuselage. The attaching plates are supported by the longerons L and the angles E. The front of the bed is stiffened by a box C and a plate T. At the rear the attaching plates are united, at the axis, by a reinforcement r, while the longerons are bent and secured to the fuselage by the gussets G.

FIGURE 42.- Spar structure. Central web of 2 mm (0.079 in.) traverses fuselage and is firmly attached to it by strong angles C. The end webs (1.6 mm (0.063 in.) dural) are attached to central web by two gussets G of duralumin of 1 mm thickness. Nos. 1 to 5 are stiffening angles of 16 by 16 by 1.25 mm (0.63 by 0.63 by 0.049 in.). L and L' rib connections, in angles 20 by 20 by 2 mm (0.787 by 0.787 by 0.079 in.); c, angles of CN12 steel, 2 mm (0.079 in.) thick; c', duralumin angles 25 by 16 by 2 mm (0.984 by 0.63 by 0.079 in.).

FIGURE 43.- Mounting of stabilizer, adjustable during flight, on the K.-B. 28 V.D.

Principle.- The method of mounting the stabilizer on the K.-B. 28 V.D. is applicable to a tail surface situated in the median line of the fuselage. When the stabilizer is in a single piece, it is necessary, in order to permit its deflection, to make a channel in the fuselage, thus weakening the latter. Mr. Béchereau preferred to divide the stabilizer into two symmetrical halves.

Description.- The transverse girder P is mounted solidly on the fuselage C, by means of angles c. The ends of P form bearings p and p', for a tube T, at both ends of which, at K and K', are mounted the two halves of the stabilizer. At the rear, these two parts rest on a girder P' traversing the fuselage through a very small channel. P' carries, in the middle, a support S, which can be moved up or down by the screw V operated from the cockpit. In short, the stabilizer is held at three points, p, p', and S.

FIGURE 44.- Structural details of K.-B. 28 V.D. Below, two drawings of stabilizer mounting, and between them a detail of the threading of the ribs on the transverse aluminum box, at the two ends of which the stabilizer can pivot. At the right, a portion of the landing

gear. At the top of the leg, note the ball (engaged in the tube with helicoidal groove), as also the arresting device. At the bottom of the page, another view of a portion of the landing gear.

FIGURE 45.- View of left engine bearer and forward portion of airplane. All the right-hand portion is removed to show inside of fuselage.

FIGURE 46.- Béchereau quick-dumping device. This device, located on the lower side of the wing was specially designed for swift airplanes. It is perfectly flush with the surface of the wing.

On the bottom of the tank is mounted a base 1; assemblage rendered tight by a patented joint 2. The dumping orifice O is normally closed by a disk 6 of 0.5 mm (0.02 in.) copper with crimped edge. To the circumference of this disk is soldered a lead shoulder 5 of 0.5 mm (0.02 in.) extending about 18 mm (0.709 in.) beyond the crimped edge. The projecting part of the lead is applied to the lower part of base 1 and is held by an annular cover 3 with the interposition of the patented joint 4. Inside of 1 is a piston 7 of stamped 0.8 mm (0.031 in.) steel, capable of sliding in the piece which receives it. Above this piston is a sort of dome or valve 8 of 1.5 mm (0.059 in.) L2R alloy. The piston and valve are normally separated from each other by a weak spring 10, leaving a chamber 9 between them.

Pressure is created in the chamber 9 (small flask of carbonic acid gas, which is led through a tube T to the connection r in the base 1. The valve 8 is pressed against its seat and the piston 7 is pushed downward, cutting the lead joint 5 along the circle FF. The parts 6 and 7 then fall, followed by the valve 8. The latter cannot possibly jam, because its diameter is less than that of the piston.

The whole mechanism weighs only 0.68 kg (1.5 lb.) for an orifice of 10 cm (3.94 in.) diameter. It has always worked perfectly in numerous tests. A pressure of only 4 kg/cm^2 (56.89 lb./sq.in.) exerts a total force of about 376 kg (829 lb.) on the joint, the diameter of the hole being 11 cm (4.33 in.).

FIGURE 47.- Retractable landing gear of the K.-B 28 V.D. The legend is given for one wheel only. B and B',

cylinders of compressed air; C_1, cable acting on lever D; C_2, cable winding on drum T; C_3, cable releasing catch K; D, lever for securing in raised position; K, catch for holding in rolling position; L and L', control levers; P, pump; R, helicoidal groove for the ball r; S, elastic cable; T, lowering drum; V, valve for initial filling; 6, valve for releasing air from P; m, manometer; r and r', extreme positions of ball; s, safety valve.

To lift.- Pull on C_3 by means of L'. This releases catch K and opens P to the air. The elastic cable S then retracts leg to elevated position. When clear up, the lower end of leg is locked at D.

To lower.- Pull on L. This liberates D and then establishes communication between B and P. The piston in P is actuated and causes the rotation of the drum T which pulls on C_2 thus lowering the wheel and putting S under tension. When clear down, the safety catch K holds it. B' is a reserve cylinder of compressed air.

ENGINES USED IN THE 1933 DEUTSCH DE LA MEURTHE CONTEST*

By L. Hirschauer

The Potez 9B Engine

This engine (fig. 48) was specially designed to satisfy the conditions for use on Potez airplanes in the Deutsch de la Meurthe speed contest. Its characteristics were established on the basis of the prescribed piston-displacement limit of 8 liters (488 cu.in.), taking into account the necessity of combining sufficient endurance with minimum frontal area and maximum power, in order to satisfy, without abnormal fatigue, the conditions of the contest, both in the qualifying tests and in the two 1,000 km (621.4 miles) flights.

It was decided to design an air-cooled radial engine, as being of homogeneous simplicity and of size compatible with the dimensions of the airplane, in order to obtain, with a suitable cowling, a very great fineness which, moreover, was verified and improved by wind-tunnel tests on a large-scale model of the engine and fuselage. This design made it possible to profit by the experience with certain details of the Potez 9A, of 9.75 liters (594.98 cu.in.), from which the 9B was derived by reducing the piston displacement and by supercharging. Supercharging was adopted in order to obtain a high power for the stipulated piston displacement, because this made it possible to obtain the requisite mean pressure without recourse to compression ratios that would produce excessive pressures and explosion temperatures. The direct propeller drive was adopted after thorough investigation, because it yielded a high propeller efficiency and because it had the advantage of simplicity and of reduced weight. The following are the characteristics of this air-cooled radial 9-cylinder engine with centrifugal supercharger.

Characteristics

Total piston displacement	8 liters	488 cu.in.
Bore	98 mm	3.86 in.
Stroke	117 "	4.61 "
Compression ratio	6	
Maximum power	310 hp. at 2,500 r.p.m.	

*l'Aérophile, June 1933, pp. 177-180.

Weight, empty	170 kg	374.79 lb.	1.21 #/H.P.
Maximum diameter	950 mm	37.40 in.	
Supercharging ratio	1.45	6.6 #/□" supercharge (?)	
Multiplication ratio of supercharger	11.5		

The Renault Bengali Engine

All the parts of this engine (fig. 49) are the same as in the stock Bengali engine, with the exception of the pistons, which were changed so as to increase the compression ratio from 5.6 to 8. The cylinder heads are made of aluminum alloy, independent of the enameled steel cylinders, and are secured by four rods screwed into the crankcase. Each cylinder has one intake and one exhaust valve. The valve rockers are bathed by the oil contained in the cases which are held by milled bolts and can be easily removed.

The crankshaft is supported by five plain bearings. A thrust ball bearing permits the use of either a tractor or a pusher propeller. The propeller is carried by a removable sleeve. It turns anti-clockwise as viewed from the pilot's post.

A gear on the crankshaft drives the camshaft and the oil pumps. A transmission shaft, at the end of the crankshaft, operates the magnetos, the fuel pumps, and the tachometer. The connecting rods are made of forged duralumin; pistons, of aluminum alloy, with two rings and one oil scraper. The piston pin is free in its bearings and in the small end of connecting rod. It is held laterally by steel cheeks. Upper part of crankcase is of magnesium and serves only as a tight cover. Lower part of crankcase is made of special aluminum alloy. The rear end carries the magnetos, the oil pumps, and the fuel pumps. The thrust bearing of the crankshaft is in the front end of the crankcase.

Ignition, by two Scintilla magnetos with automatic ignition advance. One magneto is provided with a release mechanism to facilitate starting. Light Renault spark plugs of 12 mm diameter are used.

A geared pump conveys the lubricating oil to a tank outside the engine and delivers it under pressure to the crankshaft bearings and to the rear camshaft bearing. The big ends of the connecting rods are lubricated under pressure; the small ends of the connecting rods, the pistons and cylinders, by splashing. The oil, passing through the inside of the camshaft, lubricates the bearings and then, escaping through holes in the cams, lubricates them and their tappets.

Rotary AM fuel pumps; Viet starter actuated by the forward end of the camshaft. The valves are in one of the tubes serving to secure the support of the valve rockers.

Characteristics

Bore	120 mm	4.72 in.	
Stroke	140 "	5.51 "	2290'/min
Total piston displacement	6.33 liters	386.28 cu.in.	.44 H.P./cu.in.
Power	170 hp.		139#/□" B.M.E.P.
Speed	2,500 r.p.m.		
Gross weight, with pumps	135 kg	297.62 lb.	1.75 #/H.P.

8:1 This engine has no supercharger. Its high compression ratio necessitates the use of a special fuel (fig. 50).

The Regnier Engine

This air-cooled 6-cylinder inverted engine was designed on the basis of experience acquired with many engines in use (figs. 51 and 52). It was made entirely in France, with the exception of the magnetos, which were made to order in Coventry, England, and of the carburetors, which are of the Claudel license acquired by Hobson.

This engine passed its torque-stand tests, including an endurance test of fifty hours, three hours of which were at full power (2,450 r.p.m.). Dismantling, after the above tests, revealed no fatigue.

Characteristics

Bore	114 mm	4.49 in.
Stroke	130 "	5.12 "
Piston displacement	7.95 liters	486 cu.in. .452 HP/cu.in
Compression ratio	6.2	
Power at 2,150 r.p.m.	190 hp.	
Power at 2,450 r.p.m.	220 hp.	146 #/□" B.M.E.P.
Gross weight, about	206 kg	454.15 lb.
Power loading "	0.95 kg/hp	2.09 lb./hp.

Specific Fuel Consumption

At full power	60 liters/h	15.85 gal./hr.
At 2,150 r.p.m.	45 "	11.89 "
Specific oil consumption	0.75 "	0.198 "

Ignition: two British Thomson-Houston magnetos.

Lubrication: two Martin No. 0 rotary pumps.

Two Claudel-Hobson AL48A carburetors.

Tractor propeller, without reduction gear.

The Farman 12B.R.S. Engine

This engine, with 12 inverted cylinders arranged in two banks at an angle of 60° and with reduction gear and supercharger, is cooled by water with supplementary air cooling by fins (fig. 53).

The cylinder jackets are steel. They are fitted to the bottom of the crankcase and have cooling fins. The tops of the jackets of the six cylinders of each bank are fitted into a water-cooled block of light alloy.

The crankshaft is made of high-tensile steel and has seven bearings. The front end carries the reduction gear; the rear end, the gearing for the supercharger and accessories.

The pistons are made of special alloy with piston rings and oil scraper. The piston pins turn freely in pistons. The connecting-rod assembly consists of a master connecting rod, turning on a plain bearing, and an articulated connecting rod.

There are two camshafts at the top of the cylinder banks. Each cylinder has one intake and one exhaust valve, each valve being recalled by two concentric springs.

The autonomous reduction gear is fitted to the front end of the crankcase with an aluminum housing in which are mounted: 1, a stationary gear; 2, propeller shaft on ball bearing in front end of housing and on interior crankshaft bearing. The propeller shaft has three arms on which turn intermediate gears on plain bearings; 3, gear driven by crankshaft.

Viet starter or Farman cartridge starter, with or without automatic release, the body of the starter being fitted to the cylinder block, in which a special cartridge explodes. This body is connected by a tube to a valve chamber fitted to the shoulder provided for this purpose on the cylinder. The supercharger consists of a wheel that compresses the air and forces it into a volute from which it passes into the air radiator. The control consists of a frictional device which can slip in case of too sudden acceleration and which constantly exerts a force equal to the force required for the air compression.

The cooling is effected: 1, at the top of the cylinders, by the circulation of water from a centrifugal pump with two outlets behind the engine; 2, at the bottom of the cylinders, by air-cooled fins.

Lubrication is effected by four geared pumps which insure the flow of fresh oil from the tank to the engine and the return of the excess oil.

Curves of Power and of Fuel Consumption
(fig. 54)

A, power curve at sea level, engine 12 BRS, 9.5 liters (579.72 cu.in.).

B, power curve at sea level, engine 12 BRS, 8 liters (488.19 cu.in.).

C, Deutsch-trophy type.

D, fuel-consumption curve.

The carburetion is effected by four Zenith carburetors. The air supplied by the supercharger is cooled in an air radiator before reaching the carburetors. Ignition is by two magnetos behind the engine. The variation in spark advance is effected by the rotation of the armature. The connections for the control of the fuel pumps and revolution counters are located at the rear of the engine.

Characteristics

Total length, with supercharger and reduction gear	1.280 m	4.2 ft.
Maximum over-all width	0.596 "	1.96 "
Maximum over-all height	0.740 "	2.43 "
Bore	90.5 mm	3.56 in.
Stroke	100 to 105.0	4.13
Total piston displacement	7.892 liters	481.6 cu.in. .872 HP/cu.in
Piston displacement per minute	15.800 m^3	557.97 cu.ft.
Compression ratio	7.5	
Sea-level power equivalent of supercharged engine at 4,000 r.p.m.		420 hp. 173 lb/in² B.M.E.P.

Specific fuel consumption	230 g/hp/h	.507 lb./hp./hr.
Specific oil consumption	9 "	.02 "
Reduction-gear ratio	2.25	
Pressure produced by Farman centrifugal supercharger	1,120 mm	44.1 in. (at sea level)
Total weight of engine and accessories	230 kg	507.06 lb. 1.21 #/H.P.

The Delage 12 C.E.D.1.R.S. Engine

This engine, rated at 370 hp., has already developed 420 hp. in the tests and may be expected to attain 450 hp. (fig. 55). During the flights of the "Kellner-Béchereau" airplane, the propeller was poorly adapted, revolving at 3,100 r.p.m. on the ground and 4,800 in flight; that is to say, too fast.

The accident to the airplane was due to the rupture of a rubber ring between the engine and the radiator. The steam blinded the pilot, who made a completely blind landing.

This inverted engine has 12 cylinders in two banks at an angle of 60°. The valves are operated by rockers and rods. The recall of the valves is effected by springs situated not on the valve but on the end of a reduction lever, thus reducing the amplitude of the natural oscillations of the springs and increasing their damping effect (Delage patent).

The nitrided steel cylinders are immersed in water. The cylinders serve only to guide the pistons and do not work in traction. The valve seats and spark-plug sockets are made of a special bronze. The top of the crankcase serves simply as an air-tight cover. The crankshaft is perfectly balanced, in order to eliminate the stresses on the bearings. The two-part connecting rods of chrome-nickel steel are mounted on rollers directly on the crankshaft. The supercharger is the same type as used on the Delage automobiles.

tension ?

This supercharger consists of a case (A) of light alloy, provided with two large openings: one (B) for intake, the other (C) for the outlet. Inside this case are two rotors (D_1 and D_2) controlled in their rotation by gears (E_1 and E_2). Figure 56 represents cams with two arms or cogs, but three or even more could be used. By increasing the number of cogs, the gear pump is approached.

The main case is closed at both ends by plates (F_1 and F_2), which support the cam bearings. As in a gear pump, the cams carry the air from the inlet to the outlet orifice, the output being proportional per revolution to four times the hatched area S. The volumetric output is proportional to the length of the body of the supercharger. The end of one of the cams is provided with grooves for driving the supercharger. A case houses the gears connecting the cams, insures tightness for their lubrication, and serves at the same time as a support for the supercharger.

The efficiency of this supercharger is almost constant at any speed. One can easily obtain pressures of 1.5 kg/cm² (21.34 lb./sq.in.) above the atmospheric pressure, or about 2.5 kg/cm² (35.56 lb./sq.in.) absolute pressure, and negative pressures of about 0.85 kg/cm² (12.09 lb./sq.in.) or 0.18 kg/cm² (2.56 lb./sq.in.) absolute. The carburetor can be located at either the intake or outlet end of the supercharger.

These superchargers are no heavier than centrifugal superchargers in proportion to their output. They have simplicity, reliability of operation without wear, ability, without loss of power, to deliver, at the same speed, a constant volume with intake pressures varying from 1 to 0.5, a very great output for a high compression ratio and, due to the relatively low speed, necessitate no special clutch nor change in speed.

Characteristics

Bore	100 mm	3.94 in.
Stroke	84 "	3.31 "
Piston displacement	7.95 liters	485.13 cu.in.
Compression ratio	5.2	

Rated power	370 hp.	
Speed of engine	3,900 r.p.m.	
Speed of propeller (2 superposed reduction gears)	1,900 "	
Weight	360 kg	793.66 lb.

LESSONS LEARNED FROM THE 1933 DEUTSCH DE LA MEURTHE CONTEST*

By Raymond Saladin

The Deutsch contest of July 1933 proved very instructive. We will recall briefly the reason for its regulations, namely, to obtain the maximum speed for a distance of 2,000 km (1,242.27 miles) from an airplane equipped with an engine having a piston displacement not exceeding 8 liters (488.2 cu.in.).

This left great latitude to the designers. Without wishing to disparage the Service Technique de l'Aéronautique, which does all it can (and its task is not always easy), it must be recognized that its very strict rules sometimes interfere greatly with the initiative of our airplane designers. The regulations for the Deutsch contest liberated them from their customary limitations, and the results exceeded all expectations.

In fact, Potez, Renault, and Farman obtained from their engines (all below 8 liters piston displacement) powers of 270 hp., 170 hp., and 400 hp., respectively. The refined airplane cellules enabled the following speeds: Potez, 356 km/h (221.2 mi./hr.) maximum, 322 km/h (200.1 mi./hr.) mean; Caudron, 333 km/h (206.9 mi./hr.) maximum, 317 km/h (197 mi./hr.) mean; Farman, 330 km/h (205.1 mi./hr.) maximum, 300 km/h (186.4 mi./hr.) mean. I may add that the Farman, which was obliged to quit on account of some mechanical defect, never gave the impression that its pilot, Salel, had demanded the maximum of his engine. The maximums are considered here, not as is customary but as extended to cover 100 km (62.1 miles), or one lap of the Deutsch contest, which gives them added significance.

In the present state of development, nothing better can be demanded of the engines. The 1933 Deutsch contest for medium-sized airplanes has opened the doors for the 1934 contest. It has accomplished its purpose.

The airplanes were all monoplanes. They all had high wing loadings of more than 100 kg/m² (20.48 lb./sq.ft.). The small, compact, thickset wings resembled planing fins and permitted only very long and dangerous take-offs and landings at speeds of 180 to 200 km/h (111.85 to 124.3 mi./hr.). But, once in the air, they permitted high speeds facilitated by the streamlining of the whole according to

*La Nature, August 1933.

the purest principles of hydrodynamics. The designers had given special attention to the engine cowlings, fuselages, and landing gears.

The Potez had an ordinary landing gear retractable into the wing during flight. This feature added about 40 km/h (24.86 mi./hr.) to the speed of the airplane. The Farman had a single-wheel landing gear which was "swallowed" by the fuselage during flight. The landing gear of the Caudron was not retractable, but was faired so as to offer the least possible head resistance despite the handicap of being fixed.

The fuel consumptions were extremely small for the speeds attained. Détré, winner in his "Potez-Potez," used less than 15 liters (3.96 gallons) per 100 km (62.1 miles), and Delmotte, second on his "Caudron-Renault", only 19 liters (5 gallons) for the same distance. These figures are less than for automobilles "de luxe."

The 1933 Deutsch contest made it possible to realize a superior engine-cellule assembly from which can be derived, on the one hand, remarkable pursuit airplanes and, on the other hand, fast touring airplanes. The practical use of airplanes derived from racing airplanes, with the inevitable changes for quantity production, is now only a question of months.

Parenthetically, it may be remarked that the airplanes of the Deutsch contest were very difficult to pilot (like all fine racing airplanes with heavy wing loading) and could not be entrusted to any average pilot. Only first-class pilots could make them do their best. Détré, the victor, Delmotte, Salel, Arnoux, and Lemoine all showed great skill.

I now come to the only foreign contestant for the trophy, the Englishman Comper, of whom no mention has yet been made. He finished the course at over 228 km/h (141.67 mi./hr.) with an engine of only 135 hp. and on a strictly stock airplane. This demonstration was useful. It demonstrated the qualities of the cellule and engine, as well as the skill of the pilot. The Englishman took the chance of regularity, awaiting the weakening of his adversaries in order to finish alone, trusting in the strength of his engine and thinking that the efforts required of the contesting engines would not allow them to finish the 2,000 km (1,242.7 mi.). He fell behind, but kept pegging away and finished in a veritable burst of speed, alone and without audience, since his conquerors had long since arrived.

The preparation for the Deutsch contest had cost dearly. Ludovic Arrachart had been killed, and Vallot had seriously damaged his airplane. In the contest itself, there was only one accident, that of Arnoux, whose airplane nosed over in the attempt to take off, due to the failure of the single-wheel landing gear, so that he was eliminated from the race.

After the war, when the speed of 300 km/h (186.4 mi./hr.) was exceeded for the first time (by Sadi Lecointe, October 20, 1920), piston displacements of the order of 25 liters (1,525.6 cu.in.) were employed for engines on racing airplanes, yielding about 500 hp. In 1933, a speed of 322 km/h (200.1 mi./hr.) was attained with a piston displacement of only 8 liters (488.2 cu.in.) and 270 hp. Moreover, this speed was maintained for 2,000 km (1,242.7 miles), while the first 300 km/h (186.4 mi./hr.) was maintained for only a few kilometers.

The Deutsch contest therefore illustrates the progress in speed from 1920 to 1933. We now know that future touring airplanes will have a high mean speed, because racing airplanes are always the progenitors of normal airplanes and large speed ranges. It is possible to predict new economical pursuit airplanes of increased efficiency as a result of the researches due to the Deutsch contest.

In the matter of speed (for its practical applications), it is interesting to note that a greater speed was made in 1933 than in 1920 and with a piston displacement three and one half times smaller. This fact shows a trend toward economic aviation of high efficiency. This is more important with respect to the near future than the increase in the world's speed record, for all classes, from 300 km/h (186.4 mi./hr.) with 350 hp. in 1920, to 700 km/h (435 mi./hr.) in 1933, but with the enormous expenditure of 2,000 horsepower.

The gain realized in the Deutsch contest is of much more interest, as it reveals the value of its regulations and the effect it will have on future progress. Nothing must be neglected for insuring the future of aviation. This is why the regulations of the 1933 contest should be marked with a white stone in the annals of the air. The indispensable researches in pure speed must, in practice, be accompanied by an increase in the speed range. It is in this connection that the leading-edge and trailing-edge flaps used in England and Germany are of interest.

It is asked why France has not made more use of these two supplementary methods of sustentation, with the advantages of which we are well acquainted. These advantages will become all the more marked as they are applied to very high-speed airplanes. Americans are using these devices on commercial airplanes at speeds of the order of 300 km/h (186.4 mi./hr.). It is logical that we should soon see them used in France.

Translation by Dwight M. Miner,
National Advisory Committee
for Aeronautics.

TABLE I. AIRPLANES

Type	Engine	Span	Length	Height	Area	Weight without fuel	Total weight	Weight per	Weight per hp.	Fastest lap speed
		m ft.	m ft.	m ft.	m^2 sq.ft.	kg lb.	kg lb.	m^2 in kg sq.ft. in lb.	kg lb.	km/h mi./hr.
Potez 53	Potez 9B 310 hp.	6.65 21.82	5.40 17.72	1.80 5.91	7.20 77.50	600.0 1322.8	900.0 1984.2	125.0 25.6	2.9 6.39	356.0 221.2
Caudron 360	Regnier 210 hp.	6.80 22.31	6.87 22.54	1.88 6.17	7.00 75.35	480* 1058.2	695.0 1532.2	99.30 20.33	3.31 7.30	317.0 197.0
Farman	Renault 165 hp.	5.98 19.62	5.50 18.04	1.35 4.43	6.26 67.38	425.0 936.96	615.0 1355.8	98.20 20.12	3.73 8.22	303.4 188.5
Farman	Farman 400 hp.	8.10 26.57	6.91 22.67	1.53 4.99	9.31 100.2	650.0 1433.0	1150.0 2535.3	123.5 25.3	2.88 6.35	300.0 186.4
Kellner-Béchereau 28 V.D.	Delage 350 hp.	6.65 21.82	7.16 23.49	2.64 8.66	10.6 114.1	990* 2182.6	1600.0 3527.4	150.9 30.91	4.57 10.08	400* 248.6

Note.- Data compiled from L'Aéronautique, July and August 1933.

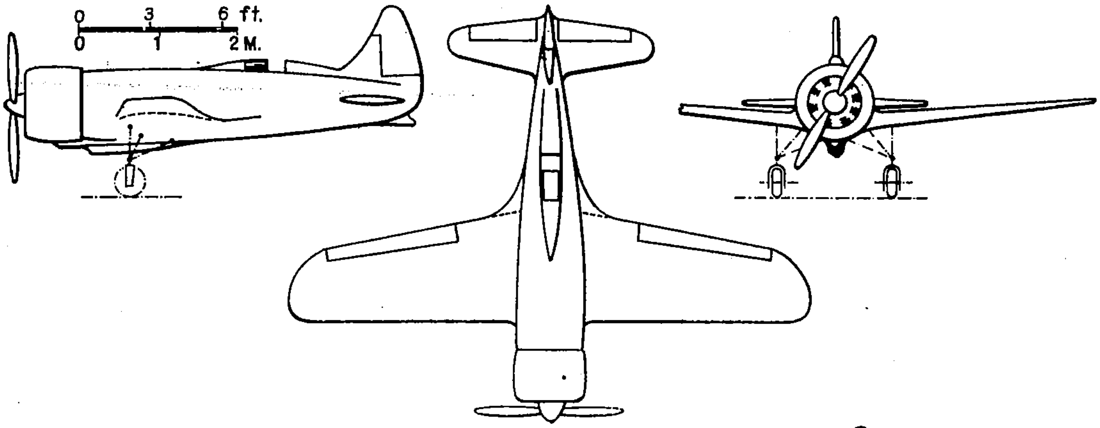
The upper figures in each case are in metric units; the lower figures, in English units.

*Estimated.

TABLE II. ENGINES

Type	Horse-power	Cooling system	Number of cylinders	Bore	Stroke	Displace-ment	Compression ratio
				mm in.	mm in.	liters cu.in.	
Potez 9B	310	air	9	98 3.86	117 4.61	8.0 488.2	6
Renault Bengali	170	air	6	120 4.72	140 5.51	6.33 386.3	8
Regnier	190-220	air	6	114 4.49	130 5.12	7.95 485.1	6.2
Farman 12 B.R.S.	400	water	12	90.5 3.56	105 4.13	7.892 481.6	7.5

Note.- Data compiled from l'Aérophile, June 1933.
The upper figures in each case are in metric units; the lower figures, in English.



Span 6.65 m (21.82 ft.) Wing area: 7.20 m^2
Length 5.40 " (17.72 ") (77.50 sq.ft.)
Height 1.80 " (5.91 ") 310 hp. Potez 9 B engine.

Figure 1.- General arrangement drawing of the Potez 53 airplane.

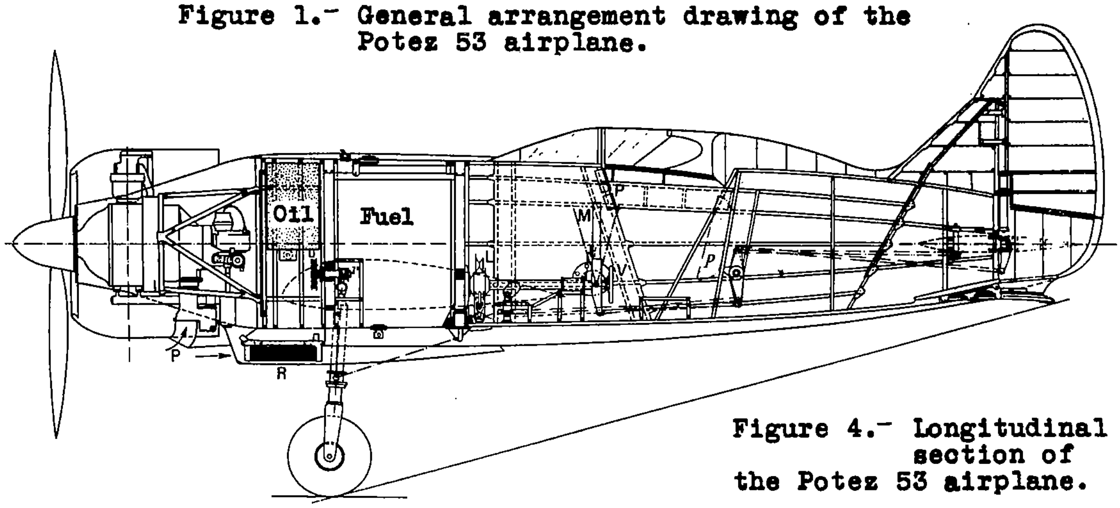


Figure 4.- Longitudinal section of the Potez 53 airplane.

Key for Figure 5.

- -------- Induced polar
- – – – – – Wing alone
- –··––––– Cockpit covered
- ○ Cockpit open
- ———— With wing-fuselage filet
- —·——— Without wing-fuselage filet
- △ With inner-wheel fairing
- ▽ Without inner-wheel fairing

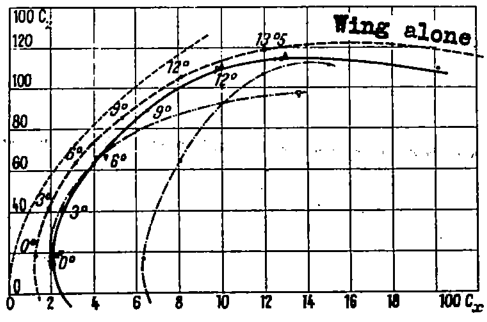


Figure 5.

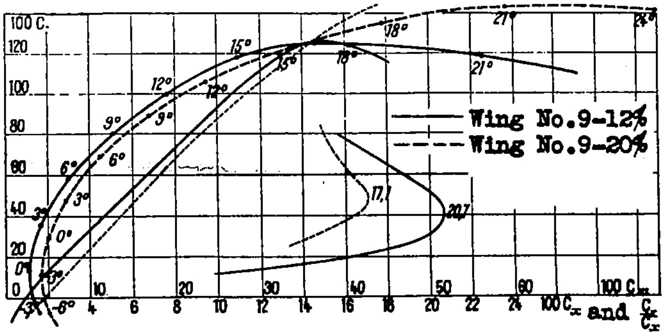


Figure 6

Figures 5,6.- Results of wind tunnel tests with models of Potez 53.

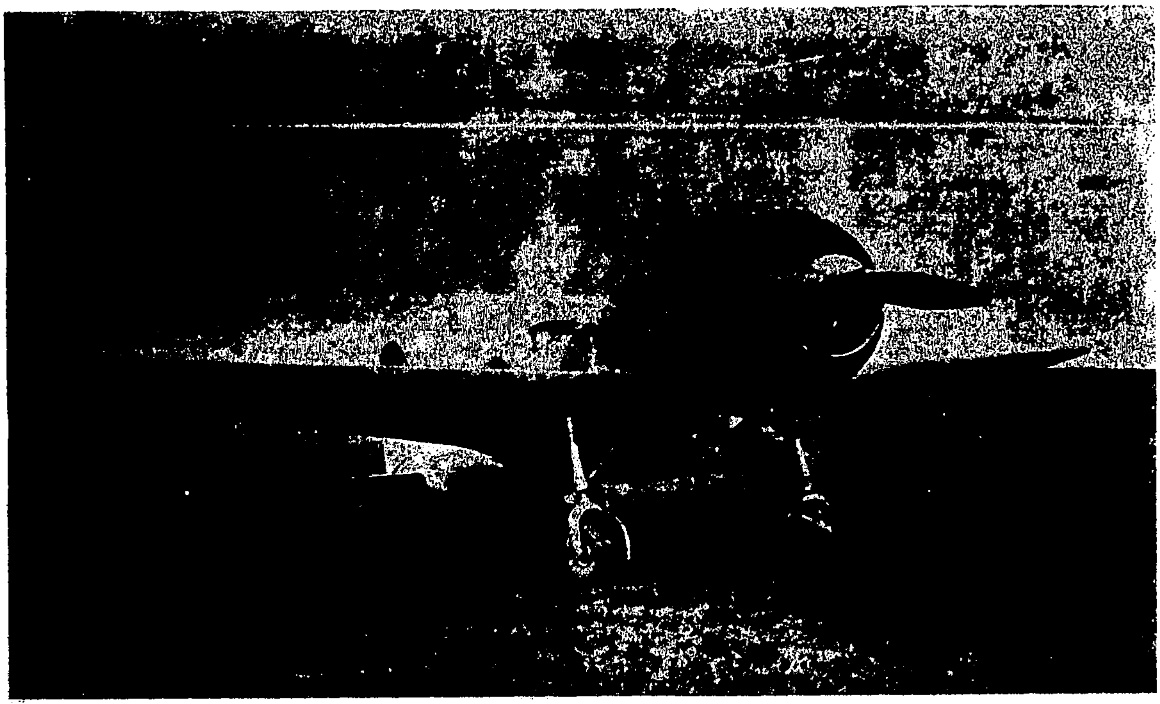


Figure 2.

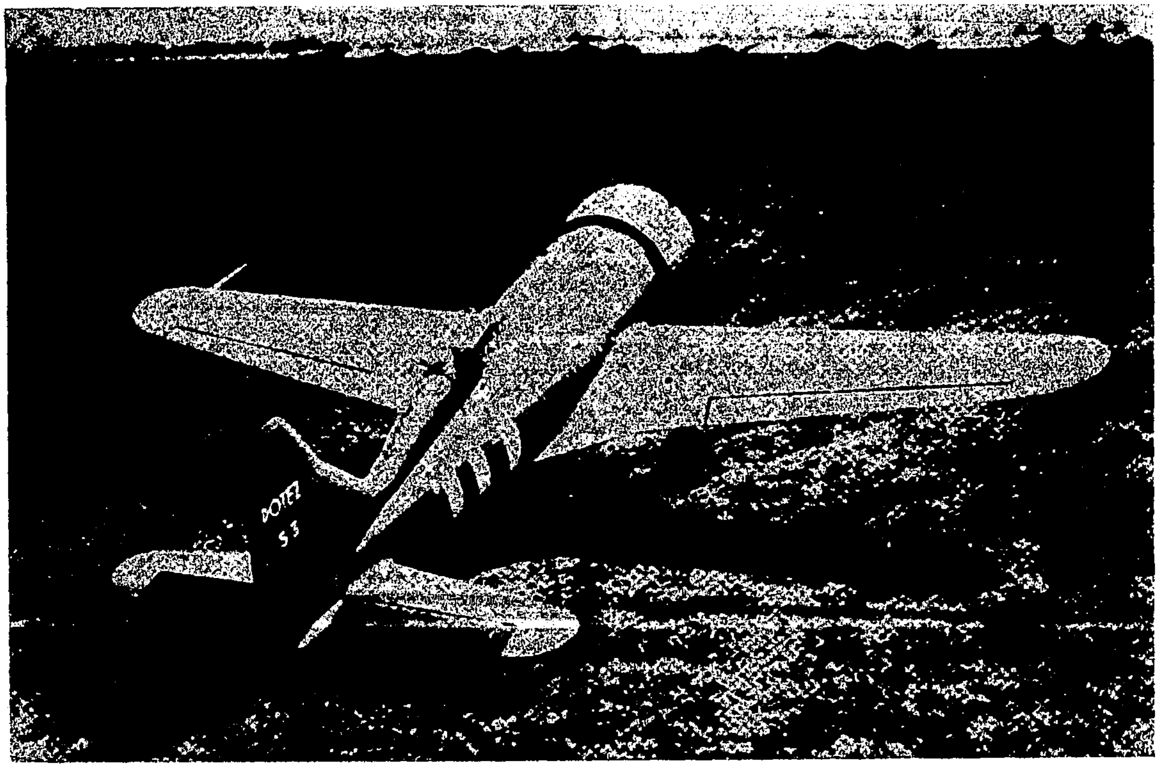


Figure 3.
(From La Nature)

Figures 2,3.- Views of the Potez 53 airplane.

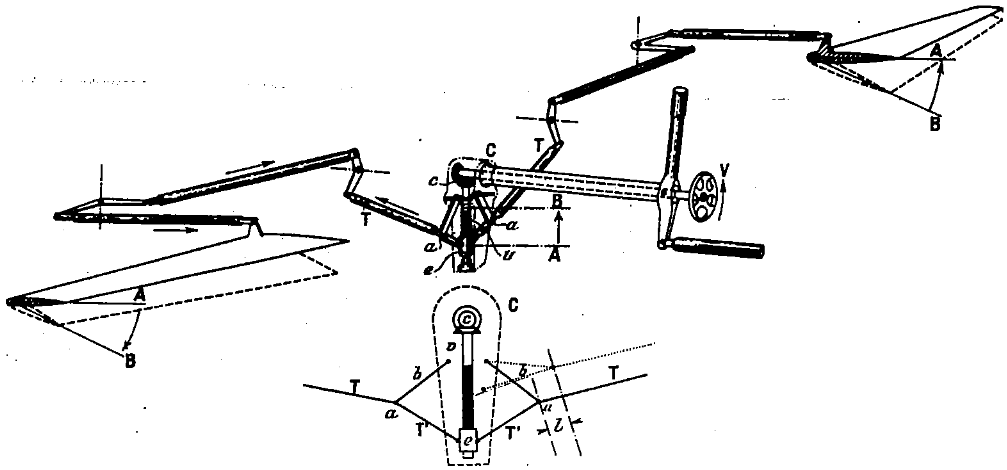


Figure 7.- Aileron controls of the Potez 53 airplane.

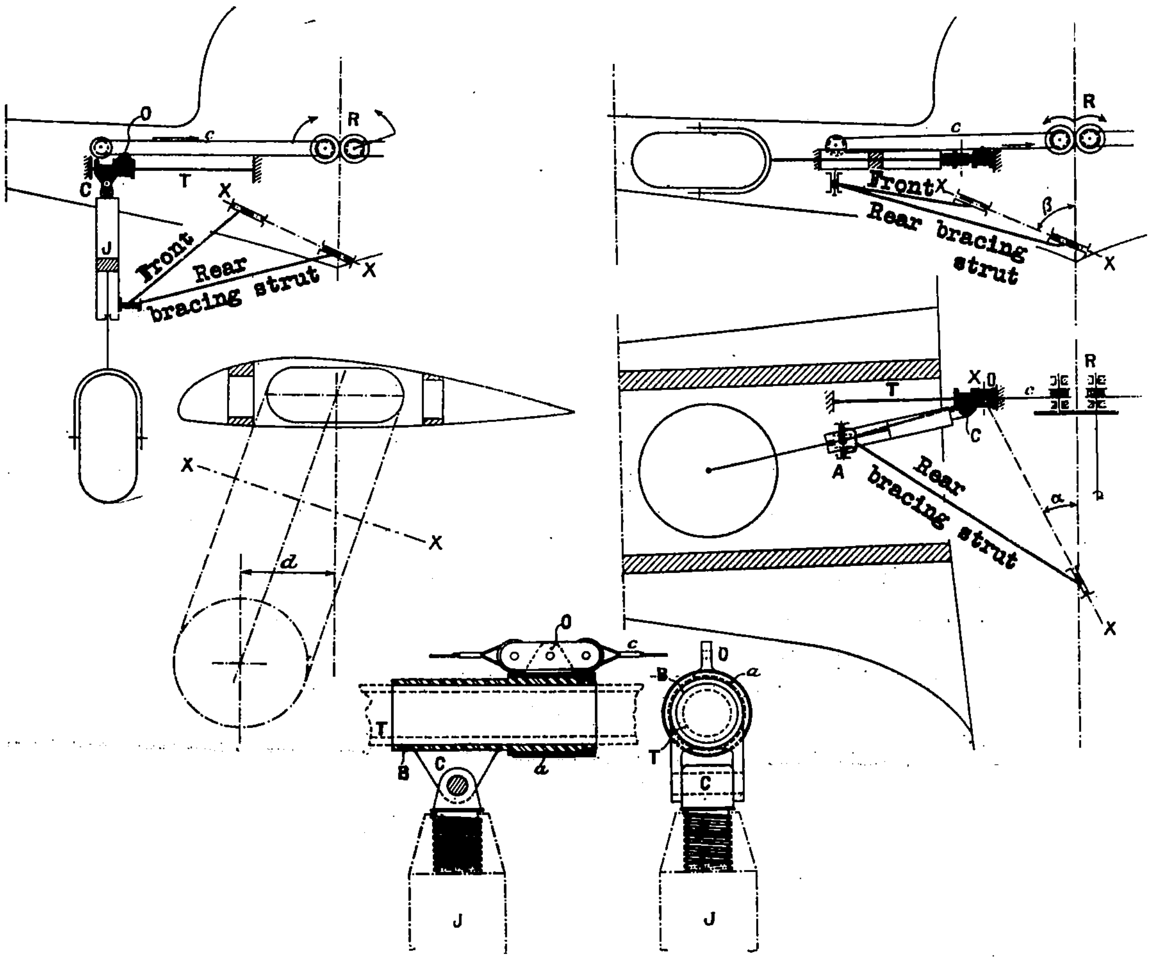


Figure 11.- Diagram of retractable landing gear.

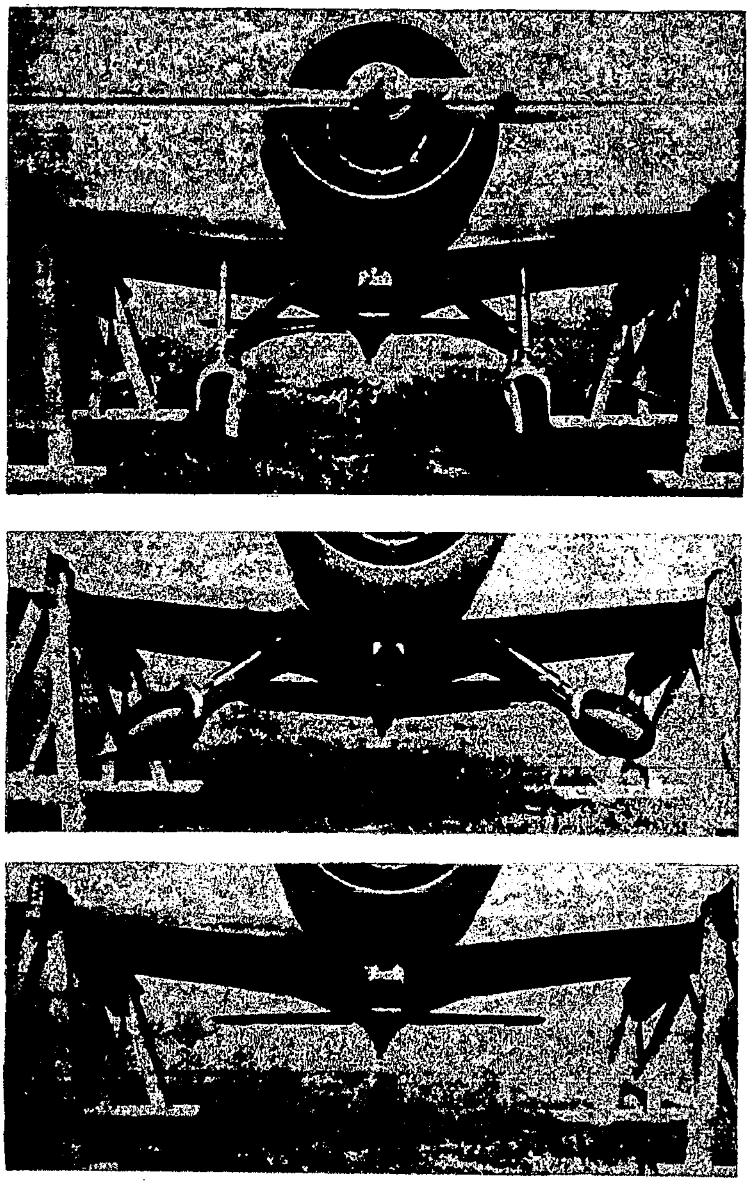


Figure 8.- Landing gear of the Potez 53 airplane.

Figure 9.- A wing-fuselage joint.

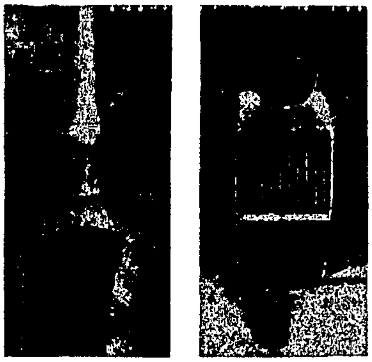
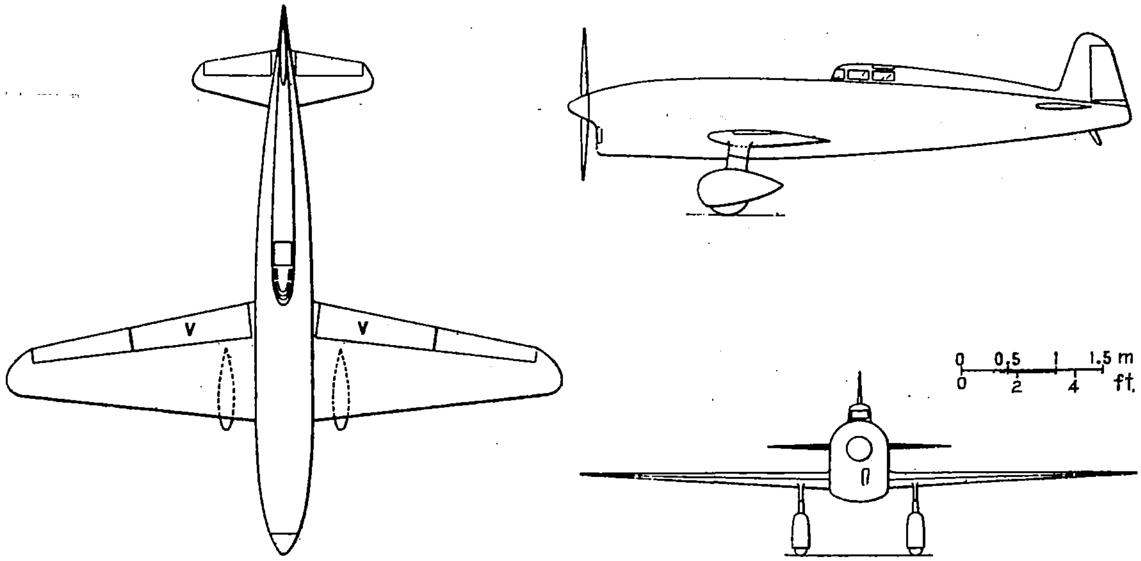


Figure 10.- Landing gear and radiators.



Span 6.80 m (22.31 ft.) Wing area 7. m^2
Length 6.87 " (22.54 ") (75.35 sq.ft.)
Height 1.88 " (6.17 ")

Figure 12.- General arrangement drawing of the Caudron 360 airplane.

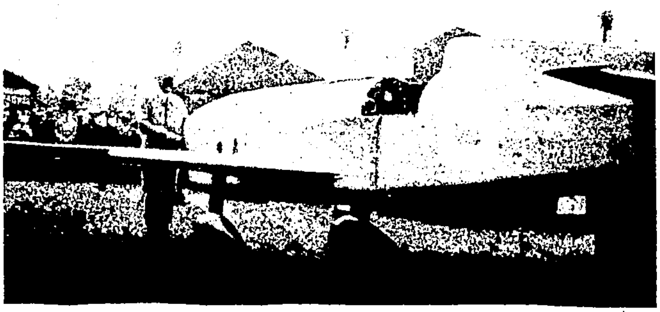


Figure 13.- The Caudron 360 in line for flight.

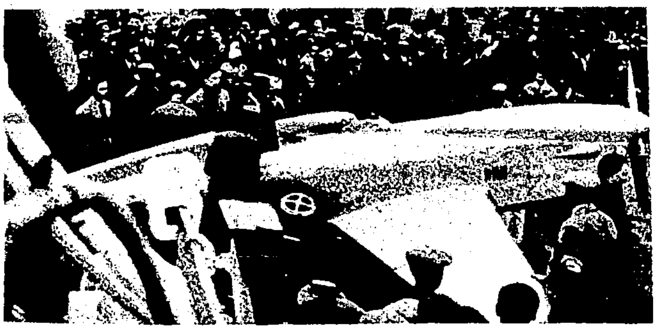


Figure 14.- The Caudron 360 being refueled.

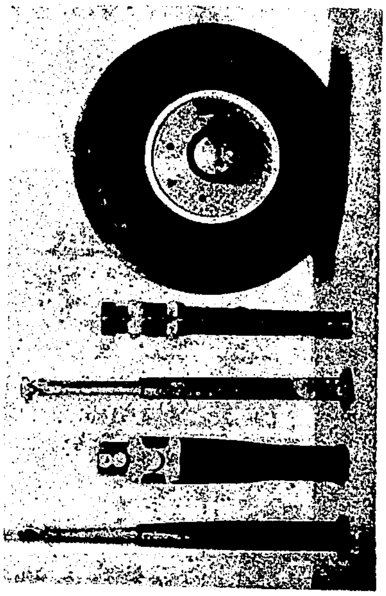


Figure 15.- Elements of landing gear.

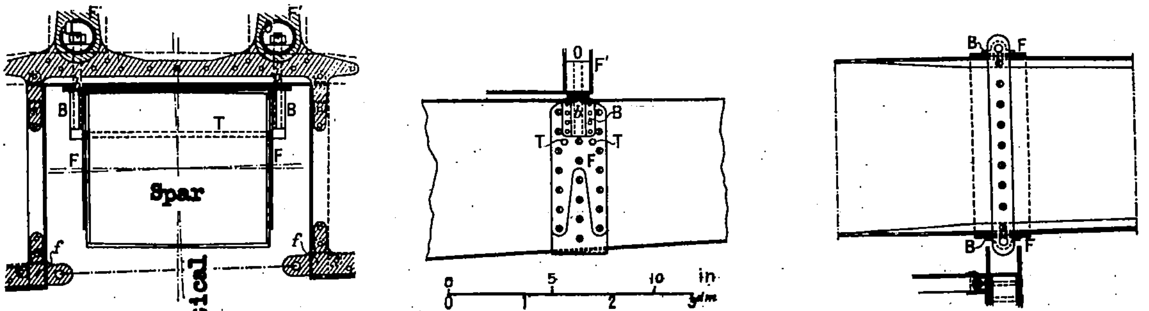


Figure 16.- Spar-fuselage attachment.

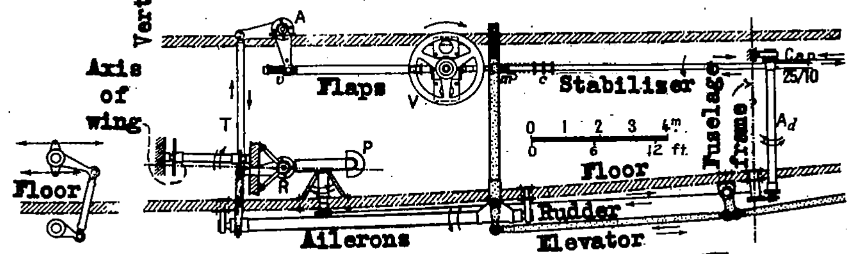


Figure 17.- Controls of Caudron 360

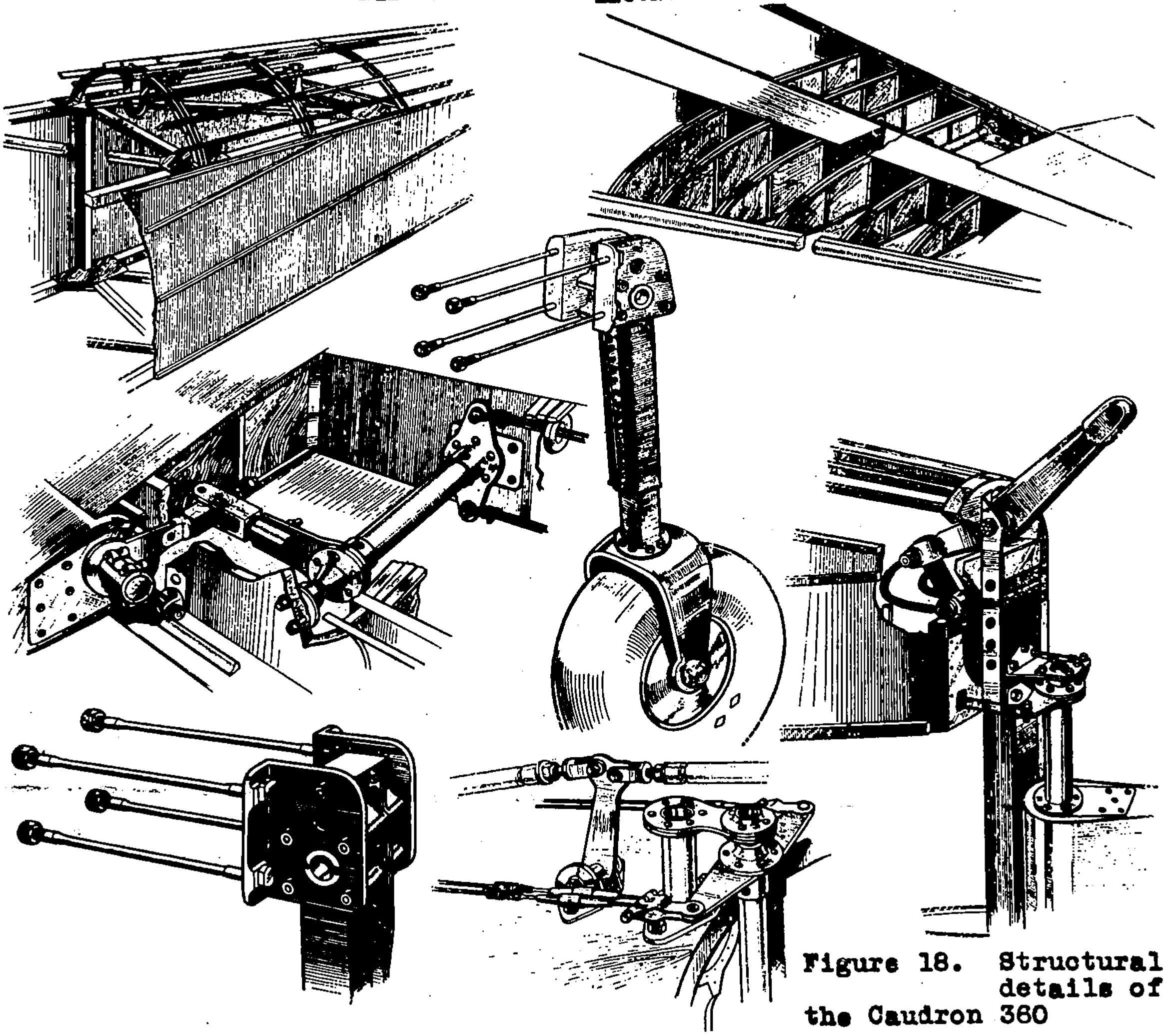


Figure 18. Structural details of the Caudron 360

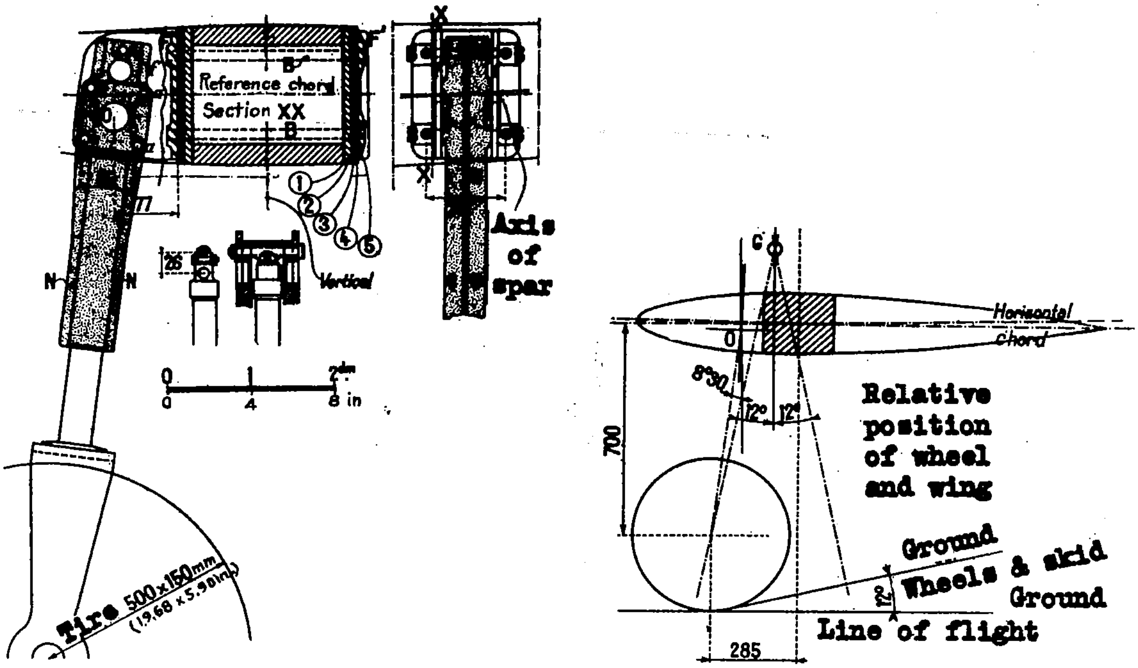


Figure 19.- Mounting of landing gear on spar.

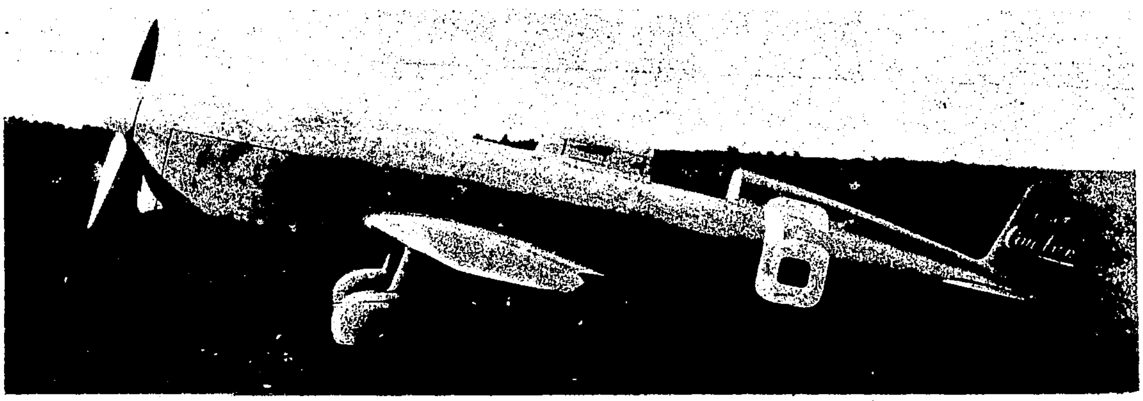


Figure 20.- Side view of the Caudron 362.

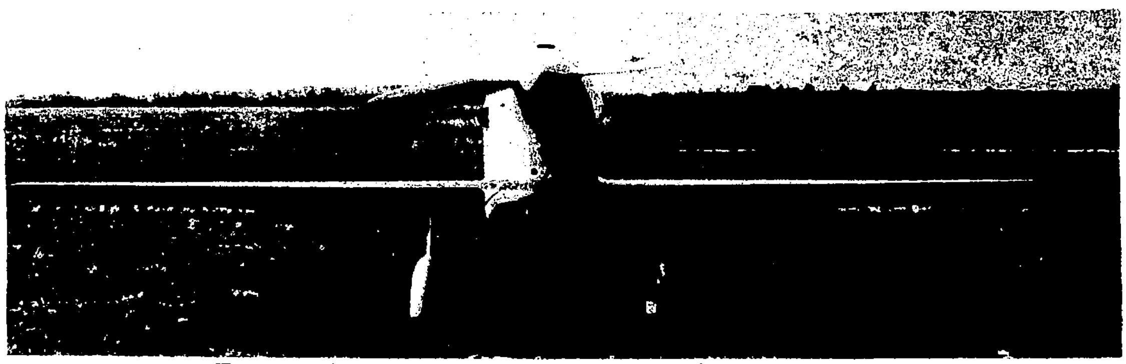
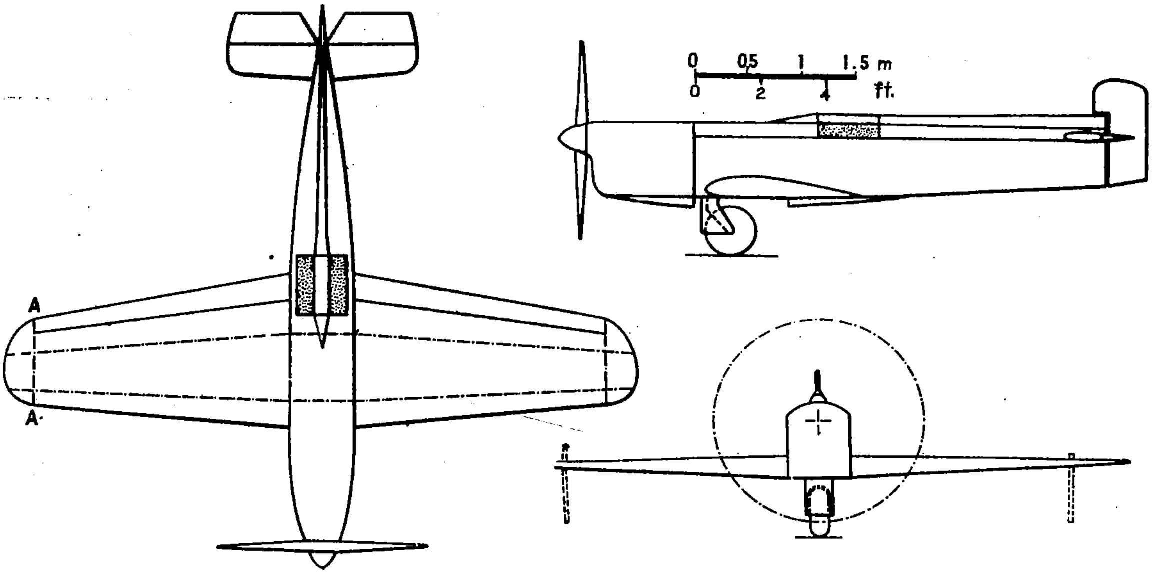


Figure 21.- Front view of the Caudron 362.



Span	5.98 m (19.62 ft.)	Wing area;	6.26 m² (67.38 sq.ft.)
Length	5.50 " (18.04 ")		
Height	1.35 " (4.43 ")	165 hp Renault engine.	

Figure 22.- General arrangement drawing of the Farman-Renault airplane.

Figure 23.- View of the Farman-Renault airplane.

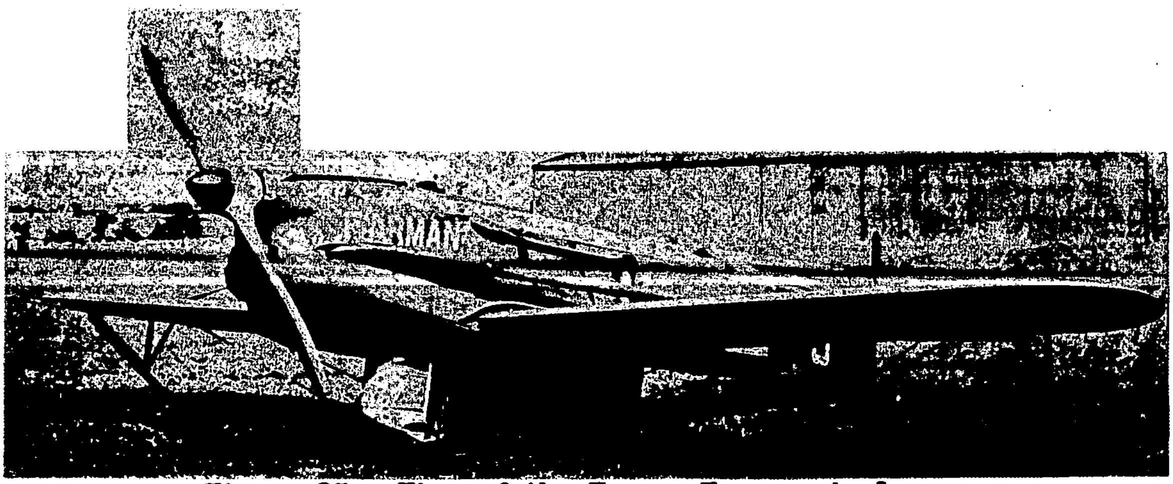
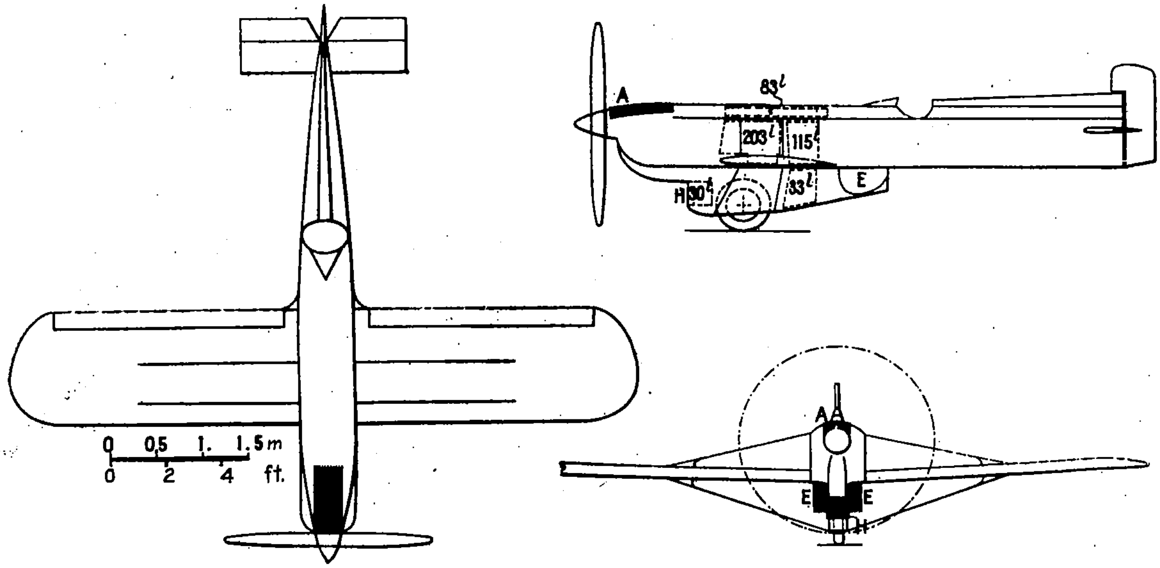


Figure 25.- View of the Farman-Farman airplane.

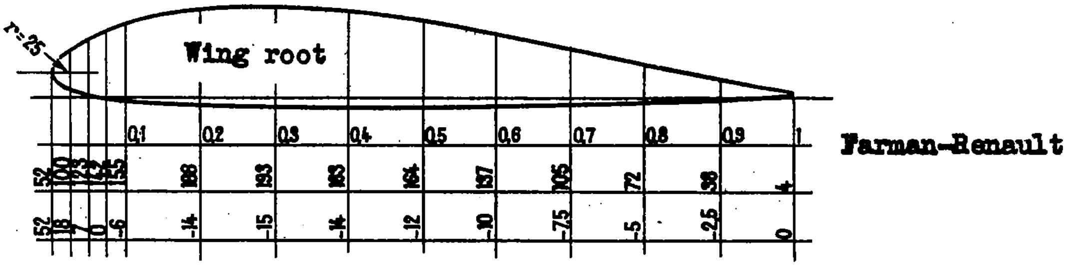


Span 8.10 m (26.57 ft.)
Length 6.91 " (22.67 ")
Height 1.53 " (4.99 ")

Wing area; 9.31 m² (100.21 sq.ft.)

Farman 400 hp engine.

Figure 24.- General arrangement drawing of the Farman-Farman airplane.



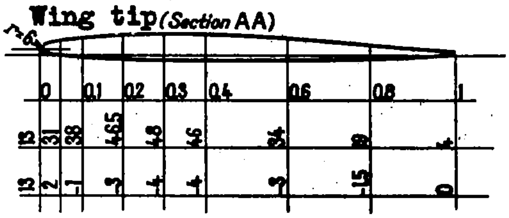
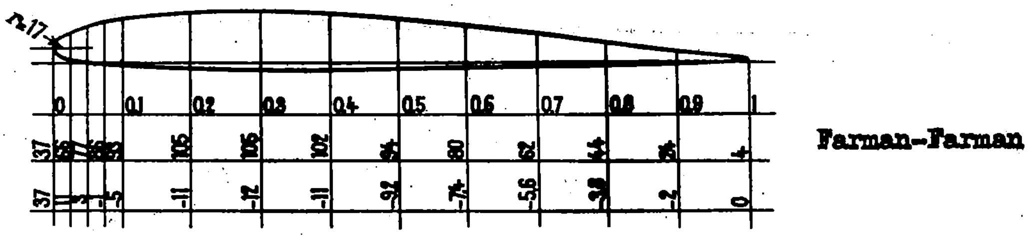


Figure 26.- Wing sections used on the Farman airplanes.



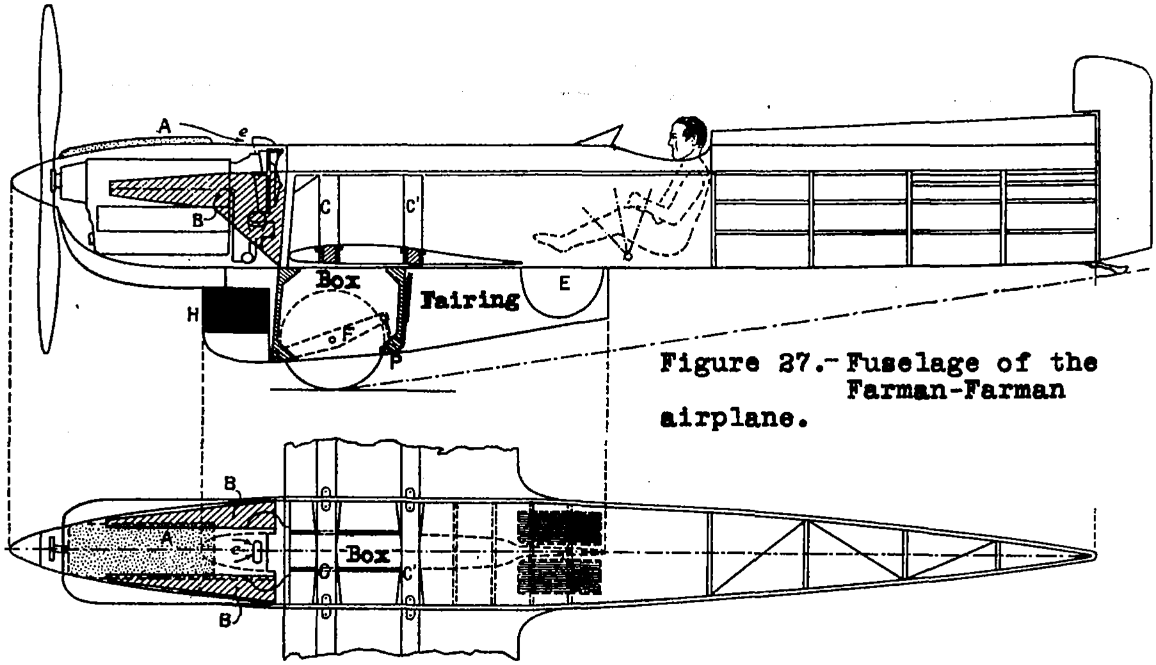


Figure 27.- Fuselage of the Farman-Farman airplane.

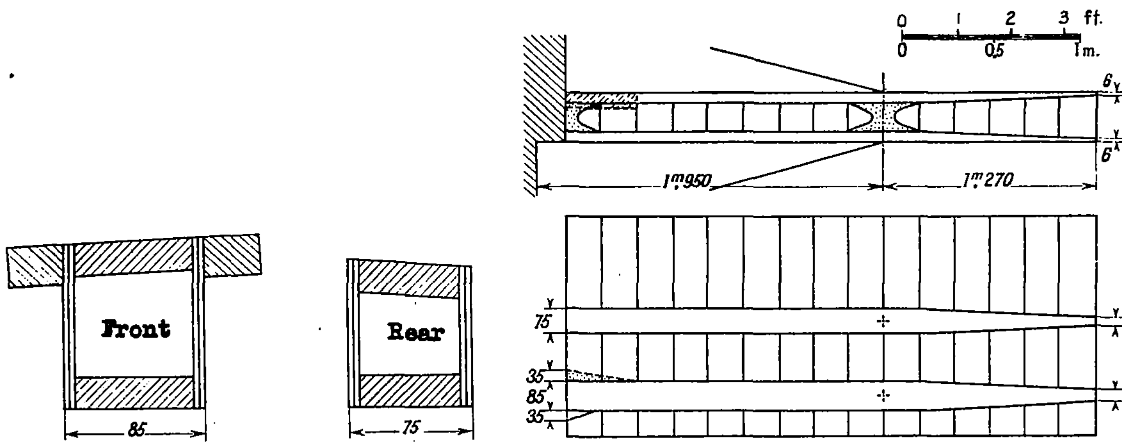


Figure 28.- Wing of the Farman-Farman airplane.

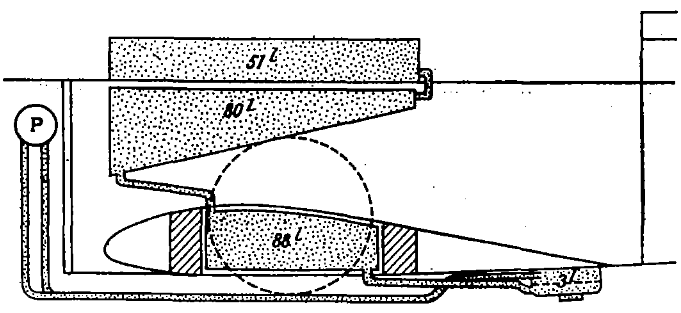


Figure 29.- Fuel system of the Farman-Renault.

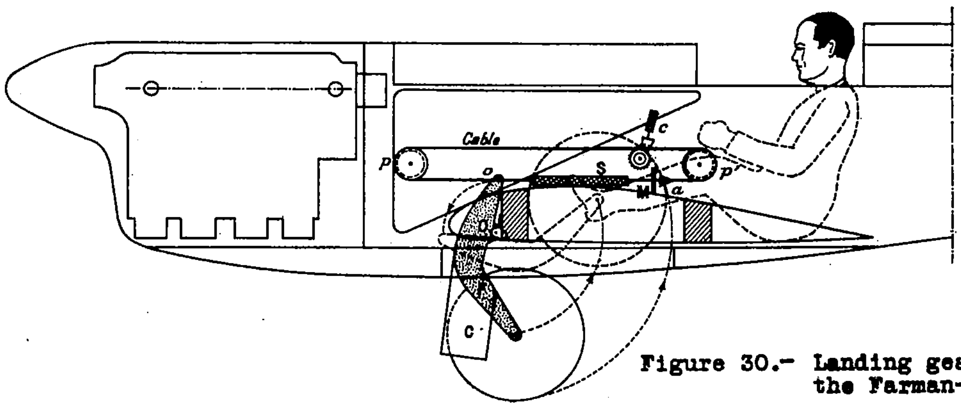


Figure 30.- Landing gear of the Farman-Renault.

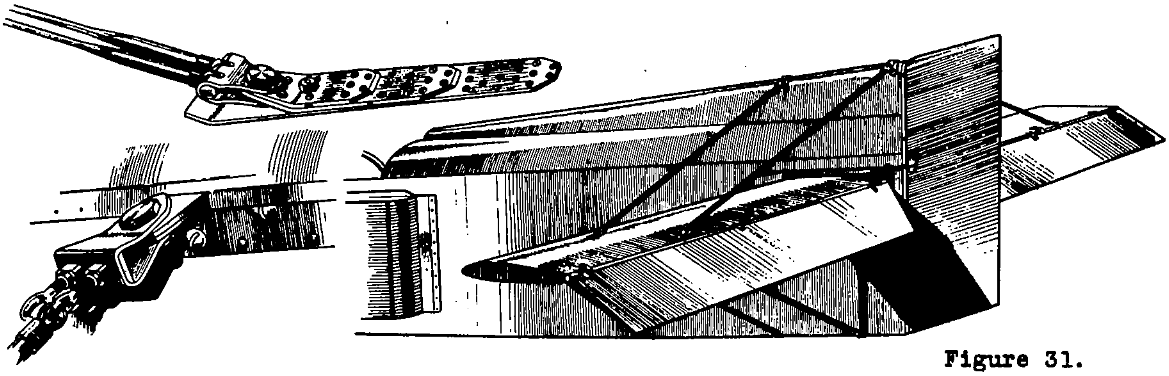


Figure 31.

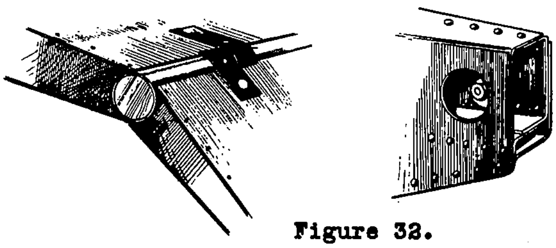


Figure 32.

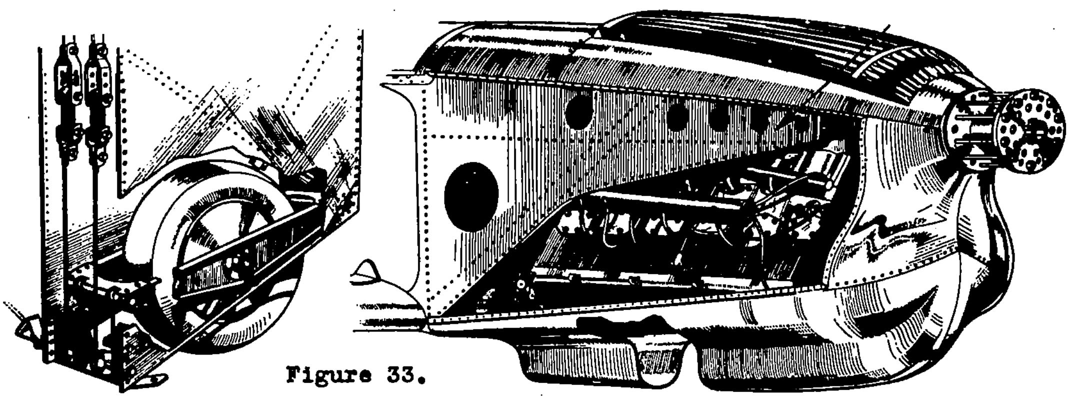
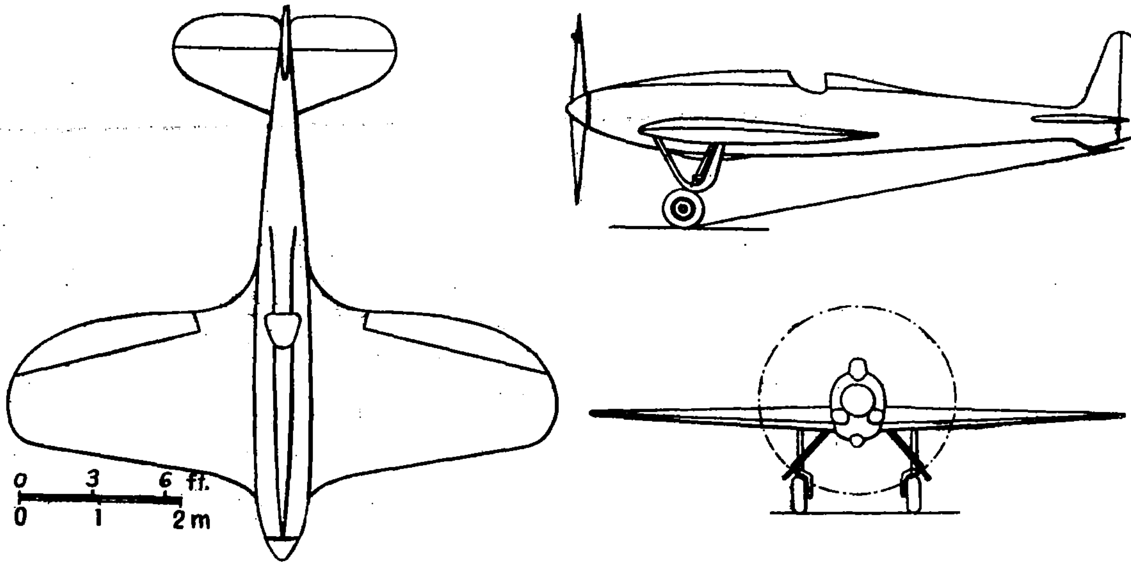


Figure 33.

Figures 31,32,33.- Structural details of the Farman-Farman airplane.



Span 6.65 m (21.82 ft.) Wing area; 10.6 m^2 (114.1 sq.ft.)
Length 7.16 " (23.49 ")
Height 2.64 " (8.66 ")

Figure 34.- General arrangement drawing of the Kellner-Bèchereau 28 V.D. airplane.

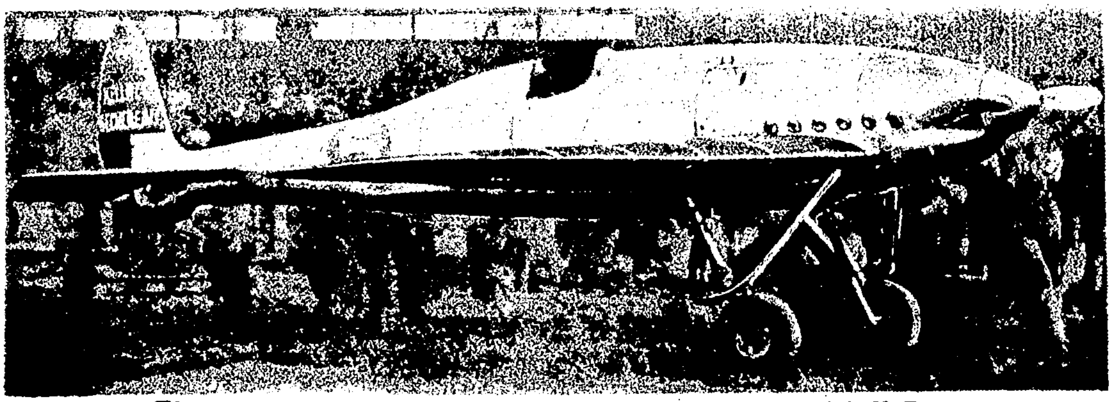


Figure 35.- View of the Kellner-Béchereau 28 V.D.

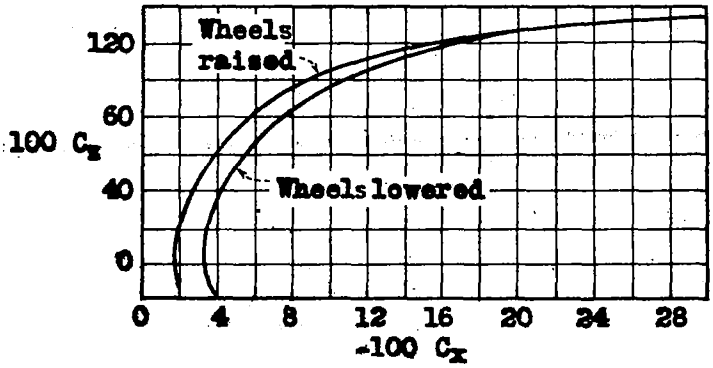


Figure 36.- Polars of the Kellner-Béchereau 28 V.D.

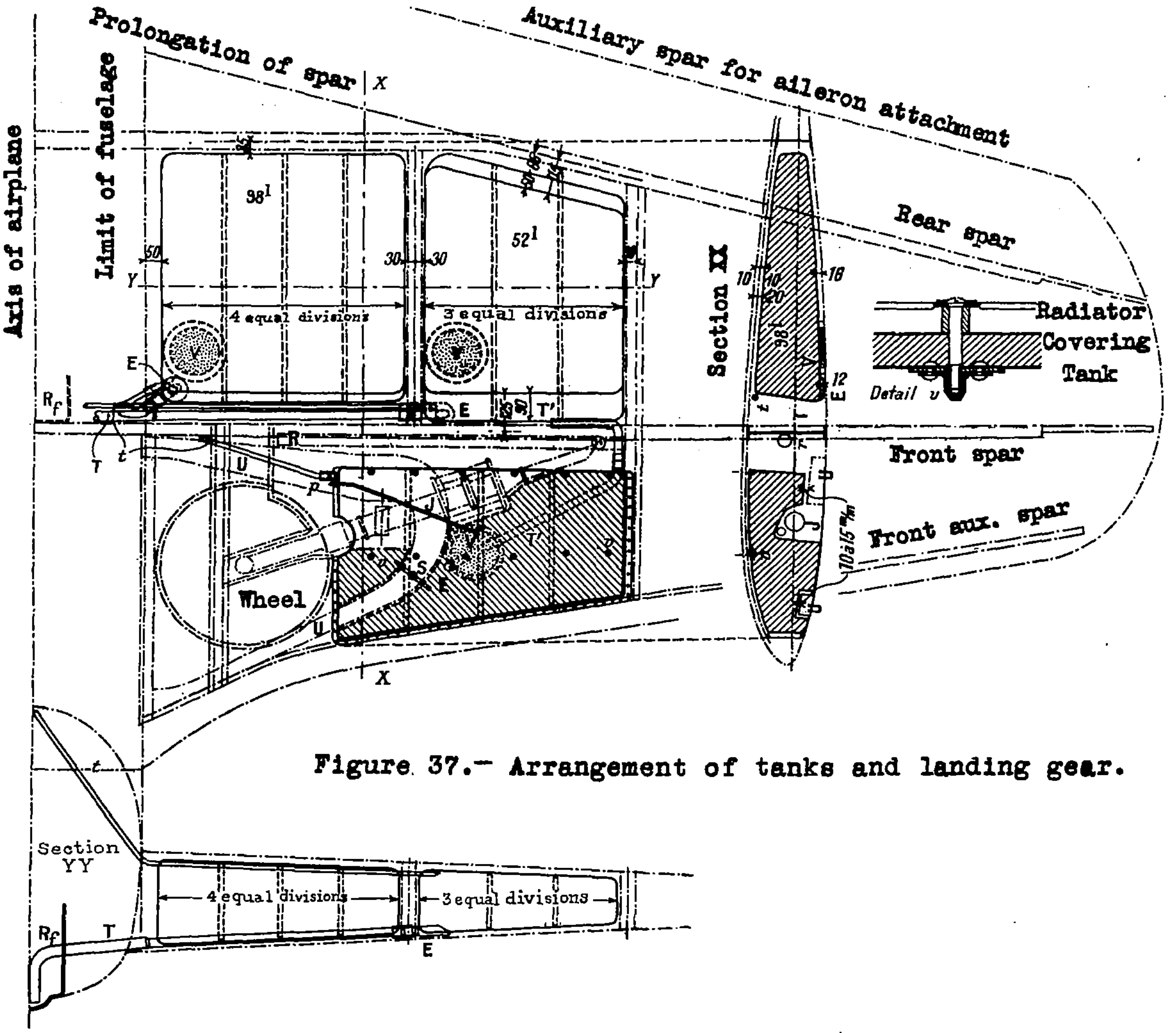


Figure 37.- Arrangement of tanks and landing gear.

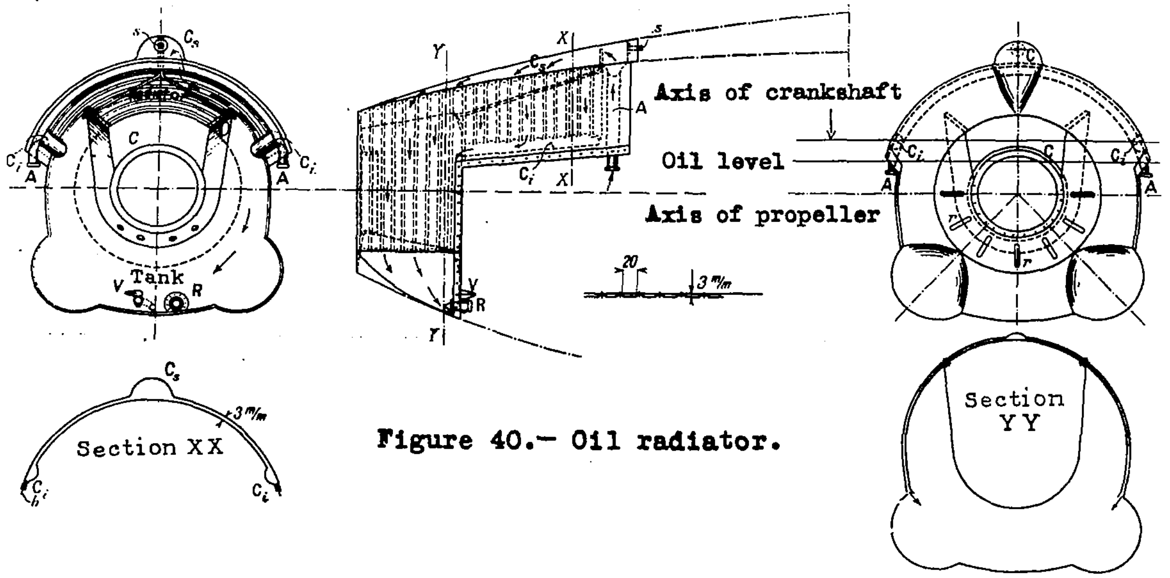


Figure 40.- Oil radiator.

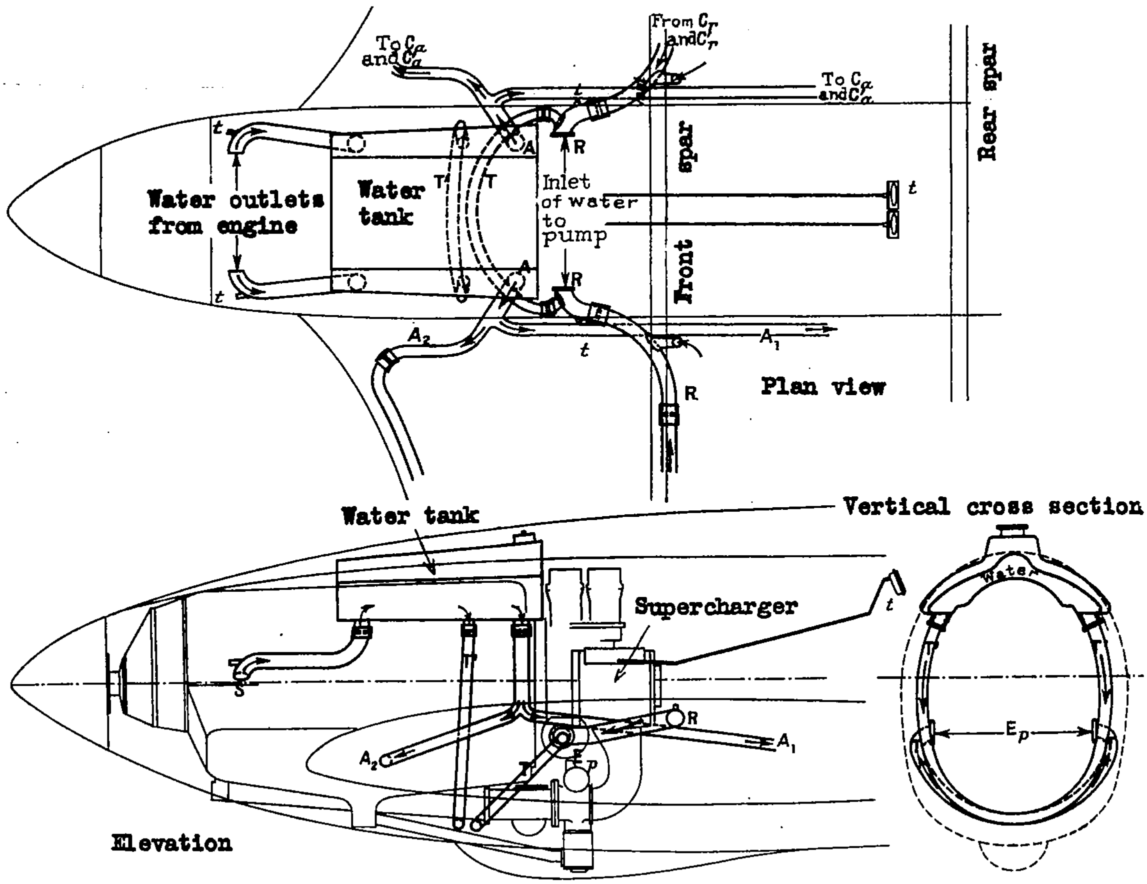


Figure 38.- Water circulation in fuselage.

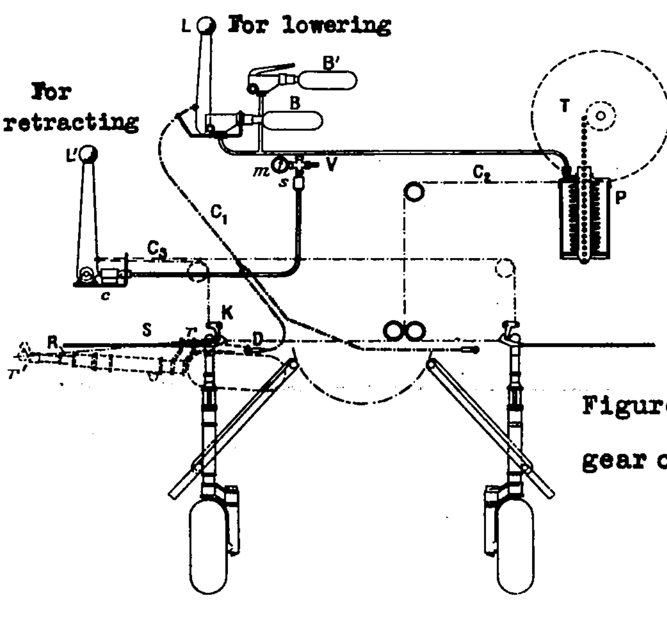
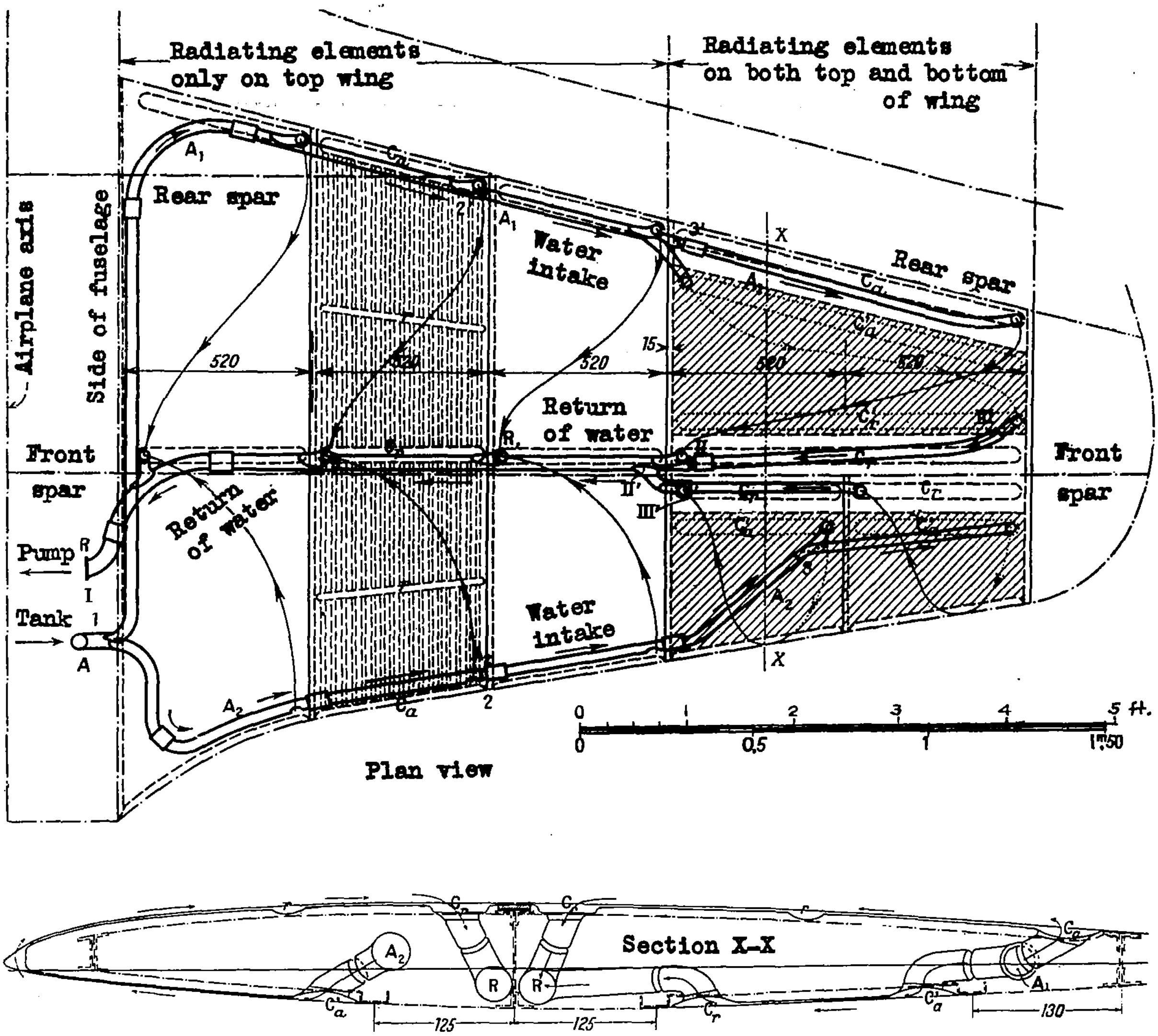


Figure 47.- Retractable landing gear of the K.B. 28 V.D.



Channel of top radiator..........................
Location of bottom " ....
Collector of top " (C_a or C_r)..............
" " bottom " (C'_a or C'_r)..............
Connection between tubes of different diameter.
(Arabic figures, water intake. Roman, return)..
Radiator collector connections..............
Direction of water circulation in tube.........
Circulation in radiator - top..................
" " " - bottom...............
Lines of force and contours of airplane.......

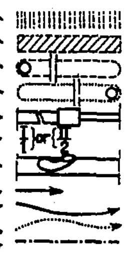


Figure 39.- Water circulation in wing

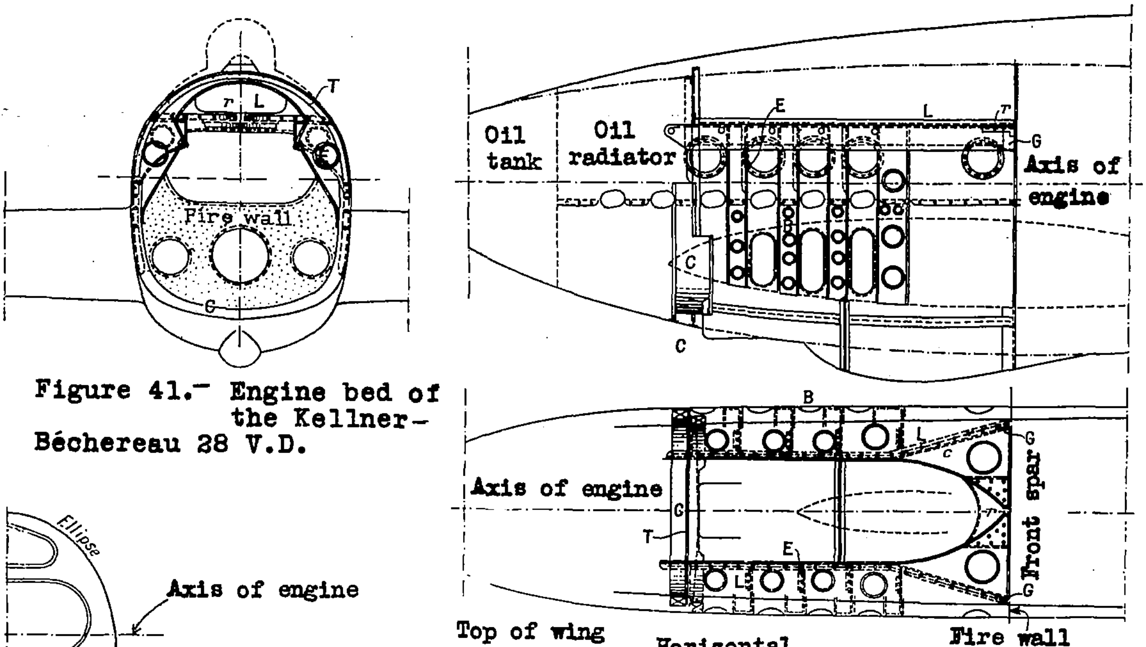


Figure 41.- Engine bed of the Kellner-Béchereau 28 V.D.

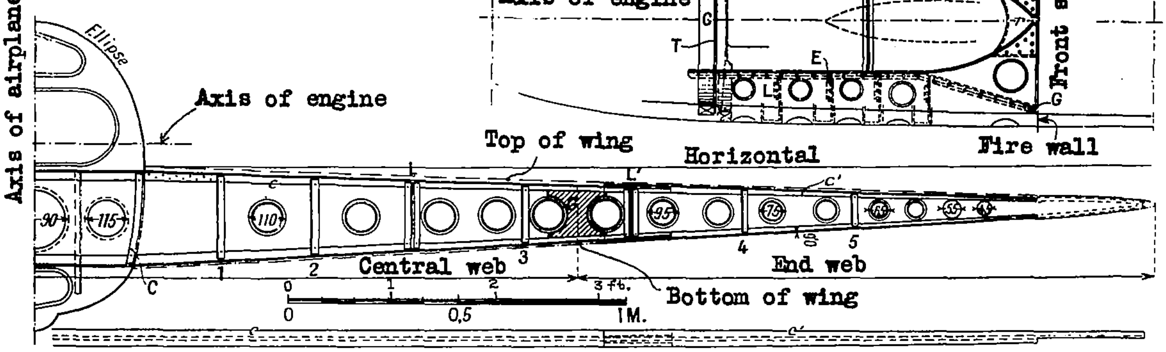


Figure 42.- Span structure.

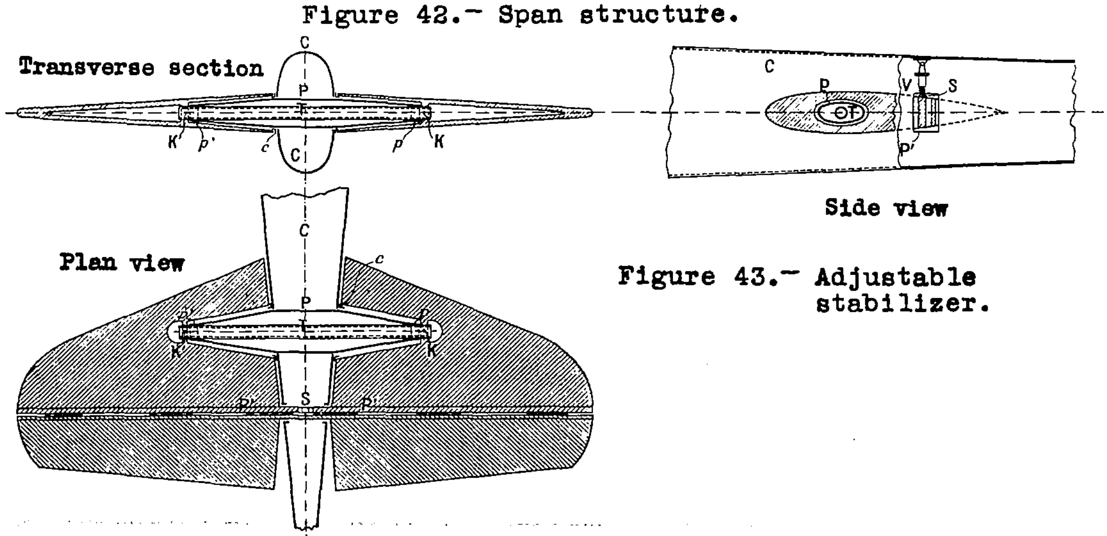


Figure 43.- Adjustable stabilizer.

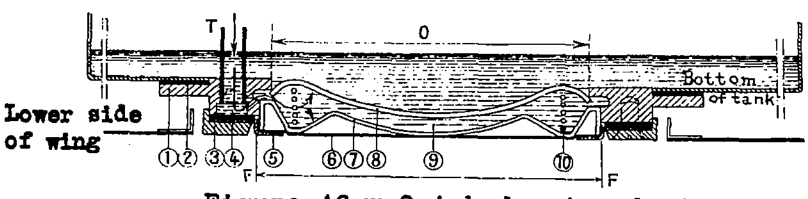


Figure 46.- Quick dumping device.

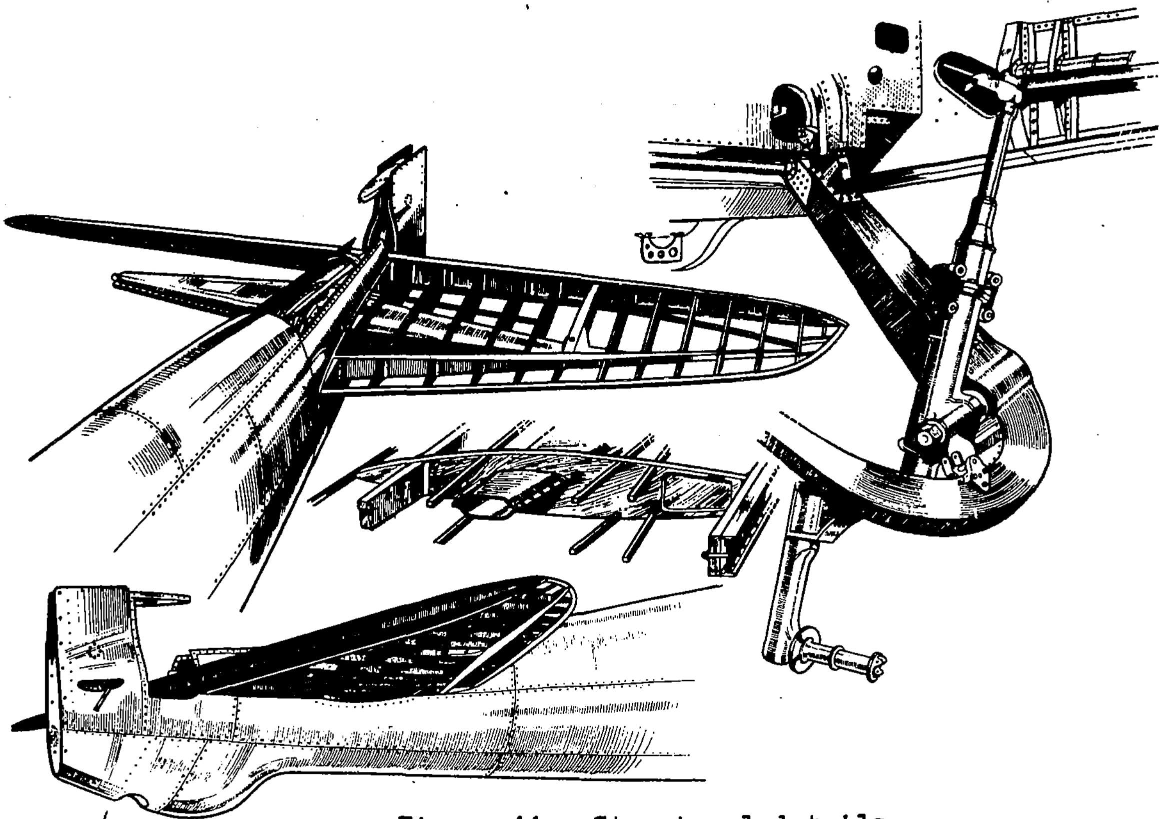


Figure 44.- Structural details of the K.B. 28 V.D.

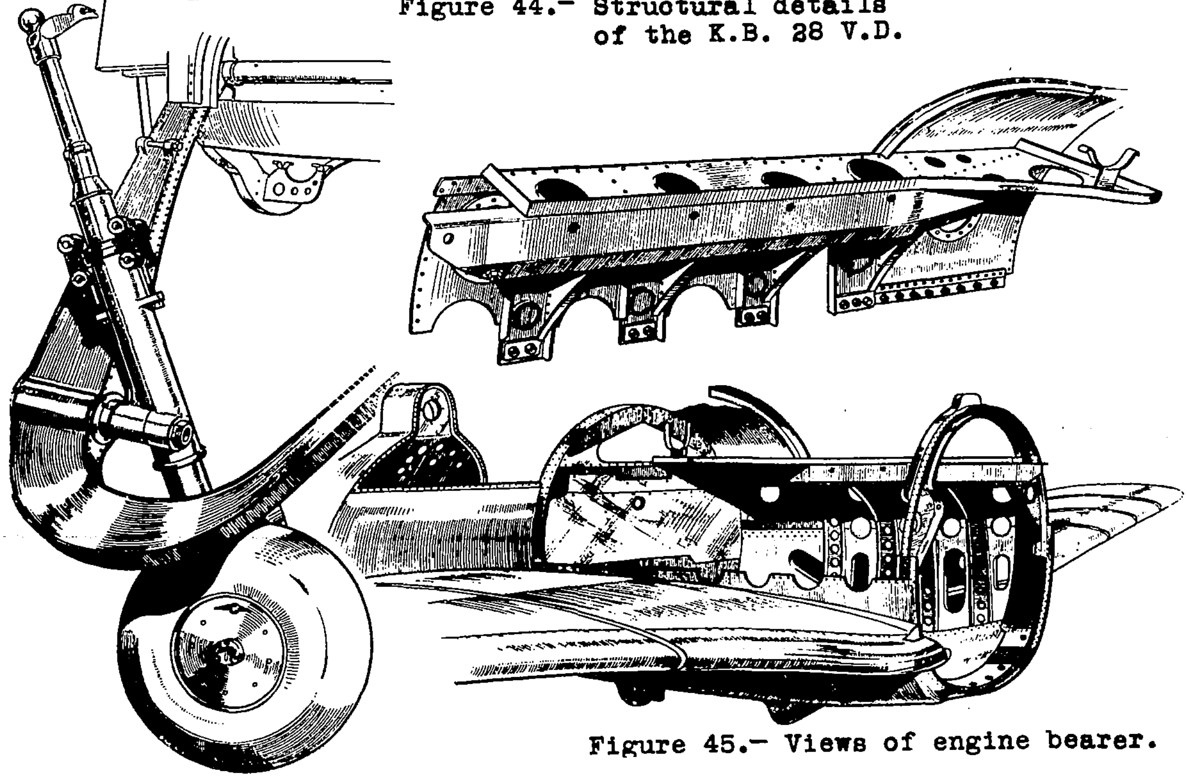


Figure 45.- Views of engine bearer.

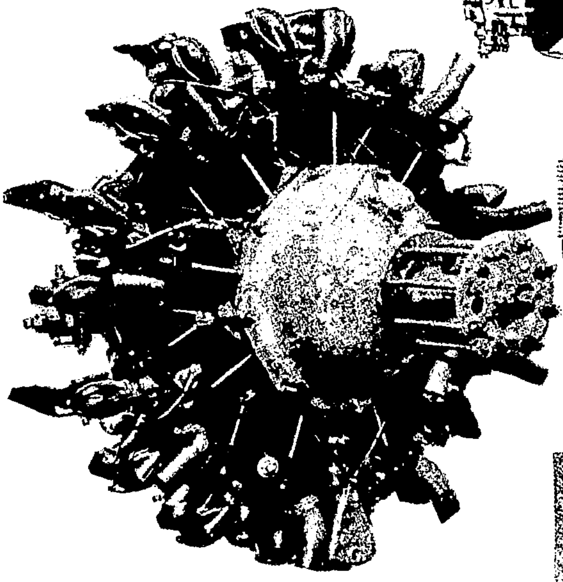


Figure 48.-The Potez 9B engine.

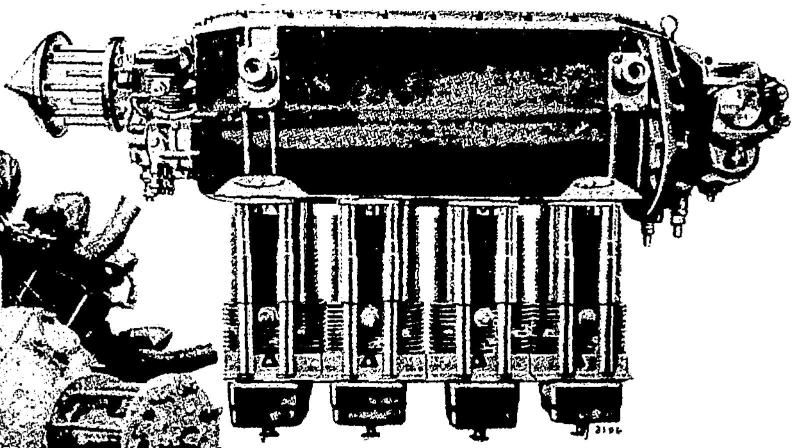


Figure 49.-The Renault "Bengali" engine.

Figure 51.-Side view of the Regnier engine.

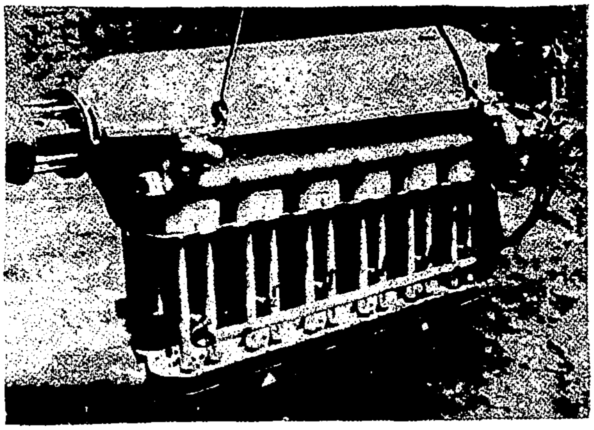


Figure 52.-Side view of the Regnier engine.

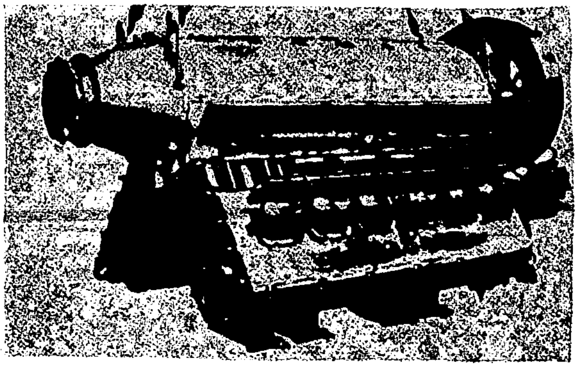


Figure 53.-The Farman 12 B.R.S. engine.

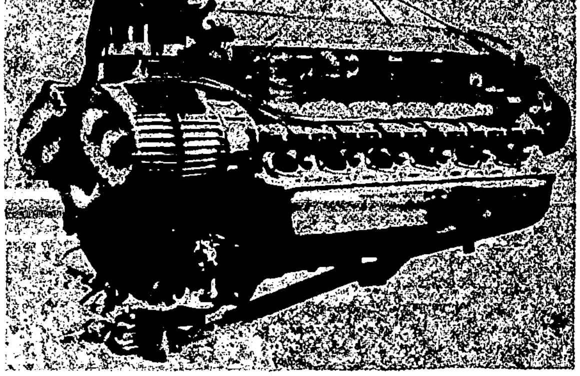


Figure 55.-The Delage 12 C.E.D. I.R.S. engine.

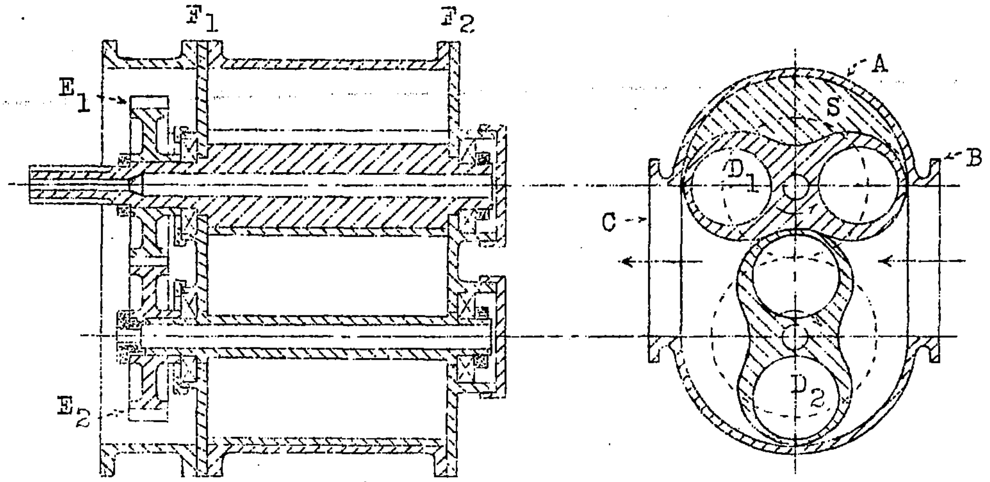


Figure 56.-Delage 12 G.V.I.S. supercharger.

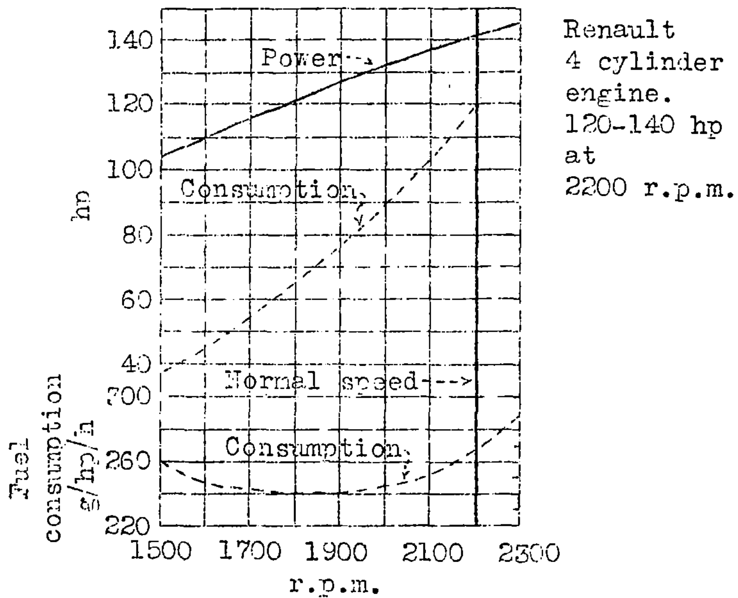


Figure 50.-Power and fuel-consumption curves of Renault-Bengali engine.

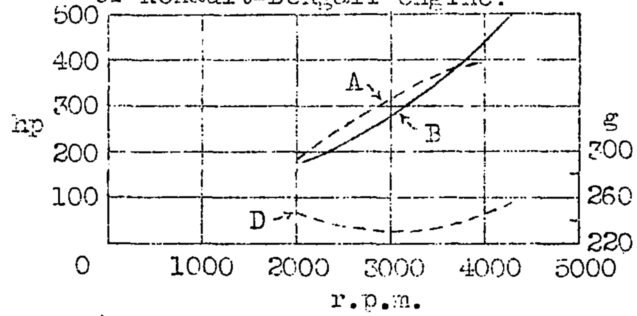


Figure 54.-Power and fuel-consumption curves of the Farman 12 B.R.S. engines.