ABSTRACTS.

Outline of History of Aviation Engine Production.

About the time of the American declaration of war a commission was sent abroad to make extensive investigation into the manufacture of internal combustion engines. The best high powered engines were considered to be the Rolls-Royce and Loraine Dietrich, the former not adapting itself to American methods of manufacture, and the latter not being completely demonstrated or accepted at the time. It was decided to design a distinctive American engine (the "Liberty") developing approximately 200 h.p. with eight cylinders and 300 h.p. with 12 cylinders.

In August, 1917, the author was put in charge of the production department, and the real work of producing aeronautical engines begun. These fell into three headings:—

1. *Elementary Training.*—Curtiss OX. 90 h.p., A—7—A, 4-cylinder 100 h.p., and the Hall-Scott.
2. *Advance Training.*—Gnome 110 h.p., the Le Rhone 80 h.p., and the Hispano-Suiza 150 h.p.
3. *Combat.*—The only one available for American manufacturing purposes was the "Liberty."

Development of Liberty 12.

The Liberty 12-cylinder engine was originally designed to produce approximately 330 h.p., weighing 765 lbs. without water and oil. By readjusting parts the engineers stepped up the h.p. to 375, with the result that certain of the parts would not stand the strain, notably the crankshaft, and production was consequently delayed. In the summer of 1918 an increase of power up to 400 h.p. was required, and the engine was re-designed, giving approximately 440 h.p. with a weight of 860 lbs. The resulting strain placed on all the parts of the engine was too great, and it became necessary to enlarge and strengthen crankshafts, connecting rods, bearings, etc., etc., together with adjacent parts. The metallurgical specifications had to be changed with corresponding modifications in the methods of the steel mills, and in increasing the size of the parts all jigs, tools and fixtures in the machine building plants, the parts factories, forging shops, etc., were rendered obsolete, and new equipment had to be designed.

The changes in the engine arranged themselves into three groups.

(*a*) *Design.*—In this there were but two changes. One was the oil system which was changed from so-called scupper feed to forced feed, the latter system being fool-proof, and the other was an alteration in one part of the connecting rod to allow the rod sufficient play without cracking.

(*b*) *Increase of Power.*—On two occasions. These were the results solely of the demands of the aviation authorities.

(*c*) *Manufacturing Limits.*—These are of the usual type.

The best known engine comparable with the Liberty is the Rolls-Royce, the most prominent English engine. This developed 100 h.p. less and weighed equivalent to 100 h.p. less than the Liberty.

In the month of October more Liberty engines were produced than the total production of engines in England and France for any month during the four years of war. (H. H. Emmons, "Aerial Age Weekly," Dec. 9, 1918.)

L-W-F Model G-2 Fighting Aeroplane.

The author, who is the chief engineer of the L-W-F Engineering Co., claims that the G-2 type is one of the most successful of American two-seater tractor aeroplanes. Its general characteristics may be judged from the following details:

Overall width: 41 ft. $7\frac{1}{2}$ in.
,, length: 29 ft. $1\frac{1}{4}$ in.
,, height: 9 ft. $4\frac{3}{8}$ in.
Tread of wheels: 5 ft. 4 in.
Wheels: 26 in. × 4 in.

Wing cure, L-W-F No. 1 (modified R.A.F.6 with less camber), upper and lower wings.

Incidence: Lower wing, 0°; upper wing, +1°.
Decalage, 1°. Chord 80 in. upper and lower.
Dihedral, 0°. Gap 72 in., nose to nose on vertical line with body horizontal.
Backsweep, 0°. Stagger $7\frac{1}{8}$ in. (positive).
Span: Upper wing, including ailerons, 41 ft. $7\frac{1}{2}$ in.; lower wing 38 ft. $5\frac{3}{4}$ in.
Aspect ratio: Upper wing, including ailerons, 6.3; lower wing, 4.78; average, 5.54.
Total supporting area (including ailerons), 515.54 sq. ft.
Net area of main wings (not including ailerons), 465.46 sq. ft.
,, upper wings (including ailerons), 268.78 sq. ft.
,, lower wings, 246.76 sq. ft.
,, upper wings (not including ailerons), 218.70 sq. ft.
Total area of one aileron, 25.04 sq. ft.; balanced area, 1.95 sq. ft.
,, both ailerons, 50.08 sq. ft.
,, one elevator, 13.85 sq. ft.; balanced area, 1.5 sq. ft.
,, both elevators, 27.70 sq. ft.
,, rudder, 12.65 sq. ft.; balanced area, 1.31 sq. ft.
,, horizontal stabiliser (both sides), 29.15 sq. ft.
,, vertical stabiliser, 5.21 sq. ft.

Controls and Control Surfaces.

Dual stick control. Aileron wires enclosed in wings. Horizontal stabiliser double camber with centre line set at 0° to thrust line.
Elevator curve included in stabiliser curve.
Aileron curve included in wing curve extended.
Rudder and vertical stabiliser flat.

Power Plant.

Liberty 12-cyl. engine, direct connected, 435 h.p. at 1,700 r.p.m.
Air screw, 2-blade, tractor, diameter 9 ft. 7 in., average pitch 7.38 ft.
Propeller turned 1,800 r.p.m.

Weights.

Case 1.—Weight of complete machine (empty with gun mounts, but no guns), 2,675 lbs.

Case 2.—Equipped as a fighter:—

Weight, light	2,675.5 lbs.
90 gal. gas	553.5 ,,
14 gal. water	118 ,,
6 gal. oil	44 ,,
Ammunition	150 ,,
7 machine-guns	152 ,,
2 men	330 ,,
Total full load	4,023 lbs.

Case 3.—Equipped as a bomber:—

Weight, light	2,675.5 lbs.
120 gal. gas...	752 ,,
6 gal. oil	44 ,,
14 gal. water	118 ,,
Ammunition	150 ,,
7 machine-guns	150 ,,
Armour	66 ,,
4 bombs, rack and release	592 ,,
2 men	330 ,,
Total full load	4,879.5 lbs.

Loadings (based on 515.54 sq. ft. area and 435 h.p.).

Case 1.—	Loading per sq. ft.	5.185 lbs.
	,, ,, horse power ...	6.15 ,,
Case 2.—	,, ,, sq. ft.	7.82 ,,
	,, ,, horse power ...	9.25 ,,
Case 3.—	,, ,, sq. ft.	9.47 ,,
	,, ,, horse power ...	11.22 ,,

Performance.

High speed at 10,000 ft. ...	130 m.p.h.	(loaded as in Case 2).
,, at low altitude ...	138 ,,	,, ,,
Low speed (landing)	50 ,,	,, ,,

Climb: Case 1.—10,000 ft. in 7 min. 28 sec.
,, ,, 2.—10,000 ft. in 9 min. 18 sec.
,, ,, 3.—10,000 ft. in 14 min. 45 sec.

Endurance.

Four hours at full speed. (G. D. Mitchell, "Aviation," Dec. 1, 1918.)

German Twin-Engined Bombers.—Gotha G.V. and G.V.a.

The article points out the differences between the Gotha G.V. and the G.III., described in "L'Aerophile" of Feb. 1-15, 1918.

There is a slight decrease in span, a slight increase in the chord of the wings, and the wing area is somewhat less. Ailerons are fitted to both planes, but only those of the upper are balanced and project beyond the main wing tips. The construction of the wings is identical with that of the wings of G.III. The interplane struts are steel tubes, and are streamlined by means of wooden sheaths.

The fuselage of the Gotha G.III. consists of longerons and wooden frames, covered with fabric; but in the G.V. plywood is employed as a covering. Two large tanks occupy the whole width of the fuselage where the wings are attached. In front of these tanks are two seats, side by side, one for the pilot and one for a passenger who has easy access to the machine-gun pit right forward. The machine-gun pit behind the tanks is isolated from the other two seats.

The motors are two 260 h.p. Mercédès as in G.III., but the engine nacelles are lightened and their resistance reduced by substituting a steel tube structure for the former erection of wood and steel, and fairing off neatly with metal sheets.

The rubber cord shock absorbers for the under-carriages have been replaced by spiral springs located within the tubular struts.

G.V. was designed to carry fuel sufficient for a flight of $7\frac{1}{4}$ hours at normal bombing heights.

G.V.a differs mainly in the fitting of a biplane tail, a feature now common to all large German machines. In the G.V.a also the area of the alierons has been

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extended by adding a narrow piece along the trailing edge of each aileron. ("L'Aerophile," Nov. 1-15, 1918.)

Loening's Monoplane.

This two-seater is said to develop 145 miles per hour with full military load, including 4 guns, and to have a ceiling of 25,000 ft. with two passengers. It is equipped with a 300 h.p. American-Hispano engine. For the purposes of production, its design has been exceedingly simplified, requiring only one-tenth the number of parts of the ordinary European design. The wire stays have been eliminated and the monoplane structure strengthened without the loss of its advantage in speed. In official trials it climbed 10,000 ft. in 8 minutes. It carries practically double the load of the latest Sopwith and Spad machines with an even greater climbing speed. For the pilot the visibility is so improved by the wings being mounted on a level with the pilot's eyes that there are practically no blind spots. The machine has a speed range of over 100 miles per hour, carries the heaviest load per sq. ft. that has ever been successfully carried, and yet has a low landing speed. Its span is 32 ft. with a 7 ft. chord, and it weighs 13,000 lb. The body is deep and constructed of veneer bulkheads, like the hull of a torpedo boat destroyer. The wings are of the usual wood construction and the large bracing struts a combination of steel tube and wood. A novelty of the machine is the fastening of the wing to the top longeron of the body. ("Air Service Journal," Dec. 14, 1918.)

Hispano-Suiza Aeroplane Engines.

Four models, designated as A, I, E and H, are stated to have been produced in the United States. After pointing out the main differences between the various models, some account is given of Model I, which is described as typical of the entire series.

Model I is a fixed cylinder, water-cooled engine with eight cylinders, arranged in two blocks of four, which are set at an angle of 90°, the engine developing 150 h.p. at 1,450 r.p.m. at sea-level. It has a bore of 120 m.m. and a stroke of 130 m.m., and is the same as Model A except that it has the new straddle fork type of connecting rod, a different magneto drive and timing, and some slight modifications in the piston mounting. Its compression ratio is 4.72 to 1. Model E is more powerful, developing 180 h.p. for an additional 300 r.p.m., and a compression ratio of 5.33 to 1; while Model H, which has a bore of 140 m.m. and a stroke of 150 m.m., develops 300 h.p.

The general characteristics and two sectional diagrams of Model I are given. The new straddle fork type of tubular connecting rod is made from heat-treated steel, being forked at the bottom and bolted to a two-piece bronze box lined with babbitt, two bolts being used at each side. The bronze box bears directly on the crankshaft, and the other connecting rod bears on the outer and central portion of the bronze box, the shaft itself working between the forked ends of the straddle rod. Attention is also drawn to the cast aluminium pistons, $\frac{3}{8}$ in. thick at the head tapering to $\frac{1}{8}$ in. at the bottom; to the overhead cam shafts and the lack of rocker arms to the valves; to the double eight-cylinder magnetos; to the pressure lubrication system; to the single Stromberg carburetter; to the fuel system; and to the water pump capacity of 100 litres per minute, at an engine speed of 1,450 r.p.m. ("Aviation," Dec. 1, 1918.)

Problems of Crankshaft Design.

This paper is confined to a study of the effect upon crankshaft design of the three most important groups of forces:—The pressures due to the gaseous mixture, the inertia forces, and the centrifugal forces. The smooth running and the life of the engine depend mainly on these three factors. The reciprocating

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masses linked to the crankshaft are considered as one mass concentrated at a point in the axis of the cylinder, and the inertia forces due to the angularity of the connecting rod are treated in the usual way.

As subjects for investigation, medium size, six and twelve-cylinder engines, both of the same cylinder volume and speed, 2,700 r.p.m., are chosen. Both engines are supposed to be similar in design and up to the same standard of construction, except that the six-cylinder engine is a vertical engine and the twelve-cylinder of the V type, with an angle of 60°. Diagrams giving centrifugal forces and combined gas and inertia forces due to a single cylinder acting on the crankpin for two revolutions—one complete cycle in the case of four-stroke cycle engines—show that these forces are much smaller in the twelve-cylinder, although quite analogous to those in the six-cylinder engine.

In the case of the twelve-cylinder engine, two single-cylinder engines act on one crankpin, and therefore, to get the resultant force on the crankpin, the forces due to each engine mutually inclined at 60° were added vectorially. Two diagrams giving the resultant force on the crankpin in the two cases show that the difference between the loads is not marked. The maximum in the case of the twelve is 4,040 lbs., and in the case of the six 4,800 lbs.

It is difficult to neutralise the effect of these forces by balance weights owing to the effect of the connecting rod, and although it is feasible in the case of the six-cylinder engine, it is almost impossible for the twelve. The diagrams reveal the fact that the forces are smallest in a horizontal direction, suggesting that the oil holes in the crankpin should be placed at right angles to the crank.

The design of the bearing is discussed with relation to the bearing pressure, mention being made of both Professor Goodman's and Beauchamp Tower's research works. To estimate the heating of the bearing, the rise in temperature is taken as a function of the work expended in friction, other things being supposed unaltered. The work expended in friction per second and per sq. in. of bearing surface is given by

$$\omega = pv,$$

where :—

ω = coefficient of friction;
p = specific bearing load, lbs. per sq. in.;
v = circumferential velocity of shaft, ft. per sec.

Guldner states that for stationary engines with white metal bearings, pv should not exceed 1,500 ft. lbs. per sec., but for well designed gas engines with forced lubrication a value not exceeding 17,000 ft. lbs. per sec. is permissible. In the cases given, $pv = 16{,}900$ ft. lbs. per sec. for the six-cylinder engine with a crankpin 2 in. long and $2\frac{1}{8}$ in. diameter, and 16,800 ft. lbs. per sec. for the twelve with a crankpin of the same diameter and 1-5/32 in. long per engine, or a total length of 2-5/16 in. These figures are for the average force during the cycle. In practice a twelve-cylinder engine runs slightly faster than the six, in which case the difference in crankpin length would be more pronounced, but the twelve-cylinder engine is superior to the six as regards maximum pressure. On the uphill runs at slow speeds the pressure is mainly due to the high explosion, but is nevertheless smaller than the average at high speed.

The design of the main bearings of a seven-bearing type is next considered. Two groups of diagrams are given, viz. :—(*a*) Main bearing load without balance weights, bearings I. and VII., bearings II., III., V. and VI., and bearing IV. (*b*) Main bearing load with balance weights, the diagrams being for the same groups as in (*a*). Although the average pressure is less with balancing, and a balanced shaft runs steadier than an unbalanced one in a balancing machine, the sudden fluctuations produced by the reciprocating masses are such as to counteract these advantages.

For the twelve-cylinder engine the bearing surface for the main bearings works out to about 15 per cent. greater than those of the six.

A rough estimate of the crankpin strength to resist the torque, etc., gives a safety factor of about 12 in the case of the six-cylinder engine where the maximum torque is about two and a half times the mean, but is as great as 20 for the twelve where the maximum torque is only 50 per cent. greater than the mean. The greatest trouble is the design of the crank cheek, which is calculated to be 15/16 in. for the six and 7/8 in. for the twelve-cylinder engine.

The two cases of three and seven-bearing shafts are next compared. Since the distance between the bearings in the former case is about two and a half times that of the second, and that the transverse deflection of a straight shaft varies as the cube of the length, it follows that in the case of the three-bearing shaft the deflection will be of the order of sixteen times that of the seven. The deflection due to the torque is 1.3 times that in the seven-bearing shaft. These defects cannot be overcome by stiffening up, but might be obviated by balance weights.

On discussing the explosive pressure of the engines, the total piston displacement for different engines is proportional to the cube of the bore with a constant stroke-bore ratio, and the explosive impulse is taken proportional to the square of the bore. Thus, for equal total piston displacement, the explosive impulse is about 1.5 times as large in the six as in the twelve-cylinder engine.

In conclusion, it is stated that to obtain satisfactory conditions, the oil supply to the bearings must be proportional to the work converted into heat. (Burkhurdt, "Aerial Age Weekly," Oct. 28, 1918.)

Working Process of Internal Combustion Engines.

It is implied in the text that this article is to form one of a series upon the subject. In the present instance a short historical survey is given of the development of internal combustion engines from the Lenoir engine to the Otto, Otto free piston, two-stroke cycle, and the Diesel engines of the present day. The cycles and the causes of heat losses, etc., are briefly discussed and illustrated by sketches of indicator diagrams. A review of the development of efficiency with time shows an increase of efficiency from 12 per cent. in 1878 to 34 per cent. in 1916 for the four-stroke cycle gas engine, and 26 per cent. in 1897 to 39 per cent. in 1918 for the Diesel. The comparison is based on the gas consumption per effective horse-power. In future contributions a study of the nature of the fuel utilised, the real process of combustion, and the experimental data on hand concerning it will be given. (E. H. Sherbondy, "Aerial Age Weekly," Nov. 25, 1918.)

Lateral Stability in Aeroplanes.

This article attempts to analyse the function of the dihedral angle in producing lateral stability in aeroplanes. The author does not mention or accept the reasoning usually given, but attributes the stabilising effect to a righting moment brought into play, as he considers, when the machine is rolled about the direction of flight. Since the lift on each wing is the same whatever the angle of roll, it follows that the resulting moment is zero. The moment given in the article is the moment of the two vertical components of the lifts on each wing, and is equal and opposite to the moment due to the horizontal components. The generally accepted theory states that a moment is produced through side-slipping, not through the angle of roll. (C. Levick, "Aerial Age Weekly," Dec. 9, 1918.)

Corrosion Prevention on Aircraft Metal Parts.

For iron and steel parts on aircraft, corrosion is stated to be best prevented by painting or by galvanising. For the latter the zinc should be preferably deposited up to a minimum thickness of 0.60 oz./ft.^{2} using the hot dip process, except for certain specially heat-treated steels or alloys, when the zinc plating process (cold galvanising) should be employed. Subsequent to plating an enamel or paint should be applied. Phospheric acid treatment or coating by tin or with tern plate are not considered desirable, because the salt process test shows marked corrosion within 5 to 24 hours compared with zinc-coated samples, which should be unaffected after 100 hours' continuous exposure.

To protect aluminium parts, "Spar Varnish" and "Naval Grey Enamel" are said to be very efficient. On Venturi tubes a thickness of approximately 0.0002 in. of Spar Varnish is recommended. (H. A. Gardner, "Aviation," Dec. 1, 1918.)

The Metal Airscrew.

A rough comparison between the respective merits and defects of wood and metal propellers is made in this article by the author, who has served as a captain in the Russian Army on the Eastern Front, and who claims that three out of seven metal airscrews which were made to his design operated successfully in service for over two years (1915-1917).

In the article attention is drawn to many of the known defects of wooden airscrews:—*e.g.*, changes of pitch due to atmospheric variations, lack of sufficient firmness to withstand blows from even small particles, the variable characteristics of the materials and the inability to preserve the adhesive properties of the glue, their high flexibility and the complications arising in their construction. To these defects the writer claims that metal airscrews are nearly exempt, adding that they may be constructed by pressing or stamping sheet metal with the various parts silver soldered, welded by the oxygen-acetylene process, electrically welded or riveted. He does not, however, make any reference to the weakness of welding or riveting when under the large centrifugal and other stresses to which an airscrew is subject.

Some calculations are given of comparative weights and strengths under centrifugal forces of steel, aluminium, and duralumin airscrews. Taking sheet chrome-vanadium steel 0.064 in. thick, aluminium 0.182 in. thick, duralumin or acieral 0.102 in. thick, he obtains factors of safety of 6-10, 3, and 7.5 respectively with weights of 52, 51, and 30 lbs., compared with a weight of 60 lbs. for a two-bladed wooden airscrew of diameter 10 feet, of blade width 1 foot, and developing 400 h.p. (V. Olhovsky, "Aerial Age Weekly," Dec. 2, 1918.)

Searchlight Arrangement on Italian Aircraft.

This article describes the arrangement used on Italian aircraft to illuminate the ground on starting and landing during night flying. Two kinds of power sources are used—first, an accumulator battery, seldom employed because of its high weight for the required capacity, and, secondly, a dynamo, sometimes in conjunction with a battery. The dynamo is either driven by a fan or connected direct to the engine, both having their advantages and disadvantages. The first is independent of the motor, but its efficiency is bad. The second is more efficient and is the one that in future will be most employed. In both cases the revolutions per minute are not constant, and therefore the voltage alters, and, accordingly, the dynamo must be fitted with a voltage regulator. Pictures are shown of both types. Diagrams of the circuits are given and explained, illustrating how the voltage is regulated by increasing or decreasing the current in the shunt winding of the motor. A description and a diagram are also given, showing the method of connection with an accumulator battery for the purpose of giving a more reliable supply of light. The voltage of the lighting system is usually about 14 volts and current 9.1 amps (125 watts). The energy, loss, etc., in various parts of the system is discussed at some length and the efficiency for a fan-driven motor system given as 125 watts/411 watts × 100 = 30.8 per cent. The weights of the parts in this case are:—

Dynamo, together with propeller and support ...	13.5 kg.
Light reflector and lamps, etc.	6.0 ,,
Controlling apparatus and lead	2.05 ,,
Accumulator	8.0 ,,
Total	29.55 kg.

(" Osterreichische Flug-Zeitschrift," Sept., 1918.)

Tacheometer for Airships and Aeroplanes.

The present instalment of this article gives an illustrated description of the Morel electric indicating tacheometer. It consists of a transmitter, taking the form of a d.c. generator, driven by suitable means from the engine shaft, and a receiver in the form of a moving coil galvanometer, this galvanometer, however, being graduated in r.p.m.

In a magnetic field, formed from a number of magnets of high alloy tungsten steel, a drum armature revolves having a commutator and a number of spring contacts for collecting the current. The magnets are so constructed as to give a constant field. The transmitter in the latest design is driven through an intermediate shaft and flexible coupling. The whole of this transmitter is contained in a casing fitted with a special dust-proof bayonet-joint cap, while the armature is driven through gearing. For airships, motor boats, etc., the transmitters are fitted with bases.

The receiver galvanometer comprises the moving coil, wound on a pressed copper frame, and fitted with spiral springs which serve at the same time as current leads from the transmitter. The movements of the coil are transmitted by teeth to a pointer fixed to the indicator spindle. (" Der Motorwagen," Dec. 10, 1918.)

" Germany First to Fly Over the Ocean?"

It is reported that at Staaken, near Berlin, an aeroplane for transatlantic flight is under construction with a wing spread of 198 feet and with engines of 3,000 h.p., and that an airship for the same purpose at Friedrichshafen has nine engines, eight propellers, and can carry a hundred passengers. The first flight, expected in July, will last forty hours. Large aeroplanes seen at Staaken had five motors each 250 h.p., and five propellers. With a span of 140 feet, they carry eight men and 2,840 lbs. of bombs, flying 14 hours at 81 miles per hour. The machines are now rapidly being converted into use for passenger and postal carrying services.

On Nov. 21, 1918, a Zeppelin with a crew of 22 and carrying 25 tons of munitions and medicines left Jamboli, in Bulgaria, and was over Khartum on the night of Nov. 22-23, when it returned. The ship is said to be capable of going from Berlin to New York and returning without a stop. (" Air Service Journal," Dec. 14, 1918.)

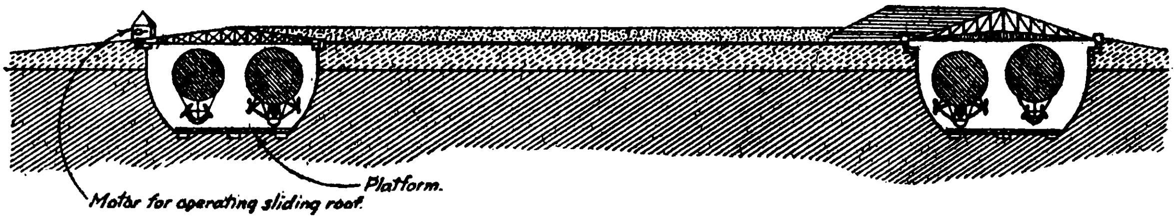
Warsaw-Lvov Aerial Post.

The first aerial post reached Lvov from Warsaw on Nov. 30, organised by the Lvov Defence Committee of Warsaw. The letters, which bore Polish stamps, were handed to the post office and there dealt with in the usual manner. (" Nowa Reforma," Dec. 2.)

Annular Underground Airship Hangar.

The writer describes a design of underground airship shed which was apparently placed before the German authorities, and which has up to now been subject to censorship.

A pit, as in the illustration, forming a closed circle, and gradually narrowing downwards, forms the underground hangar, the diameter, breadth across the wing, and height of which are chosen so as to leave sufficient clearance for the airship. From the plan it appears that an annular trench 40 m. across the annular portion, and of 185 m. mean diameter should be able to house eight airships, or, say, four of the rigid type 145 m. long, and four others of the non-rigid type from 90 to 100 m. long. The diameter of the annular trench could be reduced if it were desired to accommodate fewer airships.



SECTIONAL DIAGRAM OF AIRSHIP HANGAR.

In this system, the annular portion of the roof, as well as the doors of the shed, can be made to slide about the centre of the circle, so that if more than one of each type of airship is contained in the shed, it would be possible to send out the one whose longitudinal axis was not likely to be deflected by the direction of the prevailing wind. Again, it is suggested that the floor or platform should be capable of revolving also, which would further simplify matters.

Dealing with the cost of this design of shed, the writer estimates that less land would be required for the site, as it would be possible to use the roof of the underground hangar as a landing place. Charges for excavation and removal of earth would not be inordinate, as the material excavated need not be carried away, but could be used for banking up the ground inside and outside the annular pit. A thick masonry lining for the pit would be unnecessary, as the danger of collapse of the sides would be obviated by decreasing the diameter of the pit from the top downwards, since only room for the car is necessary on the floor. A thin layer of concrete should thus be sufficient as a lining. The site should, of course, be chosen so as to be free from ground water.

The roof of the shed would be of light iron construction with corrugated iron or similar framing, and small top lights. The space of roof to be covered in is comparatively small, as compared with the circular type of hangar. The sliding roof of the shed would be supported on wide diameter rollers running on a well machined roller path, driven from a motor placed diametrically opposite the shed opening and operating through teeth cut in the runway. The double sliding doors would also be driven from the same motor, by suitable means.

The shipping in and out of the airships could be carried out without difficulty. For the latter operation, it would be sufficient to post a squad of men at each side of the sliding doors in the roof. The men would gradually release the guy ropes and the airship would ascend by its own buoyancy. ("Der Motorwagen," Dec. 10, 1918.)

Loening Two-Seater Fighting Monoplane.

The Loening two-seater fighting monoplane has a 300 h.p. Simplex-Hispano engine, developing 145 m.p.h. with full military load, and climbing to 25,000 ft.

It is so simple that production is easy, as it requires only about 1/10 the usual number of parts. Rigidity and stability are satisfactory, so that it may

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be said to be the first load carrying machine that can be manœuvred like the smallest single-seater. The machine weighs 1,500 lbs. and carries practically its entire weight in live load compared with the more usual 50 per cent.

The low aspect ratio (32 ft. × 7 ft.) has been found efficient. The body is deep, being built of a series of veneer bulkheads. The wings are of the usual construction. A novelty of the machine is in the arrangement of its parts, particularly in the fastening of the wings to the top longerons.

The pilot and gunner have practically no blind spot, the wing being mounted on a level with the pilot's eye.

In official trials, the monoplane carried two men, four machine-guns, and 2,000 rounds of ammunition, and climbed 10,000 ft. in 8 minutes. ("Aviation," Jan. 1, 1919.)

Production Problems in the Martin Bomber.

In view of the importance of efficient and economic production, not only have the detail parts throughout the Martin bomber been so designed as to accommodate modern production methods, but all major and minor units have been so worked out as to permit efficient and speedy progressive assembly.

All metal parts and fittings such as steel tail surfaces, motor and flight controls, are so designed as to reduce hand work to the minimum, the majority of steel plate fittings permitting their manufacture by means of blanking the forming dies.

The tool design department has designed numerous machine tool attachments (particularly assembly jigs) for production and assembly. An example is the wing rib assembly jig which enables ribs to be made complete as a separate unit. It permits not only the production of the full rib but the nose and intermediate ribs equally well. Interplane struts, longerons, etc., are made of laminations each routed on the inside; this reduces the difficulty in securing lumber of sufficient size.

The assembling of the machine requires but a very short time and no more equipment than the ordinary single-engined plane. The centre sections extending over both engines are first assembled and lined up as a unit, then the panels, which are all self-aligned, by the steel tubular struts. (L. D. Bell, "Aviation," Jan. 1, 1919.)