ABSTRACTS.

Curtiss Model K-6 Aircraft Engine.

The Curtiss Model K-6 aircraft engine is of the vertical type, with six cylinders arranged in line; it is rated 150 h.p. at 1,700 r.p.m. The bore is 4.5 in., the stroke 6 in. The cooling is effected by a centrifugal water pump, and lubrication by pressure feed; two high tension magnetos are used for ignition. The engine is fitted with a Duplex type Ball Aero carburettor. It weighs without oil or water 417 lbs., which gives a dead weight per rated horse-power of 2.78 lbs. The gasoline consumption is 0.55 lb. per b.h.p.; the oil consumption, 0.03 lb. per b.h.p.

The installation dimensions are:—Over all length, 63 in.; over all width, 22$\frac{3}{8}$ in.; over all depth, 39$\frac{1}{4}$ in.; width at bed, 15$\frac{3}{4}$ in.; height from bed, 24$\frac{1}{8}$ in.; depth from bed, 15$\frac{1}{8}$ in.

General Design.—The form of construction adopted in this engine gives a minimum centre distance between cylinders, and this, together with careful placing of the accessories, makes the engine compact and easily placed in the aeroplane body. At the same time the accessibility of the various parts is such that sub-units may be readily inspected or overhauled without disturbing the engine in its mounting on the aeroplane body.

Crankcase.—The crankcase is cast of aluminium alloy with the cylinder water jackets integral; extreme rigidity and absolute alignment of parts are thus maintained, as well as an appreciable saving of lightness gained. The lower half of the crankcase, containing the oil pan, is securely bolted to the flange on the centre line of the crankshaft, which also adds to the stiffness of the assembly.

Cylinders.—The cylinders are rough machined from a special analysis hydraulic steel forging, heat-treated and finish-machined all over, with the cylinder head forged integral.

Bearings.—The crankshaft and connecting rod bearings are reamed, which eliminates the variations that are unavoidable with hand-scraped bearings and permits replacements without fitting, as both the inside and outside diameters of the bearings are made to such fine limits that new ones will drop more accurately in place than would be possible to fit them by hand.

Valve Gear.—The new valve gear used on the Model K6 is a distinct advance over previous engines. A light cam follower relieves the valves of any side strains due to cam action, and provides means of easy adjustment of clearance. As the cam shafts are directly over the valves, all rocker arms, push rods, etc., are done away with and the whole assembly is absolutely oil tight.

Lubrication.—Lubrication is secured by pressure feed through crankshaft, propeller shafts and cam shafts, which insures a continual film of clean oil on all bearings. A separate return pump, with double intake, prevents accumulation of oil in either end of pan, and the consequent flooding of cylinders, when the machine is climbing or gliding. Pressure adjustment permits of individual adequacy of oil feed on each engine and change for wear and varying conditions of service.

A photograph of the engine mounted on a tractor fuselage is given. ("Aviation," February 15, 1919.)

U.S. Navy F-5-L Flying Boat.

The boat is a large patrol craft having a wing span of 103 ft. It was built by the Naval Aircraft Factory. One of its chief features is the armament, which consists of a Davis Q.F. gun mounted on the bow, nine Lewis guns distributed in such a manner that there is hardly a dead angle of fire to the ship, and a set of triple machine-guns, aft of the engines, which can be swung out through suitable doors whilst the machine is in flight.

Further data are given in the table below:—

Wing span (upper)	103 ft. $9\frac{1}{4}$ in.
,, ,, (lower)	74 ft. $3\frac{3}{8}$ in.
Length over all	49 ft. $3^{11}/_{16}$ in.
Height	18 ft. $9\frac{1}{4}$ in.
Chord	8 ft.
Gap	8 ft. $10\frac{1}{2}$ in.
Incidence wing	4 deg.
Dihedral	$1\frac{1}{2}$ deg.
Draft (full)	27 in.
Total wing area	1,397 sq. ft.
Weight, empty (including water) ...	8,250 lbs.
Useful load	4,750 lbs.
Gross load	13,000 lbs.
Lbs./sq. ft.	9.31 lbs.
Two Liberty motors (12)	800 h.p.
Weight of crew	720 lbs.
Maximum speed	87 m.p.h.
Endurance	7.9 hours.

("Air Service Journal," March 8, 1919.)

80 h.p. Le Rhone Aeroplane Engine.

The 80 h.p. Le Rhone revolving cylinder engine is one of the few pre-war types existent to-day. It has been used extensively at the front for scout and combat duty, but of late principally in observation and bombing machines, notably the twin-engined Caudron biplane. In the United States it has been used in fast solo scouts for advanced training in aerobatics and combat flying, for the Thomas Morse S-4-E, the Standard MEI Scout and other similar planes.

The Union Switch and Signal Co., a Westinghouse concern, were called upon to manufacture the Le Rhone 80 h.p. engine in October, 1917, and the drawings were furnished them at that time.

The engine produced is a copy of the French engine, with changes in some minor details and with materials selected from American sources. The materials have been superior to those of the French, which, together with special treatment, has resulted in practically eliminating engine failures from defective materials. The engine is almost entirely constructed of steel, the only castings being pistons, connecting rod bushings, thrust block liners, and a few accessory parts; there are 32 forgings. The initial weight before machining is 1,160 lbs., the finished weight is 184 lbs., or complete with accessories, 260 lbs.

Continuing, the article gives the advantages of the rotary type engine, together with a brief description of its working principles. The features of the 80 h.p. Le Rhone design are then described with the aid of photographs and the general specifications and performance graph of the engine given. ("Aviation," February 15, 1919.)

Aeronautical Radiators.

The article begins by giving a brief account of the ribbon type radiators, constructed from thin bronze or brass ribbons, at present in general use on aircraft. The author objects to the British honeycomb type with circular tubes, asserting that its ability to cool is not very great and its head resistance is rather high. (Experiments in Britain have not pointed to such a conclusion.) He recommends the adoption of larger sizes of air passages, because in the case of the smaller sizes the heat dissipated is no greater at high speeds, while the radiators weigh more and present a higher resistance to the air.

A brief indication is given of the method of manufacture.

As regards design in general, the author recommends the enclosure of the engine, where possible, entirely in a streamline housing, excepting exposed valve springs and stems, etc., and putting the radiator by itself in the free air stream. The radiator being especially designed to cool efficiently should be given the whole task of the cooling. In the event of the engine being left entirely or mostly exposed to the air, and located out between the wings, the best location for the radiator will probably be directly in front of the engine. It is good practice to design a rectangular radiator without any tendencies towards irregularities in its outline or cooling section.

A scheme for the preliminary design of radiators is given based on an empirical formula established in the wind tunnel and checked by practice. Having determined the trial size from this information, the radiator should be installed in the machine and the inlet, outlet, and air temperatures observed during best climb. From these observations the necessary modification in size, if any, of the radiator can easily be calculated. The test will be valueless if steam is generated.

A projecting lip around the cooling sections is recommended for small and very narrow radiators, but not for medium size ones, because of the increased resistance. Yawing the radiator increases the cooling capacity, but only at the cost of a prohibitive increase in head resistance.

The upper water tank may act as a distributor and also as a reserve water supply in small machines not intended for long flights; but the reserve tank should be placed elsewhere in large machines. In either case the tank should be streamlined. An excellent position for the reserve water tank is stated to be in the wing. The lower header should act entirely as a collector and should be made as small as possible.

The assigned difference of temperature between water and air should be such as will not allow the water temperature to go above a desired maximum in best climb at the highest air temperature that may be encountered. The density of the air decreases with altitude, the power of the engine varies as the density of the air, but the cooling power of the radiator also varies as the density of the air. Therefore, the only consideration affecting the water temperature, or size of radiator required, is the air temperature (assuming that the percentage of throttle opening remains the same). The value of the temperature difference between water and air should be based on the average highest air temperature at the ground which will be encountered, say 90° F.; and the highest desired water temperature may be taken at 190° F. This gives a difference of 100° F. In all cases of test the air temperature must be taken in flight, and the engine should be thoroughly warmed up before taking off.

The writer strongly objects to the use of nose radiators, owing to the fact that the head resistance due to the radiator is very much greater when the radiator is in the nose than when it is out in the free air stream; and because of the small amount of air flowing through it, it has to be unusually large and heavy. The advantage from the point of view of efficient cooling arising from the low air speed does not outweigh these great disadvantages. An actual test of a British machine showed that the removal of the nose radiator, the streamlining of the nose and the fitting of side radiators, produced an increase of 14 per cent. in rate of climb at 15,000 ft. and an increase of $2\frac{1}{2}$ per cent. in horizontal speed. A retractable radiator is recommended, since shuttering increases head resistance.

With regard to a radiator located in a wing, the author is of the opinion that there can be no compensation in cooling for the large increase in drag of the wings, and he cites a case of a seaplane in which the top speed after installation of a wing radiator dropped 4½ per cent. at 1,000 ft. and the rate of climb to 3,000 ft. was reduced by 16 per cent. ("Aerial Age Weekly," March 3, 1919.)

New Principle in Carburetion.

The new Brown carburettor is of novel design and is very compact and neat. It is claimed that the correct ratio of air to fuel is maintained automatically at all speeds in either warm or cold weather.

The mixing chamber is spherical, with a fuel nozzle at its lowest point. There is a single intake fitted with a choke valve. Inlet and outlet baffle plates, suitably shaped and perforated, control the proportioning of fuel and air and render it automatic. A petrol bowl beneath the mixing chamber is provided with a float connected to a shut-off valve, so that the depth of petrol can be controlled.

Laboratory and road tests have covered all conditions of motor operation, and the automatic action is uniform under all conditions. Carbon residue, especially on top of pistons and heads, was found to be almost totally absent in the case of a 6-cylinder motor car, weighing 3,475 lbs., after a 78 hours' test on the road. ("Aerial Age Weekly," March 3, 1919.)

Manufacture of Veneer and Plywood.

This article gives a very detailed account of the present state of development of the new plywood industry. There are two distinct manufacturing operations—the cutting of the veneer and the making of the plywood. It is important that the logs to be cut up into veneer should be as fresh as possible, both for ease of cutting and to reduce the possibility of deterioration in the heartwood and along the season checks and cracks.

Rotary cutting, slicing and sawing of the logs are the three possible methods of production of the veneer. The first is responsible for about 70 per cent. of the output. The other two must be resorted to in the case of quartered veneer, where the beauty of the grain is to be preserved. Steaming in bins as a preliminary to cutting is needed for the harder woods, for the thicker veneers, and for wood which is dry or contains frost. The process of steaming takes from 12 to 18 hours according to the pressure of the steam and the nature of the logs.

The rotary cutter is a huge wood-turning lathe with a long stationary knife fixed in position behind the log (which is held between centres), its cutting edge being at the same elevation as the axis of the chuck and spindle. The sheet of veneer comes out at the back of the machine through a slot just below the edge of the long cutting knife. The crew of a rotary cutter consists of five men, one operator, two chippers, and two for steaming and preparation of the logs. The veneer sheets are usually a maximum of 9 feet along the grain and 20 to 30 feet across it.

For sawing and slicing, the logs are quartered and cut into wedge-shaped pieces by means of a large hand-saw. These pieces are trimmed by cutting off the three edges, leaving what is called a "flitch."

The slicer consists of two heavy castings, the stay log to which the flitch is firmly clamped, and the ribbed casting which holds the knife. The stay log has a reciprocating motion forward and downward in the positive direction, and the knife is stationary and slightly inclined upwards. The thickness of the veneer is controlled by the "pressure bar" running parallel to the knife. The veneer is usually not more than 12 to 14 ft. long and 2 ft. wide. Three men form the crew, one to operate the pressure bar, and two helpers to manage the veneer strips.

Veneer sawing is more usual than slicing for quartered veneer, on account of its comparative simplicity; but the saw kerfs lead to more waste than in slicing. The flitch is held by dogs to a heavy stay log which travels back and forth, carrying the flitch against a circular saw. The usual length of the veneer is 14 to 16 ft. and the width 18 to 20 inches. A convenient unit consists of three saws, with a total crew of five men—one expert, two sawyers and two helpers. A band-saw crew of four men will keep the unit supplied with flitches.

After cutting, the veneer is stacked in drying-rooms, where air at 100 to 110° F. is circulated.

In the manufacture of the plywood, jointing and splicing under pressure is usually a necessary preliminary operation in order to get a sufficient width to make up a panel. The inner layers of a panel, being composed of softer and cheaper woods, do not need splicing as they are rotary cut and can be obtained of any width.

Only the inner layers or "crossbands" are put through the gluer, which applies the glue to both surfaces. The core of a 5-ply panel is usually of thicker, poor quality veneer, like chestnut, and this is not put through the gluer. Adjacent plies must have their grain at right angles. The glued panels are placed in piles, $3\frac{1}{2}$ to 4 ft. high, in a hydraulic press and subjected to a pressure of 100 to 300 lbs. per sq. inch for about 5 mins. They are then dried for 72 hours at 70 to 90° F. After cutting to prescribed dimensions and smoothing in a sanding machine, the panels of plywood are ready for issue. ("Aerial Age Weekly," March 3, 1919.)

Experimental Aeronautical Engineering.

In the testing of aeroplanes it is necessary to simulate as nearly as possible the actual stresses which the aeroplane must be capable of withstanding in the severest conditions which it may be expected to have to face, such as in the execution of manœuvres like the loop, steep dive and sharp recovery from a steep dive. In sand tests air and dynamic forces are simulated by the application of loads, which in British and American practice embrace the wings, tail surfaces and controls, the fuselage and the engine mounting. The author describes the lay out, methods and calculations for carrying out these sand tests on the wings, controls and horizontal tail surfaces. The tests employed bring out weak points in the body structure of the various parts and are even more useful in detecting flaws in the attachment of one part to another.

In testing the strengths of materials of the various parts before assembly it is more possible to follow along the lines of ordinary engineering practice, and special machinery is now being developed for the proof testing of struts to the elastic limit with subsequent use on the plane. Rib-testing machines of various types are also being developed.

In testing the performance, controllability, and stability of aeroplanes, both the wind tunnel and actual full flight tests are utilised. In the wind tunnel small accurate models of the type of aeroplane under consideration are subjected to carefully controlled wind pressures and accurate measurements obtained of the stresses and results shown. The author points out, however, that in spite of the great accuracy with which such tests can be made, there is a possibility of error in certain directions, notably in the construction of the models of the identical size and strength ratio to be a true index to the aeroplanes they represent.

In describing the direct methods of testing aeroplanes, the author shows that the only sure way of calibrating the air speed indicator is by flying the plane over a measured two-mile course at a height not exceeding 1,000 ft., and to eliminate the personal equation in testing for stability, methods are being developed by which spring balances attached to the joy-stick measure the exact effort of the pilot under varying conditions of flight, and gadgets indicate the position of the elevator for various positions of flight. No satisfactory methods have as yet been found for scientifically testing lateral stability or the controllability of aeroplanes, but these problems are being closely investigated. (A. Klemin, "Journal of the Society of Automotive Engineers," March, 1919.)

Line-Reaming Crankshaft Bearings of Liberty Motors.

The Martell aligning reamer was very successfully used on nearly all Liberty engines for reaming the crankshaft bearings. The reaming is done by hand, and the operation was performed in an average time of 30 minutes per motor. The size of holes, alignment and surface of bearings passed the most rigid inspection and tests.

The reamers slip on to a supporting bar and are clamped in position by screws. The bar is supported in two of the crankshaft bearings by plain bushes, and in two further bearings by special eccentric bushes, working in an outer sleeve. By this means perfect alignment of the bar is secured whilst the remaining bearings are being reamed out. The bar is turned by means of a double-end wrench.

The reamers are adjustable and have six blades, of which four are set at a slight left-hand angle, and two at a corresponding right-hand angle.

The expanding mechanism allows of adjustment of the order of 0.0002 or 0.0003 inches. The holes are truly circular to within 0.0001 inch.

The article also describes a fixture for reaming both ends of the connecting rods at one setting. One end of the rod is held in a fixed clamp, whilst the other is gripped by a floating clamp that is securely locked when the smaller reamer, passed through guides in the fixture, locates the up and down position.

The writer considers that the Martell reaming system should find application in the manufacture of all kinds of internal combustion engines in addition to aero-engines.

Two illustrations accompany the article. ("Aerial Age Weekly," March 10, 1919.)

Aeroplane Visibility.

This article, to be concluded later, describes the investigations of the author for the Science and Research Division of the Bureau of Aircraft Production with regard to the various aspects of the visibility of aeroplanes. The paper shows the fundamental data on which the attainment of low-visibility for aeroplanes may be founded.

Objects are distinguished through differences in light, shade and colour. To obtain low visibility an object must be similar in colour and distribution of brightness to the background against which it is viewed. Pattern is an essential feature in most cases of successful camouflage, but an exception is when the background is a uniform blue sky. In land and earlier sea camouflage invisibility has been striven for, but in combating short range submarine attack confusibility is found more effectual.

The two general view points of aeroplane camouflage, from above and from below, require camouflage solutions directly contrary to each other. The aspect of the earth surface varies as much with the seasons as does the sky under the varying influence of clear blue or dark or light and bright cloud areas.

The author's first efforts were directed towards measuring the apparent reflection factor of various earth and water areas, the mean hue of earth and water areas, the size and shape of pattern for aeroplane camouflage, and certain brightness measurements in terms of the brightnesses of the sky and of clouds.

The relation of sunlight to skylight is theoretically considered. This matter is discussed very thoroughly and is explained by means of a number of diagrams.

The relative brightnesses or apparent reflection factor of various types of earth areas is dealt with, and a mean equal percentage of 6.8 is given for fields and inland water, with 1.3 for barren land and 4.3 for woods. These figures relate to the late summer, when the landscape was still predominantly green.

Grass plots, like velvet, intermixed with corn fields, ploughed land and woods, provide light traps and shadows so that the mean brightness or apparent reflection factor is materially reduced. If the brightness of the sky $= B$, the brightness of a white horizontal surface $= B$ due to skylight and $5B$ due to sunlight and skylight together. If the reflection factor of a blade of grass $= 0.16$, the brightness of the blades of grass receiving both sunlight and skylight $= 5B \times 0.16 = 0.8B$. The brightness of grass in shadow, if it receives full skylight (this is not practical), $= 0.16B$, so that the mean brightness $= \frac{1}{2}(0.8 + 0.16B)$, and the mean apparent reflection factor would $= 0.48B/5B =$ about 0.1.

Sunlit clouds are often several times brighter than an adjacent patch of blue sky. Dense clouds sunlit are commonly 5 to 10 times as bright as blue sky. Cumulus clouds are a screen as often as a background for aeroplanes, but cirrus clouds, owing to their great altitude, are usually background. Haze in general tends to lower visibility, and the author shows the results of his attempts to obtain the order of magnitude of the luminosity of low-lying dust haze. Water is of little importance in the ord'nary landscape, but is interesting as a background for seaplanes. The mean apparent reflection factor obtained by measurements perpendicular to its surface was 0.068, and most of the measurements were near the mean value. Clear deep water gave the lowest reflection values, which increased very rapidly for shallow water and water containing much suspended matter. (M. Luckiesh, "Journal of the Franklin Institute," March, 1919.)

Future of Aeronautics.

In America a great volume of business awaits the aeronautic manufacturer whose products will satisfy the demands of the critical public interested in sport and commercial aerial transportation. A definite policy must be laid down, and energetic action taken immediately. The absence of information regarding Government policy towards aerial transport is already causing the industry grave embarrassment. It is acknowledged that for some years the industry will require the aid of the State, financially and otherwise, and it is imperative that this be promptly given, before the existing technical staff (both Air Service and Civilian) is dispersed, and absorbed in other industries.

The Aeronautic Convention, to be held at Atlantic City from May 1 to June 1 next, is the industry's best asset. Governments of all Allied and Latin-American countries and their aeronautic, scientific and industrial organisations are invited to attend. The convention aims to permit thorough discussion of all phases of aeronautics, so that those interested in any branch may acquire all the information available on the subject. The subjects for discussion include:—The Large Dirigible and its Value for Transportation; Aerial Mail Plans; Need of Municipal Aerodromes; Aerial Navigation Instruments; Aerial Exploration; Use of Aircraft for Survey; Insurance, Jurisprudence, etc.; Meteorology.

Aerial mail service was inaugurated between Washington and New York on May 15, 1918, and during the first six months its operations covered 68,892 miles at a cost of $75,165.94, including 6 per cent. on investment and $33\frac{1}{3}$ per cent. for depreciation. In that period it carried $7,452\frac{1}{2}$ lbs. of aeroplane mail. The revenue derived was $60,653.28. The net deficit, not taking into account the 6 per cent. interest on investment, was $8,969.08. In addition to the aeroplane mail, there was dispatched between Washington, Philadelphia and New York, in the six months, a total of $91,926\frac{1}{2}$ lbs. of first class mail, totalling 3,667,040 letters. This mail was advanced in dispatch from 6 to 12 hours, which many times made up for the small deficit in operating this service.

The service, when operated by civilian flyers of the Post Office Department, far exceeded the record of its operation whilst under military control, the civilian flyers having a record of only seven forced landings in 100 consecutive flights, and only two failures in that time owing to weather conditions.

The greater the distance between the points on an aerial mail route the greater the saving of time, and therefore the greater the patronage extended by the public to it. It is hoped to establish an aerial mail route from New York to Chicago, and to extend it westward to the foot of the Rockies during the coming fiscal year, with a view to reaching Seattle and San Francisco. This line would be tapped by lines from various other important cities, and another trunk line running north and south and tapped likewise would link up the whole country by aerial mail. The two trunk lines are estimated to cost $1,600,000 and the essential feeders about $400,000 more. Many of these routes have already been reconnoitred, hangars ordered and army aeroplanes earmarked for the service.

Negotiations are in progress for aerial services to the West Indies, Canada, Central and South America.

With regard to the aerial programmes of other countries, Italy has eleven aerial mail lines working or planned; France, six; Great Britain, one—to Paris; Greece, two; Denmark, three; Austria, one; Norway, four; Spain, two. Some of these form parts of the numerous international aerial routes already being planned. A map is given showing the world's air routes as outlined by Mr. Holt Thomas.

A new super-Zeppelin for the trans-Atlantic service is now under construction. It is over 800 ft. in length, has gas capacity of 100,000 cubic metres, nine engines, eight propellers, and will carry 100 passengers, 45 tons of mail and baggage, and 30 tons of fuel, water, and provisions.

The first machine for trans-Atlantic service is to be complete in July. The service will have eight active machines and four in reserve.

For the Roosevelt Arctic Expedition one large seaplane and some smaller planes, based on a ship at Etah, will be used. The expedition will start in June next, and very valuable results are anticipated.

A British Expedition equipped with aeroplanes is due to start for the North Pole in April.

The Aerial Transportation Committee (America), with about 100 members, has been formed to co-operate with the Post Office and City representatives in establishing and extending the aerial mail services. Preliminary reports on the subject of aerial transportation and regulations to govern same have been made, and data has been collected showing the aerial plans of other countries.

President Hawley, of the Aero Club of America, recommends the formation of a Government organisation, capitalised at $50,000,000, to take over the $800,000,000 worth of aeroplanes, motors, and equipment, which the army and navy are trying to dispose of. This equipment and the 20 aviation stations and depots abandoned by the army are to be used for the aerial transportation service outlined above.

The British Air Ministry have sanctioned the scheme to carry foodstuffs to Belgium by aeroplane. Service pilots will be employed, and "the load carried will comprise about two tons of foodstuffs."

The article concludes with a mention of the popularity of the flying boat. ("Aerial Age Weekly," March 17, 1919.)

Aerial Transport.

The "Goliath" machine is an adaptation of the most recent Henry Farman bomber for the transport of passengers. The cigar-shaped nacelle forms a saloon carriage entirely enclosed and provided with glass sides, so that the compartment is well lighted, and yet the draught felt by the occupants is much less than in an ordinary tramcar. It is possible for the passengers to converse easily. There are at present only 15 places, but the machine could carry 30 persons if the nacelle were made more suitable for their comfort. It is claimed that the machine is very steady, and also stable in flight.

The principal dimensions of the Goliath are as under:—

Span	92 ft.
Wing surface	1,780 sq. ft.
Total weight	11,000 lbs.
Useful load	6,600 lbs.

Two 270 h.p. Salmson motors.
Speed, 104 m.p.h.

Farman has not reckoned upon running the motors at full power, which would enable an extra 1,100 lbs. of useful load to be carried. Its normal speed of flight is 94 m.p.h.

The machine will fly well with half load if one engine gives out. A forced landing due to failure of one engine when full load is being carried could be carried out very slowly. The author points out that the useful load of the Goliath is half as much again per horse-power as that of the Handley Page.

Possible means of determining latitude during long voyages are discussed; also the advisability of providing luminous buoys as an indication of position over the sea. The writer asserts that the compass should always be placed at least 11 feet from large masses of metal.

The article concludes with a comparison of the cost of transport by various means of one tonne for one kilometre. The figures are as follows:—

Vehicle.	H.P. for one tonne per kilometre.	Cost of fuel and oil per h.p. hour in centimes.	Relative total costs.
Steamboat	1/75	8	1
Railway train ...	1/22	10	4.25
Automobile	1	—	—
Aeroplane	1	40	375

In spite of the formidable difference in price between transport by aircraft and by train or boat, it appears that there is no reason why aircraft should not become as largely useful in a different way as the automobile now is. The fare per kilometre by air should not be appreciably greater in the near future than it is now for travelling first class by rail. (E. Archdeacon, "L'Aérophile," February 1-15, 1919.)

Commercial Aviation.

This article gives an estimate of the cost of maintaining a service of ten large Caudron aeroplanes, with two reserve machines. The calculations are based upon war experience, and the resultant cost may, therefore, be very excessive; for war machines are not designed primarily for economy of cost. The small scout machine is ruled out as being far too expensive, and the largest type is chosen for the calculations, although a medium-sized machine with higher speed may possibly be more economical.

A tabular statement of costs is given at the end of the article, and the fare per passenger to give a profit of 10 per cent. is estimated at 90 centimes per kilometre, or about 1s. 2½d. a mile. (Capt. E. Riche, "L'Aérophile," February 1-15, 1919.)

First French Trials in Aerial Transport.

In this article brief accounts are given of the flights of the "Goliath" from Paris to London and back, and from Paris to Brussels and back; also the voyage of the Caudron C.23 to Brussels and back.

The Goliath carried 14 persons to London in 2½ hours, the landing being made at Kenley, near Croydon. The return to Paris was accomplished in 3 hours 10 minutes.

A further note describes the crossing of the Mediterranean at its widest point by two French aviators in a 300 h.p. Breguet machine. The return journey was made on the same day, and in spite of exceedingly bad weather. 900 miles were covered in 10 hours 35 minutes. (" L'Aérophile," February 1-15, 1919.)

Spanish Air Service to America.

The Compañia Transatlantica is preparing to undertake a passenger aerial service between Spain and America, on the lines suggested by the Major of Engineers D. Emilio Herrera. The company has appointed a Commission, consisting of Major Herrera, who is Director of the Central Meteorological Observatory, and Colonel Galbis, of the General Staff, who will leave at an early date for Paris, London and Scotland to study the construction of the large airships which are being built in those countries. ("España Economica y Financiera," March 29, 1919.)

Goodyear Airship Type.

The Goodyear Tyre and Rubber Co. during the war constructed military airships, varying in size from 75,000 cu. ft. to 170,000 cu. ft. capacity, the overall length of the biggest ship being slightly under 200 ft.

An illustration is given of an airship of 95,000 cu. ft. capacity. The length of the gas bag is 162 ft., the diameter at the greatest cross-section being 33 ft. 6 in. The car is 18 ft. long and is equipped with a 150 h.p. Thomas engine. Seating capacity is provided for six, but the regular crew generally consists of three or four. The ship was designed to have a cruising radius of approximately 12 hours at full throttle and a speed of 56 m.p.h. with full load.

When flying over water, arrangement is made to take in ballast by a hose pipe to replace loss of weight due to fuel consumption. The longitudinal balance of the airship is controlled by shifting air in the ballonets.

The air valves are located on this particular ship in the ballonet, and are about 18 in. in diameter. These valves are set to operate at a pressure of 1.5 ins. of water, and weigh approximately 16 lbs. each.

The suspension of the car to the gas bag is of the finger patch type, by means of which the stresses are satisfactorily transferred to the fabric.

The blower arrangement for forcing air into the ballonets consists of a small Sturtevant fan driven by an electric motor. During regular flying the air scoop takes care of all necessary ballonet requirements and, consequently, the blower is used very seldom. (H. T. Kroft, " Aviation," March 1, 1919.)

American=Built Aeroplanes, Seaplanes and Flying Boats.

The table under this heading gives the following characteristics, etc., for various American machines:—Government department or manufacturer; type; number of crew; number and make of engines; horse-power at r.p.m.; weight of engine (lbs.); weight of radiator and cooling water (lbs.); gross weight (lbs.); weight empty, with water (lbs.); fuel and oil (lbs.); military load (lbs.); crew (lbs.); total wing area incl. ailerons (sq. ft.); power loading (lbs. per h.p.); speed (m.p.h.); level (ft.); climb (min.); ceiling (ft.); span; chord; gap; incidence of wings (deg.); dihedral (deg.); sweepback (deg.); decalage (in.); stagger (deg.); length (ft.); height (ft.); area of stabiliser (sq. ft.); area of elevator (sq. ft.); total aileron area (sq. ft.); area of fin (sq. ft.); area of rudder (sq. ft.); total vertical area (sq. ft.); fuel capacity (gal.); oil capacity (gal.); landing speed (m.p.h.).

The machines are separated into groups:—(1) Small single-seaters, (2) single-seater training machines, (3) single-seater pursuit machines, (4) two-seater training machines (primary and advanced), (5) two-seater fighter, reconnaissance, or day bomber machines, (6) night bomber machines, (7) training seaplanes (pontoons), (8) light bomber seaplane (pontoons), and (9) submarine patrol and convoy machines (flying boats).

Several gaps appear in the tables, the landing speed column being usually omitted.

The highest speed given is that for the Curtiss single-seater pursuit machine (1,820 lbs. gross weight, 1 Hispano-Suiza, 220 h.p. at 2,150 r.p.m.), viz., 135 m.p.h. at 5,500 ft. and 116 m.p.h. at 20,000 ft. This is also the best climbing machine out of those whose figures are given, climbing 10,000 ft. in 8 min. This machine is closely followed by the Packard-Lepere two-seater fighter, etc. (3,745 lbs. gross weight, 1 Liberty 12A, 597 h.p. at 1,700 r.p.m.), which travels at 130 m.p.h. at 5,000 ft. and 94 at 20,000 and climbs 10,000 ft. in 9 mins. 50 secs. The landing speed is not given in either case.

The ceiling for the former machine is 22,300 ft. and for the latter 20,200 ft. The highest figure given is 23,000 for the Loening two-seater fighter (2,360 lbs. gross weight, 1 Hispano-Suiza—H, 340 h.p. at 1,800 r.p.m.), and also for U.S.A. Bristol (2,910 lbs., 1 Hispano-Suiza, 310 h.p.). ("Aviation," March 1, 1919.)

W.K.F. Battle Triplane.

One of the most noteworthy types of aeroplanes introduced during the war is the single-seater battle triplane. It is the result of an endeavour to increase the climbing speed and hence the fighting qualities of the biplane. It has the disadvantage, however, of decreasing the range of vision of the pilot.

Two diagrams are given showing the W.K.F. triplane designed by A. Gassner. The necessity for a blind spot as small as possible, combined with the distance between the planes and the size of the 200 h.p. motor, gave rise to a deep narrow body which was streamlined and rounded off. Investigations were also made with rectangular and circular bodies, the latter being discarded on account of instability and the former because it interfered too much with the lower plane and its resistance was higher.

Ailerons are fitted to the two upper planes, those on the middle plane being controlled directly and the upper ones coupled to the lower ones. The elevator and rudder are of normal construction. The landing gear and skid are exceptionally strong and sprung with spiral springs.

The 200 h.p. motor consumes about 225 grs. of fuel per min., which allows a 1½ hour flight with a fuel capacity of 100 litres. The radiator is small, and is attached to the leading edge of the top wing in such a way as not to decrease the pilot's field of vision. The boss of the four-bladed airscrew is faired.

A table is given showing the weights of the component parts of the machine in detail. The weight of the machine, empty, is 670 kilos. The body weighs 44, the landing gear 41, the motor 308, and the radiator 25 kilos. 155 kilos are allowed for the pilot, armament, and ammunition, 70 for fuel, 15 for oil, and 25 for water, making the total weight 935 kilos.

The area of the planes is as follows:—

Top plane	9.06 sq. metres.
Middle plane	5.96 ,, ,,
Lower plane	7.47 ,, ,,

(F. Schieferl, "Oesterreichische Flug-Zeitschrift," February, 1919.)

Packard Aeroplane.

Power Plant.

Packard 8-cyl., 160 h.p. engine; 160 h.p. at 1,525 r.p.m.

Weight, complete with propeller hub, self-starter, battery, and engine water, 585 lbs.

Fuel consumption, 0.50 to 0.54 lb. per h.p. at sea level.

Wing and Control Surface Areas.

Main planes, total	387.6 sq. ft.
Ailerons, total	48.3 ,,
Vertical fin	7.0 ,,
Rudder	12.0 ,,
Tail plane	35.7 ,,
Elevator, total	21.9 ,,

Weight.

Machine empty	1,520 lbs.
Gasoline	210 ,,
Oil	30 ,,
Water	52 ,,
Tools and extras	25 ,,
Pilot	165 ,,
Passenger	165 ,,
Normal flying weight	2,167 ,,
Weight, lb. per h.p.	13.5 ,,
Wing loading per sq. ft.	5.6 ,,
Permissible extra luggage	100 ,,

Performance (Estimated).

High speed near sea level	102 m.p.h.
High speed at 5,000 ft.	100.5 ,,
High speed at 10,000 ft.	98 ,,
High speed at 15,000 ft.	90.5 ,,
Climb to 5,000 ft.	7.5 min.
Climb to 10,000 ft.	18.1 ,,
Climb to 15,000 ft.	34.5 ,,
Absolute ceiling	19,500 ft.
Fuel range, wide open near sea level	2.5 hr.
Fuel range, wide open at 5,000 ft.	3 ,,
Fuel range, wide open at 10,000 ft.	3.5 ,,
Fuel range, wide open at 15,000 ft.	4 ,,

(" Aviation," March 1, 1919.)

Packard Aircraft Engines.

Three engines are described, but as they are of similar design the following description of the smallest design, model 1-A-744, aptly describes the entire line :—

Number of Cylinders.—Eight, 4¾ in. bore by 5¼ in. stroke—set at an included angle of 60 deg.

Crankshaft is of the 5-bearing type.

Connecting rods are of the straddle type.

Pistons are of the aluminium die-cast type, equipped with floating piston pin, and a new arrangement of rings to prevent fouling of plugs when coasting down from high altitude.

Propeller Hub is of the quick detachable type, carefully designed to prevent freezing on the shaft or becoming loose.

Crankcase is of box section type, split on the centre line of the crankshaft with the main bearings carried between.

Cylinders are of the individual steel type.

Valves are 2 in. diameter in the clear, with 30 deg. seats, the intake valve lift being 7/16 in. and the exhaust ⅜ in.

Camshaft and Rocker Arm assembly is of the enclosed type.

Lubrication is of the full pressure feed type. The oil pump, screen, and blow-off valve are located low down.

Cooling System.—The engine is designed especially for the use of a nose radiator, but is equally adaptable to any other type of radiator arrangement.

Ignition is an improved Delco type, in which the heads remain stationary and the spark advance is obtained by advancing the drive shaft.

Carburetion.—The carburettor is of the double Venturi type, with improved altitude adjustment.

Weight.—The engine, complete, with propeller hub, carburettor, ignition distributor heads, ignition switch, generator, starting motor and starting switch, weighs 520 lbs. A proper battery to provide current for cranking and starting ignition weighs 40 lbs. The water contained in the cylinder jackets, pump and pipes weighs 25 lbs. A nose radiator to cool this engine holds 27 lbs. of water, making the total weight of cooling water 52 lbs. A nose-type tubular radiator weighs 73 lbs.

General Dimensions.—Centre to centre of bed timber bolts, 14½ in.; extreme width over-all, 27½ in.; highest point above bed timber, 20½ in.; necessary distance between radiator and front bulkhead for proper mounting is 34 in. to 36 in. ("Aviation," March 1, 1919.)

King 550 h.p. Aircraft Engine.

The King 550 h.p. aircraft engine is largely constructed of aluminium, the main casting, the ribless slipper pistons, the removable cylinder heads, and the removable cylinder liners, which have cast iron liners of 0.0627 in. wall thickness, being all made of aluminium. Each cylinder head is fitted with a removable cover to allow the clearance between the rocker arms and valves to be adjusted. The connecting rods are of the articulated type, in which the smaller or articulated rod, big end bearing, is carried by the master rod. The wrist pin of the piston is of the floating type, with aluminium end plugs. The crankshaft is of the six-throw 120° type, and the main crankshaft bearings are eight in number. A special King designed carburettor is used with one common float chamber. The lubrication system gives a pressure feed to all bearings, the normal pressure being about 45 lbs./sq. in.

The other and main characteristics of the engine may be briefly summarised as follows:—

Twelve cylinders, fixed, water-cooled; six cylinders arranged in each bank of a 45 deg. V.

Bore, 5.5 in., 140 mm.
Stroke, 7 in., 178 mm.
Engine displacement, 1995 cu. in.
Rated h.p., 550 at 1,886 engine r.p.m., 1,300 propeller r.p.m.
Ignition, two independent magneto systems.
Inlet cam lift, 0.396 in.
Inlet valve lift, 19/32 in.
Inlet valve seat angle, 10°.
Inlet valve lift area, 5.51 sq. in.
Inlet gas velocity, 9,500 ft.-min.
Each (2) exhaust cam lift, 0.334.
Each (2) exhaust valve lift, ½ in.
Each (2) exhaust valve seat angle, 30°.
Each (2) exhaust valve lift area, 5.625 sq. in.
Exhaust gas velocity, 9.300 ft.-min. ("Aviation," April 1, 1919.)

Lawrence 3-Cylinder Aeroplane Engine.

The performance curve shows that this engine develops 41.5 h.p. at 1,200 r.p.m., 47 h.p. at 1,400 r.p.m., and 52.5 h.p. at 1,600 r.p.m. The bore is 4.25 in., the stroke 5.25 in.

The crankcase and air-cooled cylinders are of aluminium. The crankcase contains a single-throw crankshaft of chrome nickel steel, on which the three connecting rods work, and the reciprocating and rotary forces are counterbalanced by a pair of balance weights. This gives a very good balance, far superior to the four-cylinder automobile type of engine.

The cylinders are of cast aluminium with air-cooling fins machined on them, and with the head integral with the cylinder. In the head is cast a bronze seat for valves.

The valves, one inlet and one exhaust, are mounted in the head at a slight angle with the bore. The valve springs are of a new type. They are made of a flat ribbon of steel, which is tapered so that its width is considerably less at one end than at the other. It is then rolled into a spiral, the wide part of the ribbon forming the outer coils. This gives a spring which has a very short over-all length, and in which all the coils are stressed equally.

The steel liners are pressed into the cylinder by a hydraulic press. They are 1/16 in. thick, and case hardened and ground in place. The pistons are of the ordinary round type with flat heads, and they have four $\frac{1}{8}$ in. rings at top and one wiper ring at the bottom of the skirt.

The wrist pins are of the full floating type. The connecting small end is bushed with Non-Gran bronze, and the rod itself is a hollow round rod drilled from the top end. The big end of the rod is in the form of a segment of a circle, and fits in two grooves in the bronze bearing on the crankpin. The crankshaft is made all in one piece, and the same bronze bushing is slit and bolted together with four bolts.

The valves are operated by means of three individual camshafts, one for each cylinder, which are also used to drive various auxiliaries, such as oil pump, distributor, tachometer. On account of the expansion of the cylinder, the valve clearance varies very considerably, and the camshafts are so designed that the rollers attack the cams for the proper timing with 0.060 in. clearance.

The oiling system is interesting, in that the manufacturer employs a system whereby the crankpin is oil cooled.

Two forms of ignition are used on these engines, namely, a special magneto, which was designed for this engine by Mr. Kliesrath, the engineer of the Simms Magneto Co., or the Philbrin battery ignition. Both these systems are of interest, as in both cases two plugs are fired absolutely simultaneously, only one breaker being used at a time. The high speed of the magneto makes starting easy, and the magneto can be reduced to the smallest possible proportions, weighing in this case $7\frac{1}{2}$ lbs. The Philbrin ignition runs at one-half the engine speed and consists of two separate primary breakers, two high tension distributors, and two coils. The weight of the motor is 130 pounds with magneto and 132 pounds with the Philbrin system.

The carburettor used is a Miller $1\frac{3}{4}$ in. type, with barrel throttle having an altitude adjustment by which the level in the float chamber can be varied to suit the conditions. ("Aviation," March 1, 1919.)

Thomas-Morse Model 8-90 Aero Engine.

Type: 8-cylinder "V," four cycle, water cooled, dual ignition; cylinders, 4-13/16 inches bore by 6 inches stroke; b.h.p., 250; r.p.m. of engine, 2,200; r.p.m. of propeller, 1,512; consumption of petrol and oil, 0.54 and 0.04 lbs. per h.p. hour respectively.

Weight complete with propeller hub, flanges, and bolts, but excluding radiator, water, oil, starting device, exhaust pipes, and propeller, approximately 590 lbs.

The special aluminium alloy cylinders are of the "L" head type and are cast in blocks of four with integral water jackets. The cylinder heads are bolted on and cast iron liners are fitted.

The Tungsten steel valves are made in one piece, and have a part opening of 2-13/16 in. The valve push rods are operated directly by the cams, and are adjustable.

The three-bearing hollow camshaft is located in the crankcase. The timing gear is bolted to the driven end of the camshaft, which is flanged for this purpose. Lubrication is provided by overflow through the pressure-regulating relief valve.

The crankshaft, made of special chrome nickel steel, is carried on three bearings. The journals and crank pins are 2½ in. in diameter, drilled for lightness. Oil is led to the connecting rod big ends through ducts drilled in the crank webs.

The connecting rods are of H section. They are made of chrome nickel steel, and are arranged side by side on the same crank pin for opposite cylinders. The wrist pins are locked in the connecting rods.

The pistons are made of special aluminium alloy, and are provided with two concentric lap jointed compression rings near the head, and one oil scraper in the skirt.

The crankcase is a special aluminium alloy casting; the lower half, which serves only as an oil sump, is bolted directly to the upper half.

A Stromberg, double vertical carburettor is used. The double branch manifold is an aluminium casting and is water-jacketed.

The lubricating system is of the high pressure circulating type. The pump is provided with a fine wire mesh screen. The wrist pins and pistons, cams and push rods, are lubricated by the oil thrown off the crank pins; whilst the reduction gears are constantly sprayed with a stream of oil from the main oil duct. All surplus oil collecting in either end of the oil pan is drawn off by a second oil pump, filtered, and delivered back to the supply tank.

The cooling water is supplied by a single centrifugal pump driven at camshaft speed. Water outlets are arranged over each exhaust valve.

The propeller shaft is of large diameter and drilled for lightness. It is driven from the crankshaft through two chrome nickel spur gears, and is supported on three ball bearings housed in an aluminium alloy gear case.

Two Splitdorf " Dixie " magnetos are used, with two sparking plugs per cylinder. Provision has been made to allow the use of " Dixie 84 " magnetos with adjustable spark, or fixed spark " Dixie 810 " magnetos and hand starting magnetos.

The Christensen air starting system can be used on this engine if desired. A gravity fed petrol gear pump is supplied as a regular part of the equipment, and a tachometer is also provided.

Two illustrations of the engine accompany the article. (" Aerial Age Weekly," March 10, 1919.)

Murray-Willat Valveless Rotary Engine.

The Murray-Willat valveless rotary engine is of the two-stroke type, with a pressure blower built as an integral part, which compresses the air and forces the fuel into the engine at altitudes where the rarefied atmosphere fails to perform this function.

	35 *h.p model.*	90 *h.p. model.*
Bore	75 mm.	100 mm.
Stroke	90 mm.	130 mm.
Engine speed	1,200 r.p.m.	1,200 r.p.m.
Horse-power	35	90
Gasoline consumption	14 litres p.h.	24 litres p.h.
Oil (mineral) consumption ...	6 ,, ,,	10 ,, ,,
Maximum diameter	660 mm.	737 mm.
Weight, including airscrew hub...	60 kg.	118 kg.

The cylinders are turned from forged steel billets. The crankcase consists of two halves which are machined from solid steel forgings.

The connecting rods are mounted in a spool which is carried in a ball bearing on each end, the whole unit revolving with the engine, while the crankshaft remains stationary. The latter is hollowed out for the purpose of affording passage to the gas from the blower into the crankcase, where it is held under a pressure of 7 lbs. per sq. in. furnished by the blower. ("Aviation," March 1, 1919.)

Liberty Aircraft Engine Ignition.

The reliability of all high-powered aeronautical engines in flight is largely governed by the dependability of its sparking plugs. The service, due to the extreme temperature and pressure conditions, is so severe that satisfactory performance can only be obtained by the use of duplicate sparking plugs in each cylinder. This design requires the use of an ignition system so duplicated that independent operation can be obtained with either set.

The Delco generator battery type of ignition, having proved itself particularly adapted for reliable high speed work, is used as the means of operating all Liberty aircraft engines. The Liberty ignition produces a spark of maximum intensity at low speed, ensuring easy starting and regular idling. It consists of a constant source of low voltage direct current, supplied by a generator and a storage battery. The generator is so arranged that the voltage is kept constant at all operating speeds. As the generator does not produce sufficient voltage at cranking or extreme low idling speeds, the current at this time is supplied by the battery. In this way a particularly constant pressure of low voltage current is available at all times. Above speeds of 650 r.p.m. double ignition is used, at which time the generator is automatically placed in the circuit, and supplies the current for the ignition and keeps the battery charged.

The low voltage current supplied by the battery or generator is controlled by means of a two-lever switch unit containing an ammeter which at all times indicates the flow of current to or from the battery. Through the switch the current is supplied to the distributors, which are mounted horizontally and form the ends of the overhead camshaft housings. The distributors, which are identical and interchangeable, are constructed with an ignition coil, which provides the means of transforming the low voltage current to high voltage, and a breaker mechanism. The high tension current generated in the secondary winding of the coil is delivered to a high tension rotor fastened to the cam actuating the breaker mechanism contact arms, and distributes the high tension current to the spark plug lead terminals. Advance and retard is obtained by revolving the distributor breaker mechanism and head on its base. A retard of 10 deg. and an advance of 30 deg. is provided.

Ammeter.—The use of an ammeter permanently located in the primary circuit gives a very rapid method of checking the condition of the entire low voltage circuits; this can be done with engine stopped or operating; not only proper ignition performance, but improper functioning, even though the engine may be running regularly, is immediately indicated and can be rapidly isolated.

Generator.—The generator is a four-pole shunt-wound unit of compact design and of the rugged construction which low voltage direct current machines permit. It is approximately 8½ in. high and 4⅛ in. in diameter, and weighs 11.25 lbs., and is driven at one and one-half times crankshaft speed. It is made up with a forged steel field frame and provided with four forged pole pieces securely held in place by two shoulder tap screws each. The field coils are wound and connected together, properly shaped, impregnated with insulating varnish, and rigidly held in place by the pole pieces. The upper housing contains the four brushes (*i.e.*, two positive, which are insulated, and two negative, which are grounded direct to the frame).

The shunt field obtains its current by being directly connected to the armature circuit in the generator. The voltage is controlled by the current flowing through the field, which is automatically governed by the regulator. The armature, which has twenty-one slots, is of the wave-wound type with formed coils well insulated and secured in the core slots, and held in position by banding wires. The commutator is built up of hard-rolled copper and contains twenty-one segments with mica insulation. After the armature is completely assembled, it is impregnated with heat-resisting insulating varnish and baked.

The voltage of the current furnished by the generator is that governed by a voltage regulator, so that it never exceeds 10 to 10½ volts. Its current output is governed by the battery condition and load, but the generator is arranged to carry 5 to 6 ampere load continuously without excessive loading.

Voltage Regulator.—The regulator is an automatic device, controlling the amount of current flowing through the generator field circuit. In design it consists of a soft iron core, over which is mounted a pivoted iron armature, normally held away from the core by an adjustable coil spring in tension. Mounted on this armature is an adjustable tungsten contact point in circuit when closed, with a stationary contact, and forming a generator field connection to ground of low resistance. Around the core are wound three windings, which control the opening and closing of the contacts and the current in the generator field circuit.

The voltage generated in the generature armature is impressed upon a voltage winding, and as the speed of the armature or the strength of the generator field increases, the amount of current flowing through this winding increases, producing an increasing amount of magnetism in the core, and attracting the pivoted armature which causes the contacts to open. This immediately reduces the current flowing in the generator field to the amount limited by the flow through the other two windings, causing a weakening of the generator field and a corresponding control of voltage. The decrease in magnetic attraction of the voltage coil permits the spring to again close the contacts, and establish a low resistance field path to ground. This action is repeated very rapidly causing the contacts to continually vibrate at high speed, increasing as the speed of the generator armature increases.

The regulator is adjusted by changes of spring tension. Increasing the tension increases the voltage produced by the generator, and *vice versa*.

Distributors.—To supply the duplicate ignition required, two 12 or 8-cylinder distributors are provided, each one furnishing one of the plugs in each cylinder with an ignition spark at the proper time. Each distributor weighs 5.5 lbs. and is 7¾ in. over-all diameter and 5⅝ in. high. They are mounted one on each of the two overhead camshafts, fastening direct to the camshaft housing.

The ignition coil, which is contained in the distributor head, is a device by means of which induction low voltage current is transformed to high voltage current. The high tension terminal of the coil is a carbon button, extending through the under side of the head, and when in position on the breaker mechanism makes contact with a flat spring on the high tension rotor.

The rotor carries a soft carbon brush, which bears upon a hard rubber track. The high tension terminals are spaced at proper angular relation around the periphery of the distributor head rim, the terminals being moulded in the hard rubber track. The primary winding receives its current direct from the switch. The current, after passing through the primary winding, continues to the breaker mechanism, which completes the circuit to ground. Both the battery and generator have their negative side grounded, using the engine frame as negative side of the circuit.

The breaker mechanism consists of contacts operated by a cam, which opens and closes the circuit between the primary winding and ground. Two of the contact arms, located diametrically opposite each other and called the main contacts, interrupt the primary current, producing ignition. A third contact arm, called the auxiliary arm, is electrically in parallel with the main arms, but also in series with a resistance unit, which limits the flow of current to this arm. This forms a safety feature, preventing the engine from operating in a reverse direction. ("Aviation," March 1, 1919.)