TECHNICAL NOTES.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

No. 47

RECENT EUROPEAN DEVELOPMENTS IN HELICOPTERS.

Prepared by

Paris Office, N.A.C.A.

[redacted]

April, 1921.

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TESTS MADE WITH CAPTIVE HELICOPTERS, BY PROF. KARMAN.

1) Central Development of Preparatory Work.

The tests in question were consequent upon the acceptance of a proposal for the construction of a captive helicopter, offered by First Lieutenant Stefan von PETROCZY, then Commander of Balloon Pilot Instruction, to the Imperial and Royal War Office. Lieut. von PETROCZY also requested to be accredited with a certain sum for testing expenses.

The first tests were made at the Austrian Airplane Factory, Ltd., Wiener-Neustadt, with propellers of rather large diameter. The Daimler Works at Wiener-Neustadt also received an order from the Aviation Arsenal to hurry on the construction of a light 300 HP electro-motor originally intended for giant airplanes. As this motor was intended to weigh 250 kg. only, according to the statement of the firm, the possibility of constructing an electro-motor with power provided by means of a cable was taken into consideration.

The Austrian Airplane Factory proceeded no further than general drafts. When the present writer was entrusted with the direction of all the tests of the captive helicopter, in the early part of 1917, the work was commenced systematically along two lines. First of all, tests were made at the propeller-testing laboratory at Fischamend; secondly, model tests were carried out in order to throw light on their stability conditions, beginning with very small models worked by rubber cords, then with a heavier 30 kg. model driven by a 5 HP air pressure motor specially constructed for the purpose.

These tests led to the discovery of a special kind of cable, which ensures stability and which was used in all later models.

On the basis of the above-mentioned preliminaries, tests were proceeded with along two lines: One by means of electric power, and the other with gasoline rotary motor power. We shall now give a short description of these two methods, with a report of the tests thereby carried out:

2) <u>Short Description of the Captive Helicopter having Electric Power.</u>

The machine was completely equipped with electro-motor, electric cable and winch before being tested working on the ground. The framework itself is composed of steel tubes, with an observer's car in the center, from which there is a clear view and firing range in all directions. The lifting power is furnished by 4 propellers driven by a motor by means of cone gear. Its weight empty, including motor and propeller, is about 650 kg. The electro-motor weighs 195 kg.; according to the Daimler Co., its output should be 225 HP (originally 300 HP with 250 kg. load), and it has actually yielded 190 HP, though in that case the motor was heated to such an extent, after 15 minutes' working, that it could not be carried on. Even with this reduced power, the lifting tests resulted in a carrying capacity sufficient for three men.

In consequence of difficulty with the electro-motor, the captive helicopter has not yet been flown with electric power. The electro-motor was built into the machine, which then rose from the ground and attained a low altitude with three passengers. After a run of about 15 minutes, however, the motor caught fire and had to be returned to the Daimler Aviation Section unaccepted, where it is now undergoing repairs.

The advisability of equipping the already completed machine with two rotary motors, which necessitate the installment of transmission gear, was considered, but the idea was not carried out for want of suitable motors.

The machine belongs to the Austro-Hungarian Military Administration.

3) Short Description of the Captive Helicopter having Gasoline. Motor Power.

The captive helicopter with gasoline motor power consists of a 3-armed frame made of steel tubes, in which the motors M1, M2, and M3, are built. The motors (Le Rhone motors, 3h. producing 120 HP reconstructed for the tests) drive two propeller shafts, revolving in opposite directions, by means of the transmission gear, and these propeller shafts in turn drive two wooden propellers, each 6 m. in diameter, at about 600 r.p.m. Three gasoline tanks are installed near the motors.

The entire system is supported by a large buffer, which is kept tightly filled with air through an air-pump driven by the motor; under the end of each arm three small buffers are similarly disposed. The actual object of these buffers is to reduce the shock in abrupt landings. The observer's seat, made of "Fournier" is situated over the propeller and strongly secured to the stationary gear-case by the concave interior propeller shaft. A machine-gun turret is located on the upper rim of the observer's seat.

A parachute is also located beside the observer. It has a capacity of 250 sq.m. and is so designed that in case of sudden stoppage of the motor, it can bear the weight of the entire installation, including the observer. The parachute may be worked in the two following ways:

1) Automatically, in such wise that when a regulator, adjusted for the purpose, falls below a certain number of revolutions of the propeller, it releases a mechanism which ejects the parachute. This ejection from the center causes the parachute to open instantly, and tests have proved that it begins to work after a drop of about 25 m. This device thus insures the captive helicopter against damage, in case the motor should stop at low altitudes. The same mechanism brings the motor to a standstill at the time of ejecting the parachute.

3) The parachute may be worked by hand, by the observer, who is also provided with a bag parachute for personal safety.

We may here observe that there is need for the use of the parachute only when at least two motors have stopped, two motors being capable of maintaining the propeller at a sufficiently high rate of revolution.

The climb takes place as follows: When the observer has taken up his position, the motors are started, and this creates no difficulty by reason of the fact that ONE motor at work causes the others to revolve. The functioning of the motor can be controlled by the observer, and future types of the captive helicopter will have the necessary instruments located within reach of the observer. As soon as the motor has attained the full number of revolutions, a signal will be given for the loosening of the winch, and the machine will then, according to present experience, climb at a speed of about 1.2 m. per sec. This climbing speed mainly depends upon the pitch of the propeller and the direction of the wind, and it can therefore be considerably raised. The captive helicopter is brought down by reversing the winch.

Up to date, the motors have always run at full intake, in which case the excess of lift must be compensated. In future, the motors will be throttled in order to diminish the work of the winch.

The total weight of the captive helicopter, with engine and fuel for one hour, but not including the observer and the machine-gun, is about 1300 kg. It is strongly constructed, and some slight lessening of weight may yet be attained. At starting, about 1800 kg. were measured, that is, about 5 kg. per HP. This number can be considerably augmented by enlarging the propellers.

The original type of captive helicopter with gasoline motor power was manufactured by the firm of Dr. Liptak, Ltd., Budapest-Szentlőrincz under the special supervision of my collaborator, Lieut. Eng. W. Zurovec, and the above-named firm owns our patent.

It may here be mentioned that First Lieut. v. PETROCZY was most energetic in promoting the work above described.

4) Test Flights with Gasoline Machine.

The reports of the test-flights undertaken will be added later on. They may be summed up as follows:

From April 2nd to 5th, lift and stability tests at low heights, duration tests up to 60 minutes.

From May 17th to June 10th, climbing to 10 m. - 50 m. altitude. Results: Lift excess on the ground to a load of 4 men. Perfectly tranquil soaring at an altitude of 50 m. Wind velocity during tests up to 8 m.p.sec.

The flight tests and the method of construction are shown in the accompanying album.

After about 15 successful flight tests, the machine had a breakdown when landing on June 10th. The power of the enemy motors, which had been recently repaired, diminished so considerably that there was an insuffieient excess of thrust, and the machine therefore oscillated violently, especially while being brought down. The crew abandoned it, and the machine turned over on the ground, the propeller-blades sticking into the earth.

Considering the state of the motors, my collaborator, Lieut. Zurovec and I wished to omit the tests (there being a wind velocity of 8 sec. p.m.), but were urged to carry them on by the Commission surveying the tests.

The results fully confirmed those already arrived at with model tests, so far as stability is concerned. Observations made in the wind proved that, in addition to the fundamental demand for ample excess of thrust, the position of the center of gravity of the machine in its relation to the plane of rotation of the propeller is of great importance. The results obtained in that respect, both in theory and by means of practical tests, should be of the utmost value as applied to the construction of a second type.

5) <u>Application of the Captive Helicopter</u>:

a) <u>Captive Helicopter with Crew, for Observation Purposes During War on Land</u>.

The advantages of the captive helicopter as compared to captive balloons are as follows: They are but slightly visible and therefore provide limited target area for artillery; they are mounted with guns and are specially adapted for shooting upwards during attacks by airplanes; they are non-inflammable, they can be started without any loss of time and can be rapidly transferred from one place to another.

The comparison may be continued by stating that:

A balloon-section on the southwest front, with one balloon requires:

1 automobile winch-wagon,
2 " gas-wagons,
3 freight "
6 officers,
137 men;

whereas a captive helicopter requires:

1 automobile car with three trailers,
1 freight automobile,
6 officers,
20 men.

b) Captive Helicopters for Observation from Battle-Ships:

Adapted in a suitable manner, the captive helicopter might prove to be the best possible means of taking long-distance observations from battle-ships.

c) Captive Helicopters for the Protection of Open Towns and Coasts from Airplane Raids:

A series of captive helicopters would not only be able to give warning of the approach of enemy aircraft, from a long distance, but might also be able to open effective defensive firing, if properly armed.

d) Captive Helicopters without Crew for Radio Purposes:

Tests hitherto carried out with kite-balloons or antenna have always been unsuccessful either on account of a breakdown of the kite-apparatus at a low wind velocity, or because of disturbing motion of the balloon antenna during squalls. These difficulties would be avoided by the use of captive helicopters and are therefore of particular utility for colonies and districts where stable mast-construction cannot easily be carried out and which may also give rise to great outlay.

e) Captive Helicopters for Meteorological Work:

By means of the captive helicopter, registering devices can easily be taken up and measurements carried out rapidly in all weathers.

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DESCRIPTION OF THE DAMBLANC HELICOPTER.

<u>Description of the Machine</u>.

The machine comprises:

- 2 rotating wings
- 1 fusselage
- 2 stabilizing planes with their control
- 1 rudder with its control
- 1 landing gear
- 2 engine sets with their automatic clutch device, transmission of movement and elastic coupling.
- 1 warping device with controls.

<u>Rotating Wings.</u> Each wing is formed of four blades assembled by means of four tubes on a crossbar revolving about the axis of the wings by means of ball bearings. Each blade has an area of about 5 square meters.

<u>Fuselage</u>. Consists of two parts: the fore part is metallic and is formed of steel tubes jointed together in lattice work and linked up by steel wire bracing. The other part to the rear is formed of a wooden frame and is also in lattice work and braced.

<u>Stabilizing Planes.</u> Two planes situated to the rear of the fuselage and maintained by a braced beam. They are controlled by a metallic cable worked by a flywheel.

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<u>Landing Gear.</u> Comprises 2 beams forming a V; they are braced with crossbars and with bracing wire; 2 wheels with pneumatic tires are attached to them by an elastic suspension.

<u>Engine Sets.</u> Each set comprises one Rhone engine, the characteristics of which are given further on. The main driving shaft, placed inside a tube, forms a single beam and is coupled to the engine by an automatic engaging and releasing device.

This shaft bears a pinion which works a gear wheel, this gear wheel being attached to a crankcase cover which assures the rotatory movement of the wings by means of cables fixed to the blades.

An elastic shock absorber composed of bevel gear connected by a special device provides the mechanical connection for the two transmissions.

<u>Warping Device for the Blades.</u>

A manoeuvring organ (control stick and levers)

Cables for the transmission of movement.

Warping gear and control of the blades; for each wing this device consists of: 1 support, 4 rollers rolling on a bearing cup and 4 articulated elbow levers acting on the blades of the wings by means of metal cables.

General Characteristics.

Span . . . . 15 meters.

Total length . . . . 9 m 20

Total area of rotating wings . . . . 40 sq. m.

Number of wings 8

Area of each wing . . . . 5 sq.m

Width of fuselage . . . . 1 m 20

Engines . . . . 2 rotary, 150 H.P.

Area of Stabilizing planes . . . . 4 sq. m.

Number of planes 2

Speed of Rotation of wings . . . . 160 r.p.m.

Total weight of machine in flying order,
pilot included . . . . 1200 kgs

Weight per square meter of lifting surface . 30 kgs

Area of rudder . . . . 1 sq.m

Characteristics of the Engines.

"Le Rhone" engines 110/120 HP at 1300 r.p.m.

Consumption Gasoline: 45 liters an hour.

Oil: 8 liters an hour.

Machine: Useful weight carried:

1 pilot

Gasoline for half an hour's flight
with 2 engines. . . . . about 50 liters.

Oil for half an hour's flight with
2 engines . . . . about 8 liters.

EXPERIMENTAL LABORATORY TEST.

Object of Test:

To determine the correlative values of the powers absorbed by the hub of the propeller, and of the corresponding speeds and thrusts at the fixed point.

Designation of Propeller:

According to indications given by the applicant, the propeller presented was a reduced model of one of the two lifting propellers of a new airplane called "THE ALERION". This propeller was made of walnut and its chief characteristics were as follows:

Number of Blades 4

Diameter of Propeller . . . . 1.05 m.

Maximum width of Blades . . . . 0.30 m.

Description of Installation:

The propeller was mounted on the dynamometric pendulum of the Laboratory which allows the direct measurement of the powers absorbed and of the corresponding speeds and thrusts at the fixed point.

Description of Test:

The determinations of the powers absorbed and of the speeds were effected by producing successive thrusts of 3, 8, 13, and 18 kilograms as indicated by the applicant.

For each experiment the speed of the propeller was increased until it gave the proper thrust; when the regime was established, the power absorbed by the hub was noted and the number of revolutions made by the propeller in one minute. For each thrust 3 measurements were made and the average was taken.

Results.-

The results obtained are summarized in the following table:

Date of Test . . . . . . September 5, 1918.

Designation	Units	Results		Information	
Thrusts	kilograms	3	8	13	18
Number of revolutions of propeller	r.p.m.	480	778	1008	1169
Power absorbed by the hub of the propeller	horsepower	0.25	1.03	2.18	3.47

Barometric pressure during the test (brought to 0°) 756.5 mm. mercury. Surrounding temperature: 22° centigrade.

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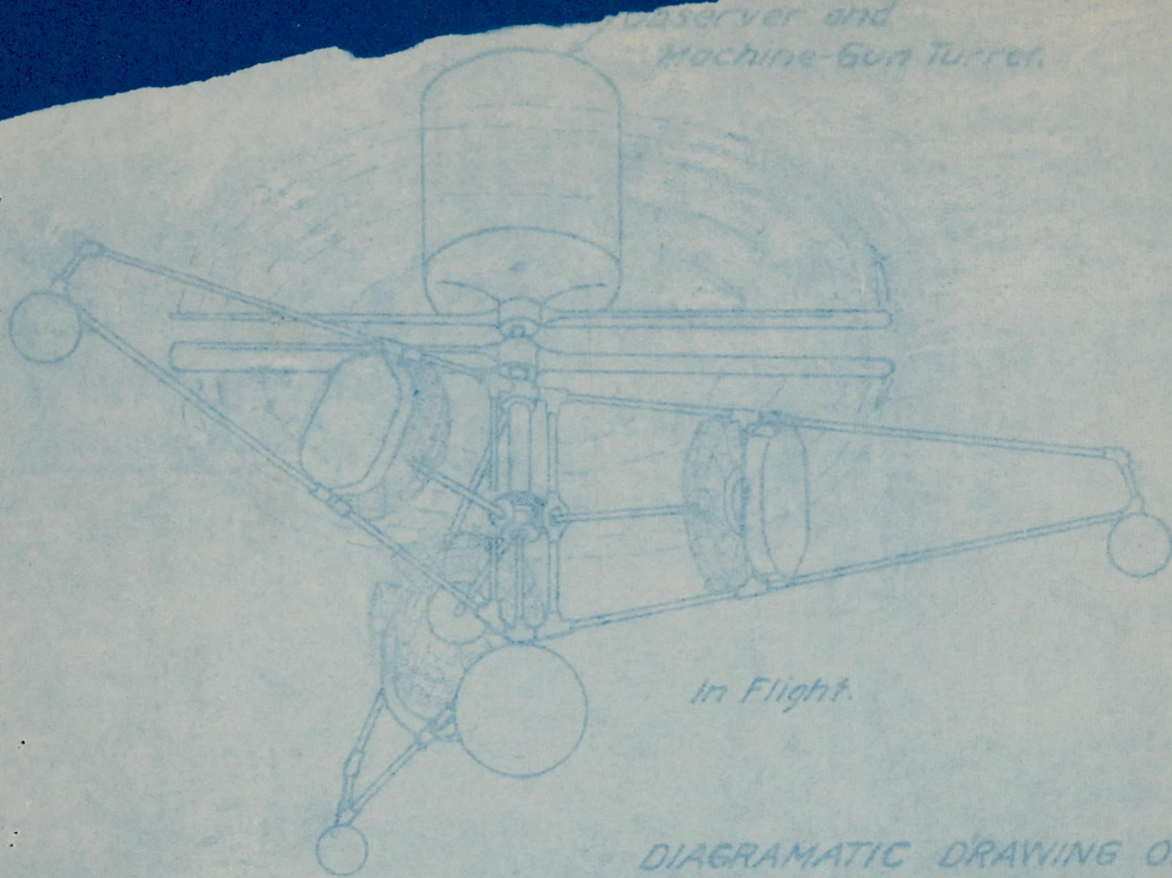
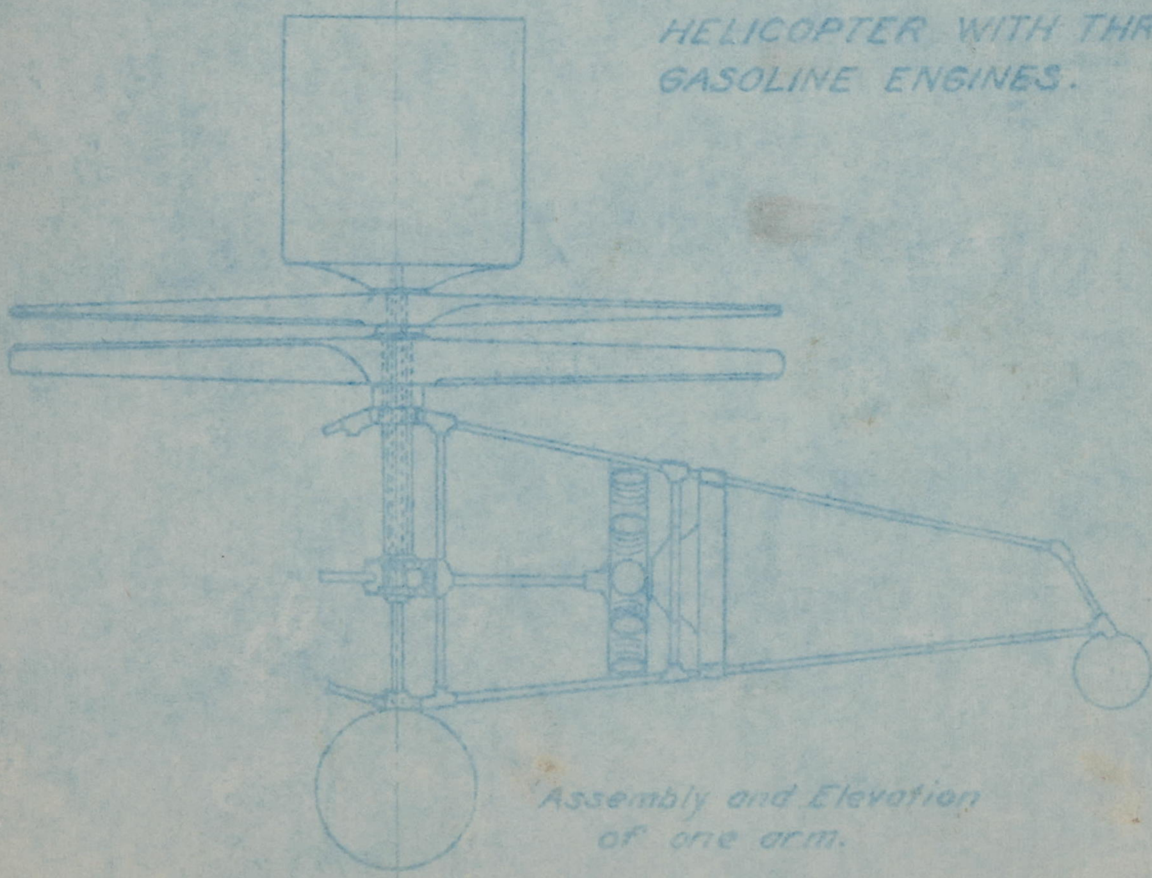


In Flight.

DIAGRAMATIC DRAWING OF
THE KARMAN CAPTIVE
HELICOPTER WITH THREE
GASOLINE ENGINES.



Assembly and Elevation
of one arm.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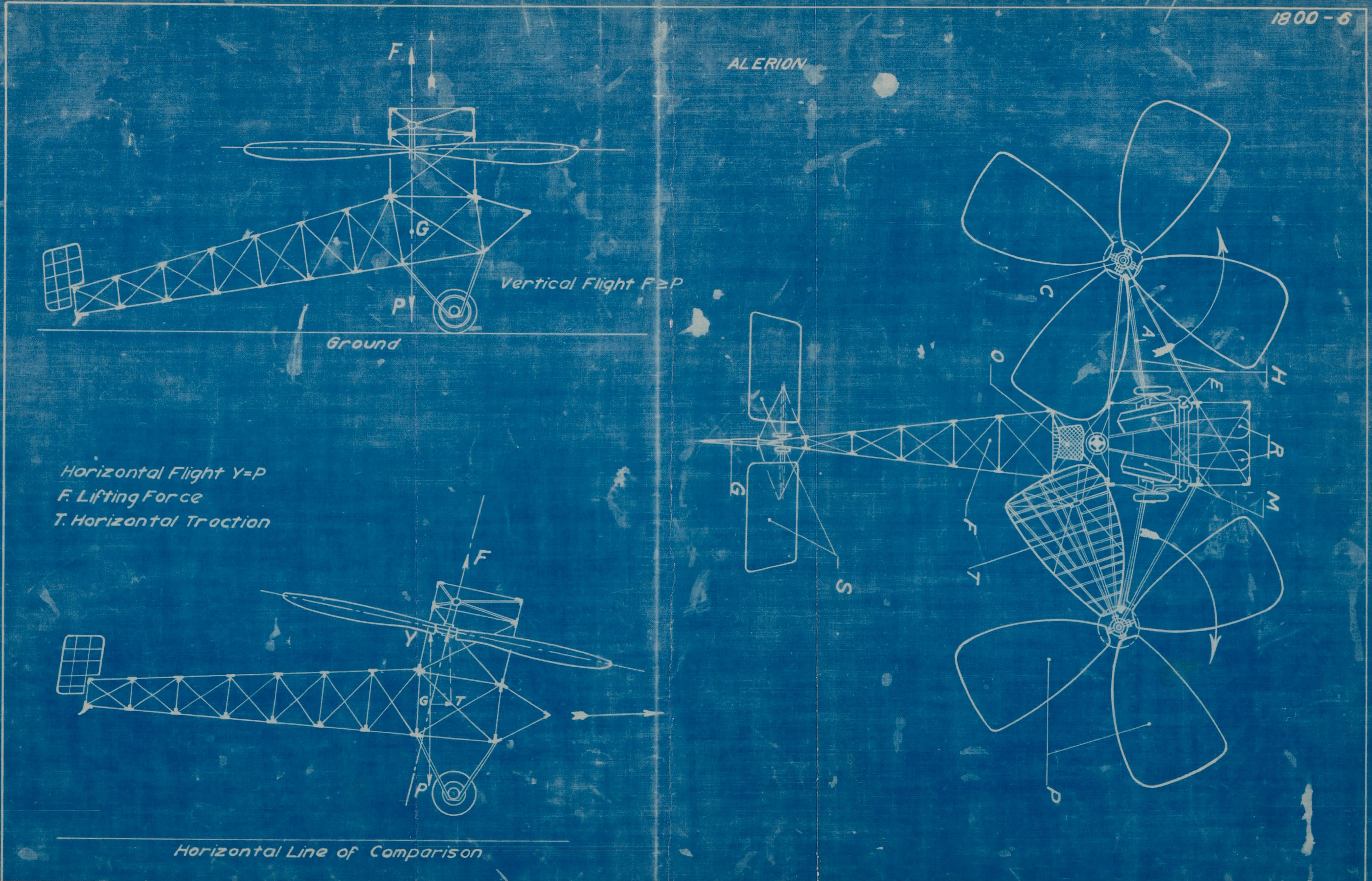
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ALERION
F
G
P
Vertical Flight F≥P
Ground
Horizontal Flight Y=P
F. Lifting Force
T. Horizontal Traction
F
Y
G
T
P
Horizontal Line of Comparison
C
A
O
H
E
R
M
G
F
T
S
D