TECHNICAL NOTES.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 50

THE GORDON BENNETT AIRPLANE CUP.

1920.

By

W. Margoulis, Aerodynamical Expert,
Paris Office, N.A.C.A.

April, 1921.

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In this Paper I propose to give briefly the characteristics of all the airplanes built for this Race, to give some quite new details concerning the French machines, to study the airplanes from an aerodynamical point of view, and lastly, to say a few words on the regulation of future Speed Tests.

1 - ELIMINATION TESTS AND THE RACE.

I shall sum up briefly the results of the elimination tests and of the Race.

The French ELIMINATION TESTS took place on September 25th, over a track of 100 km. The results were:

1st. Sadi Lecointe on a Nieuport in 21' 28". Speed 279.6 km/hr.

2nd. Kirch on a Nieuport in 22' 18". Speed 269 km/hr.

3rd. Romanet on Spad-Herbemont in 23' 16". Speed 257.9 km/hr.

These three machines were qualified to take part in the Race for the Cup.

The Borel-Boccaccio machine covered the distance in 22'23" and would have been qualified to take part in the Race instead of the Spad, had not the pilot failed to pass between the pylons at the start.

Casale on a Spad-Herbemont covered the distance in 25'27".

On September 26th, the Curtiss airplane was disqualified on account of a landing accident at Etampes (see annexed Note on this accident).

THE RACE. SEPTEMBER 28th.

During the whole of the morning a persistent mist prevented a start being made, but towards noon this disappeared under the influence of the sun, and it seemed probable that the afternoon would be very fine.

Kirch, on his Nieuport, was the first to start at 1 o'clock 36' 25-1/5" p.m.

De Romanet followed at 1 o'clock 41' 55" on his Spad-Herbemont.

Sadi Lecointe, on his Nieuport, started at 2 o'clock 8' 54-2/5" p.m. The contest is between the three French pilots.

At 1 o'clock 57' 54-1/5" Kirch was back at Villesauvage, turned, and began his second round. He had covered the first round in 21' 29", which was the best round of the day. When Kirch had completed his second round, he landed, to the great surprise of the spectators. A too liberal lubrication had fouled the spark plugs, and the pilot was obliged to give up on account of misfiring.

De Romanet was also unlucky. His machine was a trifle faster than in the elimination tests, owing to some slight alterations in the tail planes which had appeared rather too small. He covered the 100 km. of the first round in 23' 52", the 200 km. in 46' 7" and landed owing to a defect in the oil pipes. This took half an hour to repair. In spite of this handicap, the gallant pilot started again, but ill-luck dogged him. This time, on account of a leakage, the oil spurted in his face almost blinding him. Still he held heroically on his course at a formidable speed and by a miracle of energy and skill succeeded in finishing his last round and landed safely. Total time: 1 hr. 39 min., including the half-hour's stop. Speed per hour: 181 km. 616.

During this time Sadi Lecointe was continuing his round. He covered the first 100 km. in 21' 36-3/5"; the 200 km. in 43' 42-3/5"; the 300 km. in 1 hr. 6 min. 17-1/5 sec. The first round lasted 21' 36-3/5"; the second round 21' 58-2/5"; the third round 22' 31-2/5"; thus showing marvelously steady running.

The most remarkable of the foreign competitors, the Dayton-Wright, piloted by Rinehart, started at 4 o'clock 11-3/5 min. p.m. Its wheels folded back, the American monoplane gave the impression of a flying fish, but was appreciably less rapid than the Nieuport. At 37 min. past 4, it was the turn of the American pilot Schroeder on his powerful Verville-Packard. But Rinehart gave up the struggle; his controls did not act and he was unable to turn. Major Schroeder also gave up, jets of flame from the muffler threatening to set the machine on fire.

The English pilot Rayneham was the last to start on his Martinsyde, but he was forced to land at the end of the first round, the oil manifold having burst.

2. - AIRPLANES TAKING PART IN THE CUP RACE.

1) NIEUPORT (Sadi Lecointe). (Pl.B 41, Fig.1)

DIMENSIONS - Span 6 m.; length 6 m. 20; height 2 m. 50; Wing Chord 1 m. 20; aspect ratio 5; mean gap 1 m. 35; lifting surface 12.3 sq.m.; ailerons 1.23 sq.m.; tail plane 1.25 sq.m.; elevator 0.75 sq.m.; fin 0.44 sq.m.; rudder 0.45 sq.m.

WEIGHTS - Airplane without engine 300 kg.; engine set 390 kg.; pilot 80 kg.; fuel 100 kg.; total weight 870 kg. 7.07 kg/m^3, 2.68 kg/h.p.

PROPELLER - Type Chauvière, diameter 2.45 m., pitch at 3/4 of radius 2.80 m.; maximum width 0.20 m.

ENGINE - Hispano-Suiza 300 HP. The number of revolutions at full speed was 1980 r.p.m. corresponding to 320 horsepower. Compression 4.9. Lamblin Radiator, 25 sq.m. radiating surface.

2) SPAD-HERBEMONT (de Romanet). (Pl.B.42, Fig.5)

DIMENSIONS - Span 6.5 m.; length 7.3 m.; height 2.5 m.; Wing Chord 1.22 m.; aspect ratio 5.3; gap 1.25 m.;

surface 13.1 sq.m.; ailerons 1.2 sq.m.; tail plane 1.1 sq.m.; elevator 0.9 sq.m.; fin 0.35 sq.m.; rudder 0.4 sq.m.

WEIGHTS - Airplane without engine 320 kg.; engine set 390 kg.; pilot 80 kg.; fuel 100 kg.; total weight 890 kg. 68 kg/m^2; 2.7 kg/h.p.

PROPELLER - Type Lumière, diameter 2.4; pitch at 3/4 of radius 2.9 m.; maximum width, 0.25 m.

ENGINE - Hispano-Suiza 300 H.P. Speed of rotation in flight 2000 r.p.m. 330 horsepower; Compression 4.7. Honeycomb radiator 30 sq.m.

3) THE BOREL-BOCCACCIO.

DIMENSIONS - Span 7.1 m.; length 7.1 m.; height 2.4 m.; Wing Chord 0.90 m.; aspect ratio 8; gap 1.1 m.; surface 13 sq.m.; ailerons 1.1 sq.m.; tail plane 1.3 sq.m.; elevator 1 sq.m.; fin 0.4 sq.m.; rudder 0.5 sq.m.

WEIGHTS - Airplane without engine 290 kg.; engine set 380 kg.; pilot 80 kg.; fuel 100 kg.; total weight 850 kg. 65 kg/m^2; 3.5 kg/h.p.

PROPELLER - Lumière; diameter 2.5 m.; pitch at 3/4 of radius 2.9 m.; maximum width 0.20.

ENGINE - Hispano-Suiza 300 HP. Speed of rotation in flight 2050 r.p.m. 335 horsepower; Compression 4.7; Lamblin radiator, 35 sq.m.

It will be noticed that this airplane has a small wing chord and large aspect ratio (8), while the other machines had a mean aspect ratio of 5. Considering that a racing plane should fly very close to its ceiling, the increased aspect ratio seems logical. But on the other hand, when we calculate the value of k_y we see that it is very low and as we know that increase of aspect ratio does not appreciably diminish resistance at low lift, we may ask whether it was advisable to adopt a large aspect ratio. We are unable to decide the question one way or the other, for as we shall see further on, a reduction of area of the Nieuport led to a reduction of speed, which is contrary to what might have been expected.

4) THE MARTINSYDE. (Pl. 41, Fig.2)

Span 6.15 m.; length 5.85 m.; height 2.2 m.; surface 13.65 sq.m.; total weight 920 kg. Hispano 300 HP engine.

5) THE DAYTON WRIGHT. (Pl. 41, Fig. 3)

DIMENSIONS - Span 6.9 m.; length 6.0 m.; height 2.44 m.; maximum wing chord 1.98 m.; minimum wing chord 1.22 m.; mean aspect ratio 4.3; maximum thickness 0.14 m.; surface 9.6 sq.m.; ailerons 2.4 sq.m.; tail plane 1.36 sq.m.; elevator 0.9 sq.m.

WEIGHTS - Empty 636 kg.; loaded 841 kg. 87.6 kg/sq.m.; 3.37 kg/hp. Engine, Hall-Scott, 6 vertical cylinders 250 HP; propeller 2.2 m. in diameter.

The question arises whether it is preferable to have a monoplane with an aspect ratio of 4.3 or a biplane with an aspect ratio of 8.

6) THE VERVILLE. (Pl. 42, Fig. 4)

DIMENSIONS - Span 8.58 m.; length 7.36 m.; height 2.64 m.; maximum chord of upper wing 1.8 m.; minimum chord 1.05 m.; mean aspect ratio 6; surface 21.3 sq.m.; ailerons 1.72 sq.m.; tail plane 1.7 m^2; elevator 1.5 sq.m.; rudder 0.9 sq.m.

WEIGHTS - Airplane without engine 500 kg.; engine set 610 kg.; fuel 245 kg.; pilot and miscellaneous 95 kg.; total weight 1450 kg.; 68 kg/sq.m., 2.6 kg/h.p. Engine, Packard 550 HP.

3. - AERODYNAMICAL INFORMATION GAINED BY THE CONTEST FOR THE CUP.

On Pl. B.43 are shown on a groundwork of logarithmic polars:

1) The polar curve of the Borel-Boccaccio model airplane from the tests made at the St.Cyr Aerotechnical Institute.

2) The straight line indicating the conditions of flight near the ground level of the same machine, by the flight made in the elimination tests.

3, 4, and 5) The straight lines indicating the conditions of flight of the Nieuport, Verville, and Dayton-Wright airplanes.

6) The polar curve, according to the tests of the French S.T.Aé., of the Nieuport Pursuit Monoplane, from which is derived the Nieuport Racer. (Weight, 1100 kg., Area 27 sq.m., Hispano 300 HP).

7) The straight line indicating the conditions of flight of the Deperdussin Airplane of the Gordon-Bennett Cup Race of 1913. (Weight 740 kg.; area 10 sq.m.; Gnome 160 HP.)

From an examination of Pl.B.43 the following conclusions may be drawn:

1st. The laboratory test gives for the Borel-Boccaccio a resistance 50% greater than the true resistance. This, as I have shown elsewhere,* is due to the fact that in tests made in existing laboratories, the Reynolds number realized is from 15 to 25 times less than that of the plane in free flight, and that, consequently, the struts of the rigging and undercarriage have a resistance on the model 5 times as great as on the full scale machine, while the increase of resistance for the other parts of the machine vary between 100 and 200%. If the Reynolds number involved is rather high, it is perfectly useless to test a model in an existing laboratory.

2nd. The classification of the machines Borel, Nieuport, Spad and Verville seems to be quite logical when we consider that the resistance of the Nieuport was greater than that of the Borel because it had an additional cabane; that the resistance of the Spad was greater than that of the Nieuport because of its radiator placed forward,**and that the Verville having the same load per horsepower and per square meter as

* See "France-Aviation," December 1919.

** The Spad has lately beaten the speed record (309 km/hr) by almost entirely masking the radiator with a large pan-shaped screen and suppressing the wind-screen of the cockpit, the pilot's seat being moved further back in the fuselage.

the other machines and being of the same type, there was no reason why it should fly faster than the others.

3rd. I must make some remarks on the shape of the Dayton-Wright wing. It is known that this wing, in one of the extreme positions, is biconvex. Now, in 1916, at the Eiffel Laboratory, we tested a wing identical to the Dayton-Wright, that is, it was composed of three parts hinged together. These tests showed that if we plot the envelopes of the polar curves obtained with different positions of the leading and trailing edges and if we consider the range of speeds between $k_y = 0.0205$ and k_y maximum, we see that this envelope practically coincides (with an increase of 5% in landing speed) with that of a RIGID wing with a camber of 3%.

The Dayton-Wright wing would only be advantageous for an airplane with a very high ceiling, which was required to fly at high speed near the ground level, but it is not advantageous for a racer which must fly as near its ceiling as possible. If we wish to have a low landing speed, we must have a slightly concave ventral profile while keeping a variable camber.* But we shall do still better to make an ordinary wing of slightly larger area, doing away with all the superstructure of controls which absorbs quite an amount of power.

There is still much to be criticised in the Dayton-Wright, and that is regrettable, for it was the only machine offering

* We have been informed that the Curtiss of the Cup Race, which was also very heavily loaded per square meter, substituted, after tests, a profile with flat intrados for the biconvex profile first adopted.

new features and its production had cost an amount which, to European ideas, appears enormous.

4th. When we compare the Pursuit Nieuport with the Racing Nieuport, we find that the reduction of resistance is not due merely to reduction of surface, but also to a great decrease of passive resistances or, more probably, to a decrease of the coefficients of resistance with speed.

5th. The comparison of the Deperdussin with present-day airplanes shows the great progress made, not as regards the power of the engine, but as regards the forms of the machines.

6th. Attention should be drawn to the low value of k_y = 0.01 corresponding to flight at full speed near the ground level of the airplanes competing for the Cup. This low value leads to the assumption for these planes of a rather high ceiling, of the order of 6000 m.

From this we might conclude that the speed of the airplanes could be still further increased by reducing the area; but this is not so. The Nieuport of Kirch, which had 13 m^2, flew faster than Sadi Lecointe's machine with a surface of 12 m^2, and I know that a test which Sadi Lecointe made with one of 11 m^2 lowered the speed by 30 km/hr.

It is true that the surface was reduced by clipping the end of the wings, so that the aspect ratio was reduced, but none the less, considering the low value of k_y, we cannot account for this reduction of speed.

Perhaps the systematic free flight tests now being made by Mr. Boccaccio on his airplane, may throw some light on the subject.

4. - REFLECTIONS ON FUTURE REGULATIONS FOR HIGH SPEED TESTS.

Now that France has definitely won the Gordon-Bennett Cup, people are wondering how future High Speed Tests will be regulated. Many are those who think that it is time to act as was done in Automobile Races, and abandon the formula of absolute liberty under which the Gordon-Bennett Cup was contested, imposing certain restrictions on the machines, though they will still be classified according to speed. Especially it has been suggested either to limit the power of the engine, the load per square meter of the machine, or to fix a minimum landing speed.

PERSONALLY, I THINK THAT PERFECT LIBERTY SHOULD BE ALLOWED, and this for the following reasons:

1st. In order to increase speed, it is not sufficient to increase engine power; the Verville, with a 550 HP engine, did not fly any faster than the Nieuport, for the two machines had the same load per horsepower and per square meter and certainly the structural resistances of the Verville (very large fuselage, large undercarriage) were in the same ratio to those of the Nieuport as the power of their respective engines. The Verville weighed almost twice as much as the Nieuport: 1450 kg. for the former and 870 kg. for the latter.

A machine, however, which might have beaten the French Nieuport, was the English Nieuport with an ABC engine of the same power, but which allowed of a more harmonious fuselage without radiators and a gain of 70 kg. in weight on the engine set.

In the present state of things, liberty as regards engine power does not lead to a search for the most powerful engine, but for one which is reliable and light; IT THUS LEADS TO PROGRESS.

2nd. As already remarked, an increase in the load per square meter does not necessarily lead to increase of speed; this is an inexplicable fact, but it is a fact. As the optimum load per square meter, which, for the Nieuport, seems to be 67 kg/m^2, does not lead to dangerous landing speeds, there is no reason, for the present, why it should be limited. Those who watched the contesting airplanes in the Gordon-Bennett Cup land, had never for an instant the idea of danger. We must not forget that the load per square meter is constantly increasing, not only for military airplanes, but also for commercial machines. The Morane machines, the Gourdou-Lesseure, the Dornier-Zeppelins, the latest Zeppelin monoplane (Staaken), are loaded at 50 kg/m^2; all these, it is true, are monoplanes: we must then define the load of machines according to the number of planes, and that seems much too complicated and above all useless, considering our present uncertainty as to the influence of the unit load on speed.

3rd. It would be well to fix a minimum landing speed, but we must first know how to measure this speed. Many people think it should be measured by the minimum speed of the airplane. Let us remember the "Greatest Range" Competition organized by the "Auto" this last summer. Machines loaded at

20 kg/m^2 flew at 33 km/hr., which leads to admitting for bi-planes kg. = 0.12 kg/m^2:sec.; (or kg. = 0.24 lbs/ft/m.p.h.) values which might well excite the envy of even a Handley Page wing.

Unfortunately, there is another explanation of the fact; there was a light side wind blowing, and the Farman pilots, well drilled in such exercises, flew sideways when there was a head wind, so that the outward bound journey was accomplished, say, in 10 minutes, and the return journey in 2 minutes.

Thus, this question cannot be regulated by any set of reasoned regulations, since it is a question of atmospheric conditions and of skill on the part of the pilot.

In short, in the present state of affairs, I think that liberty will lead more surely to progress than any regulation can do.

THE AIRPLANES
OF THE GORDON-BENNETT
CUP RACE

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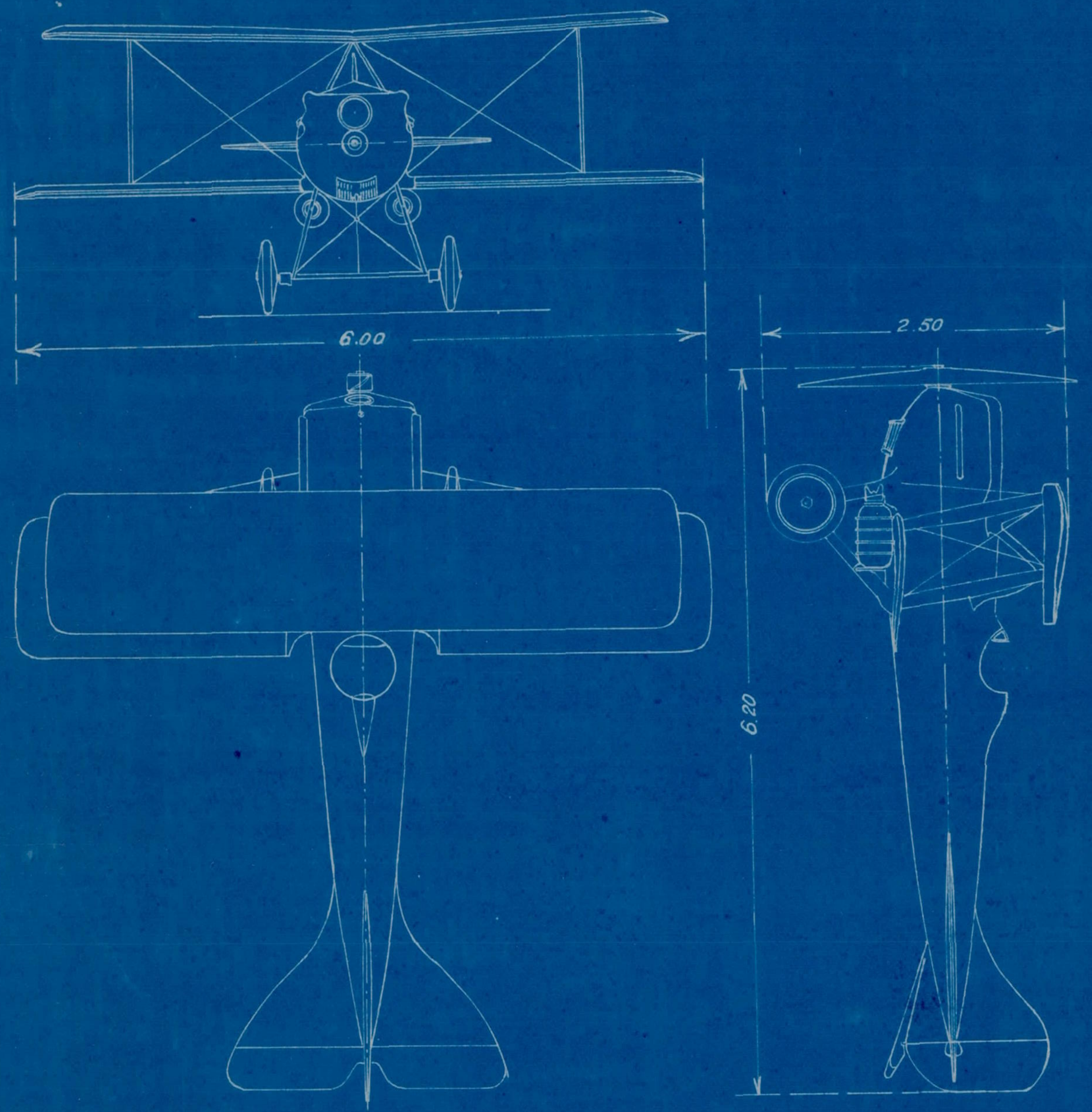

FIG. 1
SCALE 1:60

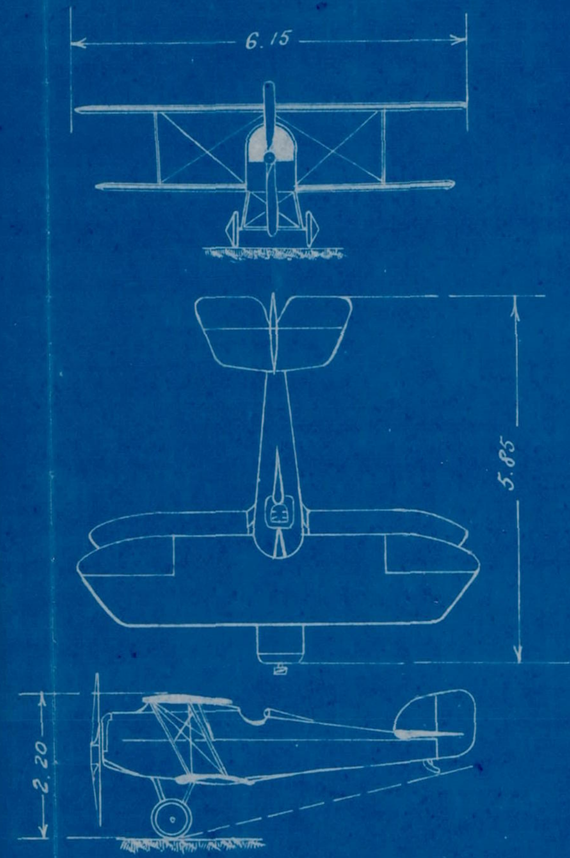

FIG. 2
SCALE 1:117

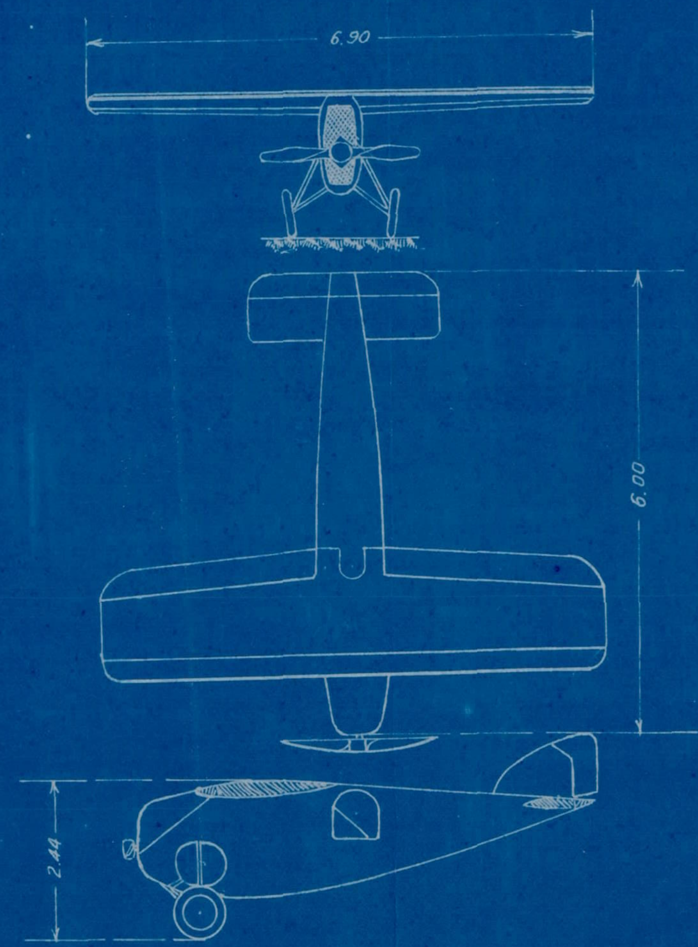

FIG. 3
SCALE 1:100

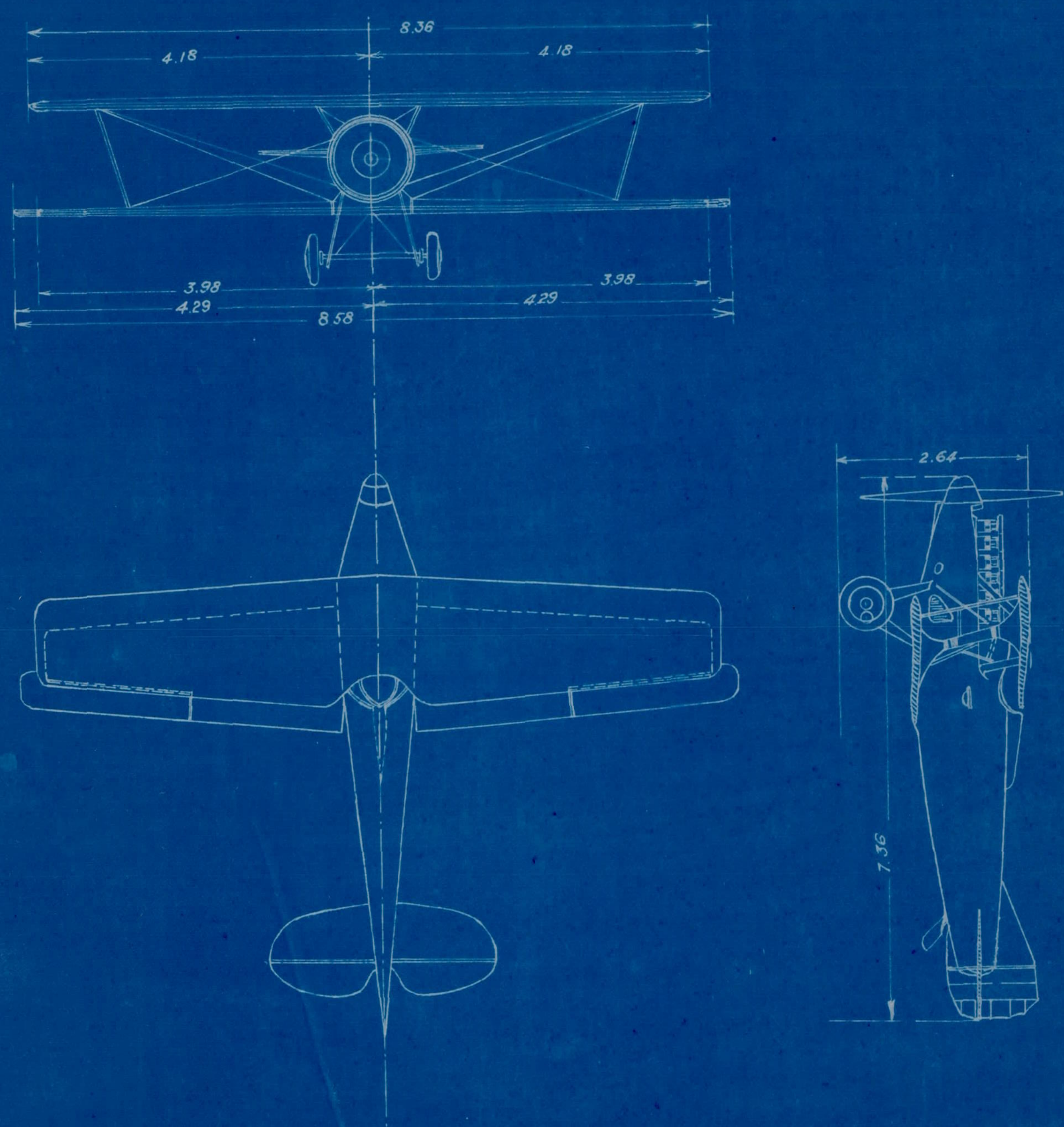

FIG. 4
SCALE 1:80

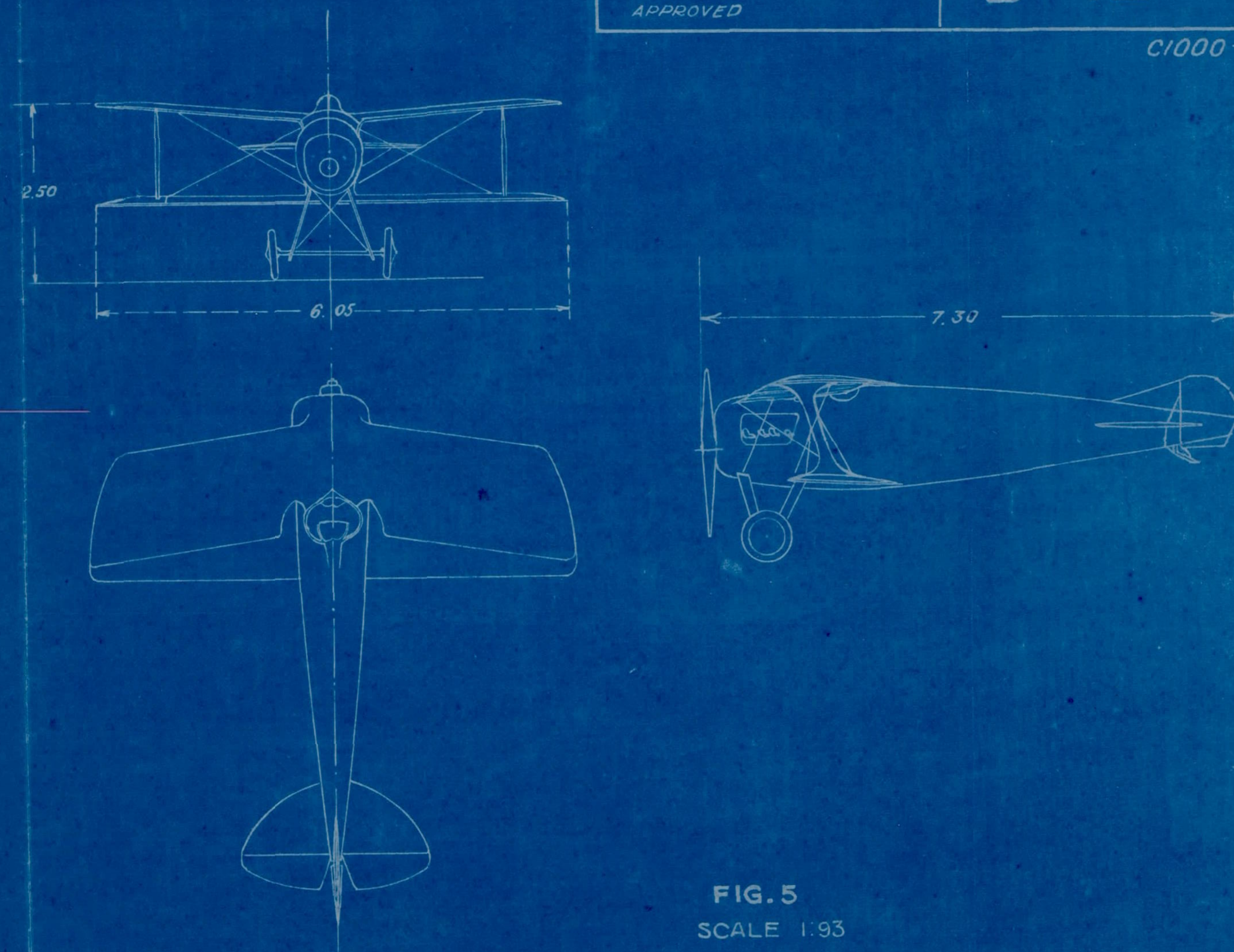

FIG. 5
SCALE 1:93

THE AIRPLANES
OF THE GORDON BENNETT
CUP RACE

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AERODYNAMIC STUDY OF THE AIRPLANES OF THE GORDON-BENNET CUP RACE

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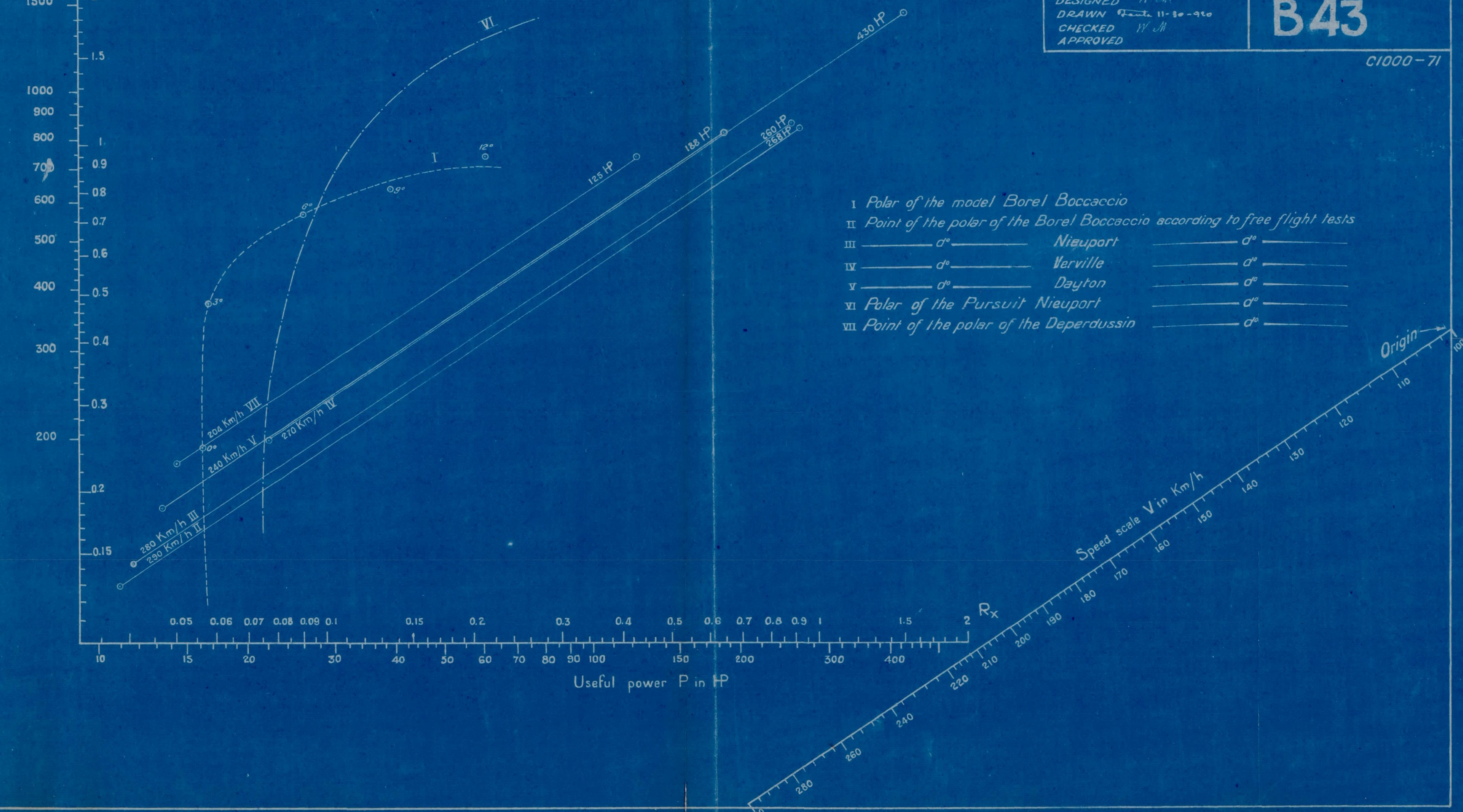

I Polar of the model Borel Boccaccio
II Point of the polar of the Borel Boccaccio according to free flight tests
III ——— d° ——— Nieuport ——— d° ———
IV ——— d° ——— Verville ——— d° ———
V ——— d° ——— Dayton ——— d° ———
VI Polar of the Pursuit Nieuport ——— d° ———
VII Point of the polar of the Deperdussin ——— d° ———