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THE RACE FOR SPEED

FROM THE BEGINNINGS OF AVIATION TO THE PRESENT DAY

by

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Summary

Significant progress was achieved in the field of aerodynamics and aircraft engines in the race for the world speed record. However, starting in 1927, the Schneider Cup seaplanes outclassed aircraft mainly because of the power of their engines.

But progress in aerodynamics is mostly due to aircraft as early as 1933. After 1945, competition regulations were adapted to jet aircraft. A sudden jump in performance occurred in the 50s and 60s. The last speed record 3529 km/hr dates from 1976 when rockets and launch vehicles reached much higher speeds. Today the aircraft speed record in its present form does no longer appears as relevant.

Introduction

The general public has for a long time now accepted the aircraft as the fastest means of travel.

Speed has therefore appeared to be the aircraft most important characteristic, which might explain why the great aeronautical countries have always sought to conquer the world speed record.

Of course there are commercial considerations, the publicity given by the press to the records serves to promote the interests of those companies that construct the successful aircraft.

However, it is paradoxical to note that, in the heroic era of the pioneers, the greatest glory was achieved not by the speed of the flight but simply by the flight itself; and that these days the quality of an aircraft is not judged solely on its maximum speed.

It was interesting, at the 14th ICAS Congress, to recall the history of the world speed record from its beginnings to the present day.

It can be divided into two major phases: the one of propeller driven aircraft and the other of jet aircraft; each one of these had its day. It is well-known that the extraordinary technical progress over 80 years, can be characterised equally by the various periods corresponding to a particular state of the art.

There is no doubt that, at least during the propeller aircraft era, the race for the record and the different speed races were factors in the development of the engine just as much as aeronautical design.

This is not quite so true for jet aircraft; as we will see, because of the considerable costs of developing modern aircraft and engines, no constructor can any longer begin such research outside of an official programme.

The first part, covering propeller aircraft, has been written by General LISSARRAGUE, Director of the Le Bourget Air and Space Museum, assisted by Mr. VITROTTO the aeronautical engineer attache at the same organisation; whereas the second part, dealing with jet aircraft, is the work of Mr. LECOMTE, (Ingénieur Général de l'Armement)

T H E   R A C E   F O R   S P E E D

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P r o p e l l e r   A i r c r a f t

The heroic era of the pioneers

Historically, the first world speed record to be recognised by the IAF (International Aeronautic Federation) was that established by the Brazilian Alberto Santos Dumont in Paris, on the 12th November 1906, with his legendary aircraft, type XIV bis.

Without doubt the Wright brothers should have been the first, but it must be remembered that their last flight in 1905 was on the 5th October and that the IAF wasn't created until 12 months later; it is well known that after this last flight the Wrights did not take their Flyer out of its hangar until 1908.

Therefore it is Santos Dumont who has the honour to be the first on the list of speed records with 41.292 km/hr; rather disappointing if one compares that with the speeds being reached by motor cars during the same period.

In truth, the major problem at that time was not how to fly as fast as possible but how to fly at all.

One should not be surprised therefore, that nearly one year later, Santos Dumont's record was only broken by 11.4 km/hr by Henry Farman in a Voisin aeroplane.

The name of Wright appears officially in this race, not yet very exciting, with the next record - the 3rd on the list - thanks to Tissandier who, at Pau, on the 20th May 1909, in a Wright Flyer B aeroplane fitted in France with a Barriquant and Marre 35 HP engine, beat Farman by a 2 km/hr and carried the speed record to 54.810 km/hr.

The sport developes

However for 3 years one must mark-time, things are going to become serious on the occasion of the Reims Meeting where, in August 1909, the Grand Prix of speed and the first Gordon Bennett Cup for aeroplanes are going to be contested.

By the middle of 1909 practical aviation was finally under way, as demonstrated by the number of registered aircraft - 34 of which 4 were foreigners; amongst those is the American Glenn Curtiss who is going to contest the speed races with Bleriot. It is Glenn Curtiss who will win the first Gordon Bennett Cup and who will break the speed record, held by Tissandier in a Wright, with 69.821 km/hr.

However, Louis Bleriot with his type XII will break the record twice, the second time with 76.995 km/hr.

This American-French contest is the first in a long competition between the two countries for the world speed record; it is a historical resumé of the record between 1909 and 1937 when Germany will come to the forefront.

In 1909 also, Col. Roche created the first school for aeronautics engineers which later on will be "Sup Aéro".

For the time being the speed record stayed with the french who disputed it between themslves - at a rate of four times per year - with the Antoinette and then with the Bleriot XI; this aeroplane was derived from that which crossed the Channel but with increasingly powerful engines upto the 100 HP Gnome in 1911. However, these aircraft in spite of being all monoplanes, were still poorly designed for speed: their fuselages were not covered and they were encumbered by struts and stays.

The first to deliberately break with this total reliance on power was Edouard Nieport - called Nieuport - who broke Leblanc's record of 111.8 km/hr, established at Pau in a 100 HP Bleriot XI, with a small machine of only 35 HP. For the first time the fuselage was completely covered and the stays were reduced to a minimum; he himself designed everything including, the engine, the propeller the spark plugs and he flew at 119.76 km/hr. With a 50 HP Gnome he will go on to reach 133.136 km/hr on the 21st June 1911; he will be the 14th holder of the title.

The lesson will be understoood and, henceforth, whilst benefiting from progress in engines, care will be taken to gain every advantage from airframe design.

Edouard Nieuport was killed prematurely whilst flying in 1911.

It was to be the engineer Bechereau - who would soon design the famous First World War SPAD - who would ensure the revival of the Deperdussin Company.

As early as January 1912 Vedrines, in a Deperdusin conceived by Bechereau and powered by a 100 HP Gnome engine, won the title with 145.161 km/hr; in the same year the beat his own record three times, to 166.821 km/hr, using the same 100 HP double star rotary Gnome engine.

Finally at Reims on the 29th September 1913, Maurice Prevost, on the occasion of the Gordon-Bennett Cup, which he will win, took the world record to 203.85 km/hr thanks to a new type of Deperdussin-Bechereau fitted with the latest 160 HP Gnome; its racey, stubby lines preview the machines post the 1914-18 war which, for the moment, was going to stop the sporting enthusiasm for a more sombre fate.

Thus since Santos-Dumont, and in barely nine years, the speed record has been broken 19 times and 200 km/hr had been exceeded. During the same period the Gordon-Bennett Cup for aircraft had been run five times and had been won twice by America (in 1909 by Curtiss with a Curtiss aeroplane and in 1911 by Weymann with a 100 HP Nieuport), once by Great Britain (in 1910 by Graham White with a 100 HP Bleriot) and twice by France (Vedrines in a 100 HP Gnome Deperdussin at Chicago in 1912; Prevost in a 160 HP Deperdussin at Reims in 1913).

After the Armistice in 1918, the world only wanted to forget the terrible war through which it had just lived; and the aviators only thought about reinstating the pre-war competition.

The prestige of speed

The war greatly changed the world and aviation progressed considerably.

The military had finally accepted aviation as the new arm and many countries now wished to create an air force as part of their defences.

Industrialists, who had produced vast quantities of aviation equipment, saw their order books empty and looked for a way of attracting potential buyers for their products.

The publicity attracted by a record is a great benefit to sales. As regards the pilots, there was no shortage of them and they were very skilled.

Therefore, by only 1920, the sixth Gordon-Bennett Cup will be in the process of being organised to take place over a distance of 300 km at Etampes in France.

This Cup, which had acquired world renown before the war, provided an excellent vehicle for returning back to the competition.

For the French, winners of the last two Cups, a third victory would guarantee permanent possession of the Cup; thus one sees five aircrafts entered: two Nieuport-Delage; two Spad-Herbemont, the latter being the engineer responsible for this aircraft; and a Borel. All these aircraft used the same Hispano-Suiza 300 HP V8 engine, without doubt the best of the period, based upon the same design which had proven themselves in the HS 180-220HP during the war. As for the aircraft themselves they were the derivatives of the latest fighter aircraft created in 1918 which would, if the war had continued, have been able to replace the Spad XIII. The most up to date way of increasing speed was to reduce the wing area and lighten the aircraft.

Great Britain entered the Martinsyde, powered by a 300 HP Hispano egine, and derived from a military aircraft in the same way as the french. Two other machines, a 300 HP Hispano British-Nieuport and a Sopwith fitted with a 400 HP British Jupiter engine, could not be prepared in time.

America, like its allies, entered a military aircraft the Verville with a rather heavier 500 HP Packard engine. However it showed its innovation by putting on the line a Curtiss Cox powered by a Curtiss 430 HP C12 and a Dayton-Wright fitted with a 250 HP, 6 cylinder Liberty engine; this aircraft had a retractable undercarriage and a very original variable camber wing. The Curtiss had been designed for a speed of 345 km/hr and appeared to be the favorite.

But the aircraft couldn't be tested in the United States with its speed wing and wouldn't arrive in France until ten days before the date of the Cup.

Then, on the first test flight, the take-off proved to be so long that the aircraft continued on past the official runway and into a neighbouring field before getting airborne.

This did not discourage the pilot who was conserving the full power of the engine; however, at about 300 km/hr the aircraft became subjected to longitudinal oscillations so strong that the pilot was forced to land straight ahead. Happily the Beauce plains are very clear and he extricated himself intact.

During the night the engineer Mike Thurston designed a new wing and a new tailplane which Morane agreed to make at Villacoublay. The aircraft was ready on the eve of the race but it had to get from Villacoublay to Etampes for the start. The take-off from Villacoublay proved to the very rough because there had not been enough time to fit shock absorbers to the undercarriage; on a rebound the aircraft became airborne and stayed there thanks to the excellence of its new wings. However, on landing at Etampes the wheels, which had suffered, broke and the aircraft sommersaulted and broke into two; by a miracle the pilot escaped but the Curtiss was out of the race.

The Verville engine ran so hot after departure that flames came out of the exhaust pipe; the pilot was forced to land immediately in order to avoid a fire. As for the Dayton, without doubt, it was also too new and insufficiently developed. It appears that an adjustment error in the mechanical linkage prevented it from turning left.

America learnt some hard lessons from the race but she would persevere and would not be slow in returning in force with Curtiss.

Finally the only british representative, the Martinsyde, was let down by a cracked oil pipe and could not complete the circuit.

The French were lucky; only Kirsch in a Nieuport, who made the best 100km circuit of the Cup at 279 km/hr, was forced to land following misfiring caused by spark plugs oiling up.

Sadi Lecointe in a Nieuport would win the Cup with 271..547 km/hr; Romanet was second, victim of an oil leak which obliged him to stop for half an hour and which reduced his speed to 181 km/hr although, during the trials he had appeared to be faster then the Nieuports.

Thus only one aircraft covered the distance without incident. The Cup, being won for the third time, stayed permanently in France; there would never be another Gordon-Bennett Cup for aircraft. The children of Monsieur Deutsch de la Meurthe, the well-known patron, will offer a new cup bearing his name and with a very similar format to that of the Gordon-Bennett.

The French again appeared to be ahead in speed; a situation confirmed from the 7th February 1920, when Sadi Lecointe in a Nieuport broke the pre-war record of 203 km/hr with 275.862 km/hr, until the 13th October 1922. On that day General Mitchell, in a Curtiss biplane powered by a CD12 engine, carried the record to 358 km/hr at a match against the French: Sadi Lecointe, Casale and de Romanet the pilots, Nieuport and Spad the aircraft. During these three years the record will be broken nine times; Sadi Lecointe being the first to pass 300 km/hr and also the first past 200 mph, which was of interest to those not using the metric system of speed measurement.

Thus the record progressed little by little from 275 km/hr to 341 km/hr.

But if the quality and skill of the pilots played major roles in this affaire, it is also clear that techniques had a part to play.

In fact, until Sadi Lecointe's record of 313 km/hr in the Nieuport biplane in December 1920, the contest was between two identical biplanes equipped with the same Hispano engine. Improvements were made to the surface of the wings and in their positioning in respect of the fuselage; however, one cannot go very far down this road without using high-lift devices, a retractable undercarriage and a variable pitch propeller - things which one could not hope to see in the speed race before December 1934 and the Delmotte CAUDRON 460 - it was necessary to resolve the problem of take-off and landing.

The biplane, which had practically been the exclusive format throughtout the war, had the advantage of being of a well experimented design. For a modest weight it allowed the use of reasonably thin and cambered wing sections allied with a wing loading in the order of 70 to 80 Kg/sq.m. This could explain why, during the preparation of the Nieuport biplane, Sadi Lecointe made several emergency landings without damage.

The struggle was between two biplanes, the Spad of Romanet and the Nieuport of Sadi Lecointe. Sadi Lecointe will be the first to pass the 300 km barrier, with 302.529 km/hr, on the 20th October 1920; on the 4th November, by cutting down his windscreen and withdrawing into the aircraft, Romanet reached 309.012 km/hr in his 14 m^2 biplane. However, Sadi Lecointe would imitate him by obtaining a light plywood box type cockpit - he could only see out through the side portholes - and, on the 12th December, limiting his petrol to 80 litres and discarding one of his two Lamblin radiators, he tried again; result: 313.043 km/hr.

Obviously, with a biplane and a 300 HP Hispano engine, one could not go much further.

A new design of aircraft

It was then the Nieuport Company completely re-thought the problem around the only available engine, the 300 HP Hispano which delivered 320 HP at 1800 rpm. They selected a monoplane with a 12.7 m^2 wing surface and, although the wing section was calculated for its low drag, a slight camber was included in order to improve the C_L at angles greater than 5°. The wing loading was limited to 77 Kg/m^2 and the take-off speed to 107 km/hr. For speed they hoped above all to reduce the interactions inherent in the biplane and design a better fuselage.

But, because of the worry about the elasticity of the structures, the aircraft had to be very solid; a design load factor of 12g was used.

For the relative thickness of the wing, 12% was chosen which allowed the inclusion of strong wing spars; the wing was entirely covered in plywood which contributed to its strength and flexibility and the oblique struts were retained.

In accordance with the normal Nieuport practices, the fuselage was monocoque and the undercarriage was very robust.

On the 26th September 1921, Sadi Lecointe pushed the record to 330.275 km/hr whereas, three days before, de Romanet was killed during a test flight of the prototype racing aircraft Monge.

The Deutsch de la Meurthe Cup began at Etampes on the 1st October. During his first circuit Sadi Lecointe, speed indicating 314 km/hr, saw his propeller shatter in the air; he managed to recover and land his aircraft in a field but, although he escaped quite lightly, the aircraft was broken.

The Italien Brack-Papa, in a 700 HP FIAT biplane, covered the 100 km at 298.7 km/hr - a new world record over this distance - but because of a breakdown he couldn't finish the race.

The Englishman Herbert James, in a Bamel - Mars biplane powered by a 450 HP Napier engine with a reduction-geared propeller, showed a considerable range of speed for a racer. Unfortunately the canvas on his wing began to rip and he was forced to land.

Only the Frenchmen Lasne, in a Nieuport biplane, and Kirsch in a sesquiplane are left in the race and they prudently position themselves: Kirsch will win with 278 km/hr with Lasne second at 257.42 km/hr.

On the 22nd September 192, Sadi Lecointe will take the world record to 341.233 km/hr.

The progress was achieved with the Hispano engine which had its compression boosted to 6 and turned at 1900 rpm, thanks to the use of benzol; the engine now gave 370 HP.

The Deutsch Cup of 1922 sees the return of Brack-Papa who completed a circuit at 286 km/hr before stopping - the victim of a ruptured pipe. Sadi Lecointe will also be obliged to interrupt his race following a ruptured spark plug and an accident on landing which slightly damaged his aircraft. Lasne, in a Nieuport biplane powered by a 300 HP boosted engine, will be the victor with 289.4 km/hr.

Four days after the race, in an attempt on the speed record, the Gloucestershire "Bamel" Mars biplane fitted with a 500 HP Napier-Lion engine reached 341.423 km/hr; however, the difference between that and the record established by Sadi Lecointe did not exceed the 1% demanded by the IAF and the record was not confirmed.

But the French, too sure of themselves because they had not followed closely enough what was happening in the United States, were very surprised to see themselves disposessed of the record which seemed to belong to them.

The american breakthrough

At Detroit on 13th October 1922, Brigadier-General Mitchell broke the world record, in a Curtiss R6 powered by a 450 HP D-12 engine, with 358.836 km/hr.

It was a biplane derived from the Curtiss CR1 race - the NAVY winner of the 1921 Pulitzer Trophy with 283 km/hr - fitted with a Curtiss CD 12 400 HP engine. In effect, the R6 was an aircraft entirely redesigned around the Curtiss 12 cylinder, 60°V, D12 engine which was designed to offer the minimum frontal surface area and to be light whilst giving the maximum power; this engine was the result of a long design enterprise with the Curtiss AB from 1916 and after successive important alterations to the original concept. By 1922 the D12 was finally giving the desired results.

However, a great deal of care was taken with the aerodynamics of the R6 whilst conserving the biplane formula which, at that time, offered the best compromise between the search for lower drag and the strength required for a racing aircraft.

The main frame of the fuselage, a rounded form, did not exceed 1.12 m in height and 0.84 m in width; the french biplanes were always more "comfortable" with the rounded shape, the Spad-Herbemont being 1.36x0.9 m and the Nieuport 29 limited to 1.02x0.95 m.

The hunt for parasitic drag had even lead for the first time to the use of radiator surfaces integrant with the surface of the upper wing; studied for over two years it was successfully used on the R6.

It is interesting to note that the Navy, after the aerobatic take-offs in the Curtiss-Cox during the 1920 Gordon-Bennett of which we have already spoken, had imposed a maximum take-off speed of 120 km/hr (75 mph).

It was that which caused the R6 to use a wing area of 13 m^2 in order to limit the wing loading to about 63 kg/m^2. The remarkable result lead to the design of a marvellous little biplane.

The awakening of the French

All of a sudden it was discovered in France that the Hispano Company had not made much progress with its ideas since 1916; furthermore, it was discovered that the Wright Motor Co, under license to Hispano for the 300 HP, had perfected it to much a point that they were obtaining more power than the parent company.

Immediately 300 HP Wright-Hispanos, giving 410 HP at 2000 rpm, were ordered from the United States; the Lamblin radiators - used by Curtiss Racers until 1922 - were withdrawn and replaced by radiator surfaces, developed by the Moreux Company, which were fitted under the wings; these were slightly modified to give them a double convex profile.

The last version of the Nieuport Sesquiplane saw the wing surface further reduced from 12.7 to 11 m^2. In this condition, which guaranteed stalling speed without ground effect of 117 km/hr, the overall aircraft C_D in flight was reduced from 3.28, for the first Sesquiplane, to 3.09. The Mitchell R6 gave 3.19 with a 13 m^2 wing surface (stall without ground effect at 109 km/hr).

Table 3 gives the characteristics known, or reconstructed by calculation, of the greater part of the aircraft having held the world record.

At Istres, on the 15th February 1923, Sadi Lecointe returned the record to France with 375 km/hr.

For a short time only because, on the 29th March 1923 at Dayton, Lt Maughan regained the record with 380 km/hr in a Curtiss R6 fitted with a Curtiss D12 engine boosted to 507 HP.

1923: the american year

Dr Reed perfected an entirely metal fixed pitch propeller which incorporated very slim blade tips; this allowed it to work with great effectiveness at higher rotation speeds despite the speed reached at the tip of the blade.

Maughan's D12, like all the engines of the period, directly drove the propeller. This type of Reed propeller, which was going to know world-wide success, allowed to run the engines faster.

Essentially, it was thanks to that, that Maughan succeeded.

But that wasn't the end of it.

A new type of carburettor would allow the D126A to turn at 2500 rpm.

What had happened with the Spad-Herbemont biplanes was going to come to Curtiss; in order to reduce the interaction drag the longer wing surface was going to be placed high above the fuselage. Curiously, for the R2C1, Curtiss adapted the wing configuration of the 1920 Spad-Herbemont and not that with which the Spads had been successful in 1922. The 100 C_D of the R2C1 was remarkably low for the period - 2.39 - but the wing area was slightly increased to 13.75 m^2 (stalling speed - 113.5 km/hr).

The Curtiss engine was one of the D12A type rated at 500 HP; lighter than the D12, but with a larger cylinder capacity, it was boosted for the record and approached 600 HP.

For two days, Lts Bow and Williams battled against each other in the same type of Curtiss R2C1 aircraft.

The world record holder will be Lt Bow with 417.078 km/hr on the 2nd November 1923; on the 4th November Lt Williams will beat that with 429.095 km/hr.

But William's last run nearly turned into a catastrophe as, only by a miracle, he avoided crashing into a flight of bombers.

The Navy command stopped the competition.

The return of the french

In France the Hispano Company had been dumfounded by the american results; it was clear that its engines no longer had sufficient power. Consequently its director, Mr Birkight, had decided by the begining of 1923 to begin research into two 12 cylinder engines: one of three blocks of 4 cylinders in W and one in a 60°V (like the D12). However, both of these engines will retain the same characteristics, proven in the 300 HP, to guarantee endurance and reliability.

The most powerful and the lightest will be the W which is going to be used by a newcomer Mr Hubert, of the Société Industrielle des Métaux et du Bois managed by Mr Bernard; this explains why this aircraft was called "Bernard-Ferbois".

For the first time in the history of the race, Hubert was going to design a true cantilever monoplane of about 13 m^2 to limit the landing speed. He will break the french speed record with 375 km/hr. Then, in view of these good results, he reduced the surface to 11.5 m^2 (stalling speed of 125 km/hr).

The aerofoil was a dissymetrical biconvex, 15.7% thick at the root and 8% at the extremity. The french Service Technique Aéronautique, conscious of the newness of the monoplane concept, demanded a load factor of 20! This explains the weight of the aircraft which, constructed in wood, reached 1.175 Kg.

Surface radiators were not used in this aircraft which was equipped with a flat Lamblin, of small size and little drag, situated under the convex surface of the wing.

The Reed propeller, built under licence by Levasseur, allowed the Hispano W to turn at 2100 rpm and to develope 560 HP.

The aircraft was well streamlined after a careful wind tunnel study. The C_D of flight of the Bernard-Ferbois, despite the large frontal area of the W engine and the use of the new, vertically vaned, Lamblin radiator under the wing, was 2.42 - scarcely greater than the 2.39 of the R2C1; but this was accompanied by a wing area of 11.5 m^2 as opposed to 13.75 m^2. The "equivalent parasitic surface drag" (aircraft C_D x S)(1) was reduced from 0.329 for the Curtiss to 0.279 for the Bernard. With comparable power (580-560 HP) the advantage was with the latter.

At Istres on the 11th December 1924, Adjudant Florentin Bonnet broke the world speed record with 448.171 km/hr.

This absolute speed record was only broken on the 26th September 1927 by Webster's Supermarine S5 seaplane, thanks to a Napier Lion V11 reduction motor of 875 HP, with 453.282 km/hr; but the Bernard-Ferbois held the speed record for aeroplanes until the 3rd September 1932 whenJ.H. Doolittle, in a 900 HP Gee Bee special, reached 473.8 km/hr.

This long record of the Bernard-Ferbois merits some explaination.

In fact the Bernard possessed some very interesting, and instructive, characteristics. We said earlier that it had a new 450 HP W Hispano engine boosted to 560 HP for the record; if that power compared favourably with that of the Curtiss D12-A by contrast the engine itself was less developed: it had a cylinder capacity and a weight one third greater than the Curtiss; furthermore, its frontal surface area was equally larger. This is why the engineer Hubert was going to have to find a better aerodynamic formula.

He will be the first to choose a true monoplane solution without any struts or stays (the only other monoplane, the Nieuport Sesquiplane, retained a strong oblique strut and a small cross plane between the wheels). At St Cyr he modified the Bernard 202 dissymetrical biconvex wing section of 16.5% thickness at 135 of 100 C_D max for an aspect ratio of 5. Careful to keep the landing speed within reasonable limits, he opted for an increase in aspect ratio to 8.16 for a 13 m^2 surface. The wing marginal edges were obliqued to 30° in plan view; this, after Hoermer, again improved slightly the effective aspect ratio.

The wooden wing was very robust: four wing spars, for a maximum chord length of 1.64, with overlapping spruce slates (like a parquet floor) and a surface of thin plywood which will be carefully rubbed down and lacquered. Thus were guaranteed the best aerofoil section, rigidity and surface; this aircraft nerver had a flutter problem.

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(1)Like Mr. Ermanns Bazzachi (see bibliography), we use here the term "Equivalent parasitic surface" for $C_{Da}S$, where C_{Da} is the total flight C_D.

The wing was fitted mid-way up the fuselage and flushed to avoid the problem of recess angles. The streamlining and condition of the surfaces were excellent. Despite the handicap of a huge engine, Hubert succeeded in designing an airframe nearly as small as that of the Curtiss R6.

This machine, equipped with a wooden Regy propeller, easily succeeded in taking the french speed record to 393.340 km/hr on the 8th November 1924 while the world record was held by Williams R2 C1 at 429 km/hr. But the stalling speed without ground effect of the Bernard did not exceed 117 km/hr (113 for the R2C1).

Hubert then decided to shorten the central section of the wing span in order to reduce the surface area to 11.5 m^2; he also fitted a Reed metal propeller to his aircraft.

On the 11th December 1924, the modified Bernard took the world record to 444 km/hr.

The cantilever monoplane wing had an aspect ratio reduced to 7.2; it was the largest aspect ratio of any of the record breaking aircraft and the only one to exceed 7: the more usual value was between 4.5 and 5.5.

It was clear that with the same engine the Bernard again had some potential for improvement: with a better adapted propeller one could increase efficiency and engine power; without doubt it would be possible to lighten the aircraft, reduce the surface area by 1 m^2 and improve the streamlining (wheels, tailskid). One could have imagined that this machine would have been capable of reaching 480 or 490 km/hr without much difficulty: it was that level of performance that will be achieved by Wedell-Williams on the 4th September 1933...

The Bernard was an aircraft specially conceived for the speed record.

It was probably that fact which, for the moment, discouraged its rivals. It was, in any case, what brought the Navy to cancel spending money on the development of any new aircraft without a direct military application; it preferred to put its efforts into the Schneider Cup by transforming its Curtiss Racer into a seaplane with floats.

During the same period an important change to the Navy's engine policy developed in the United States: deciding that liquid cooled engines were too heavy and too vulnerable in combat, it pushed for the perfecting of air cooled radial motors. The President of the Wright Company, seeing which way the wind was blowing and feeling the need to radically change the companies engines, resigned in 1924 and created a new engine firm from the Pratt and Whitney Tool Company which he bought. In December 1925 the first 9 cylinder, 450 HP P W Wasp was produced; it had the same power as the Curtiss D12 and weighed 100 Kg less; the D12, and its even more brilliant successor the V1400, will never get over it.

The Schneider Cup

This speed cup for seaplanes, created in 1913 by the french patron Jacques Schneider, was competed for regularly every year; the speeds achieved stayed far below those speeds reached by aeroplanes because of the large drag inherent in the marine ancillary equipment.

It is only from 1923 that one sees the appearance of specialised machines; the CR3, derived from the Curtiss R6, will win the cup that year with 285 km/hr (aircraft will reach 375 km/hr during the same period).

In 1924, only the americans are entered to race and, very sportingly, they postpone the trial until 1925 in order to give other countries time to prepare.

Great Britain will introduce a remarkable machine - the Supermarine S4 - derived from the CR3 formula for the floats, from the Bernard-Ferbois for the aerodynamics which it adopted - the only one to do so in the history of the Schneider Cup - the cantilever wing fixed at mid-height, the vertically vaned Lamblin radiators and for the attention given to the streamlining of its Napier Lion V11 W engine. It was also fitted with a better designed 680 HP derivative; above all it was the first to be equipped with landing flaps and, until 1934, remained the only racing aircraft to use a high-lift device.

The aircraft clocked 364.6 km/hr shortly before the 1925 race; but is was on one of its first flights.

Unfortunately this seaplane was destroyed a few days before the cup, undoubtedly the victim of control surface flutter, of a stall at landing or of wing flutter; it was not possible to determine which.

The winner that year will be a Curtiss R3 C2 derived from the R2 C1.

However, in 1926, the Italians won with the Macchi M39 which was going to become the archetype for all Schneider seaplanes: two catamaran floats, low wing fixed rigidly to the airframe and allowing for a thinner aerofoil section; the engine was liquid cooled with Curtiss type radiators; the propellers were all metal and fix pitched.

It is interesting to observe that for six years this format remained unchanged : one will never see landing flaps and one will never see either the appearance of variable pitch or closed cockpits.

In fact, the aerodynamic effort will be reserved solely to the perfecting of the shape and the state of the surface.

However, there will be considerable progress with liquid engines at Rolls Royce, Fiat and Isotta Fraschini.

It was essentially the competition created by this prestigious Cup which led to the development of reduction gearing, of high rotation speeds, of compressors and, as if that wasn't sufficient, the use of exotic fuels to the point where they contained no petrol at all.

One goes, therefore, at Rolls Royce from the R type with 36.7 litres of cylinder capacity and 1900 HP at 2900 rpm, to 3200 rpm that is, from 51.7 to 72.2 HP/litre for a weight going from 695-740 Kg.

Fiat, who worked on four successive engines in six years, progressed from a 800 HP, 31.4 litre V at 2300 rpm to a 25.1 litre approx of 1000 HP at 3200 rpm, and to the famous Agelo twin engine (709 km/hr in 1934), of 50.2 litres giving 3000 HP at 3300 rpm, driving two contrarotating propellers.

From 1927, the speed record became solely the province of the seaplanes.

The essential reason was the constant increase in wing loadings accompanied by the growth in power. In 1926, the winner of the Cup was the Macchi 39 of 800 HP loaded to 102 Kg/m^2. The S5 of 1927 - the first to win the absolute record - was equipped with a 875 HP engine and loaded to 138 Kg/m^2. The S6 in 1926, giving 1900 HP will use 194 Kg/m^2. All these aircraft, then, used biconvex wing sections of 12% thickness of which the 100 C_L max hardly exceeded 1.1; that took the S5 to a stalling speed without ground effect of about 160 km/hr; the S6 of 1929 stalled at 191 km/hr.

Furthermore, the exclusive use of fixed pitch propellers for maximum speed resulted in low power during the lower take-off speeds. That is why the hydroplaning of these aircraft greatly exceeded one minute despite their excessive power. For the MC 72, which had the best directional stabilisation, thanks to a double propeller and had allowed it to reduce the size of its floats, therefore more deeply immersed, the hydroplaning clearly lasted for more than two minutes.

It is clear that, given the airfields of the period, not only would the shock absorbing systems of aircraft not allow such wing loadings but they would not allow such long take-off runs in safety.

That is the explanation of the success of the seaplanes between 1927-1939.

New start for the aircraft speed record

A record is made to be broken.

The ball was in the american court and it was natural that the race for the aircraft record should come from there.

On the 3rd September 1932, J.H. Doolittle succeeded in breaking the old record, set up by Bonnet in December 1924, thanks to a Gee-Bee R1 fitted with a 800 HP Pratt and Whitney Wasp Senior radial engine boosted to 900 HP.

It was a monoplane with a low braced wing of slim biconvex profile, greatly influenced by the general conception of the Schneider formula; in order to keep a reasonable stalling speed (132 km/hr) one needed a solid construction as light as possible, hence short stays and a stubby shape.

But the engine had a large frame and the fuselage was relatively monstrous (1.55 m in diameter). Hence an aircraft 100 C_D of 4.075 (against 2.42 for the Bernard).

Despite its 900 HP and its lightness (100 Kg less) it will only beat the Bernard by 25.6 km/hr in reaching 473.8 km.

Thanks to a better designed aircraft, equipped with a 550 HP Wasp Junior boosted to 800 HP, the following year Wedel, in his Wedel-Williams, reached a speed of 490.8 km/hr on the 4th Sptember 1933. It was based upon the same fixed wing monoplane and great lightness; aerodynamically the aircraft was more successful and its aircraft 100 C_D was 3.03.

Obviously one marked time because of the inability to adapt the aircraft to the strong power formula of the Schneider Cup.

It was necessary to find something else.

The last french record

The new format of the Deutsch de la Meurthe Cup, which was inaugurated in France in 1933 over a 2000 km course with an obligatory staging and an engine capacity limitation of 8 litres, revealed the talents of a great engineer - Marcel Riffard. He was chosen by Mr Renault to be the technical director of the firm of Caudron-Renault which had just been created following Mr Renaults purchase of the old Caudron Company.

From 1934 the Caudrons, designed by Riffard, will win all the Deutsch speed records. It was natural that he would think of preparing one of his aircraft with a view to breaking the world speed record.

Startig from the 8 cylinder C450 with a fixed undercarriage, he built along the same lines the C460 fitted with an air cooled Renault 9.5 litre inverse 6 cylinder engine developing 370 HP; the Ratier metal propeller had two pitch settings of which the second - the course pitch - was automatically engaged in flight. The aircraft had a retractable undercarriage and trailing edge flaps.

The wing had an aspect ratio of 6.6, the largest value used in the history of speed records after that of the Bernard. It was fitted 1/4 up the fuselage without any recess angle with eliminated the need for Karman fairing; the main fuselage section was situated a little aft of the trailing edge of the wing. The aerofoil was a symetrical biconvex of 12% thickness at the root and 6% at the outer section.

The pilots head was protected by a closed glass canopy of very small dimensions.

The aircraft was constructed in wood with some magnesium cowling covers; the state of the surface was perfect.

Of small size - 6.9 m^2 of wing ksurface - the machine weighed 775 Kg. Of all the speed record aircraft, from 1918 to the present day, it will be the lightest and will have the least parasitic drag (CDa x S): 0.126 m^2 (Note: the least parasitic surface drag of all the aircraft to win the Schneider Cup was that of the Supermarine S5: 0.32m^2).

Its stalling speed with flaps was 122.5 km/hr.

By taking the world speed record to 505.848 km/hr, at Istres on the 25th December 1935, with an engine limited to 370 HP, Delmotte was demonstrating the most elaborate racing aircraft: Riffard was showing the way ahead.

It was natural that Riffard had thought to fit one of his marvellous speed aircraft with a more powerful engine. He did not covince Renault to design a new prototype until it was a year too late, when Howard Hughes will have, in his turn, recaptured the record.

It will be an inverse V12 Renault of 19 litres turning at 3200 rpm; using benzol it produces 750 HP.

An aircraft - the 712 R - of the same style as the V460 was designed around this engine. It had nearly the same dimensions as the C460, but weighed 1200 Kg; its wing loading was 173 Kg and its stalling sped was

145 km/hr, practically the same as all its successors.

On the 9th October 1937 at Istres, Delmotte made an attempt at the record; after taking-off in less than 20 seconds, he departed and set his speed before attacking the run; he was then at 620 km/hr - seen on the airspeed indicator - and not yet at full speed.

It was at this moment that Delmotte felt that he was losing control; he pulled up and succeeded in bailing out; a pebble had been thrown into the tail plane during take-off and during flight the stabilizer gave in tearing the end of the elevator....

In 1939, Riffard would construct a new aircraft which was to be fitted with a new 1000 HP Renault prototype; but the engine could not be perfected in time; the war was approaching and there were other things to do in the immediate future. The airframe of this aircraft, which never flew, is preserved in the Air Museum at Le Bourget where one can admire the purity of its lines.

The last american record before 1939

The celebrated american Howard Hughes decided one fine day in 1934 to construct a racing aircraft, of his invention and under his name, with the help of the engineer Dick Palmer.

By July 1934, the aerodynamic trials were arriving at a formula for the aircraft conceived around the Pratt and Whitney, 14 cylinder, Twin Wasp Junior engine of 700 HP at 2500 rpm, boosted to 900 HP thanks to the employment of a special 100 octane fuel. The propeller was a Constant Speed Hamilton Standard. The fuselage was monocoque in duralumin with an open cockpit. The wing was one piece in wood, with two spars and a plywood skin thickly glued and painted in such a way as to ensure the exact shape of the wing section and an excellent surface. The wing section was a thick biconvex shape based on the NACA 2418 (modified by A312R) at the wing root, transformed at the outer section by a NACA 2409. A large Karman flushed the wing to the fuselage.

One cannot refrain from finding in this wing of thick wood, a similarity with Renard-Ferbois rather than with those of the seaplanes; the flaps used in the Hughes allowed the adoption of a smaller aspect ratio: 4.54 in place of 7.2.

The loading per m^2 came to 156 Kg/m^2 giving a stalling speed of 141 km/hr.

This machine, well designed and well produced, had an aircraft 100 CD a little better than that of the Delmotte C460, despite its thick wing and probably thanks a lower cooling drag. But its greater size was to give him a greater equivalent parasitic surface drag; 0.224 m^2 instead of 0.126 m^2.

The aircraft, constructed in the greatest secrecy in 16 months, was ready in August 1935. After four test flights, totalling 2 hrs 20 mns, and several incidents necessitating the change of the propeller regulator and the hydraulic pump, Howard Hughes launched his assault on the record and, on the 13th September, reached 567.115 km/hr.

But to be sure of having reached the fastest speed, Hughes, having completed two figures of eights of the run, was going to continue to try a second series; unfortunately he had insufficient fuel and, on the seventh pass, the engine stopped. He succeeded in belly-landing his aircraft in a beet field. The IAF, considering that the pilot had control of his aircraft to the end and that strictly speaking there had not been a crash or accident, confirmed the record.

Only minor damage was caused to the aircraft and Hughes modified it by giving it a greater wing surface and better aspect ratio, fitting a NACA 23012 allowed a greater weight of fuel to be carried. The engine was changed from the standard to a more recent model which would improve his endurance; this engine delivered 850/900 HP in continuous cruise and 1000 HP for short periods.

On the 19th January 1937, H.R. Hughes established a new record for the west-east crossing of the United States - his great dream... - in 7 hrs 28 min 25 secs from the Burbank airfield to that in Newark at an average speed of 526 km/hr. THis record was only beaten after the war by Paul Mantz in a P-51 Mustang.

The Germans arrive on the scene

It was already clear that the speed records were so high that in order to break them it would be necessary to design a new prototype using the very latest techniques and the most powerful engines; only very rich men -like Renault or Hughes - could still compete in this adventure without any guaranteee of ultimate commercial success, and so the racer was far removed from the military aircraft.

Unless a government, for reasons of prestige, set out to conquer the records.

This is precisely what happened in Germany.

As early as the 11th November 1937 Wurster in a special aircraft introduced as the BF 113 R derived from a prototype Messerschmitt fighter aircraft powered by a Daimler - Benz 600 of 950 HP (the brilliant winner of the Zürich Meeting), reached 610.960 km/hr.

Few details were given by the official german authorities at the time; today we know that it was a Messerschmitt BF109 - V13, very similar to a Messerschmitt 109E. One may suggest, without much fear of contradiction, that the admitted power of the engine was a nominal power; it is probable that, as the knowledge was available to the whole world at that time, the engine could be pushed to at least 1400/1500 HP; Mr Riffard, interviewed at the time, declared that by 1937 one would be able to almost double the nominal power for a short record.

One knows a little more - but only after the war - about the two other speed records established within a month in 1939 by Dieterle in a Heinkel 100 and by Wendel in a Messerschmitt 209-V1; they were presented to the press at the time under the designations He 112V and Me 109R to suggest that they were direct derivatives of in-service fighter aircraft. The only authorized photographs then did not allow any characteristic details to be identified. As for the files set to the IAF, they do not say much.

The Heinkel was equipped with a DB601-E giving 1175HP, like the Messerschmitt; one suspects that the effective power would have been closer to 2000 HP.

But the increase in power between the 610 km/hr of Wurster and the 746.660 of Dieterle or the 755.11 of Wendel - about 5 to 600 HP, some 30% -is not sufficient to explain the enormous increase in speed: it would have been necessary to have 85% more power.

In fact it was necessary to have a very refined airframe, with good high lift devices to increase the wing loading to 175-180 Kg/m^2; the aircraft was reduced in size as much as possible ; 14.5m^2 for the Heinkel and 13.2 for the Messerschmitt, the smaller of the two; their take-off weights were respectively 2600 Kg for the Heinkel and 2300 Kg for the particularly squat ME 209-V1.

The war would follow, preventing the record race from continuing. It is during this conflict that the jet aircraft appears which, at the end of the war, was to fly faster than Wendels aircraft thanks, above all, to an effective power that left piston engines far behind: on the 7th November 1945, a Gloster Meteor, with 975.675 km/hr, smashed the german record.

Then, another race for the speed record will start: it is reported in the second part of this paper.

However, in the United States, certain enthusiasts felt that they couldn't leave the propeller aircraft speed record unbroken.

Sporting exploits after the war

Of course, to beat the german speed record of 1939 for propeller aircraft in the 60's and 70's was a very difficult proposition without any patron or government showing any interest.

Only some determined and competitive men could attempt it for national pride or the love of sport.

One can only admire the test pilot Darryl Greenmayer (1) and his team, all volunteers, for having succeeded in the exploit; but not without hardship.

It was only after four years of effort that, in 1967 on the 16th August, they were successful in taking the propeller aircraft record to 777.35 km/hr.

Using only limited funding,their personal resources and some private assistance, the Greenmayer team selected as a basic aircraft the F8-F2 Bearcat, in service with the NAVY at the end of the war; they carried out considerable modifications to it with a view to reducing its drag and weight.

The wing surface was reduced by shortening the wing span from 10.85m to 8.71m. A Hoerner wing tip was fitted to compensate for the enormous torque of the propeller with the shorter wing. To save weight, the split flaps were fixed and all their control systems were suppressed; all the military equipment was discarded and the electrical system

(1) It is the same Darryl Greenmayer who, in 1977, will establish the low-level record for jet aircraft at an astonishing speed of 1590 km/hr in a F104.

simplified.

The canopy was replaced with a smaller version; the air intakes on the leading edge, feeding the internal oil radiator, were blocked and the necessary cooling was obtained by a water evaporation heat exchange system.

The tail and rudder were reduced and a tail cone installed. A propeller spinner, coming from the P51, was fixed in front. Careful filling and smoothing of gaps, a requirement that was well understood, was then completed.

The original Pratt and Whitney T2800-34W engine with high altitude compressor was modified thanks to parts from other series of the same type of engine: a lighter compressor adapted for low altitude, a reduction gear turning slower than the propeller, water injection, a 4.11 in diameter, four bladed, Skyraider propeller, so big that it forced the pilot to take-off tail low.

Finally an exotic fuel, including a little nitromethane, allowed the engine to give 3300HP.

It was in these rather stunty conditions that this team improved the maximum speed of the basic aircraft by more than 100 Km/hr, with a stalling speed of 146.4 km/hr, a little less than that of the Me 209-V1 thanks to a total weight reduced to 3,515 Kg for a wing area of 20.6m^2.

But this extraordinary record would next be broken by another american team, that of Steve Hinton, who this time chose a P51 Mustang whose original engine was replaced by a Rolls-Royce Griffon driving two contrarotating propellers. The power of this engine was boosted to 3800 HP! and the gain obtained fromthe double propellers, equal to nearly an extra 10% power - combined with the excellent lift to drag ratio of the basic aircraft, made it unnecessary to modify the basic aircraft as profoundly as the Bearcat; apart from reducing the wings and preparing the surfaces well.

The record was taken to 803.069 km/hr on the 14th August 1979.

It is difficult to imagine going much further with propeller driven aircraft. But if one realises that the last two aircraft presented were around 3600 Kg, 21m^2 and 3500 HP whereas the two previous germans were around the 2450 Kg, 14m^2 and 2000 HP level, for a difference of 50 km/hr, one can imagine that it is still possible, if not to go much faster because of the Mach problems at the propeller tips, then to fly as quickly with much less power than 3000 HP. But it would be necessary to design a new prototype.

PART 2

Jet aircraft

General remarks

The end of the Second World War coincided with the start of the jet aircraft era. This offered the prospect of considerable gains in speed, far greater than anyone imagined in 1945.

But the new method of propulsion which was gaining ground possessed its own characteristics, its advantages and its limiations. In order to adapt to these new conditions it was necessary for the rules of the IAF to evolve; it was also necessary to use appropriate procedures.

These two approaches were established possibly thanks to the considerable progress in measuring instruments. This, however, had a drawback for the continuation of the records: because aircraft performances could be measured with precision, traced in detail in manuals, networks of graphs, charts and in a computer mathematical models, the record was no longer necessary to "prove" actual performances to the eventual client. Commercial interest in the records was growing thin, leaving in its place the motivation of prestige, often at a national level. One sometimes has the feeling when examining the timetable of events that some intermediary records could have been obtained.

Moreover, aircraft performance was presented with such complexity, by functions of configuration, test conditions, the atmosphere... etc that the "direct" description of the record often appeared inadequate to the expert.

This explains, without doubt, why the last 40 years have not seen the development of record aircraft. Records have been broken, rarely by special versions of existing aircraft (the Lockheed P80R, the Hawker Hunter Mark 3), but more often by standard aircraft a little "cleaned" (removing of aerials, filling in some openings, smoothing the surfaces with filler, polishing etc) and authorised to exceed the usual limits; frequently by standard operational aircraft.

Therefore, at the same time as the speeds attained nearly quadrupled (from about 900 km/hr to about 3500 km/hr), the interest in the records waned and some important questions present themselves today.

The types of record are too numerous to be all studied. One limits oneself here to three typical cases:

- the 3 km record at low-level
- the 15 km to 25 km record at any height
- the 1000 km closed circuit record

Table 1 gives the essential conditions for these records as determined by the IAF and notes chronologically the principal change.

The rest of this document will attempt to analyse the simultaneous evolution of these three records and the associated principal technological stages that one has judged convenient to regroup into four typical periods. Figures 1-2 and 3 are a synthetic representation of all

these records. The principal characteristics of the corresponding aircraft are shown in table 3.
The list of the records is given in table 2.

A word of caution is necessary here: it has not been possible, in the time available, to verify all the given characteristics. They are "given with all reservation" - for which the constructors will forgive us - but are sufficient to illustrate the idea, even if they are incomplete or erroneous in certain points of detail.

First period : the first gambols (1945-1947)

Only the 3 km run was recognised during this perod which corresponds to an awakening to the new possibilities of jet aircraft. Those are the first generation: fighters of the immediate post war (Meteor IV) or derived from them (P80R: specially modified version of the Shooting Star) or, finally, on experimental aircraft: the Douglas D558 Skystreak: straight wings, aspect ratio of 4 to 5, without power assisted controls (booster on the P80 ailerons).

While being cautious about the problem of flutter (existence of "tabs" on the "free" control surfaces) these aircraft "Hit" against compressibility which awaited them in the vicinity of less than 0.8, a little (0.83) for the D558.

In these conditions, after the two records obtained by the Meteor IV in the climate of a british autumn, the three amerian records were in California over "Muroc Lake"; the last two by the same aircraft, at the the same Mach (0.828), the temperature having had the happy idea of climbing from 25°C to 34°C over a five day period.

The second period : maturity or the breakthrough

It goes from 1948 to 1955 except for the 100 km record where it will extend until 1958.

It is breakthrough to the extent where it corresponds to the breaking of the "sound barrier", for the main part by the aircraft concerned diving, and "by force" in just level supersonic flight for the last aircraft of the period.

It is also maturity to the extent where the essential characteristics of jet aircraft, capable of high subsonic and transonic flight, become stable.

What are these principal characteristics?

First of all: the swept back wing: from 25° (SAAB 29) to 45° (F100 - Etendard IV - Breguet 1001) of which the relative thickness simultaneously reduced from about 12% progressively to about 6%. Flight controls evolved considerably. Irreversible servo-controls became general; then pitch control by a horizontal one-piece tail unit appeared in general use.

Together these advancements, made possible by the improvement as much in aerodynamics as in the methods of construction (integral manufacturing in particular) made easy the prevention of flutter - even if it did not eliminate the problems of static aeroelasticity - improved the effectiveness and the "well being" of the flying controls and gave these aircraft level performances, without afterburner, decidely better than

Mach 0.9 and generally transonic with afterburner.

Note the existence of two "cuckoos" in the nest: the Douglas XF4D Skyray, holder of the 3km record in 1953, was a Delta aircraft and the Tupolev 104, which broke the 1000 km record in 1957, is the only civilian transport aircraft figuring in the table.

As far as the measured 3 km record is concerned, in the cases where the aircraft are still limited by the increase in transonic drag, hot or even below sea-level terrain was favoured. Lybia for the Supermarine Swift, Salton Sea in California at minus 72 m for the american records.

In the 15/25 km, apart from the 1953 record gained at low-level at Salton Sea, the other two, canadian Sabre and F100 in 1955, were around the tropopause, the second being the first supersonic record.

It is also from 1955 to 1958 that the 1000 km records reappeared; later than the SAAB 29 and the TU104 they are held by french aircraft in 1958 (Etendard IV, Breguet 1001). Candidates in the NATO contest for tactical support aircraft, they are relatively light aircraft having sufficient internal fuel to maintain a flight at more than Mach 0.9 for one hour.

Figures 4 and 5 illustrate the increase in aircraft performance for the first and second periods: the first represents in a chart - air speed against altitude - details of flight envelope in relation to iso-Mach and iso Vc (calibrated airspeed). Also traced is the iso "W/V" expression in which V is the air speed and W the total climbing speed; W/V measures the excess power/drag and shows the possible acceleration. For a given altitude figure 5 gives acceleration as a function of Mach number.

It is clear that these aircraft "hit" at their compressibility, acceleration is good until maximum speed, a deceleration in turn is quickly compensated by a reacceleration,the Mach number stabilises in straight and level flight and varies very little over a range of altitudes. Consequently, the 1000 km records were generally run in two opposite directions with only one turning point.

Very different are the characteristics of the aircraft which, from 1956, opened the era of the truly supersonic aircraft.

Third period

What are these these "truly supersonic" aircraft? It is established that the reduction of compressibility drag, the continuous use of afterburner and above all, the improvement to air-intakes thanks to the introduction of variable geometry, pushed the potential performances of aircraft from Mach numbers a little above 1 to about 2.

If one accepts the particular case of the original shape of the F104 with wings slightly swept, the record aircraft are combat aircraft, fighter or bomber, which come from two different aerodynamic families.

The most part are the Delta aircraft of 60°, relative thickness close to 3% (Fairey Delta 2, E66, F106, Mirage IV, B58), in particular the Fairey Delta 2 which, according to the slogan of the time, became the first in an official record "to beat the sun". The others (F101, F4H) are aircraft with swept wings more or less accentuated (35 to 45°) and relative thickness 5 to 6%.

It is close to the tropopause that these aircraft have their maximum performance and why they were particularly well adapted for the 15/25 km record at altitude. Only the bombers (Mirage IV, B58), using afterburner and getting maximum performance without external tanks, could altitude the 1000 km record.

This is illustrated by figure 6 and 7 analog to figures 4 and 5 which show the typical characteristics of the performance of an aircraft capable of Mach 2+. One sees their maximum speed being reached at the tropopause. The available excess power, transferable into acceleration, is relatively modest: acceleration times are relatively long. The supersonic induced drag is relatively large during turns and the deceleration becomes noticeable as soon as the load factor increases. The turning radius is becoming important as one will see from table 4.

Table 4 - Turning radius (km) as a function of Mach number

Bank	Load Factor	M = 1	M = 2	M = 3
37°	1.25	13.33	53.33	120
48°	1.50	8.94	35.78	80.5
60°	2.0	5.77	23.09	51.96

Consequently, at the time of the records, the only way to avoid large deceleration during the turn was with a moderate load factor and hence a large turning radius - or it will be necessary "to pay" for the deceleration with a reacceleration which takes time and incurs extra consumption.

Precise optimisation depends upon the individual characteristics of each aircrft. Nevertheless it is obvious that, for the closed circuit 1000 km record, one tends to select a large number of turning points so that a continuous turn under a moderate load factors constitute a major part of the course.

As much for structural reasons as for general engine limitations, the supersonic performance of these aricraft at low-level is somewhat more modest. This explains the large gap between the last 3 km record of the F4D and the subsequent two records attributed to the F4H and F104. When one thinks about the demands of the record, some 7 seconds at a height less than 100 m, it is clear that that constitutes a severe test for the materials, but above all for the nerve of the pilot! The time period between the last records in this category (1953-1961-1977) is not unaffected by the dangerous nature of the course.

Furthermore, the measured 3 km record holds no interest for the trisonic aircraft of the fourth period.

Fourth and last period

There is a certain grey area between the boundaries of the third and fourth periods. In fact there isn't any discontinuity in behaviour between M=2 and M=3. It is the duration of flight above a certain Mach number which is going to become a design parameter determining, on the one hand, the behavior of materials at high temperatures (of the aircraft, the engines and certain pieces of equipment), and on the other hand the air conditioning system for the crew. The same technical solutions will not be applicable if the excursion into very high speeds lasts for 1 min as opposed to a half-hour.

On the other hand, operational requirements don't demand extreme performance at low or medium altitudes, the technical optimisation leads to reduce aerodynamic loadings and, in consequence the mass, by working at the higher altitudes, in excess of 20.000 m.

The previously mentioned problem of turning is even more true when the speed exceeds 3000 km/hr.

For example, fig. 8 represents the trajectory adopted by the SR 71 when the last 1000 km record was broken on the 27th July 1976. It clearly illustrates the problem of turning already mentioned.

The aircraft of this fourth period are too few in number (2 types: Y12/SR 71 and E 266) and too little known for one to be able to philosophise on their parameters and conception; equally important are the characteristics of the engine. It is, therefore, necessary to leave the subject for one of the next ICAS Congresses......

The future of aircraft speed records

The last records were broken in 76/77. Moreover, the attempts have become less numerous since 1963. The 3 km record is becoming more and more of a delicate operation; that of the 1000 km closed circuit is resembling more and more a continuous circle.

The overall aspect, just smoothed of the evolution of speed records as a function of time is shown at fig. 9. One will see there the rapid transition from Mach 1 to Mach 2, then a levelling out of all the curves.

Clearly it is not a question of developing machines of the cost and complexity of the MIG 25 or the SR 71 with the "sporting" aim of breaking a record.

In cases where such aircraft will be sold for export, the eventual clients will evaluate on documents their operational capabilities and their missions.

Conclusion

We have just looked through the history of aircraft speed records from the beginnings of aviation to the present day.

We have been able to appreciate ourselves the stumblings of the pionneers who did not have the benifit of the yet to be discovered theory of aerodynamics; nevertheless, from this era the gifted greats, such as Nieuport and Bechereau, had some inspired intuitions.

Naturally, after the 1914-1918 war, racing aircraft were easily derived from military materials; we have a tendancy to smile at the meagre science of the engineers who were working experimentally.

Progress, in the design of airframes, engines, propellers and radiators, was already apparent from these successful solutions and some outstanding aircraft; amongst which one can identify the Nieuport-Sesquiplane, the Curtiss R6 and R2 C1 and the Bernard-Ferbois which will remain unbeaten for nearly eight years.

However, because of the poor state of the airfields, the take-off speeds had to be limited and that allowed the seaplanes to take the initiative. Curiously, the progress due to the Schneider Cup was above all reflected in the perfecting of liquid cooled engine, of which one would finally benefit Great Britain and, more precisely, Rolls Royce.

France didn't have a powerful engine programme and, despite some weak efforts,will not participate in the Schneider Cup; from 1926 America will practically abandon the liquid cooled engine in order to concentrate on air cooled engines which will soon prove themselves by recapturing the speed record; in order to follow the american example, Italy will not advance its experience in liquid motors until after 1935. Germany, who participated in neither the speed record nor the Schneider Cup has, however, followed the general development and in 1934, launched a very good liquid inverse V engine - very advantageous as regards its integration into the aerodynamic design of the aircraft.

In 1934, Riffard's Caudron 460 offered a new direction, that of aerodynamic refinement; but the lack of a powerful engine will limit the result.

In 1935, Howard Hughes brings out an excellent racer.

But it was the Germans who, taking the lessons from the history of the races and thanks to generous cash, bring out the archetypal racing propeller aircraft; successful aerodynamic design, compact and powerful engine.

It was only missing the double propeller used by Agello; this final step was accomplished by the meritious private initiative of Steve Hinton which took us to 803 km/hr and which will be difficult to follow.

The jet aricraft, which very soon after the second World War flies off to conquer the record, at first followed the way of its immediate predecessors.

But very quickly the cost of researching a new specialist prototype is so obviously high that the building of racers as such is stopped.

It is only on the occasion of military programmes - and exceptionally civilian programmes - that a specific aircraft will again be suited to breaking a record; one of a series will be specially prepared. The record has become an off-shoot from research conducted for another objective. Under these conditions it is natural that one rediscovers in the history of speed records, different periods corresponding to the state of the art at various stages of evolution.

The record "off-shoot", of the difficult or expensive execution, appears more and more as a mark of national prestige, of certifying the maximum performance of the most developed products in a country.

But the interest carries on in other respects - more and more on economy, operational equipments, the complete system - such that the techniques can be judged seperately without the need for a record.

Everyone, in saluting the passionate adventure of speed from its origins to the present day and at the sight of the stagnation of all records (1976 for jet aircraft and 1979 for propeller aircraft) is allowed to wonder if there is still much future for the world speed record.

TABLE 1

EVOLUTION OF THE IAF SPORTING CODE

From 6.01.1920

1 km run twice in each direction
(necessary to exceed the previous record by at least 4 km/hr)

June 1920

First record over a 1000 km circuit

1.4.1923

Distance increased to 3 km.

4.6.1950

Creation of a 15/25 km record at altitude

Since 3.10.1979

a) 3 km distance extended at each end by corridors of at least 1 km, run twice in each direction.

Maximum height on the run and the corridors: 100m
Maximum height during the flight: 500m

b) 15 to 25 km distance extended at each end by 5 km corridors run once in each direction;

Unlimited altitude but cannot vary on the run or in the corridors by more than 100m.

Maximum altitude during the flight: 200m higher than run altitude.

c) 1000 km closed circuit:

obtained in one or several circuits

horizontal flight for at least 1 km before the starting line (100m tolerance)

finishing height greater than or equal to departing height.

TABLE 2
A — List of the speed records — Propeller aircraft
Distance 1 km and later 3 km at low altitude

DATE	LOCATION	SPEED (Km/h)	AIRCRAFT	PILOT
12.11.06.	Bagatelle (France)	41.292	Santo-Dumont XIV Bis	A. SANTOS-DUMONT (Brésil)
26.10.07.	Issy-les-Moulineaux (France)	52.700	Voisin Farman	H. FARMAN (France)
20.05.09.	Pau (France)	54.810	Wright	P. TISSANDIER (France)
23.08.09.	Reims (France)	69.821	Herring Curtiss	G. CURTISS (USA)
24.08.09.	Reims (France)	74.318	Blériot XII	L. BLÉRIOT (France)
28.08.09.	Reims (France)	76.995	Blériot XII	L. BLÉRIOT (France)
23.04.10.	Nice (France)	77.579	Antoinette Levasseur	H. LATHAN (France)
10.07.10.	Reims (France)	106.508	Blériot XI	L. MORANE (France)
29.10.10.	New-York (USA)	109.756	Blériot XI	A. LEBLANC (France)
12.04.11.	Pau (France)	111.801	Blériot XI	A. LEBLANC (France)
11.05.11.	Châlons (France)	119.760	Nieuport	E. NIEUPORT (France)
12.06.11.	Etampes (France)	125.000	Blériot XI	A. LEBLANC (France)
16.06.11.	Châlons (France)	130.057	Nieuport	E. NIEUPORT (France)
21.06.11.	Châlons (France)	133.136	Nieuport	E. NIEUPORT (France)
13.01.12.	Pau (France)	145.161	Deperdussin	J. VÉDRINES (France)
22.02.12.	Pau (France)	161.290	Deperdussin	J. VÉDRINES (France)
29.02.12.	Pau (France)	162.454	Deperdussin	J. VÉDRINES (France)
01.03.12.	Pau (France)	166.821	Deperdussin	J. VÉDRINES (France)

TABLE 2
A – List of the speed records – Propeller aircraft

DATE	LOCATION	SPEED (Km/h)	AIRCRAFT	PILOT
02.03.12.	Pau (France)	167.910	Deperdussin	J. VÉDRINES (France)
13.07.12.	Reims (France)	170.777	Deperdussin	J. VÉDRINES (France)
09.09.12.	Chicago (USA)	174.100	Deperdussin	J. VÉDRINES (France)
17.06.13.	Reims (France)	179.820	Deperdussin	M. PRÉVOST (France)
27.09.13.	Reims (France)	191.897	Deperdussin	M. PRÉVOST (France)
29.09.13.	Reims (France)	203.850	Deperdussin	M. PRÉVOST (France)
07.02.20.	Villacoublay (France)	275.862	Nieuport-Delage 29 V	S. LECOINTE (France)
28.02.20.	Villacoublay (France)	283.464	Spad-Herbemont 20 bis	J. CASALE (France)
09.10.20.	Buc (France)	292.682	Spad-Herbemont 20 bis	B. de ROMANET (France)
10.10.20.	Buc (France)	296.694	Nieuport-Delage 29 V	S. LECOINTE (France)
20.10.20.	Villacoublay (France)	302.529	Nieuport-Delage 29 V	S. LECOINTE (France)
04.11.20.	Buc (France)	309.012	Spad-Herbemont 20 bis	B. de ROMANET (France)
12.12.20.	Villacoublay (France)	313.043	Nieuport-Delage 29 V bis	S. LECOINTE (France)
26.09.21.	Etampes (France)	330.275	Nieuport-Delage Sesquiplane	S. LECOINTE (France)
21.09.22.	Etampes (France)	341.233	Nieuport-Delage Sesquiplane	S. LECOINTE (France)
13.10.22.	Détroit (USA)	358.836	Curtiss P-6	Brigadier-General W. MITCHELL (USA)
15.02.23	Istres (France)	375.000	Nieuport-Delage Sesquiplane	S. LECOINTE (France)

TABLE 2
A – List of the speed records – Propeller aircraft

DATE	LOCATION	SPEED (Km/h)	AIRCRAFT	PILOT
29.03.23	Dayton (USA)	380.751	Curtiss R-6	Lt R. RUSSELL MAUGHAN (USA)
02.11.23	New-York (USA)	417.078	Curtiss R2-C1	Lt H. J. BROW (USA)
04.11.23	New-York (USA)	429.025	Curtiss R2-C1	Lt A.J. WILLIAMS (USA)
11.12.24	Istres (France)	448.171	Bernard Ferbois (SIMB) V2	Adj. Chef F. BONNET (France)
03.09.32	Cleveland (USA)	473.820	Monoplane Gee-Bee	Major J.H. DOOLITTE (USA)
04.09.33	Chicago (USA)	490.800	Monoplane Wedell-Williams	J.R. WEDELL (USA)
25.12.34	Istres (France)	505.848	Caudron-Renault 460	R. DELMOTTE (France)
13.09.35	Santa-Anna California (USA)	567.115	Monoplane Hughes Special	H. HUGHES (USA)
11.11.37	Augsbourg (Gr.)	610.950	Monoplane BF 113R	H. WURSTER (Gr.)
30.03.39	Oranienburg (Gr.)	746.604	Heinke HE.112.U	Flugkapitän H. DIETERLE (Gr.)
26.04.39	Augsbourg (Gr.)	755.138	Messerschmitt BP 109R	Flugkapitän F. WENDEL (Gr.)
16.08.69	Edwards AF.B California (USA)	776.449	Grumman F8F-2 Bearcat modified	D. GREENMAYER (USA)
14.08.79	Tonopah Nevada (USA)	803.138	North-American P-51 D. Mustang, modified	S. HINTON (USA)

TABLE 2
B — List of the speed records — Jet aircraft

1 - Distance 3 km at low altitude

DATE	LOCATION	SPEED (Km/h)	AIRCRAFT	PILOT
07.11.45.	Herne Bay (UK)	975,675	Gloster Meteor IV	Gr.Cn.H.J. WILSON
07.09.46.	Little Hampton (UK)	991	Gloster Meteor IV	Gr.Cn.E. MORTLOCK DONALDSON
19.06.47.	Muroc (USA)	1003,811	Lockheed P80R	Col. BOYD
20.08.47.	Muroc (USA)	1031,78	Douglas D558	Comm. TF. CALDWELL
25.08.47.	Muroc (USA)	1047,356	Douglas D558	Major M.E. CARL
15.09.48.	Muroc (USA)	1079,841	F 86 A	Major R.L. JOHNSON
19.11.52.	Salton Sea (USA)	1124,137	F 86 D	Cn. J.S. NASH
16.7.53.	Salton Sea (U.S.A.)	1151,883	F 86 D	Lt.Col. W.F. BARNS
07.09.53.	Little Hampton (UK)	1171	Hunter Mk 3	Sq.Lr.N.F. DUKE
25.09.53.	Castel Idris (Libye)	1184	Supermarine Swift	M.J. LITHGOW
03.10.53.	Salton Sea (U.S.A.)	1211,746	Douglas XF 4D	Lt.Com. J.B. VERDIN
28.08.61.	Holloman AFB (U.S.A.)	1452,777	Mc Donnell F4H	Lt. H. HARDISTY
24.10.77.	Tonopah (U.S.A.)	1590,45	Lockheed F 104	D.G. GREENMAYER

3 - 1000 km close circuit

DATE	LOCATION	SPEED (Km/h)	AIRCRAFT	PILOT
23.03.55.	Nyköping (Suède)	900,660	SAAB 29C	Cn. A.H.M. NEY
24.09.57.	U.R.S.S.	970,821	TU 104 A	V. KOVALEV
18.01.58	Istres (France)	1025,315	Etendard IV	P. GALLAND
25.04.58.	Istres (France)	1050,636	Breguet 1001	B. WITT
23.07.58.	Istres (France)	1075,347	Breguet 1001	B. WITT
08.04.59.	Edwards AFB (U.S.A.)	1126,619	RF 101 C	Col. E.H. TAYLOR
19.09.60.	France	1822	Mirage IV	Cdt R. BIGAND
14.01.61.	Edwards AFB (U.S.A.)	2067,58	B 58	Mr. H.E. CONFER
16.03.65.	Podmoskovnoe (U.R.S.S.)	2319,2	E 266	A.V. FEDOTOV
01.05.65.	Edwards AFB (U.S.A.)	2718,006	Y 12 A	Mr. W.F. DANIEL
27.10.67.	Podmoskovnoe (U.R.S.S.)	2920,67	E 266	P. OSTAPENKO
27.07.76.	Beale AFB (U.S.A.)	3367,22	SR 71	A.H. BLEDSOE Jr.

2 - Distance 15 to 25 km

DATE	LOCATION	SPEED (Km/h)	AIRCRAFT	PILOT
03.06.53.	Muroc (U.S.A.)	1087,068	Sabre Canadien M K 3	Jacqueline COCHRAN
01.09.53.	Vandalia (U.S.A.)	1139,219	F 86D	Cn. H.E. COLLINS
29.10.53.	Salton Sea (U.S.A.)	1215,298	Y F 100	Lt. Col. F.K. EVEREST Jr.
20.08.55.	Palmdale (U.S.A.)	1323,312	F 100 C	Col. H.A. HANES
10.03.56.	Chichester (U.K.)	1822	Fairey Delta 2	L.P. TWISS
12.1.57.	Edwards AFB (U.S.A.)	1943,5	F 101 A	Mr A.E. DREW
10.05.58.	Edwards AFB (U.S.A.)	2259,538	F 104 A	Cn. W. W. IRWIN
31.10.59.	Petrovskoe (U.R.S.S.)	2399	E 66	G. MOSSOLOV
15.12.59.	Edwards AFB (U.S.A.)	2455,736	F 106 A	Mr. J. W. ROGERS
22.11.61.	Edwards AFB (U.S.A.)	2585,425	F 4 H	Lt. Col. R.B. ROBINSON
07.07.62.	Podmoskovnoe (U.R.S.S.)	2681	E 166	G. MOSSOLOV
01.05.65.	Edwards AFB (U.S.A.)	3331,507	Y F 12 A	Col. R.L. STEPHENS
28.07.76.	Beale AFB (U.S.A.)	3529,560	SR 71	Cn. E.W. JOERSZ

TABLE 3.1

MAIN CHARACTERISTICS OF THE RECORD AIRCRAFT (Propeller) (from known data or reconstructed by calculation)								PROPELLER		AERODYNAMIC PARAMETERS at the time of the record				AERO. COEFFICIENTS		MAIN PERFORMANCE	
YEAR	TYPE Pilot	Mass P Kg	Surface S m^2	Aspect ratio	Maximum power W Cv	P/S kg/m^2	P/W kg/cv	Diameter m	Max. result. Mach. Mr	100 C_D	100 C_D	100 C_D	100 C_D	Equivalent parasitic surface $C_D . Sm^2$	Total effi. $Cv/m^2 x100$	Stalling speed out of ground effect km/h	Stalling speed with ground effect km/h
12.11.1906	SANTOS-DUMONT XIV bis A. Santos-Dumont	300	50	5,29	40	6	7,5	2,00	0,37	73,00	41,35	3,24	38,11	20,681	1,93	37,2	32,6
26.10.1907	VOISIN N°1 bis H. Farman	530	40	5	50	13,25	10,60	2,60		98,93	33,47	6,29	26,18	13,39	3,73	51,2	44,9
20.05.1909	WRIGHT BARRIQUAND Tissandier	430	47,40	6,59	35	9,07	12,29	2,85		62,62	17,57	1,91	15,66	8,33	4,2	38,8	34,0
23.08.1909	CURTISS-HERRING Curtiss	320	21	6,75	51	15,24	6,27	2,60	0,72	64,82	27,96	0,20	27,76	5,87	8,69	56,2	49,3
28.08.1909	BLERIOT XII L.Blériot	575	21,40	4,67	50	26,87	11,50	2,70	0,25	93,98	20,60	6,11	14,49	4,41	11,35	66,8	58,6
23.04.1910	LATHAM ANTOINETTE H. Latham	500	50	4,15	50	10	10	2,40	0,52	34,45	8,39	0,92	7,47	3,74	13,39	43,4	38,1
10.07.1910	BLERIOT XI 100 cv L. Morane	300	15	5,28	100	20	3	2,60	0,49	36,56	22,24	0,82	21,42	3,34	29,94	56,7	50,5
12.04.1911	BLERIOT XI 100 cv Leblanc	300	15	5,28	100	20	3	2,60	0,49	33,18	19,23	0,67	18,56	3,21	31,15	56,7	50,5
11.05.1911	NIEUPORT 2 N E. Nieuport	290	14	5,34	35	20,71	8,29	2,00	0,56	29,95	5,87	0,54	5,33	0,82	42,56	59,8	52,5
12.06.1911	BLERIOT XI Bis Leblanc (Alias XXIII)	300	9	5	100	33,33	3	2,60	0,49	4,24	22,93	1,26	21,67	2,06	48,54	75,9	66,6
21.06.1911	NIEUPORT G 50 E. Nieuport	340	14	5,34	50	24,29	6,8			28,41	6,10	0,49	5,61	0,85	58,48	64,8	56,8
13.01.1912	DEPERDUSSIN 100 cv J. Védrines	370	10	4,9	100	37	3,7	2,50	0,48	36,41	13,36	0,87	12,49	1,34	74,63	75,4	66,1
01.03.1912	DEPERDUSSIN 100 cv modified J. Védrines	350	8	4,09	100	43,75	3,5	2,50	0,48	32,60	11,00	0,84	10,16	0,88	113,64	82,0	71,9

TABLE 3.2

MAIN CHARACTERISTICS OF THE RECORD AIRCRAFT (Propeller) (from known data or reconstructed by calculation)								PROPELLER		AERODYNAMIC PARAMETERS at the time of the record				AERO. COEFFICIENTS		MAIN PERFORMANCE	
YEAR	TYPE Pilot	Mass P Kg	Surface S m^2	Aspect ratio	Maximum power W Cv	P/S kg/m^2	P/W kg/cv	Diameter m	Max. result. Mach. Mr	100 C_D	100 C_D	100 C_D	100 C_D	Equivalent parasitic surface $C_D \cdot Sm^2$	Total effi. $Cv/m^2 \times 100$	Stalling speed out of ground effect km/h	Stalling speed with ground effect km/h
09.09.1912	**DEPERDUSSIN 100 cv** modified & improved J. Védrines	350	8	4,09	100	43,75	3,5	2,50	0,48	29,96	10,43	0,70	9,73	0,83	120,48	82,0	71,9
17.06.1913	**DEPERDUSSIN 160 cv Prévost**	480	12	3,41	160	40	3			25,65	10,01	0,62	9,39	1,20	133,33	79,9	70
29.09.1913	**DEPERDUSSIN 160 cv** modified Prévost	450	9	4,55	160	50	2,81			24,95	9,28	0,44	8,84	0,83	192,31	89,3	78,3
07.02.1920	**NIEUPORT 29 V Sadi-Lecointe**	850	13,2	5,45	300	64,39	2,83	2,50	0,75	17,55	4,79	0,18	4,61	0,63	476,19	112,8	98,9
28.02.1920	**SPAD 20 bis 4 Casule**	1050	15	5,46	300	70	3,5			18,01	3,87	0,19	3,68	0,58	526,32	117,6	103,1
09.10.1920	**SPAD 20 bis 5 Romanet**	1050	15	5,56	320	70	3,28			16,94	3,76	0,17	3,59	0,56	555,55	117,6	103,1
20.10.1920	**NIEUPORT 29 V Sadi-Lecointe**	840	13,2	5,45	340	63,63	2,47	2,45	0,76	14,42	4,17	0,12	4,05	0,55	625	112,1	98,3
04.11.1920	**SPAD 20 bis 6 Romanet**	995	14	5,85	335	71,07	2,97			15,43	3,63	0,13	3,50	0,51	666,7	118,5	103,9
12.12.1920	**NIEUPORT 29 bis Sadi-Lecointe**	830	11	5,30	360	75,45	2,31	2,45	0,74	15,97	4,78	0,16	4,62	0,53	679	122,1	107,1
26.09.1921	**NIEUPORT** Sesquiplane Sadi-Lecointe	980	12,7	5,29	370	77,17	2,65	2,30	0,73	13,74	3,28	0,11	3,17	0,42	909,09	106,9	93,8
13.10.1922	**CURTISS R 6 Mitchel**	820	13	5,12	430	63,08	1,91			10,16	3,19	0,06	3,13	0,41	1048,78	109	95,6
15.02.1923	**NIEUPORT** Sesquiplane Sadi-Lecointe	1014	11	6,11	400	92,18	2,54	2,40	0,80	13,59	3,09	0,10	2,99	0,34	1176,47	116,9	102,5
29.03.1923	**CURTISS R 6 Maughan**	820	13	5,12	507	63,08	1,62			9,02	3,16	0,05	3,11	0,41	1236,58	109	95,6

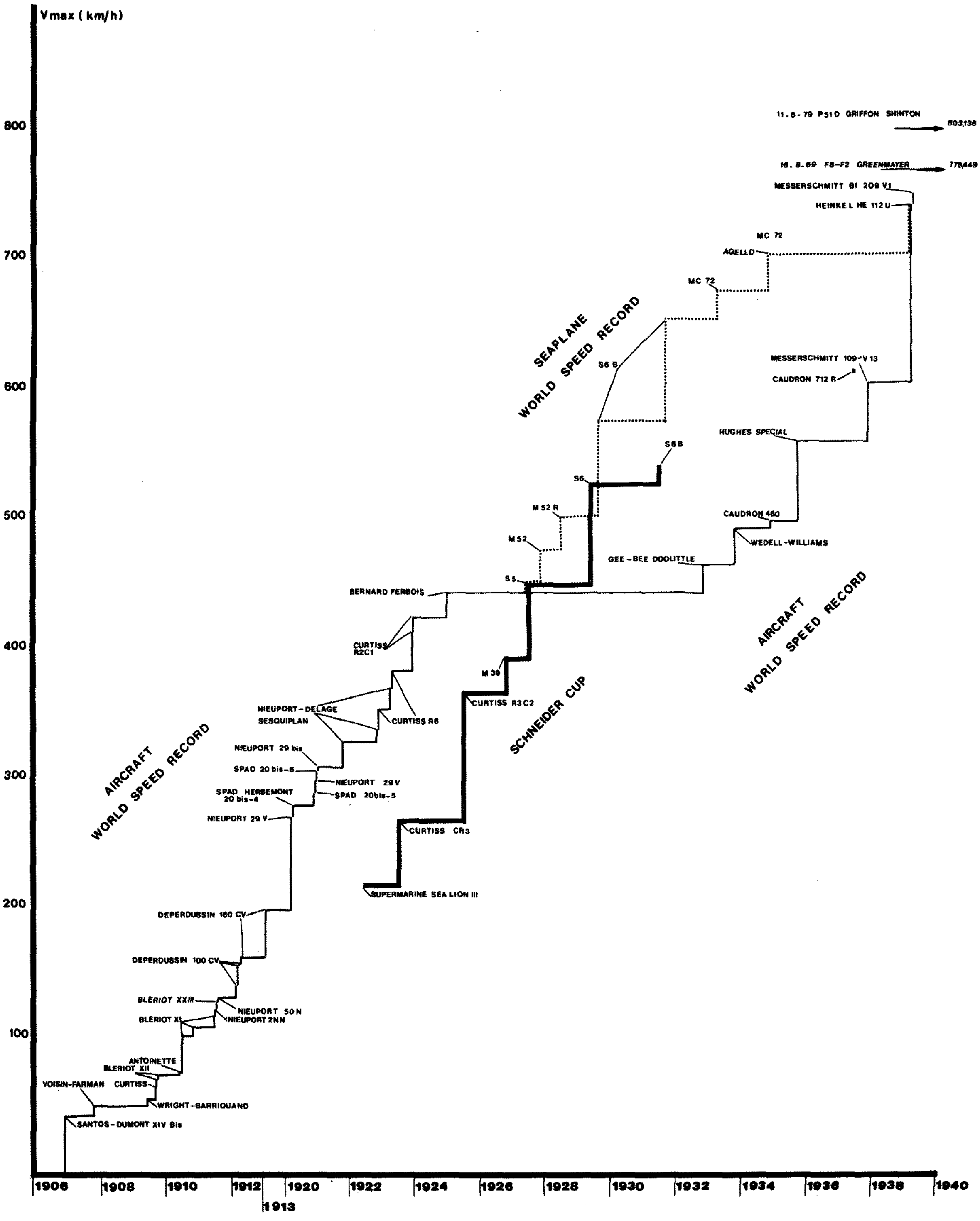


Fig. 1 — FAI world speed records. Aircraft and seaplanes.

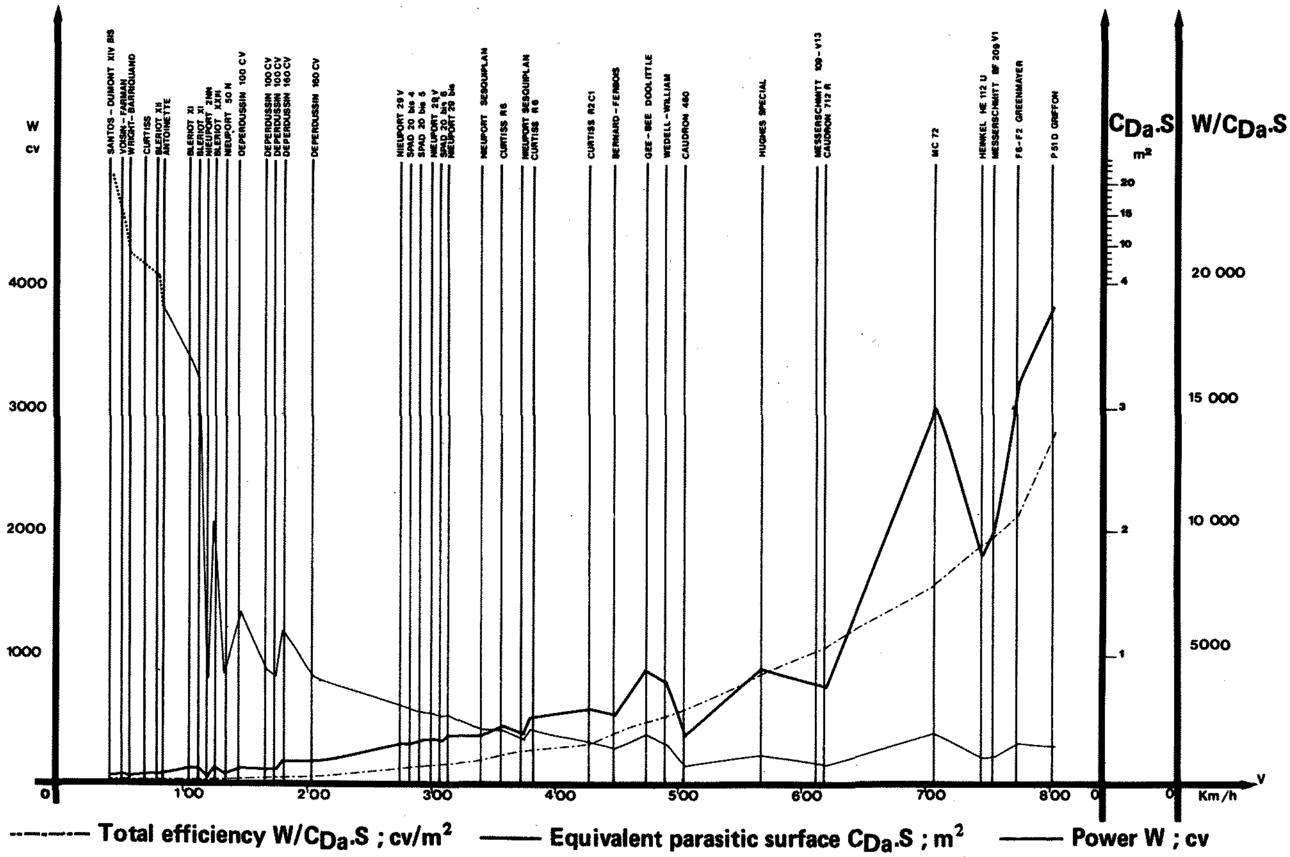


Fig. 2 – Some characteristics of record aircraft.

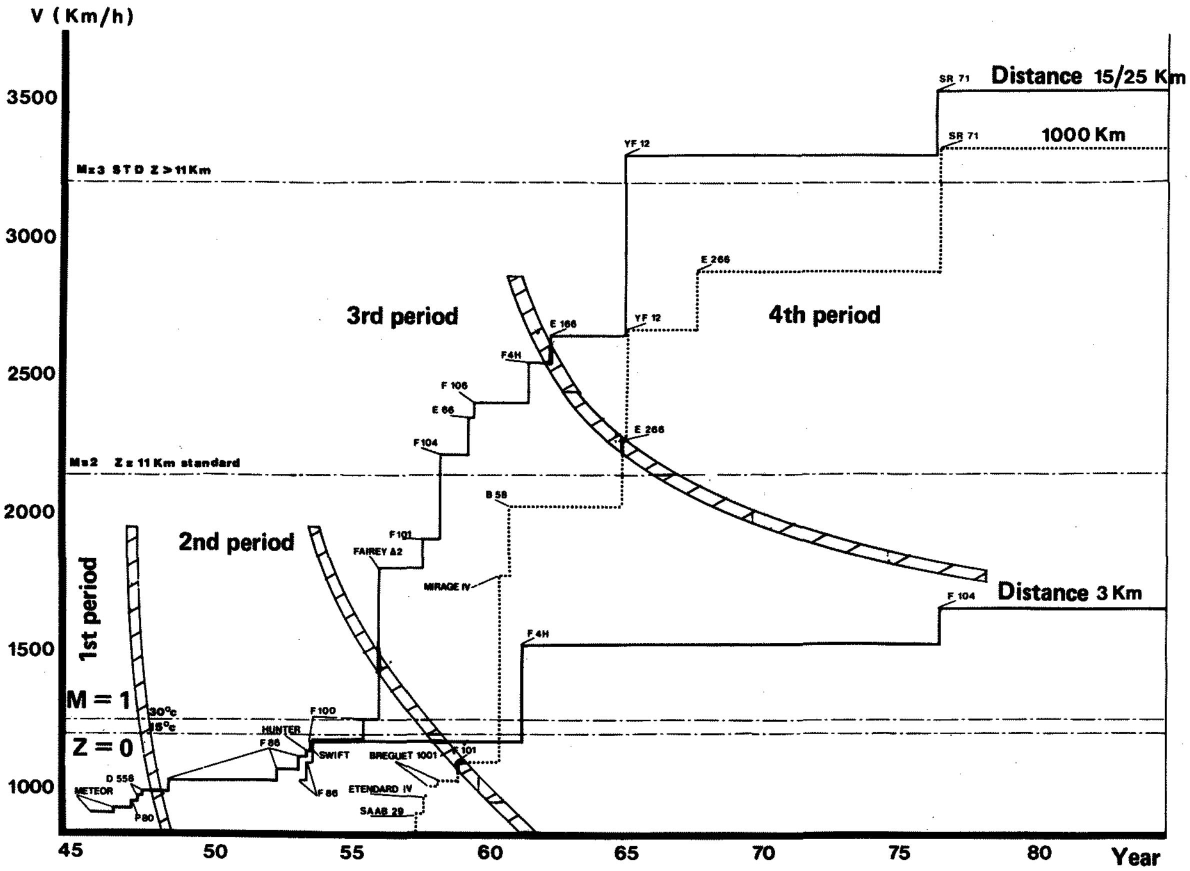


Fig. 3 – Evolution of the speed records from 1945 to the present day.

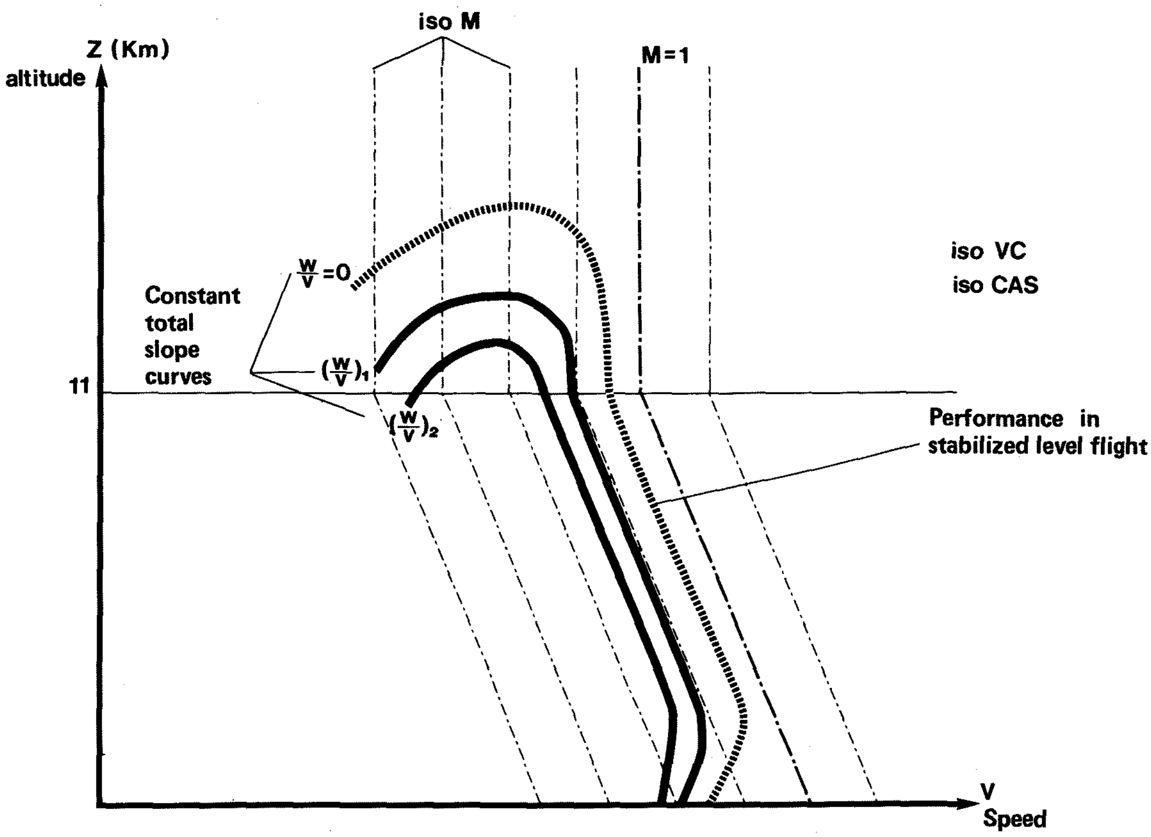


Fig. 4 — Typical performance of 2nd period aircraft.

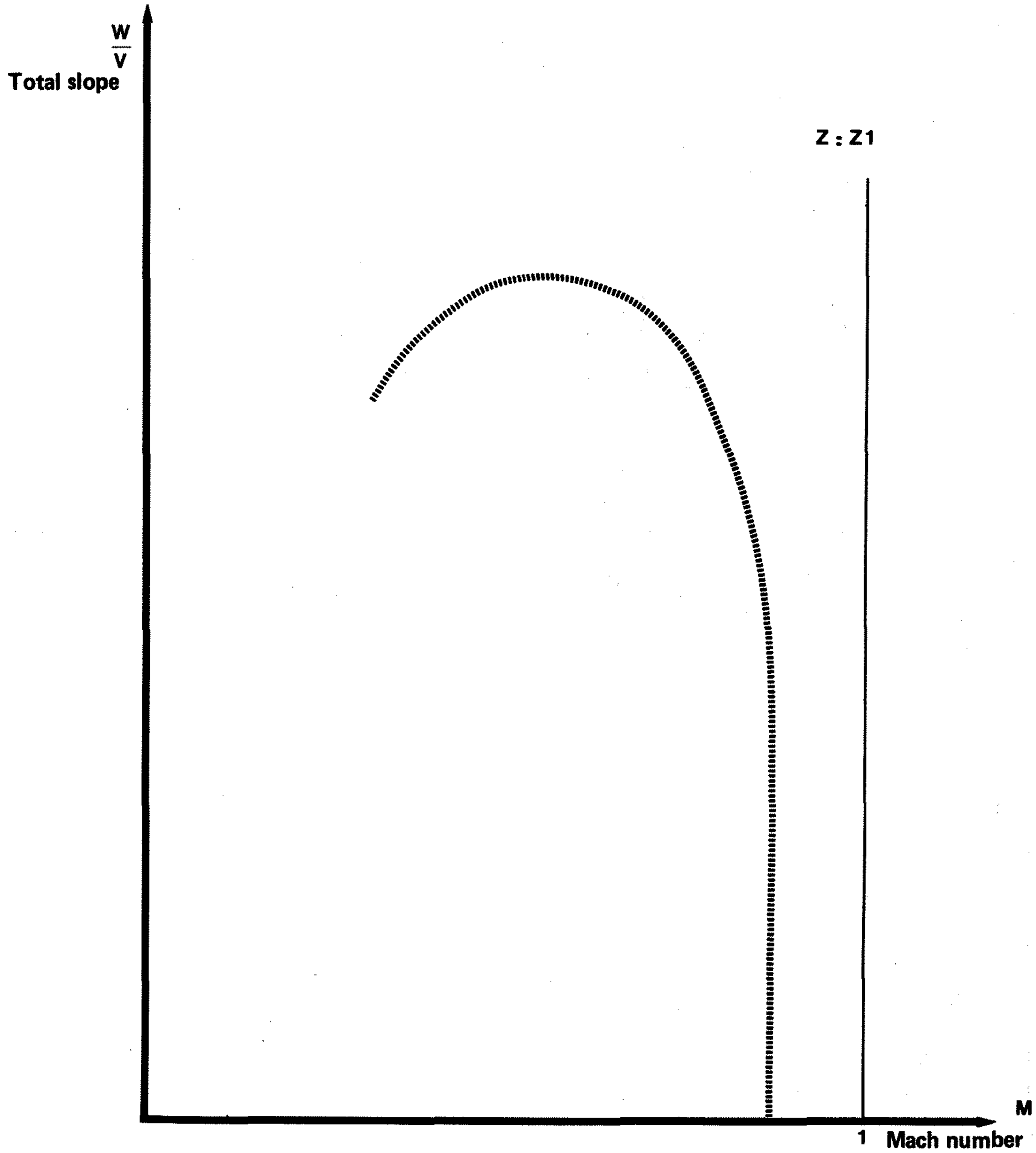


Fig. 5 — 2nd period aircraft. Acceleration in level flight.

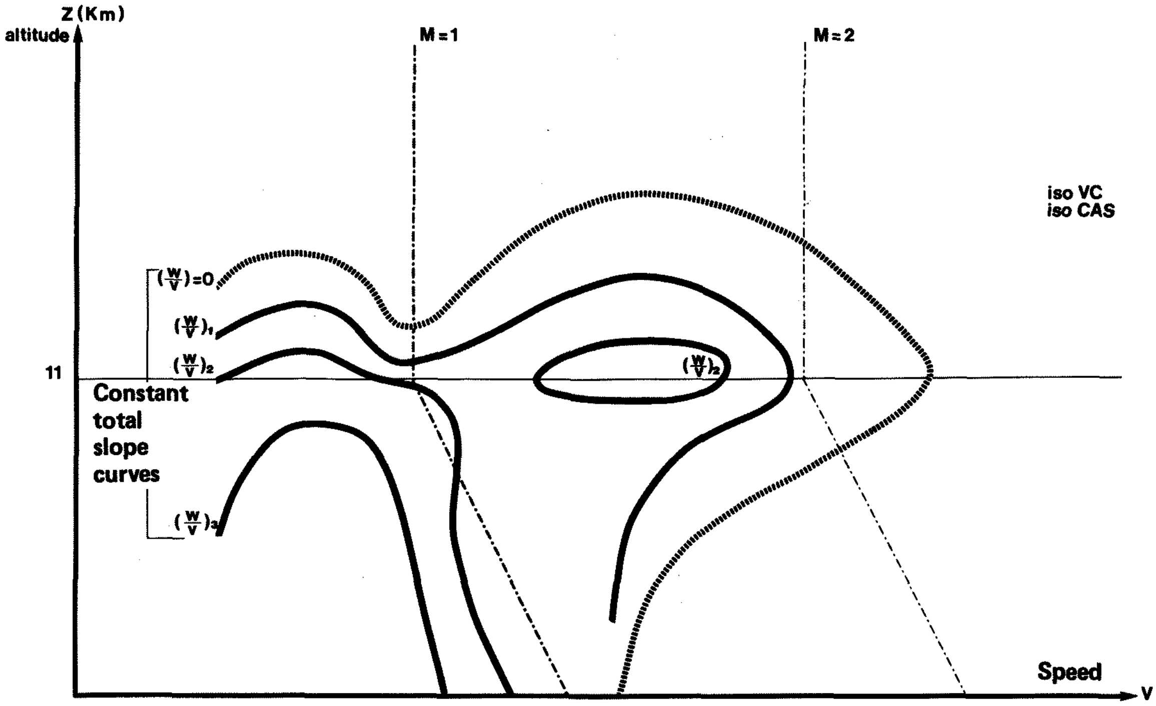


Fig. 6 — Typical performance of 3rd period aircraft.

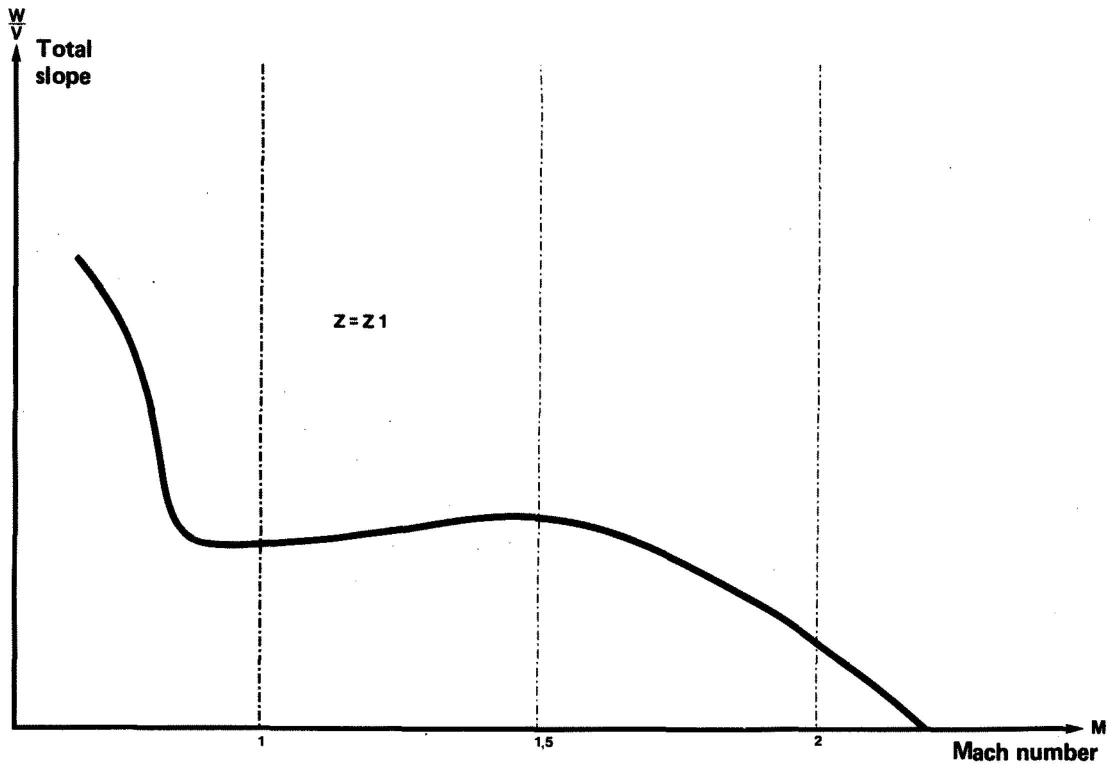


Fig. 7 — 3rd period aircraft. Acceleration in level flight.

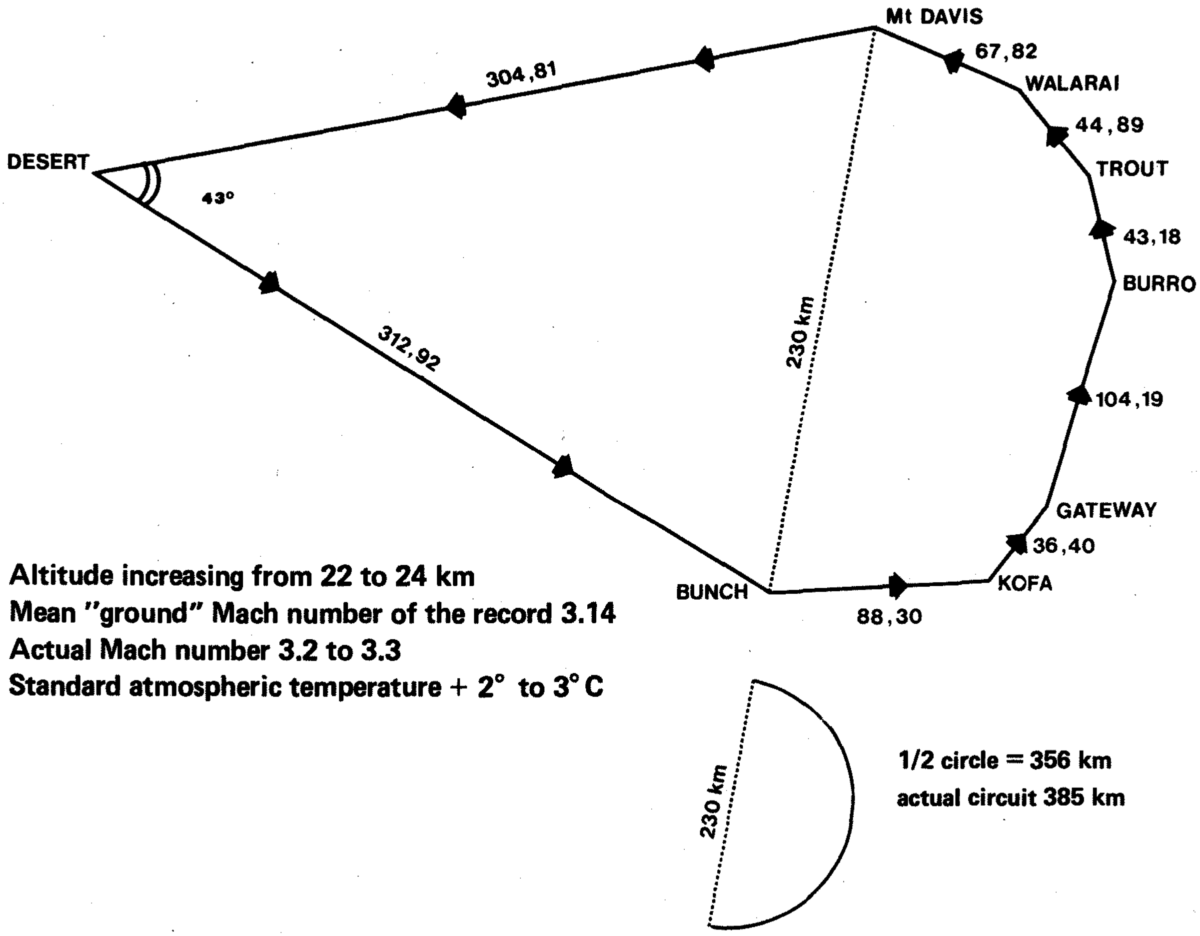
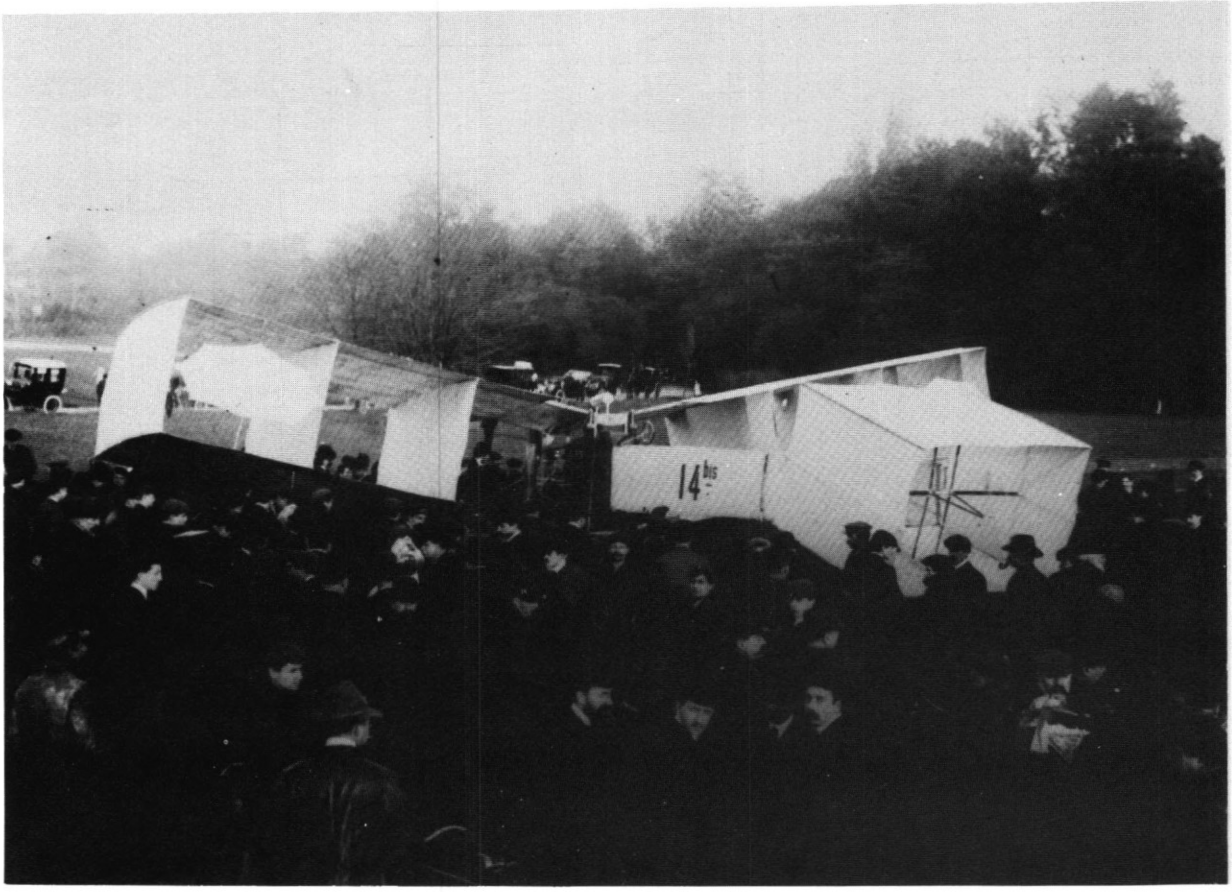


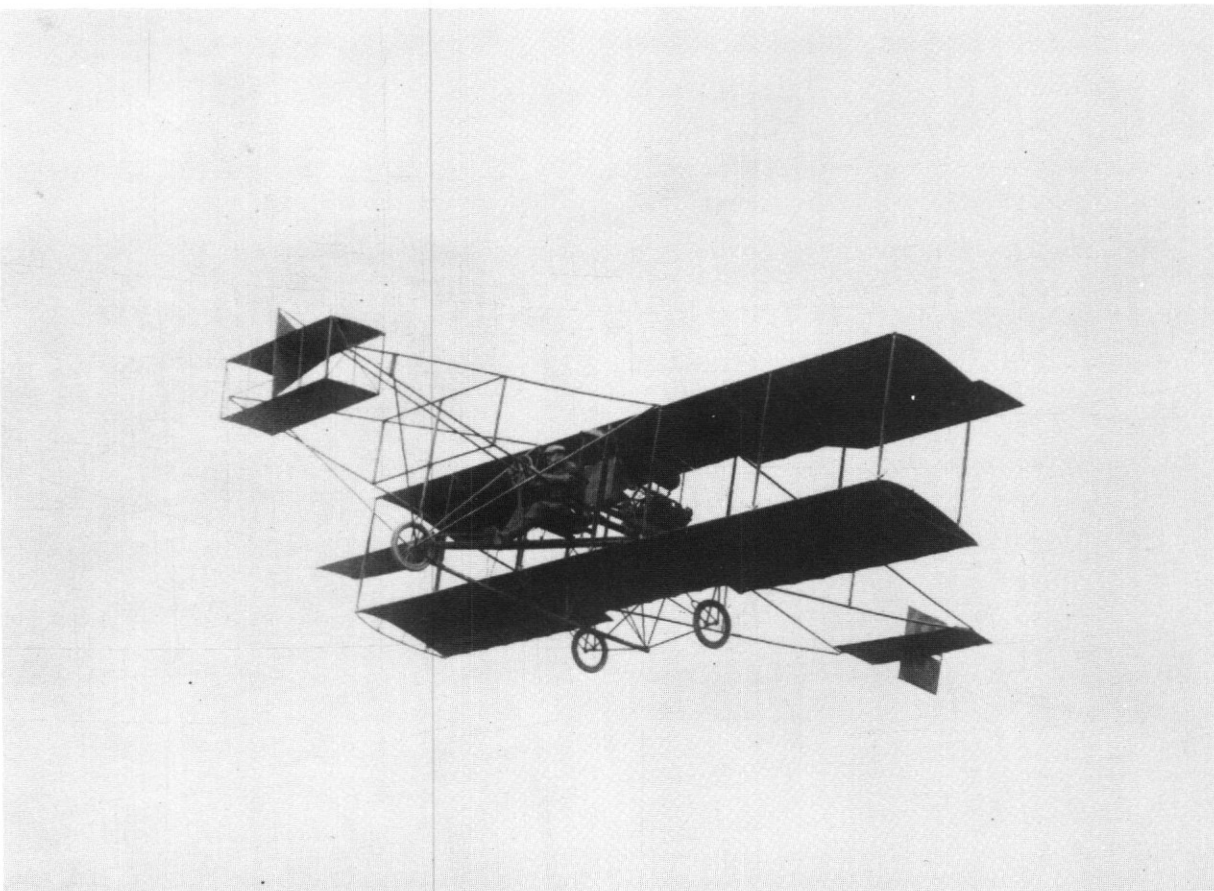
Fig. 8 – Speed record over a 1000 km circuit. SR 71..14-7-75

ANNEX

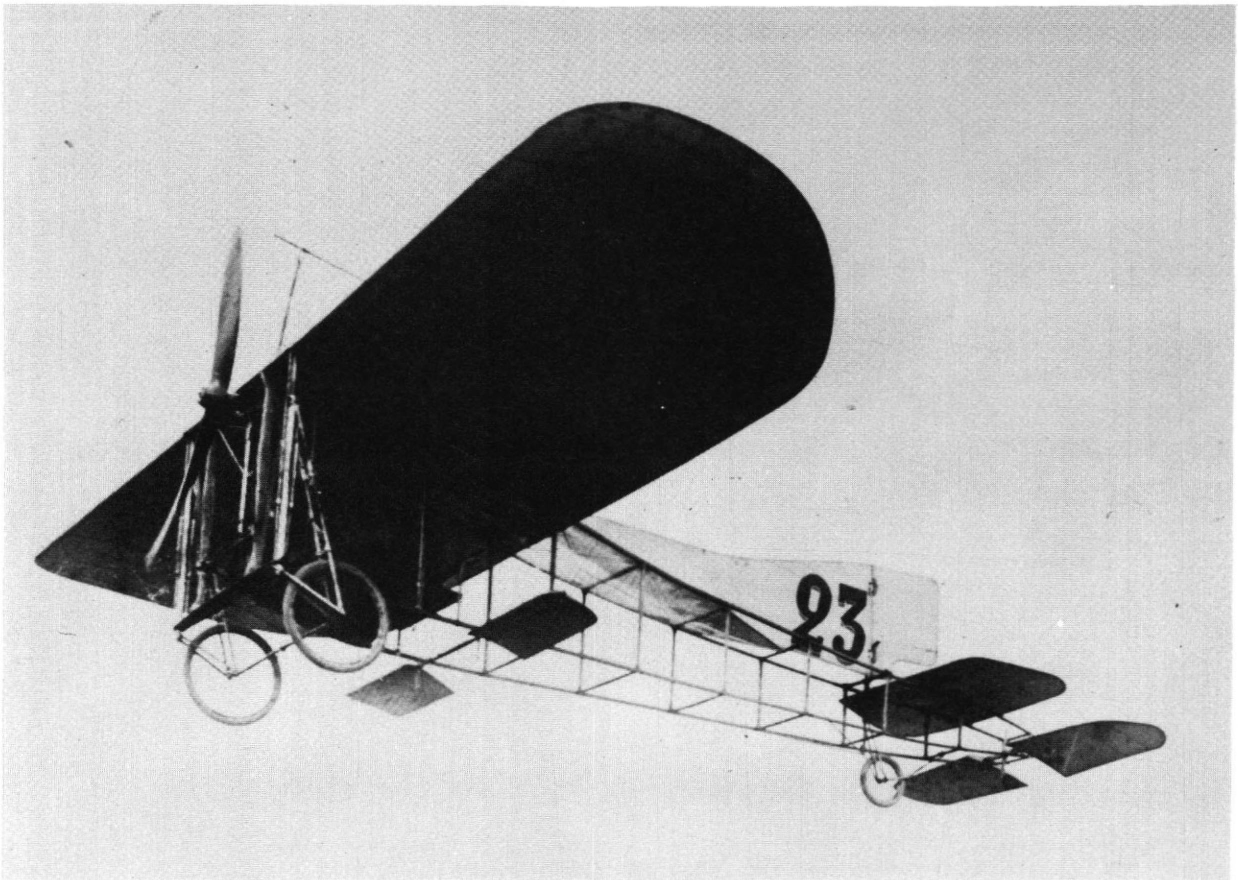
PHOTOGRAPHIC DOCUMENTS



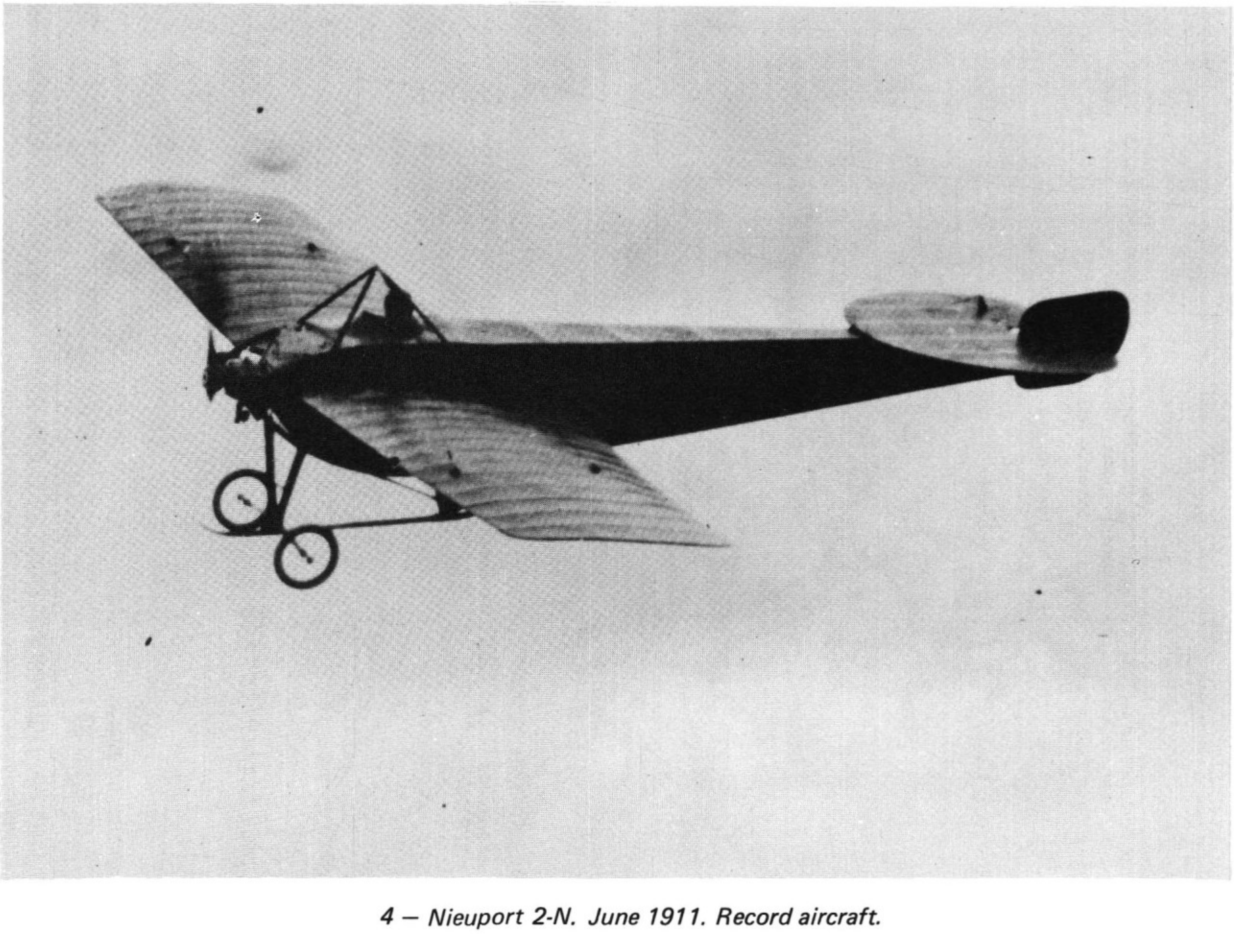
1 – Santos Dumont 14 bis. Record aircraft.



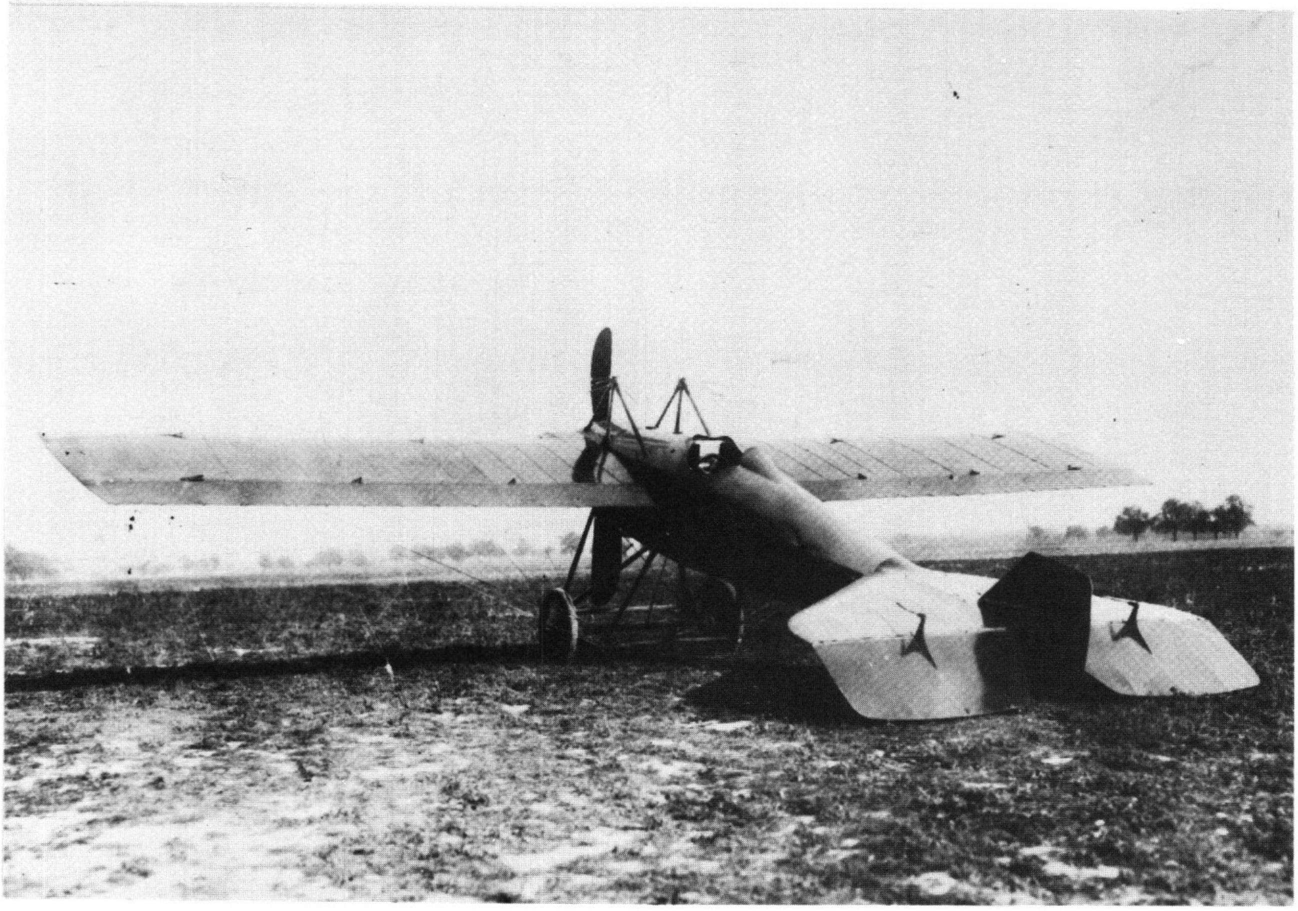
2 – Curtiss in flight. Reims 1909. Record aircraft.



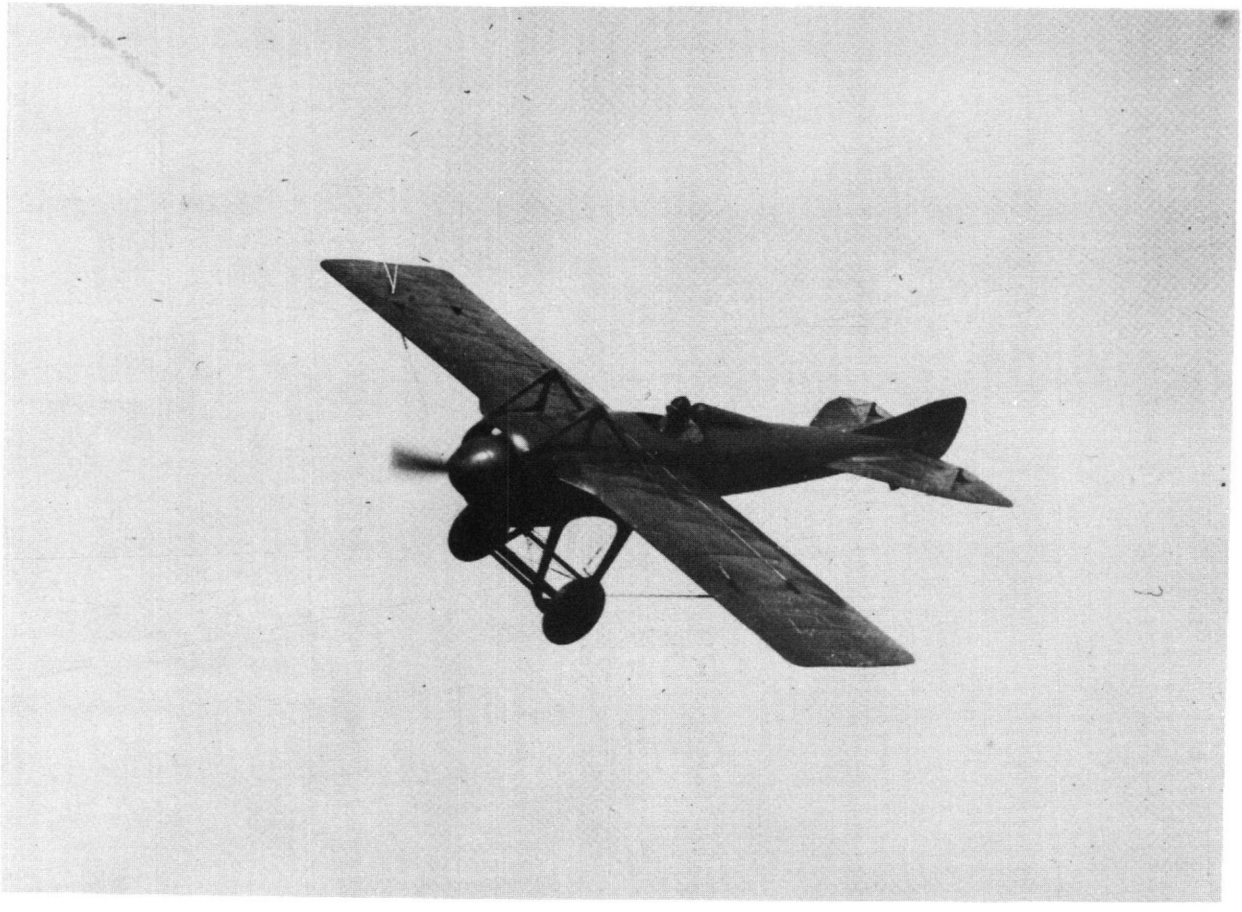
3 — Blériot 12. Reims 1909. Record aircraft.



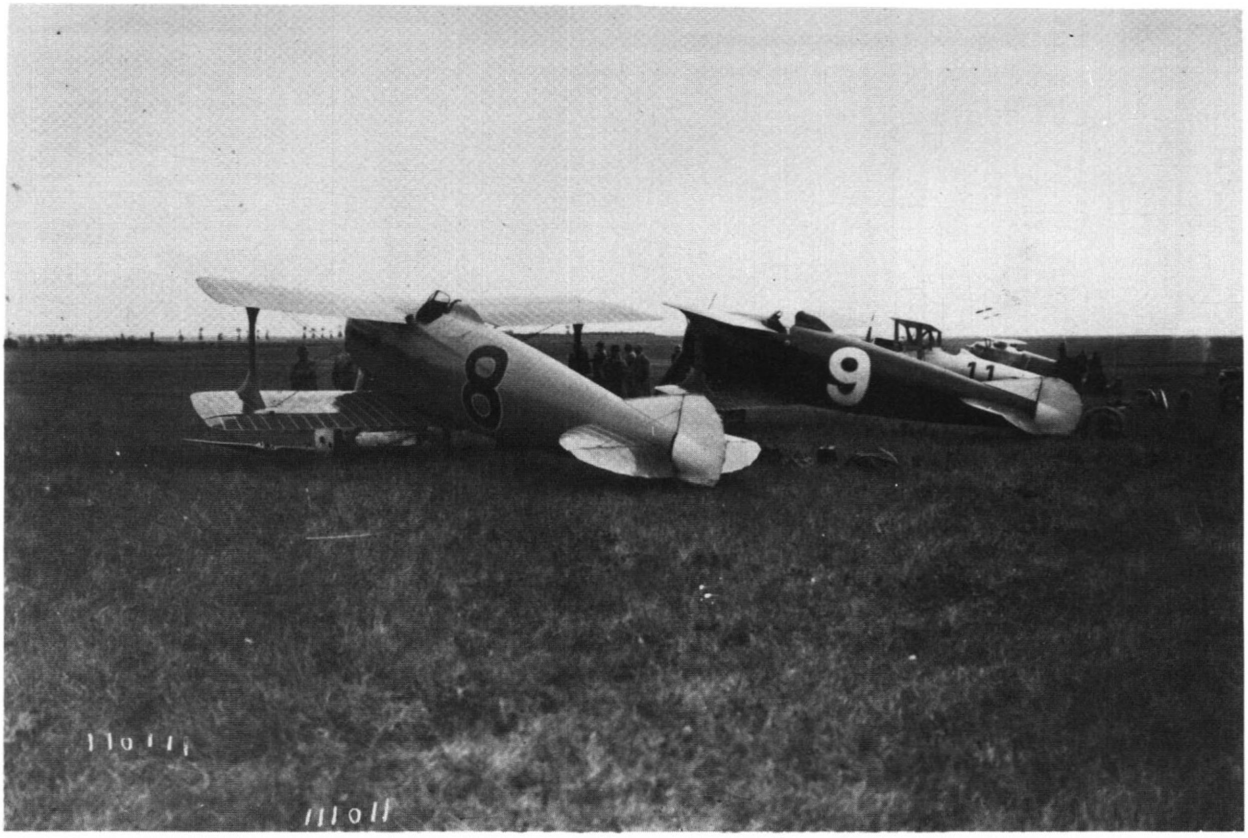
4 — Nieuport 2-N. June 1911. Record aircraft.



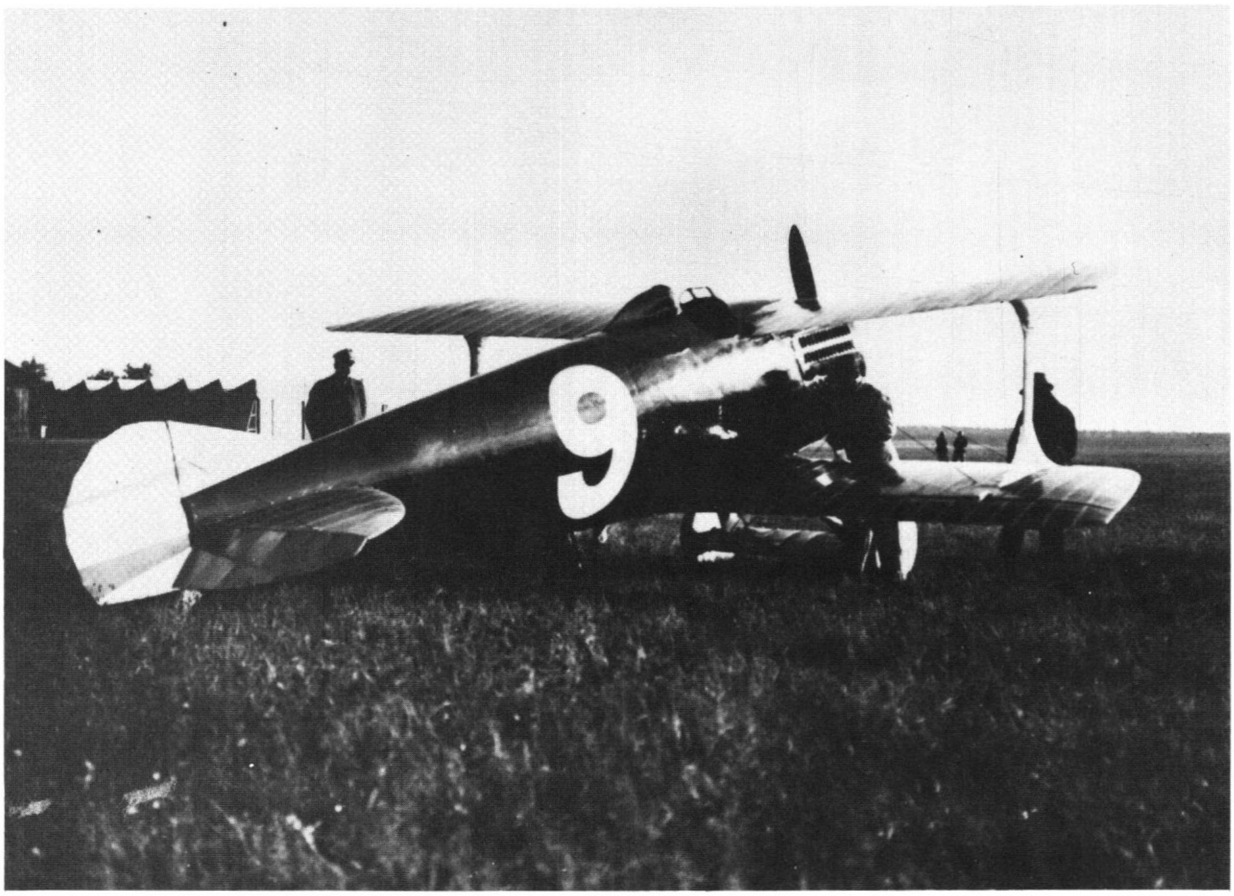
5 — 100 HP Deperdussin flown by Jules Védrines. September 1912. Record aircraft.



6 — Deperdussin flown by Prevost. September 1913. Record aircraft.



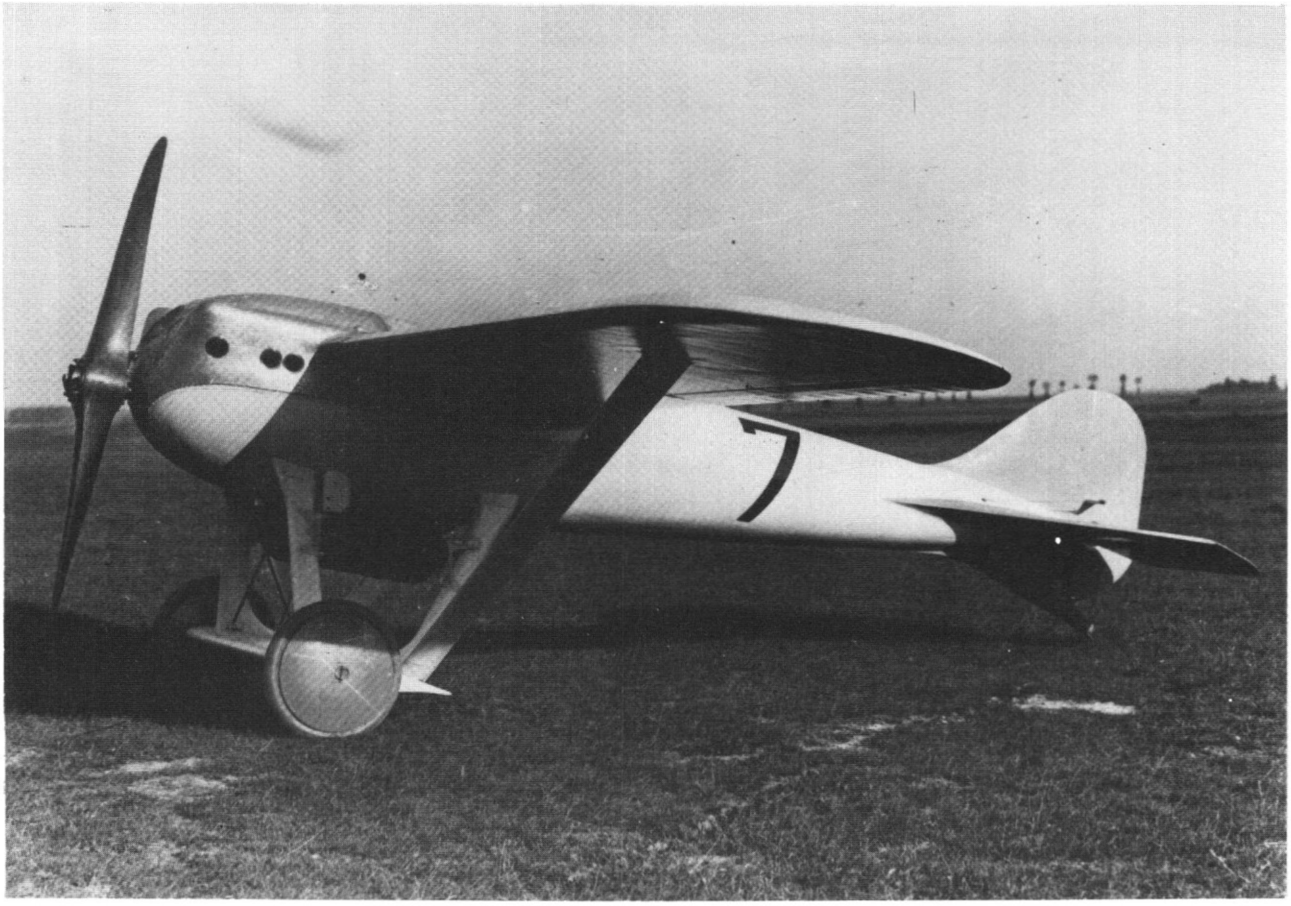
7 – SPAD n° 8 flown by Romanet and SPAD n° 9 flown by Casale during the Gordon-Bennett Cup. Etampes 1920.



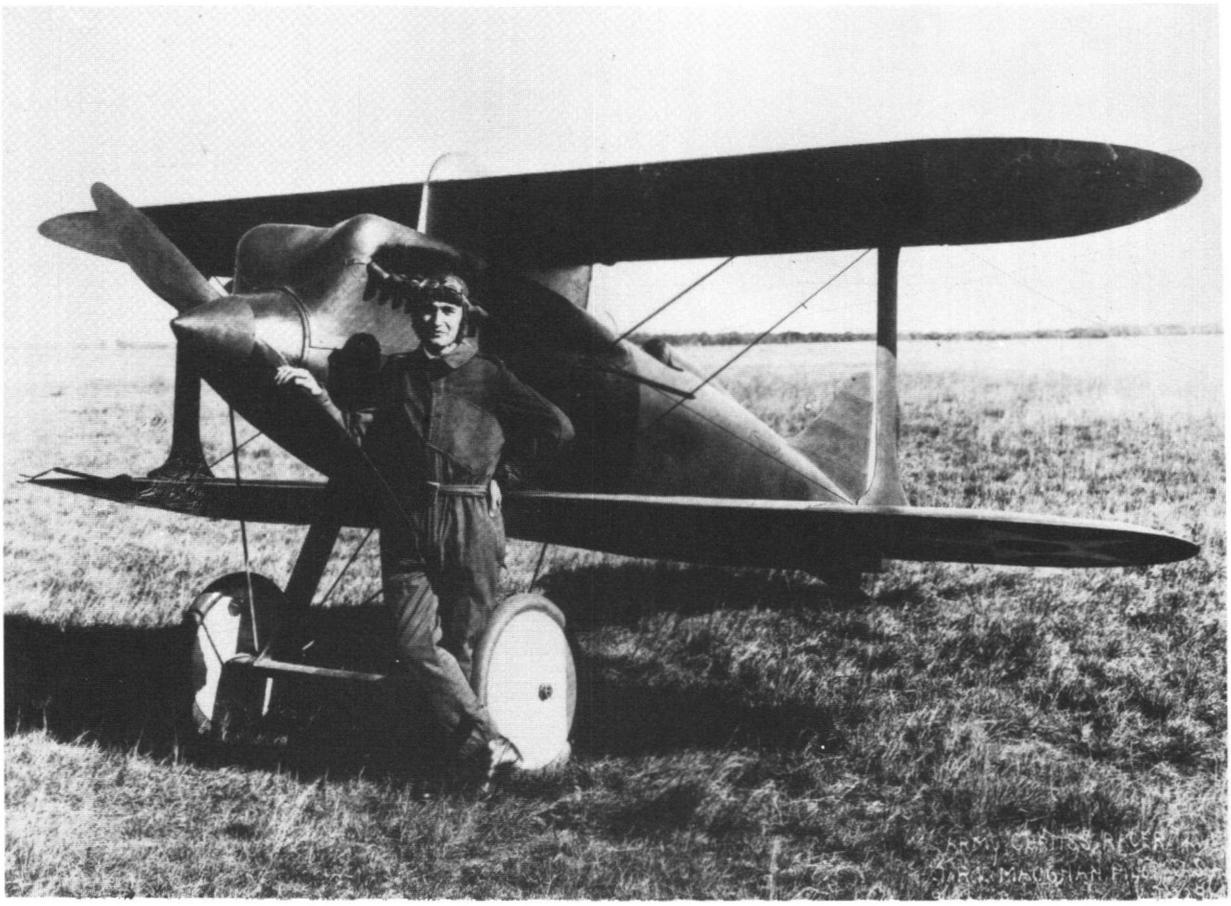
8 – SPAD 20 bis flown by Jean Casale. Record aircraft.

9 – Nieuport 29V flown by Sadi-Lecointe. Record aircraft.

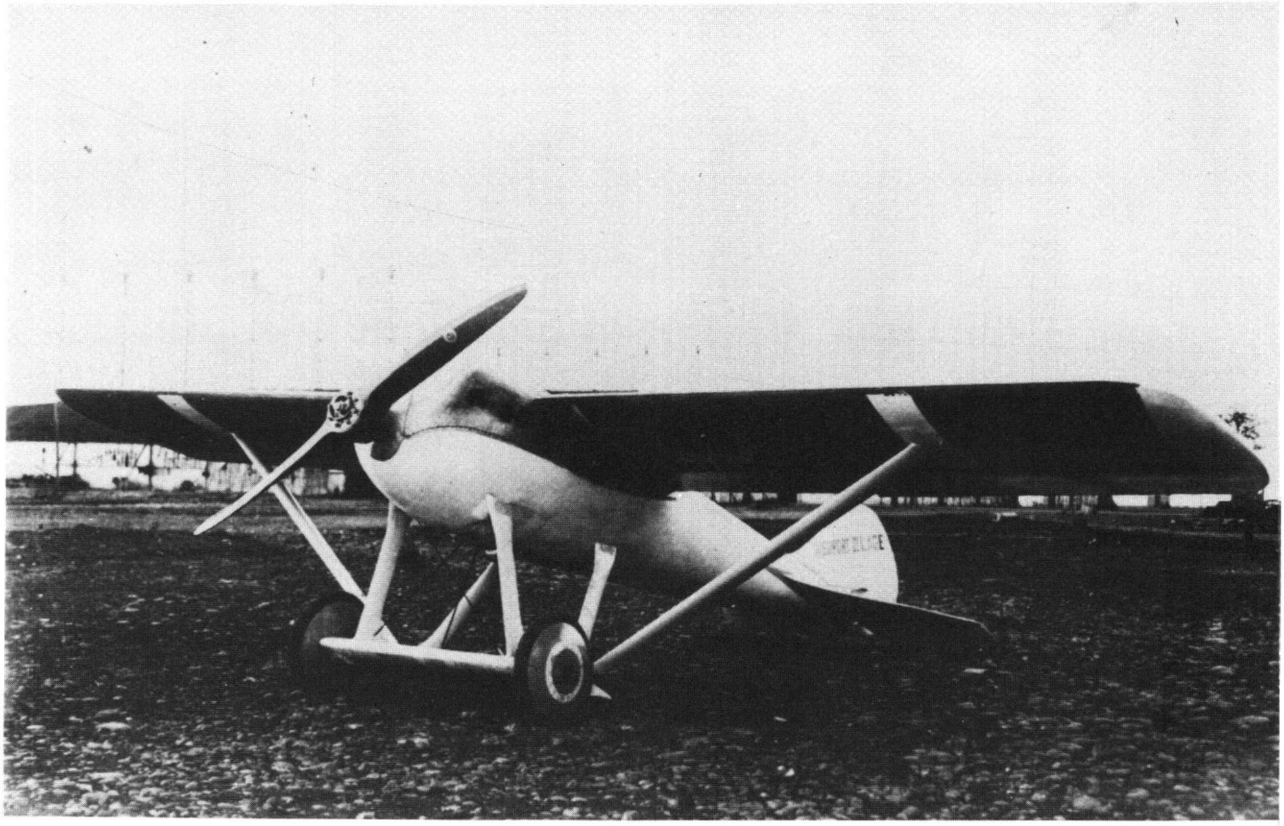
10 – SPAD flown by Bernard de Romanet. Last version of the 20bis 6. Record aircraft.



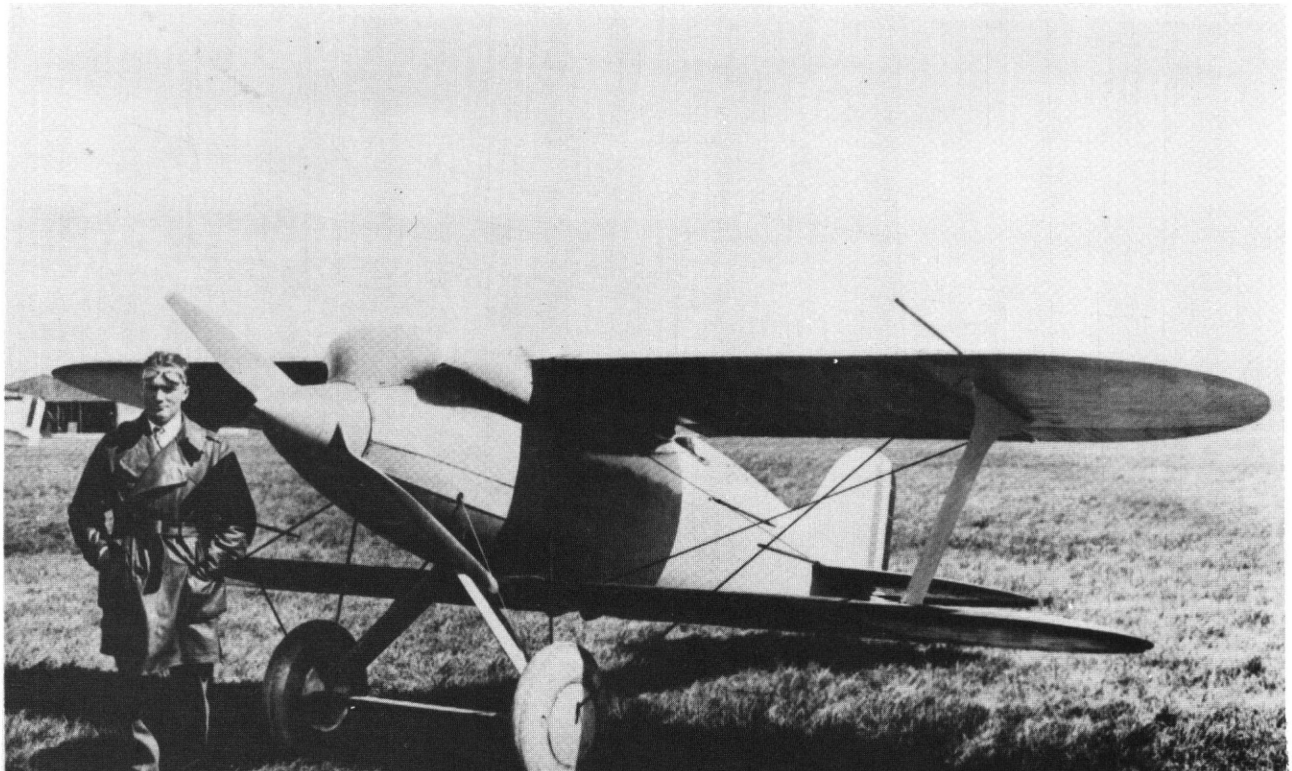
11 – *Nieuport sesquiplane fitted with Lamblin radiators. 1921.*



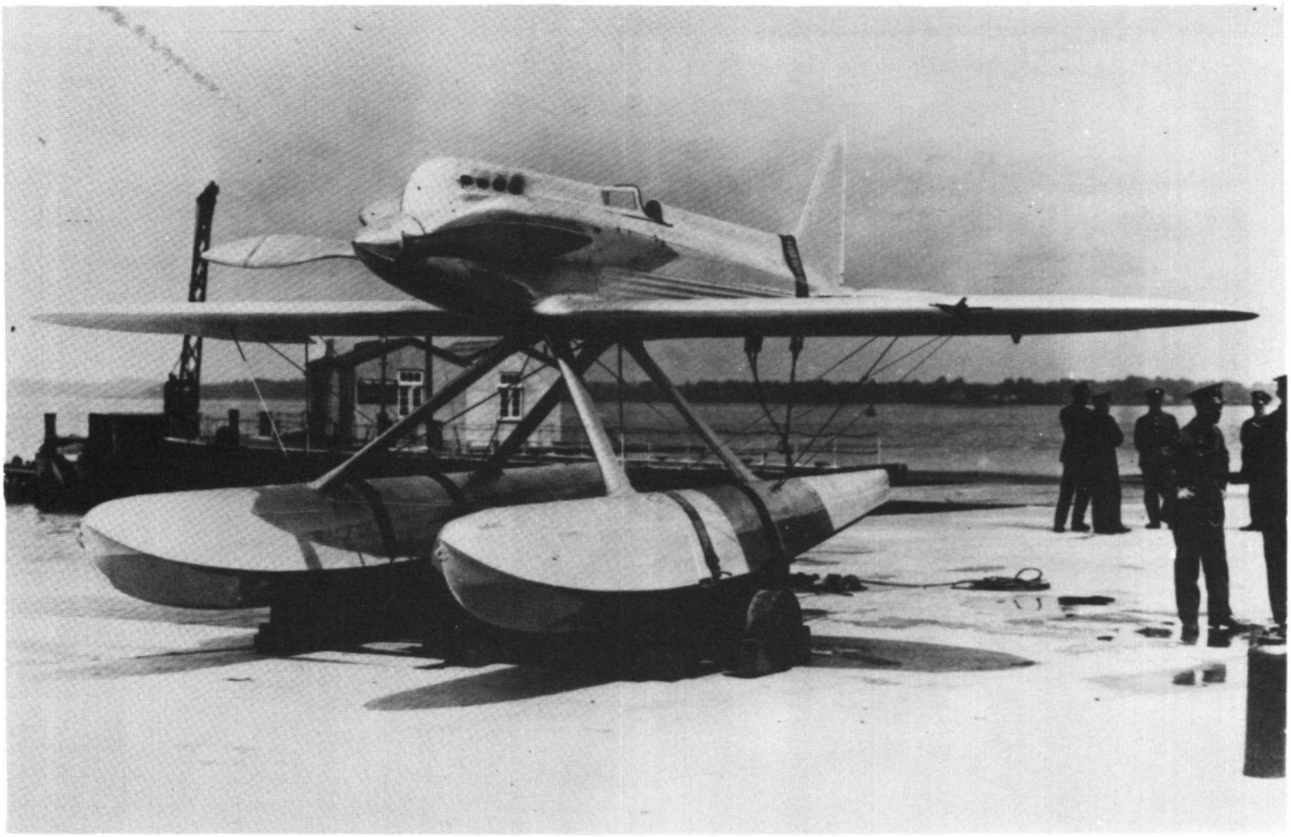
12 – *R6 flown by Lt. Maughan (Photo NASM).*



13 — Nieuport sesquiplane fitted with underwing radiators.

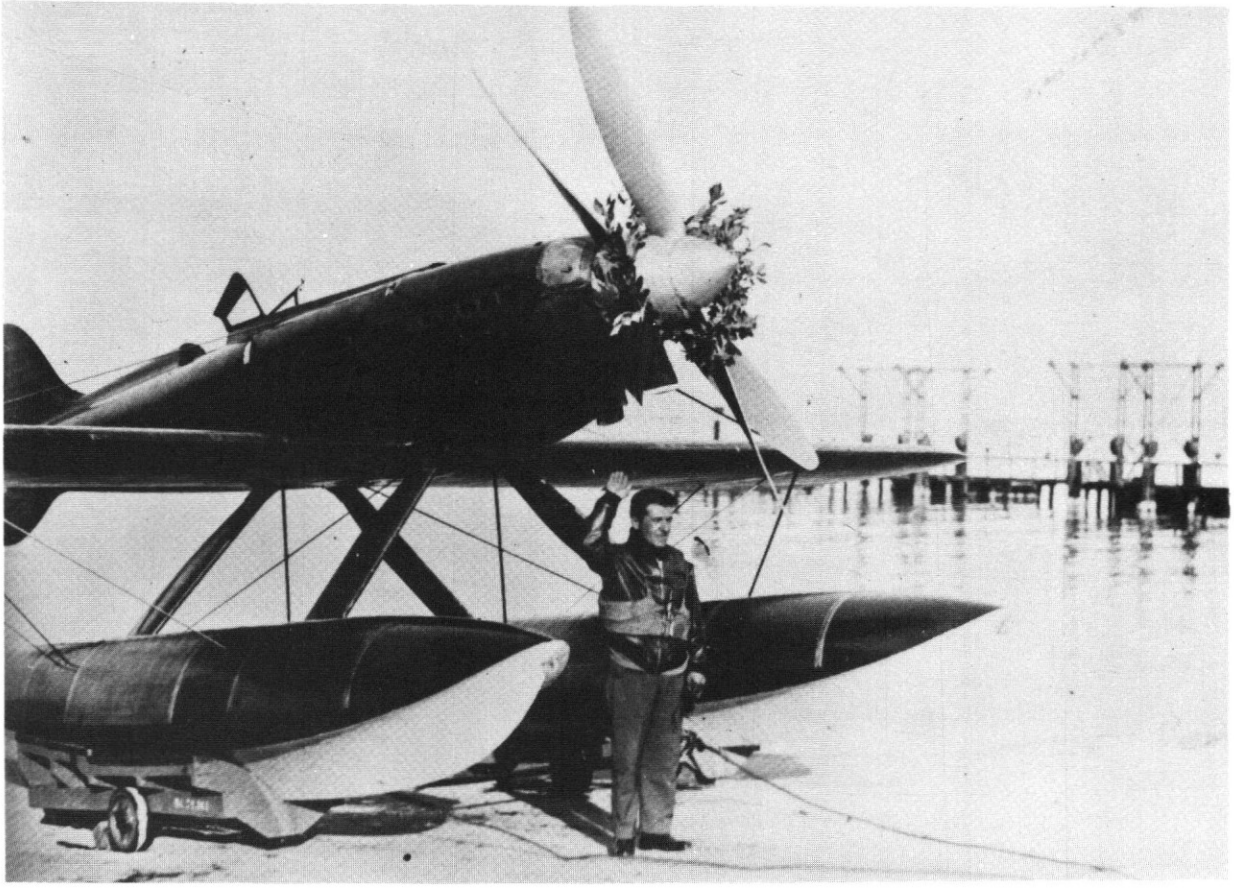


14 — Curtiss R2C-1 flown by Williams. 1923. Record aircraft.

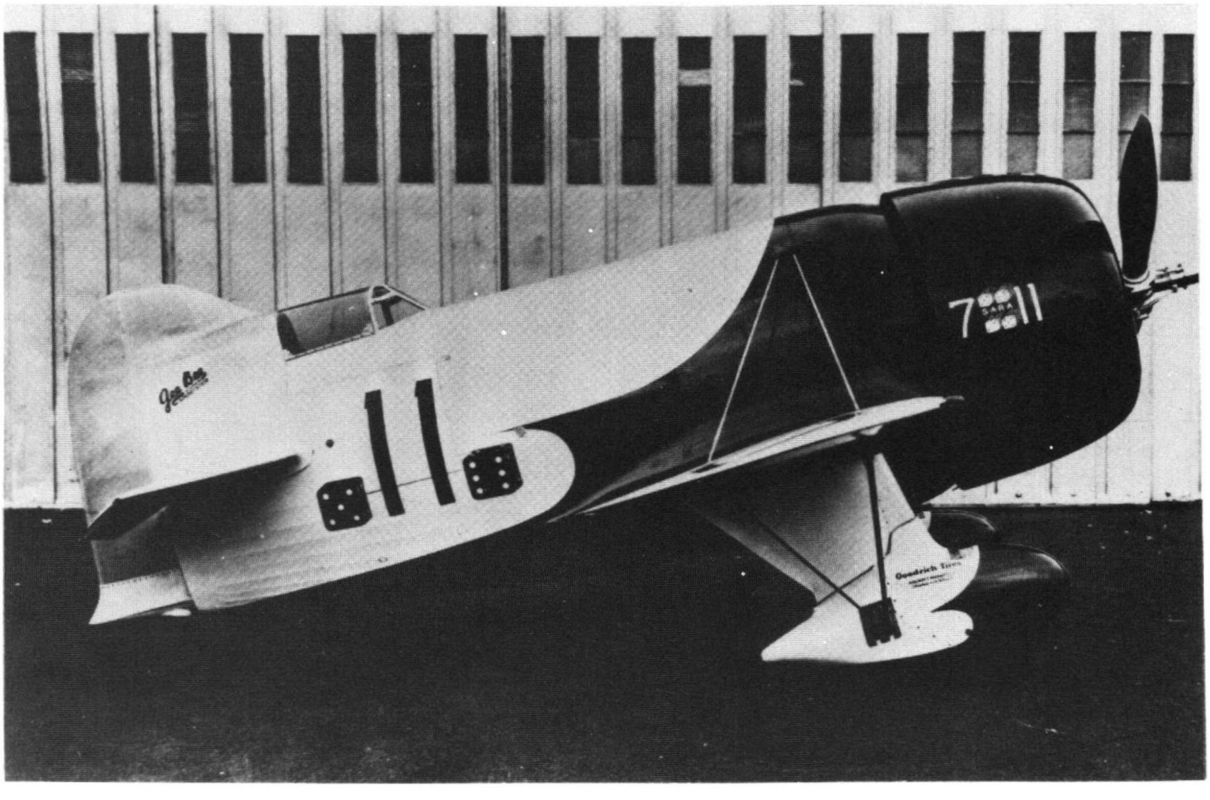


19 — Supermarine S.5.

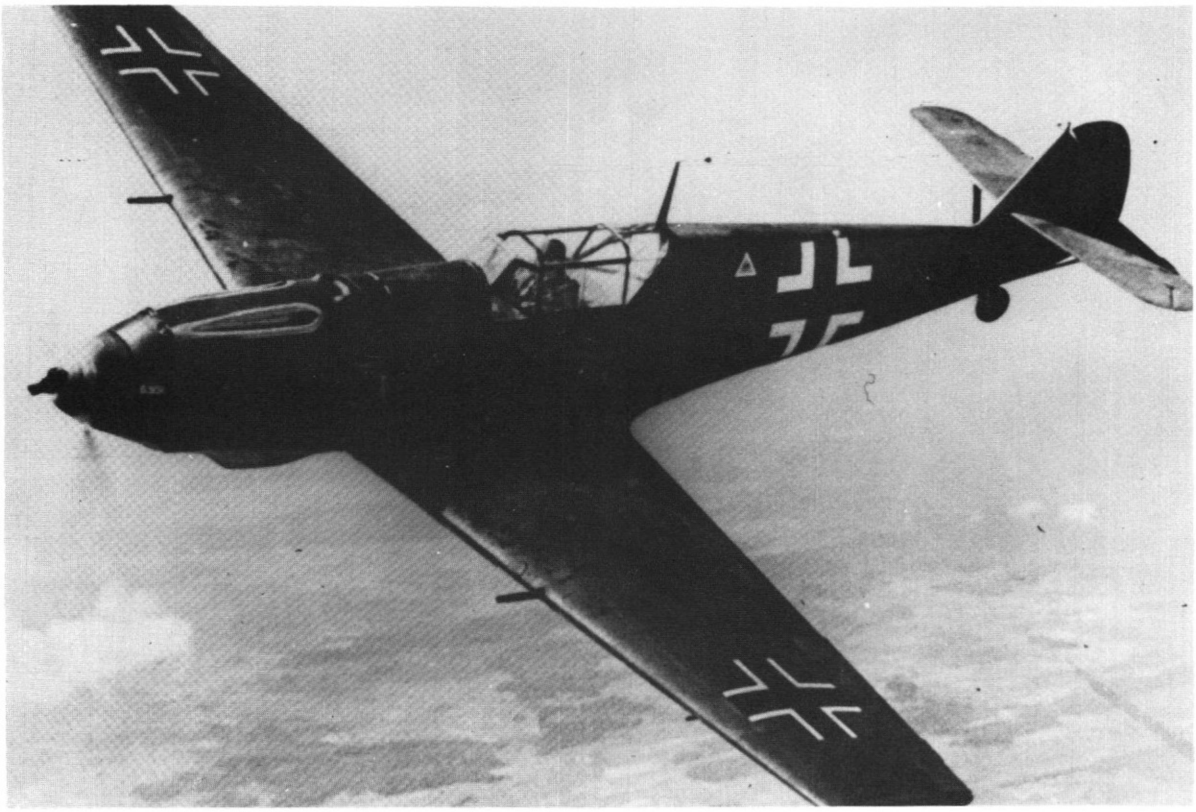
20 — Supermarine S.6.



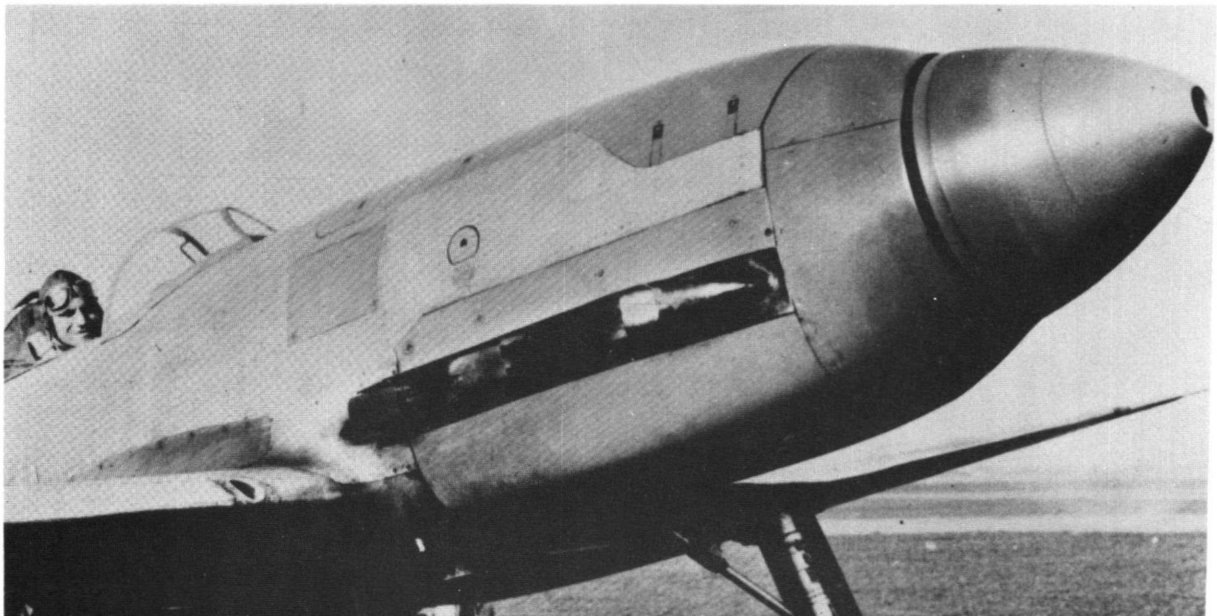
21 – Macchi M 72 flown by Francesco Agello. Record aircraft.



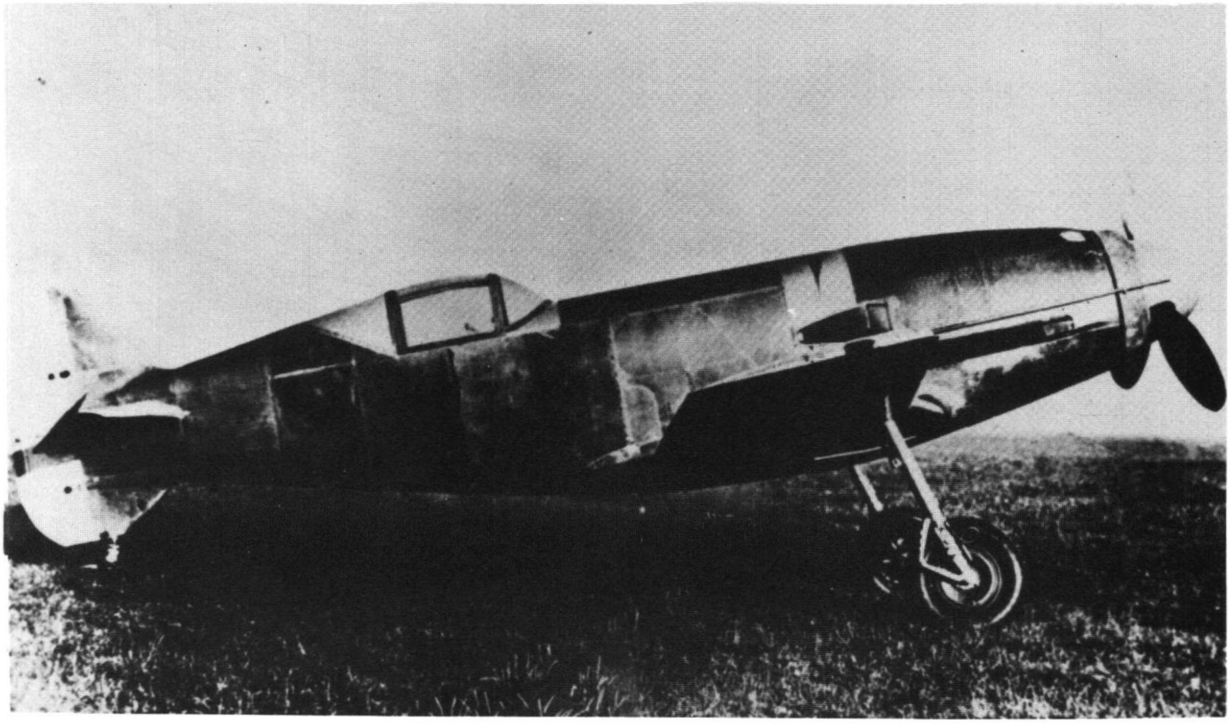
22 – Gee-Bee R1 flown by Doolittle. Record aircraft.



27 – *Messerschmitt Bf 109 E (similar to the 109 V-13 flown by Wurster).*

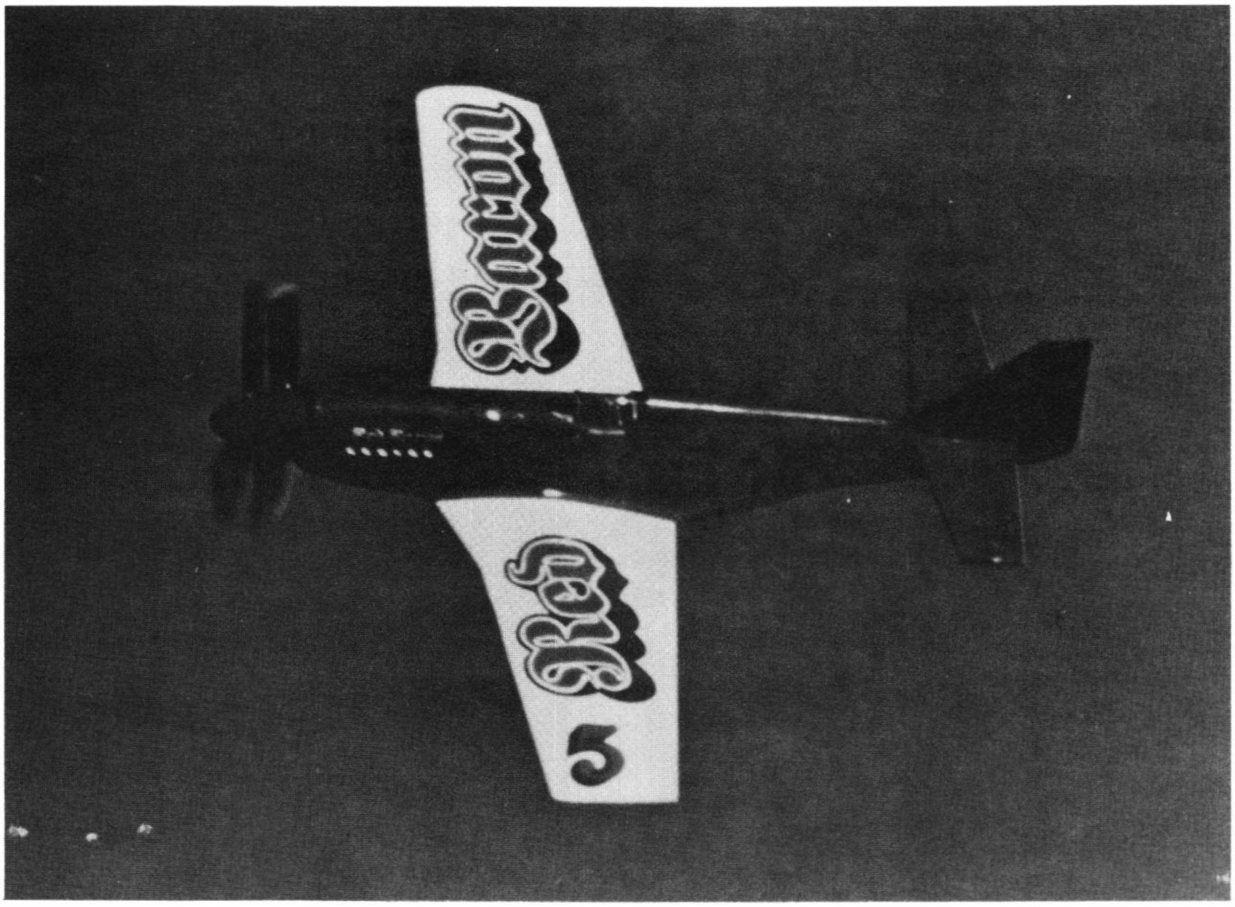


28 – *Heinkel 112-U flown by Dieterlé. Record aircraft.*

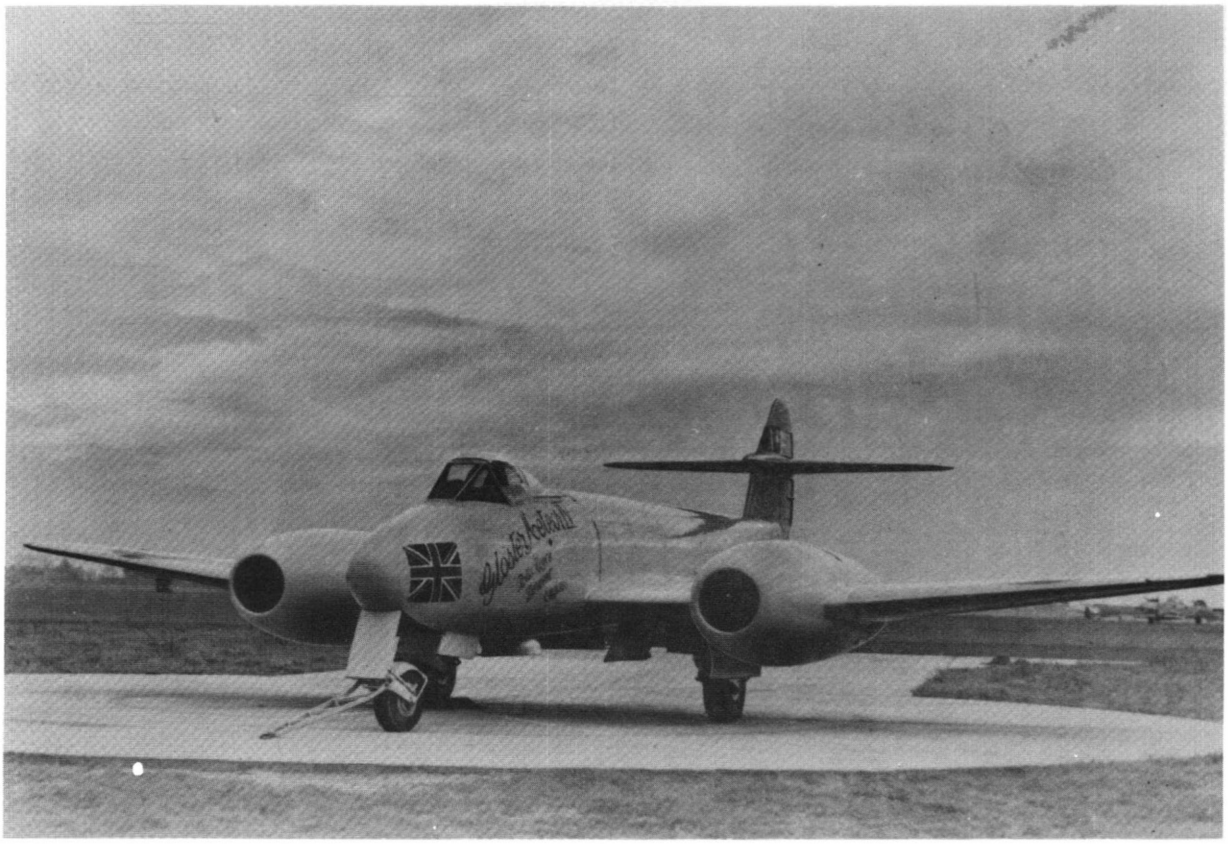


29 – Messerschmitt Bf 209. V1 flown by Wendel.

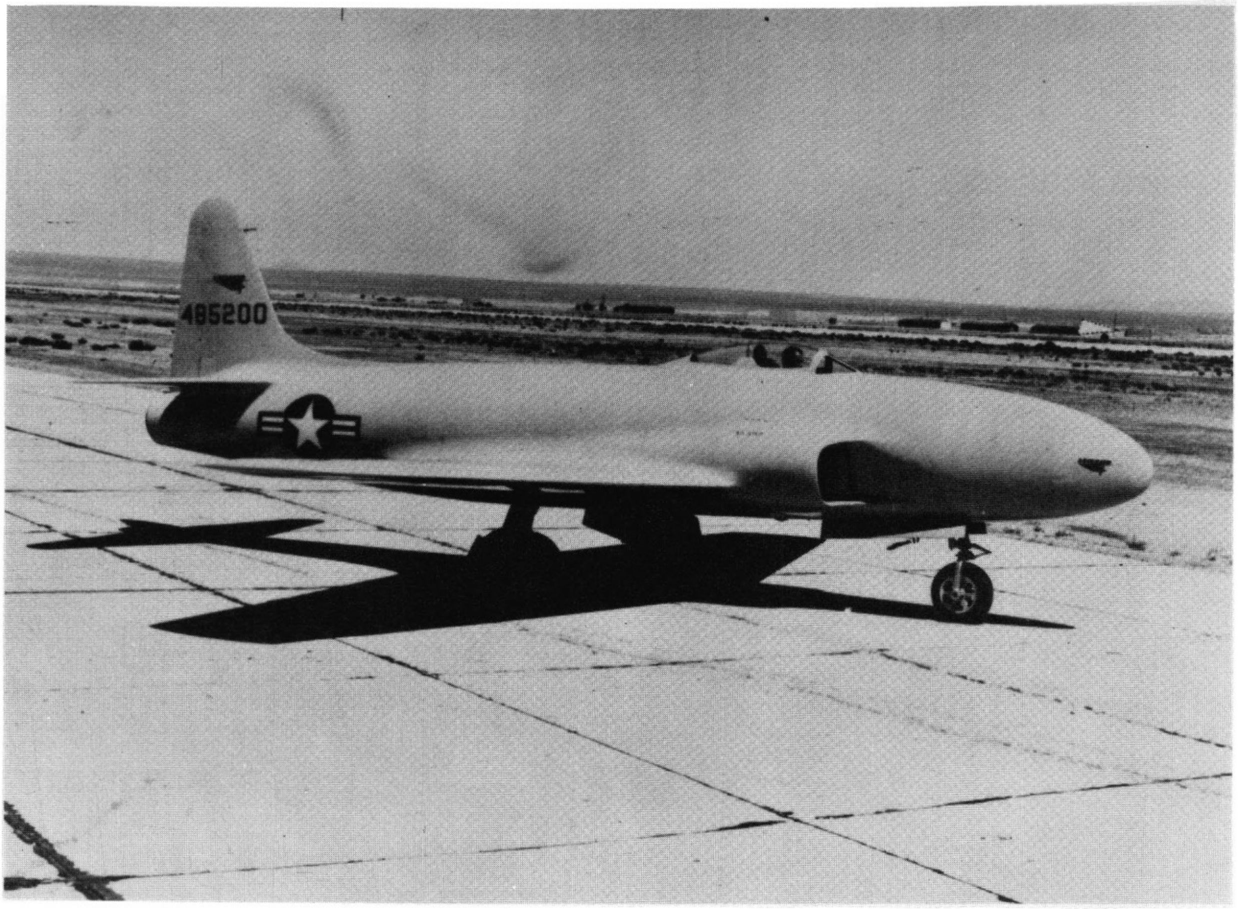
30 – Grumman F8-F. ''Bearcat'' . 1969. Record aircraft.



31 – P-51 "Mustang" flown by Steve Hinton. 1979. Record aircraft.

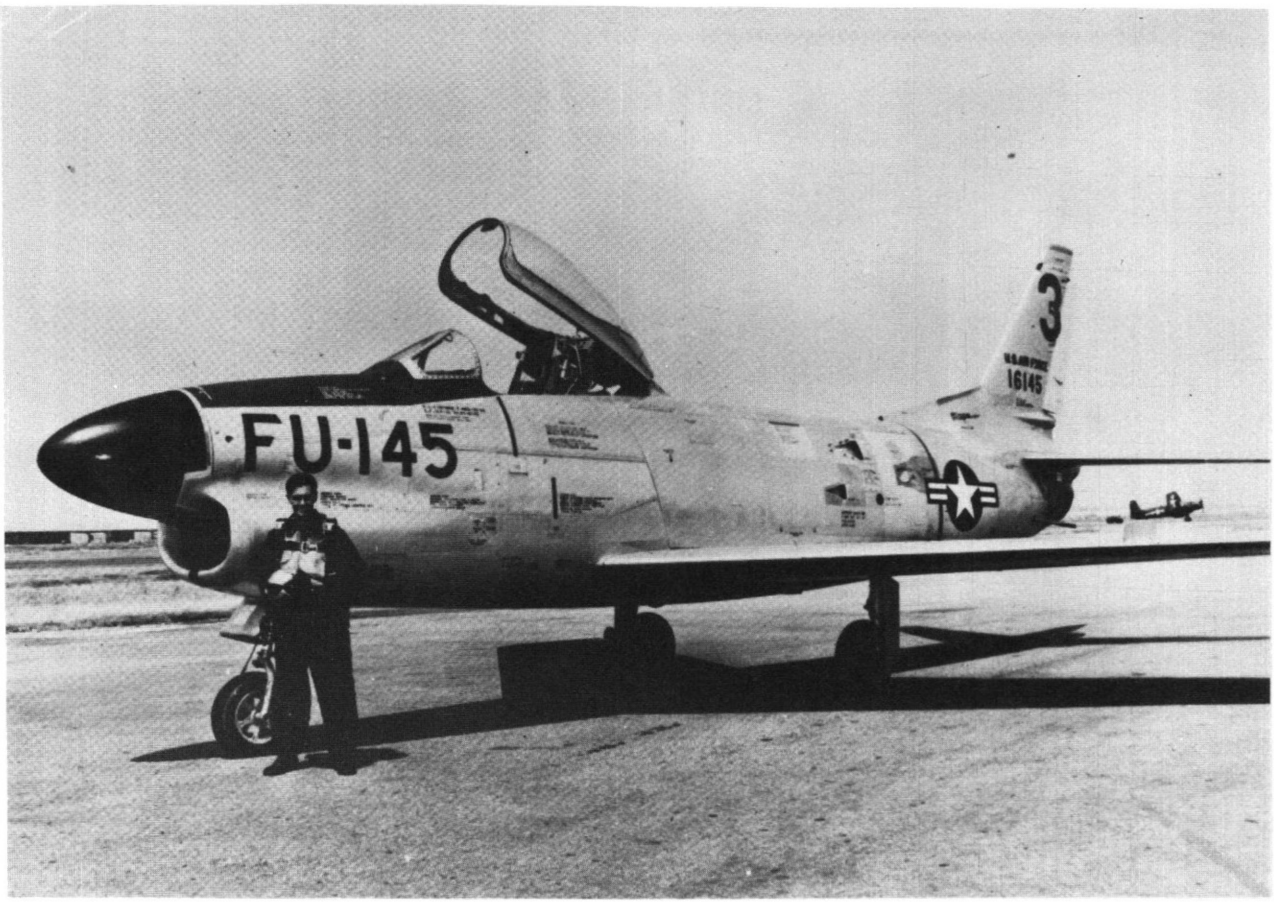


32 – Gloster "Meteor" IV.



33 – Lockheed P-80 R. Record aircraft.

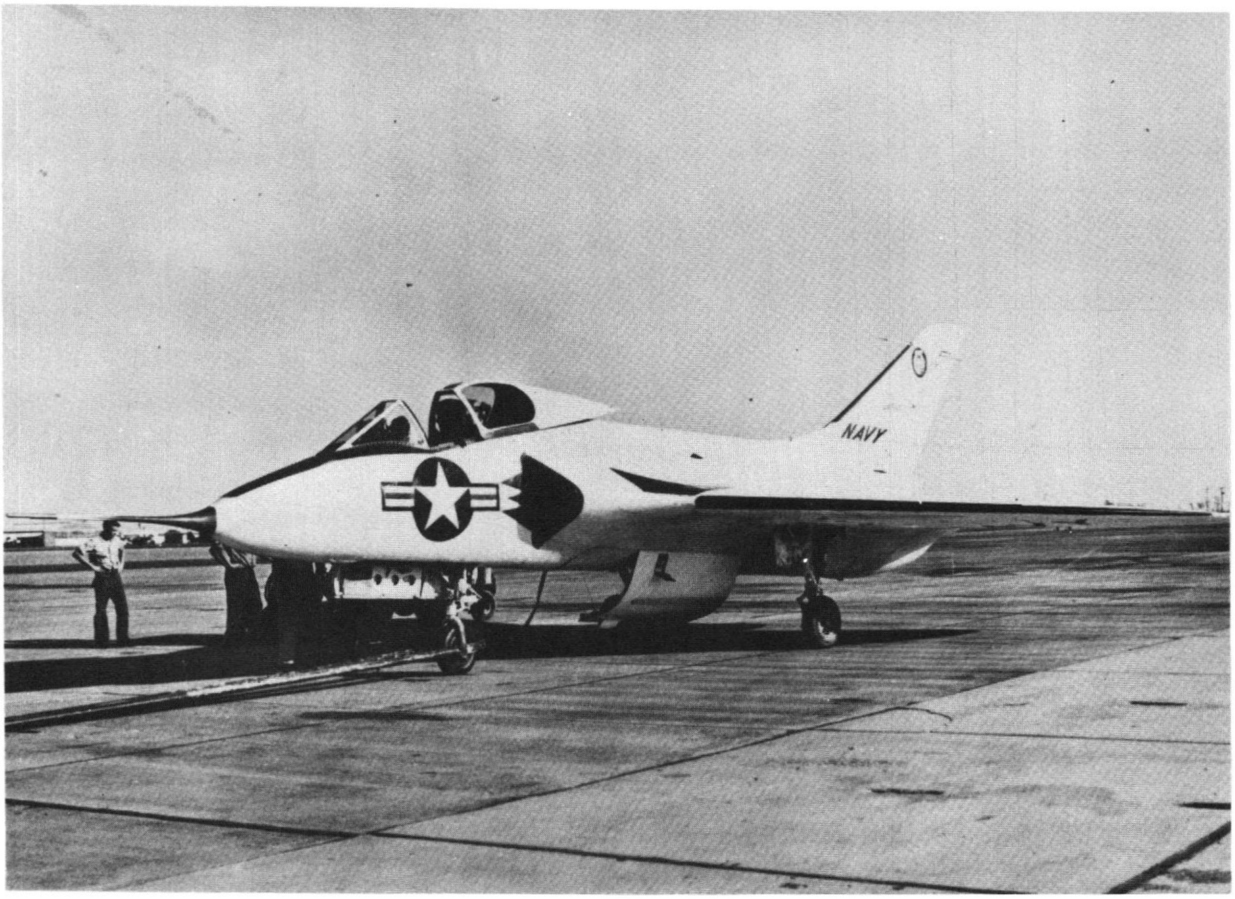
34 – Douglas 558 ''Skystreak''. Record aircraft.



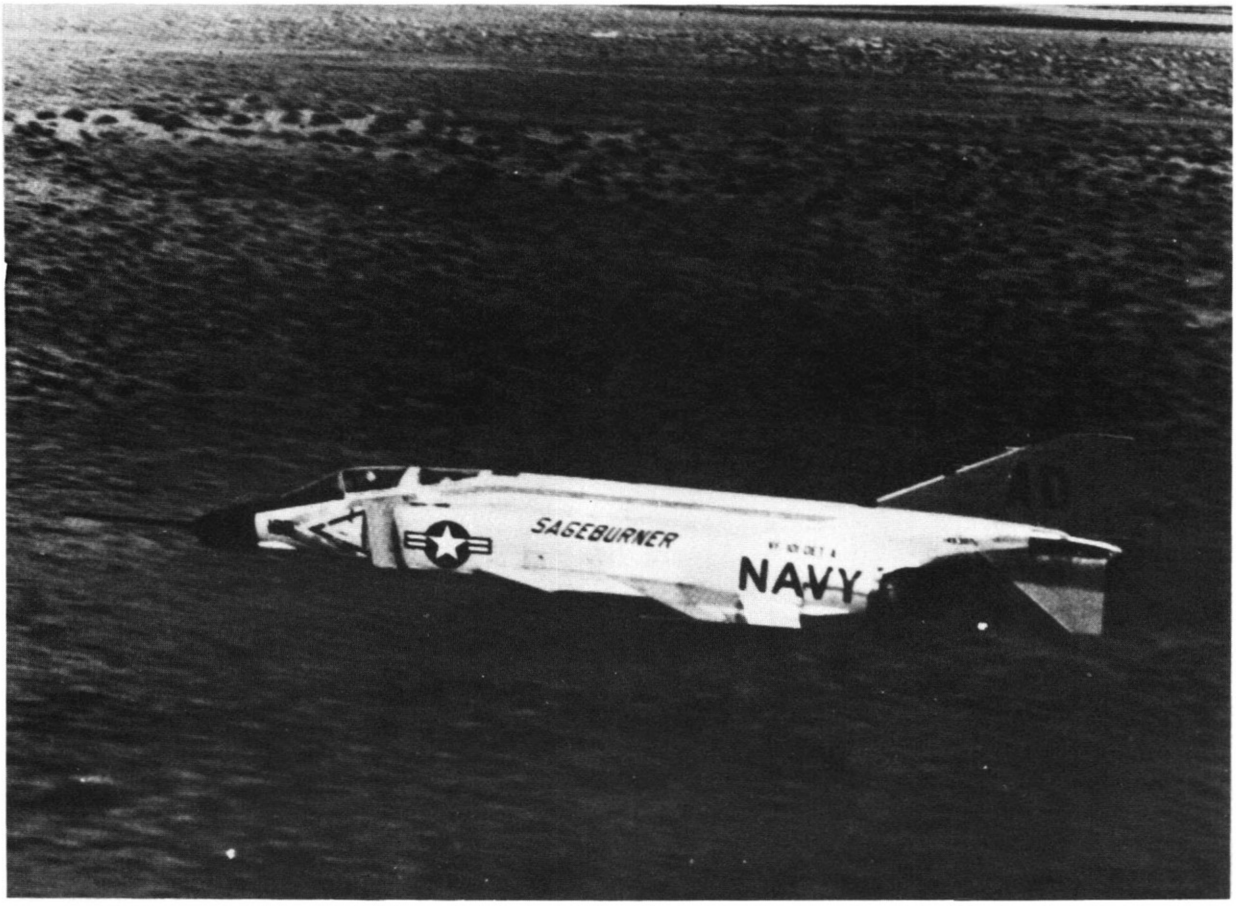
35 – F.86.D "Sabre" flown by Barns. Record aircraft.

36 – Hawker "Hunter".

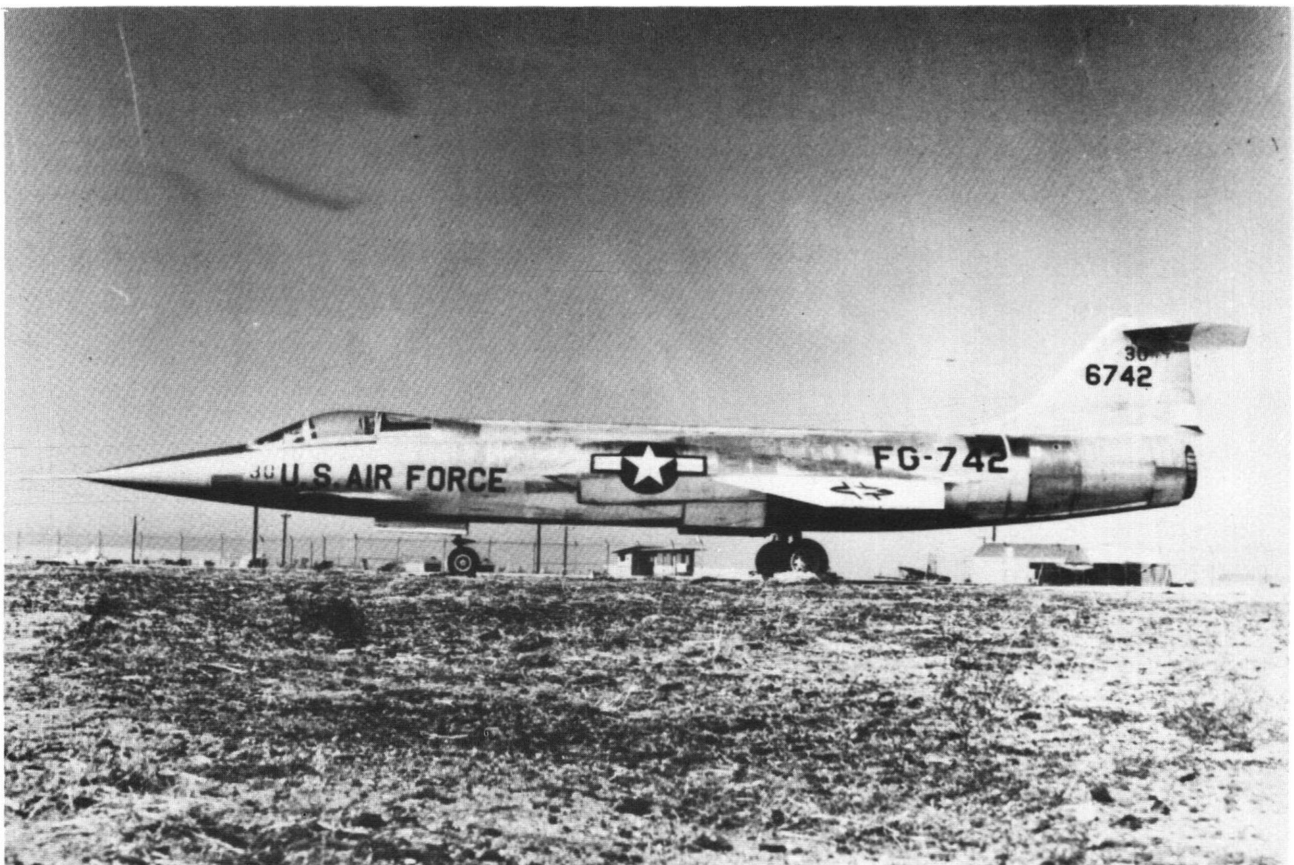
37 – Supermarine "Swift". Record aircraft.



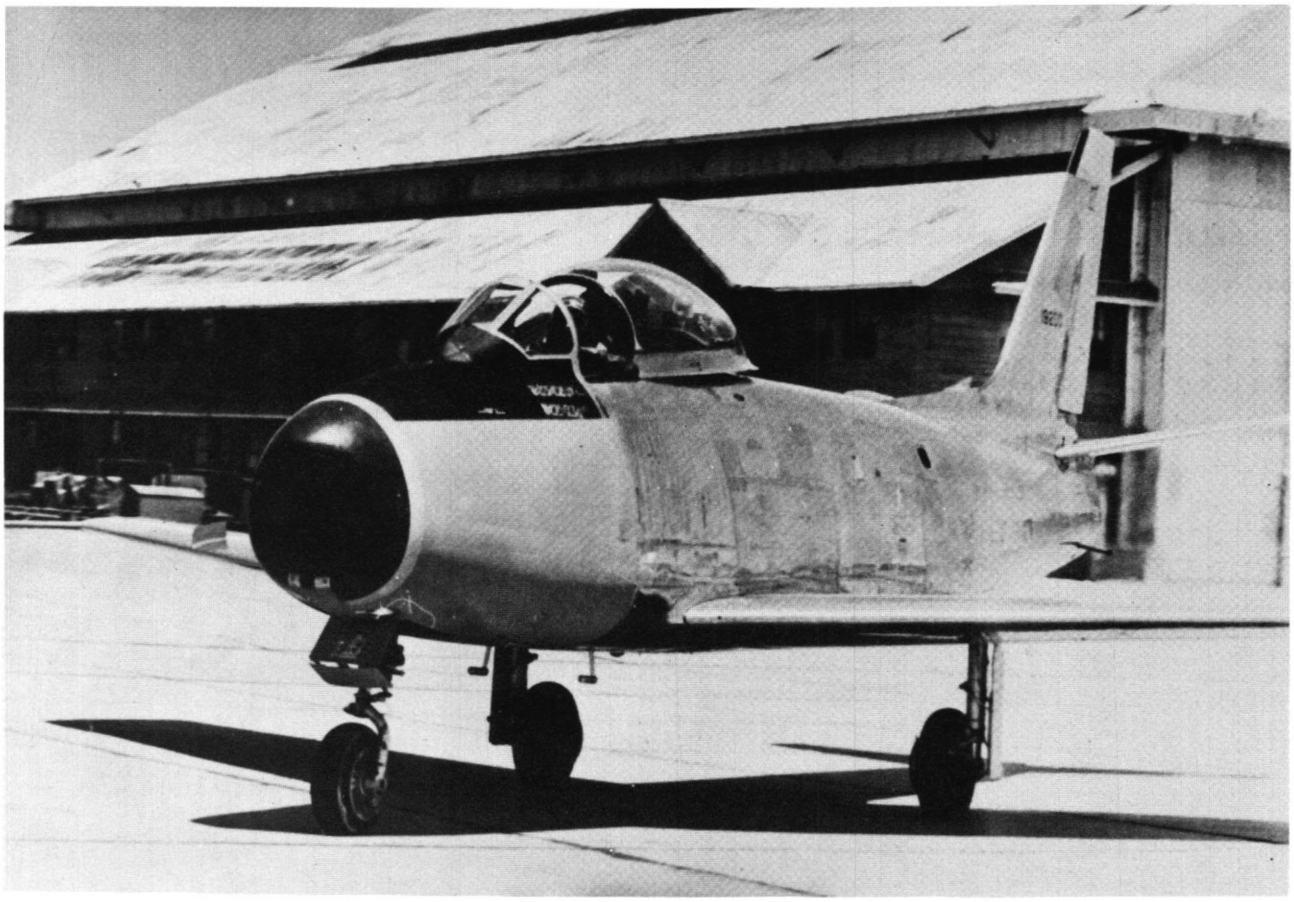
38 – Douglas XF-4D1. October 1953. Record aircraft.



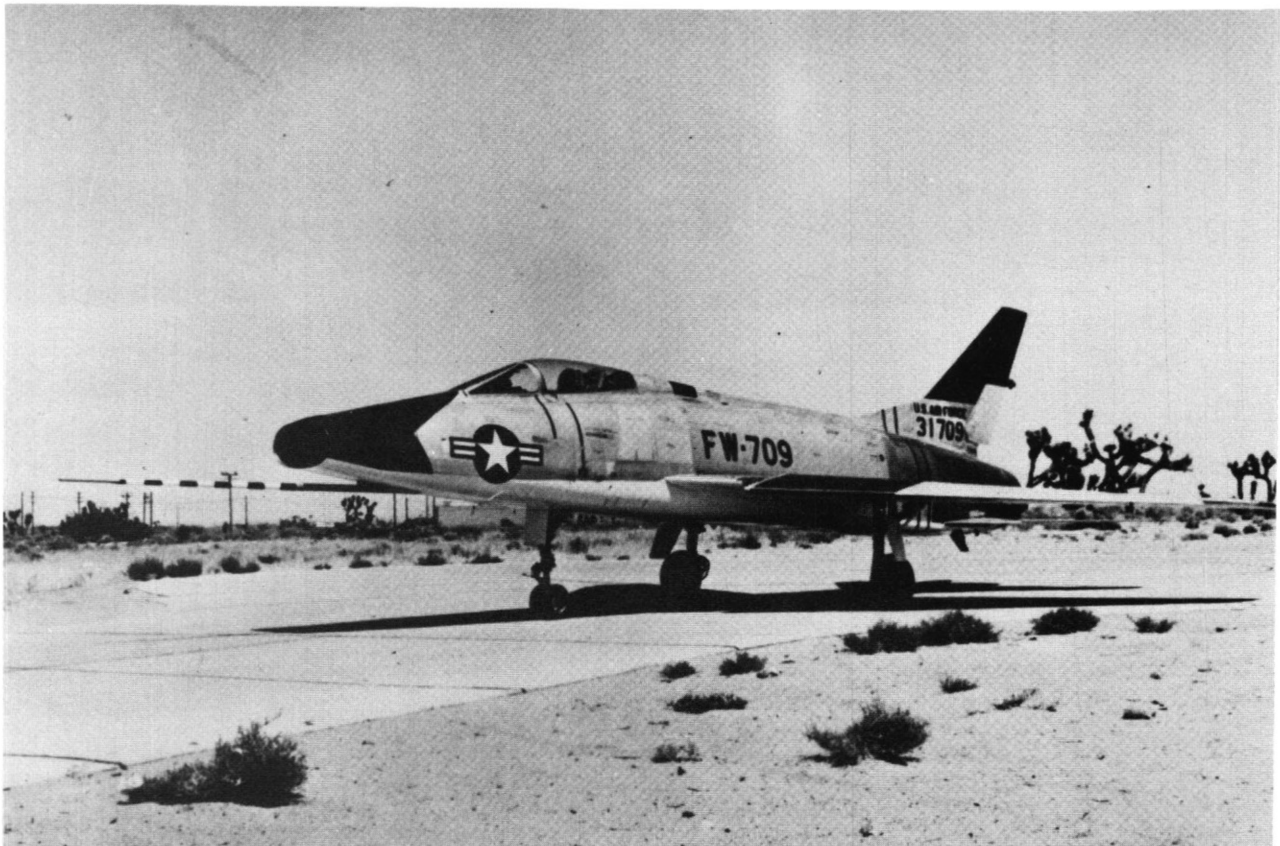
39 — Mc Donnell F-4H flown by Lt. Huntington Hardisty. Record aircraft.



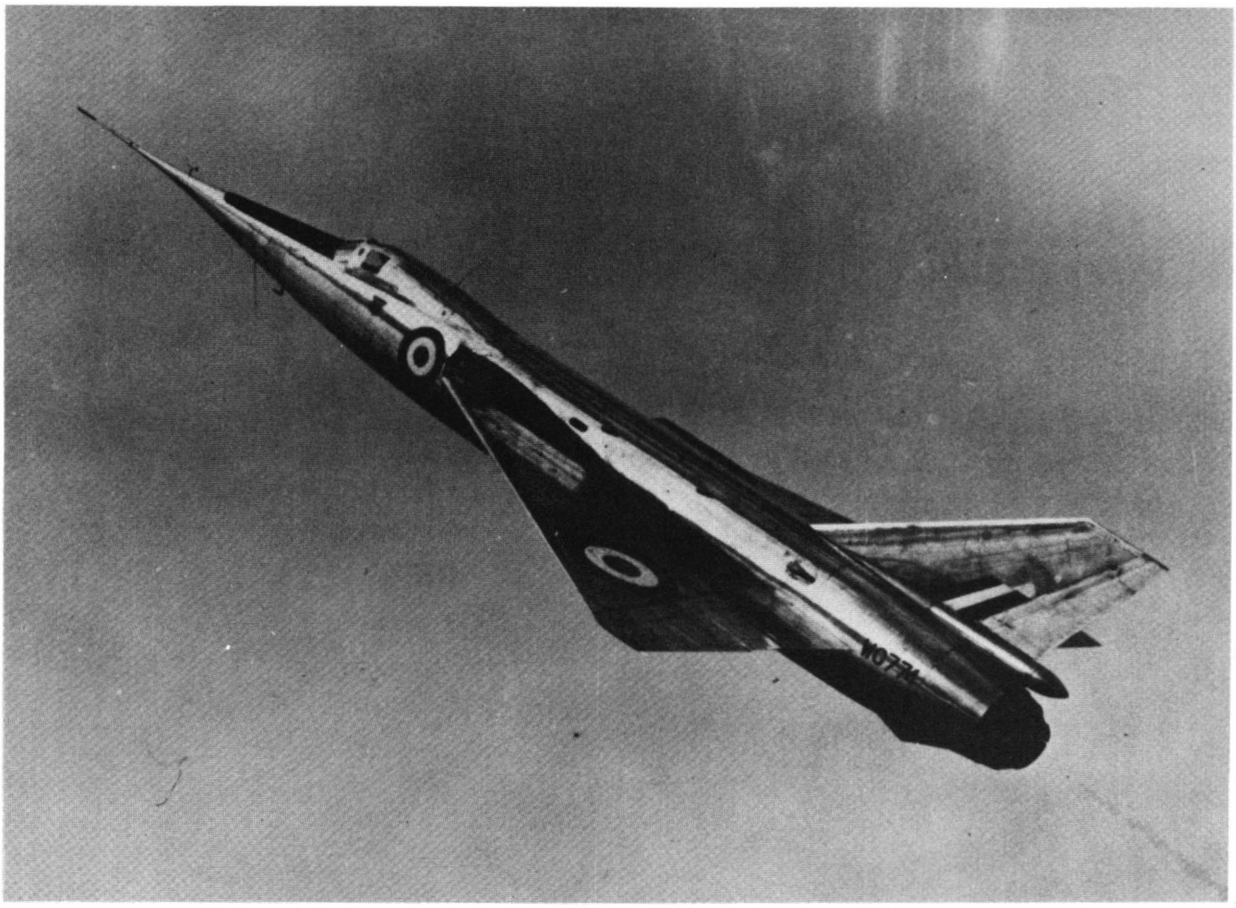
40 — Lockheed F-104 A.



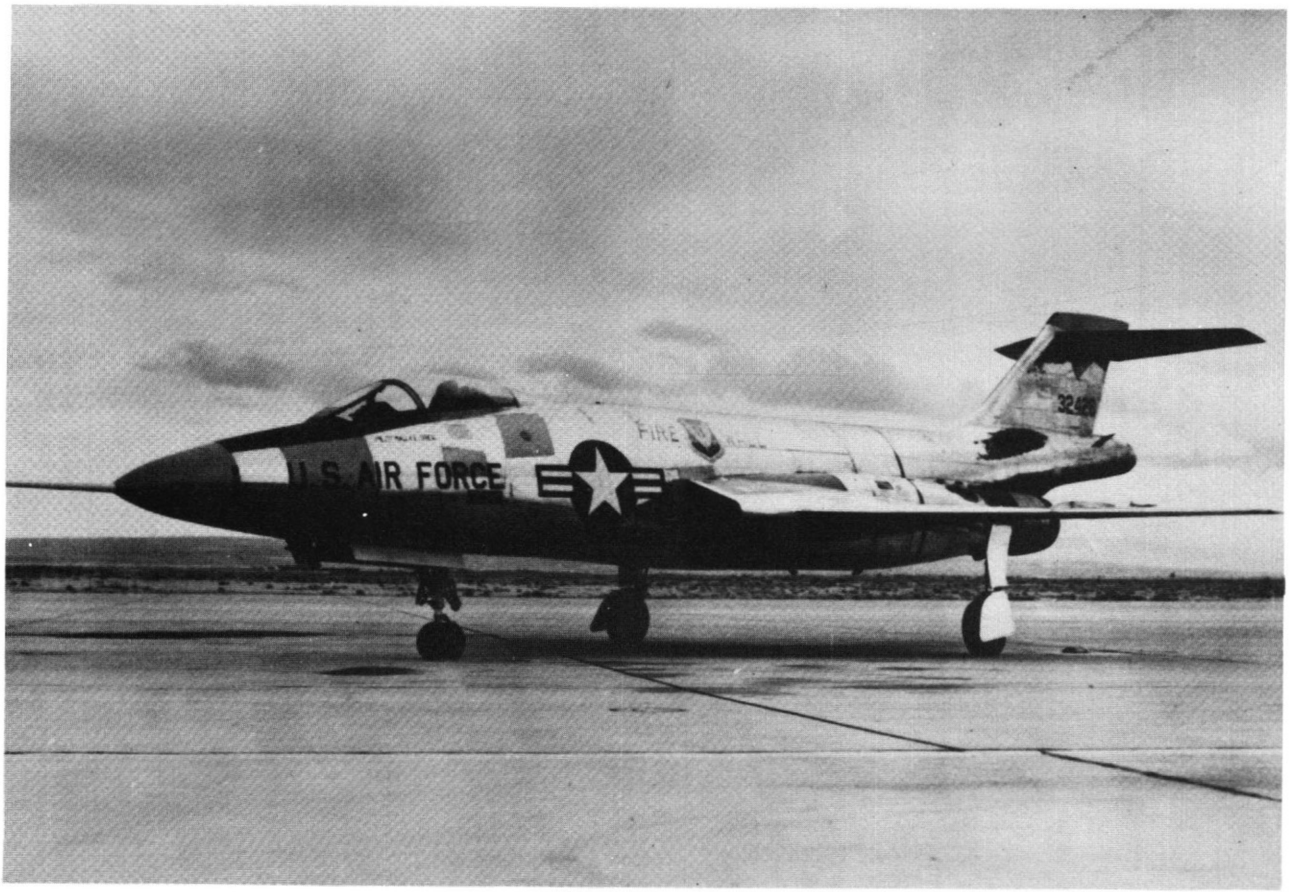
41 – Canadair F-86 "Sabre" flown by Jacqueline Cochrane. Record aircraft.



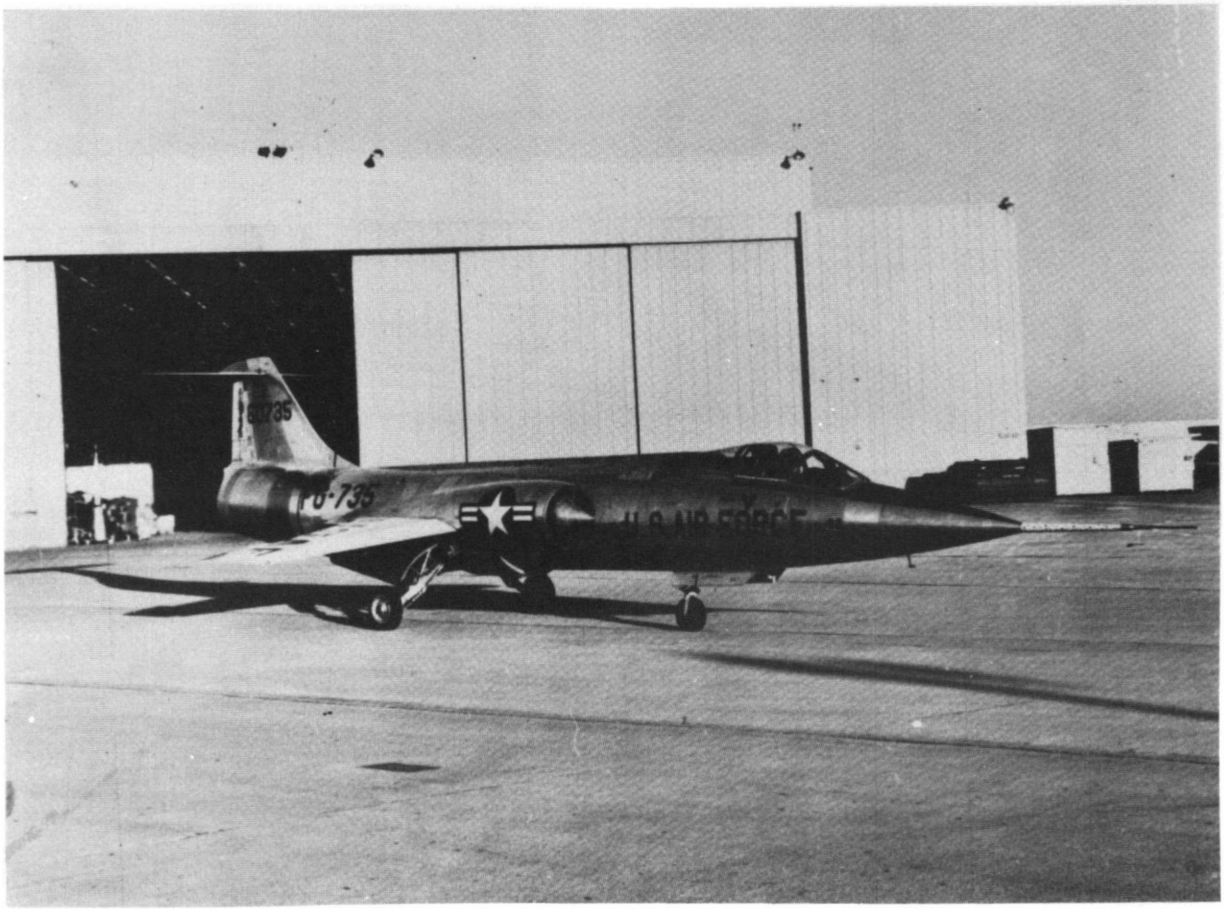
42 – North-American YF-100 flown by Col. Everest. Record aircraft.



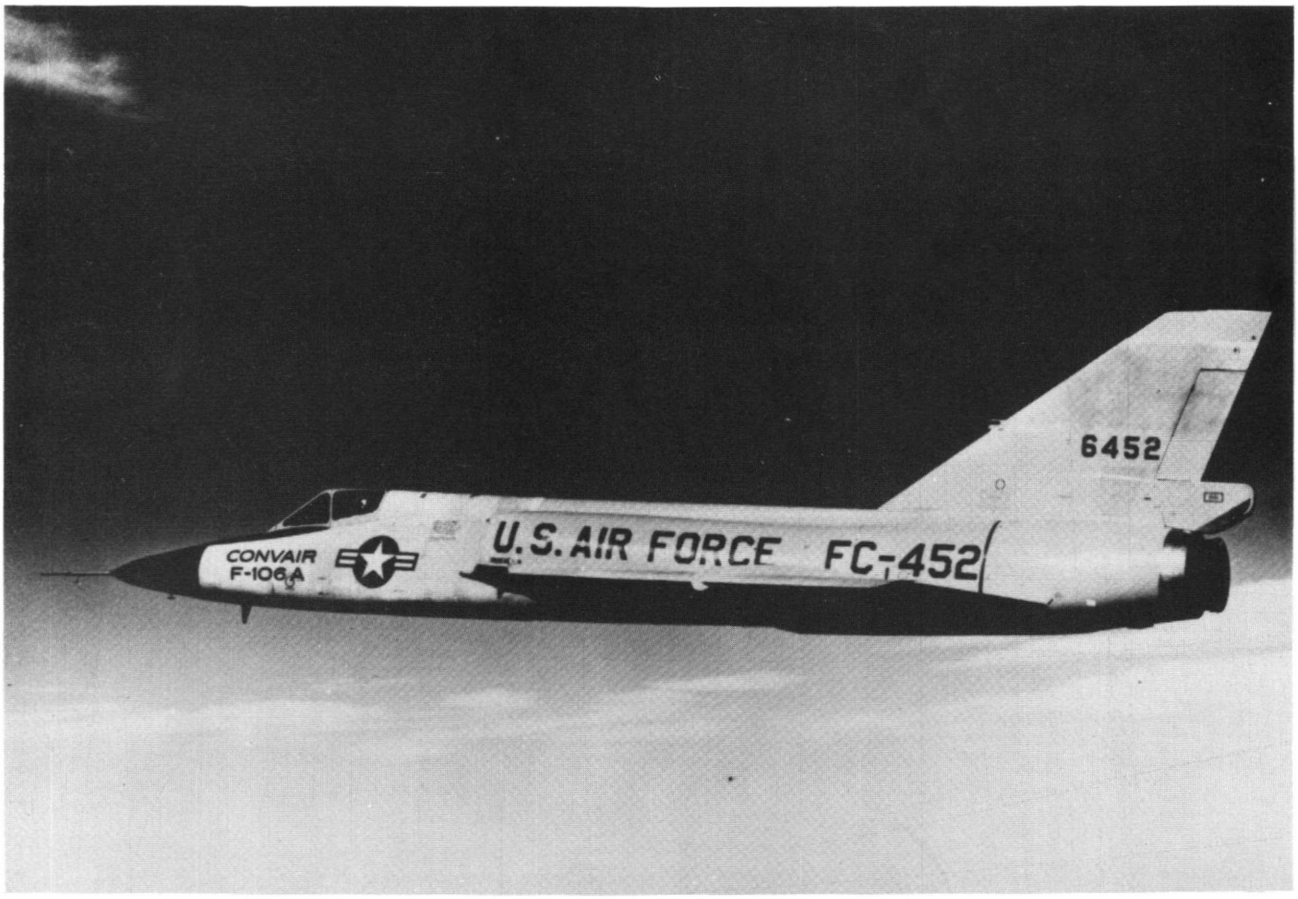
43 – *Fairey "Delta" 2.*



44 – *Mc Donnell F-101 A flown by Maj. Drew. Record aircraft.*

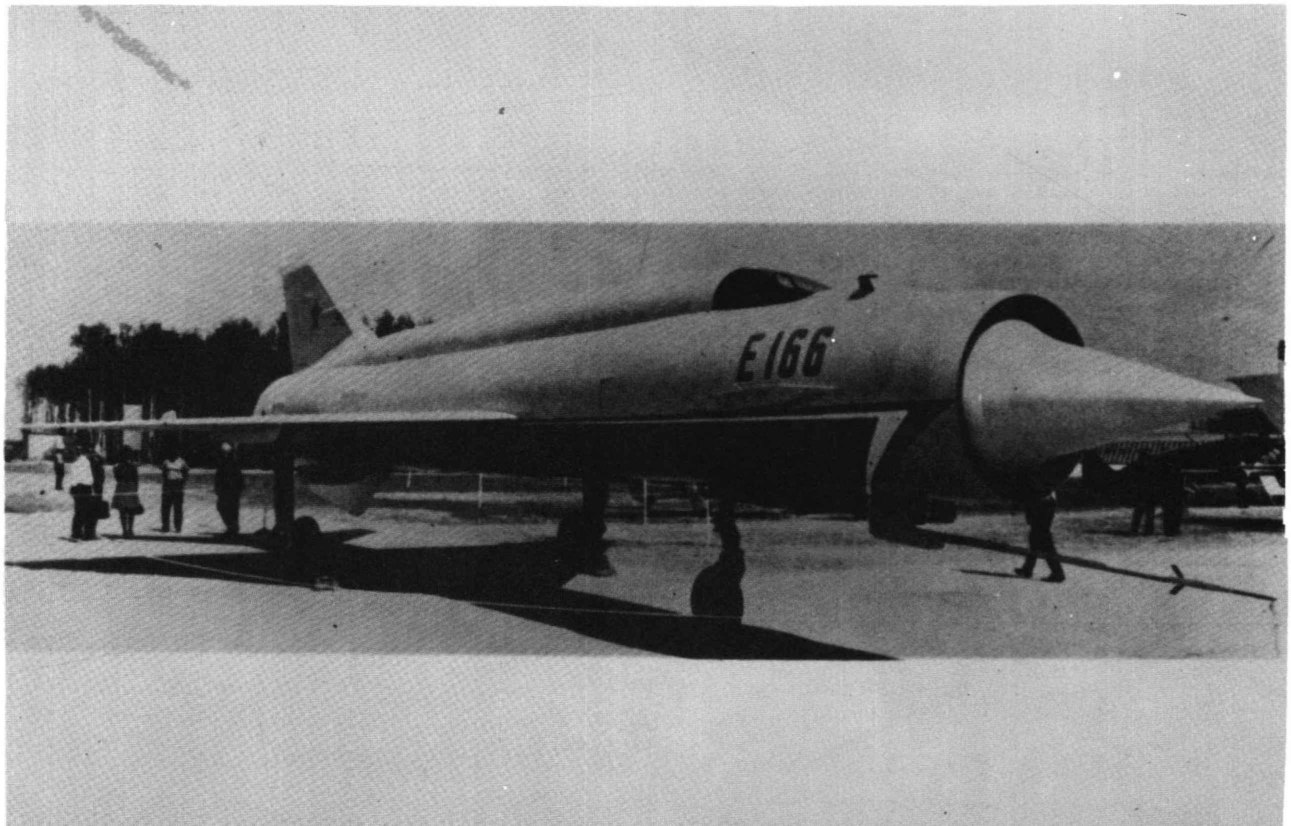


45 – Lockheed F-104 A flown by Irwin. Record aircraft.

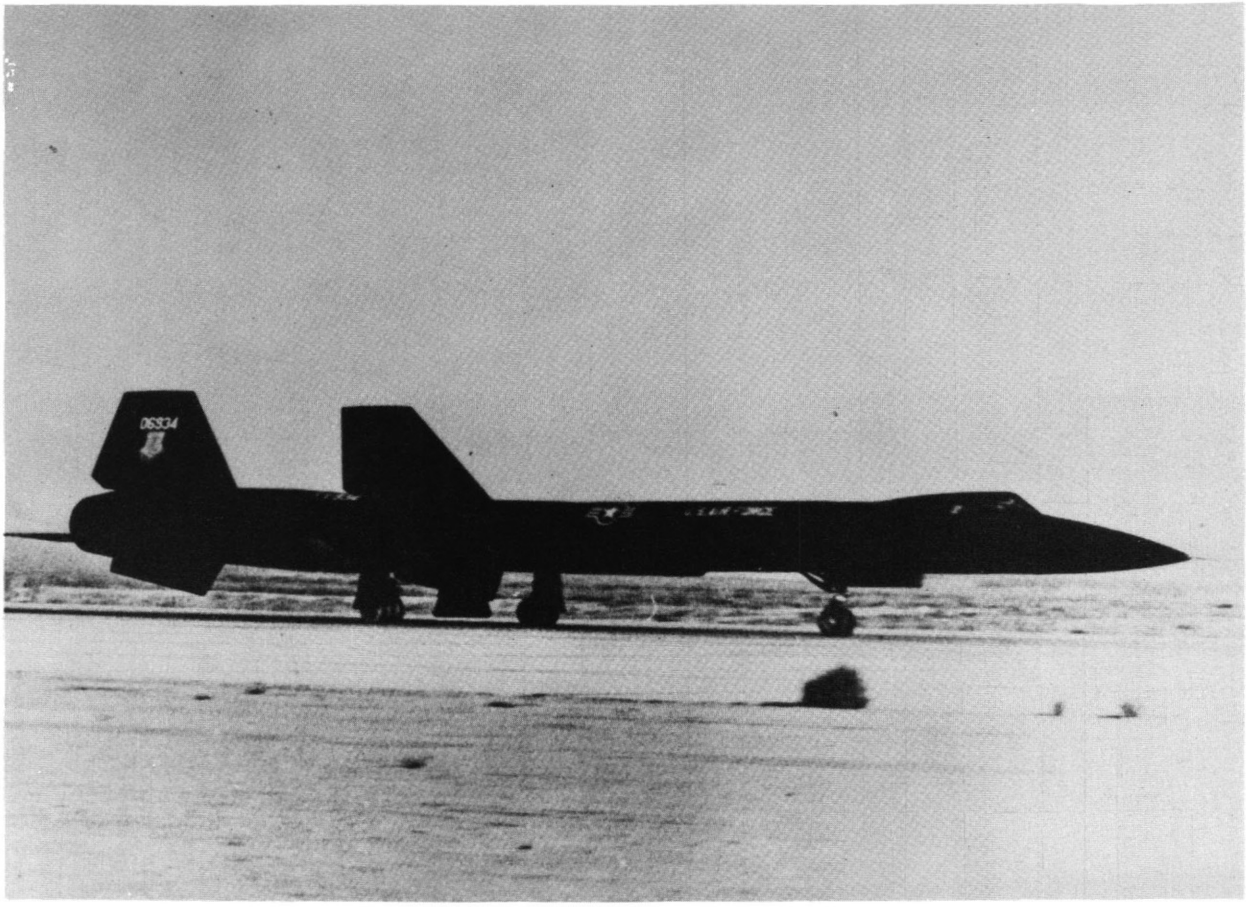


46 – Convair F-106 A.

47 – Mc Donnell F4H flown by Lt. Col. Robinson. Record aircraft.

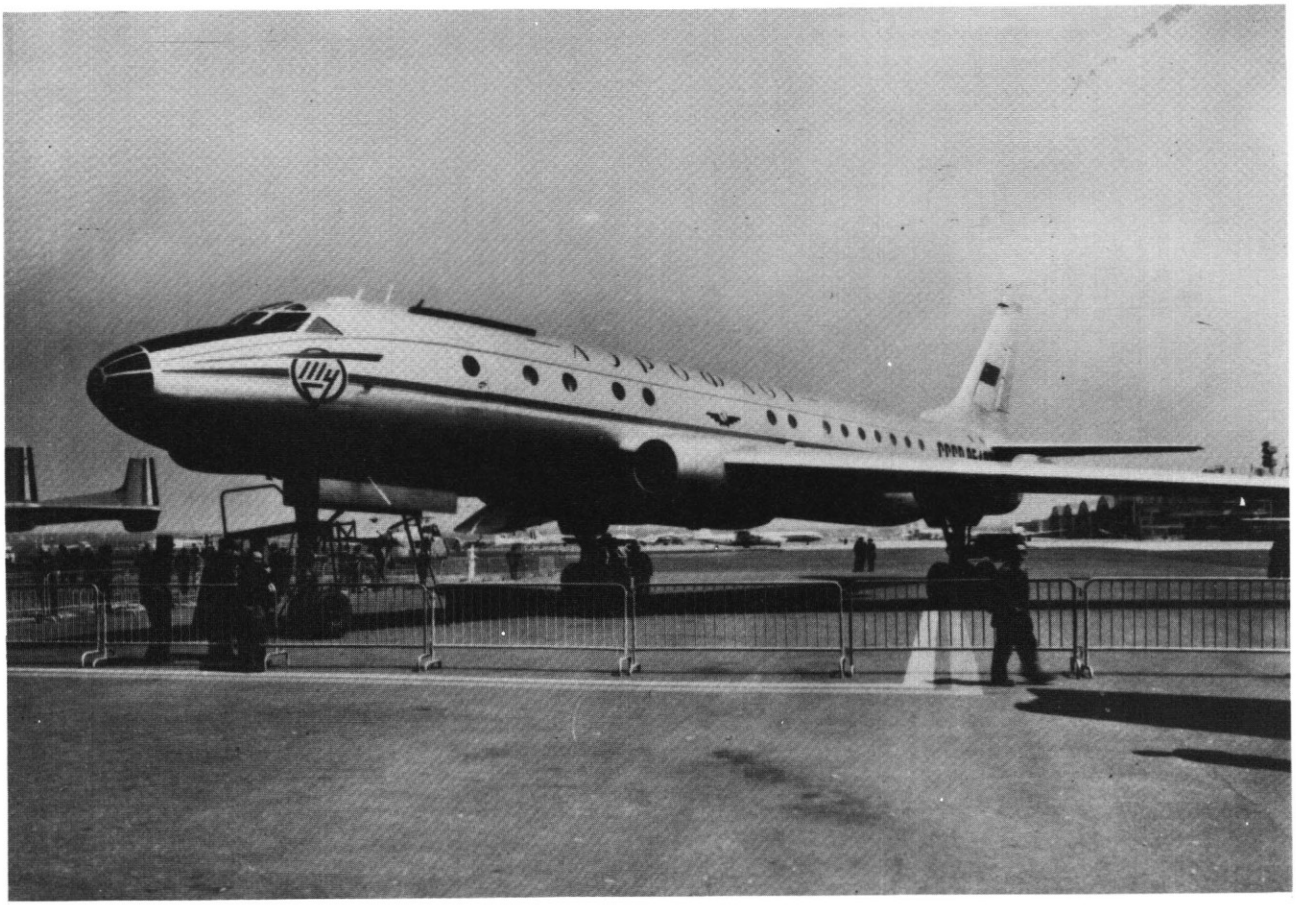


48 – E.166. MIG.

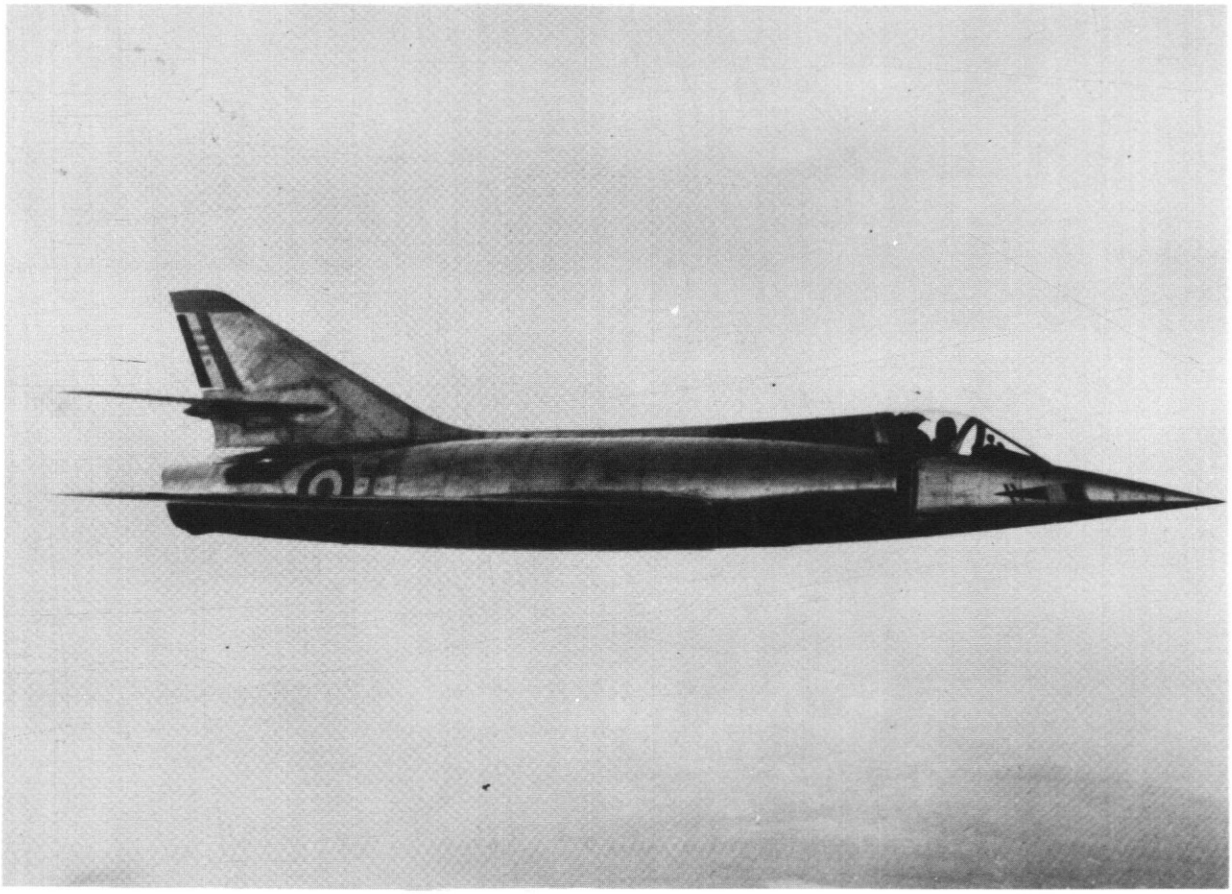


49 – *Lockheed YF-12 A.*

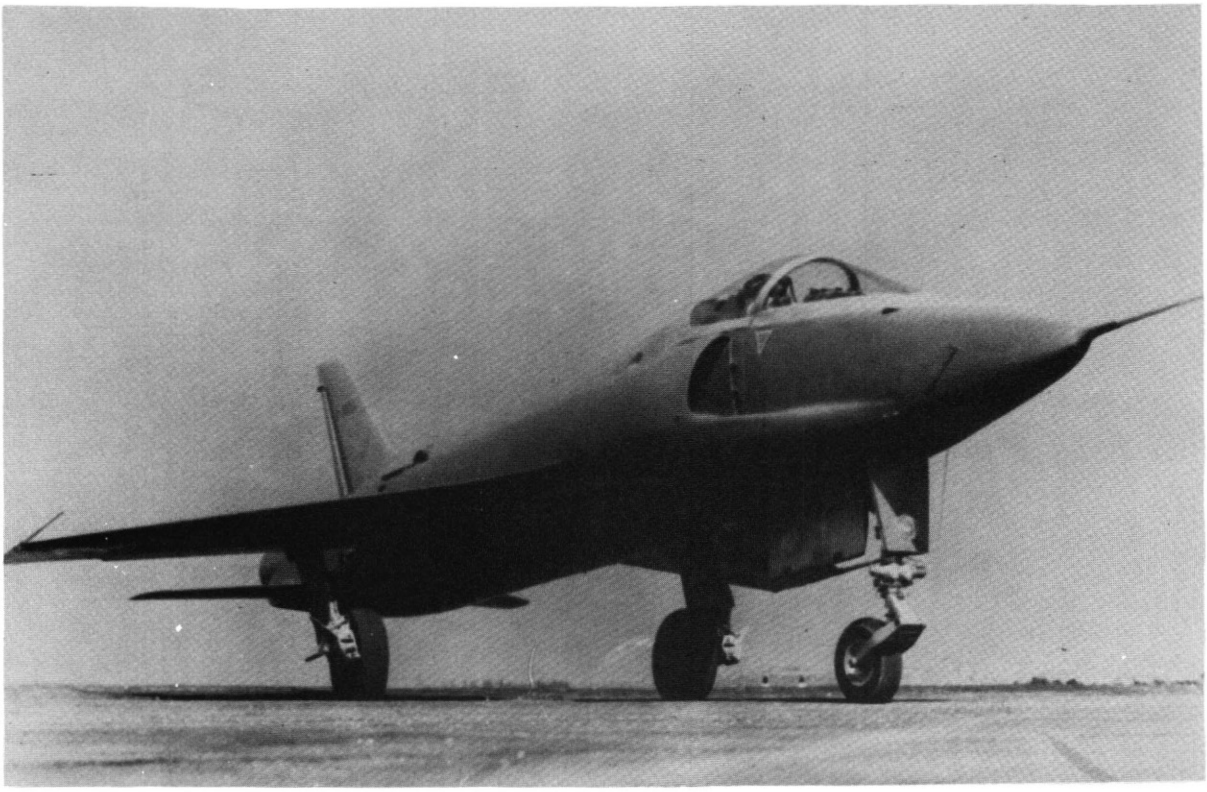
50 – *SAAB. J.29 "Tunnan".*



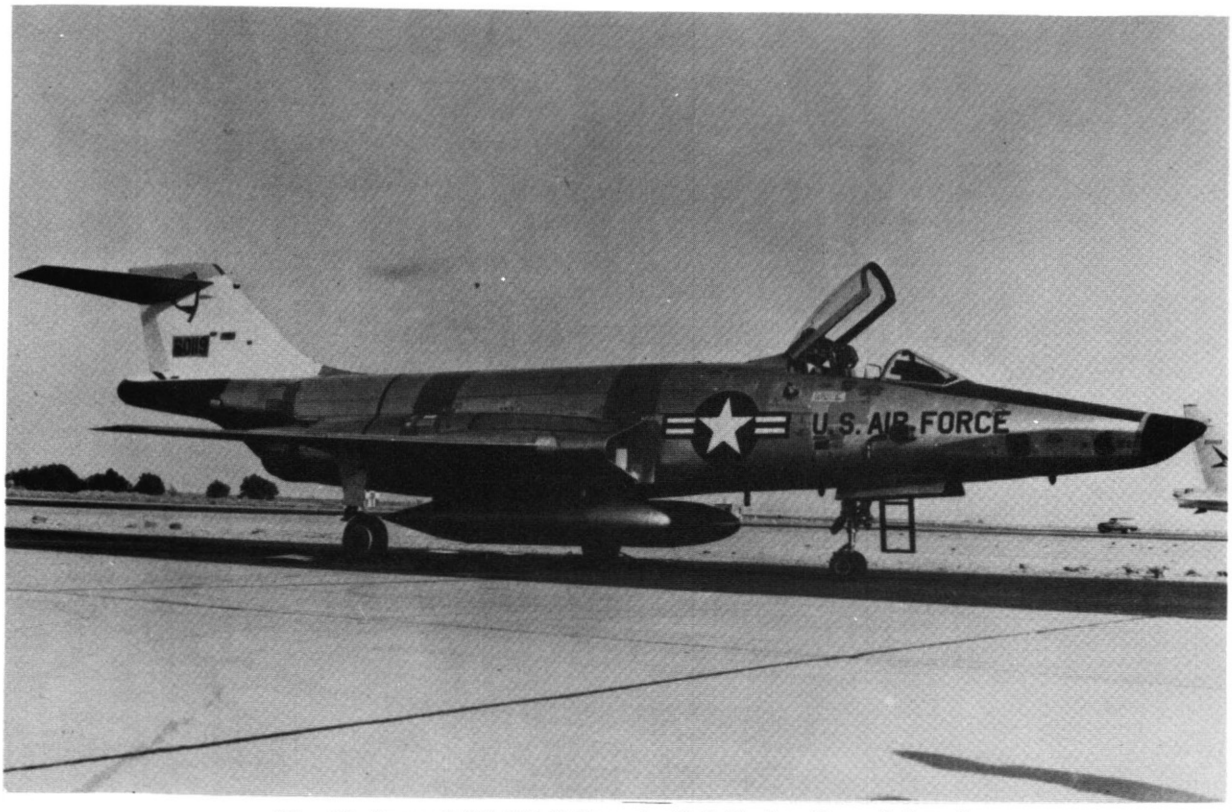
51 – Tupolev 104 A.



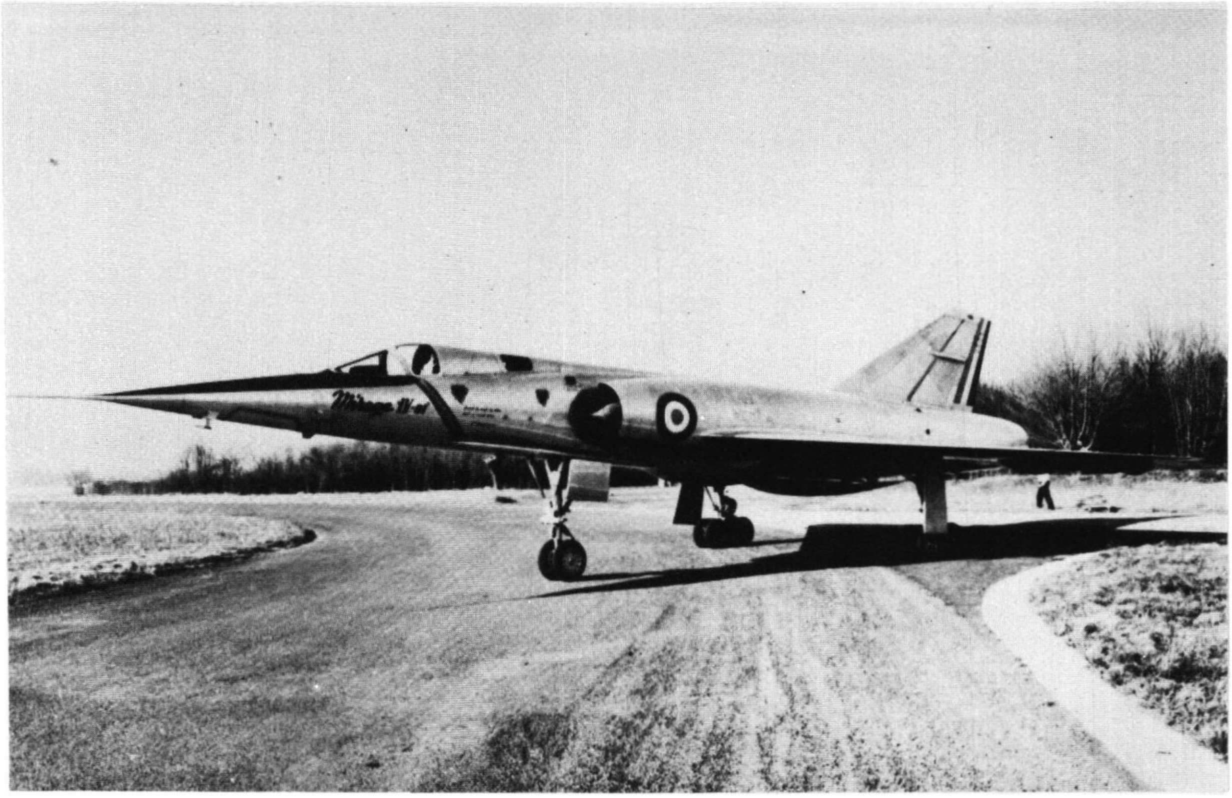
52 – Dassault "Etendard" IV (prototype).



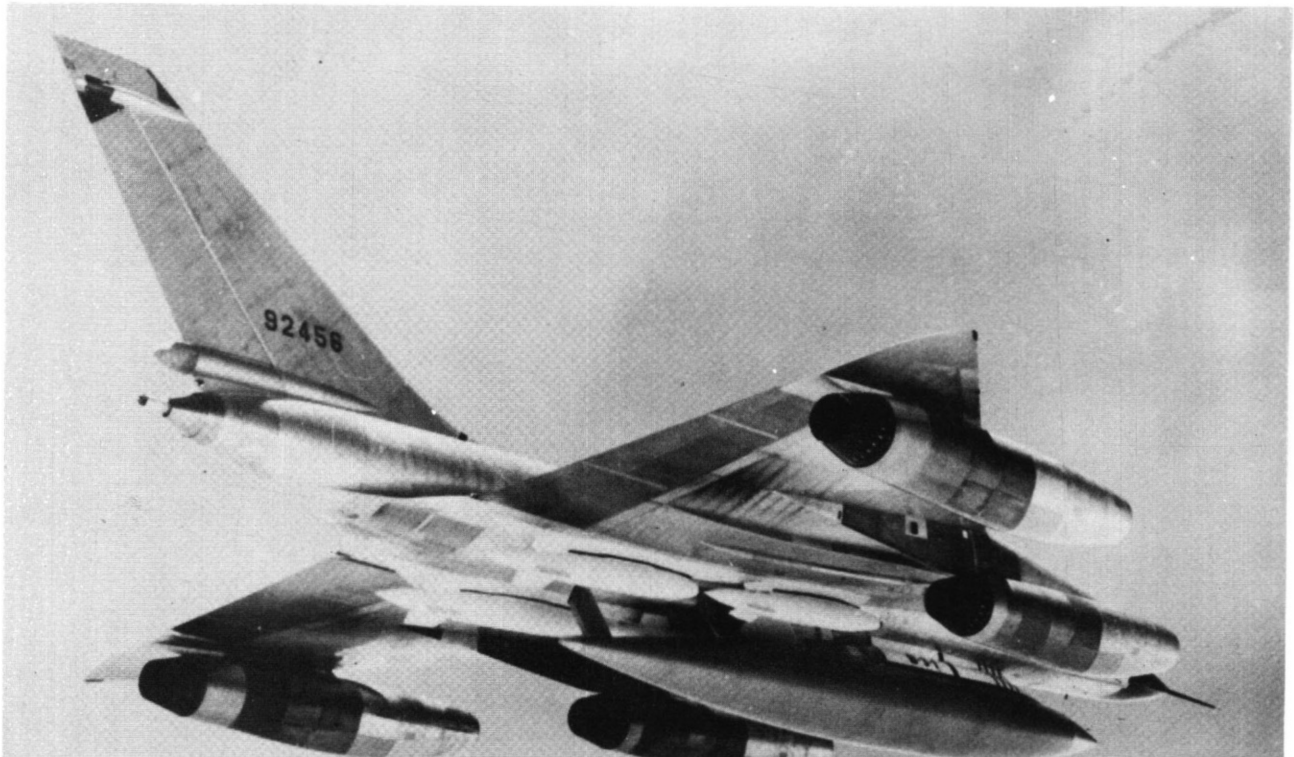
53 – Breguet 101 "Taon".



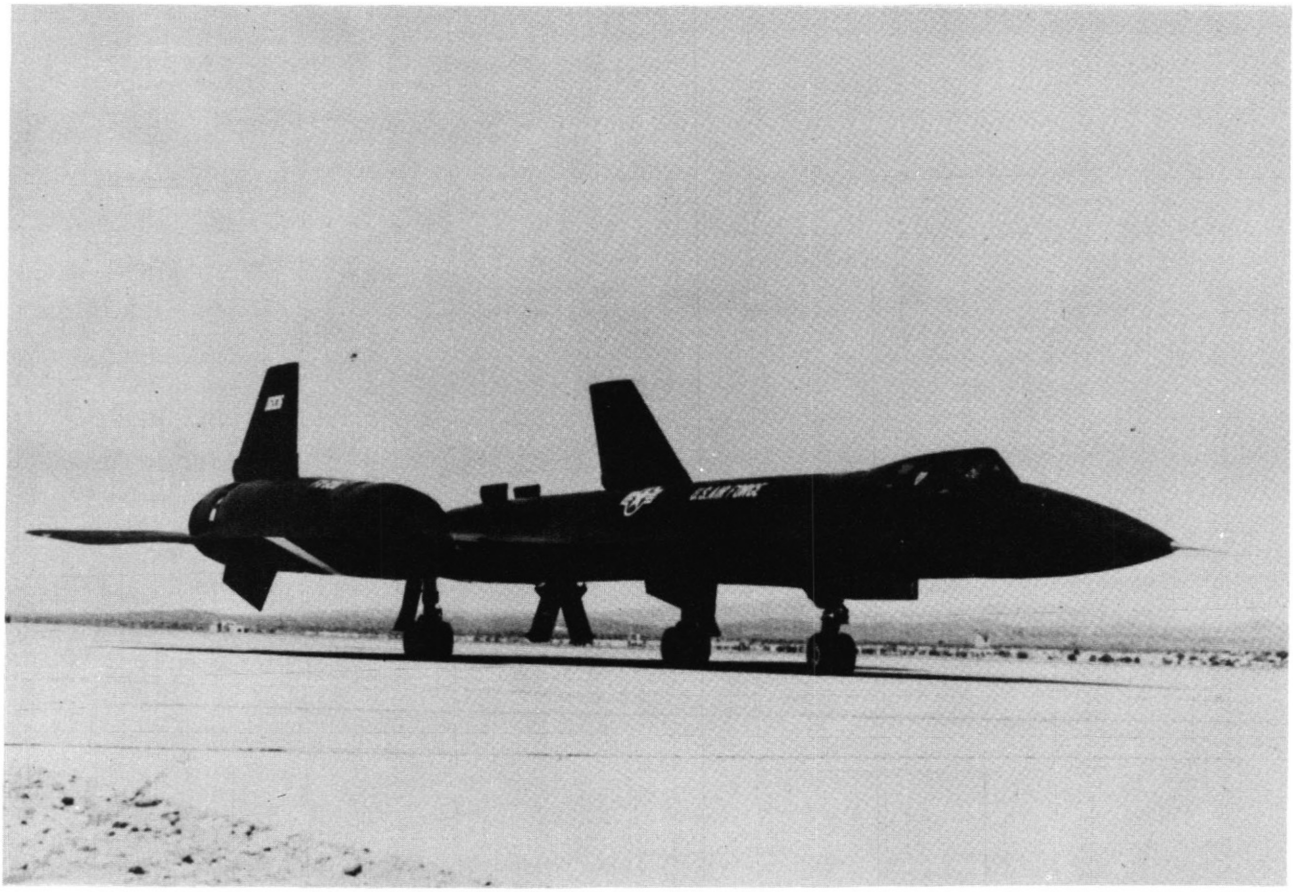
54 – Mc Donnell RF-101 C flown by Col. Taylor. Record aircraft.



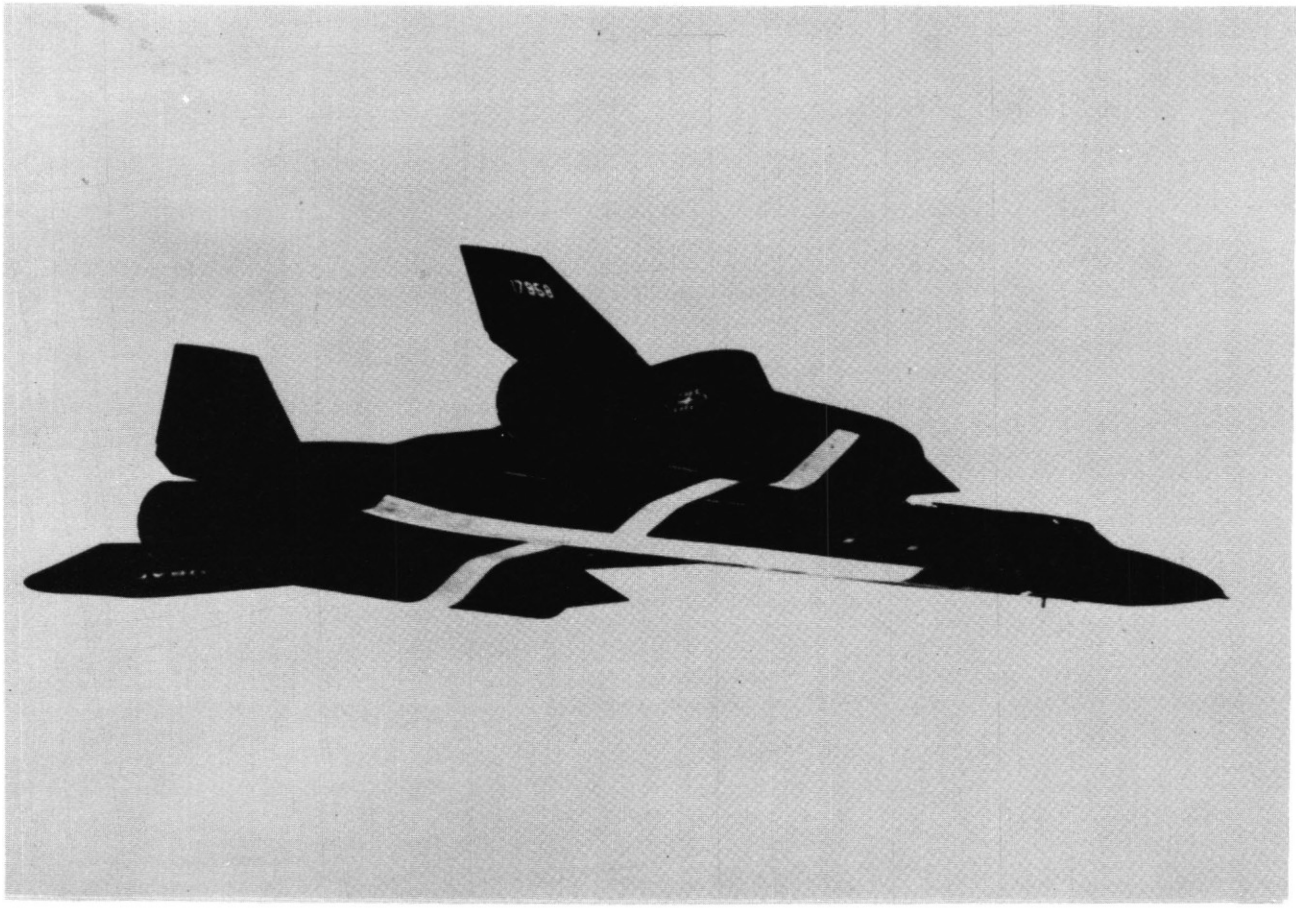
55 – Dassault "Mirage" IV-01. Record aircraft.



56 – Convair B.58 A.



57 – YF-12 A.



58 – Lockheed SR-71. July 27, 1976. Record aircraft.