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Chapter 9

Louis Damblanc: Multistage Rocket Pioneer*

Jean-Jacques Serra† and Philippe Jung‡

Abstract

Louis Damblanc himself presented a synthesis of his rocket activities during the 1967 International Astronautical Congress.[1] It however is important to set this research, not only in the wide range of his scientific activities, but also in the technical and political context of the times.

Louis Damblanc was born in Lectoure (Gers department, west of Toulouse), on 29 June 1889, No. 3 *Avenue Magne*. His mother, Catherine Escalup, was a native of this town, while his father was a coachbuilder in nearby Fleurance. He went to primary school in the latter town, then secondary school in Auch (Gers *Préfecture*), before being accepted in 1907 in *Institut Electrotechnique de Grenoble* (IEG), graduating in 1910.

During the latter part of WWI, he was mobilized in *Sous-Secrétariat d'Etat des Inventions* as an engineer for technical experiments. After the Armistice, he created a consultant office under the name of *Bureau d'études aéronautiques*, hiring at least three years later *Arts et Métiers* and *Sup'Aéro*§ engineer Tuffery.

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† AAAF (*Association Aéronautique & Astronautique de France*).

‡ AAAF (*Association Aéronautique & Astronautique de France*), 150 route de Pégomas, F-06130 Grasse, France.

§ The first aeronautical engineering school in the world, from which he graduated with the first class in 1910.

On 27 May 1927 he married Belgian Martha Wehrlé in Paris. This may explain why several of his patents were filed in Belgium before France.

Damblanc and Aeronautics

Damblanc quickly got in touch with *Institut d'Aérotechnique* (IAT) in Saint-Cyr.* He started working on rotary wings and aircraft engines.

Rotary Wings

a) The Lacoin and Damblanc Alérion

A. Beurrier, E. Bougourdan and L. Lacoin had filed in 1915 a patent for an "aircraft with a rotary wing."[2] Damblanc, interested by such rotors from 1917, thus cooperated with Lacoin to develop a helicopter, *Alérion*, with a funding from *Section Technique Aéronautique*.[3] Its description can be found in NACA Technical Memorandum No. 340[4]:

"Two lifting airscrews were used, driven by cables from two *Le Rhône* 110 HP engines. The drive was so arranged that either or both of the two engines could operate both lifting rotors. An automatic clutch and an elastic shock absorber were embodied in the transmission.

Control was secured by a mechanism for warping the blades (which were built very much like airplane wings), a horizontal stabilizer, and a vertical rudder. Forward speed was to be achieved by inclining the rotors. Apparently, for descent the blades were to be put in negative pitch.

The main characteristics were:

• Span	15 m
• Overall length	9.2 m
• Total area of rotors	40 m^2
• Width of fuselage	1.2 m
• Area of horizontal stabilizing planes (2)	8 m^2
• Area of rudder	1 m^2
• Rotors RPM	160
• Total gross weight†	1,200 kg
• Power of engines	110 HP at 1,300 RPM

† including pilot and gasoline for half an hour's flight.

* Founded in July 1911, it was attached to *Université de Paris* and was headed by Charles Maurain. In February 1920 it went under *sous-secrétariat d'Etat à l'aéronautique*, with Albert Toussaint its director. In 1933, IAT was attached to *Conservatoire National des Arts et Métiers* (CNAM).

On 14 September 1920, the *Alérion* was ready for a static test on the Villacoublay airfield.[5] But when the engines were started, a main gear strut failed. One blade detached and broke the fuselage, hitting Damblanc on his side.[6]

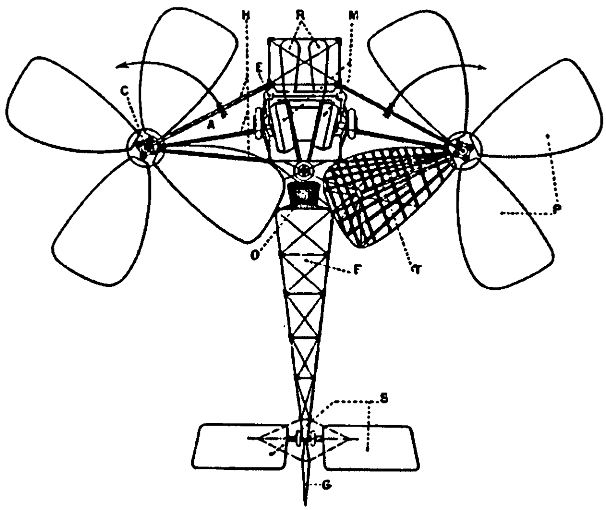


Figure 9–1: The Alérion in its final version.
Credit: La Vie Aérienne illustrée 11.12.1919.

This failure led to the end of the association between Lacoin and Damblanc, who had filed two other common patents.[7,8] While Lacoin continued working on other helicopter projects, Damblanc soon altered his course.

Before that, on 18 November 1920, he made a presentation in London, "The problem of the helicopter"[9] to the *Royal Aeronautical Society* under the presidency of Air Vice-Marshal Sir Edward Ellington. He specified some *Alérion* characteristics: with a factor of safety of 7, he found that the optimum diameter of a lifting propeller was about 6.9 m, and that the weight of the propeller per square meter of surface was 6.98 kg. Damblanc estimated the horizontal speed at 132 km/h, and the initial climb at 3 m/s.

b) Autogyro with Variable Pitch Blades

At the end of 1920, Damblanc started analyzing the lift created by rotary surfaces in free fall. He was thinking about rotary helicopter-parachutes, with a nacelle and one or several free wind milling surfaces to slow down their descent.

First experiments already started in December 1920 with a laboratory car equipped with free wind milling wings mounted on a rear frame. A dynamometer measured the corresponding slowdown imparted to the vehicle.[10] Some sources report that Damblanc tried testing his helicopter-parachute from the top of the Eiffel tower, and that this was refused,[11] but we have not found any confirmation of it.

Figure 9–2: Damblanc's Laboratory Automobile.
Credit: Bibliothèque Nationale de France.

In March 1922, Damblanc filed a patent for a "flying machine of helicopter type"[12] with among others:

- a mechanical system to simultaneously control the angle of attack of the blades of the two contra-rotating wings;
- the use of a small diameter lifting airscrew, driven from the support of one of the main rotors but at a higher speed. The axis of this so-called regulating propeller could be tilted in any direction, both for flight control and stability, even without engines running;
- the ability, once the engines were unclutched, to glide back in any direction.

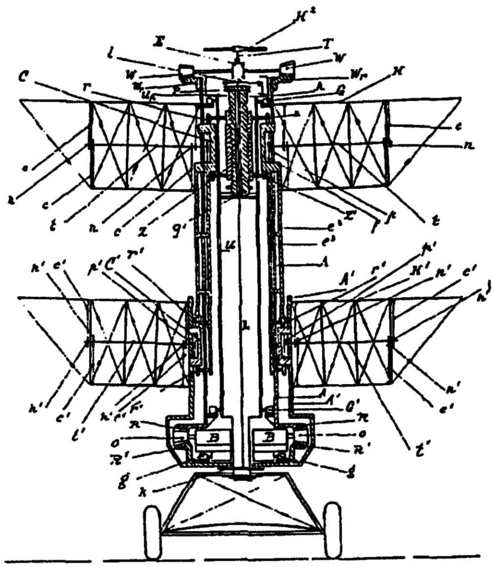


Figure 9–3: "Hélicoptère" according to Damblanc patent No. 555.460.

A new step was achieved in August 1923 in the Saint Cyr airfield, with tests of parachute helicopters released from a tethered balloon at 300–400 m altitude.[13] Various equipment was used to record the behavior of the mock up during the descent. As a consequence of these trials, Damblanc filed in January 1928 an improvement to his 1922 patent,[14] now linking the two opposite blades with cables or equivalent, via pulleys on the main rotor axis.

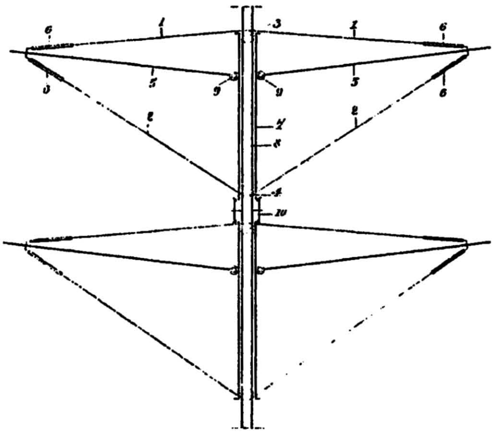


Figure 9–4: Rotary wing according to Damblanc patent No. 661.239.

Starting in 1930, Damblanc used for his tests the aerodynamic sled of IAT.[15,16] Electrically powered, this sled ran on 1,400 m long tracks. Several parameters were continuously recorded during the run: thrust, speeds (sled, rotors rpm, wind), rotations (pitch and roll), drag, etc.

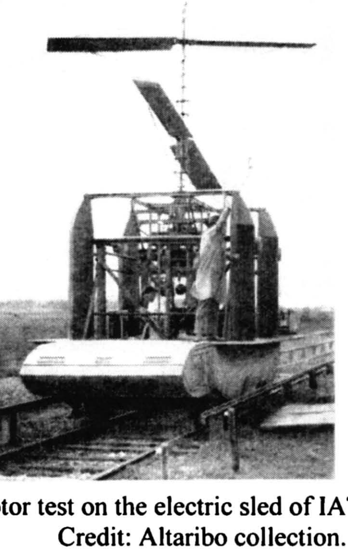


Figure 9–5: Rotor test on the electric sled of IAT in Saint Cyr.
Credit: Altaribo collection.

A true visionary, Louis Damblanc was confident that the future of commercial aviation lied in long-haul aircraft flying at high altitude. Already in 1920, he described a planned aircraft, *Titan*, able to fly from Brest to New-York in twenty hours, at 12,000 meters altitude.[17] To this aim, he developed with a certain Louis Mutti a rotary motor with variable compression ratio, to keep a good efficiency even at high altitude.[18]

This motor, which exhibited unique features for its time, with compression ratio adjustable by the pilot from 4.8 to 6.5 (thus increasing power from 200 to 300 HP), was estimated to be able to be used at altitudes of 11,000 to 12,000 m, according to *La Nature* in 1920.[19]

A 165 hp version was built to allow the SPAD 32 establish a new world altitude record. After a first flight on 10 May 1920, the motor had to be removed for balancing. The second flight on 20 December showed the same problem, leading to cancellation of the attempt.*

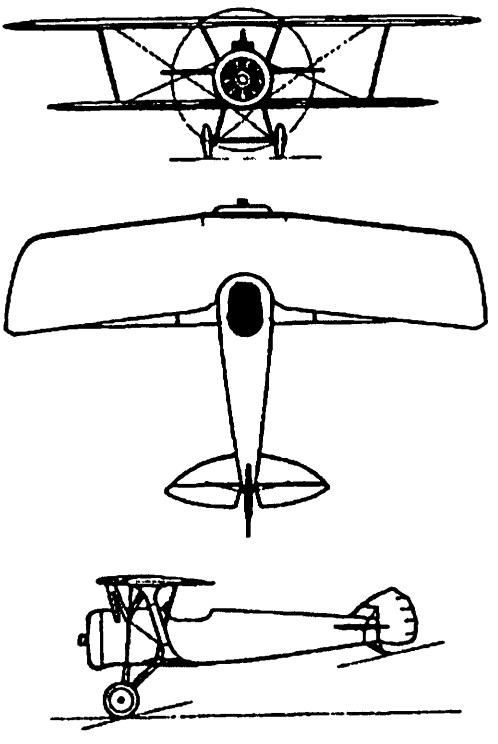


Figure 9–6: SPAD 32 3-view drawing. Credit: *Aviation Magazine*, 15 July 1971.

Mutti and Damblanc proposed in 1921 improvements to increase the efficiency of rotary motors by supercharging.[20] The following year Damblanc filed another patent to solve the balancing problem.[21]

Finally, on 14 April 1925, a Damblanc note *On a device to reduce the power losses of aircraft motors in altitude* was presented by Paul Painlevé himself during a session of *Académie des Sciences*.[22]

This device seems to have been adapted on a 200 HP Breguet motor[23] and on a 300 HP Salmson motor.[24,25] Damblanc continued working on variable compression motors until the end of the 1920s, his last patent being filed in 1928.

* The 10,000 m barrier had been beaten for the first time in Dayton on 27 February 1920, 10,093 m with a Lepère LUSAC 11, built by a French engineer who had emigrated to the USA.

Damblanc, Press and Politics

Damblanc aeronautical activities were not restricted to technical aspects, as he also was a press man, writing numerous articles, also being the director of several papers: he founded the weekly *L'aviation française* in 1926, and took over the monthly *La vie aérienne et sportive* in 1929, merging them into *La vie aérienne*. On *Radio-Vitus*, he was leading in 1931 a broadcast *Le quart d'heure de l'aviation française*.

Damblanc engaged himself in politics, as a member of the *Union des Républicains et de Défense Paysanne* (farming), and of the *Parti Républicain Socialiste*. He was elected mayor of Fleurance in 1927, until 1940 when the Vichy government nominated somebody else. In May 1932, he lost in the legislative elections in the Condom-Lectoure district.[26]

In the field of engaged press, he founded several papers, in Paris *La Gauche* (1931–1932) and *La Concorde* (1932–1939), and in Gers *La démocratie paysanne* (where he was the director for politics) and *L'écho du sol* (ground echo). These local papers helped him during his electoral campaigns. He was a visionary, promoting an international surveillance of armaments and budgets, a control of military and civil aviation by the *Société des Nations*, prohibition of chemical and bacteriologic warfare, and an economical cooperation between European states to rationalize Europe organization.

Damblanc and Rocketry

Starting in 1932, until the beginning of the Second World War, Damblanc worked on a new scientific theme, rocketry.

It should be stressed that he had previously addressed the subject of guided weapons, as mentioned in *Flight* in 1921:[27] "From Paris it is reported that a French engineer, Damblanc, has designed an aerial torpedo which can be launched from an aeroplane and then controlled on its path by wireless. The new torpedo is said to be provided with small planes, which enables it to glide towards its objective, and it is thought that this will be a great advantage over a bomb, which has to be dropped approximately above the target." This project was not immediately followed up,[*] although it was restarted at the end of the 1930s (see later).

[*] French officer Ageorge started working on automatic stabilization of aircraft in 1916. This allowed developing a radio command system for pilotless aircraft as soon as in 1917, such as used by a Voisin VIII LBP on 14 September 1918. ["*Génèse des engins téléguidés*," in "*Engins téléguidés - Avions robots*," A. R. Weyl, 1952].

Static Tests

In a first step, Damblanc developed a test bench to automatically record axial pressures. Patented in 1936,[28] it was located in IAT. The following measurements were made:

- Maximum rocket thrust by compression of a calibrated spring, the latter keeping its minimum length once the latter had been reached;
- Instantaneous thrust, thanks to an arm transmitting the spring movements to a needle recording these variations on a rotating drum actuated by a clock mechanism.

A cine camera also recorded the spring displacements. Elapsed time was shown on the film, thanks to a pendulum of one second period.

There were numerous advantages to using this test bench, as it allowed among others:

- continuous thrust recording;
- record on film the combustion, such as flame shape and acoustic levels;
- testing powerful motors outside, with personnel at a safe distance.

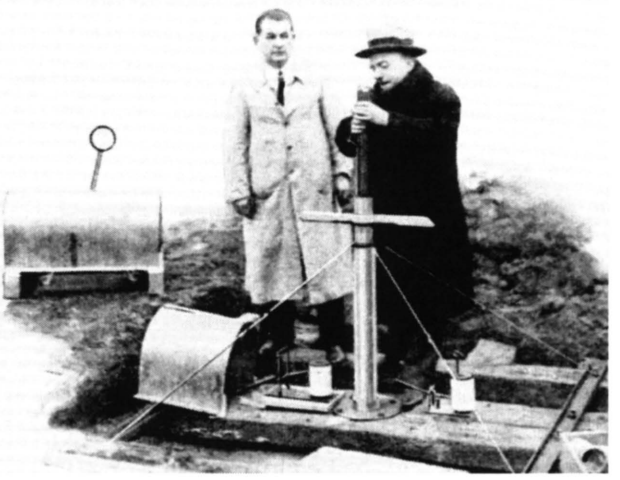


Figure 9–7: Mounting a rocket on the test bench in IAT in Saint Cyr.
Credit: Serra collection.

Four rocket types were tested.

Rocket No. 1: Life-Saving

This rocket could pull a wire weighing 35 kg over a distance of 400 meters in 12 seconds, to connect a distressed ship to the coast. A salient feature of this rocket was the use of two stages, although they could not be separated (see Appendix). Thickness of the rocket body was 2.5 mm.

Maximum mass: 7.82 kg
Outside diameter: 70 mm
1st stage grain mass: 1.85 kg
1st stage grain length: 375 mm
2nd stage grain mass: 1.165 kg
2nd stage grain length: 265 mm

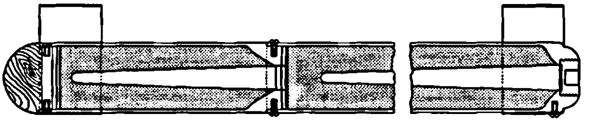


Figure 9–8: Rocket No. 1 (note stick attachments).
Credit: Serra from Damblanc document.

These rockets used a stabilizing stick 3 m long, made from fir tree, weighing 2 kg.

Rockets No. 2 and 3: Anti-Hail Ruggieri Rockets

These were robust and safe rockets, the casing of which was in thick cardboard.

Rocket No.	2	3
Motor mass	1.9 kg	1.28 kg
Outside diameter	67 mm	58 mm
Inside diameter	47 mm	41 mm
Casing length	500 mm	430 mm
Grain mass	1.1 kg	0.8 kg

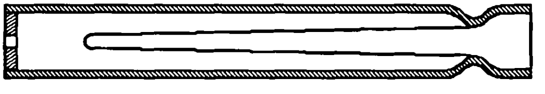


Figure 9–9: Rocket No. 2 motor. Credit: Serra, from Damblanc document.

Rocket No. 4: Anti-Hail Rocket from ECP in Bourges

The casing was made from cardboard reinforced with an inside steel liner of 1.5 mm thickness. It was loaded with four grains, compressed at 25 kg/mm^2 (1 full and 3 with a central core), after the latter had been covered with paraffin wax.

Total mass with stick: 1.236 kg
Outside diameter: 46 mm
Grain mass: 0.345 kg

Figure 9–10: Rocket No. 4 with four grains and central stick.
Credit: Serra, from Damblanc document.

The stick was bolted in the center of the casing, there being three exhausts at the rear.

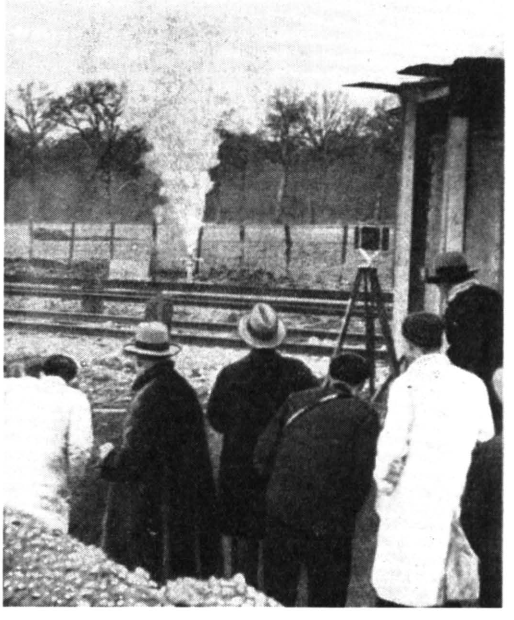


Figure 9–11: Static test on the IAT bench in Saint Cyr. Credit: ONRSII.

The results of Damblanc experiments were published in April 1935.[29] On June 19th, the *Comité d'astronautique* of *Société Astronomique de France* awarded him the prestigious *Prix International d'astronautique REP-Hirsch* 1935, the first one given for experimental work.

From his test results, Damblanc established semi-empirical laws on rocket flight.* He was not aware of Tsiolkovsky's work, but often referred to Piobert. The rockets he studied never exhibited a plateau of constant thrust level. In his conclusion, he stressed that three points had to be further studied:

1. Manufacture grains, the maximum thrust of which should be kept constant during the maximum fraction of the burn;

* The theory for the flight of non separable multi-stage rockets was established three years later ["*Flight analysis of a sounding rocket with special reference to propulsion by successive impulses,*" H. S. Tsien and F. Malina, *J. Aeronautical Sciences*, Vol. 6, pp. 50–58, 1939].

2. Significantly increase the maximum thrust, without increasing too much combustion speed, and use high resistance metallic envelopes of low weight;
3. Multiply the number of combustion stages (like rocket no. 1) to significantly increase total burn time, and thus considerably increase apogee and range.

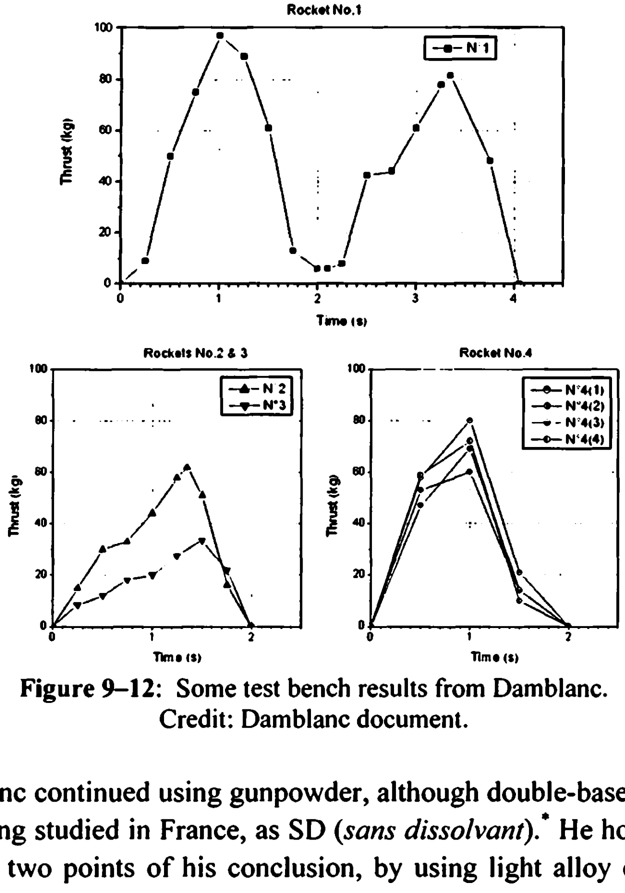


Figure 9–12: Some test bench results from Damblanc.
Credit: Damblanc document.

Damblanc continued using gunpowder, although double-base propellant already was being studied in France, as SD (*sans dissolvant*).* He however did develop the last two points of his conclusion, by using light alloy envelopes and favoring multi-stage rockets.

It should be noted that in the April 1935 paper, he refers to rockets with several grains, and not to separable stages (see Appendix). However, the idea of a casing progressively shortening itself in the course of combustion is defined in the patent he filed in Belgium on 9 March 1935 and on 7 March 1936 in Paris.[30] This staging was implemented by using connections made from tin/lead/bismuth

* *Laboratoire de balistique intérieure* of *Service Technique des Fabrications d'Armement* already was developing in Bourges in 1933 80 mm rockets using SD grains, for air-launched bombs. A very successful test (probably a launch) was performed on 6 June 1940. ["*Des fusées de guerre*," J-J. Barré, *Revue historique des Armées*, No. 4, pp. 157–162, 1956].
This work, directed by *Ingénieur Général* Desmazières, was performed by civil engineer Tercé, who gave the initial of his name to the air-to-ground T-10 rocket, built just after WWII.

alloys melting under heat fluxes generated by grain combustion: the so-called *Rose metal* (melting temperature, T_m=110°C), *Wood metal* (T_m=70°C) or *Lipowitz metal* (T_m=60°C).

Damblanc thus was led to make research on heat propagation during grain combustion, with publication in 1938.[31] Development of the separation technique took a lot of time, so that Damblanc continued working on concepts of rockets with several grains, but no staging. He proposed in 1939 a method to assemble these elements with screwed sleeves.[32]

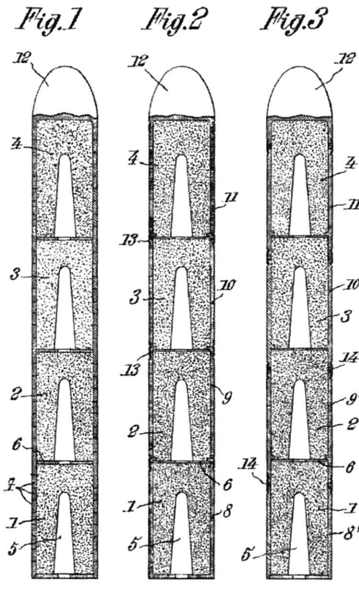


Figure 9–13: Multistage (separating)rockets according to patent No. 803.021.

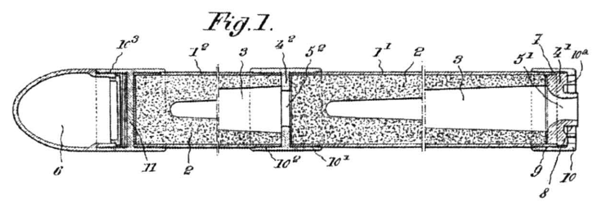


Figure 9–14: Assembly of elements via screwed sleeves according to patent No. 859.352.

Flight Test

Damblanc followed his static tests with launches of his own rockets. He thus had to find a proper range, choosing the one of *Ecole Centrale de Pyrotechnie* (ECP) in Bourges.* ECP also provided the grains.

Figure 9–15: Damblanc presenting one of his rockets assembled with screwed sleeves. Credit: Altaribo collection.

* *Ecole Centrale de Pyrotechnie militaire* was created in Metz in 1824 to teach handling of explosives, including launching rockets, together with a research function. It progressively became one the biggest rocket research and manufacturing centers in the world. In 1860, *Second Empire* decided its transfer in Bourges, effective in June 1870.

We have not been able to find all the ECP test reports dealing with Damblanc rockets, only those of *Etude No. 617* on rockets and self-propelled vehicles. This study was initiated in 1923–1925 with research on Makhonine* rockets.[33] It re-started in 1937 with the Damblanc rockets.[34]

The first test campaign took place on 23 September 1937.[35] Damblanc launched three 2-stage rockets (that we will designate as *Type 2*) and 3-stage ones (*Type 3*). They used steel tubes of 38.5 mm outside diameter and 1.5 mm thickness, connected together with screwed fusible sleeves, for automatic stage separation when the sleeves melted away. Only the first stage had a nozzle, with a throat diameter of 10.3 mm. Incorporating a lateral stick of 1.8 m length, they were launched at a 45° angle. Ranges up to 1,650 m were achieved, but stabilization was shown to be insufficient.† They thus are the first known modern multi-stage rockets launched in history.

1937–1938 Rocket Characteristics				
Type	Length 1st stage (mm)	Length 2nd stage (mm)	Length 3rd stage (mm)	Mg (g)
2	220	153.5	–	581
3	220	153.5	153.5	826

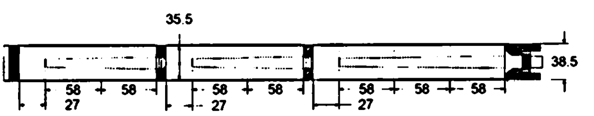


Figure 9–16: Three-stage rocket drawing, September 1937 version (dimensions in mm). Credit: Serra, from ECP report.

On 4 January 1938,[36] Damblanc tested two 2-stage rockets and two 3-stage ones. The internal arrangement of these rockets was identical to the previous ones. But this time they had central sticks, bolted in three locations at the base of the first stage. Launches were made at 63° inclination. For all of them, except one, stick screws were sheared off.

* Russian emigrant who flew the first variable geometry aircraft, the M 10, on 11 August 1931.

† Damblanc did not select a central stick configuration, with multiple circumferential exhausts, although he proposed this solution in another patent [*Brevet* No. 840.391, "*Perfectionnements apportés aux projectiles pour transporter une charge, notamment un produit volatil, devant être libérée au point d'impact*" filed on 31 December 1937].
At the time, he also did not choose to use fins, although he already had thought about it, as shown on a drawing on the front cover of an American magazine ["*Big Guns May Speed Mail Rockets,*" *Popular Science*, April 1936].

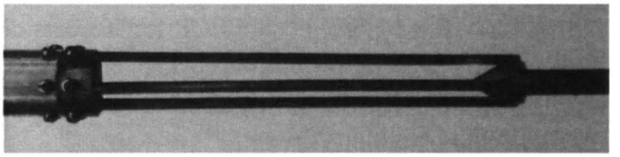
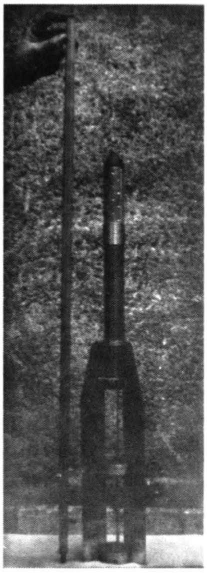


Figure 9–17: Central stick with its three attachments. Credit: ECP.

A few weeks later, on 31 January 1938,[37] Damblanc tested a 2-stage rocket and a 3-stage one, with two modifications: the nozzle throat diameter increased from 10.3 to 11 mm and the fixation bolt diameter from 4 to 7 mm. Launches were made at 50° inclination. However stabilization remained unsatisfactory.



Damblanc worked during more than one year to replace the screwed fusible sleeves by new fusible sleeves threaded to the two adjacent stages, and to develop a new stabilization system, before settling on 3 fins of very long chord. It was first tested on a single stage ECP rocket.[38] The fins, made of 1 mm thick duralumin, had a length of 420 mm and a width of 50 mm. The nozzle throat diameter was further increased to 11.5 mm. The rocket, of 750 mm height with its tracer container, was launched vertically. Although the apogee was not measured, the trajectory was considered to have been correct.

Figure 9–18: Single-stage rocket for fin testing. Credit: ECP.

With this solution now validated, Damblanc tested a series of 11 finned rockets and their tracer containers (400 g), vertically launched on 24 April 1939:[39,40]

- two single-stage rockets (*Type 1*—authors' designation—in the table below): one worked properly, the other one exploded at launch;
- five two-stage rockets (*Type 2*): one worked properly and climbed to 501 m, the others exploding at launch;
- two two-stage rockets (*Type 2a*): they worked properly, one climbing to 1,161 m, the other one disappearing in a cloud;
- two three-stage rockets (*Type 3*), which exploded at launch.

Four of these shots were cine-filmed.

April 1939 Rockets Characteristics (Mg=grain mass)					
Type	L_1 (mm)	L_2 (mm)	L_3 (mm)	M_t (g)	M_g (g)
1	279	–	–	1,900	465
2	279	250	–	2,790	880
2a	279	200	–	2,645	805
3	279	250	250	3,680	1,295

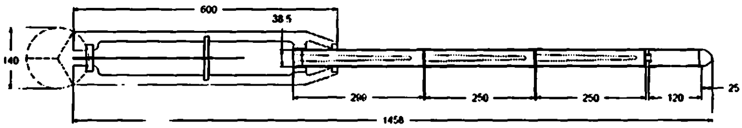


Figure 9–19: Three-stage rocket drawing, version April 1939 (dimensions in mm). Credit: Serra from ECP report.

On 24 August 1939,[41] ECP experimented its own single-stage rockets (aerial mines), with Damblanc type fins, vertically launched:

- two rockets with a tracer container (L_1=279 mm; M=1,875 kg including a grain of 440 g and a 350 g payload): both worked properly, climbing to 750 m and 705 m;
- one rocket with an aerial mine (L_1=279 mm; M=5,120 kg including a grain of 475 g and a 1,600 g payload): it worked properly and climbed to 311 m.

A new phase for *Etude n° 617* started in May 1939.[42] On 30 August 1939, a series of 14 Damblanc rockets with fins and 400 g tracer were vertically launched.[43] Some had steel cartridges (∅ext = 38.5 mm), but others used a lighter magnesium/aluminum alloy, called metal M1 *Electron* (∅ext = 40 mm). The diameter of the nozzle throat was reduced from 11.5 to 10.5 mm:

- one single stage rocket made from M1 (*Type 1*): it worked properly, but its apogee was not observed;
- two two-stage rockets using M1 (*Type 2a*): the cartridge melted down and the fins were torn away at the end of the first stage burn, delaying the ignition of the second stage, which took a nearly horizontal trajectory. Apogee was between 750 and 1,250 m;
- two two-stage rockets with M1 (*Type 2*): the second stage of one of them did not ignite, while the second one hit the same problem as *Type 2a*, reaching an altitude of about 700 m;
- two three-stage rockets with M1 (*Type 3*): the first one behaved like *Types 2a*, climbing to about 400 m. In order to understand what happened, the

second one was ground-tested: melting of the casing was observed at the end of first stage burning time; all three stages ignited correctly;

- four two-stage rockets made from steel (*Type 2b*): the second stage of the first one did not ignite, while the second one behaved like the *Types 2a* and climbed to about 800 m. Results for the two others were not reported;
- one three-stage rocket made from steel (*Type 3a*): the second stage flew horizontally at about 300 m height, and the third one burnt on the ground;
- Two other steel rockets were not launched.

We did not find any drawings for these rockets, but the description of their flight behavior points to separating stages.

August 1939 Rocket Characteristics						
Type	L_1 (mm)	L_2 (mm)	L_3 (mm)	M_t (g)	M_g (g)	H (m)
1	279	–	–	1,790	475	0.88
2	279	250	–	2,320	895	1.13
2a	279	200	–	2,190	810	1.08
2b	279	250	–	2,720	895	1.09
3	279	250	250	2,980	1,315	1.34
3a	279	250	250	3,390	1,315	1.34

On 7 October 1939, Damblanc vertically launched two 2-stage finned rockets with a 325 g tracer, using new types of grains.[44] Of identical dimensions (L_1=279 mm; L_2 = 200 mm; H=1.10 m), both used steel for the first stage (∅ext = 38.5 mm) and M1 for the second stage (∅ext = 40 mm);

- No. 1: the 710 g grain used mining powder *Spécial No. 1*. It worked properly, but the apogee was not measured;
- No. 2: the 705 g grain used musket powder, with the same results as for No. 1.

The last campaign of *Etude n° 617* dedicated to Damblanc took place on 31 October 1939.[45] He tested a steel single stage finned rocket (72 mm internal diameter, 79 mm outside). A 1,650 g tracer was carried. Nozzle throat diameter was 27.5 mm. Of a total length of 1.51 m (L_1=445 mm), it weighed 10.85 kg, including a grain of 3.2 kg. It had a good flight, and climbed to 940 m.

The last launch in the frame of *Etude No. 617* in April 1940 was of a rocket built by Jacques and Grande.[46] It appears that not all Damblanc launches were made within this *Etude*. In his 1967 paper,[1] he writes: "Magnesium-alloy (M1) rocket of 88 mm diameter and a total length of 2.20 m: it had three stages and three 120°-spaced stabilization fins. Figure 9–20 shows this, as well as a two-stage, 55 mm diameter rocket with different stabilization tail planes for each stage. These were successfully launched on the Bourges firing ground in July 1938."

Etude No. 617 does not refer to any 55 or 88 mm diameter rockets. The 55 mm one had fins on each stage, which implies that were separable. The July 1938 date is compatible with the end of his studies on heat propagation during combustion.

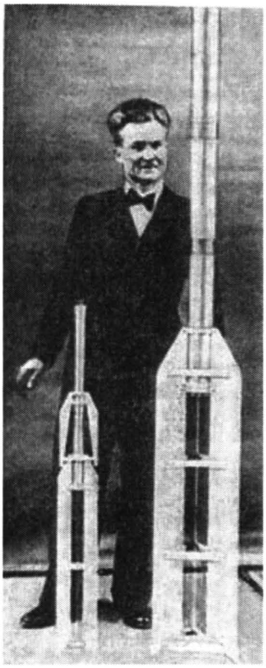
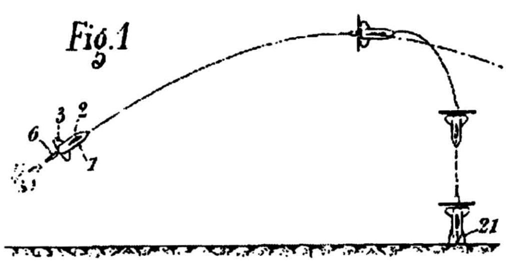
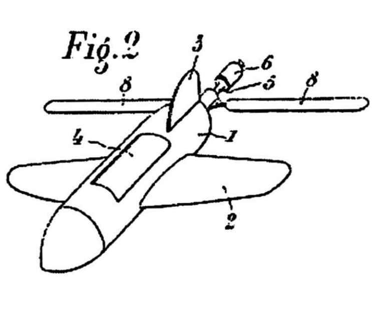


Figure 9–20: Damblanc rockets of 55 mm and 88 mm diameter, shown by Damblanc assistant. Credit: CNES.

Damblanc also mentions: "133 mm rockets, the most powerful ones built in France at that time, of which the structure was obtained by cutting of a shell-body. Capable of transporting heavy loads, their drift did not exceed 2 percent. They were built in three stages, each automatically separable after complete combustion of the lower stage, by means of a device I had invented." This 133 mm diameter rocket, which seems to have been tested in 1939, is not either mentioned in *Etude No. 617.*

In the end of 1939, Damblanc proposed a new patent on aerial torpedoes.[47] This vehicle associated rocket propulsion with autogyro-type vertical landing.





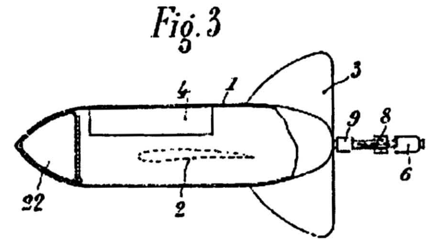


Figure 9–21: Multifunction aerial torpedo according to patent No. 864.212.

Contrary to what its name implied, this aerial torpedo had no military applications. The text specifies that it could be advantageously used for carrying food, ammunitions, post, cargo, etc...to areas difficult to access and even, in some cases, for transporting passengers, provided the speed had been selected to reduce acceleration below 2g's.

Damblanc improved the concept during World War II, and filed a new patent a few weeks after the liberation of Paris.[48]

Because of the German occupation, Damblanc patents in the USA were seized, as American law considered they came from an enemy country! Damblanc had to wait until 1965 for the Finance Ministry to compensate him for the use by the USA of his patents until they expired. The Blum-Byrnes agreement of 1946 between France and the USA effectively stipulated that: "the French Government has agreed to process and pay all unpaid claims of French residents against the United States Government arising out of the use or infringement in war production of patent rights held by them..."

Activities after the War

Damblanc, who also had initiated in the 1930s studies on imaging techniques, continued the latter after World War II. He filed no less than 14 patents between 1936 and 1952 on various applications such as:

- means to show movements with successive images (1936, 1951)
- drawing devices (1937)
- devices for observation of cinematographic rolls (1937)
- devices to distribute books or documents contents (1937)
- devices to reproduce and transmit images and documents (1941, 1942, 1945)
- projectors (1945, 1946)
- devices to read microfilms (1946)
- devices to process positive microfilms (1947)
- devices for photographic reproduction at variable scales (1951)
- devices for observation of the transparent contents of a container (1952).

One of his most interesting realizations is the *Imagiscope*, which allowed the screening of, either non-transparent documents (episcopy), or static films or slides (diascopy).[49] It also was possible to use an outside screen, providing an additional amplification with a factor of 1,600. The device could as well ensure surface control of mechanical parts in workshops. One of these devices has recently been found in an attic, and a team is planning to restore it. To be noted as well is an automatic film viewer on paper support, the prototype of which was built for Damblanc by Hachette, the notorious editor.[50]

Starting in 1956, Damblanc was a partial-time advisor to SNECMA. He filed two additional patents in 1960 on a demining vehicle using jet lift.[51,52]

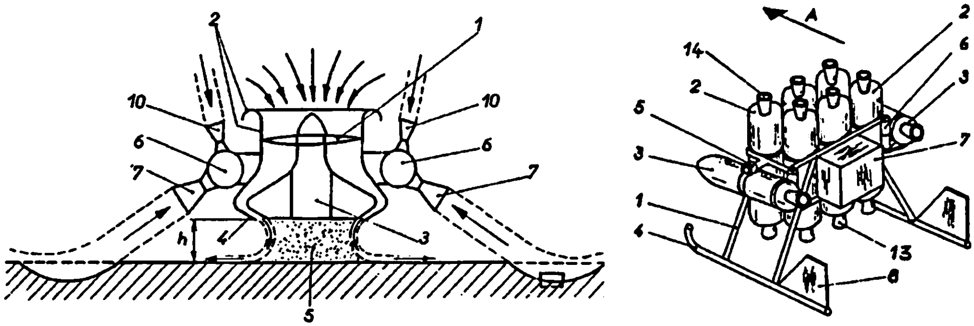


Figure 9–22: Vertical take-off and landing platforms, according to patents no. 1.284.563 (left) and no. 288.750 (right).

His last patents, filed in 1967 when aged 78 years, concerned protections against thermal shocks, and windmill blades.

He died on 2 December 1969 in Levallois-Perret, a Paris suburb, and was buried in Fleurance, the town of which he had been the mayor during 14 years. The town of Lectoure has dedicated a plaque on his native house, and a street in Fleurance bears his name.

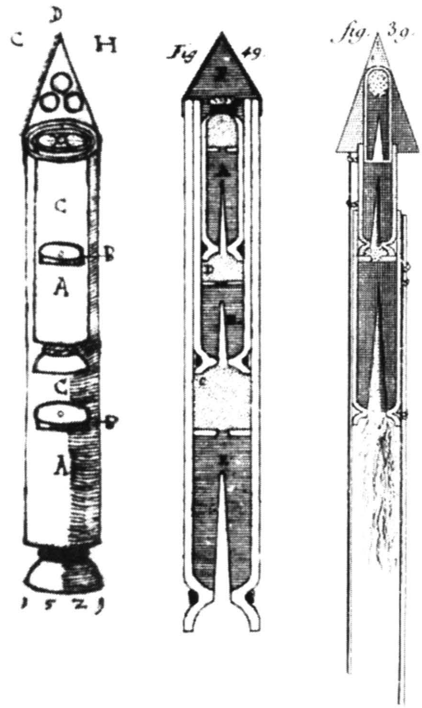
His honors and awards included:

- *Prix International d'Astronautique REP-Hirsch* 1935
- *Médaille d'or des recherches scientifiques*
- prize-winner of *Société d'encouragement au progrès*
- *Chevalier de la Légion d'Honneur.*

This first detailed paper on Damblanc not only unravels so-far unknown test results for some of his rocket launches, but also allows new and startling conclusions:

- so-called old multi-stage rockets actually used non-separable stages, with the exception of Frézier (see Appendix);
- Damblanc is confirmed to be the father of the modern multi-stage (separable) rocket, from 23 September 1937, as cited by von Kármán and Tsien;
- the figure of 360 cited by Damblanc probably refers to the total of static tests and actual launches.

Appendix: Multistage Rockets before Damblanc



The oldest document describing multi stage rockets is the "art book" of Conrad Haas during the XVIth century. However, as Carafoli says,[53] and this can be seen on Figure 9–23 (left), the stages of these Haas rockets, while being ignited in sequence, could not be separated at burn out. This is so for the rockets shown in *Grand art de l'artillerie* by Casimir Simienowicz in the XVIIth century (see center of Figure 9–23). The goal for these rockets only was to improve range by adding up successive short impulses, the only ones possible at the time.

Figure 9–23: Multi stage rockets before the 19th century. Left to right: Haas, Simienowicz, Frézier. Credit: Kunstbuch (Book of technics, by Haas), *Traité des feux d'artifice* (Frézier, 1747), *Grand art de l'artillerie* (Simienowicz).

The first known document showing a rocket with separable stages is *Traité des feux d'artifice* by Amédée Frézier in the XVIIIth century.* On Figure 9–23 (right) one can see that the two lower stages each have a stabilizing stick, and that the upper stage remarkably has fins.

During the XXth century, the activities of the Scottish amateur club *Paisley Rocketeers Society* (PRS) are worth noting, as they started launching rockets as soon as in 1935.[54] On 21 December 1937, PRS launched a RR-47 rocket with separable stages: its first stage allowed it to reach a height of 60 m, after which it pitched over in a quasi horizontal direction. The first stage was found at a distance of 75 m from the launch site, the second at 250 m and the third, smaller, one could not be found.

* Two books published in France at the same time carry similar titles: *Traité des feux d'artifice* (1706 and 1747) by Frézier and *Essai sur les feux d'artifice* (1745), then *Traité des feux d'artifice* (1750) by Perrinet d'Orval. Only the books of Frézier mention multi-stage rockets, the second edition providing further details. A third edition of the book of Perrinet d'Orval was renamed *Manuel de l'artificier* (1755).

Figure 9–24: RR-47 rocket of the Paisley Rocketeers Society. Credit: PRS.

Acknowledgments

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References

[1] L. Damblanc, "My Theoretical and Experimental Work from 1930 to 1939, Which Has Accelerated the Development of Multistage Rockets," in *First Steps toward Space—Proceedings of the First and Second History Symposia of the International Academy of Astronautics at Belgrade, Yugoslavia, 26 September 1967, and New York, U.S.A., 16 October 1968*, Smithsonian Annals of Flight, Frederick C. Durant III and George S. James, editors (Washington, D.C.: Smithsonian Institution Press, 1974), pp. 49–55 [reprinted in *First Steps Toward Space* (Proceedings of the First and Second History Symposia of the International Academy of Astronautics, Belgrade, Yugoslavia, 26 September 1967 and New York, U.S.A., 16 October 1968), AAS History Series, Volume 6, IAA History Symposia, Volume 1 (San Diego, California: Published for the American Astronautical Society by Univelt, Inc., 1985) (paper presented at the 1st History Symposium of the International Academy of Astronautics as part of the 18th International Astronautical Federation Congress, Belgrade, Yugoslavia, 24–30 September 1967)].

[2] Patent No.502.520, "*Avion à voilure tournante*," A. Beurrier, E. Bigourdan et L. Lacoin, filed on 6.11.1915, registered on 24.02.1920.

[3] "Les hélicoptères modernes," J.-A. Lefranc, *La Nature*, 1920.

[4] "An Introduction to the Helicopter," A. Klemin, NACA T.M. No. 340 from "*Mechanical Engineering*," November 1924.

[5] "*L'Alérion, nouvel appareil d'aviation, se disloque à son premier essai,*" *Le Petit Parisien*, 15.09.1920.

[6] "Nouveaux hélicoptères," J.-A. Lefranc, *La Nature*, 1921.

[7] Patent No.505.445, "*Dispositif amortisseur de transmission,*" L. Lacoin et L. Damblanc, filed on 25.10.1919, registered on 6.05.1920.

[8] Patent No.505.446, "*Dispositif d'embrayage et de débrayage automatiques,*" L. Lacoin et L. Damblanc, filed on 25.10.1919, registered on 6.05.1920.

[9] "The Problem of the Helicopter," L. Damblanc, *Flight*, 25.11.1920.

[10] "*Une expérience originale de Louis Damblanc,*" *Camions et tracteurs*, 19.12.1920.

[11] "No Drops from Eiffel Tower," *Flight*, 20.01.1921.

[12] Patent No.555.460, "*Hélicoptère,*" L. Damblanc, filed on 28.03.1922, registered on 23.03.1923.

[13] "*L'ingénieur Damblanc entreprend une nouvelle série d'essais d'hélicoptère,*" *Le Petit Parisien*, 23.08.1923.

[14] Patent No.661.239, "*Aéronef à voilure tournante,*" L. Damblanc, filed on 20.01.1928, registered on 4.03.1929.

[15] "*A quand la voiture volante ?,*" *L'Ouest-Eclair*, 21.11.1930.

[16] "Helicopter Railway Runs in France," *Popular Science*, May 1931.

[17] "*Brest-New-York en vingt heures,*" L. Damblanc, *La vie aérienne illustrée*, No.191, 18.07.1920.

[18] Patent No.496.811, "*Perfectionnements apportés aux moteurs rotatifs,*" L. Mutti et L. Damblanc, filed on 11.03.1919, registered on 16.08.1919.

[19] "*Le moteur rotatif Damblanc,*" *La Nature*, 15.05.1920.

[20] Patent No.532.921, "*Perfectionnements apportés aux moteurs rotatifs à l'effet d'en augmenter le rendement par surcompression,*" L. Mutti et L. Damblanc, filed on 29.03.1921, registered on 24.11.1921.

[21] Patent No.550.404, "*Système d'équilibrage pour moteurs à cylindre fixe fonctionnant à compression variable,*" L. Damblanc, filed on 13.04.1922, registered on 12.12.1922.

[22] "*Sur un dispositif applicable aux moteurs d'avion pour réduire les pertes de puissance en altitude,*" L. Damblanc, report *Académie des Sciences*, Vol.180, No.15, 1925.

[23] "*Breguet,*" *Flight*, 29.01.1920.

[24] "*La solution de M. Louis Damblanc au problème de l'aviation aux hautes altitudes,*" *Science et Vie*, No.96, 1925.

[25] "A Second Wind for Airplanes Six Miles Up," *Popular Science*, August 1925.

[26] "*Louis Damblanc : scientifique, élu politique et publiciste,*" P. Léoutre, BSAG (*Bulletin de la Société Archéologique du Gers*), No.404, p. 244, 2012.

[27] "*An aerial torpedo,*" *Flight*, 28.04.1921.

[28] Patent No.802.422, "*Perfectionnements apportés aux moyens pour l'essai des appareils à réaction, notamment des fusées,*" L. Damblanc, filed on 26.02.1936, registered on 06.06.1936.

[29] *"Les fusées auto-propulsives à explosifs - Essais au point fixe - Application des résultats expérimentaux à l'étude du mouvement,"* edited by *Office National des recherches scientifiques et industrielles et des inventions*, then published in *"Recherches et Inventions,"* April 1935.

[30] Patent No.803.021, *"Perfectionnements apportés aux projectiles auto-propulseurs, notamment aux fusées,"* L. Damblanc, registered on 7.3.36, filed on 29.6.36.

[31] *"Les fusées auto-propulsives à explosifs - Recherches sur les vitesses de propagation de la chaleur développée au cours de la combustion de la poudre,"* edited by *Office National des Recherches Scientifiques et Industrielles et des Inventions*, January 1938.

[32] Patent No.859.352, *"Perfectionnements apportés aux fusées ou semblables,"* L. Damblanc, filed on 11 May 1939, registered on 3 juin 1940.

[33] Implementation of instructions of missive No.39.021-2/3 of 23 May 1923.

[34] Implementation of instructions of missive No.5.195-1/12 of 9 June 1936.

[35] ECP - *Etude n° 617*, PV No.11 of 11.10.1937.

[36] ECP - *Etude n° 617*, PV No.12 of 18.01.1938.

[37] ECP - *Etude n° 617*, PV No.13 of 08.02.1938.

[38] ECP - *Etude n° 617*, PV No.14 of 13.04.1939.

[39] ECP - *Etude n° 617*, PV No.15 of 03.05.1939.

[40] ECP - *Etude n° 617*, PV No.16 of 12.06.1939.

[41] ECP - *Etude n° 617*, PV No.17 of 06.09.1939.

[42] Implementation of instructions of missive No.6.292-1/12 of 15 May 1939.

[43] ECP - *Etude n° 617*, PV No.18 of 16.09.1939.

[44] ECP - *Etude n° 617*, PV No.19 of 24.10.1939.

[45] ECP - *Etude n° 617*, PV No.20 of 08.11.1939.

[46] Implementation of instructions of missive No.10.932 3 2/1 of 13 October 1939 ; PV No.21 of 20.04.1940.

[47] Patent No.864.212, *"Perfectionnements apportés aux torpilles aériennes, notamment à celles propulsées par réaction,"* L. Damblanc, filed on 24 November 1939, registered on 13 January 1941.

[48] Patent No.992.881, *"Perfectionnements apportés aux engins automoteurs du genre des torpilles aériennes,"* L. Damblanc, filed on 20 September 1944, registered on 18 July 1951.

[49] *"Louis Damblanc avait fait breveter un appareil permettant de projeter documents, films et diapositives,"* H. Altaribo, *La Dépêche du Midi*, 27.12.2009.

[50] *"Celui qui fut maire de Fleurance avait inventé une visionneuse automatique de films sur support papier,"* H. Altaribo, *La Dépêche du Midi*, 03.01.2010.

[51] Patent No.1.284.563, *"Engin de déminage,"* L. Damblanc G. Ernst, E. Gire, J. Rona, filed on 14.12.1960, registered on 08.01.1962.

[52] Patent No.1.288.750, *"Plate-forme sustentée par réaction, à poussée tarée, utilisée notamment au déminage,"* L. Damblanc, filed on 14.12.1960, registered on 19.02.1962.

[53] W. von Braun and F. I. Ordway III, *The Rockets' Red Glare*, (Garden City, New York: Anchor Press, 1976).

[54] J. Bonsor from *Paisley Rocketeers Society*, private communication, 2009.