

An important achievement of Professor Ion Stroescu: the wind tunnel of the Polytechnic School of Bucharest

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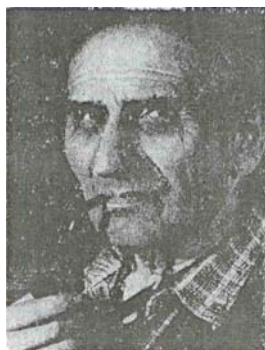
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Abstract: *This paper summarizes the contribution of Ion Stroescu to the experimental aerodynamics development in Romania through the design, in collaboration with Professor Elie Carafoli, of the subsonic wind tunnel of the Polytechnic School in Bucharest. Without any exaggeration, the paper also presents the general context in which this construction was built, when aeronautical higher education was being set up in Romania and young aviation industry made strides to world affirmation by its achievements.*

Key Words: *Aerospace, Education, Wind tunnel*

1. INTRODUCTION

Among the first Romanian scientists who had concerns in the field of experimental aerodynamics we shall mention Ion Stroescu (1888-1961). Keen to discern the secrets of flight, Ion Stroescu studied experimentally the movement of aircraft in turbulent atmosphere, using airplanes of its own design and construction. At the same purpose during the years 1926-1927, he built the first wind tunnel in Romania which he located in the gym hall of the high school in Ramnicu Sarat, where he was teaching sports.



Ion Stroescu 1888 - 1961

Not many were those who understood its importance and therefore some rushed to destroy that construction that looked like a barrel and occupied too much space of the gym hall. His luck, as well as that of the aircraft manufacturers in Romania was that Professor Elie Carafoli from the Polytechnic School of Bucharest, a world-renowned specialist in aerodynamics, found out about that achievement. Professor Carafoli failed to recover the “barrel” built in Ramnicu Sarat, which had been shattered meantime, but managed to bring Ion Stroescu at the Polytechnic School of Bucharest.

In 1929, as he felt that Stroescu was a true genius in subsonic experimental aerodynamics, Professor Elie Carafoli appointed him as assistant at the Department of Aerodynamics within the Polytechnic School in Bucharest. His great value was undeniable and demonstrated by his notable achievements. Thus, on February 7, 1927, Stroescu obtained the patent no. 13677 for a device designed to “enhance sustentation by increasing the back pressure of the airplane wing” and patent No. 13678, for a “rigid device for air streams constrained channeling”. It was just the beginning of a series of great achievements. As a close collaborator of Professor Elie Carafoli, Ion Stroescu designed together with that great scientist the project of the subsonic wind tunnel which was implemented at the Polytechnic School of Bucharest.

Thus, in May 1931 the first wind tunnel in South - East Europe was inaugurated in presence of HM the King Carol II. Ion Stroescu's achievements continued. In 1932 he built together with Professor Victor Valcovici, at the University of Bucharest, a didactic tunnel with elliptical jet and double return. Moreover, in 1937 Ion Stroescu was subsequently appointed lecturer at the Laboratory of the University of Bucharest. In 1946, Ion Stroescu built in Paris a wind tunnel for the study of the icing, having characteristics superior to all types of existing wind tunnels of that kind at the time. There are still many things to say about the creation and work of Ion Stroescu, but this paper will focus on the subsonic wind tunnel located at the Politehnica University of Bucharest, the fruit of close collaboration with Professor Elie Carafoli.

2. GENERAL CONTEXT.

ESTABLISHMENT OF AERONAUTICAL HIGHER EDUCATION

In the years following the World War I, the need for a national aviation industry to ensure the design, construction and repair of military and civilian aircraft, had become increasingly apparent in the Romanian economic development. Since 1920, the Council of the Polytechnic School of Bucharest raised the issue of aviation higher education establishment in our country, deciding to start first courses once they would have had teachers of recognized competence and appropriate laboratory facilities needed for aircraft engineers training. This goal was accomplished only in 1928, when engineer Elie Carafoli, who had just received his doctoral degree in physics and mathematics at the Sorbonne was given the opportunity to organize aviation engineering education and to inaugurate the first course of general aviation. At the same time intensified the concern for ensuring the necessary material and technical basis needed for this education, but also for the design of new aircraft to be made by the young Romanian aeronautics industry. In this respect, the first notable achievement was the design and construction of experimental aerodynamics laboratory, equipped with the wind tunnel conceived, designed and built during the years 1926 - 1930, under the guidance of Professor Elie Carafoli and with substantial contribution of Ion Stroescu.

The construction works were entrusted to “Edilitatea” Company and were conducted under the direction of its chief engineer Mihail Hangan, who was also a graduate from the Polytechnic School of Bucharest and in that time a teaching assistant of the “Construction” course held at the Polytechnic School (later, in 1931 he became a substitute professor of the “Reinforced concrete” course).

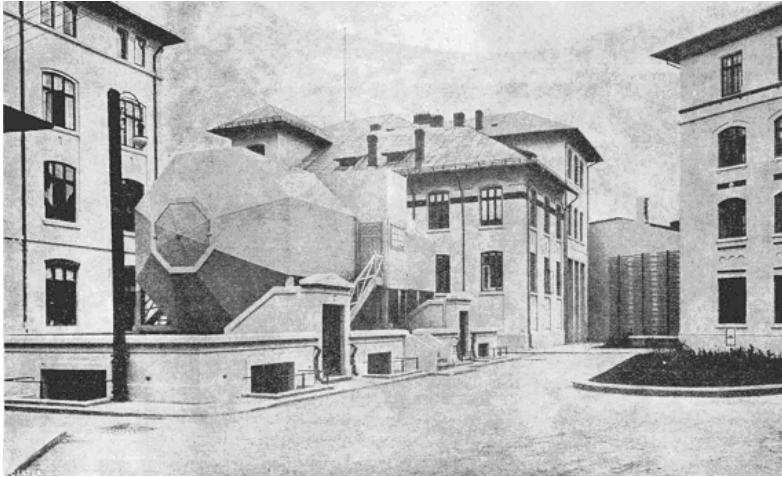


Fig. 1 View of wind tunnel (building D view)

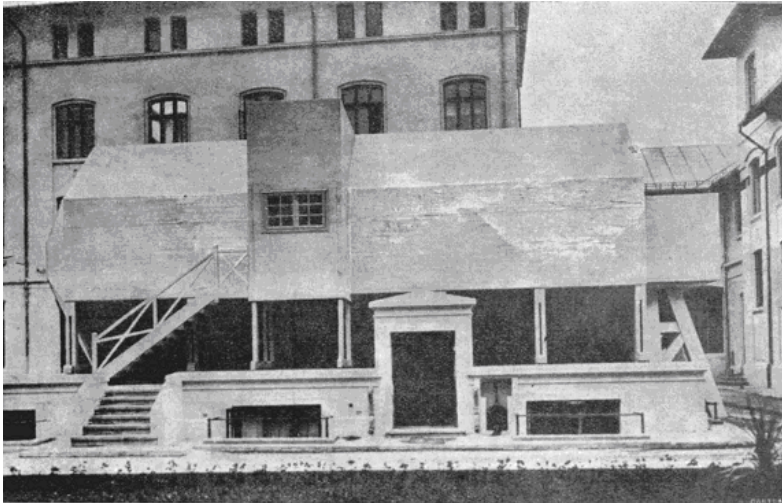


Fig. 2 The wind tunnel, as it looked like in 1931 - View of buildings C and E of the Polytechnic School (Polizu Street), [3]

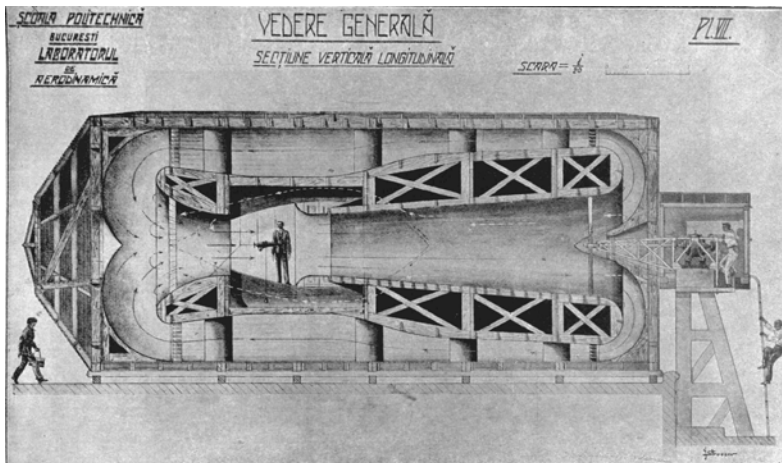


Fig. 3 Longitudinal section of the wind tunnel in vertical plane [3]

The construction included the tunnel itself, and on the basement an office, a library, the workshops, and the materials and models store. The workshops had all wood and metal working machines to build models. All utilities, namely the electricity supply, central heating and mechanical workshops were provided by the common School administration.

Achieving the wind tunnel, at that time, meant overcoming numerous technical and financial difficulties. The Rector of the Polytechnic School at the time, Professor Nicolae Vasilescu-Karpen fully supported the achievement of the wind tunnel, seeing in it a useful investment for education and science, technique and national defense. The official opening of the wind tunnel was held on May 7, 1931, in the presence of HM the King Carol II, HRH. Prince Nicholas, HB. Patriarch Ph.D. Miron Cristea, Prime Minister Professor Nicolae Iorga, Marshal Constantin Prezan, members of government, teachers and students of the Polytechnic School.

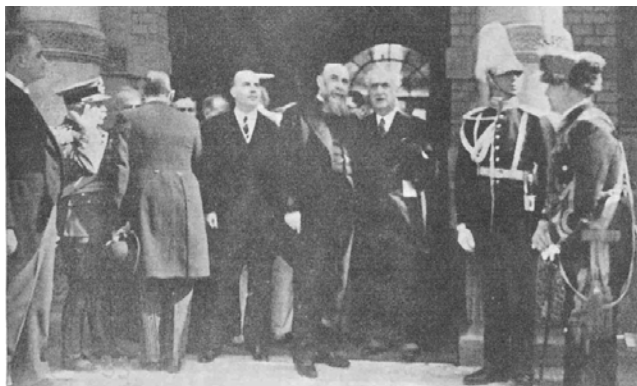


Fig. 4

May 7, 1931 - Members of the Government and the Rector of the Polytechnic School at the Polytechnic School main entrance of Gh Polizu Street, waiting for HM King Carol II to the inauguration of laboratories including the wind tunnel (in the middle, Romanian Prime Minister Professor Nicolae Iorga and Rector Nicolae Vasilescu-Karpen in his left), [2]

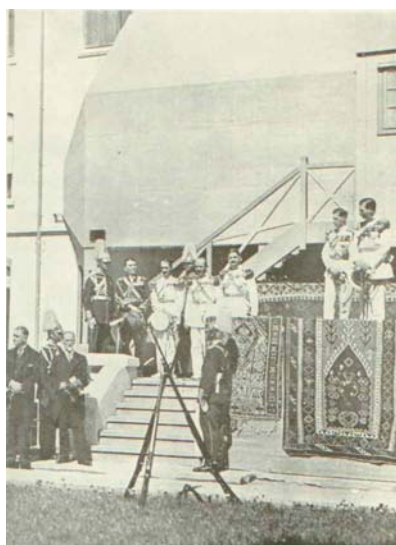


Fig. 5

May 7, 1931 - Inauguration of the wind tunnel. In front of the wind tunnel during the religious services (the first in the upper right corner is HM King Carol II, followed by HRH Prince Nicholas, and the first in the lower left corner is Professor Nicolae Vasilescu- Karpen, Rector of the Polytechnic School), [2]

The first tests in the *Aerodynamics laboratory* were made on models of aircraft wings, engine fairings, landing gears, fairings for land vehicles.

Studied on the effect of wind on buildings were also made and calibrations of anemometers were performed. There were extensive studies on various wing profiles, drawn, in fact, according to the methods given by Elie Carafoli during the preparation of his doctoral thesis.

Early researches carried out in the wind tunnel were published in the first paper of this kind «Travaux du Laboratoire Aérodynamique» written by Elie Carafoli, work that has been a guide for subsequent attempts, serving the Romanian aircraft designers over the years, work published in 1938 by The State Printing House, in the National collection of scientific publications of the Polytechnic School *King Carol II*, Bucharest.

3. THE WIND TUNNEL OF THE POLYTECHNIC SCHOOL OF BUCHAREST. CONSTRUCTION AND PERFORMANCE

The wind tunnel, as seen from the scheme in Fig. 6, is of closed circuit type, with symmetrical return and concentric with the diffuser, experimental chamber and collector.

The experimental chamber section is circular with a diameter of 1.5 m and can be used, depending on experimental requirements, as a closed experimental chamber or with semi-guided flow.

SECTION A-B

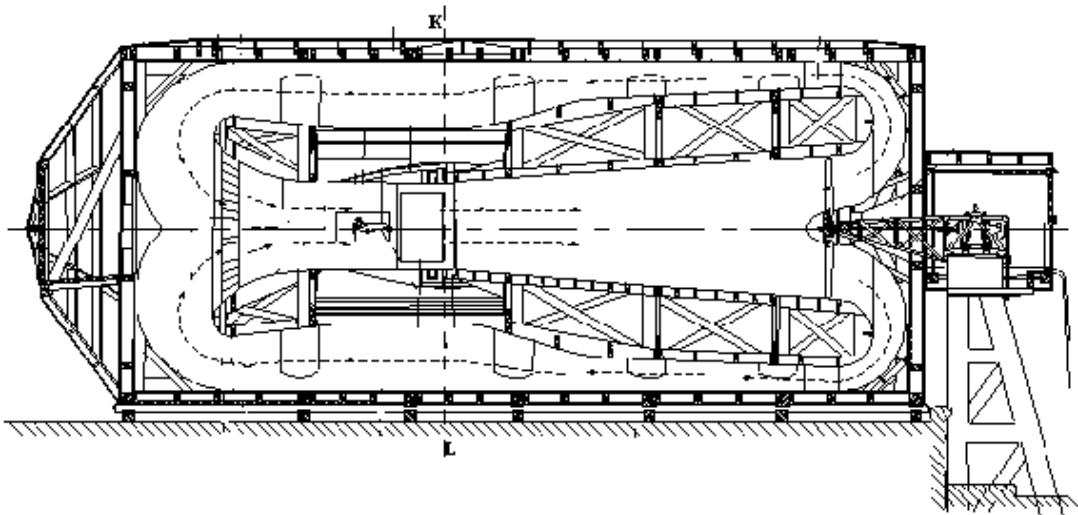


Fig. 6 Longitudinal section in vertical plane through the tunnel axis

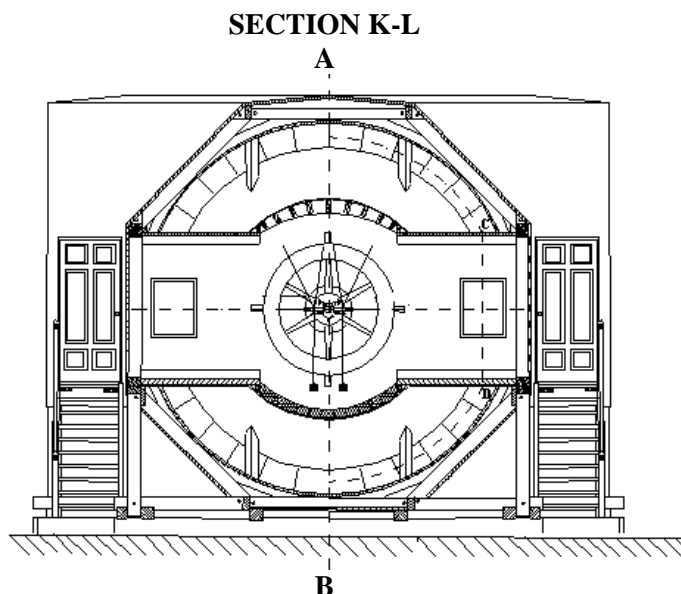


Fig.7 Cross section through the tunnel

The wind tunnel collector has a length of 4.56 m and an entry section of 3.2 m diameter and continues with a test section with an inner diameter of 1.5 m and a length of 2.5 followed by a diffuser having a length of 6.5 m and an exit diameter of 2.55 m. In the enlarged section of the diffuser a 6 -blade adjustable pitch fan is installed which is made of duralumin, has a diameter of 2.5m and is powered by a 40 kW three- phased asynchronous motor. This assembly having a total length of 13.65 m is placed coaxially inside a cylindrical body. Between the outer surface of the assembly and the cylinder inner wall the air return path is formed that is obviously crossed in the region of the test section by a cylindrical housing for instruments and experimenters (see fig 7), and the symmetrical biconvex section. The outer shape of the tunnel is prismatic, octagonal in section having 6.5 m maximum height and 15.235 m total length.

On the exterior side of this prismatic structure there are two small cabins with airtight sealed doors allowing access by side stairs. These cabins communicate with experimenters' room.

To avoid flow separation in the experimental chamber and to reduce the degree of turbulence and the thickness of the boundary layer, a metallic channel connects the upstream of the profiled chamber to the maximum speed experimental section, through an annular chamber communicating through a circular opening with the diffuser junction. In this manner, an automatic suction is provided which is sufficient to avoid the flow separation and reduce turbulence.

On the return circuit, after the fan, a crown made of small radial metal panels was installed to avoid the current deviation effect induced by the fan. A second filter is placed at the collector entry.

The Tunnel described above is built entirely of wood except foundations and support of the electric engine chamber, which are made of concrete. The whole building is covered with painted plate.

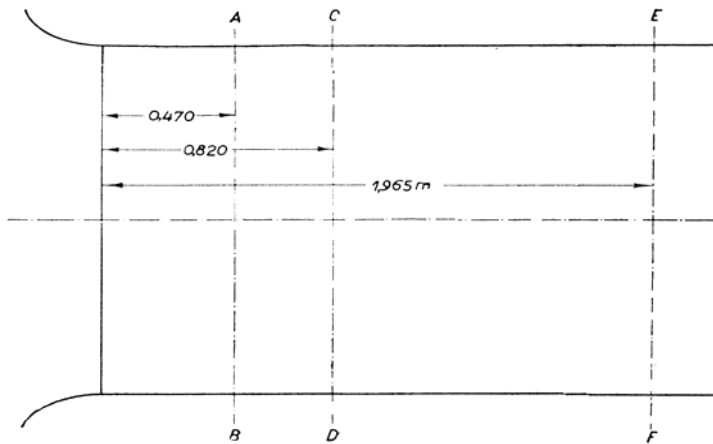


Fig. 8 Experimental chamber and the three sections in which speed measurements were made

In sections AB, CD and EF (see Fig. 8) speed measurements were made horizontally and vertically.

The suction device described above can reduce the boundary layer thickness and allows obtaining a very uniform distribution of speeds, up close to the wall (seeing Figures 9 - 11).

It can be also seen that this uniform distribution is valid throughout the entire volume from the collector exit to the entry into the diffuser.

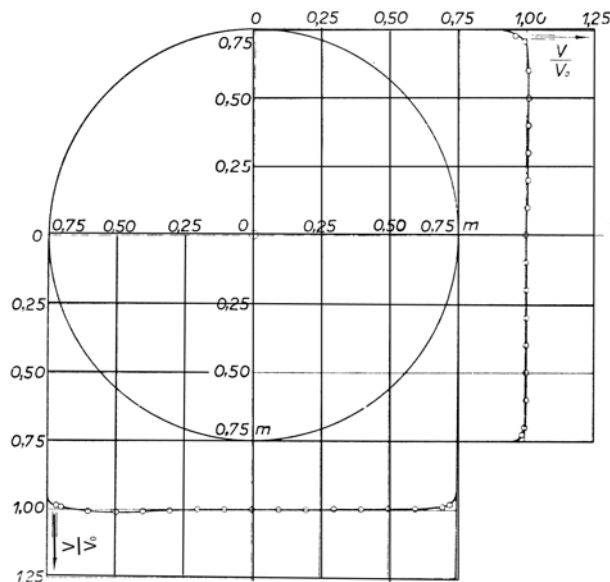


Fig. 9 Speed distribution in section A-B, [1]

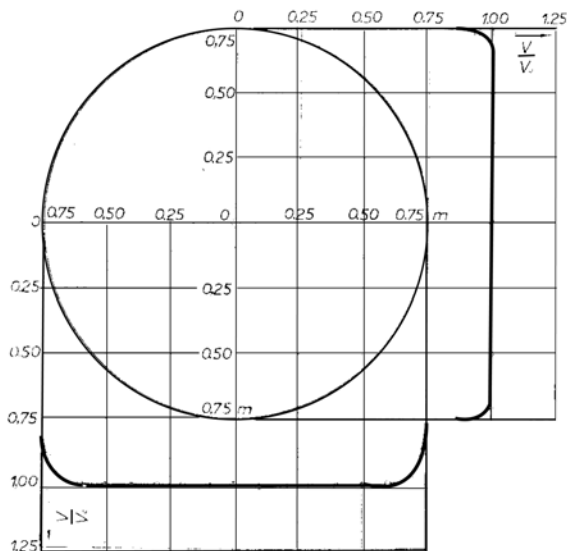


Fig. 10 Distribution of speeds in section C-D, [1]

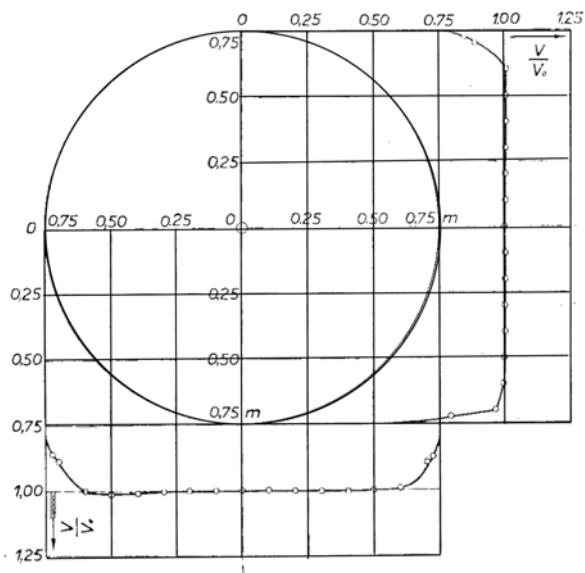


Fig. 11 Distribution of speeds in section E-F, [1]

Aerodynamic balances

Balances in Fig. 12 and Fig.13 are designed to measure forces in the vertical plane as the appropriate momentum. The models are suspended by means of metal wires which are initially stretched by two weights E and E1.

By moving the balance vertically, the approach angle is modified in the two cases. At small incidents, forces on the model are determined with a certainty of 1 to 3 grams.

Pitch balances

To measure the momentum around the center of gravity of an aircraft, a fork-shaped device is used as shown in Fig. 14. This fork allows the variation of the rotation axis passing through the center of gravity, fixed in front side according to experimental need.

The wires connect the models to balances X and Z and are part of balance Zm assembly as shown in Fig. 13 and using, of course, the additional weights E_1 , Fig. 12.

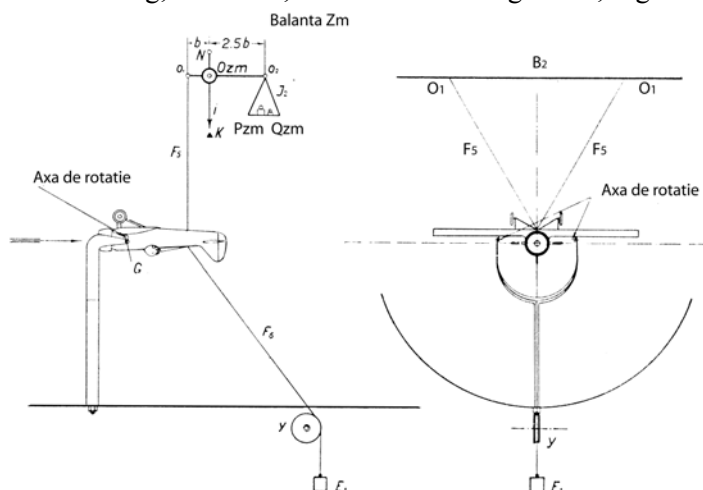


Fig.14 - Rotational balance, [1]

As we can see, the aerodynamic wind tunnel has the possibility of measuring forces and moments using a first order system, but which involves a true art of experimental operation.

Validation of wind tunnel Stroescu-Carafoli from Politehnica of Bucharest

To validate the accuracy of measurements in the wind tunnel, extensive calibration work was required in terms of repeatability of experiments and numerous comparisons with the results obtained in similar facilities.

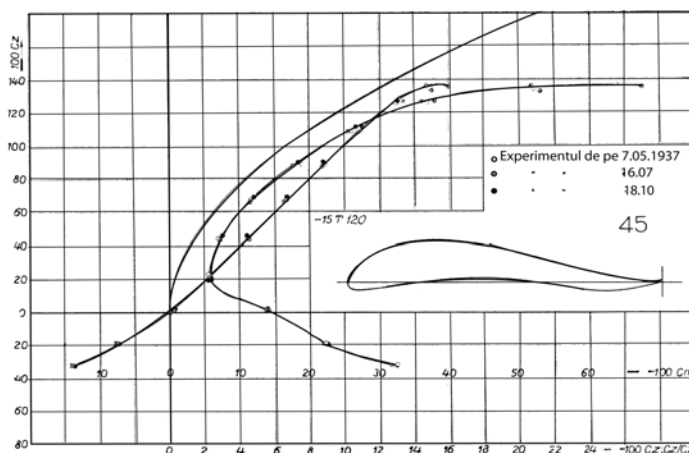


Fig. 15 - Experience carried out on the same model at different times of the year, [1]

Repeatability is very good. Figure 15 shows that the results obtained with the model 45 (the number indicates the profile from the catalog profiles Carafoli) are remarkable in terms of repeatability.

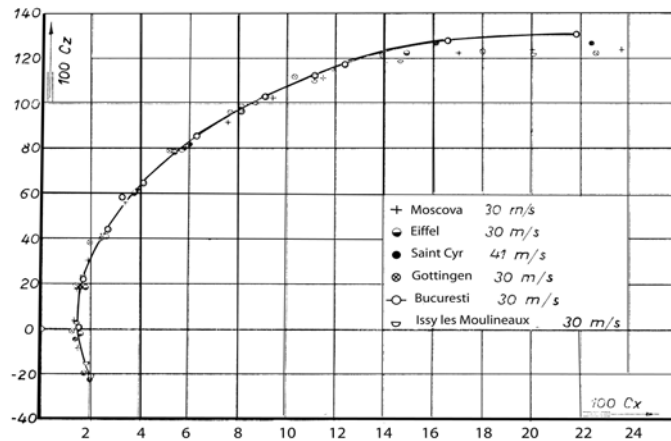


Fig. 16 - Experiences on the same model. Polar [1]

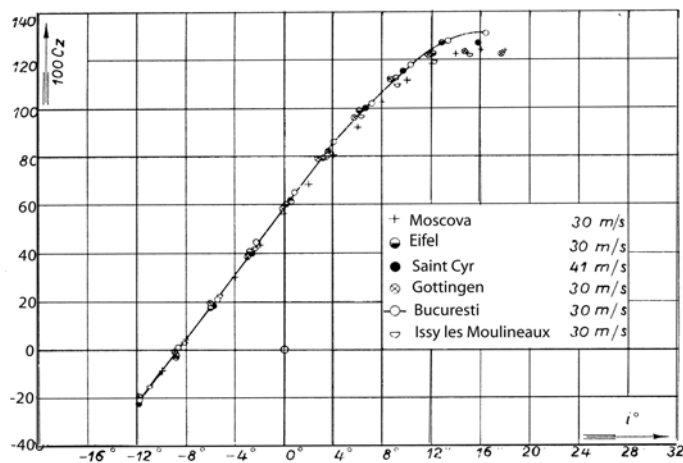


Fig. 17 - Experiences on the same model. Curve $C_z = f(i)$. [1].

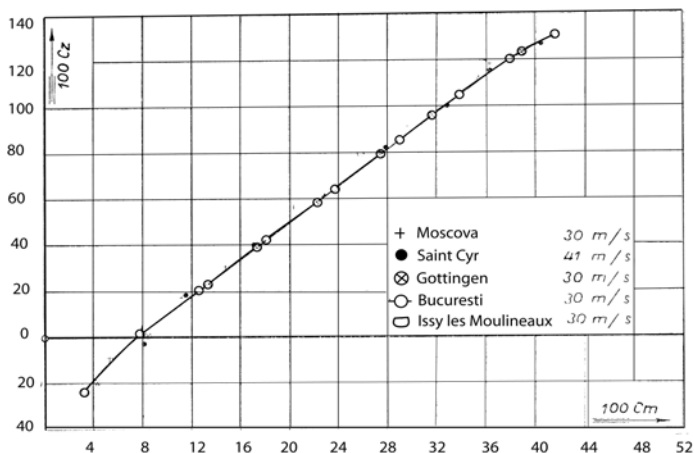


Fig. 18 - Experiences on the same model. Curves of moment [1]

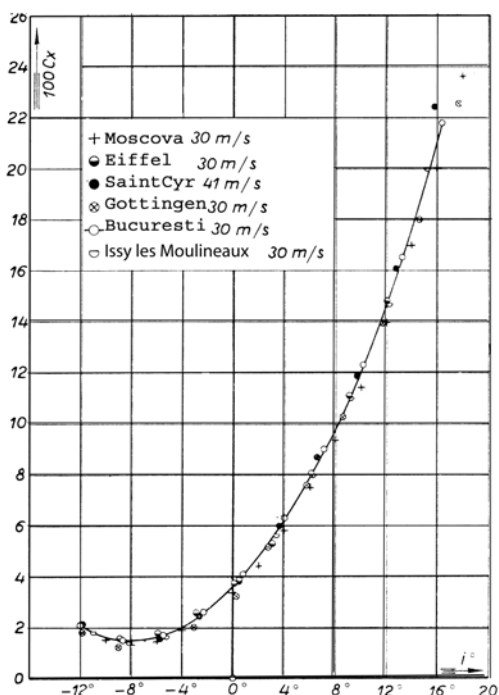


Fig. 19 - Experiences on the same model. Curve $C_x = f(i)$, [1]

Experiments were made on the same model in the wind tunnel from the Polytechnic School of Bucharest and other wind tunnels already established at that time. As shown in Figures 16 to 19, the coincidence of results is remarkable. The wind tunnel Stroescu-Carafoli, thus entered the great family of prestigious aerodynamic laboratories with the aerohydrodynamics lab of the Central Institute in Moscow and laboratories Eiffel, Saint-Cyr, Issy-les-Moulineaux and Göttingen.

During the years 1931-1937, a large number of wings with profiles drawn using Carafoli method were tested in this wind tunnel, thus making a catalog of profiles very useful for manufacturers of aircraft. The catalog is published in paper [1].

4. CONCLUSIONS

Until 1955 this wind tunnel was the only laboratory, both didactic and industrial, where all aircraft built in Romania between 1931 and 1955 were tested. It was and still is a remarkable structure, unique in the world in its own way, thanks to the genius of Ion Stroescu. In fact, the subsonic wind tunnel of the Institute of Applied Mechanics of the Romanian Academy (now belonging to INCAS "Elie Carafoli") bears the imprint of knowledge and skill of the remarkable scientists Stroescu and Carafoli.

In 1942, the aerodynamics laboratory of the Polytechnic School is visited by the famous scientist Ludwig Prandtl.

He was curious to see at home a pleiad of Romanian researchers in the field of mechanics and fluid mechanics and why- not, to see with his own eyes that remarkable building -Stroescu Carafoli wind tunnel- about which he had heard a lot from various scientific sources.



Fig. 20 Ludwig Prandtl's visit in 1942. Photo in front of the wind tunnel
(From left to right, Constantin C. Teodorescu-rector of the Polytechnic School, Elie Carafoli, Ludwig Prandtl, Dionisei Germani, Victor Valcovici, Lucius Saveanu, Ion Carstoiu and Nicolae Tipei)

The wind tunnel is still functional, it has been refurbished, without interfering with the basics; it is now given an invaluable historical and technical value.



Fig. 21 The experimental Chamber in 2009 after reconditioning



Fig. 22 The wind tunnel seen from the outside in September 2011

In the near future removable elements will probably build concerning a minimal automation of measurements, without affecting in any form the original construction, so without lowering its historical the technical value.

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