The Konopacki Brothers as the creators of an innovative shaping method for aircraft plywood. The history of the plywood factory in Mosty 1926-1939

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This article presents activities of the Konopacki Brothers who in the interwar period owned an aircraft plywood factory in Mosty. The method of hot spatial shaping of plywood developed by them allowed significant reduction of production costs of the DH.98 Mosquito aircraft plating from World War II and the elements of aviation equipment, including drop fuel tanks.

Mosty, a small village located at the borderland of eastern pre-war Poland between Grodno and Lida, after more than a hundred years of partition found itself again within the borders of the Republic of Poland as a result of signing the Treaty of Riga in March 1921. The centuries of economic and civilisation backwardness of this territory were overlapped with war destruction and looting. Hope of providing a decent living to the citizens was associated with private initiative and support of the central government. For eight Konopacki Brothers – young and dynamic industrialists who already had experience in wood processing and trade, this lands were the perfect scene. First they built a plywood factory in Pińsk next to the Pripyat river, then in Szczuczyn, and finally in Mosty. These factories were a family venture – some of the brothers were engaged in the production of plywood for various purposes, others kept watch over the production of adhesives in Krakow, or ran supplying points in Warsaw.

In 1925 the brothers Wacław (1885-1950) and Ignacy (1893-1957) established a company under the name Bracia Konopaccy Przemysł Drzewny i Fabryka Dykt [Konopacki Brothers Woodworking and Plywood Factory]. Its share capital amounted to half a million zlotys.[1] They bought thirty-three hectares of land in Mosty, that at that time was located in the Białystok province, and now in Belarus. The factory was launched in 1926. The fact that it still exists proves that the location next to navigable rivers (Neman, Shchara, and Zel'vyanka), near the railway junction of Lida-Grodno, and nearby the Naliboki Forest, the main source of raw

[1] *Rocznik Polskiego Przemysłu i Handlu* 1938.

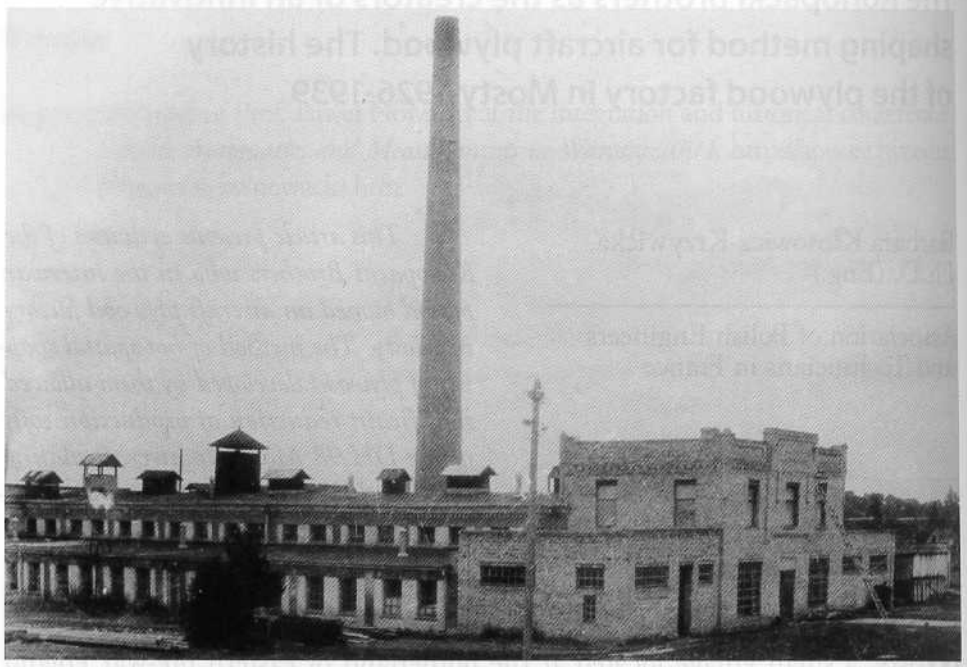


Photo 1. The factory in Mosty in 1928: the administrative building and halls
Source: Konopackis' Archive.

material, was chosen perfectly. The Konopacki Brothers relied on modernity. As a result of their numerous trips to Europe and to North and South America aimed at learning about the manufacturing works over there, the factory was equipped with the most modern machines for the production of furniture and aircraft plywood.[2]

The factory in Mosty was indicated as a model of a successful Polish investment in the Białystok region. As follows from an article in "Tygodnik Ilustrowany" of September 21, 1929: *This factory, due to its purposeful planning, as well as the equipment that is the last word of art, is unquestionably the premier plywood factory not only in Poland, but also on the European continent. [...] Currently, the company produces up to 50 wagons of plywood per month, employing 300 workers in the factory in Mosty and 150 workers in the factory in Szczuczyn. [...] Dry gluing of plywood that significantly improves the plywood quality requires, however, expensive and sophisticated equipment. The factory of the Konopacki Brothers is equipped with such devices, and it allows production of goods of high functional quality. 90% of the production of the Konopacki Brothers factory that, as already indicated, is expressed by the number of nearly 600 wagons a year, is exported mainly to European countries, then to South American republics, to Indies, French and English colonies, and partly to the United States.*[3]

[2] Konstanty Konopacki's letter to his daughter Zofia, January 16, 1929.
[3] *Fabryka Dycht Braci Konopackich*, „Tygodnik Ilustrowany" 1929, No. 38 of September 21.

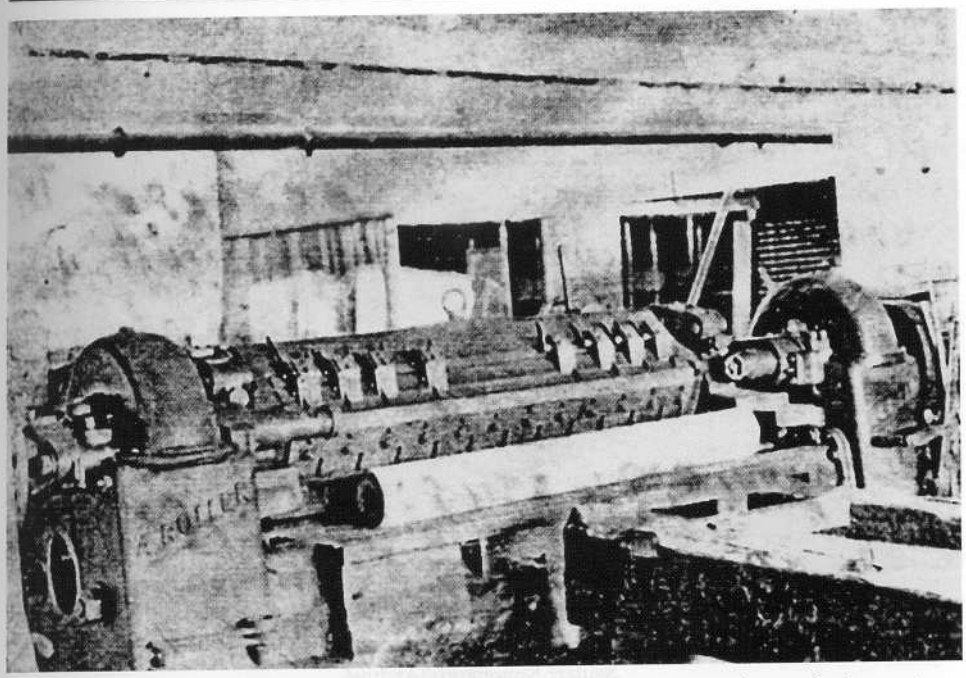


Photo 2. A peeler produced by Roller dedicated to the production of aircraft plywood
Source: Konopackis' Archive.

Reconstruction of the post-war damage created a ready market for building materials. The demand and sales of plywood grew year by year.[4] Therefore, already at the beginning of 1928 the Konopacki Brothers could afford to make large investments. They raised a chimney and installed additional boilers to produce steam.[5] Things were going well until the Great Depression of 1930-1934. During this period the Konopacki Brothers nearly went bankrupt. However, in 1932 the business went well enough to make possible building a new hall with an area of 900 m^2. Everyone worked very effectively until the fire in the factory in 1935.[6] At this time, the Konopacki Brothers company was already considered one of the best investments on the Polish eastern borderlands and the State Bank gave it a long-term amortisation loan for a quick rebuilding. The construction of a modern pavilion with an area of 1020 m^2 was completed in the fall of 1935. In 1937, simultaneously with the reconstruction of the factory, the machinery stock was modernised and the production profile was properly set, which allowed to conduct a strict control of the technological process.[7] In 1936, the factory turnover amounted

[4] Konstanty Konopacki's letter to his daughter Zofia, December 19, 1928.
[5] Konstanty Konopacki's letter to his daughter Zofia, March 15, 1928.
[6] E. Jaworski, *Moje czasy (1910-1952)* [manuscript], Warsaw 1997.
[7] F. Wasiak, *Sprawozdanie z pracy zawodowej* [manuscript], Warsaw, 15.11.1951.

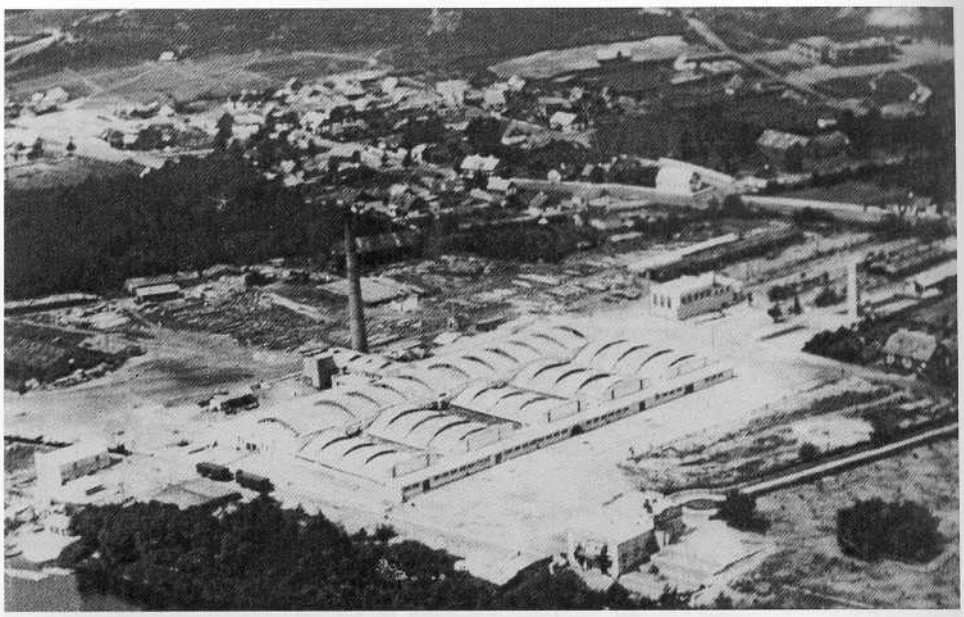


Photo 3. Aerial view of the factory after the reconstruction in 1935
Source: Konopackis' Archive.

to 2,600,000 zlotys, while employment grew to 510 workers and 35 of technical staff. The production included cold pressed wooden furniture, ordinary plywood, waterproof plywood, and aircraft plywood, as well as veneered oak plywood.

The factory had its own representative offices, branches and sales offices in Gdańsk (Eugen Blioch company), Warsaw (Janor company), and Milan, and it represented a German company Th. Goldschmidt A.G. from Essen. The Eugen Blioch agency distributed plywood to European countries: France, England, Ireland, Sweden, Denmark, and Germany, as well as to Canada, Australia, New Zealand, and Mexico. The Konopacki Brothers ran the sales to India, Egypt, and to new markets on their own. The list of companies with which they maintained regular business connections is long, and in Europe itself it includes several items: Amerlach in the Netherlands, Tiss-Kapel in Belgium, Gerolanca-Serolanca in Genoa, Karlin in Rome, Fingerhut und Bauman in Vienna, Kaufman in Berlin, and Jacobcan in Copenhagen.

The main raw material used in the production of plywood was alder (60%) and birch (40%), and oak for furniture. Initially, the factory produced just wet pressed plywood with the use of casein adhesive, and then with the addition of adhesives based on albumin. Until 1938 for the production of high-quality cold pressed plywood the Konopacki Brothers factory used only a bakelite adhesive in a form of film with a thickness of 0.127 mm (0.005"), imported from Germany. The strength parameters of the film were higher than that of wood and twenty five times higher

Co

KOPAK

NALEŻY WIEDZIEĆ

O DYKCIE WODOODPORNEJ

KOPAK

Sklejanej klejem bakelitowym gwarantującym absolutną wodoodporność, elastyczność i odporność na działanie bakterji i termitów.

Produkcji: Firmy

PRZEMYSŁ DRZEWNY — FABRYKA DYKT

BRACIA KONOPACCY

MOSTY I. WOJ. BIAŁOSTOCKIE. TEL. MOSTY Nr. 9.

Zastosowanie sklejki wodoodpornej.

Sklejkę wodoodporną naszej fabrykacji można użyć do budowy łodzi, kajaków i karoserji samochodowych, na wewnętrzne urządzenia kabin parowców, łazienek, klatek schodowych, autobusów, wagonów, kamer suszarniach gdzie temperatura dochodzi do 140° C. i t. p. miejsc, mających bezpośrednią styczność z wodą.

Stosowanie sklejki może mieć miejsce we wszystkich konstrukcjach drewnianych lekkich, tam gdzie chodzi o odporność na wodę i wpływy atmosferyczne. Lotnictwo nasze stosując sklejkę wodoodporną, jako najlepszy materjał do budowy samolotów, hydroplanów i szybowców; wyraża się z wielkiem uznaniem o jej wysokich zaletach technicznych.

Sklejka wodoodporna naszej produkcji zdobyła również zaufanie w klubach wodnych i sportowych, jako najlepszy materjał do budowy łodzi rasowych, turystycznych, żaglówek, motorówek, kajaków i t. p.

Chcąc uprzystępnić szerszemu ogółowi korzystanie z naszych rewelacyjnych wytworów, skalkulowaliśmy ceny sklejki wodoodpornej tak przystępne, by mógł z niej każdy korzystać.

Sklejka wodoodporna produkowana jest w rozmiarze 150×120 cm. w grubościach od 0,8 mm. wzwyż.

Opakowanie: Sklejka pakowana jest w bednarkę w arkuszach ochronnych.

Tabela wagi sklejki

waga 1 m² w kg.

grub. w mm.	Rodzaj sklejki		
	brzozowa	klonowa	olchowa
1	0,85	0,86	0,63
2	1,59	1,61	1,32
3	2,35	2,38	1,99
4	3,02	3,04	2,69
5	3,80	3,84	3,19
6	4,62	4,65	3,95
7	5,39	5,36	4,45
8	6,05	6,08	5,08
10	7,48	7,51	6,26
12	9,00	9,05	7,50

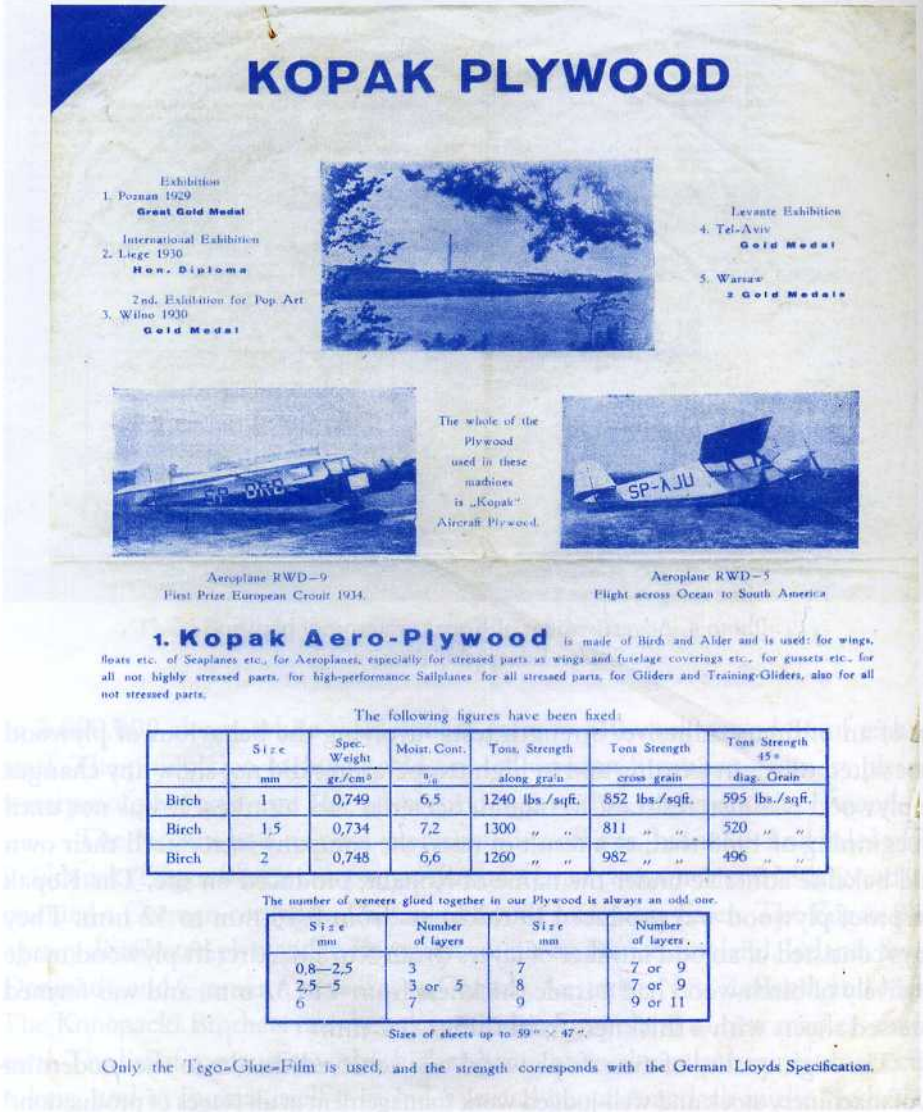
Na życzenie służymy próbami i ofertami.

Photo 4. Advertisement of Kopak waterproof plywood
Source: Konopackis' Archive.

than of an ordinary adhesive. Strength tests involving the behaviour of plywood in hot salted water, in freezing and in high temperatures did not show any changes. The plywood was also resistant to mould, bacteria, and termites. It was not until the beginning of 1938 that, as a result of tests, the company introduced their own liquid bakelite adhesive under the name of Kopalit, produced on site. The Kopak waterproof plywood was produced in thickness from 8/10 mm to 52 mm. They always consisted of an odd number of layers (from 3 to 11). Aircraft plywood made exclusively of birch wood had a trade thickness from 4 to 32 mm, and was formed of pressed sheets with a thickness from 0.15 to 1.2 mm.

The high quality of aircraft plywood was achieved thanks to the modernisation of machinery stock and well-judged work management at all stages of production.[8] At the very beginning, twelve-meter logs delivered by waterway or rail were sorted by a sorter and stored separately based on the quality of wood. The average annual consumption of raw plywood was approximately 30,000 m. In the next stage the logs were rolled to a pre-steaming area where the logs were again sorted with a great precision. The logs of a higher quality, cut into pieces of 130 cm were steamed in heated water pools. The raw material was sent to steamers on the basis of daily operative plans developed in consultation with sale services. The procedure of steaming was aimed at sterilisation and protection of the raw material against cracking, especially

[8] F. Wasiak, *Sprawozdanie z pracy zawodowej* [manuscript], Warsaw, 15.11.1951.



KOPAK PLYWOOD

Exhibition
1. Poznan 1929
Great Gold Medal

International Exhibition
2. Liege 1930
Hon. Diploma

2nd. Exhibition for Pop. Art
3. Wilno 1930
Gold Medal

Levante Exhibition
4. Tel-Aviv
Gold Medal

5. Warsaw
2 Gold Medals

The whole of the Plywood used in these machines is „Kopak" Aircraft Plywood.

Aeroplane RWD—9
First Prize European Croult 1934.

Aeroplane RWD—5
Flight across Ocean to South America

1. Kopak Aero-Plywood is made of Birch and Alder and is used: for wings, floats etc. of Seaplanes etc., for Aeroplanes, especially for stressed parts as wings and fuselage coverings etc., for gussets etc., for all not highly stressed parts, for high-performance Sailplanes for all stressed parts, for Gliders and Training-Gliders, also for all not stressed parts.

The following figures have been fixed:

	Size	Spec. Weight	Moist. Cont.	Tens. Strength	Tens Strength	Tens Strength 45°
	mm	gr./cm³	%	along grain	cross grain	diag. Grain
Birch	1	0,749	6,5	1240 lbs./sqft.	852 lbs./sqft.	595 lbs./sqft.
Birch	1,5	0,734	7,2	1300 „ „	811 „ „	520 „ „
Birch	2	0,748	6,6	1260 „ „	982 „ „	496 „ „

The number of veneers glued together in our Plywood is always an odd one.

Size mm	Number of layers	Size mm	Number of layers
0,8—2,5	3	7	7 or 9
2,5—5	3 or 5	8	7 or 9
6	7	9	9 or 11

Sizes of sheets up to 59" × 47".

Only the Tego-Glue-Film is used, and the strength corresponds with the German Lloyds Specification.

Photo 5. A leaflet advertising the Kopak Plywood company in English
Source: Konopackis' Archive.

in the production of hardwood plywood. For the manufacture of aircraft plywood they used a peeler produced by the Roller company. The quality of veneer was carefully controlled during peeling. If any defect was discovered, the bolt would be sent to other peelers for the production of plywood of an inferior quality. In the case of aircraft plywood substantial thickness of the peeled veneers was 0.15, 0.2 to 1.2 mm.

Veneers for aircraft plywood were dried in a drying chamber. Then, before gluing and pressing, they were stored for a period of about two weeks in special conditioning

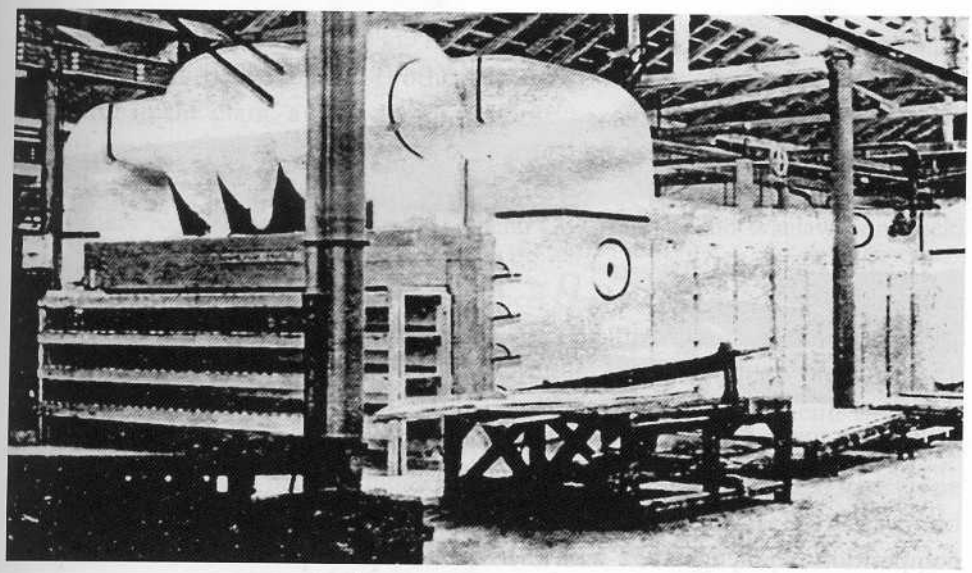


Photo 6. A drying chamber
Source: Konopackis' Archive.

rooms at the temperature of 25° C. There was an important rule for gluing – the central sheets of plywood with a thickness above 0.8 mm were coated with a liquid bakelite adhesive, and the sheets with a thickness below 0.8 mm were layered with a bakelite film. Pressing was carried out at a temperature of 135-145° C. After gluing the sheets were cut, cooled down, polished, and scanned, and the thin sheets of less than 2 mm were additionally moistened. A serious impact on the quality of aircraft plywood had the guidelines developed by the Institute of Aviation and the International Association of Producers and Consumers of Aircraft Plywood.

The factory in Mosty was the only manufacturer of aircraft plywood in Poland. It is estimated that between 1930 and 1939 at least 2,000 planes of wooden or mixed construction (wood and steel) were produced using plywood from Mosty. Moreover, at the same time, 1,370 gliders were built with plywood from this factory as well.[9] The Konopacki Brothers cooperated among others with air workshops at the Warsaw University of Technology[10], where the RWD-5 touring and sports plane was developed, famous for Cpt. Stanisław Skarżyński's flight across the Atlantic, whereas Lt Franciszek Żwirko and engineer Stanisław Wigura won the international

[9] Letter of engineer Andrzej Glass to Barbara Kłosowicz of May 16, 2007. The aircraft was manufactured by the following producers: Lubelska Wytwórnia Samolotów – 600 units, Podlaska Wytwórnia Samolotów in Biała Podlaska – 1150 units, Państwowe Zakłady Lotnicze in Warsaw – 50 units, Doświadczalne Warsztaty Lotnicze in Okęcie – 250 units. The gliders were produced in Wasztaty Szybowcowe in Warsaw, Warsztaty Związku Awiatycznego in Lviv, Lwowskie Warsztaty Lotnicze, Wojskowe Warsztaty Szybowcowe in Krakow, and Śląskie Zakłady Szybowcowe in Bielsko.

[10] J. Wędrychowski, *Rola przemysłu krajowego przy budowie samolotów RWD-9*, „Skrzydlata Polska" 1934, No. 362.

Photo 7. RWD-5 bis SP-AJU on which Stanisław Skarżyński flew across the Atlantic in 1933. All wooden components were of the Kopak brand
Source: A. Glass, *Polskie Konstrukcje Lotnicze*, 1977.

competition Challenge 1932 with the RWD-6 sports plane. The RWD-9 plane of the same series came in first and second at the Challenge 1934.

At the end of 1936 engineer Wacław Czerwiński[11], the known designer of the Żaba and Salamandra gliders, became the chief engineer in Podlaska Wytwórnia Samolotów near Biała Podlaska. At the request of the Aviation Command, he designed together with engineer Zygmunt Jabłoński the twin-engine trainer aircraft PWS-33 Wyżeł. Calculations and some of technical drawings were prepared by a group of employees of the PWS construction office under the guidance of Franciszek Misztal, Ph.D. Eng. It was the first Polish wooden plane of a semimonocoque structure with an elliptical cross-section. The fuselage was covered with birch and bakelite plywood. The curved sheets of plywood were calculated in such a way that depending on the degree of curvature they could be used for covering both the sides and the top of fuselage. At the end of 1937 the Konopacki Brothers' factory undertook production of these elements. Sheets of plywood softened with steam were then shaped on hot forms. With the right arrangement of directions of the wood grains it was possible to obtain spatially complex shapes.

The prototype was presented already in November 1938 at the 16 International Air Show in le Bourget near Paris. Apart from the Wyżeł, the following planes were presented there: the PZL P-46 Sum, the PZL-44 Wicher, the PZL M-20 Mewa, the PZL-38 Wilk, the PZL-37 Łoś. The French aviation press, showing a photo of the PZL (PWS-33) Wyżeł wrote[12]: *The stall of the Polish industry stands out both in terms of quality and variety of aircraft types. One example is a twin-engine fighter-diver*[13] *and a twin-engine trainer aircraft.*[14]

[11] A. Glass, *Polskie konstrukcje lotnicze 1893-1939*, Wydawnictwa Komunikacji i Łączności, Warsaw 1977, p. 210-211.
[12] Musée de l'Air et de l'Espace le Bourget: Dossier XVI Salon Aéronautique 1938, coupure presse.
[13] PZL-38 Wilk.
[14] PZL (PWS-33) Wyżeł.

Already on September 4, 1939 the Luftwaffe bombed the Podlaska Wytwórnia Samolotów and the Konopacki Brothers' factory. The first prototype of the Wyżeł was burnt in the plant, and the second prototype, that was stored at the Okęcie Airport, was captured by the Germans and taken to Berlin, where it was destroyed. The Konopacki Brothers' factory was taken over by the Soviets on September 17, 1939. Ignacy Konopacki escaped to the General Government, and Wacław Konopacki was sent to a labour camp near Karaganda.[15]

Many Polish aviation designers, engineer Czerwiński among them, managed to escape through France to the UK. After the occupation of France by the Germans and due to the growing threat of German bombing of the UK, there was an urgent need to move the aviation production to the US American continent. Branches of British companies in Canada were a natural place to continue the previously started work. Since there was a need to find experienced technical staff, Polish engineers were sent to Canada. The first group of Polish experts with engineer Wacław Czerwiński arrived in Toronto in March 1941.[16] When in mid-1942 the preparations began for the production of the multi-role DH.98 Mosquito combat aircraft, designed by the parent company de Havilland in the UK, with a covering made of a deficient aluminium, the experience of Polish engineers in the field of wooden structures gained in the interwar period turned out to be a great facilitation. Wooden aircraft plywood covering produced by means of technology similar to the Polish one was used in the mass-produced Mosquito planes, following the example of the Polish Wyżeł. The airframe, commonly used on many fronts of World War II, was one of the few aircraft constructed almost entirely of wood and was nicknamed "The Wooden Wonder". It was part of the equipment of No. 307 Polish Squadron (City of Lviv Polish Night Fighter Squadron), which was based in the UK in 1940-1945.

The success of the technology consisting in making aircraft plating of plywood instead of strategically important aluminium was an inspiration to the use of this method for the production of other aircraft components as well. In 1942, the Canadian Wooden Aircraft Ltd. was established in Toronto with the use of the US capital. Czerwiński became the chief engineer and production manager, and the employees were mostly Poles, who already had several years of experience in the field of spatial shaping of plywood. In the period of 1942-1945 many thousands of aircraft parts were produced from plywood, e.g. spare fuel tanks for the Mosquito night fighters and air intakes for engines of the Anson aircraft. After the cessation of hostilities and completing the task, the company was terminated.

Technical press of the interwar period gave little information about the Konopacki Brothers' factory of plywood. Engineer Andrzej Glass only mentions this plant in his monograph *Polskie konstrukcje lotnicze 1893-1939*, published in 1977. The glory days

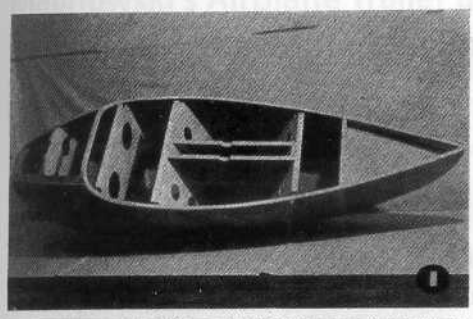
[15] B. Kłosowicz-Krzywicka, *Konopaccy z Fałku*, published by the author, Warsaw 2012.

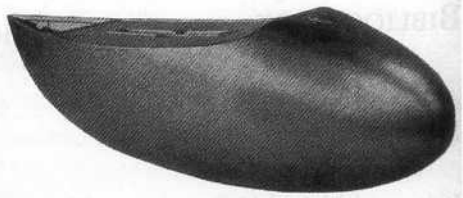
[16] J. Płoszajski, *Technicy lotnictwa polskiego na Zachodzie 1939-1946*, Z.P. Poligrafia, Warsaw 2007.

Photo 8. The PZL (PWS) Wyżeł aircraft exhibited at the 16 International Air Show in Le Bourget in December 1938
Source: Musée de l'Air et d'Espace, Le Bourget.

of the factory did not last long – World War II proved to be its turning point. Its fate was determined by the history.

The author of this paper would like to express her heartfelt thanks to the Director Jan Tarczyński and the organisers of the conference during which she had an opportunity to present fragments of technical thought of the Konopacki Brothers who, unexpectedly even for themselves, thanks to Wacław Czerwiński in Canada, contributed to the victory of the Allies in World War II.





Tanks of Wood

FORMED in September, 1941, by Dr. H. Stykolt and W. Czerwinski, Canadian Wooden Aircraft Limited employs some 400 men and women in the construction of external tanks, tail cones and alcohol tanks for the Mosquito.

Mr. Czerwinski, chief engineer, had considerable experience with wooden construction in Poland before the war, and was a noted glider designer.

The gas tank, which mounts in the standard wing bomb fitting, is perfectly streamlined and an outstanding example of forming wood into a difficult shape.

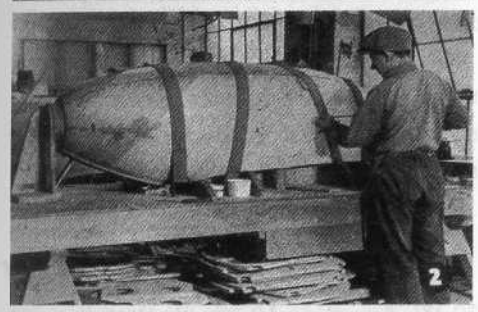
First part constructed is the centre section which supports the tank, and the baffle framework. The three-ply skin is formed into shape under heat and pressure and then fastened to the framework.

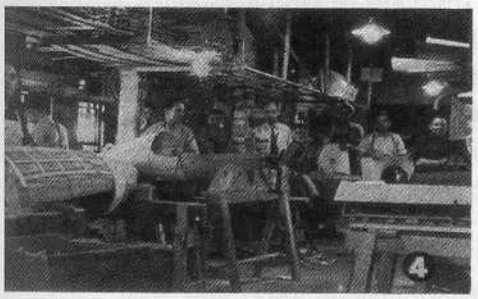
Finished tanks are tested under pressure and flushed with a plastic flushing compound which liquidproofs the interior. Exterior finish follows standard practice with special care being taken to make the skin friction as small as possible.

The tail cone, which bears no structural load, is formed from molded plywood and strengthened with light ribbing and a circular form shown in the photograph.

The alcohol tank is of simple barrel construction, formed of plywood, flushed with plastic compound and tested under pressure. Gas tanks and alcohol tanks leave the factory complete with fittings and ready for service.

1. Showing bracing and baffles of tank; 2. Fastening the skin; 3. Finishing outer surface; 4 and 5. Making tail cones.





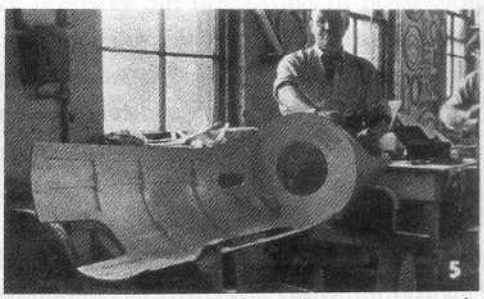


Photo 9. An article from Canadian press describing the production of wooden aviation tanks in the Canadian Wooden Aircraft Ltd.
Source: Andrzej Glass' collections.

Bibliography

Sources:

Konopackis' Archive:
Correspondence of Konstanty Konopacki and Zofia Konopacka from the years 1927-1930;
Letter of engineer Andrzej Glass to Barbara Kłosowicz of May 16, 2007;
Wasiak Feliks, *Sprawozdanie z pracy zawodowej* [manuscript], Warsaw 1951.
Musée de l'Air et de l'Espace le Bourget:
Avion P25, Dossier 12 PZL Wyzel : Photo PZL_WYSEL ; *Avion d'entraînement « WYŻEŁ » (Braque)*, Etablissement Nationaux d'Aéronautique PZL; Dossier XVI Salon Aéronautique 1938, coupure presse.

Non-serial publications:

Glass A., *Polskie konstrukcje lotnicze 1893-1939*, Wydawnictwa Komunikacji i Łączności, Warsaw 1977;
Kłosowicz-Krzywicka B., *Konopaccy z Fałku*, published by the author, Warsaw 2012;
Płoszajski J., *Technicy lotnictwa polskiego na Zachodzie 1939-1946*, Z.P. Poligrafia, Warsaw 2007;
Rocznik Polskiego Przemysłu i Handlu 1938, Warsaw 1938.

Serial publications:

Fabryka dycht Braci Konopackich, „Tygodnik Ilustrowany" 1929, No. 38 of September 21;
Mortkowiczówna H., *Wieczór w Mostach*, „Bluszcz"1930, No. 35;
Wędrychowski J., *Rola przemysłu krajowego przy budowie samolotów RWD-9*, „Skrzydlata Polska" 1934, No. 362.

Unpublished materials:

Jaworski E., *Moje czasy (1910-1952)* [manuscript], Warsaw 1997.