# POLISH FLYING EXPERIENCE WITH TAILLESS GLIDERS

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SUMMARY

The tailless aircraft named "Lotnia" was the first ship designed by Polish flying pioneer Czeslaw Tanski in 1894. Then followed:

- "Dziaba" designed by Stanislaw Malinowski, 1923
- JN-1 "Zabus" designed by Jaroslaw Naleszkiewicz, 1931
- SZD-6x "Nietoperz" designed by Wladyslaw Nowakowski and Justyn Sandauer, 1951
- SZD-20x "Wampir 2" designed by Jan Dyrek, 1959
- AV-36 CR designed by Charles Fauvel. This ship was bought from Austria for comparison studies.

The regular flight test reports were available for the last three types mentioned above only, so their flying properties could be described.

SZD-6x "Nietoperz" was tested in three variants having different yaw control system arrangements. More than 50 flying hours were completed during the factory tests. Now "Nietoperz" is displayed in the museum. SZD-20x "Wampir 2" was destroyed in a flutter case accident in its 14th flight. Box

SZD types, with swept-back wings, were very sensitive in the turbulence in the wake of the towing aircraft. AV-36CR obtained a Polish C of A and is used even today by the Student Flying Club of the Technical University, Warsaw, with its straight wing, it has behaviors rather similar to that of conventional ships.

All types showed a tendency to non-damped short-period pitching oscillations in gusty conditions. This limited the thermal flying tests considerably.

Now these three tailless gliders belong to history. None of them meets the requirements for acceptable flying properties and performance.

The rapid development of conventional sailplanes has pushed the tailless concept aside. To smooth this conventional- ships domination, the idea for designing the modern tailless models like SB-13 arose.

**PHOTO 1.** SZD-6x


**PHOTO 2.** SZD-20x. Elevator deflected upwards when stick is pushed forwards!

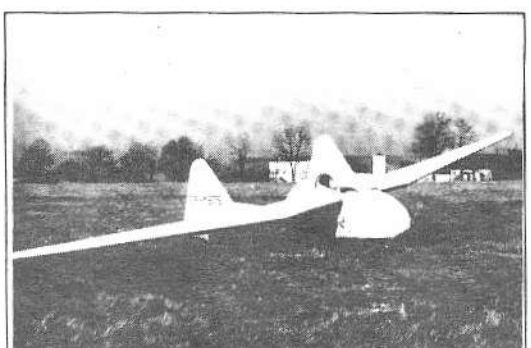

**PHOTO 3.** AV-36 CR

**Table 1**
**Numerical Data**

| | | Lotnia I | Lotnia III | Dziaba | Zabus | Nietoperz | Wampir |
|---|---|---|---|---|---|---|---|
| Span | m | 8-6-110 | 10.8-11 | 6.75 | 17.g | 12.0 | 15.0 |
| Length | m | 2.2 | 3.6-3.8 | 5.0 | 3.0 | 5.05 | 3.g |
| Wing area | m2 | 7 | 12 | 15 | 16.8 | 14.4 | 15 |
| Aspect ratio | | | | 3 | 19 | 10 | 15 |
| Wing profile | | | | | | 23012 | 23112 |
| Empty mass | kg. | 15-18 | 20-25 | - | 136 | 196 | 175 |
| Load | kg. | 60-65 | 60-65 | 70 | 75 | - | - |
| Mas. mass | kg. | 75-80 | 80-90 | 115 | 211 | 269 | 250 |
| Wing loading | kg/n2 | 11.5 | 7 | 8 | 12.5 | 18.7 | 16.7 |
| Load factor | | - | - | - | - | 6.5 | 6.5 |
| Glide ratio | | - | 00.4 | - | 16 | 17.5 | 24.4 |
| Min. sink | m/s | - | 00.2 | - | 0.8 | 1-35 | - |
| Never exceed speed length- | | | - | - | - | 300 | 200 |

## 1. HISTORICAL INTRODUCTION

The history of tailless gliders is as old as the history of gliding itself. In the pionerr hang gliding times some of the ships use this principle, among them the original design of the Polish flying pioneer Czeslaw Tenski, the "Lotnia" (FLIER)" (Figure 1). Czeslaw Tenski was a painter but he had exceptional technical abilities. He experimented at the same time as Otto Lilienthal and was in correspondence with him. The first "Lotnia" constructed in 1894 allowed the tailless conception to be tested in practice. Later, it was equipped with a small tailplane and further changes were made to the stabilizing surfaces for better trim.

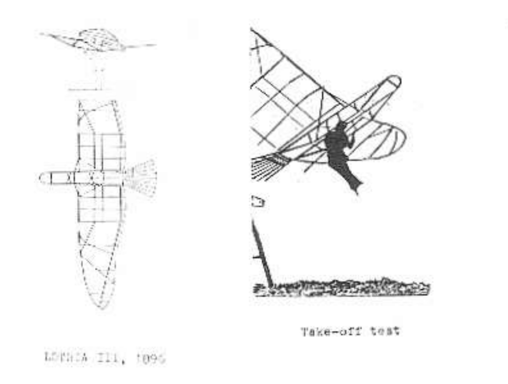


**FIGURE 1.** Lotnia tailless glider designed by Czeslaw Tanski.

The "Dziaba" (FROGGY) (Figure 2) designed by Stefan Malinkowski, 1923, had a wing of great area and maximum profile thickness of about 50 cm (20 in.). Take off was by the pilot running. Control was by means of variation of profile camber and thickness on right and left wings separately for rolling and on both wings simultaneously for pitching. The pitching could also be adjusted by means of a forward extended "wind detector." It could also allow for dynamic soaring in gusty conditions. Stefan Malinowski declared his entry in the Gliding Competition At Bialka near Nowy Targ, but when ready for take off the glider was lifted by a strong gust and destroyed completely, so this original concept could not be flight tested.

The first tailless model on which some flight tests were

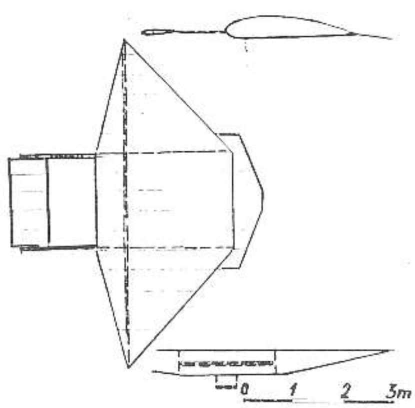



FIGURE 2. Dziaba tailless glider(designed by Stefan Malinowski) with wind sensor and control by means of profile variation, 1923.

performed in Poland was JN-1 "Zabus" (PIGGY) (Figure 3) designed by Jaroslaw Naleszkiewicz, 1931. This concept embodied the ideas created by Prof. A. Lippisch. JN-1 had a wing of trapezium planform, a high span of 17,9 m and high aspect ratio of 19. The aileron and elevator were located along the wing trailing edge. The rudder surfaces used also as air brakes, were installed on the wing tips; right and left were deflected independently. The closed canopy was a novelty at that time.

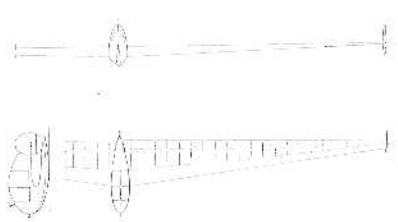

FIGURE 3. JN-1 Zabus designed by J. Naleszkiewicz, 1931.

The first flight was made in June 1932 at Deblin airfield by Captain Franciszek Jach. Bungee take off was used initially, then motor car tows. The results were, however, not satisfactory. Too high elevator sensitivity and violent stalling led to serious damage that stopped further testing.

While those tailless models did not give epochlike results, they made an interesting contribution to the history of flying wings.

The next chapter of this story was written in the early fifties by the SZD factory at Bielsko-Biala. Principal data for all types are given in Table 1.

## 2. SZD-6x "Nietoperz" (BAT) (Figure 4)

### Description

Mid-wing arrangement. Swept forward inner wing integral with fuselage. Swept back outer wing panels. Wooden structure. Alternative yaw control arrangement were provided (Figure 5), changes from one to another requiring only a few hours.

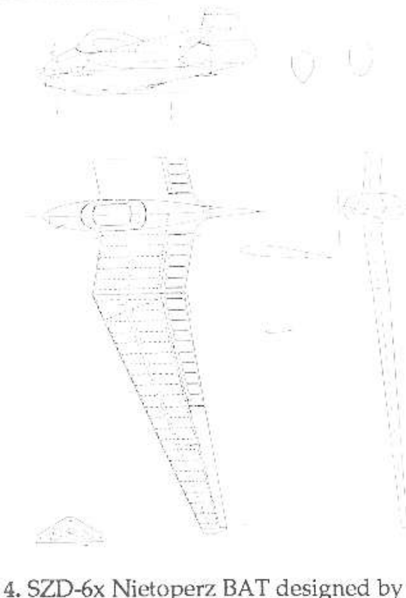

FIGURE 4. SZD-6x Nietoperz BAT designed by Wladyslaw Nowakowski and Justyn Sandauer, 1950. Maiden flight at Katowice, January 5, 1951, flown by test pilot Adam Zientek.

Variant I: The glider was equipped with a normal foot actuated rudder. The other control surfaces were located on the wing trailing part namely:

- lift flap (F) on the central wing part controlled by a hand wheel,
- combined aileron/elevator surfaces AE1 and AE2 on the outer panels with different deflections in 1:2 ratio. A separate lever actuated the outer ones to 90 degree deflection as air brakes, the aileron/elevator action remaining.

Variant II: The rudder was fixed as a fin, yaw being con-

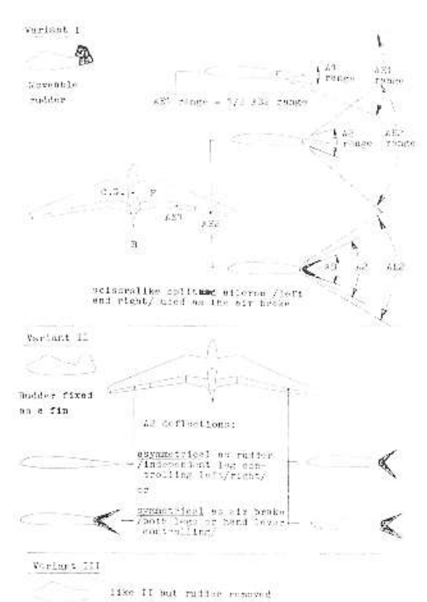

FIGURE 5. SZD-6x Control system variants.

trolled by asymmetrical (on one wing only) deflection of aileron/elevator. Pedals were operated independently to right and left. For air braking either both pedals simultaneously, or a hand lever, were used.

Variant III: As variant II, but the rudder was removed.

**Flight testing**

In view of the lack of experience of tailless gliders at SZD, the maiden flight of "Nietoperz" was prepared very carefully. The tests started with many short winch launches of 1-2 to 10 m of altitude covering distances up to 300 m. to determine basic flight properties before allowing aero towing. One short aero tow was then made to 2 to 3 m of altitude, at which the cable was released, simulating it being suddenly broken in normal operation. In the first proper aero tow something went wrong. When the glider entered the towing airplane turbulent wake after being initially above it, it pitched suddenly to the ground, then jumped up, lost airspeed and dove down. The fuselage front part and right wing were severely damaged. After repairs the tests were continued meeting no more problems. First, several short winch launches up to about 20m of altitude were made. Then the normal aero towing up to 2000m of altitude allowed the regular flight testing to start.

During these factory tests on variant I nearly 50 flying hours and a distance of more than 1000 km in many aero towed transportations were completed. In September 1951 the glider took part in a great Flying Show at Warsaw.

Variant II performed 6 wing launchings and 1 aero tow and variant III 3 aero tows.

In all the factory tests the glider was flown by one pilot only. Other pilots were allowed when all the tests had been completed.

Now the ship is in the Aviation Museum, Cracow.

**Special flying behavior**

Variant I:

- Unpleasant pitching on the ground run in take off and landing due to the curved skid.
- Poor scarcely noticeable flap effect.
- Very sensitive elevator producing vigorous response even for small deflections. Too sensitive in gusty conditions especially at rear c.g. location.
- Distinct short period pitching oscillation without control stick action and not noticeable without instrumentation. The estimated frequency was of about 2 Hz.
- Dangerous non-compensable tendency for nose-heavy pitching as a consequence of entering the towing airplane turbulent wake. Every entering into it led to a dive through and below this zone. It was the reason for the damage at the first aero tow. For the explanation see Figure 6.
- Positive static and dynamic longitudinal stability. The phugoid period was 11.5, 16 and 20 seconds at 75,90 and 120 km/h respectively.
- Astonishing ability to control the pitch by means of pilot's body position in cockpit (body movements forward and backwards as far as the back belts allowed). The resulted c.g. travel was about 1 cm. Unlike other gliders "Nietoperz" could be, in smooth air, controlled in aero towing with the stick free using the movements of pilot's body upper part only. It was even possible, though difficult, to fly above and below the airplane wake and to pass this zone in a dynamic way hands off, small aileron corrections being made by knocking the stick with the knee. The trimmed airspeed range obtained by the c.g. travel was 72-110 km/h. (Pilot of 75 kg).
- Poor aileron efficiency in the smooth air and unsatisfactory in gusty conditions.
- Strong negative (adverse) aileron yawing moment created problems in aero towing, especially in gusty conditions.
- Short-time action of aileron when not aided with rudder resulted a weak roll. With prolonged aileron deflection the bank slowly reached 20 degrees and then during about 3 seconds, the glider yawed into the direction opposite to the bank. In consequence the bank returned to zero; it then developed further in the original direction, the glider now circling that way more and more steeply until it entered a spiral dive (Figure 7).
- Precise straight flight controlled with aileron only (rudder free or locked) was difficult.
- Yawing was generally controlled with the rudder in a satisfactory way in smooth air. In gusty conditions it was unsatisfactory especially when compensation of towing

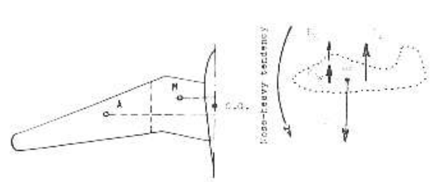

FIGURE 6. SZD-6x. Nose heavy behaviour inside the towing airplane turbulent wake as a consequence of the lift decrement on the central wing p[art being in the turbulent airflow. $P_A$-lift on the central wing part; $P_M$-full lift on the central wing part before thedisturbance; $P_{MW}$-lift on the central wing part decreased by the disturbance.

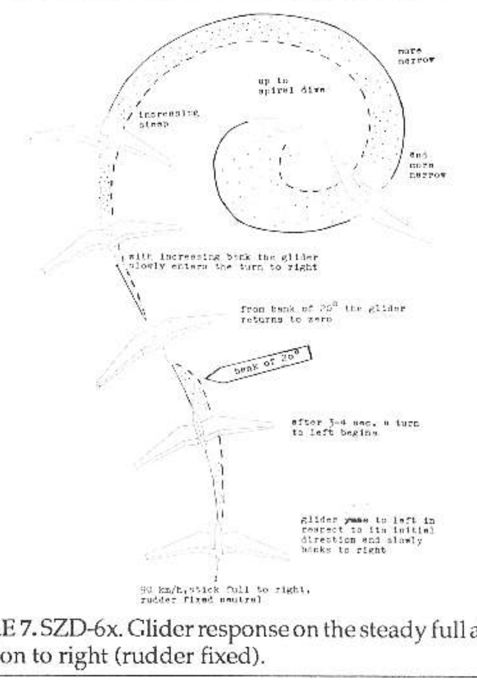

FIGURE 7. SZD-6x. Glider response on the steady full aileron deflection to right (rudder fixed).

cable side surgings was necessary.
- Bank reversal time, when both rudder and aileron were used, was about 4,4 sec. at 90 km/h airspeed (normal value for gliders).
- Side slip was possible up to 10 degrees bank for aileron fully and rudder partly deflected. Full rudder deflection resulted in a turn opposite to the bank.
- Considerable lateral instability with rudder free. At 100 km/h the yawing oscillations had a period of about 4 sec. associated with about +/- 30 degrees bank and about +/ - 15 degrees yaw.
- Good air braking effect of slotless aileron. The control force increased in line with increasing deflection. On the ground run a slight tendency to nose up motion appeared.
- Stalling was possible with the rear c.g. limit only. The stalling speed was about 65 km/h.
- Spinning was impossible at all tested c.g. locations.
- Diving up to 210 km/h airspeed were performed. With the airbrake (split aileron AE2) the value of 190 km/h was reached. The rather high stick force made diving difficult.
- Initial airspeed necessary to perform loops was 170 km/h. Pull out stick forces were rather high. The stick movement had to be slow to avoid the pitching oscillations. When at the top of a loop the airspeed was too slow, the glider hung in the inverted position. After some time, considerably longer than for the conventional gliders, the ship pitched rapidly and unpleasantly into the normal flying attitude, then dropped nose down owing to insufficient airspeed.

Because of the low performance and flying difficulties in gusty conditions most of the thermal flying tests were useless. The maximum gain of height in a thermal was only 150 m owing to the tendency to pitching oscillation and the poor aileron efficiency making control difficult.

Variant II:
- Controllability, aerobatics included, was nearly the same as for variant I.
- Yaw control was satisfactory although difficult with the separate pedal deflections because of ergonomic reasons. The pulling leg force applied to the pedal necessary to support the closing spring was too weak and the aileron was not fully retracted.

Variant III:
- In steady straight flight aileron deflection (without rudder) led to the following result:
  - small, relatively vigorous nose down pitching,
  - entering a turn opposite to the aileron deflection,
  - banking opposite to the aileron deflection (increasing to steep circling).
- In aero tow small aileron deflection (without rudder) caused slight directional deviation and banking, both opposite to the aileron. Every attempt to correct by means of more aileron only made matters worse. The very poor aileron efficiency made it possible to control the glider mainly using the yaw effect of the slotless aileron.

**General Appreciation**

Variant III, without the central rudder, was considerably more difficult to control in yaw by means of the asymmetric action of one aileron only than the previous variants with rudder or fin. The main reason was the negative aileron moment.

Further development of this variant would have required great improvement of aileron efficiency and elimination of the negative moment.

### 3. SZD-13x "Wampir" (VAMPIRE) and SZD-20x "Wampir 2" (figure 8).

On the basis of the experience gained with "Nietoperz" the SZD factory at Bielsko-Biala returned in 1955 to the tailless concept.

The new model SZD-13x "Wampir" designed by Irena Kaniewska employed the laminar 6-H-15 wing profile. The swept-back wing was arranged in the mid position. Two vertical tail surfaces were installed on the wings.

This design was not actually built but provided many general ideas and technical background for its successor namely SZD-20x "Wampir 2" (Figure 8).

**Description:**

Experimental tailless glider. Mid-wing arrangement. Trapeze planform of the swept back wing. Wooden structure. Fuselage of egg-shaped cross section integral with the wing central portion. The undercarriage comprised main wheel aft of the c.g. and twin nose wheels with solid rubber tires. Towing hook in the fuselage nose. Two part elevator on the wing central portion adjacent to the fuselage. Two anti-balance tabs and rubber cord trimming device. Increased elevator action by means of aileron coupled for pitching with control stick by means of continuously adjusted clutch. The slotted aileron mass balanced, compensated, with no differential. Two considerably swept back vertical tail surfaces installed at 70 percent of wing semi span. Air brake located between the vertical tail surface and elevator.

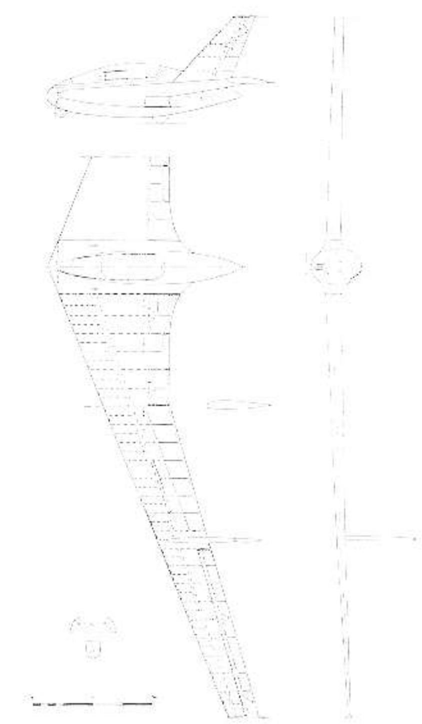

FIGURE 8. SZD-20x. Wampir 2 designed by Jan Dyrek, 1959. Maiden flight, Katowice ,1959 by test pilot Adam Zientek.

**Special Features:**

-Unconventionally small wing/ground clearance. The wing tip to surface distance was 53 cm only, corresponding to 4 degree bank when touching the ground.

-Outstanding elasticity of the wing. The eigenvibrations of frequency 128 per minute gave the period of 0,47 sec.

-Inverted elevator deflection when compared with standard sailplanes. With the stick pulled back, the elevator is deflected downwards but the glider response is correct i.e. the fuselage nose lifts above the horizon (Figure 9).

against the canopy forwards and backwards. Disconnection of the aileron/elevator coupling did not eliminate the pitching. When a safe altitude was attained, the pilot got some degree of familiarization. In every case it was possible to retain the necessary height distance above the towing aircraft turbulent wake. At 1800 m and at 11o km/h airspeed this height margin was slowly reduced and when the glider entered the airplane wake it sank into it briskly. The towing cable swung dangerously above the wing, so it was necessary to release.

In free flight the glider flying behavior was found to be satisfactory. When the aileron/elevator coupling was disconnected, the control sensitivity decreased but the stick had to be pushed nearly fully forward. Extending air brakes tended to stall the ship.

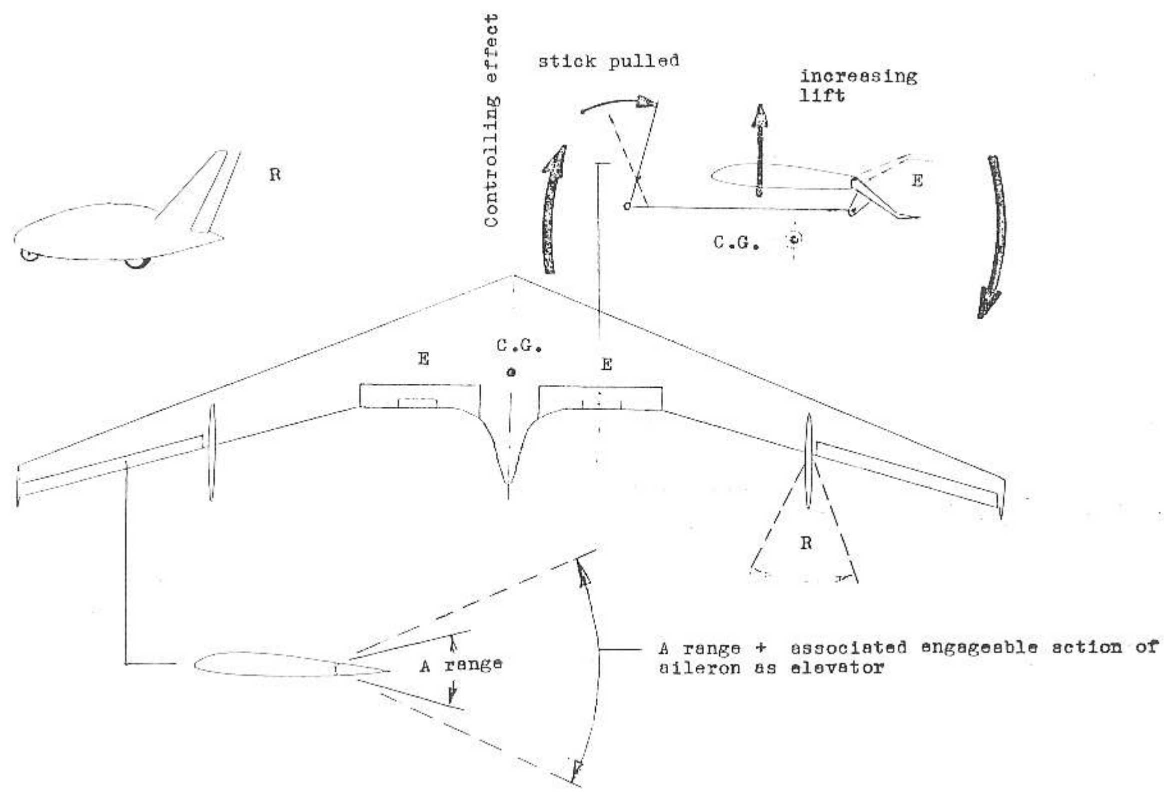


FIGURE 9. SZD-20x. Controlling.

**Flight testing**

Before the first flight, several short hops free of towing airplane turbulent wake were necessary. With respect to the small wing tip to ground clearance, a concrete runway was selected. Motor car take off using nylon launching cable of 50 m length was chosen. To test this take off method (at this time not popular in Poland). initial launches were performed on a "Mucha 100" glider having a similar all up mass.

For the first flight of "Wampir 2" the c.g. location was 27 percent of standard mean chord. The aileron was adjusted as combined with elevator.

The glider became airborne at about 60 km/h airspeed. 14 motor car launches were made to an altitude of about 10m to check control, air braking and landing, before the decision of aero towing was taken.

The first surprise appeared in the first aero tow at a few meters of altitude the glider began to oscillate in pitch, maybe as a result of moderate turbulence. It was difficult to hold the stick against the movements. The pilot's safety helmet beat

The first stalling test was carried out at an airspeed of 56 km/h. In stalled condition control was lost, the glider made a flat half turn to the left and then pitched down below the horizon.

At low altitude the sensitivity came back in the gusty conditions. The landing was performed on the concrete runway using careful air brake action.

The next take off was for the transportation flight from Katowice to Bielsko Biala (about 50 km distance) which finished with a safe landing on the grassy surface.

In the course of flutter testing the exceptional sensitivity of the glider in even small air turbulence was confirmed and found to be worse then that of "Nietoperz."

The short period oscillations, shorter than 1 second could not be measured with a stop watch or controlled by elevator action, since after some time they returned automatically. Apart from these oscillations "Wampir 2" also performed phugoids of 1/2 to 1 minute period (calculated value of 22 sec.).

Entering the towing airplane wake was tested many times and after some practice it was possible to pass through this zone. It was easier to do this in the upward direction. The glider lifted the nose itself but it was necessary to pay attention to the towing cable which swung freely above the wing. If it struck the wing, a rough rather brutal pull out would be necessary to avoid getting too low.

One of the stalling tests for c.g. location at 23,5 percent of standard mean chord ended with an unintentional spin. After one turn to the left the glider nose dropped below the horizon but the flat rotation remained. Recovery action, taken at once, had no effect. Additional impulses with controls and air brake had no appreciable effect. After a few turns in about 10 seconds the glider slowly pitched nose down and allowed recovery. Unfortunately, these characteristics could not be tested more.

In spite of the difficult flying characteristics, 14 high altitude flights were completed and allowed the pilot to gain some experience. The c.g. locations varied between 21,5 and 27 percent of standard mean chord.

The last flight in which the glider was completely destroyed in a surprising manner, was described by the pilot in the following way:

"As in the previous flights on this day (October 6, 1959) I found favorable smooth air conditions in the whole altitude range. No clouds in the sky, zero wind, very stable air...just after releasing the towing cable at 1500m altitude, I wanted to glide through the towing airplane turbulent wake to test the ship properties in this "artificial turbulence." Sudden strong pitching oscillations of less than 1 second period took place. After 1 minute this turbulent zone disappeared and in the smooth air no other turbulence could be found. I began to test the lazy eight. Increasing the airspeed on the glide I entered a climbing curve. In every test I increased the initial airspeed step by step. The critical case took place at an altitude of 1200 m about 3 minutes after release. Shortly after the last controlled airspeed indication of 140 km/h, attained for the first time on this ship, there started a pitching impulse, the same as encountered in turbulence but very sudden, similar to the motor car reaction when at full speed on an asphalt highway it would pass into a grassy surface. The swing instead of being damped began to grow rapidly.

In sympathy with these swings my body was subjected to increasing periodic loadings of 1/2 to 1 second period against which, in spite of very well fastened safety harness, I was completely helpless. As a passive component of this vibrating system, I was periodically pressed into the seat and pulled upwards into the back belts with increasing brutality leading to loss of consciousness. My senses registered an increasing flutter noise.

After a few (5-8) swings, only a few seconds after this situation started, while being subjected to the high loadings, I suddenly felt a boom associated with the load being released. The rhythm was broken in a moment. The glider entered an inverted flight path similar to that of negative looping. It was not necessary to jettison the canopy since it went off before I noticed what happened. I released the safety belts and with a great force I was thrown out..."

The above is the report of the pilot who safely landed with the aid of a parachute but owing to suspected internal injuries and visible blood effusions—probably as a result of reciprocal loadings—he was placed under medical care for a period of 1 week.

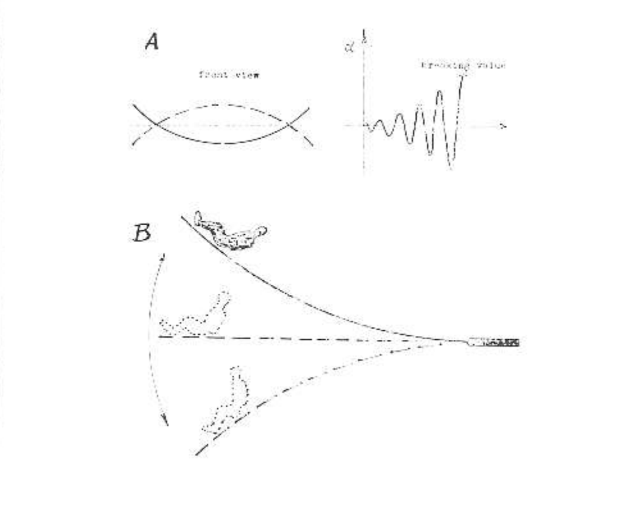


**FIGURE 10.** A-wing vibration mode; B-pilot as the passive component of elastic system (the picture of dynamic influence of the variable load on pilot's body).

As a result of oscillation induced resonance, the mass and force impulses rapidly increased in amplitude leading to the collapse of the ship. (See Figure 10). From the very careful investigation the following hypothesis was derived:

> Both damaged parts (left wing separated, right wing with fuselage) dropped down together, and collided in the rotation. At this moment, the canopy was destroyed (yellow lacquer spots on parts of the canopy perspex and on the pilot's helmet were found) as a result of contact with the left wing. Then both destroyed parts of the damaged glider turned together and finally dropped on the ground (Figure 11).

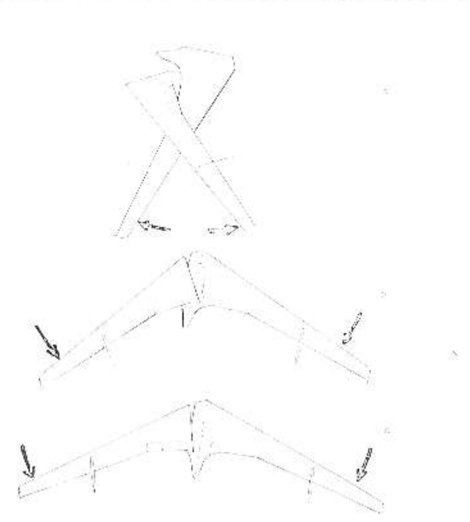

**FIGURE 11.** SZD-20x. History of damage: a). Both parts begin to rotate one onto another; b). Left wing root end destroys the canopy; c). Further collision of both parts of the wreckage.

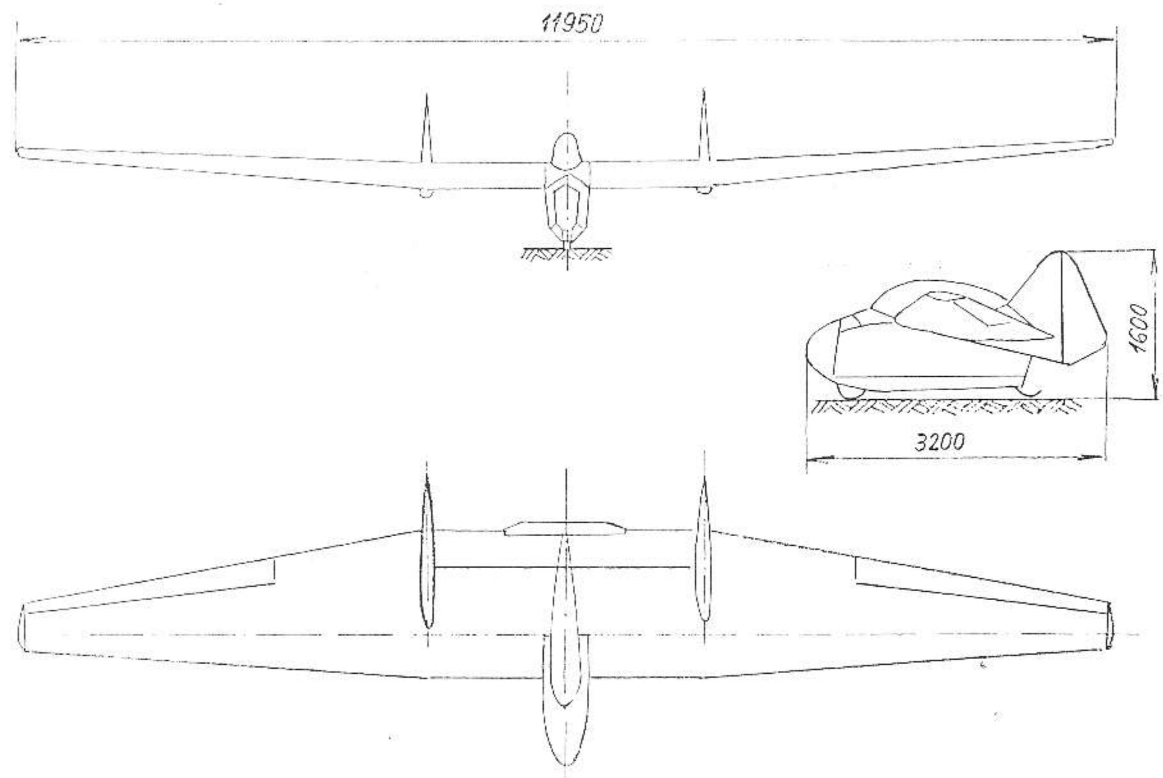


**FIGURE 12.** AV-36 CR tailless glider.

**Summary of the flight experience**

It was found that the tailless glider experiences a tendency to short period oscillations. Therefore, it is difficult to fly even in the weak turbulence to be encountered in thermals. The flow disturbance on the swept back wing leads to rather great variations of the trimmed flight conditions. Moreover, when the eigenfrequencies of the wing and short period pitching oscillations are coupled the case should be investigated very carefully.

## 4. AV-36 CR

In 1961 the SZD factory bought the French flying wing AV-36 CR constructed in Oberlerchner factory in Austria to carry out a short test program. This ship was the developed variant of AV-36 "Monoblock" designed by Charles Fauvel (Figure 12).

Contrary to both SZD designed tailless models AV-36 CR as all Fauvel's types has an upswept wing. The self stable F2 wing profile has the S-shaped camber line. Characteristic is its integral design with one piece wing. For road transportation only the fins and rudders are (on both wings) removed. The ship was then only 2,4 m long and could be installed on the trailer laterally.

The twin fins and rudders work similarly to those of the "Wampir 2." The elevator and aileron deflections are arranged in the conventional way. The flight properties of AV-36 CR in smooth air are conventional. The pilot has a feeling it is not a flying wing. Interesting is the fully controllable "stalled flight" without nose dropping. Spinning is impossible in the allowed c.g. range. In the towing airplane wake AV-36 CR reactions are like those of a conventional glider with tailplane. In gusty conditions the special tailless characteristics appear, namely the short period oscillations that create some problems in thermal flying. The flying properties of AV-36 CR are comparable to those of "Grunau Baby Class" today rather poorly known.

Now the ship, fully airworthy, is owned by the Student Flying Club of Technical University, Warsaw.

## 5. CONCLUSIONS

All three tailless models tested by SZD belong now to history. None of them would now comply the requirements concerning flying properties or have a satisfactory performance level.

The rapid development of conventional sailplane designs has rather pushed aside the tailless concept. However, against this priority of conventional ships there has come the brave creation of modern tailless models like the SB-13.

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