The Landing Gear of High Performance Sailplanes

Solution of the CVT-2 "Veltro" and CVT-4 "Strale", by Dr. Ing. Alberto Morelli

Summary

The landing gear of a high performance sailplane must satisfy several requirements, some of which are peculiar to this type of aircraft.

A study of these requirements is made and actual solutions are reviewed.

An original solution, adopted in the CVT-2 "Veltro" and CVT-4 "Strale" sailplanes, is finally illustrated.

Requirements

We list the requirements in order of importance:

1. *Minimum aerodynamic drag:* It is not necessary to emphasize the importance of this requirement; we can state however that its importance has been growing since better high speed performance, with no (or little) sacrifice of low speed characteristics, has been required of sailplanes.

It is clear that, if good performance at high speed only is aimed at, this would be attainable simply by increasing the wing loading. But, for the best compromise in good high and slow speed characteristics, the "penetration" has to be improved, that is, any source of parasitic drag has to be, as far as possible, eliminated.

2. *Safeguard of the structure in rough field landings:* The landing out of an airport is a normal event for a competition sailplane. The probability of a damage in such cases must then be reduced to a minimum.

Let us consider the various types of fields that are likely to be chosen for a landing away from base:

a) fields of corn or long grass: The damage that a dense growth of long grass or corn can do to a sailplane is well known to any experienced glider pilot; it is able to damage main structural parts such as plywood coverings and even spars. Frequently it happens that the horizontal tail is seriously damaged, owing to its low position and light structure. Catching a wing tip can often produce a swing on landing; a remedy for this is to design the sailplane with a high set wing and tail surfaces;

b) ground with pebble and stones (possibly the case of a shore): Such ground is often chosen for landing because it offers the possibility of a low approach on the water side. Moreover, it is generally free of obstacles and quite level. There is always the risk, however, of a damage to the plywood covering by stones. The shaking of the whole structure, due to the low resilience of this soil, may also have a detrimental effect.

It seems to us that the only remedy in this case, is to keep the structure sufficiently high off the ground (30 cm, at least), and to adopt a landing gear of great flexibility and appropriate damping;

c) hard soils (as after the mowing of wheat): The braking may represent a difficulty in this case. The skid, which generally produces a satisfactory braking, is ineffective on this soil. The skid is a powerful brake when it can slightly sink in the ground. The friction coefficient, moreover, is greatly reduced if straw is present.

An irregular soil with cracks, as for instance a dry clayish soil, shakes the structure. It is therefore desirable in this case to have a suspension of high flexibility and damping characteristics.

To obtain the required braking effect, the best solution would be the adoption of some device capable of sinking in the ground.

Other types of possible landing grounds are:

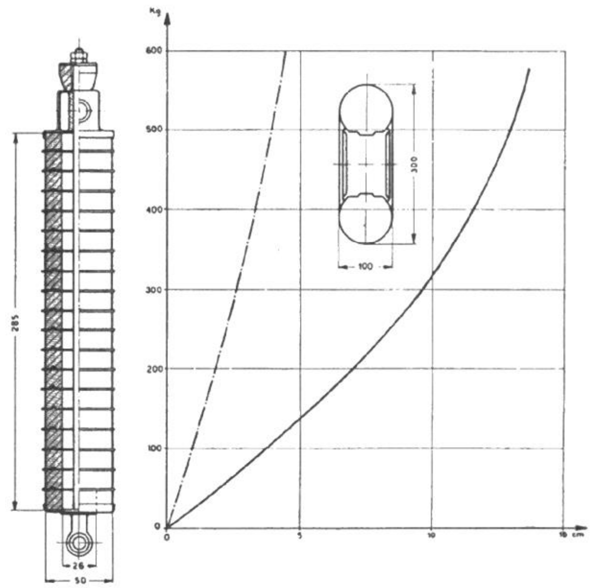

Fig. 1

d) a ploughed or weeded ground; a boggy ground: Such grounds are generally safer than those considered above.

A conclusion from this analysis is that a suitable landing gear should satisfy the following requirements:

I. To keep the wing and horizontal tail conveniently high off the ground (70 cm, at least).

II. To keep also the fuselage sufficiently high off the ground (30 cm, at least).

III. To possess a high flexibility and damping.

IV. To allow a powerful braking on any kind of ground.

3. *To allow a suitable ground attitude:* When the landing field is small, it is convenient to land at a speed that is very close to the stalling speed. It is therefore necessary that the sailplane is designed with a ground attitude giving adequate wing incidence.

The adoption of a large wing-fuselage setting is generally rejected, because it produces a serious reduction of the high speed characteristics. It is therefore necessary to have a sufficiently long landing gear.

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Fig. 2

4. *To allow easy ground handling.*
5. *Lightness.*
6. *Robust construction and safe operation.*
7. *Small dimensions.*
8. *Low cost.*
9. *To minimise cutouts in the plywood skin.*
10. *Comfort.*

Actual solutions

1. *Skid with fixed wheel:* This il a very common solution, having the merit of being simple and robust. Ground handling is also satisfactory.

Defects:

Not very good from the aerodynamic point of view: the wheel projects 4—5 cm under the skid, producing drag.

Even if the skid is 12 cm high, the fuselage is not sufficiently protected.

If the wheel is not provided with brakes, the braking from use of the skid may be inadequate.

If the wheel (as usual) is rigidly connected to the fuselage structure, and the elastic suspension is provided only by a pneumatic tyre, the flexibility is insufficient. The load-deflection curve is of the type indicated in fig. 1 (dotted line): the flexibility is around 100 mm/100 kg; damping is poor.

A satisfactory ground attitude is difficult to obtain.

The weight of this landing gear is around 10 kg for a sailplane of empty weight about 200 kg.

2. *Skid with a jettisonable undercarriage:* If compared with solution 1., this offers the following advantages:

— smaller aerodynamic drag,
— better braking,

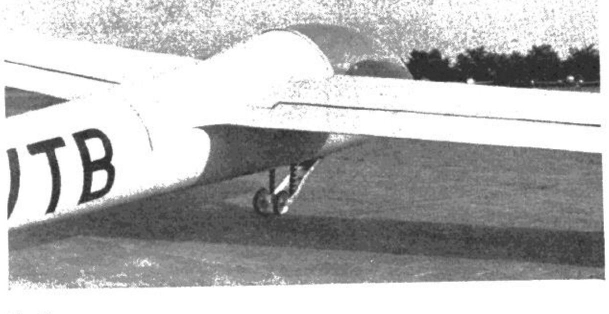

Fig. 3

— a better suspension, because the skid does not transmit loads due to small ground irregularities to the main structure,
— less weight in flight (6—7 kg for a sailplane empty weight of about 200 kg).

Defects:

— insufficient protection of the fuselage,
— after every landing the undercarriage has to be refitted to the skid.

3. *Single wheel retractable landing gear:* This solution has the great advantage of eliminating aerodynamic drag and, moreover, ensuring:

— easy ground handling,
— good ground attitude,
— satisfactory protection of the structure,
— good braking, since an adequate wheel brake can be provided.

It should be remarked, however, that in some cases (for instance, on a muddy soil) the braking may be ineffective.

Defects:

If the wheel is small:

— it can easily sink in the ground and produce heavy loads on the structure,
— it is not easy to provide an efficient brake.
— it quickly wears out.

With a big wheel:

— the weight is high.

If the retraction movement is longitudinal, the wheel well fairing doors that have to be provided are close to the ground and may thereafter be easily damaged.

If the retraction movement is lateral, large cutouts are necessary with an evident structural penalty (first solution of the CVT "Veltro", fig. 2).

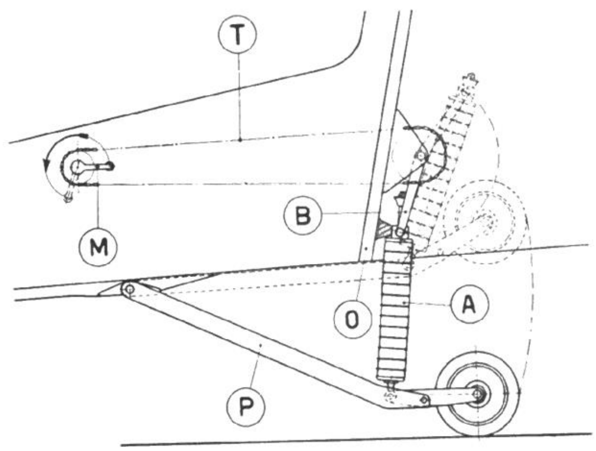

Fig. 4

If satisfactory flexibility and damping characteristics are to be obtained, a shock absorber should be provided.

In conclusion, such a landing gear should have:

a) a big wheel with an efficient brake;
b) a shock absorber;
c) an articulated wheel supporting structure and retraction mechanism;
d) fairing doors.

The solution is therefore rather complicated, heavy and costly. The weight may be 10—15 kg or more, for a sailplane of about 200 kg empty weight.

4. *Elastically suspended and retractable skid with small auxiliary wheel:* This solution has been adopted on the CVT-2 "Veltro" and CVT-4 "Strale" sailplanes, constructed by the "Centro di volo a vela del Politecnico di Torino, CVT" (Soaring

Experimental Center of the Turin Institute of Technology). In the case of the CVT-2 "Veltro", the original single wheel landing gear, retractable sideways into the fuselage (fig. 2), was replaced by two shock absorbers and two auxiliary wheels (fig. 3). This layout suited the existing fuselage structure.

In the CVT-4, where the undercarriage was devised in the design stage (this sailplane is derived from the CVT-2), a single shock absorber and a single auxiliary wheel were adopted. The solution is therefore simpler.

In fig. 4, the device is schematically illustrated in the landing (full lines) and retracted (dotted lines) positions. A short skid (P), made of steel, is hinged by a lateral pin at its fore end to the fuselage keel. At the other end, a rubber (not pneumatic) wheel, of small diameter and width, is fitted. A shock absorber (A), consisting of a series of rubber elements working in compression, provides the required elastic and damping characteristics. At the same time, this shock absorber is a part of the retraction mechanism.

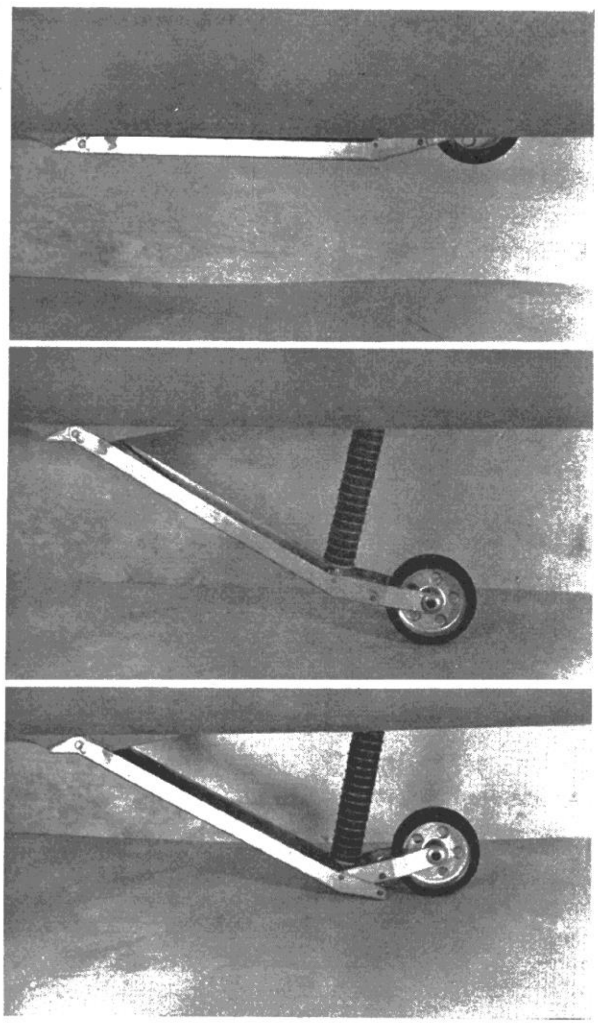

Fig. 5

The retraction is obtained by the rotation of the arm (B), connected to the upper end of the shock absorber. The rotation of (B) is produced by the pilot by means of a handle (M) and a chain transmission (T).

In the landing position the transmission is not subject to any load, being rotated over dead-center to contact the frame (O). In the retracted position, the skid folds against the bottom of the fuselage and the wheel is almost completely retracted into it (fig. 4 and 5).

Advantages:

a) The solution is satisfactory from the aerodynamic point of view. In the retracted position, the skid forms a continuation of the wooden keel, only 3 cm high; this is a convenient protection for the fore part of the fuselage.

b) The small diameter wheel is necessary for take-off (generally made on a runway or a hard ground) and for ground handling. On a soft ground, the wheel sinks in it and a strong braking force is produced by the skid, that is inclined at a sharp angle to the ground. On a hard soil there would be little braking effect. To overcome this difficulty, the wheel has a levered suspension which is normally locked to, and forms an extension of the skid. When necessary, the pilot, by operating a control lever, can free wheel suspension from the skid (fig. 5), which then contacts the ground directly, and produces a powerful braking effect.

c) The necessary ground attitude is easily obtained with an appropriate length of the shock absorber.

d) The fuselage and wing are kept at a sufficient distance from the ground. In the CVT-2 and CVT-4 sailplanes, for the same reason, the sailplane is mounted on the fin.

e) The weight of this landing gear is 6 kg, the empty weight of the sailplane being 175 kg.

f) Owing to the flexibility of the suspension (fig. 1), the landing loads are greatly reduced.

The shock absorber is made of 19 rubber elements having a hardness of 45 shore. They have a precompression load of 50 kg (compression stress: 3,5 kg/cm^2). At normal static load the stress rises to 19 kg/cm^2 and at the maximum load of 530 kg (corresponding to a landing limit load factor $n = 2$), the stress is 38 kg/cm^2. These values are referred to the net section of the unloaded element. The load-deflection curve is indicated in fig. 1 (full line). The initial deflection rate is 45 mm/100 kg, and at maximum load is 7 mm/100 kg. The particular rubber composition of the elastic elements provides a hysteresis of about 20%. The corresponding damping effect has proved adequate.

g) The overall dimensions of this landing gear (retracted position) in the fuselage interior is:

length × width × height = 270 × 340 × 130 mm

The cutout in the fuselage skin, necessary for the retraction of the wheel, shock absorber and a small part of the skid, is about 100 × 300 mm. There is no need for doors, the skid and the wheel, when retracted, closing the opening almost perfectly.

h) The remarkable flexibility of the suspension ensures, in addition to the above mentioned reduction of landing loads, a comfortable ride during take-off and landing runs.

Separate print from OSTIV Section of the "Swiss Aero Review", September No. 9/1957

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