

The design of a glider winch

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Today gliders are mainly launched by winch or by aerotowing, with a small amount of car launching.

Launching by winch is often preferred because of its simplicity and low cost. For gliding clubs which cannot spend much money on costly equipment it is the most attractive launching method. In the Netherlands and some other European countries launching by winch is commonly used. Generally, the winches are built by the gliding clubs themselves, so some directives for the design can be very useful, especially concerning the transmission between the engine and the cabledrums.

1. Design criteria

A glider winch must be reliable and easy to operate. Its construction should be as simple as possible for it has to be built by the glider clubs themselves.

As several glider clubs move their activities to other airfields for summer camps the mobility of the winch should be as high as possible. Performance requirements: A fully loaded two-seater with an all-up weight of 500 kg should be launched at all wind strengths to a height of 500 m.

From a safety point of view the maximum wind velocity is limited to 10 m/sec. On calm days the wind direction changes often and tailwind can easily happen; the strength of this tailwind is fixed to 2 m/sec. In order to avoid confusion tailwind will hereafter be marked with a minus sign.

2. The general construction of a winch

For many glider clubs a self-propelled winch with two cabledrums will be the best solution.

It is true that the construction of a winch with only one drum is less complicated, but such a winch has an insufficient production.

Moreover for each launch the cable car has to pick up the cable and is consequently in continuous use, so that it cannot be used to tow the gliders to their launching place.

On the other hand a four drum winch is very complicated from a technical point of view and moreover expensive, so that such a winch will only pay on a busy gliding centre.

As far as known the Terlet Gliding Centre of the Royal Netherlands Aero Club is the only place where a four-drum winch is used and it is employed there to everybody's satisfaction.

The two-drum winch is a favourable compromise and has proved itself to be the most appropriate solution for medium gliding clubs. The choice between a winch whether or not self-propelled is less simple; much depends on the circumstances under which gliding takes place.

In Holland many gliding clubs organise during the summer vacations flying camps on a suitable airfield with good thermal conditions. The transport of a tugged winch often gives unsurmountable problems because of its size and weight. A self-propelled winch can solve these problems.

Setting up a winch prior to operation can cost a lot of time due to the nature of the terrain and the situation of the hangars. Moreover the relocating of a winch as a result of a change of the direction of the wind can take up much time.

These problems, too, will be much simplified by a self-propelled winch. The construction of a self-propelled winch need not to give rise to many additional problems because the winch can be easily built on a truck chassis.

3. The transmission between engine and cable drums

For the calculations some assumptions have been made, that will now be discussed.

The cable drums are often fitted on the wheels of the rear-axle of a truck. As a result hereof the drums often have a diameter between 0,4 and 0,6 m. The calculations are made with a diameter of 0,5 m. The calculations have been based on measured values of cable-loads and cable-speeds. These data have been taken from the literature. The course of the calculations will be explained with the aid of diagrams.

The cable-load

Fig. 1 shows the cable-load as a function of the launching time. The load increases rapidly in the first seconds from 0 to 450 kg and can be considered constant to the end of the launch, when it decreases rapidly to zero at the time of cable-disconnection.

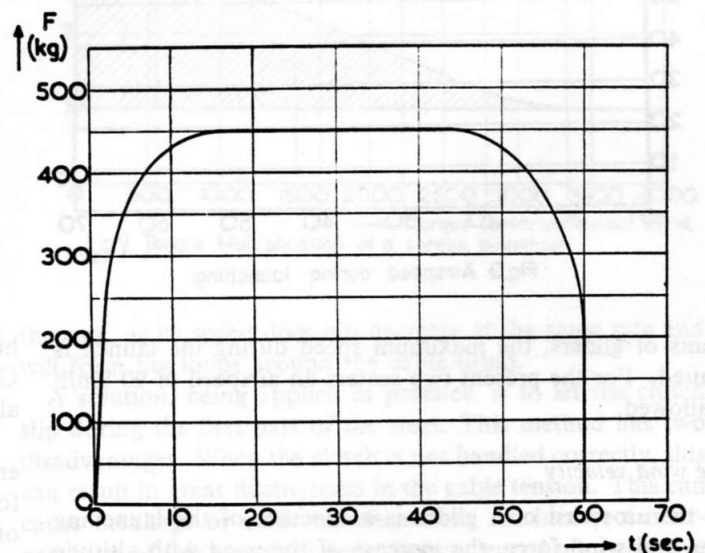


Fig.1 The cable-load during launching

The torque

Based on a cable drum diameter of 0,5 m the torque required at the drum can be calculated from fig. 1. The variation of the torque as a function of the launching time is plotted in fig. 2.

The airspeed

As can be seen from fig. 3 the airspeed of a glider remains constant during the launch after take off.

The altitude to be reached is increasing with growing launching speeds. However owing to the strength-require-

situation has remarkable possibilities; by blocking the cable drum when the rotational speed of the drum is zero, the glider can be held on a certain altitude depending on the wind velocity and the cable length. By paying out the cable this "flying" altitude can even be increased. With a cable length of 1500 m, members of the Delft Student Aero Club

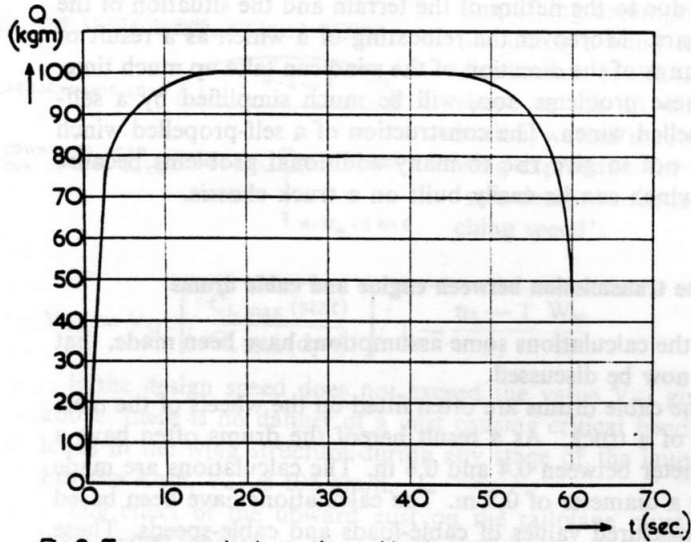


Fig. 2 Torque required at the cable-drum during launching

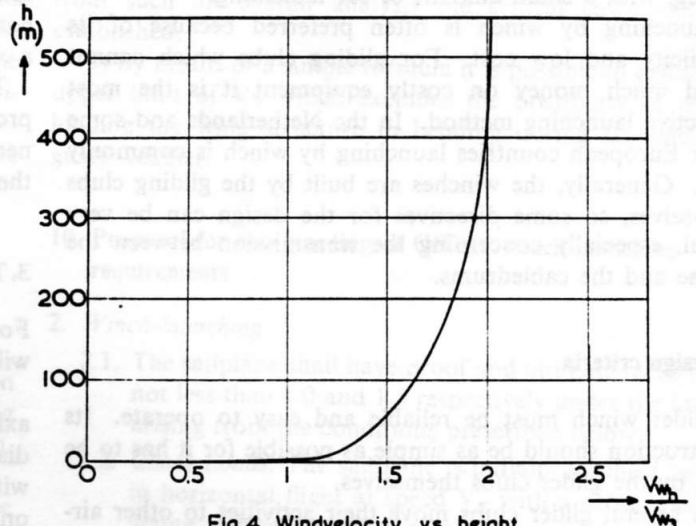


Fig. 4 Windvelocity v.s. height

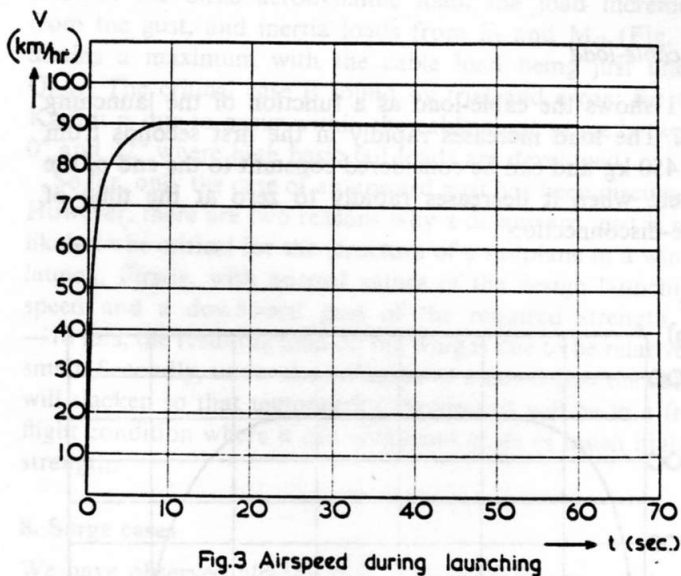


Fig. 3 Airspeed during launching

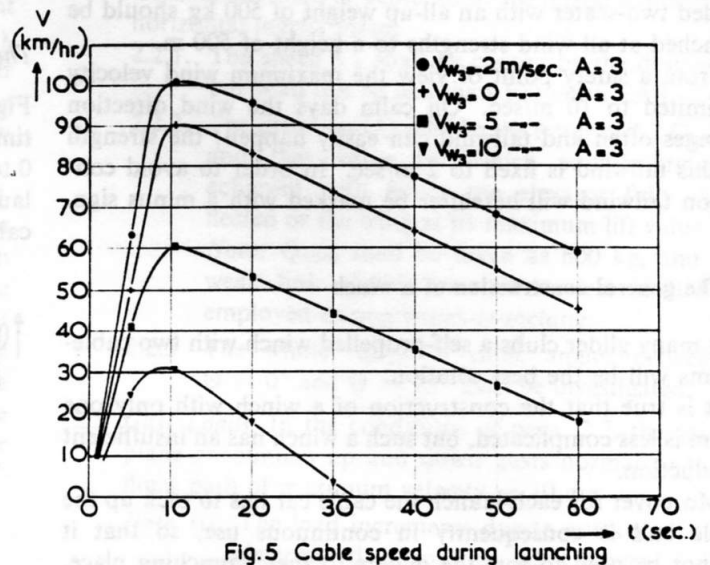


Fig. 5 Cable speed during launching

ments of gliders, the maximum speed during the launch is limited. For the present two-seaters an airspeed of 90 km/hr is allowed.

The wind velocity

As the air-speed of a glider is a function of the launching time and wind force, the increase of the wind with altitude should be considered. In fig. 4 the relation between wind velocity and altitude is shown, based on the wind velocity measured at 3 m height (V_{w_3}).

The cable speed

As can be seen in fig. 5 the cable speed decreases when the launching time increases. At wind velocities of 8 to 10 m/sec the cable speed can become zero and even negative. This

have reached an altitude of 1250 m in this way with a Gö-4 two-seater. Had the cable been longer, even greater altitudes could have been reached.

From the preceding diagrams the required power and engine torque can be calculated. An allowance must be made for a certain power loss in the transmission. The efficiency of the transmission might be estimated at 90%. Calculations show that a transmission ratio between engine and cable drums $A = 3$ is the best compromise. Maximum required engine power is then 162 hp. Maximum required engine torque is 37 kgm. In fig. 6 the performance diagram of an engine meeting these requirements is shown. The considered engine is a Buick "Loadmaster" with a swept volume of 5,4 liters and a compression ratio of 1:8. Maximum power is delivered at about 4000 rpm. The required and delivered engine power and engine torque are calculated for wind

velocities of -2, 0, 5 and 10 m/sec. In fig. 7, the required and delivered power are plotted against the launching time. The available power is about sufficient, except in the first seconds of the launch.

Due to the low cable speed in this period the number of revolutions of the engine decreases to such an extent that

Firstly, the cable tension will become zero during the gear-shifting as a result of which the cable can drop from the glider.

Secondly, the cable drums are not driven on during shifting. Owing to the friction in the bearings the number of revolutions of the drum will decrease. The cable will slip

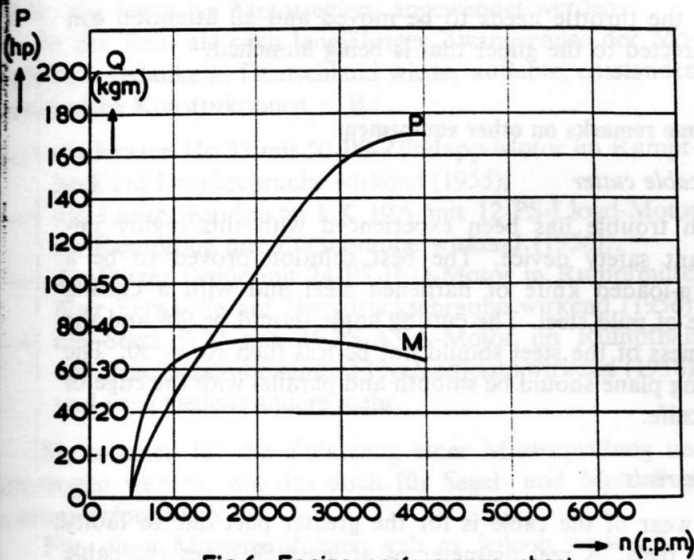


Fig. 6 Engine performance chart

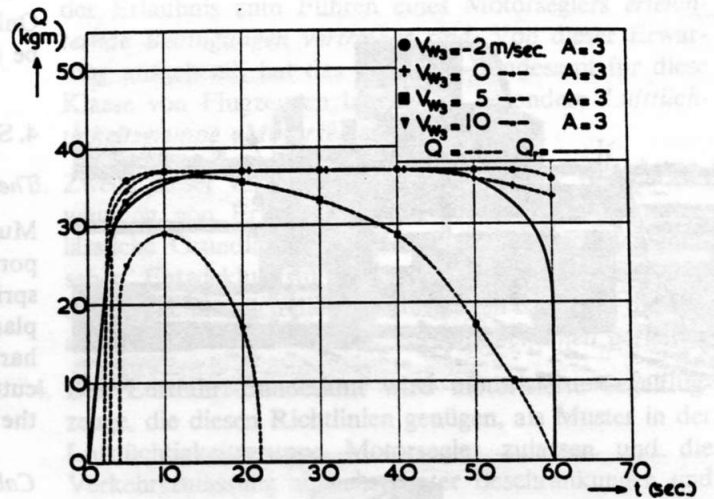


Fig. 8 Available and required engine-torque during launching

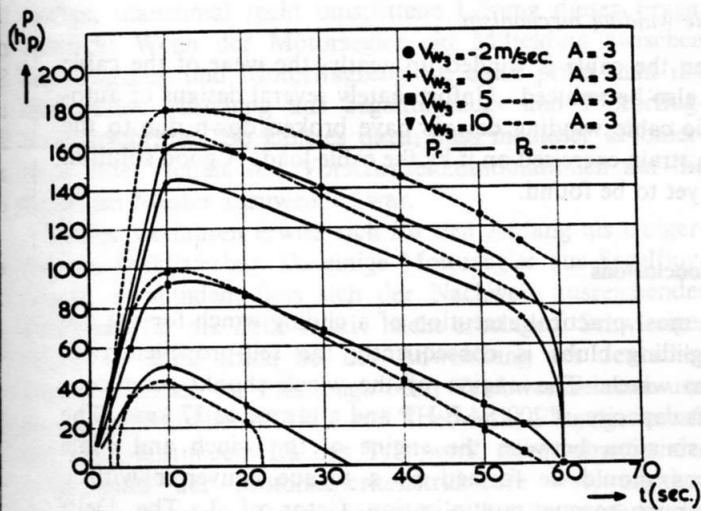


Fig. 7 Available and required engine-power during launching

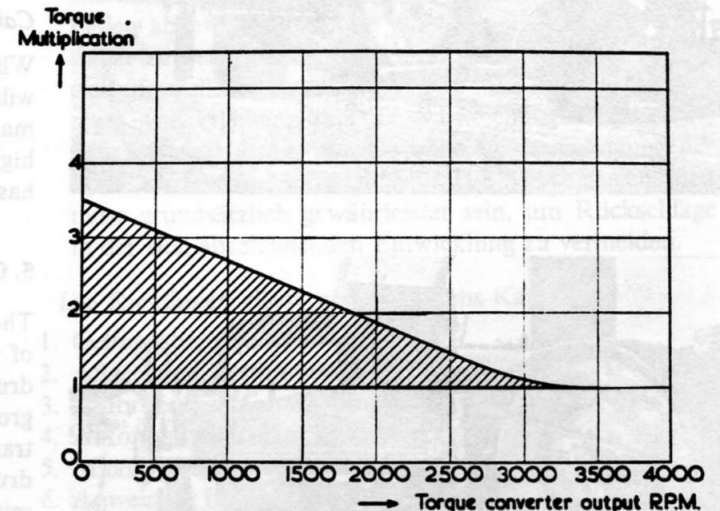


Fig. 9 Torque Multiplication of a torque converter

the engine does not produce any power. The same applies to the engine torque.

In fig. 8 the required and delivered engine torque are plotted against the launching time. It appears from this figure that when the wind increases the available engine torque becomes insufficient during an ever bigger part of the launch.

A solution of this problem can be obtained by changing the transmission ratio.

In that case the gear box should be suitable to bring the transmission ratio A , from 3 to 9. The reach of the transmission should therefore be 1:3.

By selecting an other transmission ratio the problem of insufficient power and engine torque in the initial stage of the launch could also be solved. It will then be necessary to shift the gear during the launch. This is unfeasible.

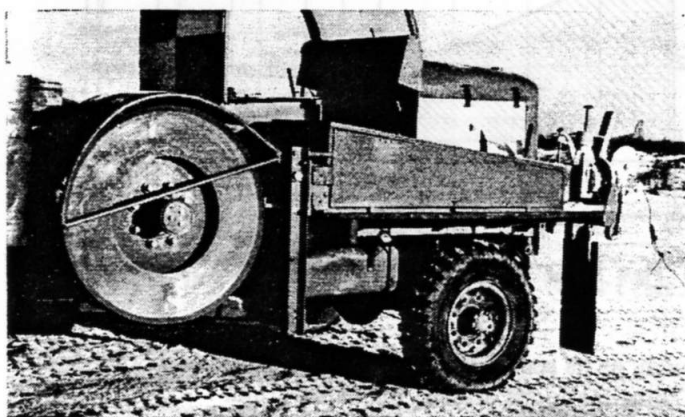
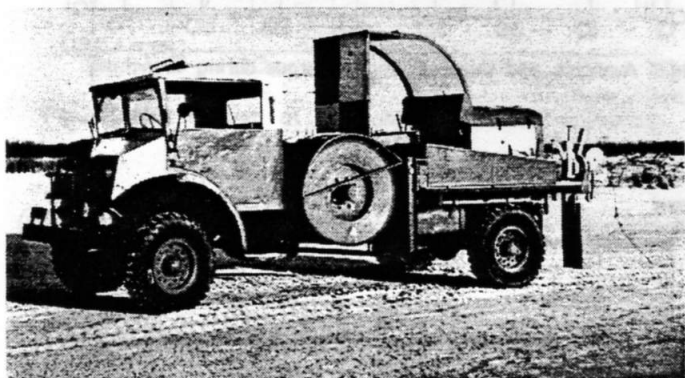
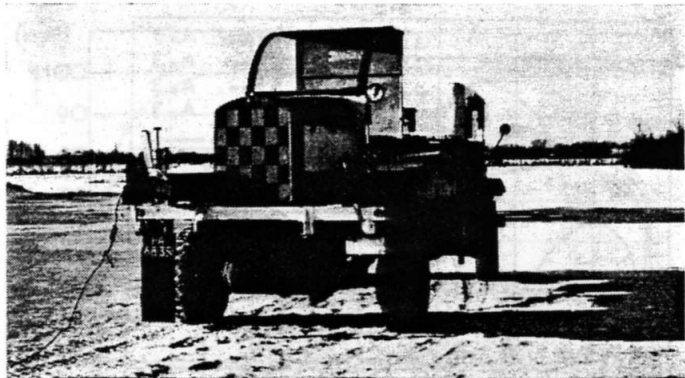
through, as its speed does not decrease at the same rate and will form big loops around the cable drum.

A solution, being applied in practice, is to let the clutch slip during the first part of the start. This method has two disadvantages. When the clutch is not handled correctly, this can result in great fluctuations in the cable tension. This can cause breakage or cable disconnection. An incorrect interpretation of this symptom by an inexperienced pilot can give rise to stalling of the glider. Moreover the wear and tear of the clutch discs is very great, so that it needs regular adjustment and replacement, costing time and money.

A variable transmission that can produce, also at low cable speeds, a fairly good torque and having a transmission reach of 1:3, is the most suitable solution.

For a glider winch there are two types of hydraulic transmissions meeting the requirements. These are the hydraulic

coupling combined with an automatic transmission and the torque converter. The hydraulic coupling combined with an automatic gear box has the disadvantage that during a gear-shift the cable tension becomes zero. Although this lasts only during a very short time it is as a matter of fact rather annoying.



The torque converter does not have this disadvantage; the change of transmission ratio is continuous.

A modern torque converter with several turbines and possibly adjustable vanes in a stator wheel has a high efficiency and a wide range of transmission ratios. Consequently the torque converter is the ideal transmission for a glider winch.

The shaded part in this figure is the area of the possible transmission ratios as a function of the output rpm of the

converter. It shows that the torque multiplication is at its maximum when the converter output rpm is zero. The maximum torque multiplication is then 3,5.

The problem of insufficient power and engine torque in the first stage of the launch, due to the low cable speed, has been solved by the torque converter. Also at strong wind the engine can easily supply the required torque.

Another advantage is the ease of operating of the winch. Only the throttle needs to be moved and all attention can be directed to the glider that is being launched.

4. Some remarks on other equipment

The cable cutter

Much trouble has been experienced with this highly important safety device. The best solution proved to be a spring-loaded knife of hardened steel and with a cutting plane of mild steel. The cutting angle should be 90° and the hardness of the steel should not be less than $Rc = 50$. The cutting plane should be smooth and parallel with the edge of the knife.

Cable reels

The wear of the cable is for the greater part due to faulty cable reels. A reel diameter of at least 50 times the cable diameter will substantially reduce the cable wear.

Cable winding mechanism

When the cable is wound up neatly, the wear of the cable will also be reduced. Unfortunately several designs of automatic cable winding devices have broken down due to the high strain exercised on it by the cable load. A good solution has yet to be found.

5. Conclusions

The most practical execution of a gliding winch for the use of gliding clubs is consequently the self-propelled two-drum winch. The engine of the winch should produce a gross capacity of 200 SAE HP and a torque of 37 kgm. The transmission between the engine of the winch and cable drums should be formed by a torque converter with a minimum torque multiplication factor of 3. The Delft Student Aero Club built a winch observing the above mentioned requirements. Also the Royal Dutch Air Force is building such winches for its glider clubs.

This winch has now produced about 5000 launches and has in every respect come up to the expectations. As a chassis an army truck has been used, that can be purchased cheap in the army dumps.

Thanks to the extra front wheel drive of this type of truck the winch can be used on practically all kinds of grounds.

Because a few gliding grounds in Holland have many marshy spots, often a grateful use has been made of this possibility.

The motor of the winch is a 225 HP (SAE) engine of a Buick passenger car. In combination with this engine the "Dynaflo Transmission" is used, a combination that has given excellent results.