Stresses In Auto Towed Glider Flight

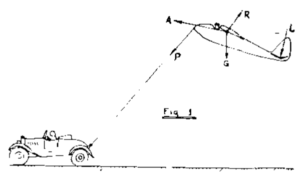
by Arthur Schultz

THE de-winging of gliders in auto and winch towed flight has happened only a few times in the last few years. Structural failure of this sort can be eliminated by the use of a little foresight. Failures are caused, of course, by over-loads on the wings due to too high a towing speed, probably combined with dry rot in spars of wings.

There are several methods of limiting maximum stresses in auto towed flight.

The first and most generally employed is to use a tow line which will break before the load on the wings becomes dangerous. This has the disadvantage that when the line is new (assuming the use of rope) it is liable to be overstrength, and when worn it will be too weak, breaking on the least provocation and sometimes leaving the pilot in a dangerous situation. To use an old line can, without doubt, cause many more accidents than neglect of any other part of glider equipment.

The next best is to use a stronger line but incorporate a safety link of a weaker material or an automatic release,



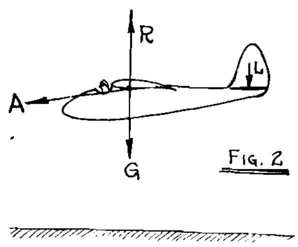


FIG. 2

either of which will let go when the pull becomes too great.

A third method is to limit the load on elevators, either by relying on pilots' judgment, by installing mechanical stops to limit their upward travel, or by limiting their size and so locating release that at any towing speed elevators will never have sufficient effect to maintain the wing at or near its maximum angle of lift. Varying weights of pilots makes the former method subject to great compromise while the latter is dangerous practice in a training ship.

A fourth and very satisfactory method is to control the air loads by controlling speed of tow car. The dangerous part of an auto tow is illustrated in the above sketches.

In figure (1) glider is being auto or winch towed. "A" indicates flight path, "G" indicates action of gravity which will be the same as the gross weight of the glider, "L" is a download on tail sufficient to take care of aerodynamic moments as well as counteract the moment due to tension "P" in tow line, "R" is lift of wing which is roughly equal to sum of "P", "G" and "L".

Figure (2) shows glider in a normal glide where "R" will approximately equal "G" because of "L" being negligible. Wings will weigh about 100 lbs. and have been designed to carry the weight of the rest of the ship with an inertia load factor of 6. The weight of the wings themselves is not included in this load factor of 6 because they are uniformly supported in flight and the only stress in the structure is due to weight of ship. Thus in this case, wings will be designed to carry a load of (400 —100) x 6 or 1800 lbs. Included in load factor of 6 is factor of safety of 1½ for deterioration, so really the safe load on wings is only 1200 lbs.

Now refer to figure (1) and assume tow car is traveling 30 m.p.h. against a 15 mile headwind with wings held at the angle of maximum lift. The towing air speed will be 45 m.p.h. Reaction "R" on wings will be in proportion to the square of air speed/stalling speed ration or $(45/22)^2 \times 400 = 1680$ lbs. Subtracting weight of wings, 100 lbs., gives an actual load of 1580 lbs. on wing structure. This is 380 lbs. in excess of safe load on wings—an exceedingly uncomfortable load if the pilot only knew it.

As the air speed increases as much as 10 m.p.h when glider is well up in the climb and overtaking tow car the actual load may increase, provided tow car has not been slowed up, to *double* the safe load on wings. A horizontal gust or sudden jerk of tow line might easily cause a structural failure even before this extreme condition was reached.

The above situation applies to a glider with elevator surface sufficient to maintain the wing at its angle of maximum lift. Under stated conditions a glider without adequate elevator area or with limited movement thereof would not reach the angle of maximum lift and would be a safer ship. Even at that it might become overloaded if it encountered a strong vertical gust.

Load Factors in Auto Towing

Applied load factors obtained when auto or winch towing at maximum lift coefficient or when struck by gust producing maximum lift conditions.

Fig. 3

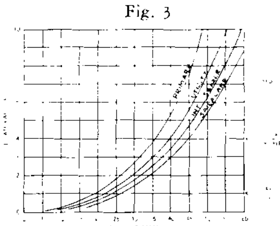


Table I.

TYPE	W_G	W_W
Primary	350	100
Utility	400	100
Intermediate Soarer	475	175
Advanced Sailplane	525	225

$$LF = \left(\frac{V}{V_S}\right)^2 + \frac{W_W}{W_G - W_W}\left[\left(\frac{V}{V_S}\right)^2 - 1\right]$$

LF = Load factor developed by auto tow.
V = Towing air speed of glider.
Vs = Normal stalling speed.
WG = Gross weight of loaded ship.
Ww = Weight of wings alone.

Curves in figure 3 show load factors developed by various gliders through usual range of auto tow speeds. These values are approximate only for weight relations as shown in table I and for a wing area of 175 sq. ft. and maximum lift coefficient of 1.5. Nevertheless, these values are close enough for normal use.

It seems obvious that the wise thing to do is to limit towing speed of glider rather than depend on weak links in tow line or pilot's good judgment. It is the practice in some localities to limit the speed to not over 40 m.p.h. Clubs whose towing speed is not limited should take warning—perhaps those old wings are no longer as strong as when they were new!