At any point in the tow the climb can be increased only by increasing the G loading on the glider. This is done either by increasing the elevator at constant flight speed or having the winch operator increase the flight speed while the pilot holds a constant elevator setting. In both cases, the effect is to increase the pitching moment of the tail. However, as we can see from figure (1), the gain in angle of climb diminishes rapidly once we exceed a 2 G load.[2] Also, when the loading becomes excessive, there is some danger of "folding the wings up" should the glider experience severe gust or bucking loads. It is for this reason that the placard winch towing velocity is always considerably lower than the corresponding airplane towing velocity.

Wire Force

The force which must be transmitted through the wire from winch to glider is plotted in figure (2). β is again chosen for the abscissa while the force ordinate is in terms of the gross weight of the glider (glider + pilot+passengers+weight of wire). To apply the results to any particular glider simply multiply the gross weight as defined above by the corresponding value of F/W.

As we might have guessed the force is highest during the initial stages of the tow and decreases rapidly until a β of about 30°, it then levels off the remainder of the launch. The magnitude of the force as the glider first assumes its maximum climbing altitude is of special interest since it determines the maximum required torque output of the winch drive and the breaking strength of the line. For a 2-22 with two people and about 100 lbs of wire line (4000 ft) the gross weight is about 750 lbs. A normal tow as practiced by the Mohawk Soaring Club pulls between a 1.5 and 2.0 G load and thus requires an F/W of about 1.5 or a force of 1125 lbs. A 3.0 G climb would require a force of 2250 lbs. From this we can see that wire of proper breaking strength can be chosen so as to be the safety valve to prevent excessive loadings during the initial climb.

The force information of figure (2) together with the ratio of glider velocity to wire speed of figure (3) have led to a very practical and useful method of winch towing. However, the static relations of this analysis are not capable of telling the whole story and the dynamic forces which occur have been considered as well. These forces are due to the interaction of the winch inertia, engine-torque speed characteristics, tow line spring tension and the glider. They give rise to transients during the take-off and initial climb and can result in an unstable pitching oscillation called "bucking."

Winch Technique

The functions of the winch operator are both to provide sufficient power so that the desired rate of climb can be maintained and to control the reeling speed so that the glider velocity remains substantially constant throughout the tow. From figure (3) we see that the wire-glider speed ratio remains approximately constant irrespecive of the steepness of climb for β up to 30°. In terms of altitude gained this represents about $\frac{3}{4}$ of the tow. For the remaining quarter the speed ratio decreases about linearly. Thus, the winch reeling rate or engine tachometer setting should be constant from the time the glider assumes its climb to a β of 30° and decreases gradually thereafter. In accordance with this procedure, the following winch technique has been developed.

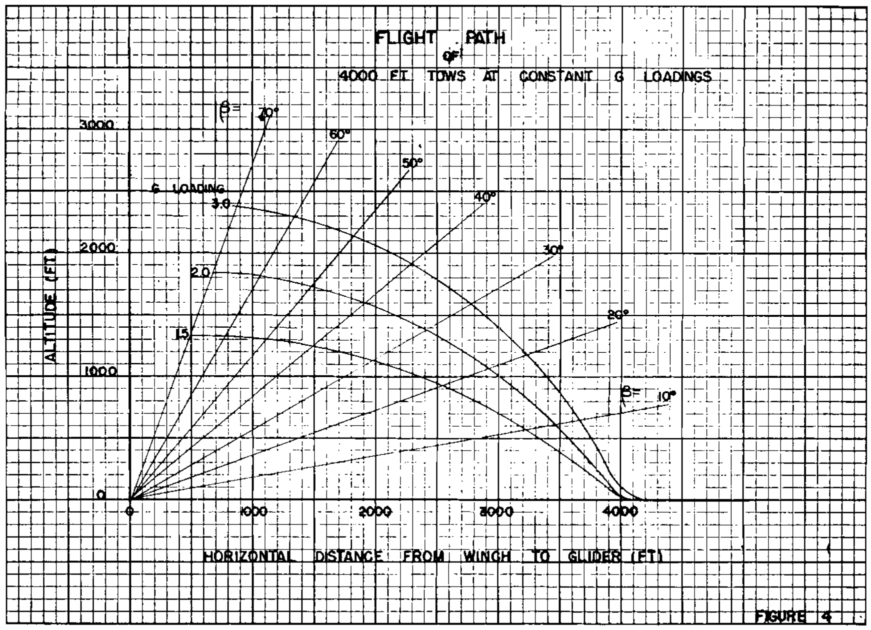

FIGURE 4

Before the tow begins, the winch operator estimates how much of the available power the glider will be able to absorb. As a bench mark, we might use a 2-22 at 2 G climb which requires approximately 84 hp to the wire. On the other hand an L-K, because of its small elevator area, is limited to a 1.5 G climb and can only absorb about 45 hp. If less than the maximum power is available, the angle of climb will simply be less than the optimum. However, if more power is applied than can be safely absorbed, the glider will over-speed or go into oscillations or become over stressed.

As soon as the glider has become airborne the throttle is advanced to the desired, predetermined setting for the initial climb. Once the climb has been well established, the winch tachometer reading is noted and the throttle is controlled to maintain this RPM until a β of 30° to 40° is reached. The throttle may have to be slackened off slightly during this period. For the remainder of the tow, the RPM must be continually decreased in accordance with figure (3) or the glider will rapidly gain speed.

The technique of slowing the winch down properly is the most difficult phase of the tow for new winch operators to master. Possibly this is because the force requirements are reducing rapidly once β exceeds 30° and the throttle must be retarded much further and more rapidly than the reduction in RPM would normally indicate.

Initially, as the pilot seeks his best

(Continued on Page 8)

1. G Loading = $\frac{\text{Lift supplied by the glider}}{\text{Gross weight of the glider}}$

2. In unaccelerated flight the G loading is 1 and it may be a new concept for aircraft to pull more than 1 G in a steady climb.