consideration of transportation with the CG-4A will inevitably be adversely affected by the built-in headwinds of the glider. The curves for a modified CG-4A are shown in Figures 3 and 4. The basis for these curves consists in certain gains in flat plate area which seem attainable. In the curves for CG-4A (M), it was assumed that the value of "f" could be reduced to 22 sq. ft. Although a proper control of flow around the fuselage would certainly improve the value of the effective span, no such assumption was made in computing the curves. In these curves, the value of b_e was taken as 47.2 ft. The curves obtained for the modified glider show a very distinct improvement in performance of the combination, glider-towplane. The L/D max is increased to 10.25. The THP_r at L/D max for the combination is reduced from 990 to 940 HP.

A computation of the value of f and b_e for the composite aircraft leads to an interesting result. The composite aircraft is treated as one airplane having the power curve shown in Figure 2. If the values of f and b_e be computed we find $f = 62.5$ sq. ft.

$b_e = 87.5$ sq. ft.

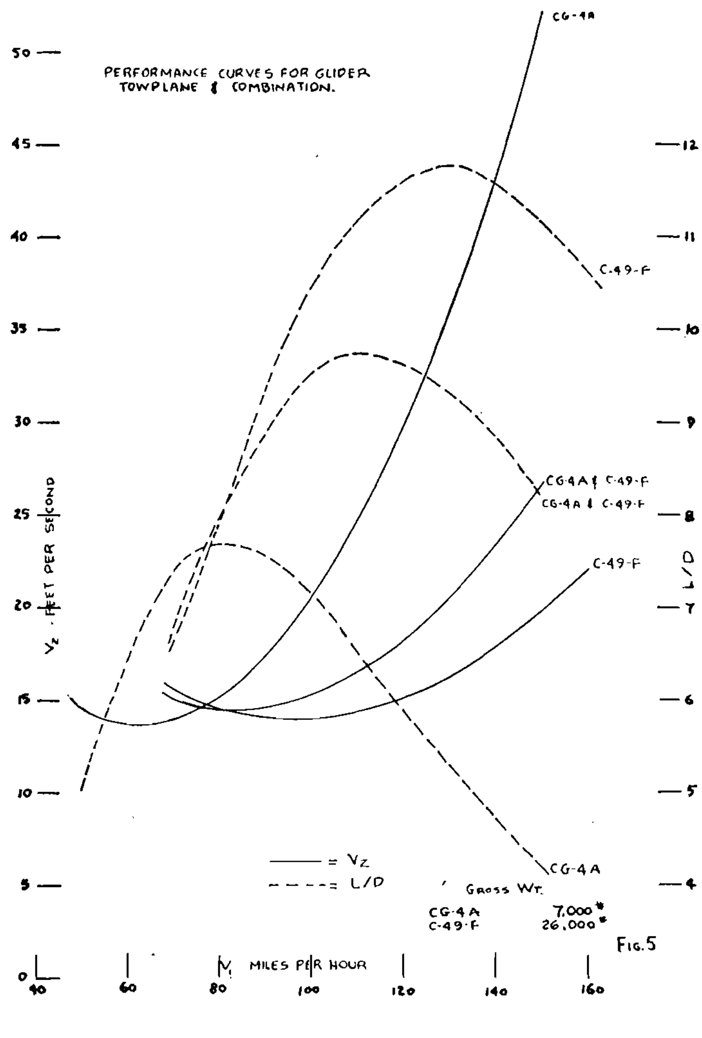

Fig. 5

The parasite loading of the combination $\frac{W}{f} = \frac{33{,}000}{62.5} = 529$ pounds per sq. ft. If this be compared with the parasite loading of the C-49F, we see $\frac{26{,}000}{27.4} = 950$, and that therefore any consideration of operational economy of such a composite aircraft is definitely out of the picture when comparison is made with a clean airplane.

The performance of a glider-tug combination may also be determined analytically by the use of Oswald's equation. The glider's power required curve is given by

$$P_{rg} = \frac{Vi^3 W_g}{841 \frac{W_g}{f_g}} + \frac{268 W^2_g}{Vi b_e{}^2{}_g} = \frac{Vi^3 f_g}{841} + \frac{268}{Vi}\left(\frac{W_g}{b_{eg}}\right)^2$$

The curve for the towplane will be given by

$$P_{rt} = \frac{Vi^3 f_t}{841} + \frac{268}{Vi}\left(\frac{W_t}{b_{et}}\right)^2$$

The power required for the combination will be given by

$$P_r = P_{rt} + P_{rg} = \frac{Vi^3}{841}(f_t + f_g) + \frac{268}{Vi}\left[\left(\frac{W_t}{b_{et}}\right)^2 + \left(\frac{W_g}{b_{eg}}\right)^2\right]$$

Examination of this relation discloses the fact that the equivalent flat plate area of a composite aircraft is given by the sum of the flat plate areas of its components and the span loading by

$$\frac{W}{b_e} = \sqrt{\left(\frac{W_t}{b_{et}}\right)^2 + \left(\frac{W_g}{b_{eg}}\right)^2}$$

Comparing the theoretical flat plate area of the composite with that computed from the performance curve of the composite discloses a discrepancy of 105.8 vs. 87.5 ft.[2] The latter figure was obtained from actual performance data, whereas the former came from the analytic determination of the performance. The poor showing of the effective span for the composite craft is no doubt due to the effect of turbulence from the towplane on the lift distribution over the glider's wings.

This study, in addition to presenting original numerical data on a glider-tug combination, has delineated the cause of poor performance on one such combination, namely the adverse effect of poor lift distribution over the wing of the glider. By comparison, it has been shown that the C-49F is a much more efficient aircraft than the CG-4A. The aerodynamic properties of an ideal cargo glider should simulate those of the C-49F.