A Specialised Glider Launching Aeroplane

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Introduction and General Discussion

The most satisfactory way of launching a glider from the average aerodrome is undoubtedly by aeroplane tow. At least this is so from the glider pilot's point of view. Unfortunately aerotowing also tends to be expensive and so is often used by clubs as a secondary means of launching only for use when serious soaring is contemplated; the majority of launches being made by tow car or winch.

If one considers the average aeroplane used for glider towing one finds it has about a 140 horse power engine. However from the point of view of work done on the glider only about 20–30 horse power is used for the intended purpose of launching the glider. It therefore seems that there is considerable scope for improvement in this 'Power Efficiency' factor of about 18%. If the available horse power could be better utilised, then the cost of aerotowing could be reduced. It might be possible to reduce the cost sufficiently to enable clubs to use aerotowing to the exclusion of other methods of launching. This in its turn would produce the following advantages:

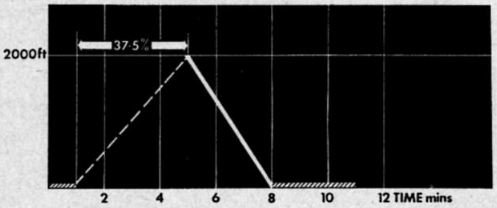
1. All launches would be satisfactory from the glider pilot's point of view.
2. Lower number of persons involved in non-gliding activities – a fair number of people are required to operate, and keep operating, ground borne equipment.
3. Improved reliability: the average aeroplane is serviceable more often than the average winch or tow car, particularily so if cable breaks and other 'temporary losses of service' are considered.
4. Smaller airfields: ground borne launching equipment requires 4,500–5,000 ft. run for a decent launch whereas aerotowing can use 2,000 ft., or even shorter, fields.

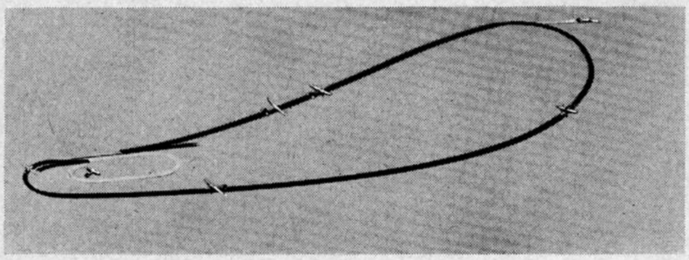
Accordingly a project study was undertaken to determine the significance of the leading parameters affecting the design of a more efficient tow plane. The object was stated to be a cost of 10/- for a 2,000 ft. tow (Present costs [1965-Ed.] are about 15/- to 17/- in the United Kingdom, which with overheads, result in charges of about 20/- to 22/- per launch.)

Firstly a review of the achieved performance. Fig. (1) shows the results from tows with the Auster 6a aircraft used at

Lasham. A barograph was carried in the tow plane and was only turned on when the engine was operating. Accordingly it was possible to determine from the traces the times spent in taxi, climb and descent. The average of the results for several tows by two different pilots are shown. The flight profile shown is considered representative for tows of single seat gliders by good quality pilots. Poorer pilots may use more time for descent and taxi. Landings in these trials were made with the tow rope attached to the tug. The point to note is that the potential power of the engine is only used for 37.5% of the total time for the mission. So for 37.5% of the time the glider manages to obtain about 18% of the engine power!

Fig. 1 – Auster 6a performance with single-seat glider





The flight profile established by these trials is used for the subsequent discussion, with modifications to the time for climb.

Fig. (2) shows the effect of power in an idealised towing aeroplane sinular to that described later in this paper. Power plant cost includes fuel, oil and cost of maintenance and overhaul. It is approximately £1/hour per 50 installed horse power. Fig. (2) also shows the effect on performance in terms of reduced mission time with increasing horse power. There is a general feeling that more power gives better tows: whereas it is true that the rate of climb is much improved, this is not reflected well into the total time to carry out the tow. The difference between 150 and 200 horse power changes the rate of climb from 1200, to 1,640 ft./min but this results in only 0.6 mins time reduction.

Fig. (3) relates these figures to costs of an actual operation. Aircraft cost has been taken as (power plant cost per hour) + (30/- per hour for airframe). It is appreciated that in fact the slightly larger, heavier aeroplanes required for the more powerful engines will probably cost more than this, but this assumption allows the general trends to be determined. It will be seen that very low-power tugs are expensive to operate. This is because they take too long to complete the mission, so that there are not sufficient tows accomplished per hour. Increase in power rapidly improves the situation up to 100 horse power, but above this figure the increased cost of the power is not offset by increased productivity. Also shown is the effect of a 2 minute reduction in mission time, This is worth about 2/6 per tow. It is therefore well worth while improving the rate of descent, but even more worth while to speed up taxying and/or cut down taxying distance.

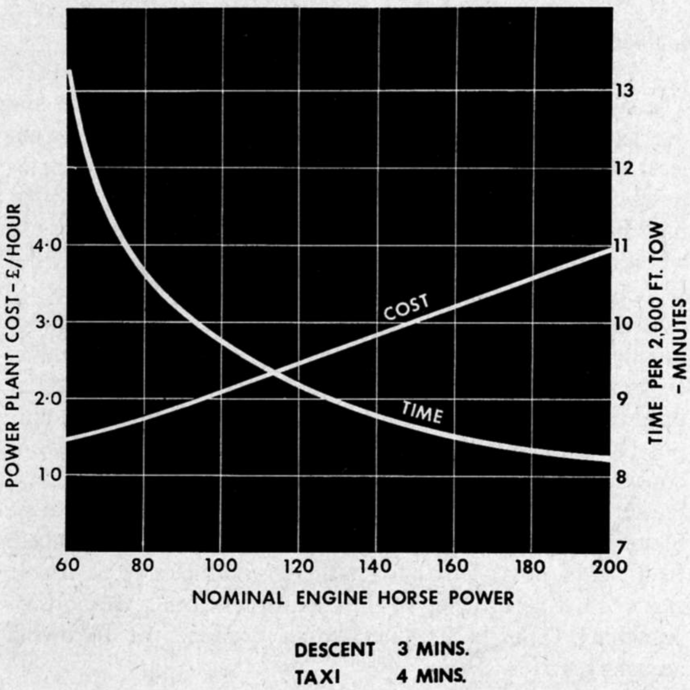
From fig. (3) it seems that there is a good prospect of meeting the design object of '10/- to 2,000 ft.' with a well designed 100 h.p. towing aeroplane.

Fig. (4) shows the effect of weight, L/D ratio and propeller efficiency on the performance of a specialised aeroplane, each parameter being varied in turn, the others being fixed at their datum values, which are those at which the three curves intersect. The aircraft was seen as a small, simple single seater. It will be seen that L/D ratio of the tug is relatively unimportant and so aerodynamic efficiency can be sacrificed for ease of construction, and hence cheaper first cost. Weight reduction is reasonably important, whereas propeller efficiency is of paramount importance.

Because of the importance of propeller efficiency it was the first to be considered. About 85% is the best that could be hoped for. By comparison, from a brief measurement of performance of the Auster 6a's used at Lasham, the propeller efficiency was found to be about 64%. It would appear that for the low speeds used for towing a geared engine would produce the best results. Although enquiries for a geared engine to be developed were made, it appeared that the engine manufacturers consider it too expensive and too difficult for limited application. 'Why not just install more power in the first place?' was their argument. A belt drive from an existing engine was considered but the overall efficiency of belts plus propeller may well be not much better than the simpler direct drive propeller. It was also thought that an external gear or chain transmission to a countershaft would be unreliable and difficult to develop privately.

Despite the foregoing the author still feels that a geared engine would be of considerable advantage to the light aeroplane movement, mainly to reduce noise and hence the irritation to communities surrounding training airfields. It seems that at least 50% of the noise of a light plane is from the propeller. This noise problem may, in fact, be even more important for the glider tug.

Fig. 2 – Effect of power on power-plant cost and total time per tow



Since engine/propeller gearing was not readily available one is left with trying to get the best out of a direct drive propeller despite the high engine R. P. M.'s used by modern engines and the low speed of towing. Calculation shows that about 71 % should be possible for a direct drive propeller for this task.

At this stage it was concluded that a specialised glider tug was a practicable proposition but no further progress could be made without undertaking detailed design.

Specialised Design

During 1964 a Midget Racer Design competition was sponsored by Rollason Aircraft in England. At the end of the year the results were announced. It appeared that the winner of the third prize, the Mitchell-Prizeman 'Scamp' (fig. [5]) had many of the features envisaged for the ideal tow plane. It had obviously been designed more as a practical aeroplane than as an out-and-out racer. It was an all-metal single seater with tricycle landing gear and was designed for a 65 h.p. engine. The design had been gone into in considerable detail, an included several hours of wind tunnel work (Fig. 6).

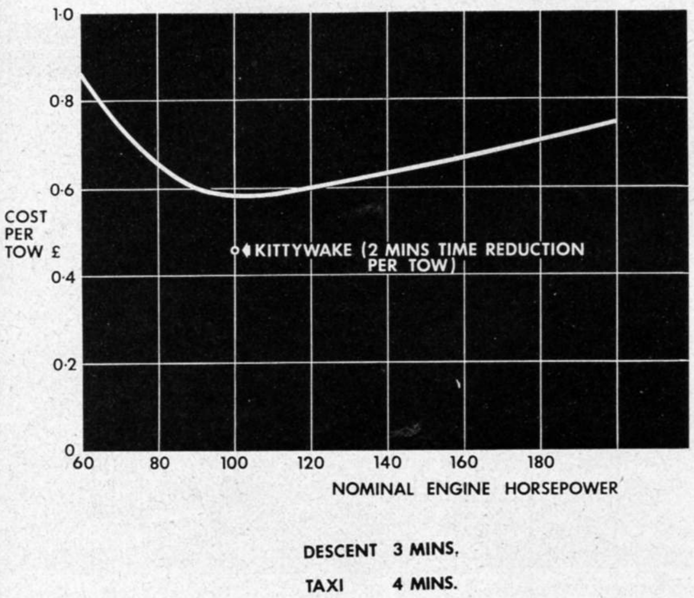


Fig. 3 – Effect of power on cost per tow

Contact was made with the designers of 'Scamp' and it was suggested that the design should be modified to fit in with the towing aircraft project study. Suprisingly enough they agreed to the 'minor' change of a 40% increase in wing area and power! The resulting design is known as the Mitchell-Procter 'Kittiwake' (fig. 7).

The main parameter, power, has been discussed at length and is 100 h. p. The Rolls-Royce Continental 0-200 A engine is specified. Size of the aeroplane is fixed by the chosen wing area. For this design wing area is a direct function of the desired stalling speed. The higher the stall speed, the smaller the wing, the lighter the aeroplane. It was decided that stall speed was itself a fonction of the design towing speed in that a reasonable margin should be kept between the two. In the event it was decided that 65 m. p. h. was the highest minimum towing speed that could be accepted and that this should be at least 15 m. p. h. above the stall. The higher forward speed also tended to favour propeller efficiency.

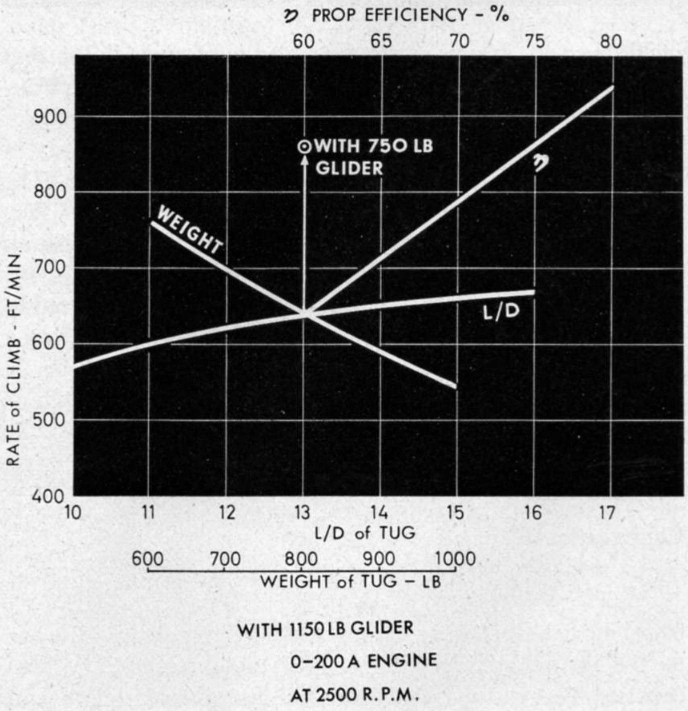
100 sq. ft. was chosen for the wing area which resulted in a flaps up stall speed of 50 m. p. h. Kittiwake should stall at 43 m. p. h. with full flap. Despite these somewhat high speeds take off should be no problem since there is much extra power. At a weight of 900 lbs take off to 50 ft. should take 900 ft., or 1,800 ft. with a 1,000 lb glider, in zero wind. Landing distances should not be excessive due to the large flaps giving good deceleration and also a rugged tricycle landing gear with really adequate hydraulic brakes.

Kittiwake is being designed for 6.67 G and a maximum diving speed of 220 knots. The rate of descent at 90 knots should be 2,000 ft./min with full flap.

In order to reduce time it was considered that the tow rope should be wound in during descent. This removes the need for a circuit after dropping the rope, or for landing well into the field so that a trailing tow rope can clear the downwind boundary by a reasonable margin. It is therefore proposed to install an electrically driven winch behind the pilot's seat. The rope will pass through a guillotine, for emergency release, and out through a large diameter tube with a fairlead at the end under the tail. The guillotine is operated by cable from a big lever in the cockpit. It is felt that the installation of this device, combined with a good tricycle landing gear, good brakes and nosewheel steering will materially reduce taxi distance and increase safe taxi speeds. These features, and the large flaps, between them are items that will result in significant saving of time per tow, and hence cost, without use of more power. Between them they should enable the 2 minute improvement in minimum time whose effect is shown in fig. 3.

Despite the extra weight it was considered that an electrical system should be fitted so that engine starting can be provided. It also enables electric instruments to be used, powers the tow rope winch, and enables radio to be fitted if desired.

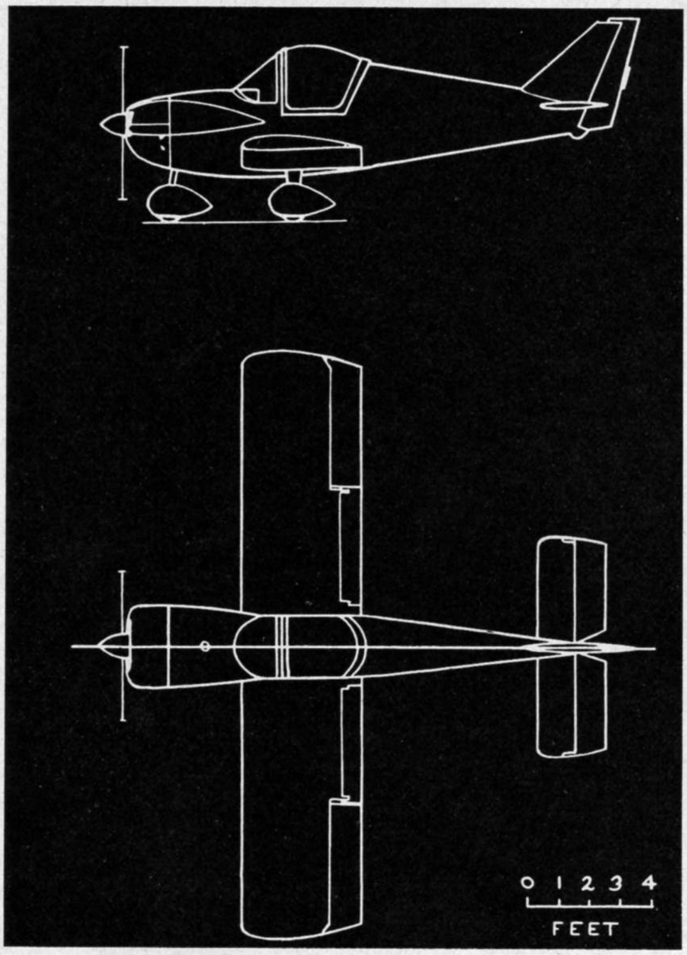
Fig. 4 – Effect of main parameters on climb performance



Detail design was commenced. It is the designers' intention to produce a strong, simple and good quality aeroplane. Very definite attempts are being made to avoid inadequacies, such as inability to fit all pilots, marginal vision, marginal controls etc.

It has been decided to build Kittiwake of metal as this seems more acceptable for modern aircraft. The author has had considerable experience of work on wooden gliders, including very extensive rebuilds, and is of the opinion that fewer man hours are likely to be required for a metal aircraft. It is doubted if a higher degree of skill is required for metal: particularly when the skill requirements for, say, a mainspar splice on a wooden glider are considered. The authors look forward to completing Kittiwake when they feel they will be in a better position to give a positive opinion on this point!

Fig. 5 – Mitchell-Prizeman 'Scamp'



As part of this effort a simple mock up was constructed to determine how easy it would be to get in and out wearing a parachute, and also how wide the cockpit should be. It was also possible from the mock-up to determine the pilot's view, particularly while taxying. The pilot should be able to see the ground about 20 ft. directly in front of the nose.

Construction

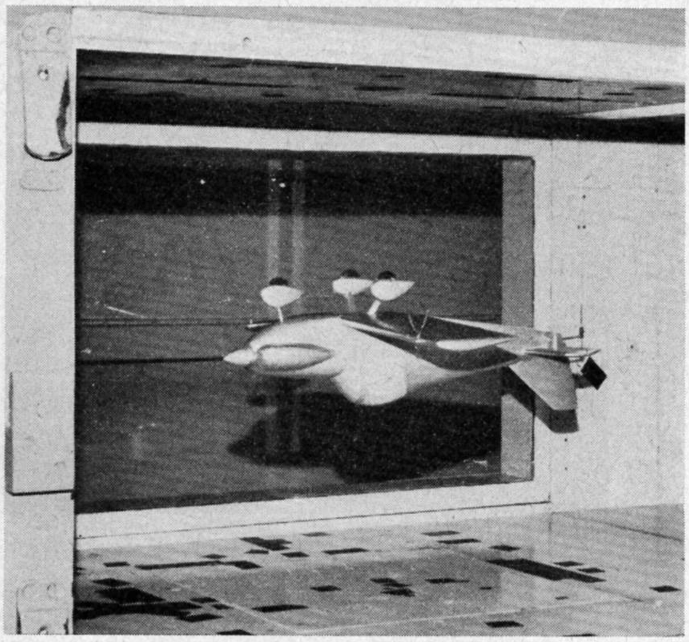
Wing

The wing is a single spar, twin torque box, structure attached to the centre section outboard of the fuselage. The spar consists of extruded L 64 'T'-section booms and a plate web. The wing skins are light gauge (22 s. w. g.) stabilised by close-pitch ribs. All platework is L 72 aluminium alloy. Flaps are single slotted, supported on swinging links and an actuating torque tube. Ailerons are fabricated from 26 s. w. g. platework and are mounted by simple piano hinges on the top surface.

Fuselage

The fuselage is based on four angle section longerons. The centre section spar and torque box forms the pilot's seat. There is a crash pillar behind the pilot. The windscreen and forward top decking is removeable to give access to the instruments, radio and fuel tank. The cockpit hood slides aft to open and may be opened in flight to provide direct vision.

Fig. 6 – Model of 'Scamp' in wind tunnel



Landing Gear

The main undercarriage consists of 5.00 – 5 wheels with hydraulically actuated disc brakes mounted on spring-steel leaf legs. The undercarriage is built into the fuselage so that the wings may be removed without jacking the aircraft. The nose gear has compression rubber springing and is linked to the rudder system for steering. The nose wheel is also 5.00 –5.

Tail Surfaces

Tail surfaces and controls are fabricated from light gauge skins, ribs and spars. Control hinges are simple bolts in steel plate brackets.

Control Systems

Control systems are a combination of pushrod and cables. The latter are only used for straight runs where no pulleys are necessary. Elevator trim is by means of a tab actuated by a trim wheel mounted at the side of the cockpit. Flaps are manually operated, the linkage being a torque tube. Maximum use is made of bearings which do not require lubrication. Good access is provided where necessary to the control system for maintenance and overhaul.

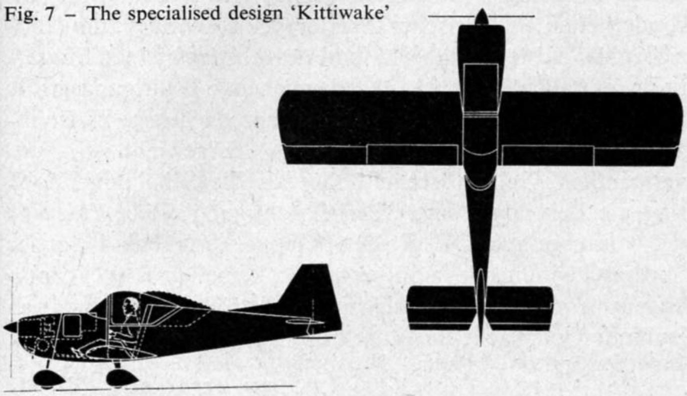
Powerplant

Rolls-Royce C-90 or O-200A flat four engine. Special attention is being given to engine cooling and propeller design. Generator, starter and (if required) cockpit heater are installed. A silencer may be installed as the author feels quite strongly that noise should be kept to a minimum.

Progress to date (June 1965)

Design and detail drawings are complete for the wings, the rest of the aircraft is schemed and detailed drawings are being made as fast as time permits. Sheet and spar extrusions have been delivered for the wing and construction has been started at the homes of the authors. Templates and compressed wood form tooles are being made for plate parts. This will enable subsequent aircraft to be produced relatively rapidly, even on a one off amateur basis. Agreement has been reached with the training department of British European Airways whereby they will make certain parts for the first aircraft as part of their training programme. This will very materially reduce the time scale to first flight.

Fig. 7 – The specialised design 'Kittiwake'



Future plans

The first Kittiwake is being built by the designers in order to determine whether the hopes for a specialised tow plane can be realised in practice.

The Mitchell-Prizeman design was the result of about 300 engineering man-hours work. It was fully costed and a production programme outlined. On the basis of this work in quantity production (batch in excess of 40 aircraft) the Kittiwake should cost about £ 2000 ready to fly.

Design and construction of the prototype recognises the requirements of series production and also of home construction of factory-produced kits. If flight trials are successful the designers would hope that an organisation could be found to undertake production at a reasonable cost.

By change of propeller to one more suited for general use, it is hoped that Kittiwake will appeal to a wider market as a good sport and aerobatic aircraft. Cruise speed should be 130 m. p. h. The strength factors and high D not only provide a useful reserve of strength, but also allow full aerobatic manoevres. Space and power is available for radio and full blind-flying instrumentation.

Tip fuel tanks are envisaged to increase range, partly for aerotow retrieves, and partly to add to Kittiwake's attractiveness as a touring aircraft. The first aircraft is being provided with structural attachments and plumbing for these tanks. They will be designed when the wing and landing gear stiffness has been measured.

A two-seat version using the same wings, tail, landing gear and power plant is also being considered and should be able to be produced merely by building a wider fuselage. If the designers' energy remains, they may attempt to build this fuselage after certification of the single seater.

It is intended to fly Kittiwake under the Popular Flying Association 'Permit to Fly' scheme. However, if successful it is intended to obtain full Air Registration Board type certification if this can be achieved at reasonable cost.

Editor's Note. The above paper represents the state of the project as at June 1965. The authors' now give the position, as at July 1967, to be as follows:

The first 'Kittiwake' (fig. 8) has been built and has flown successfully. At the time of writing about ten hours of test flying have been carried out. So far no attempt has been made to tow a glider, it being desired to complete basic aeroplane test work first.

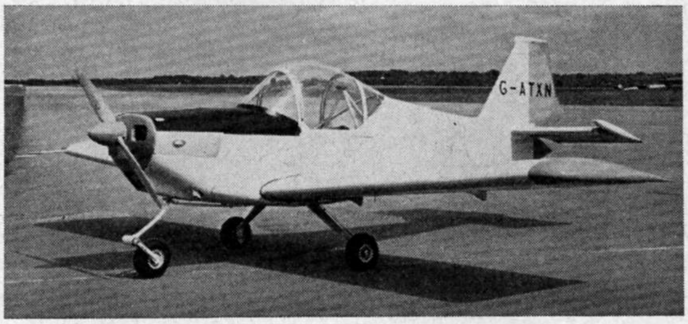
Some changes have occurred in the aircraft since the paper was written. The most noteable has been to avoid the use of a fuselage fuel tank: instead 22 Imperial Gallons of fuel are in integral fuel tanks in the wing leading edge structure. The empty weight (inevitably!) has come out higher than estimated, but not so high as to prevent the towing of gliders.

To date performance measurements have been made in climb and, allowing for the empty weight increase, are as predicted. The engine/propeller matching is as calculated. Controls are powerful and effective and the visibility from the cockpit is exceptionally good. The large flaps have proved very effective, rates of descent of 2500' per minute being achieved. There have been no change-of-trim-with-power problems with full flap, an area where some difficulty was anticipated. Handling on the ground is also simple and positive. Some development work is required on engine cooling, and the high-speed handling has yet to be investigated. Testing continues and a full A. R. B. permit to fly is expected shortly.

On construction the authors feel that metal is just as easy, if not easier, than wood to use. Problems encountered in build were mainly associated with systems which are common to all aircraft and were not a result of metal construction.

'Kittiwake' has aroused a great deal of interest and discussions are in progress with manufacturers for production aircraft. It is intended to continue development with the two-seater version, probably with a 150 h. p. engine.

Fig. 8 – 'Kittiwake' prototype



Zusammenfassung

Obwohl der Flugzeugschlepp die angenehmste Art des Starts eines Segelflugzeuges ist, wird er wegen seiner Kosten nur begrenzt angewendet. Ein grosser Teil dieser Kosten hängt vom geringen «Leistungswirkungsgrad» von ungefähr 18% ab (die vom Segelflugzeug aufgenommene Leistung im Verhältnis zur Leistung des Triebwerks). Es wurde eine Studie für den Entwurf eines wirkungsvolleren Schleppflugzeuges durchgeführt, wobei man hoffte, Kosten von nur 6 Franken für einen Schlepp auf 600 m Höhe zu erreichen (Preise für 1965).

Die vorhandene Leistung ist in Figur 1 dargestellt. Sie zeigt, dass die Motorleistung des Schleppflugzeuges eigentlich nur während 37,5% der Gesamtzeit zwischen zwei Starts benötigt wird.

Die nächsten Figuren zeigen den Einfluss verschiedener Parameter. Figur 2 lässt erkennen, dass wachsende Leistung die Zeit zwischen zwei Schlepps verkürzt, wie es ja allgemein festgestellt wird, doch ist die Verkürzung geringer, als man oft denkt; hierbei steigen die Kosten merkbar. Der Einfluss von Zeit und Kosten wird in Figur 3 dargestellt: man erkennt ein Optimum bei ungefähr 100 PS. Die Wirkung von Änderungen des Gewichts, der Gleitzahl und des Luftschraubenwirkungsgrades ist in Figur 4 für einen kleinen, einfachen Einsitzer gezeigt. Danach ist die Gleitzahl kaum von Bedeutung, doch ist der Propeller-Wirkungsgrad sogar wichtiger als das Gewicht. Der übliche Wirkungsgrad von ungefähr 64% könnte durch optimale Wahl des Propellers auf 71% erhöht werden, doch würde eine weitere Verbesserung ein Untersetzungsgetriebe erfordern. Geeignete Getriebemotore sind aber nicht verfügbar.

Der «Scamp» (Figur 5) schien die Merkmale für ein Schleppflugzeug aufzuweisen; er wurde im Windkanal untersucht (Figur 6). Eine Version «Kittiwake» wurde in Verbindung mit den Konstrukteuren des «Scamp» entworfen (Figur 7 und 8). Die «Kittiwake» hat ein 100-PS-Continental 0-200 A-Triebwerk, ist für eine Schleppgeschwindigkeit von 100 km/h vorgesehen, und hat eine Flügelfläche, die 25 km/h Geschwindigkeitsspanne bis zum Überziehen ergibt, wenn ohne Klappen geschleppt wird. Klappen reduzieren die Überziehgeschwindigkeit auf 70 km/h. Die Startstrecke bis 15 m Höhe beim Schlepp eines Segelflugzeuges von 450 kg Fluggewicht wird auf 550 m geschätzt.

Das Flugzeug ist in Metall gebaut und hat folgende Besonderheiten: elektrischer Starter; eine Winde zum Einziehen des Schleppseiles während des Abstiegs; einen Führerraum, der allen Piloten passt; ausreichende Betätigungsgriffe.

Im Juli 1967 wurde das erste Flugzeug fertig; es ist inzwischen 10 Stunden geflogen. Das Leergewicht ist – unvermeidlich – ein bisschen höher als die Schätzung, doch sind die Leistungen unter Berücksichtigung dieser Tatsache wie vorausgesagt. Die grossen Klappen erlauben 13 m/sec Sinkgeschwindigkeit und ergeben keine grosse Trimmänderung mit der Motorleistung. Der Metallbau hat sich zumindest so leicht ausführbar erwiesen wie der Holzbau.

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