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THE DHA GLIDERS

AUSTRALIA'S "WOODEN WARBIRDS"

Gp Capt Keith Isaacs AFC, RAAF (Retd) reveals the hitherto untold story of the de Havilland Australia G1 and G2 gliders of the RAAF in WW II, and how they spawned an exotic post-war gem — a suction wing glider with a Ford V-8 engine.

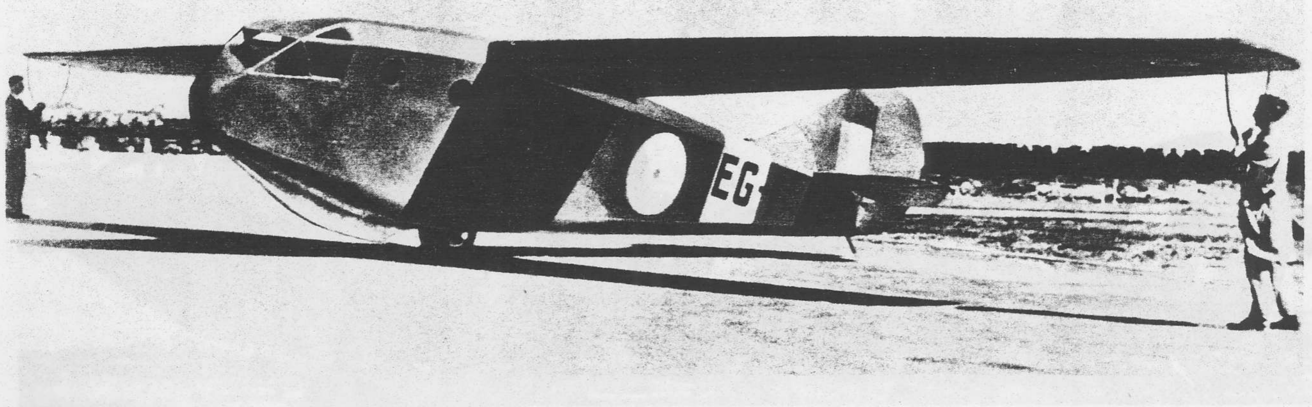
THE HISTORY of airpower in the Antipodes began, tentatively, in 1909 when a fragile biplane glider with a boxkite tail became the first aerodyne to fly in Australia. On 11 September 1909, the Commonwealth Government had announced a competition for "Flying Machines For Military Purposes" and one contender for the £5,000 prize was George Augustine Taylor. During September, Taylor opened an aeroplane factory — the first in Australia and, probably, the first in the southern hemisphere — at Redfern, a suburb of Sydney, New South Wales. There he constructed a glider based on the boxkite experiments of Lawrance Hargrave, a close friend and mentor for some years. Thus on 5 December 1909, Taylor became the first man in Australia to fly a heavier-than-air craft when he completed a number of flights in his glider from the sand-dunes at Narrabeen Beach, near Sydney.

Taylor's historic glider was built under the aegis of the army and, on 20 December, he was made an honorary lieutenant in the Australian Intelligence Corps. Early in 1910, Taylor designed a 20 hp engine which he planned to install in his glider to meet the requirements of the government's competition for a powered military aeroplane. The engine was not a success, however, and he abandoned the project. Nevertheless, Taylor's glider is recorded in history as the unpowered precursor of the military aeroplane in Australia.

Gliders subsequently disappeared from the Australian military scene for almost 33 years; except, perhaps, for the pseudo-glider demonstrations during the three great RAAF displays at RAAF Laverton, Victoria, on 10 November 1934, Flemington Racecourse, Victoria, on 9 April 1938, and RAAF Richmond, NSW, on 23 April 1938. Each of these pageants featured a popular event showing "a possible method of rescue of light aircraft after engine failure". In each instance a D.H.60 Gipsy Moth appeared over the spectators, simulated an engine failure and made a spot landing with a "dead stick". Mechanics immediately removed the propeller and attached 300 ft (91,5 m) of towline cable, with a special quick-release fitting, to the propeller boss. A Westland Wapiti then towed the Moth to 3,000 ft (915 m) before casting it off over the landing area; in the 1938 displays the "glider" slow-rolled during the climb to height. After release, the Moth dived for speed, made a perfect loop off the glide, executed a stall turn or two to dispose of surplus height and concluded by making another excellent spot landing. The propeller was immediately refitted and the aircraft flew off under its own power. Thus, these RAAF "Moth Gliders" — like their insect namesakes — enjoyed but a minuscule life span.

Such demonstrations were in keeping with the happy, carefree days of the inter-war air displays, but all-too-soon

(Below) The first prototype DHA G1 glider, EG-1, photographed on the tarmac outside the Special Duties and Performance Flight, RAAF Laverton, in November 1942. (Heading photo) The first of the six production DHA G2s, A57-1, in free flight near RAAF Laverton, whilst in use as a trials and pilot-conversion aircraft at the SDPF between 1943 and 1945.



these gave way to the grim reality of global conflict and, early in 1942, Japanese forces were poised around northern Australia where an invasion appeared imminent. One immediate problem facing Australia was the inability to transport, rapidly, large numbers of troops and equipment across the vast inland areas of the continent to the northern defence perimeters. Existing road and rail facilities were inadequate and the RAAF transport aircraft element was practically non-existent. In fact, a small number of civilian airliners, including Short Empire flying boats, Douglas DC-3s and de Havilland D.H.86s and D.H.89s, had been chartered and impressed to augment the RAAF's sole transport aircraft type, the Wackett-designed Tugan Gannet. In addition, a varied collection of privately owned Percival, Fairchild, Miles, Stinson, Beechcraft, Cessna, de Havilland and Lockheed light aircraft was taken over for communications duties. At the time, the demand for transport aircraft was at a premium throughout the world and the possibility of Australia obtaining such machines in a hurry was extremely remote. From this desperate situation, therefore, a need arose for production of a transport aerodyne — which could be constructed quickly and easily — for use in conjunction with the existing transport force. One answer to the problem appeared to be the military glider.

The experimental gliders

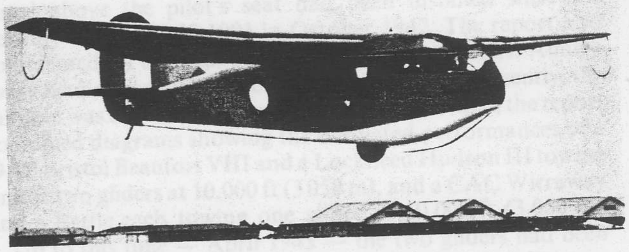
On 24 March 1942, the Aircraft Advisory Committee — which had been set up by the War Cabinet in 1941 to advise the Director-General of the Department of Aircraft Production — received a communication from the Director-General of Supply and Production, Department of Air, stating that an immediate requirement existed for 126 gliders. Accompanying the communication was an RAAF specification for an experimental seven-seat prototype glider, which was submitted to the Commonwealth Aircraft Corporation and to de Havilland Aircraft Pty Ltd (nominally known as de Havilland Australia or simply DHA). L J Wackett, as Chief Technical Adviser to the committee, considered that the project could be handled by DHA, and committee member Major A Murray Jones, General Manager of DHA, concurred with Wackett's suggestion.

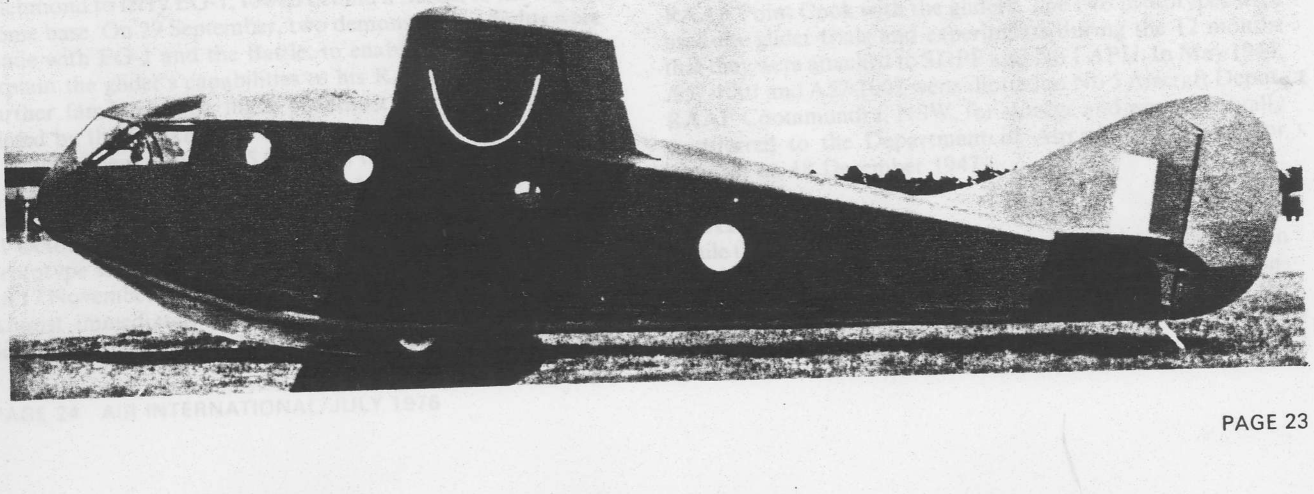
The terms of reference specified that no equipment or labour — other than a chief designer and an organiser and stressing expert — would be provided by DHA. This was because of the priority allotted to contracts for the D.H.82A Tiger Moth and the DHA.84 Dragon Trainers, both of which were in full production at Mascot Aerodrome, Sydney. Furthermore, tentative plans were already in being for the construction by DHA of Australian versions of the D.H.98 Mosquito. In the event, the Sydney branch of Slazengers (Australia) Pty Ltd provided a foreman, a draughtsman, most of the labour force and all the woodworking equipment. Perhaps the most surprising aspect of the project was the locale selected for the production of the prototype glider — the fifth floor of the Bradford Cotton Mills building at Camperdown, Sydney.

As chief designer, DHA selected Martin Warner, who was not only an engineer but a keen glider pilot and a member of the Sydney Soaring Club. Warner had already designed two attractive and efficient pod-and-boom sailplanes, the Kite I and Kite II (in no way connected with the English Slingsby designs of the same name). DHA also provided Steve Newbigin, while Gordon Andrews became the main draughtsman. As the project got under way the transport gliders became known, unofficially, as "Warner's Wooden Warbirds".

In April 1942, the RAAF authorised the construction of a second DHA G1 prototype glider, for military trials, before a production line was laid down. It is interesting to note that the RAAF referred to both aircraft as Experimental Glider 1 types, whereas DHA identified them as Experimental Glider-1 and Experimental Glider-2.

EG-1 and EG-2 were built entirely with Australian materials in accordance with the specification. Each glider was a high wing cantilever monoplane with a thick plywood covered monospar wing of 59 ft (17,9 m) span. The wing section at the root of the mainplane was NACA 23015 and changed to NACA 4415 near the wing tips. The ailerons were of a simple unbalanced type and spoilers were located on the upper surface of each wing near the maximum thickness. The box-section fuselage was plywood covered and was built up on four longerons. Seats were provided for a pilot, and six passengers in three pairs. Access doors were positioned on each side of the fuselage and a luggage locker was situated at the back of the rear seat. The windscreen and window frames of the DHA utility version of the Dragon radio and navigation trainer — equivalent to the British Dragon Mk I — were incorporated in the glider design, but the rest of the nose section was an original pattern. The tail unit was of simple construction with unbalanced elevator, "cheesecutter" longitudinal trim and a horn balanced rudder with a fixed metal trimming tab. The control surfaces were fabric covered. The undercarriage consisted of a single wheel, approximately





(Below) The second prototype DHA G1 at RAAF Laverton in 1943. The original marking EG-2 has been removed but the serial A57-1002 has yet to be applied; white and blue Pacific markings are carried. (Above right) The first production G2 being towed-off from RAAF Laverton (by a Dakota) during a display in August 1947.

De Havilland DHA G1 Specification

Performance: Towing speed, 130 mph (209 km/h); maximum speed, 185 mph (298 km/h); stalling speed, 48 mph (77 km/h).
Weights: Empty, 1,240 lb (563 kg); loaded, 2,800 lb (1 272 kg).
Dimensions: Span, 59 ft 0 in (17,99 m); length, 35 ft 0 in (10,68 m); height, 7 ft 10 in (2,39 m); wing section NACA 23015.
Accommodation: Pilot and six troops.

De Havilland DHA G2 Specification

Performance: Towing speed, 130 mph (209 km/h): max speed, 200 mph (322 km/h); stalling speed, 48 mph (77 km/h).
Weights: Empty, 1,450 lb (658 kg); loaded, 3,250 lb (1 476 kg).
Dimensions: Span, 50 ft 6 in (15,40 m); length, 33 ft 0 in (10,07 m); height, 7 ft 10 in (2,39 m); wing section NACA 23015.
Accommodation: Pilot and six troops.

beneath the aircraft's centre of gravity and braced to the mainplane spar on a tubular steel frame. The nose skid was sprung by rubber buffers and the tail skid was of laminated ash with a metal shoe sprung by coiled elastic bands.

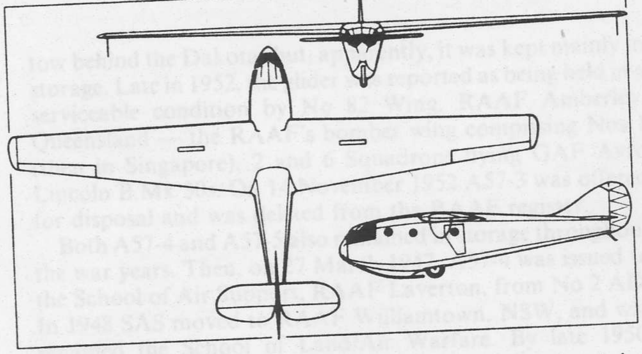
The pilot's controls consisted of a conventional column and rudder pedals, "cheesecutter" tail trim, spoiler control lever and brake lever. The flying instruments comprised an ASI, altimeter, fore and aft level and cross level. The glider was towed from two points under the main spar and the towline about 200 ft (61 m) of 2½ in (6.4 m) manila rope — had a 28 ft (8,5 m) bridle at the end. Maximum tow speed was 130 mph (209 km/h) which brought the gliders into the minimum tug speed range of a Supermarine Spitfire. Although the Spitfire was used for subsequent trials, the initial flying tests were made behind Wapiti and Battle aircraft; a photograph of Wapiti, A5-16 with EG-1 and EG-2 on tow appeared in "Project Skywards" (*Air International,* July 1975). The gliders had a gross weight of 2,800 lb (1 271 kg), and a tare weight of 1,240 lb (563 kg) which comprised the pilot, six passengers and 160 lb (73 kg) of luggage.

Flight testing by DHA of EG-1 began on 14 June 1942, after the glider had been assembled at RAAF Richmond. The first taxi tests were made behind a RAAF motor vehicle and a Wapiti then took over for the initial flight tests. The tests were satisfactory, although an accident occurred in the first week of July, during full load trials, when the tow rope broke on a flight behind a Battle, between Bankstown and Richmond. Warner was flying the ballast-loaded glider, and Newbigin was also aboard as an observer. Although the pilot landed successfully in a small field, the brake structure on the single landing wheel failed and the glider went through a fence with barbed-wire strands. The nose of the aircraft was considerably damaged, and Warner spent some weeks in hospital with badly lacerated shins. Meanwhile, the incomplete second prototype, EG-2, was transferred from Camperdown to a building which had previously been used as the Slingo and Williams toy factory. In early November the glider was assembled at Mascot where flight tests were made.

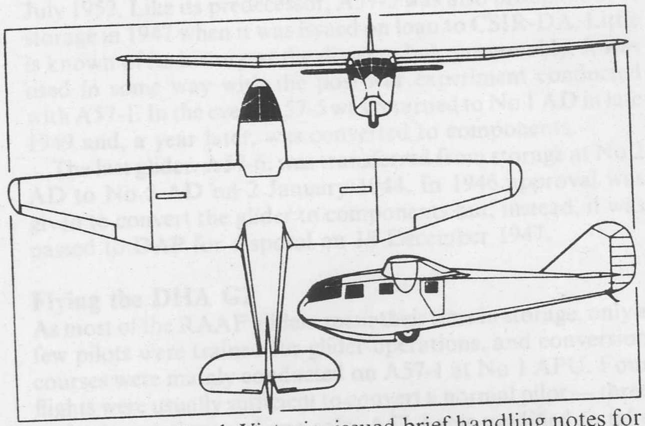
Prototypes enter service

In late September 1942, personnel from the Special Duties and Performance Flight, RAAF Laverton, arrived at RAAF Richmond to ferry EG-1, towed behind a Battle, to the flight's home base. On 29 September, two demonstration flights were made with EG-1 and the Battle, to enable the DHA pilot to explain the glider's capabilities to his RAAF counterpart. A further familiarisation flight of almost one hour was completed by the RAAF on 2 October.

During the morning of 5 October, the Battle took-off from RAAF Richmond with EG-1 on tow, bound for RAAF Laverton, where EG-1 was officially accepted by the RAAF on 11 October 1942 and it was later renumbered with the service prototype serial A57-1001. It was joined at RAAF Laverton on 17 November by EG-2 which eventually became A57-1002. Almost immediately the RAAF, through the Council for Scientific and Industrial Research — Division of Aeronautics



Three-view drawings depict the different wing plan forms of (above) the DHA G1 and (below) DHA G2.



at Fishermen's Bend, Victoria, issued brief handling notes for the gliders. Part One of this report, published in November 1942, detailed the operating capabilities of A57-1001 on the ground, in towed flight, in free flight and during the landing pattern.

Part Two of the CSIR-DA report, dated April 1943, revealed that "further flying has been done on A57-1001 (EG-1), including the rate of descent in free flight and the investigation of stability on tow". This report stated that the most stable condition for towing was at 120 mph (193 km/h) with the glider below the tug; presumably, the clear vision panel above the pilot's seat had been installed since the delivery flight of A57-1001 in October 1942. The report also commented on the high accident rate with tail skids. Almost every landing resulted in a broken skid and, consequently, the tail skid was considerably strengthened. In addition, the report contained diagrams showing the estimated performances of a DAP Bristol Beaufort VIII and a Lockheed Hudson III towing one or two gliders at 10,000 ft (3 050 m), and a CAC Wirraway and a Battle each towing one glider at 10,000 ft (3 050 m).

Up to this time — April 1943 — the two gliders had been held on charge by No 1 Aircraft Depot, RAAF Laverton. During the month, however, they were transferred to SDPF, RAAF Laverton — this flight subsequently became No 1 Aircraft Performance Unit, and a detachment moved to RAAF Point Cook with the gliders. The two prototypes were used for glider trials and experiments during the 12 months that they were attached to SDPF and No 1 APU. In May 1944, A57-1001 and A57-1002 were allotted to No 5 Aircraft Depot, RAAF Cootamundra, NSW, for storage and were eventually transferred to the Department of Aircraft Production for disposal on 18 December 1947.

RAAF glider element

While the DHA G1 prototypes were undergoing initial tests in mid-1942, the RAAF glider specification had been considerably changed, necessitating a major redesign for the production models. One change involved the division of the wing into three parts for ease of transportation. A two-wheel undercarriage was also proposed, but this was rejected in favour of the original monowheel. Also, by the time production commenced on the improved DHA G2 gliders, the original requirement for a large number of these aircraft had been negated by several factors — the improved military situation, the acquisition by the RAAF of Douglas Dakotas and other transport aircraft and the availability of the Waco CG-4A glider which accommodated 15 troops. Consequently, only six DHA G2 gliders were ordered in accordance with RAAF Specification 5/42, and they were allotted the RAAF serial numbers A57-1 to A57-6. It is pertinent to record that during November 1942, DAP received an enquiry from the USAAF in connection with the supply of 20 DHA G2 gliders. Follow-up action was initiated, but an order from the USAAF did not eventuate.

The six production gliders were all built in the Slingo and Williams building and were assembled at Mascot Aerodrome for testing. Battles were flown in from No 1 Aircraft Park, RAAF Geelong, Victoria, for towing, and the tests were carried out at No 3 Communications Flight, RAAF Mascot. DHA tested the first glider on 20 March 1943, and the ailerons were found to be very heavy owing to the fitment of substitute bearings. The incorporation of a balance tab rectified this fault and, by July, all six gliders had been tested by the company.

In contrast to the DHA G1, the DHA G2 glider had a slightly larger fuselage although it still retained the DHA.84 Dragon fittings. Also, the one-piece straight wing of 59 ft (17,99 m) span on the G1 was replaced with one of 50 ft 6 in (15,40 m) span with a single box spar, a 23 ft (7,02 m) constant chord centre section and two tapering outer sections. In addition the round windows and short wingtip skids on the G1 gave way to square windows and longer wingtip skids on the G2. Most of these changes were made, under the direction of Martin Warner, by the complete fourth year University of Sydney aeronautical class of students. Professor A V Stephens, who had assisted in solving the aerodynamic problems on the prototypes, also took a close personal interest in the construction of the DHA G2s and in March 1943 he proposed fitting an experimental laminar flow wing to a DHA G2 glider for aerodynamic tests, but this project was held in abeyance.

The first production glider, A57-1, was handed over to the RAAF at DHA Mascot on 6 May 1943 and, on 11 June, it was delivered to SDPF for service trials. The glider was damaged in a landing at RAAF Laverton on 22 October and was issued to No 1 AD for repairs. On 10 January 1944, A57-1 was allotted to No 1 APU where it completed its wartime service as a trials and pilot-conversion aircraft. It was transferred to No 1 Central Recovery Depot on 20 January 1945 for storage and, as from November 1946, was kept in Category E storage at No 1 Stores Depot. But A57-1 had yet to reach the zenith of its career, and the rôle it played post-war in a major experiment is subsequently related.

The remaining five gliders, A57-2 to A57-6, were all delivered to No 2 Aircraft Depot, RAAF Richmond, from No 2 Aircraft Park, RAAF Mascot, in July 1943. On 30 August it was decided to transfer the five gliders, for temporary storage, to No 1 Air Observers School, RAAF Evans Head, NSW (where the author first saw the DHA G2 glider while on an interim posting to No 1 AOS as a staff pilot flying Avro Ansons in 1944).

The third glider, A57-3, remained in storage until March 1948 when it was transferred for overhaul from No 2 AD to DHA. It was then allotted to No 86 Wing, RAAF Richmond — comprising Nos 36, 37 and 38 Squadrons flying Dakotas — but was damaged during take-off on the delivery flight from Mascot Aerodrome on 31 May 1948. In the event, the glider continued the towed flight to Richmond and was repaired by No 2 AD before it joined the transport wing on 10 August. A57-3 is believed to have completed the occasional flight on tow behind the Dakotas but, apparently, it was kept mainly in storage. Late in 1952, the glider was reported as being held in a serviceable condition by No 82 Wing, RAAF Amberley, Queensland — the RAAF's bomber wing comprising Nos 1 (then in Singapore), 2 and 6 Squadrons flying GAF Avro Lincoln B.Mk 30s. On 14 November 1952 A57-3 was offered for disposal and was deleted from the RAAF register.

Both A57-4 and A57-5 also remained in storage throughout the war years. Then, on 27 March 1947, A57-4 was issued to the School of Air Support, RAAF Laverton, from No 2 AD. In 1948 SAS moved to RAAF Williamtown, NSW, and was renamed the School of Land/Air Warfare. By late 1950, SCLAW had relegated A57-4 to an instructional airframe and it was eventually converted to components at the school on 7 July 1952. Like its predecessor, A57-5 was also brought out of storage in 1947 when it was issued on loan to CSIR-DA. Little is known of its history at the division but, presumably, it was used in some way with the post-war experiment conducted with A57-1. In the event A57-5 was returned to No 1 AD in late 1949 and, a year later, was converted to components.

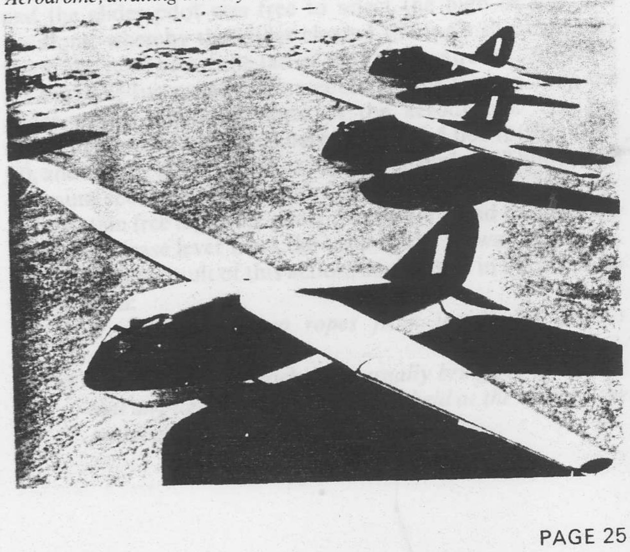
The last glider, A57-6, was transferred from storage at No 2 AD to No 5 AD on 2 January 1944. In 1946 approval was given to convert the glider to components but, instead, it was passed to DAP for disposal on 18 December 1947.

Flying the DHA G2

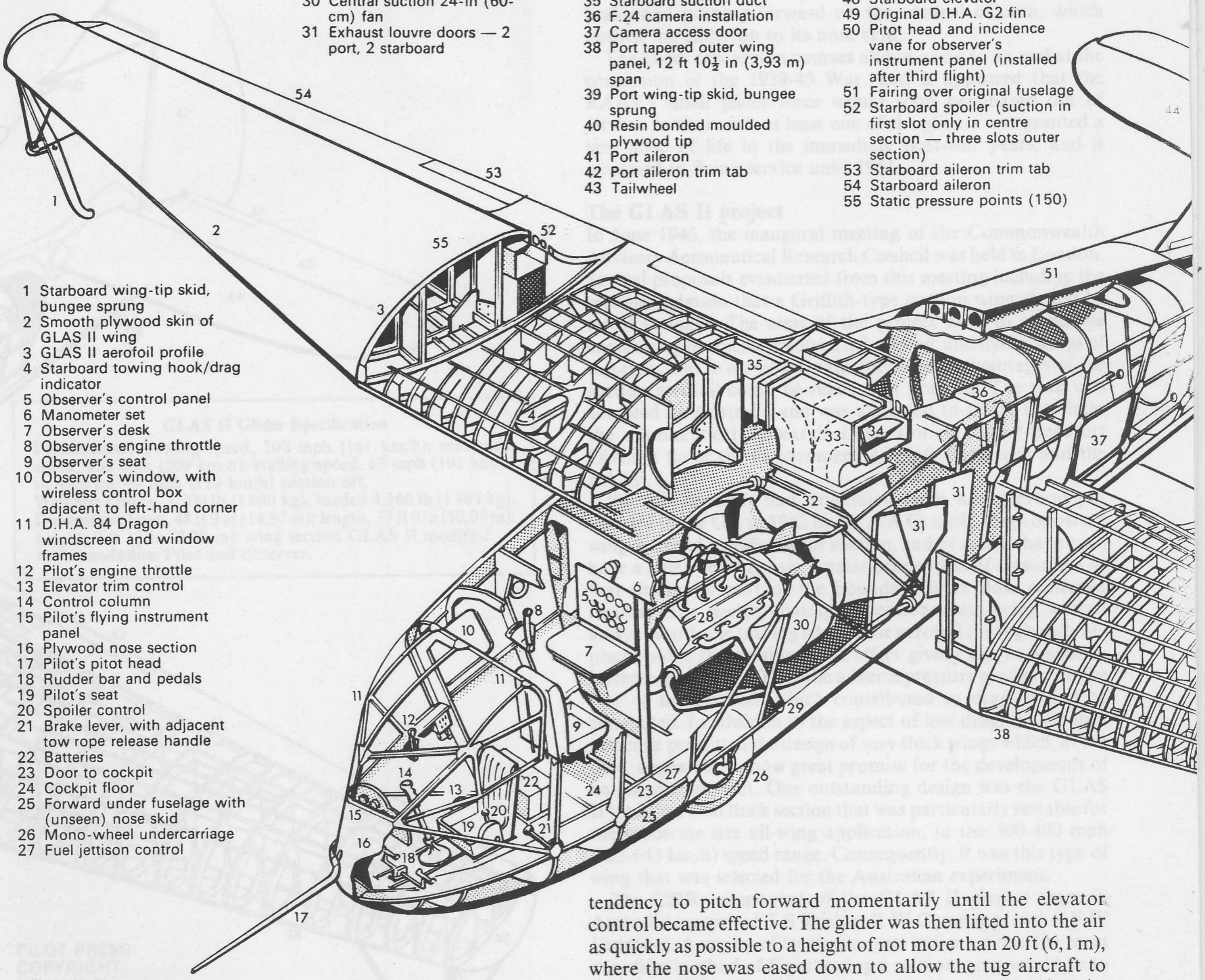
As most of the RAAF gliders spent their time in storage, only a few pilots were trained for glider operations, and conversion courses were mainly conducted on A57-1 at No 1 APU. Four flights were usually sufficient to convert a normal pilot — three under instruction, and one solo. A57-1 was modified to take dual controls, although the second set comprised only a control column and rudder bar. When required, the latter installation was mounted behind the normal pilot's seat, in front of the forward row of passenger seats, where it was possible to see the instrument panel — comprising an airspeed indicator, altimeter, pitch indicator and bank indicator — over the shoulders of the first pilot.

Preparations for flight included a normal pre-flight inspection of the glider with particular attention being paid to the tow rope and release gear of the tug aircraft. On the glider the pilot checked that the tow release catches under the wing were properly closed, and that the lever for the tow rope release was in the lock position; this lever was on the left hand side of the cockpit above the cable-operated brake lever for the single landing wheel. The spoilers — which were fitted to the top surface of the wing, and were operated by a lever forward, and to the left, of the pilot's seat — were checked in the closed

Three of the DHA G2 gliders after assembly at DHA Mascot Aerodrome, awaiting delivery to No 2 AD, RAAF Richmond, in July 1943.



GLAS II cutaway drawing key



1 Starboard wing-tip skid, bungee sprung
2 Smooth plywood skin of GLAS II wing
3 GLAS II aerofoil profile
4 Starboard towing hook/drag indicator
5 Observer's control panel
6 Manometer set
7 Observer's desk
8 Observer's engine throttle
9 Observer's seat
10 Observer's window, with wireless control box adjacent to left-hand corner
11 D.H.A. 84 Dragon windscreen and window frames
12 Pilot's engine throttle
13 Elevator trim control
14 Control column
15 Pilot's flying instrument panel
16 Plywood nose section
17 Pilot's pitot head
18 Rudder bar and pedals
19 Pilot's seat
20 Spoiler control
21 Brake lever, with adjacent tow rope release handle
22 Batteries
23 Door to cockpit
24 Cockpit floor
25 Forward under fuselage with (unseen) nose skid
26 Mono-wheel undercarriage
27 Fuel jettison control
28 Ford Mercury 59A 96 bhp V-8 engine
29 Engine exhaust pipe
30 Central suction 24-in (60-cm) fan
31 Exhaust louvre doors — 2 port, 2 starboard
32 Engine coolant radiator in suction duct
33 Suction "T" duct
34 Turning vanes in suction "T" duct
35 Starboard suction duct
36 F.24 camera installation
37 Camera access door
38 Port tapered outer wing panel, 12 ft 10½ in (3,93 m) span
39 Port wing-tip skid, bungee sprung
40 Resin bonded moulded plywood tip
41 Port aileron
42 Port aileron trim tab
43 Tailwheel
44 Tailplane set at 8½ deg negative incidence
45 Port elevator
46 Port elevator trim tab
47 Original D.H.A. G2 rudder
48 Starboard elevator
49 Original D.H.A. G2 fin
50 Pitot head and incidence vane for observer's instrument panel (installed after third flight)
51 Fairing over original fuselage
52 Starboard spoiler (suction in first slot only in centre section — three slots outer section)
53 Starboard aileron trim tab
54 Starboard aileron
55 Static pressure points (150)

position. When checking the flying controls it was necessary to obtain full movement of the ailerons to ensure that the gap between the balance tabs and the ailerons was clear.

The glider was positioned off the runway for take-off to ensure that it would not pitch forward on its nose during the initial take-off stage; otherwise, it would stop on the nose skid and lift the tail high off the ground and, of course, the tail would be damaged when released from the tug in this condition. It was also desirable to have the wings held level before the take-off commenced. The brakes were then released by the glider pilot and take-off trim was set — longitudinal trimming was effected by a trim tab on the elevators which was operated by a lever on the right hand side of the cockpit. The tug, having been attached to the glider, would then taxi slowly forward to take up the slack in the tow rope.

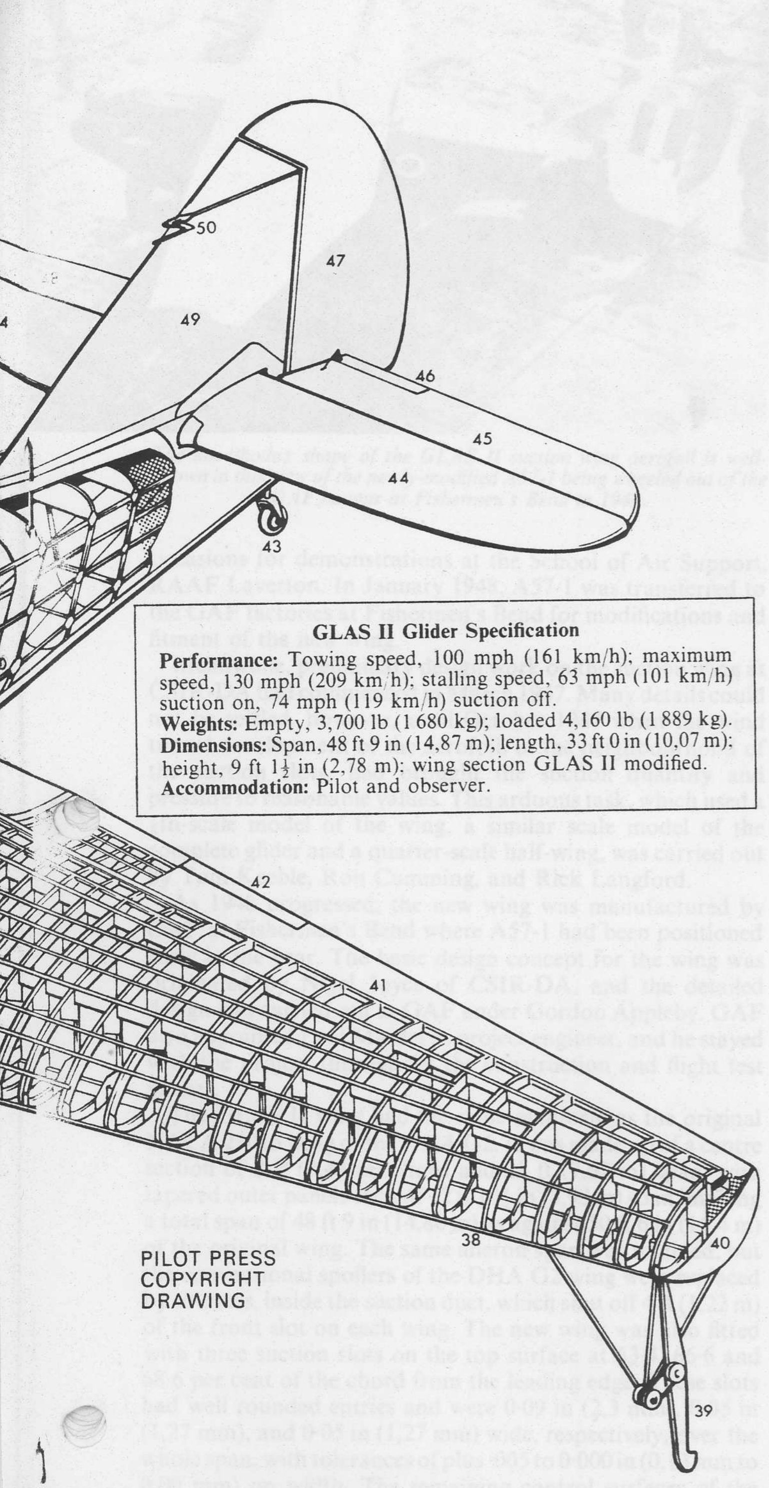
For take-off the pilot of the tug applied as much power as possible while holding his aircraft on the brakes. As soon as the brakes were released full take-off power was applied. If power was not applied rapidly the glider would drag one wing on the ground for some distance before aileron control was obtained, and this could damage the wing skid. As the glider got under way the pilot would find that his aircraft had a tendency to pitch forward momentarily until the elevator control became effective. The glider was then lifted into the air as quickly as possible to a height of not more than 20 ft (6,1 m), where the nose was eased down to allow the tug aircraft to accelerate and take-off. The pilot's notes emphasised that the glider must not be flown too high above the tail of the tug, otherwise it would "pull the towing aircraft's tail up and place the tug pilot in an extremely embarrassing position".

After take-off the tug climbed away at 115 mph (185 km/h), and the glider pilot was free to select the high or low tow positions, whereby the glider cleared the tug's slipstream by flying above or below the tail of the towing aircraft. At 400 ft (122 m), the tug usually commenced a port turn to keep the glider within gliding distance of the aerodrome. The tug normally climbed to heights between 3,000-5,000 ft (915-1 525 m), and towing speeds never exceeded 160 mph (257 km/h), the optimum speed being 130 mph (209 km/h).

To obtain free flight the glider pilot merely had to move the tow-rope release lever from the back to the forward position. The immediate result of this action, as outlined in pilot's notes was twofold:

"(a) *It releases the two ropes from under the glider's mainplanes and*

(b) *Causes a sharp 'crack' that usually brings to an abrupt halt any light conversation being held at the time by the passengers.*"



GLAS II Glider Specification

Performance: Towing speed, 100 mph (161 km/h); maximum speed, 130 mph (209 km/h); stalling speed, 63 mph (101 km/h) suction on, 74 mph (119 km/h) suction off.
Weights: Empty, 3,700 lb (1 680 kg); loaded 4,160 lb (1 889 kg).
Dimensions: Span, 48 ft 9 in (14,87 m); length, 33 ft 0 in (10,07 m); height, 9 ft 1½ in (2,78 m); wing section GLAS II modified.
Accommodation: Pilot and observer.

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DRAWING

The glider stalled at about 48 mph (77 km/h) with the spoilers out, or in the retracted position. The stall was extremely gentle and there was no tendency of a wing to drop. The nose merely dropped slightly and, as the speed built up, control was quickly regained.

The approach to land was initiated at about 80 mph (129 km/h) with the spoilers in. The spoilers were used only when the pilot felt he was overshooting or required to lose height more rapidly. S-turns were also recommended to keep the glider on the down-wind edge of the selected landing spot. On the final approach a careful use of the spoilers enabled the pilot to reduce speed to about 55 mph (88 km/h).

The landing was made on the wheel at the slowest speed possible. If the glider landed into a wind of moderate strength, the pilot could maintain control until the glider ended its landing run. At the end of the run the glider rocked back on its tail skid, and over on to one of the wingtip skids. The glider could be brought to a halt in an emergency by applying the brake and pushing forward on the control column, which pushed the glider on to its nose skid.

The glider conversion courses all but came to an end at the conclusion of the 1939-45 War, and it appeared that the RAAF's small glider force would soon be phased out of service. In the event, at least one of the gliders was granted a new lease of life in the immediate post-war years, and it remained in flying service until 1951.

The GLAS II project

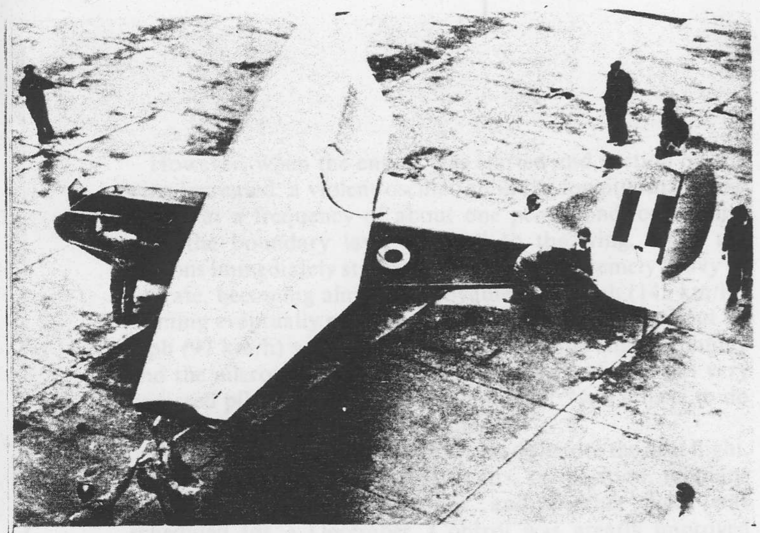
In June 1946, the inaugural meeting of the Commonwealth Advisory Aeronautical Research Council was held in London. Several proposals eventuated from this meeting including the recommendation that a Griffith-type suction wing should be tested in flight. The aims of the project were to assess the engineering problems involved in building, and flying, wings of this type, and to see how far the theoretical advantages of the suction aerofoil could be realised in practice. The task was accepted by Australia and was allocated to CSIR-DA (later the Aeronautical Research Laboratories), DAP-Beaufort Division (later the Government Aircraft Factories) and the RAAF.

Suction aerofoils had originated from a suggestion put forward in the UK in 1942 by Dr A A Griffith. He proposed a wing designed specifically for suction, and of such a shape as to have a rising velocity over a great proportion of its surface so that the major part of the boundary layer flow remained laminar. His design envisaged boundary air being sucked away towards the trailing edge of the aerofoil through suitably placed slots, the resulting sink effect giving rise to a sudden increase in pressure. Thus the adverse pressure gradient on the rear of the aerofoil, which contributed to drag, would be eliminated. In addition to the aspect of low drag, the Griffith principle permitted the design of very thick wings which, at the time, appeared to show great promise for the development of an all-wing aircraft. One outstanding design was the GLAS II*, a 31 per cent thick section that was particularly suitable for the moderate size all-wing application, in the 300-400 mph (482-643 km/h) speed range. Consequently, it was this type of wing that was selected for the Australian experiment.

The CSIR component of the GLAS II project team in Australia comprised T S Keeble, R W Cumming, and A F W Langford. A review of local resources indicated that the most expedient method of flight testing a suction wing would be to modify a DHA G2 glider by replacing the existing unswept wing with a suction aerofoil of the same plan form — a second stage of the investigation was planned to determine the effect on a swept-back wing. It was decided to accommodate the suction plant in the glider's fuselage where, unfortunately, weight and space limitations prevented the installation of a standby emergency plant. Consequently, it was necessary to provide for the possibility of suction failure. Thus, the GLAS II aerofoil was an ideal choice for the project because of its simplicity — it required suction on the upper surface only — and because the cambered aerofoil was expected to have safer characteristics in the event of suction failure.

Anticipating the requirement for a DHA G2 glider, the RAAF arranged to take A57-1 out of Category E storage at No 1 SD. On 15 January 1947, an allotment authority was issued for the aircraft to be transferred to No 1 APU. Throughout the year a limited number of flying tests were carried out with the glider at No 1 APU, RAAF Point Cook and, later, ARDU, RAAF Laverton. These flights were made with the orthodox wing to form the basis of comparison with the planned suction wing, and the glider was also used on

**Some doubt now exists as to whether the abbreviation stood for Griffith Laminar Aerofoil Section or Glauert Lighthill Aerofoil Section.*



The unorthodox shape of the GLAS II suction wing aerofoil is well-shown in this view of the newly-modified A57-1 being wheeled out of the GAF hangar at Fishermen's Bend in 1948.

occasions for demonstrations at the School of Air Support, RAAF Laverton. In January 1948, A57-1 was transferred to the GAF factories at Fishermen's Bend for modifications and fitment of the new wing.

Meanwhile, preliminary design work on the suction wing at CSIR-DA had commenced in March 1947. Many details could not be settled, however, until October 1947 when the wind tunnel development of the aerofoil, in the neighbourhood of the suction slots, had brought the suction quantity and pressure to reasonable values. This arduous task, which used a ⅛th-scale model of the wing, a similar scale model of the complete glider and a quarter-scale half-wing, was carried out by Tom Keeble, Ron Cumming, and Rick Langford.

As 1948 progressed, the new wing was manufactured by GAF at Fishermen's Bend where A57-1 had been positioned early in the year. The basic design concept for the wing was originated by Nigel Joyce of CSIR-DA, and the detailed design was carried out at GAF under Gordon Appleby. GAF also appointed Paul Mardel as project engineer, and he stayed with the project throughout the construction and flight test phases.

The GLAS II wing had the same planform as the original NACA 23015 wing of the DHA G2. It was made up of a centre section of 8 ft (2,44 m) chord and 23 ft (7,02 m) span, with tapered outer panels each of 12 ft 10½ in (3,93 m) span, making a total span of 48 ft 9 in (14,88 m) as against 50 ft 6 in (15,4 m) of the original wing. The same aileron span was retained, but the conventional spoilers of the DHA G2 wing were replaced by shutters, inside the suction duct, which shut off 4 ft (1,22 m) of the front slot on each wing. The new wing was also fitted with three suction slots on the top surface at 63·4, 66·6 and 68·6 per cent of the chord from the leading edge. These slots had well rounded entries and were 0·09 in (2,3 mm), 0·05 in (1,27 mm), and 0·05 in (1,27 mm) wide, respectively, over the whole span, with tolerances of plus ·005 to 0·000 in (0,13 mm to 0,00 mm) on width. The remaining control surfaces of the DHA G2 glider were retained. The other major modification was the installation of a Ford V-8 Mercury 59A automotive engine of 96 bhp in the fuselage to drive the CSIR-DA designed centrifugal blower for the suction. The final assembly work on the glider was carried out at RAAF Laverton.

The reconstructed glider had a soundproof bulkhead dividing the fuselage into two sections with a separate access to each bay; the bulkhead was positioned approximately in line with the leading edge of the wing. The forward bay comprised the crew compartment for the pilot and observer. The pilot's controls and instruments remained standard, except for the spoiler lever. Instead of opening the surface spoilers, this lever operated a shutter which closed the exit from the slot for a distance of 4 ft (1,22 m) on each wing. This had the same effect as the spoilers and avoided the necessity of cutting into the skin to fit normal top surface flaps. Additional fittings on the starboard side of the cockpit included the engine throttle and the radio control box; a subsequent recommendation suggested that all controls should be on the port side, so that the trimmer and engine control could be operated without changing hands on the control column.

The observer sat with his back to the pilot at a desk, and his controls included the engine starting button, switches, choke, throttle, and the automatic observer camera operating button. The panel in front of the observer contained a duplicate set of flight instruments (airspeed indicator, altimeter, rate of climb, air temperature, and angle incidence), engine instruments (RPM, boost, temperature, and oil pressure gauges), and the fire warning light and extinguisher control. Three sets of indicators recorded the pressure and quantity of suction air, towline drag by direct measurement, and aerofoil pressure which showed the static pressure and, thus, the state of flow on the wing behind the slot. The observer also controlled the speed of the suction motor, but the pilot had an over-riding throttle control in case of emergency. A radio was fitted to give contact with the tug and the ground and a normal intercommunication system was installed for the pilot and observer.

The Ford Mercury car engine was housed behind the observer's compartment and was fitted with the specially designed centrifugal fan with the inlet duct coming down from the wing. The suction air passed through the radiator of the engine and provided cooling independently of aircraft speed. The suction air was discharged through two louvre doors, one on each side of the fuselage.

The next compartment contained the automatic observer, comprising a panel containing 30 standard airspeed indicators, a lighting system and an F.24 camera which was motor operated and controlled by the observer. These instruments formed, in effect, a 30 tube multi-manometer; their leads were carried forward to a connection board in the observer's compartment where they could be connected to any of the 150 pressure points fitted to the wing and suction duct.

Flight tests

After the GLAS II glider was assembled at RAAF Laverton it was allotted to ARDU where the chief test pilot, Sqdn Ldr D R Cuming, AFC, initiated the flight testing programme. Gel Cuming, as he was universally known, arranged for the glider to be tested on the ground before the first flight was made. A57-1 being tethered in the slipstream of ARDU's GAF Avro Lincoln B.Mk.30. An appreciation of the aileron handling characteristics was obtained in this way, with suction on and off, and as these tests indicated that the ailerons were positive in their action, it was decided to go ahead with the air tests.

On 26 October 1948, the GLAS II was attached to ARDU's Douglas Dakota by means of a 300-ft (92-m) nylon cable, for the first take-off. It was decided to make the flight with the glider's engine running in idle, with negligible suction, but at a speed of 60-80 mph (97-129 km/h) during the take-off, the wings started to rock laterally, the ailerons appeared to become ineffective, the port wing dropped as the glider became airborne and the wing-tip skid hit the runway. Cuming immediately released from the tug and landed straight ahead.

A second flight was attempted almost immediately, with the glider engine off, as it was thought that the lateral instability might have been caused by the transitional stage between suction-on and suction-off at low airspeed. On the second attempt, the GLAS II became airborne at 90-95 mph (145-153 km/h), but the aileron controls became slack at 150 mph (241 km/h) and were effective only when the stick was moved to the extreme of its range. The flight was continued to 10,000 ft (3050 m) and Cuming ascertained that the glider could be controlled down to 64 mph (103 km/h) with suction off.

However, when the engine was started and suction on the wing increased, a violent oscillation in the longitudinal plane began, at a frequency of about one per second, continuing until the boundary layer adhered to the wing, when the ailerons immediately stiffened and became extremely heavy to operate, becoming almost unmovable at 90 mph (145 km/h). Cuming eventually effected a reasonable landing at about 60 mph (97 km/h) with the stick hard back, the engine running and the ailerons locked solid. A somewhat relieved but very harassed pilot emerged with the comment "you'll have to do something about the b——— ailerons!".

A number of modifications were made before the next flight, involving the aileron control circuits, CG position, tailplane incidence and instrumentation, and another flight was scheduled for 3 December. Control was greatly improved although some characteristics were still unsatisfactory, and further small changes were made for the next flight, made on 7 December. Aileron control was again found to be unsatisfactory and after release at 4,000 ft (1 220 m), when suction on the wing was increased, the glider entered a spiral dive to port that was stopped only when the engine was closed down. The loss of height in the spin forced an immediate landing, which Cuming executed with considerable skill and a measure of luck on the airfield boundary; the time from casting off at 4,000 ft (1 220 m) to touch down was 1¼ minutes!

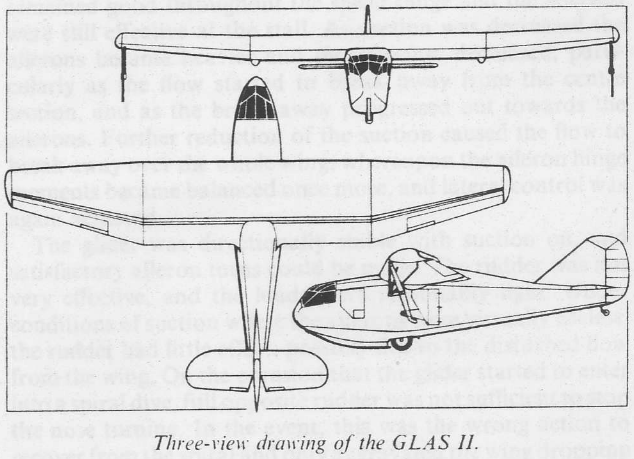
A57-1 remained grounded until early 1949 while repairs and adjustments were carried out. The starboard wingtip skid was repaired, the tailplane fittings were strengthened and the tailplane itself was braced. A swivelling pitot static system, installed after the first flight, was removed from the port wing tip and installed on top of the fin. And, once again, the aileron circuit was altered to remove excessive frictional loads and to stiffen the circuit generally.

By March 1949, two more flights had been made, but the lack of lateral stability still remained a problem. The glider was grounded again so that the wing joints could be improved and the area of the trim tabs on the elevator increased. It was also suggested that the swivelling pitot and incidence gauge should be removed from the fin to a more suitable position. Cuming recommended, at this time, that any further research gliders of the suction wing type should have a conventional three-wheel undercarriage, and a variable incidence tailplane controlled by the pilot so that he could cope with suction on and off conditions.

The test flights continued for another nine months and, in January 1950, Cuming compiled his final report on the GLAS II trials before handing over the project to another pilot. Between April and November 1949, 25 flights had been completed — making a total of 30 since October 1948 — and it was during this latter stage that an answer was found to most of the peculiarities of behaviour in the boundary layer of the GLAS II aerofoil with suction on.

Contaminated wing problem

As a result of visual and instrument observations, it was established that foreign bodies adhering to the wing, with suction on, had a marked effect on the performance of A57-1. These foreign bodies were, in fact, insects which stuck to the wing during take-off and created a contaminated, or dirty, leading edge on the GLAS II aerofoil. The presence of these foreign bodies became known to the pilot in the form of buffeting or asymmetric control loads, and the location of the insects also showed up on the observer's manometer; when the insects were small in size and number their presence was revealed only when the suction was reduced. The contaminated wing condition could be measured by the engine rpm required to stick the flow over the wing — the rpm could be as low as 1,500 before the flow would unstick but, in bad cases, full rpm of 2,850-2,900 were insufficient to stick the flow.



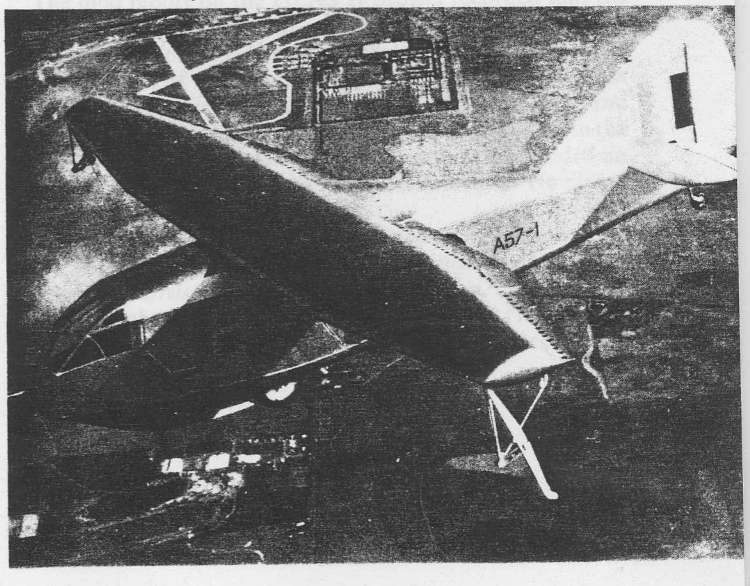
Three-view drawing of the GLAS II.

The effect of unstuck flow due to the presence of insects on the leading edge caused a loss in the lift, and increase in drag, over the section of the wing behind the insects. The aileron sections appeared less affected by the insects, and it was only on rare occasions that the flow would unstick due to insects on the leading edge. When this happened the ailerons would try to apply themselves which the pilot had to counteract by applying a considerable amount of side force.

In retrospect, it was ascertained that a badly contaminated wing was the reason Cuming almost lost control of the glider during the third test flight on 7 December 1948. The purpose of the flight had been to assess the effect of a transition on the vortex formation over the centre section of the glider — apparently, however, a considerable number of insects were collected at about 2,000 ft (610 m) on the climb away from the aerodrome. This caused a breakdown in the flow over the wing and over a portion of one aileron and, on the glide down, asymmetric control forces were required to maintain level flight. The situation was aggravated at about 800 ft (244 m) when, either, more insects were collected or one of the transition cords fell off. At this stage the spiral dive to port commenced, and application of full aileron failed to lift the wing. The only course left was to switch off the engine and carry out an emergency landing without suction — which, of course, Cuming did. As a result of these findings on the contaminated wing, plans were in hand in 1950 to modify the front slot in an endeavour to improve the flow and nullify the effect of insects on the leading edge.

By July 1951, 47 flights had been made with the GLAS II aerofoil, and most of its handling qualities were well known. A vital pre-flight requirement had been introduced whereby the

The GLAS II suction wing glider in free flight, with RAAF Point Cook in the background. This photograph was taken after the third test flight on 7 December 1948, when an additional pitot-head for the observer had been fitted to the top of the fin.



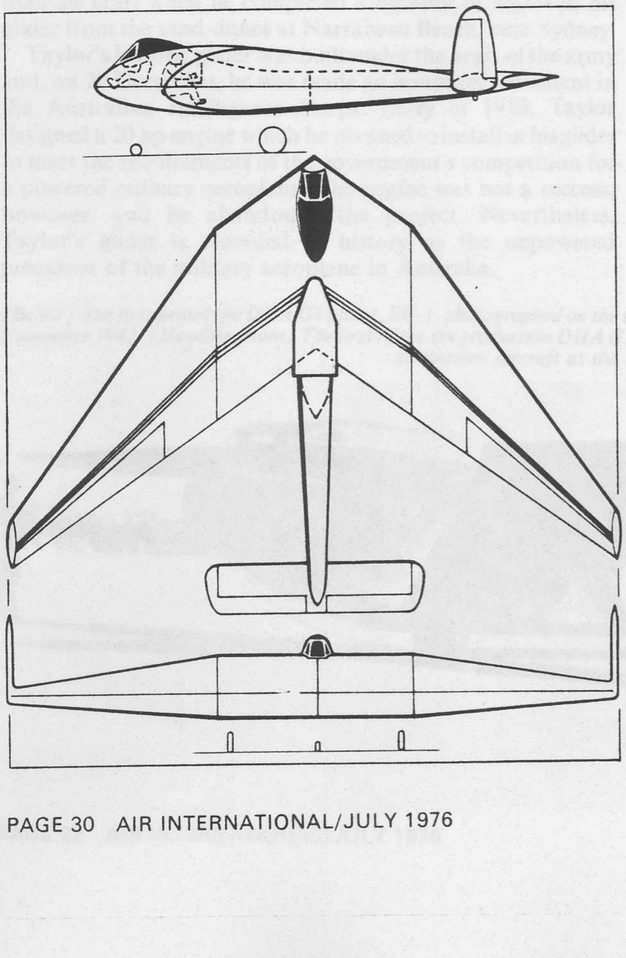
glider's wing was thoroughly cleaned before it was taken from the hangar. Prior to take-off the wing was cleaned again to remove any dust or dirt that may have collected while the glider was towed out to the starting point.

The glider was usually towed to 15,000 ft (4 575 m), and after release it settled down to a steady glide at the trimmed speed. The glider was free of any buffeting, and the only vibration was that due to the engine. All the controls worked in their normal sense, and at normal gliding speeds up to 85 mph (136 km/h) they were reasonably light and effective.

With full suction, the glider was longitudinally stable stick free, and if displaced from a trimmed speed it would return to it with practically a dead beat oscillation. When the suction was reduced the glider eventually became difficult to maintain at a steady speed — within a mile an hour or so — due to slight changes in the longitudinal trim. This appeared to be due to the formation of a fixed vortex just forward of the front slot. Further reduction of the suction after the vortex had formed produced little effect until the flow over the centre section became unsteady and broke away. This caused a further nose down change of trim and, as the suction was again decreased, this change of trim became progressively greater until the flow broke over the whole wing. The minimum steady speed achieved under these conditions was 64 mph (103 km/h) with stick full back. With suction on, the minimum speed was governed by the stall which occurred at 52-53 mph (84-85 km/h), the stick still not being fully back.

Under suction-on conditions, the aircraft was laterally unstable, and it was possible to get out of control by allowing too much skid or slip to develop. The ailerons were reasonably light and very responsive under stuck flow conditions and gliding speeds up to 80 mph (128 km/h). As speed increased the

A three-view drawing of the proposed GAD-4 suction-wing glider with sweepback which was in effect a half-scale model of a 72-passenger all-wing airliner. The glider had a span of 50 ft (15,25 m), length of 33 ft 9 in (10,30 m) and height of 12 ft (3,67 m), and a loaded weight of 3,500 lb (1 590 kg). The suction plant and air discharge fitting can be seen behind the cockpit in the plan view. The dotted cone aft of the suction plant represents the fairing that was to be installed for later tests after the temporary tailplane had been removed.



aileron forces became progressively heavier until, at 110 mph (177 km/h), they were quite high. The response, however, remained good throughout the speed range and the ailerons were still effective at the stall. As suction was decreased the ailerons became heavier and the response decreased, particularly as the flow started to break away from the centre section, and as the break away progressed out towards the ailerons. Further reduction of the suction caused the flow to break away over the whole wing, whereupon the aileron hinge moments became balanced once more, and lateral control was again achieved.

The glider was directionally stable with suction on, and satisfactory aileron turns could be made. The rudder was not very effective, and the loads were reasonably light. Under conditions of suction where the ailerons were virtually useless, the rudder had little effect, possibly due to the disturbed flow from the wing. On the occasion that the glider started to enter into a spiral dive, full opposite rudder was not sufficient to stop the nose turning. In the event, this was the wrong action to recover from the spiral and only aggravated the wing dropping tendency by increasing the slip.

The stall, suction full on, occurred at 52 mph (84 km/h) and was accompanied by a rapid dropping of the nose and buffeting over the rudder surfaces. The stall occurred first over the centre section and, as the nose dropped immediately, it was not possible to stall the whole wing. There was no warning of the stall and the flight of the glider remained smooth right up to the stall or break away at the centre section. In turns the same effect occurred, and the nose dropped out of the turn without any tendency for a wing to drop.

With suction-on, the approach speed over the last 1,500-2,000 ft (458-610 m) was 100-105 mph (161-169 km/h). This was well above the approach speed that was normally used on an orthodox glider with a stalling speed of 52 mph (84 km/h), but was necessary to ensure that the glider would still be controllable in the event of suction failure. This procedure had been justified on two occasions — once when the engine boiled and there was a chance of engine seizure, and also when the glider got out of control on the third test flight, at about 800 ft (244 m), and the engine had to be stopped to regain control. The approach path was made so that the aerodrome was always within suction-off gliding distance, even though the landing might have to take place dead across wind if the suction failed; two such landings had been made in cross winds of 15-20 mph (24-32 km/h), suction off, without difficulty. For a normal landing the speed over the fence was reduced to about 95 mph (153 km/h), and the glider was held just above the ground until a normal two point touch-down occurred. The touch-down speed was below 52 mph (84 km/h).

As from July 1951, A57-1 was kept in Category B storage at ARDU pending the results of the scientific assessments of the flying trials. Eventually the glider was grounded in December by the Director of Technical Services. It remained in Category B storage at ARDU for a year and, on 17 December 1952, A57-1 was offered for disposal.

The final report on the GLAS II project recorded that the objective of the investigation — the full-scale flight evaluation of a suction aerofoil — had been achieved. Although interest in the principle of the suction aerofoil subsequently waned as other means of achieving BLC to obtain high lift became more attractive, the GLAS II remains an important milestone in the history of Australian aeronautical research, and provided an unusual finale to the story of the little-known de Havilland Australia gliders of World War II. □

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