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DSTL, AVIA 18/4034, 19 Feb 2009; DSTL, AVIA 18/4034, 19 Feb 2009
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Progress of Issue of Report

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<tr>
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<th>Title</th>
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<tr>
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<td>WK, 376 Brief tests at high Mach number and approximate measurements of stick force per 'g' at interim stage of development.</td>
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<tr>
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<tr>
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<td>WK, 376 Dock landing assessment and dock trials (by day) after further development.</td>
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<tr>
<td>6th - do -</td>
<td>WK, 376 Brief assessment of longitudinal control characteristics including high Mach no. behaviour and approximate measurements of stick force per 'g' after further modification.</td>
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<td>7th - do -</td>
<td>WK, 376 and WK, 379. Summary of handling tests up to October, 1952.</td>
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Summary:

Modifications made to WK, 379 since the last dock landing trials have been successful in eliminating the self stalling characteristics with the c.g. aft and the inequality in stick forces for forward and rearward stick movements, at least in the low speed range tested.

Two new criticisms are now made however. These are:

(i) The trim changes with power and speed are too large.
(ii) The elevator stick forces are too heavy.

There is still no stall warning.

The combined result of (i) and (ii) is that, apart from the annoying hand movements involved in constantly retrimming in the circuit, there is a tendency for the aircraft to become too low on the approach and it is difficult to regain the lost height without changing the power (thus conforming to the standard method of approach) due to the pilot's reluctance to apply the necessary heavy stick force.

Hook damping is now satisfactory.

A serious criticism of the cockpit is that with the rudder pedals adjusted fully forward, as required by a tall pilot, full travel of the rudder pedals could not be obtained due to the pilot's toes touching the front bulkhead.
The urgent necessity for a windscreen wiper was confirmed by experience of night A.D.D.L.'s and day A.D.D.L.'s in rain.

Other criticisms of the cockpit layout were made.

This report is issued with the authority of

Air Commodore,
Commanding, A. & A.E.E.
1. Introduction

The previous dock trials on a Sea Venom NP, WX. 20 (made on the first prototype, WX. 376) showed that the aircraft had excellent deck take-off and landing characteristics apart from hook damping. Unfortunately, with the c.g. near the aft limit appropriate to that aircraft there was an insufficient margin of longitudinal stability in dives and in cruising flight and in the approach condition there was a push force on the stick at the stall. Also, the heaviness of the clover-tor was unequal for forward and aft movements from the trimmed position.

Modifications were incorporated in WX. 379 to overcome these criticisms and the deck landing assessment and dock trials now reported were made. It had been intended to do night dock landings but these had to be cancelled owing to lack of time for night A.D.D.L. practice.

2. Condition of aircraft relevant to tests

The condition of the aircraft was generally as described for WX. 376 in the 5th part of this Report with the following exceptions (para. 2.1 to 2.6).

2.1. General. The wing tip tanks were of the production type with a 10 lb. weight in each tank nose and fitted with strakes.

The fixed leading edge slats at the wing tips were of 4.9 in. chord (previously 4.6") and were increased slightly in span (from 18.0 in. to 18.7 in) so that the gap between the end of the slat and the wing tip tank was almost closed.

A camera gun was suspended in a fairing below the port wing root.

A flap topped cockpit canopy was fitted (not representative of production).

2.2. Ailerons. Two rows of internal mass balance weights were fitted in the ailerons from stations 1 to 9, one row each on the top and bottom surfaces, near the leading edge.

Previously the weights were at stations 3 to 11.

The aileron movements were as follows (previous movements, for WX. 376, are given in brackets).

\[
\begin{array}{ccc}
\text{Up} & \\
\text{Starboard} & 16^\circ 54' \ (17^\circ 17') & 16^\circ 14' \ (17^\circ 36') \\
\text{Port} & 16^\circ 14' \ (17^\circ 17') & 16^\circ 54' \ (17^\circ 36') \\
\end{array}
\]

The aileron spring tab movements were as follows (previous ranges, for WX. 376, are given in brackets).

\[
\begin{array}{ccc}
\text{Tab up} & \text{Tab down} \\
\text{Starboard} & 22^0 12' \ (17^0 48') & 24^0 4' \ (24^0 0') \\
\text{Port} & 23^0 48' \ (14^0 36') & 27^0 48' \ (21^0 48') \\
\end{array}
\]

2.3. Tailplane and elevator. The tailplane incidence was 0° 50' (1° on WX. 376). The elevator range of movement was from 11° 36' down to 29° 4' up (previously 16° 31' down to 30° 12' up).

The destabilising bungee fitted to WX. 376 was not present in WX. 379. The inertia weight was increased from 15 lb. to 16 lb. 6 oz. The elevator mass balance weights were 24 lb. each (20 lb. each on WX. 376).
The "ocrd" along the trailing edge of the elevator, including elevator tabs, was 5/16" o.d. instead of ⅜" o.d. as fitted to WK376.

The elevator cable tensions were 70 lb.

2.4. Elevator tabs. The chord of the geared tab was reduced from 5.0 to 4.5 in.

The chord of the spring tab was reduced from 3.75 to 3.25 in. A differential type of spring was fitted with pro-loads in the spring of 80 lb. for rearward stick movements and 0 lb. for forward movements. Taking into account the friction in the circuit the corresponding pro-loads at the stick were (according to De Havillands) approximately 10 lb. for rearward stick movements and 5 lb. for forward movements.

As mentioned above, the "ocrd" along the trailing edge was 5/16" o.d. instead of ⅜" o.d. as fitted to WK376.

2.5. Rudders. The ground adjustable rudder tabs were rigged neutral instead of 22° to port as on WK376. 10 lb. mass balance weights were fitted on the rudders (7.2 lb. previously.)

2.6. Loadings. The following loadings were used during the trials.

<table>
<thead>
<tr>
<th>Loading No.</th>
<th>Take-off weight (lb.)</th>
<th>Position of o.g.s</th>
<th>Remarks</th>
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<tr>
<td></td>
<td></td>
<td>U/c down</td>
<td>U/c up</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ins. aft</td>
<td>%MAC</td>
</tr>
<tr>
<td>1</td>
<td>10,960</td>
<td>9.6</td>
<td>24.2</td>
</tr>
<tr>
<td>2</td>
<td>11,160</td>
<td>8.2</td>
<td>22.6</td>
</tr>
<tr>
<td>3</td>
<td>12,265</td>
<td>9.1</td>
<td>23.6</td>
</tr>
</tbody>
</table>

The three outboard tanks in each wing were drained and isolated for loadings 1 and 2 by means of cocks specially provided. The total amount of fuel for each of these loadings was 204 gallons.

The design o.g. range was from 5.1 in. to 10.1 ins. aft of datum (19.0 to 24.7% S.M.C.) undercarriage down. The o.g. range had thus shifted forward as a whole, the previous limits on WK376, being from 5.7 in. to 11.6 in. aft of datum (19.7 to 26.5% S.M.C.) undercarriage down. The new aft limit is nearly the same as will occur on production aircraft. The new forward limit is still short of the expected limit for production limit.

For the transit loading, full internal fuel was carried together with all the ballast required during the carrier trials.

At loading 1, the aft o.g. limit was approached within 0.1 in. due to the consumption of fuel in flight, as described below.

At all loadings, after the consumption of about the first 20 gallons of fuel, the o.g. was 0.5 in. aft from the take-off position. With further use of fuel, the o.g. moved forward until after the consumption of 160 gal., the o.g. was 0.7 in. forward of the take-off position. With continued use of fuel the o.g. again moved aft but never attained the original position.

/2.7.........
2.7. Airframe limitations. The airframe limitations as laid down in the O.R.T.O. Form I were identical with those listed in the 4th part of this Report. In particular, the maximum permissible weight for deck landing was 11,000 lb.

There was however a local speed limitation. It was considered that pending the investigation of a recent accident the speed should be restricted to that necessary for the performance of deck landing tests. A limitation of 200 knots I.A.S. was therefore imposed.

2.8. Engine limitations. The engine limitations were as listed in the 4th part of this Report with the following additional restrictions.

Max. \( r.p.m \) for climbing, above 25,000 ft. 10,100 r.p.m.
Max. \( r.p.m \) for level flight, above 35,000 ft. 10,100 r.p.m.

3. Scope of tests

At each of the loadings 1 and 2, the following tests were made.

(a) Brief ground handling
(b) Stalls in the approach configuration with approach power
(c) Airfield dummy deck landings by the standard method.
(d) Deck take-offs and landings on H.M.S. 'Illustrious'.

A brief cockpit assessment was also made.

Stalls in other configurations and slow flying characteristics were not investigated due to shortage of time.

4. Results of tests

4.1. Ground handling. Ground handling was not appreciably different from that previously reported for WK.376 except that the tendency for the aircraft to turn to starboard while taxiing was not present on this aircraft.

4.2. Airfield take-off and initial climb. Take-offs were made as before with flaps at the take-off position (30° down). At either loading, neutral elevator trimmer setting was used. The characteristics during take-off appeared to be unchanged from the previous assessment (5th part of this Report), but on the initial climb, on reducing power to prevent the speed rising unduly, there was a marked nose-down change of trim which it was found necessary to trim out.

4.3. Stalls. The behaviour of the aircraft at and near the stall was investigated with forward and aft a.e. position (Loadings 1 and 2) in the approach configuration, with power for level flight at the test altitude.

The characteristics were not appreciably different at the two a.e. positions and were similar to those of WK.376, with no tendency to wing heavy- ing until the stalling speed was approached within one or two knots. The stall occurred at 92 knots I.A.S. with 160 galls. fuel remaining, about 2 knots (indicated) lower than the stalling speed of WK.376, in a similar condition.

At the a.e. positions tested, there was no self-stalling tendency, a continuously increasing pull force being required as speed was reduced. There was no stall warning, any pre-stall buffet which may have occurred being masked by the usual continuous buffet which commenced when the flaps were lowered to 60° and which appeared to be somewhat more marked than on WK.376.

4.4. Airfield dummy deck landings. The circuit was flown at speeds from 135 to 145 knots at approximately 300 ft. If the aircraft was not re-trimmed after take-off, the stick force to hold this speed was 15 to 20 lb. push. However, the aircraft was normally re-trimmed by winding the trimmer wheel half a turn forward. On the downwind leg, the flaps were lowered to the 60° position. With 8,100 r.p.m. this resulted in a speed of about 120 knots I.A.S.
and a slight nose-up change of trim requiring a push force of about 5 lb, which was held without re-trimming. Small changes of power and speed resulted however in comparatively large trim changes and during the turn in on the crosswind leg it was necessary again to re-trim when reducing speed to about 110 knots I.A.S. with 7500 r.p.m.

The final approach was made at just under 110 knots I.A.S. and at this speed the controls were assessed as follows. The elevator was moderately heavy, effective, and with good response. The inequality in heaviness of the elevator control for forward and aft movements from the trimmed position appeared to have been eliminated in the approach. The ailerons were light and very effective with good response. The rudder was moderately heavy, effective, and gave moderate response.

On making "standard method" height reductions from level flight, - i.e. at constant power and almost constant airspeed by use of elevator alone, - the initial pull force to restore the original attitude after the height reduction was about 10 lbs. Using power reductions as an alternative to strict standard method, was also inconvenient as nose down change of trim with such reduction of power together with the heaviness of the elevator again involved the pilot in larger stick forces than he felt appropriate to the size and speed of the aircraft. As a result of these features there was a marked tendency for the pilot to allow the aircraft to become too low on the approach. "Standard method" height increases - i.e. by elevator alone - were not considered feasible as the stick forces to make the initial change in attitude for such small height increases were higher than the pilot felt inclined to apply.

At the cut there was a small nose down trim change which made a deliberate forward movement of the control column to initiate the descent to the deck unnecessary. The check was easily made with approximately one half rearward movement of the stick from the neutral position with a pull force of 6 to 10 lb. There was no tendency for the aircraft to float.

The above characteristics applied broadly to both alpha positions (Loadings 1 and 2) but the changes of trim with power and speed were slightly more marked at the forward alpha (Loading 2).

As stated in earlier reports, the view on the approach was good in dry weather. An attempt was made to do A.D.D.L.'s in heavy rain. In those conditions vision ahead through the main windshield panel was almost nil. Vision was maintained without difficulty through the D.V. panel in its closed position but, since the line of sight was then approximately 15° to port of the plane of symmetry, as soon as the straightaway was reached the pilot lost sight of the batman. Height judgment also became extremely difficult, making continuation of the approach hazardous.

A few A.D.D.L.'s were made at night and apart from some criticisms arising from the cockpit layout and lighting, no difficulties were experienced additional to those occurring in day A.D.D.L.'s. A slightly higher approach speed, about 113 knots I.A.S., was preferred however due to the improved view at this speed.

4.5. Dock Trials.

4.5.1. General. The trials were made in calm sea conditions in smooth and in moderately turbulent air. The windspeed over the dock varied between 35 and 45 knots.

A total of 23 free take-offs and landings (by day) was made by three pilots, including the transit flights. The landings were made by the standard method.
The fuel pump control system isolating switch was set to 'Isolate' for all take-offs and landings. The undercarriage was left down after take-off. The flaps were lowered from 30° to 60° and the arresting gear lowered early in the circuit.

4.5.2. Deck take-off. All take-offs were made with the flaps at the take-off position (30° down). No difference in the deck take-off behaviour was detected compared with the results of the last trial (5th part of this Report) allowing for the small differences in cg, position.

4.5.3. Deck landing. The circuit was flown at about 130 knots I.A.S., having re-trimmed the elevator from the take-off setting. Speed was reduced to 115 knots on the crosswind leg with flaps 60° down with about 7800 r.p.m. while height was lost. A final approach speed of just under 110 knots I.A.S. was used with about 7550 r.p.m.

As in D.D.D.L.'s there was a tendency to allow the aircraft to become too low on the crosswind leg and approach due to the marked nose down trim changes with reduction of power (and hence also speed) and the heaviness of the elevator control for countering the trim changes. Having allowed the aircraft to become too low, the pilot found it difficult to regain height by the "standard method" and in consequence had to resort to increasing power. The change of trim with speed and the heaviness of the elevator combined therefore to make height changes at constant power (implicit in the standard method difficult while the change of trim with power provided power changes an unsatisfactory alternative. The change of trim with power was excessive and a grave disadvantage for the circuit also, particularly in the final approach leg.

The very good aileron control characteristics were unchanged from previous assessments and were especially appreciated in the moderately turbulent conditions in which some of the landings were made.

The view during the circuit and up to the final approach was considered good but during the last stages the batsman was sometimes partially obscured so that the pilot tended to lower the nose slightly to keep him in view. When the cut was taken late the left bat and arm of the batsman was frequently obscured.

At the cut, the nose down change of trim was welcomed as it eliminated the necessity for deliberately initiating a rate of descent towards the dock. The check was easy and similar to that of W.K.376 as previously reported.

The excellent arresting characteristics were again apparent and the hook damping was now very good.

There was little difference in the behaviour of the aircraft in deck landing at the two cg positions except that according to the pilots, as in D.D.D.L.'s the trim changes with power and speed were slightly more marked with the cg forward (Loading 2).

4.6. Cockpit assessment

4.6.1. During these trials, the aircraft was flown by pilots with a leg length requiring the full forward adjustment of the rudder pedals. It was found that with the pedals in this position full travel could not be applied with the pedals under the pilot's insteps, as the pilot's toes then fouled the forward bulkhead. One pilot found that his left knee touched the bottom of the instrument panel at all rudder angles.

4.6.2. The following comments were made on the cockpit layout in addition to previous criticisms.

/Thes....
The throttle movement was too long and, to obtain the last few hundred r.p.m., was too far forward for the pilot to reach easily when strapped in.

The grouping of switches controlling ancillary services was considered to be haphazard and such as to lead to the pilot overlooking one or more switches when starting up.

For a tall pilot, it was not possible to see one of the green lights of the undercarriage indicator due to the pilot's eyes being outside the cone of visibility. The instrument should be canted to eliminate this feature.

The E.2 compass obscured the most important section of the Machmeter scale.

An internal A.S.I. with a scale suitable for deck landing is essential.

The observer's head fouls the hood operating controls.

The pressurising air blows into the observer's face.

4.6.3. The following criticisms apply to night conditions.

The E.2 compass could not be used owing to inadequate lighting. It should be placed within range of the emergency lighting.

The elevator trim indicator could not be seen owing to inadequate lighting.

The radio altimeter, which was not easy to interpret in daylight due to the red transparency over the front of the instrument, was almost impossible to read at night.

5. Discussion

5.1. Ground handling. The tendency for the aircraft to turn to starboard, reported to occur on WK.376, is not evident on WK.379 and was probably a peculiarity of that particular aircraft.

5.2. Stall warning. As on WK.376, there was no stall warning. The increased buffet from the flaps served rather as a distraction to the pilot when full concentration was needed on the approach.

5.3. General longitudinal characteristics. The chief criticisms of the longitudinal behaviour of WK.376 made in the 5th and 6th parts of this report were the self-stalling characteristics and inadequate stability with the a_g aft in dives and cruising flight, and the inequality in heaviness of the elevator for forward and backward movements of the control column.

The latter characteristic has been eliminated in the approach condition but the elevator stick forces are too high generally. Due to the local restriction to 200 knots L.A.S., it was not possible to investigate the behaviour at high speeds. It is of course at high speeds that inequality of stick forces for forward and rearward stick movements would be a dangerous feature.

The aft a_g. position used in the present tests was 1 in. further forward than that used in the last sets of tests on WK.376, due to the more forward a_g. range as a whole on WK.379. In flight the a_g. approach was the aft limit within 0.1 in., as described in para. 2.6. The new aft limit for WK.379, which it is understood will be closely matched by production aircraft, is 0.4 in. further forward than the aft a_g. position used for test on WK.376 (see 5th part of this Report).

The difference in a_g. position between the two aircraft on test and the removal of the destabilising bungo together appear to have been sufficient to eliminate the forward stick force at the stall in the approach condition.

/Again......
Again, due to the 200 knot L.I.S. limitation, no checks of the stability in dives and in cruising flight were made.

5.4. Dock landing and A.D.D.L. characteristics. The trim changes with power and speed are too large as, apart from the most undesirable hand movements involved in re-trimming in the circuit, they lead in conjunction with the elevator heaviness to a tendency for the aircraft to become too low on the approach. The nose-down trim change at the cut is however considered to be a good feature but not essential; it will presumably have to be sacrificed if the trim changes with power in the circuit and on the approach are to be reduced.

No trim change with power was present on WK.376.

The partial obscuring of the batsman in the final stages of the approach did not contribute to the tendency to get too low, as it occurred only at the end of the approach, but was nevertheless a hazard. The choice of approach speed, 4 knots (indicated) higher than that used for WK.376 was however influenced mainly by the view and attitude which seemed to be similar at 109 knots L.I.S. in WK.379 to that in WK.376 at 105 knots L.I.S. The windscreen and fuselage noses were identical in the two aircraft. Subsequent examination of the records taken by the R.C.E. during the deck trials on WK.376 and WK.379 showed that the average combined speeds (wind speed plus closing speed) were identical in the two cases. Evidently there is some difference in the airspeed systems of the two aircraft.

The elevator heaviness for checking was not specially criticised on this aeroplane even at the forward (Loading 2) but in production aircraft it will be possible to attain a 2.0 position nearly 2 in. further forward according to the latest estimates (as Havilland letter to A. & B.E. dated 6th October, 1952) and this feature may then be the subject of criticism.

Due to the poor view through the D.V. panel, A.D.D.L.'s or deck landings in rain at night would be impossible without a windscreen wiper and hazardous in rain in daylight.

5.5. Directional characteristics. The suggestion made in the 6th part of this report that the aircraft should be checked for rudder overbalance in sideslip is no longer relevant since the αw range has been moved forward.

6. Conclusions

The chief criticisms of the aircraft for dock landing in its present condition are as follows:

(i) The trim changes with power and speed are too large.
(ii) The elevator stick forces are too heavy.
(iii) There is still no stall warning.

The combined result of (i) and (ii) is that, apart from the annoying hand movements involved in constantly retrimming in the circuit, there is a tendency for the aircraft to become too low on the approach and it is difficult to regain the lost height without changing the power, (thus conforming to the standard method of approach) due to the pilot's reluctance to apply the necessary heavy stick force.

Hook damping is now satisfactory.

A serious criticism of the cockpit is that with the rudder pedals adjusted fully forward, as required by a tall pilot, full travel of the rudder pedals could not be obtained due to the pilot's toes touching the front bulkhead.

The urgent necessity for a windscreen wiper was confirmed by experience of night A.D.D.L.'s and day A.D.D.L.'s in rain.

Other criticisms of the cockpit layout were made.
7. **Further developments**

Since the trials described in this report were made, modifications have been made to gear the elevator trim tab to act as a balance tab and to increase the spring rate in the spring tab circuit. Also the jet pipe nozzle has been changed.

Subsequent to these modifications the aircraft displayed reduced trim changes.

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Record Summary: AVIA 18/4034
   Sea Venom NF Mk 20 WK.379 (Ghost 3): deck landing assessment and deck trials (by day) on the second prototype
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