A.&A.E.E. Report No. AAEE/758.

Tests with Split Trailing Edge Air Brakes. (Beaufighter I)

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13th Part of Report No. A.A.E.E./758.

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AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT,
BOSCOMBE DOWN.

Beaufighter I, R.2057.
(2-Hercules III)
Tests with split trailing edge air brakes.

A.& A.E.E. Ref:- 4476/73-A.M.53/15.
M.A.P. Ref:- B.986501/39/R.D.L.3(b).

This report deals with the aircraft (or equipment) as tested. Action to defects or decisions to accept items not in strict compliance with the specification are matters for decision and action by the Ministry of Aircraft Production.

Progress of issue of report.

Part of Report.	Subject
8th Part of A.& A.E.E./758.	R.2063. Single engine performance with 20° and non-feathering hydromatic airscrews.
9th do.	R.2268. Longitudinal stability with large tail plane and unshielded horn-balance elevators.
10th do.	R.2063. Fuel consumption and range trials.
11th do.	R.2063. Cabin and gun heating tests.
12th do.	R.2063. Single engine tests with De Havilland hydromatic airscrew and A.Y.7 control units.

SUMMARY.

Both Beaufort and Beaufighter aircraft have been fitted with air brakes. The development of these brakes, so far as this Establishment is concerned, has taken place in four phases. In their final form the brakes give a marked deceleration without change of trim or height.

1. Introduction:

For some time past the pilots of night fighters and torpedo carrying aircraft have been asking for an effective brake to be introduced on their aircraft capable of materially reducing the forward speed for a given attitude, and capable of producing a greater angle of dive for a given speed. Although a large braking effect was required, it was also required that there should be no change of trim about the three axes, nor should there be a sudden loss or gain in height. To meet these requirements the Bristol Aeroplane Co. have produced and developed the brake described below.

The present series of tests have been made from 15/5/42 to 26/5/42.

2. Description of braking system as tested on Beaufighter.

The brakes consist of approximately rectangular flaps, 6'6" by 1'6½" in size, mounted on the top and bottom trailing edge surfaces of each wing, extending spanwise from approximately 6" outboard of the extension mainplane joint to about 3" inboard of the aileron. Both top flaps are hinged to the wing surface at their leading edges, and the trailing edges are joined to the wing by means of hinged sheet metal sections so as to form a bellows. The external panels of the brake flaps are re-inforced by shallow transverse members of inverted "U" section. The bottom flaps are attached to the lower surfaces of the landing flaps. Thus, they completely cover the landing flaps situated in the extension mainplanes, but they in no way interfere with the normal operation of the landing flaps. (See Photo A.).

The brakes are actuated by means of a pressure difference inside and outside the bellows. Under each wing, approximately 2'7" outboard of each engine nacelle, is situated a venturi (see Photo.C) the mouth of which is $5\frac{1}{2}$ inches in diameter. At the outlet end of each venturi is a butterfly throttle controlled by Bowden cables and M.R.C. controls connected to a lever operated by the pilot. In flight, when the butterfly is open, the venturi produces a suction, which is transmitted to the brakes by $2\frac{1}{4}$ inch. diameter pipelines from a distributor box, and so the brakes are kept closed. When the butterfly is closed, the venturi tube becomes a pressure head transmitting by the same system a pressure equal to the total head and this pressure causes the brakes to move out against the airstream. When fully extended, their angle relative to the wing surfaces is approximately 60°.

In its final form the system also included small vertical "fins" at the outboard end of each brake flap. These "fins", as explained later in Para.3.4, were introduced to act as air straighteners and so prevent interference with the ailerons. Photo.D shows the fins in place, but it should be noted (para.4) that we recommend their deletion from production.

The distributor box previously mentioned has also a spring-loaded lid designed to relieve the system if it is operated at speeds in excess of 285 m.p.h. A.S.I.

Some trouble was previously experienced with the upper brake flaps lifting from the closed position in normal flight. To overcome this, rubber shock absorber cords were connected to the upper flaps at points approximately $\frac{1}{4}$ span from each end, and about $2\frac{1}{2}$ inches from the trailing edges. The cables connecting the brake flaps to the shock absorber cord can be clearly seen in Photo B.

An indicator to the pilot is provided on top of each wing immediately behind each engine. This consists of a large quadrant, mounted vertically, and fitted with two pointers, one each for top and bottom brake flaps. The zero position, or closed position of the brake flaps, is in the centre of the quadrant, so that when both brake flaps are closed in flight, one pointer is superimposed on the other. As the brake flaps open, the pointer relating to the top one moves upwards, and the other moves downwards. The scales are graduated in increments of 10°.

The usual indicator on the dashboard for the landing flaps is retained.

The attached photographs show clearly the position of the brakes and their operating venturis.

3. History of development:

So far as the tests at this Establishment are concerned, the development has been in 4 phases: first and second, application to a Beaufighter; third, application to a Beaufort; and, finally, application again to a Beaufighter.

3.1. Phase 1. As first tested, the installation consisted of brake flaps on the under surface of the wing only, and these forward of the landing flaps. This installation was known by the Firm to be unsatisfactory since the Firm's test pilot complained of large changes in longitudinal trim and tail buffeting when the flaps were applied. However, it was decided to send the aeroplane to this Establishment for a day so that our pilots could offer comments as well. From the brief handling completed here, it was confirmed that the change in longitudinal trim was large, but our pilots did not complain of tail buffeting. No measurements of deceleration were obtained.

3.2. Phase 2. Before the second series of tests made on a Beaufighter, the brake flaps were moved to their present position, i.e. over the landing flaps and in the same relative position on the top surface of the wing. The inner surfaces of the "bellows" were of fabric and, owing to strength limitations, the chord of the brake flaps was less than that given in Para.2. The brakes were operated by a single venturi placed nearer to the lower brake flaps than are the twin venturi now used. There were no rubber shock absorbers used to prevent the upper flaps from rising in normal flight, nor were vertical "fins" fitted at the ends of the brake flaps.

/Our tests

Our tests, confined to one flight only, were made with a view to determining the degree of change of trim when the brakes were applied and taken off. The brakes were operated over a speed range of 140 to 250 m.p.h. A.S.I. No measurements of deceleration were obtained. The pilot's control lever, mounted next to his seat, was provided with a ratchet in the quadrant so that the brake flaps could be opened to any intermediate position.

Throughout the speed range tested there was a slight tail heaviness introduced as the brakes were applied. This tendency increased with increase in speed, but was never disconcerting, and could be easily held with one hand on the control column. No noticeable change of height was observed during the tests.

As the aeroplane decelerated with the brakes on there was a lateral rolling tendency introduced. When the brake flaps were opened at 250 m.p.h. A.S.I., and the speed had dropped to about 200 m.p.h. A.S.I., the brakes were open about 40° and one wing suddenly started to drop. The pilot found the stick force to keep level laterally increased to such an extent that the brakes had to be taken off or both hands used on the control wheel to keep the wing up. The same thing happened at the lower speeds with the brakes open more fully. As a result of the rolling tendency there was a yawing tendency introduced which had also to be overcome. As soon as the brakes were released the stick force disappeared and the aeroplane resumed normal flight without any noticeable change of trim.

3.3. Phase 3. Tests were next made on a Beaufort fitted with the same brake flap system as was tested on the Beaufighter and described in Para. 3.2 above. The only difference was that the pilot's control lever was mounted on the top of the dashboard and was provided with two positions only: brake flaps "off", and fully "on". This alteration was made because the Firm were of the opinion that the rolling tendency complained of in the Beaufighter was caused by the slow opening of the brake flaps with the pilot's control provided.

Tests were made over a range of speeds from 160 to 275 m.p.h. A.S.I. As a measure of deceleration the time taken to lose speed with the brakes on and off was recorded (see Fig.1), and the effect on trim due to the application and removal of the brakes, was explored. The curves shown in Fig.1 are for constant engine conditions. The aeroplane will decelerate more quickly if, at the same time as the brakes are applied, the throttles are fully closed.

When the brakes were applied at any speed up to 275 m.p.h. A.S.I., there was a very slight tail heaviness introduced but this was easily overcome by a small push force on the control column. As the brakes opened there was also a slight tendency for the aeroplane to roll to the right, but if this was not corrected, the wing righted itself, when open there was a continuous tendency to roll through about 10° to either side. The force required to check this roll was small and could be easily overcome with one hand on the control column.

As the brakes were removed the aeroplane accelerated rapidly accompanied by a slight tail heaviness which could, however, be easily overcome by a small push force on the control column. One test was made in which advantage was taken of the brakes to maintain the maximum speed of 275 m.p.h. A.S.I. at a steeper angle of dive. When the brakes were removed there was a small change in longitudinal trim to nose heaviness but this was again overcome by a small push force on the control column.

The Beaufort installation was, of course, a prototype, but it is felt that a word could be said in favour of a modification to the pilot's actuating lever for the brake flaps. It was mounted on top of the dashboard and was moved downwards for application of the brakes. To lock the brakes on, it was necessary to push a spring-loaded knob in. The lever was some distance from the pilot and the spring-loaded catch did not always engage. It is emphasized that, what is wanted, is a control which comes readily to hand and is quick and positive in operation. The Beaufighter installation which is described later is satisfactory as regards position, but is still subject to difficulty as regards positive operation because the spring-loaded knob has been retained.

3.4. Phase 4. We come now to the final installation. The system as tested on the Beaufort was installed in Beaufighter I. R.2057 and the pilot's actuating lever was moved to a position beside his seat on the left as it originally was. The ratchet control was replaced by the two-position lever with the spring-loaded knob for locking the brakes on.

/Before the

Before the aeroplane arrived at this Establishment, the Firm's pilot complained of riding up of the top brake flaps and vibration of the ailerons when the brakes were on. To overcome these criticisms, the Firm introduced the rubber shock absorber cords and vertical fins described in Para.2. We were asked to test the aeroplane with and without the "fins" fitted. (See Photo D.)

The tests on Beaufighter R.2057 were made in the same manner as those on the Beaufort. The range of speeds covered was from 140 to 280 m.p.h. A.S.I. The time taken to lose speed with the brakes on and off was recorded, the engine conditions being constant (see Fig.2), the effect of the brakes on trim was noted, and the effect of the "fins" was checked.

The brake flaps open quickly and evenly, taking about 2 seconds. When they are opened at a speed of 280 m.p.h. A.S.I. there is a slight change of trim to tail heavy, but this is gradual and is easily overcome by the pilot without conscious effort. There is no rolling tendency nor change in height.

The use of the brake flaps in the dive enables the angle of dive to be greatly increased for a given airspeed. At 280 m.p.h. A.S.I., the diving angle without the brakes on is about 10° at 2400 R.P.M. and -4 lb. boost. With the brakes on, the angle becomes about 45° under the same conditions.

With the brakes full on, and without the end "fins" fitted, there is a slight "trembling" of the ailerons which is noticed on the control wheel more as a vibration than actual movement. Fitting the "fins" (see Photo.D) eliminates this, but it is not considered a serious point, and we do not therefore recommend their fitment.

The rubber shock absorber cords appeared to keep the top brake flaps down in normal flight except that, towards the end of our tests, the port top brake flap started to ride up at speeds above 210 m.p.h. A.S.I. It is thought that this may have been due to slight distortion of the flap.

The curves of the reduction in speed against time given in Fig.2 show that the aeroplane takes 2 mins. 40 secs. to lose speed from 280 m.p.h. to 160 m.p.h. without brakes, and, with the brakes on, the time for the same loss of speed is only 36 seconds. The engine conditions for these tests were kept the same in order to make the results comparative, but in practice, a night fighter, overtaking an enemy aircraft at full throttle, would decelerate more quickly due to throttling fully back as soon as the brakes are applied.

4. Conclusions and recommendations:

The brake flaps, as finally tested, are satisfactory for Service use on Beaufighter aircraft in that they provide a marked deceleration without change of trim or height. Without the vertical "fins" fitted at the outboard ends of the brake flaps, there is a slight interference with the ailerons when the brakes are applied which can just be detected on the control column. This is not serious, however, and, for this reason, we do not recommend the fitting of the "fins.".

The position of the pilot's control is satisfactory, but the way in which it acts is open to criticism. The range of movement is large and because of the locked position for "brakes on" is not very positive nor easy to engage quickly. On the other hand the lever springs back immediately when "brakes off" is required. The lever provided moves through 90° (approximately) and is fairly short. An improvement would result from a longer lever and reduced angular travel, say, three times as long and $\frac{1}{3}$ the angular range.

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DECELERATION CURVES
WITH AND WITHOUT AIR BRAKES.

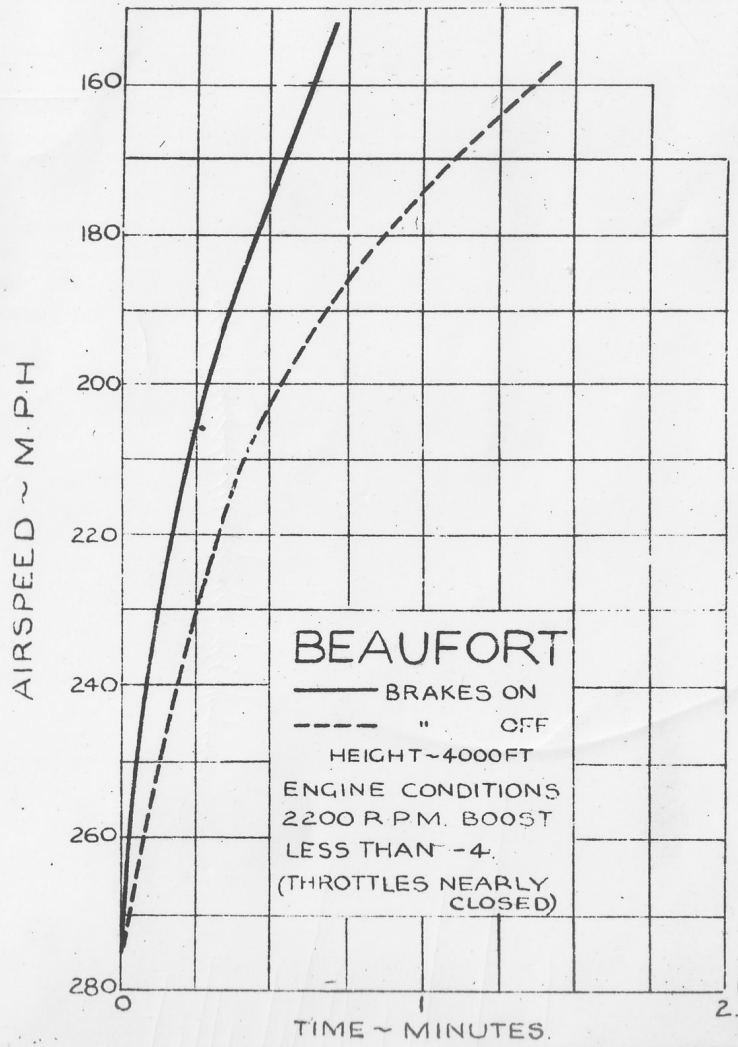


FIG 1

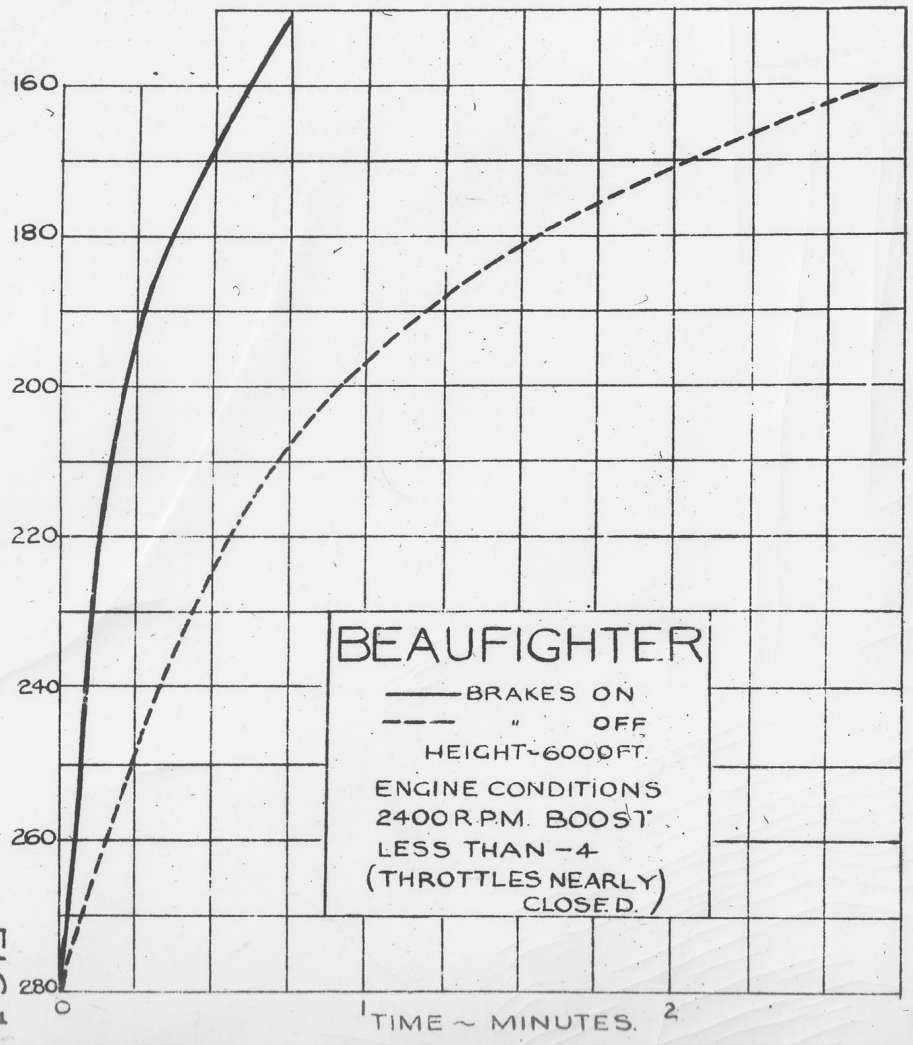


FIG 2

AM.11011.



A. REAR VIEW OF PORT BOTTOM BRAKE FLAP SHOWING LANDING FLAP ABOVE

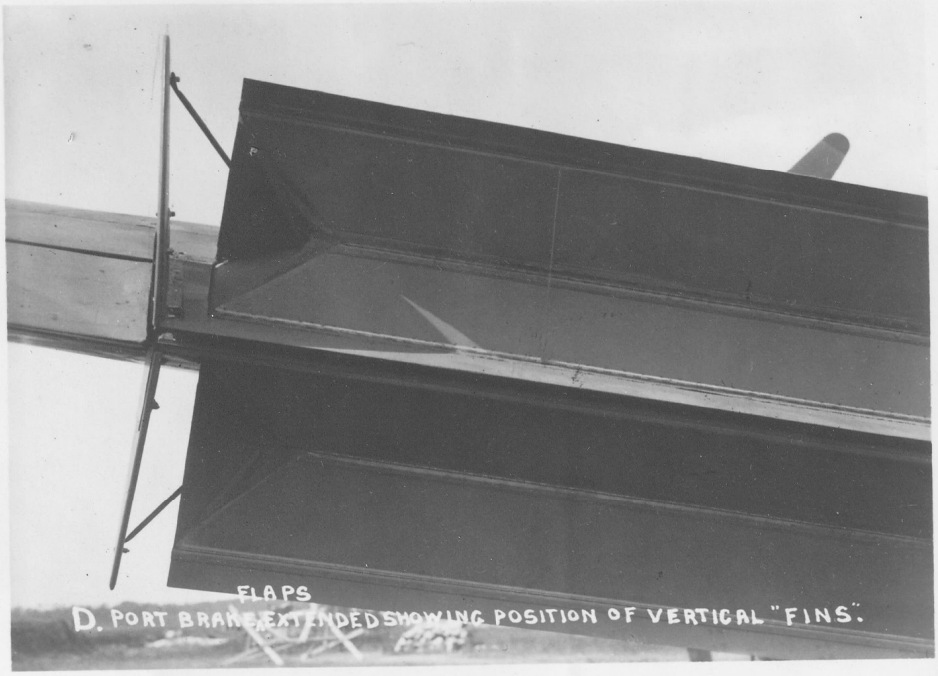


B. PORT BRAKE FLAPS EXTENDED SHOWING CABLES CONNECTING TO RUBBER SHOCK ABSORBER CORDS IN WING

AM 11011

C FRONT VIEW OF PORT BOTTOM BRAKE FLAP SHOWING POSITION OF VENTURI.





FLAPS

D. PORT BRAKE EXTENDED SHOWING POSITION OF VERTICAL "FINS".