CHAPTER ONE

A&AEE Report No. 760

The Case of the Disappearing Halifaxes

Handley Page Limited, of Cricklewood, London, had been designing and producing heavy bombers for the RAF since its inception in April 1918; even before that, the Handley Page O/400 had been the largest aircraft in the Royal Flying Corps. Its successor, the four-engined V/1500, had been the largest aircraft built in Britain during the First World War; it had been designed to bomb Berlin but the war ended before the type became operational. Other Handley Page bombers that equipped RAF squadrons between the wars were the Hyderabad, Hinaidi, Heyford and the monoplane Harrow which, though ordered as a bomber, was never to be used as such, being employed on training and transport duties. With such a background, the Handley Page Company was, not surprisingly, one of the contractors tendering for the B.l3/36 prototypes which were to be powered by the then new Rolls-Royce Vultures - this being the same specification that resulted in the ill-fated Avro Manchester.

The Air Ministry contract for two prototypes, L7244 and L7245, to B.13/36 was signed by the Handley Page Company in April 1937, the aircraft then being known as Type H.P.56. The design team, led by G. R. Vollkert, had been at work for only a month or two when it was rumoured that there could be a possible shortage of Vulture engines - that, at any rate, is one version of the story; it may be, however, that the Handley Page team had heard of the very considerable ‘teething’ troubles that the Rolls-Royce X-24 engine was suffering from, to the extent that the engine was in danger of being, at the very least, delayed in production. A. V. Roe pressed on with their Manchester, but there could well have been disquiet at the Air Ministry about the ultimate future of the Vulture so, possibly to hedge the bets, Handley Page Ltd were officially encouraged to revise their design while it was still on the Cricklewood drawing boards to take four Rolls-Royce Merlins - unlike Avro’s, who had eventually to modify substantially (under pressure of war) an actual aircraft. The Handley Page team was able to effect a considerable revision at the cost of only the paper; the result was a very much enlarged and far heavier aircraft than the original, the gross weight rising from 26,300 lb for the twin to around 40,000 lb for the revised four-engined bomber.

Two prototypes, known simply as Type H.P.57, were constructed at Cricklewood, work commencing in January I938. The first prototype, L7244 (the original service serials allocated for the two Vulture engined aircraft were retained), was transported by road to RAF Bicester and flew from that grass airfield for the first time on 25 October 1939 with Handley Page Cornpany’s chief test pilot, Major Cordes, in command. The prototype was powered by four Rolls-Royce Merlin Xs, each offering 1,075 hp for take-off. On the first flight the prototype was not fitted with armament or turrets but it still tipped the scale at 55,000 lb. The flight was uneventful, which was just as well since the type had been ‘ordered off the drawing board’ in September 1937, when contracts for 100 Type H.P.57s were issued. This was later increased; the Air Staff envisaging 500 Handley Page Halifaxes, as the new bomber had been named, in RAF service by April 1942. (The plan had also called for 1,500 Manchesters by the same date.) The second prototype flew for the first time on 17 August 1940, by which time production was well under way, the first Halifax I (L9485) flying on 11th October 1940.

By the time the Mk I production aircraft were flying, the maximum take-off weight was 55,000 lb. Maximum speed of the Mk Is was 265 mph at 17,500 ft, with 2,242 Imperial gallons of fuel and a normal bomb load of 5,800 lb. Range was 1,860 statute miles; operational ceiling 22,800 ft. The standard armament consisted of two .303-inch guns in the nose turret and four .303-inch guns in the rear turret. A number of Mk I aircraft also had two single-beam .303 guns on either side of the fuselage. On the night of 10/11th March 1941, six Halifax Is of No.35 Squadron, based at Linton-on-Ouse, made the first operational sortie of the type: an attack on targets at Le Havre. A daylight raid was made on the German naval base at Kiel on 30 June 1941, followed by further daylight attacks on the battleship *Scharnhorst*, lying at the French Biscay port of La Pallice. Further daylight sorties followed, culminating in an attack on the battleships *Scharnhorst* and *Gneisenau*, then at Brest. This was to be the last major daylight bombing raid by Halifaxes; mounting losses, due to increasingly effective Luftwaffe fighters, caused Bomber Command to change to a policy of night bombing. (The Luftwaffe had come to the same decision, following unacceptably heavy losses of bombers during the Battle of Britain in the summer of 1940.)

An appreciation, following the introduction of the Halifax I into Bomber Command’s Order of Battle, was that the aircraft was to some extent under-powered and, certainly on daylight sorties against well defended targets, under-armed. To remedy the latter shortcoming, the Handley Page design staff proposed an increase in the defensive armament. The first production Halifax I, L9485, was extensively tested at Boscombe Down, with ventral and dorsal turrets. After the tests, the ventral turret (and beam guns) were deleted but the dorsal turret became standard for B.Mk II production aircraft. The turret chosen (made by Boulton and Paul) was a somewhat bulbous affair, mounting twin .303s, and essentially the same as was then fitted to Coastal Command’s Lockheed Hudsons, for which reason the turret, when fitted to Halifaxes, was usually referred to as the ‘Hudson’ turret.

The gross weight of production Halifaxes had by now risen to 60,000 lb, necessitating more powerful engines, these being, on early B.Mk II series Is, 1,390 hp Rolls-Royce Merlin XXs. The higher all-up weight, together with the drag of the ‘Hudson’ turret and a power wasting, flame-damping exhaust system, correctly considered essential for night operations, caused the already under-powered bomber to become distinctly tricky to fly, to the extent that, when fully loaded, the aircraft was prone to fall into uncontrollable spins. Accidents - many fatal - mounted, causing official alarm and considerable unpopularity among the operational Halifax squadron crews.

In an endeavour to alleviate the problem, a standard production Halifax (R9534) was sent to Boscombe Down where an intensive programme of weight and drag reduction was implemented. The result was the deletion of the nose turret, which service experience had shown was seldom used, particularly at night. A neat Perspex fairing replaced the twin gun turret, though a single, hand-operated Vickers 'K' .303 was mounted in some aircraft, more to encourage the bomb-aimer than seriously to discourage enemy fighters. The bomb-aiming 'chin' was replaced by an optically flat panel, which in itself must have considerably reduced drag. The large dorsal turret gave way to a much shallower type, similar to that fitted to the two-seater, single-engined Defiant night fighter. The engine cowlings were cleaned up aerodynamically, mainly by redesigning the radiators, and the power consuming exhaust flame-dampers were removed. A good deal of unnecessary internal equipment was jettisoned; the tail-wheel was made semi-retractable; radio and D/F aerials were revised. Other detail modifications included redesigned bomb-doors and fuel jettison pipes. All these, together with still further uprated engines, Rolls-Royce Merlin XXIIs, were to enable the subsequent production Halifax B.Mk II Series IA to show a ten per cent increase in performance over the earlier marks. (Pending the supply of the new production Mk II, early aircraft were retrospectively modified to incorporate most of the A&AEE (Aeroplane and Armament Experimental Establishment) recommendations.These aircraft were then known as B.Mk II Series I (Special).)

When the Mk II Halifaxes entered squadron service, the increased performance was welcomed, but unfortunately the number of Halifax losses continued to mount steadily, to the point where the Air Ministry Departments CI (Accidents) and S4 (Statistics), on analysing the reports, came to the inescapable conclusion that the numbers of Halifaxes missing over enemy territory were more than could be ascribed solely to battle losses. There had, in addition, been a number of inexplicable accidents - all fatal - over the UK; one, which occurred on 7 June 1942, was to have a serious effect on the radar war. The most secret prototype H2S centimetric radar was being tested in Halifax V9977, which had taken off from the Telecommunications Research Establishment (TRE) airfield at Defford, with practically the entire H2S development team on board, including the brilliant scientist A.D.Blumlein. V9977 did not return: it had crashed from unknown causes into a field near Ross-on-Wye, killing all the occupants. Further Halifax crashes followed, none of the aircrews surviving to give an account as to the cause. Minute inspection of squadron aircraft or sifting through the remains of Halifaxes which had crashed in the UK revealed no clues, though some form of structural failure was naturally suspected.

As part of a separate investigation into the performance of Halifax IIs, a representative aircraft had been acquired from an operational squadron in the summer of 1942. This aircraft, DG22l, when flown by A&AEE test pilots, showed with stark reality the narrow margins which operational pilots and aircrews unwittingly accepted.

The A&AEE report noted that the aircraft had been flown direct from an operational squadron 'in the condition in which it had been operating'. The report continued:

'This aeroplane [DG22l] showed evidence of bad workmanship and poor servicing, and had also been treated with a particularly rough brand of special night black finish...

This particular aircraft had completed nine operational sorties; its poor servicing was reflected in the fitting of an odd propeller: the starboard inner had a Rotol R7/35/55 but the three remaining engines drove Rotol R7/35/54s. The carburettor hot air shutters were found to be working loose and had to be wired permanently in the cold air position. The handling test of this aircraft revealed from the outset a marginal performance, as the report reveals:

'Take off: *The aeroplane had a poor take-off performance . . . the take-off run on a warm day became critical. On the final flight, with the ground temperature at 25°C, a take-off run of 42 seconds was registered. On this occasion the aerodrome boundary was cleared with difficulty after two previous attempts had been made to lift the aeroplane off the ground. It was obvious that the slightest faltering on the part of any engine or on the part of the pilot would have been disastrous.*
It was intended to test this aeroplane in the worst operational conditions, i.e. with exhaust shrouds [flame-dampers] and 2/4,000lb bombs fitted. In view of the poor performance at take-off and at altitude these tests were cancelled. We consider this aeroplane so loaded to be unairworthy on a hot summer's day.'

The poor performance at altitude was frankly reported on:

'Operation at Altitude: *Finally it is interesting to record flight experience on this aeroplane [DG221] at altitude in hot weather (approximately 10°C above standard). The aeroplane was flown with exhaust shrouds on and with bomb doors closed.*

At 18,000 ft a speed of 150 mph A.S.I. (Cruising threshold) was just maintained using maximum all-out level power. At 15,000 ft the aeroplane would just maintain height at maximum weak mixture cruising power (M.S. gear) at 142 mph A.S.I., a speed which is far too low either for comfort or emergency. These observations were made at an all-up weight (in flight) in the neighbourhood of 57,000 lb.

In this condition of flight a minor emergency did in fact occur, the starboard outer engine boiled and the pilot immediately throttled back the engine slightly. The right wing dropped sharply, followed by the nose.'

The A&AEE discovered that the performance of DG221, a representative squadron aircraft which had, as stated above, already completed nine operations, could not maintain 15,000 ft in normal weak mixture cruise and that in hot weather 13,000 ft was, to all intents and purposes, the operational ceiling of the aircraft and that even then:

'when flying in these conditions [i.e. the 'cruising threshold'] it is impossible to take sudden violent evasive action or carry out any quick manoeuvres because this may lead to the aeroplane falling out of control.'

Although the performance of DG221 was poor, it did not, in itself, explain the mounting losses of Halifaxes. The A&AEE began to suspect that rudder over-balance could be a contributory cause and an investigation was decided upon.

The A&AEE was requested to investigate the possible causes of the mounting accidents.

The first step was to examine the reports of the early handling trials which had been made at Boscombe Down on the second prototype, L7245, and also on the first production aircraft, L9485. In the **3rd part of the Report A&AEE/760**, dated 21st December 1940, was this significant observation:

Para 4.4: Response of Controls: Rudders*.*
'At speeds below 120 mph these give little response. They are effective at higher speeds and appear to have sufficient power to cope with engine failure. . . . At speeds below 150 mph there is a tendency for rudders to overbalance with application of rudder trim. This is particularly noticeable when speed is reduced through throttling one engine and application of rudder to prevent yaw. This is being investigated and a modified [trim] tab has been fitted in an attempt to prevent this.'

Three weeks later another Halifax handling report had been issued; this, too, contained a significant observation:

4th Part of A&AEE/76O (17January 1941): **L7245 Airscrew feathering tests**

Para 3.2: Handling
'Further tests were made with both engines on one side throttled back and airscrews feathered. The minimum speed at which the aeroplane could be flown straight and level was determined. . . [minimum speed with both starboard airscrews feathered was 122 mph and 140 mph with both port engines feathered]. The factor limiting the minimum speed . . . was overbalance of the rudder. If the angle of the rudder trimmer was reduced to avoid overbalance the force on the rudder bar became excessive.'

Para 5: Recommendations
'The rudder overbalance, which is manifest when both port airscrews are feathered, would cause great fatigue to a pilot attempting to keep straight and level under such conditions, and modification action is necessary in order to overcome this defect.'

It appeared, in the light of the original A&AEE reports, that rudder overbalance could be a likely lead in the enquiry.

The fins and rudders on the Halifax II were in the form of ‘end plate fins’; that is the tailplane terminated in two arrow-shaped fins, each with an interconnected rudder. This form of tail assembly was a common feature of several contemporary multi-engined aircraft - the Lancaster had a similar layout; it was a popular arrangement with designers for it placed the rudders in the slipstream of both the port and starboard inner engines, making the rudders highly effective, particularly on take-off. Take-off with four-engined tail-wheel aircraft, especially with a fully loaded heavy bomber, could be difficult; as the throttles were opened to full take-off power, the aircraft tended to swing off the runway, due to engine torque. As the tail-wheel left the ground, the only directional control was from the rudders which, had they not been in the propeller slipstream, would, at the low air speeds in the early part of the take-off run, have been largely ineffective. (The Stirling had a single large fin and rudder on the aircraft’s centre line; as a consequence, it was notoriously prone to ‘swing’ on take-off, requiring deft differential throttle control when on the ground to keep the bomber straight.)

The wartime RAF heavy bombers did not have power-operated controls, the pilot moving them directly. To help ease the considerable manual control loads, the elevators and rudders were aerodynamically balanced; that is, part of the actual control surface projected in front of the hinge line. The air loads on these forward projections acted to oppose the loads on the rest of the control surface, considerably easing the manual force required on the rudder bar. This assistance was necessary if the pilot had to apply large angles of rudder, as when taking evasive action or compensating for an engine failure. Without 'balancing', the rudders on an aircraft the size of the Halifax would be virtually solid at all but very low airspeeds.

Clearly, since the effect of the balancing areas of the rudder depends on the airspeed over the rudders, the size was inevitably a compromise between sufficient power to aid the pilot with the worst case of two dead engines on the same side, and not being over effective and taking over control of the rudders. This last case is the effect of overbalancing - a tendency noted by the A&AEE test pilots when conducting the original type handling trials.

As a result of those trials, a series of additional test flights was undertaken at A&AEE by Sqn. Ldr. W.J. Carr AFC, and a civilian scientist, J. Unwin MBE, to examine Halifax asymmetric flight characteristics. The tests were conducted with L9515, an early production Halifax I which had been used at Boscombe for previous trials. In their reports on the tests, Carr and Unwin recommended a re-design to the leading edges of the rudders, making them bulbous, and a reduction of the total movement of the rudder balance tab.

When the above modifications, which became known as Mod 413, were recommended, it was thought the Halifax II simply had a *tendency* to overbalance; it was not at that time known to be a definite hazard when flying the type, which continued to be used operationally. As the accident rate increased, however, it was decided that further flight trials with a standard service Halifax should be undertaken by A&AEE test pilots and scientists, to ascertain the extent of rudder overbalance and to assess if this was a likely cause of the accidents. As stated above, the original Halifax handling tests at Boscombe Down had been with the first prototype and first production aircraft, which were not representative of subsequent RAF squadron machines. The Carr and Unwin trials were also made with a non-standard aircraft. A standard production Halifax II, W7917, was therefore borrowed from 102 Squadron of No. 4 Group. This aircraft was new; it had flown a total of only 40 hours and was in every way representative of the Halifax MkIIs then in squadron service with No. 4 Group, Bomber Command.

The test programme began on 4 February 1943, when W7917 took off from Boscombe Down with Unwin on board. The pilot on this latest test flight was Flt. Lt. S. Reiss, a Pole serving with the RAF, who had been with the A&AEE for some time. The crew was completed by the flight engineer, Sgt. Fielding.

Reiss was, as one would expect, an experienced pilot; his total hours were in excess of 1,640 and he had, whilst acting as a Boscombe Down test pilot, enjoyed something of a charmed life, surviving two crashes the previous year. The first had been on 17th August I942, when the nose-wheel of a B-24 Liberator (AL505) collapsed on landing. Three weeks later (6th September) Reiss was involved in a much more serious incident, when a fire broke out in the starboard outer engine of a Stirling III (R9309) which he was flying. The flight engineer found he could not extinguish the blaze, which began to spread alarmingly; Reiss then gave the order for the crew to bale out, which they did without injury, and then Reiss courageously attempted to perform the first duty of a test pilot: to bring the aircraft safely down, if at all possible. Unfortunately, when approaching Boscombe Down, the aircraft became uncontrollable, crashing into a wood on Porton Ridge. Reiss was very lucky to escape with broken ribs.

To return to the flight of Halifax W7917. It took off from Boscombe at a recorded all-up weight of 50,000 lb, with the stated intention of investigating rudder overbalance.
Just what happened on the flight is conjecture, for when at an altitude of 12,000 ft, according to the official report, it:

'was seen to dive and [then] pulled out in a shallow turn which terminated in a flat spin in which condition it struck the ground. The airframe broke into three sections, the front section consisting of the portion forward of the trailing edge of the wings catching fire on impact. All three occupants were killed immediately.

A full investigation of the wreckage at the crash site, a field two miles north-east of Sutton Scotney, near Winchester, revealed that the top half of one of the rudders had broken away in flight. This was attributed by the investigators to the rudders overbalancing with such force that one had fractured, rendering the aircraft uncontrollable.

As a result of the crash of W79l7, witnessed by competent observers on the ground, any lingering doubts as to the reason for the mounting Halifax accidents were now dispelled.

The problem confronting A&AEE and the manufacturers of the Halifax, Handley Page Ltd, was to try to ascertain if a relatively simple alteration to the rudder or fins could be recommended, preferably one that could be applied by the squadrons as a retrospective field modification, rather than a disruptive redesign on the production lines. It was considered by the investigation team at Boscombe that this latter course would probably prove to be the case and that the over-balancing of the rudder was inherent in the original design. As the accident rate was still rising, the problem was assuming major proportions.

As an emergency interim measure, a series of flight tests was to be made to explore more fully the motion of the aircraft subsequent to rudder overbalancing, and it was hoped that a study of this motion might result in a means of reducing the accident rate.

Two Halifax Mk II, Series IA aircraft, HR679 and HR727, both of which had been used for various experiments, were made available for the trials. These machines, though nominally the same Mark, were in fact similar but not identical and both differed from operational RAF Series ll bombers in the shape of the nose.

HR679, with a standard production fin and rudder assembly, incorporating the recommended modification 413, was to be used principally to ascertain if it was feasible to make a relatively simple modification to reduce the rudder overbalance by limiting the movement of the rudders. A description of this Halifax was as follows:

HR679

- *(i) The front turret was removed and the nose of the aircraft was streamlined in Perspex.*
- (ii) *The Gallay coolant radiators were replaced by Morris block type radiators.*

This (and [iii] and [iv]) were part of the earlier A&AEE recommendations made to 'clean up' the Halifax Mk.II; the radiator change enabled a narrower cowling to be used, causing less drag.

(iii) A Defiant-type [.303] 4-gun turret was fitted in the dorsal position.
(iv) The inboard engine nacelles were extended beyond the trailing edge of the wings. [This was for another A&AEE trial unconnected with rudder overbalance]
(v) The tail-wheel was retractable.
(vi) A Mk VIII pitot-static head was mounted in the under-nose position but only the pressure head was connected during the major part of the tests, the static pressure being supplied from a static vent situated on the port side of the fuselage near the tail. Toward the end of the tests it was decided to change over to the static side of the Mk VIII head because it was thought this source of static supply gave more reliable readings under conditions of sideslip.
(vii) The fins and rudders were standard production items embodying Mod. 413.

The second Halifax, HR727, to be used in the tests was, like HR679, a non-standard aircraft, it too having been used for various tests unconnected with the investigation into rudder overbalancing. However, it was to fly with a re-designed rudder and fin which Handley Page Ltd had supplied. For interest, the other differences between the two aircraft, which with the exception of (iv) are irrelevant, are given as they appeared in the original report:

HR727
(i) Items (i), (ii) and iii) [of the details of HR679] apply also to this aircraft.
(ii) The inboard engine nacelles finished flush with the trailing edge of the wings, as on all production [Mk II] Series I aircraft.
(iii) The tail-wheel is non-retractable. This cannot be classed as a difference from the production Series I.
(iv) The fins and rudders were further modified [i.e. in addition to Mod. 413] by removing the bulbous noses, setting back the portion of the leading edges forward of the hinge line by 2 in, and by filling in the space with additional fin surface. In addition, the balance tab gearing was increased.
(v) A Mk VIII pitot static head was mounted in the under-nose position and the static side of this head supplied static pressure to the pilot's airspeed indicator throughout the tests.

The primary role of this second Halifax, HR727, was to determine whether the revised Handley Page rudder/fin assembly would be successful in eliminating the overbalance trouble, assuming - as most of the people concerned with the investigation did - that the simple modification made to the other test Halifax would fail to cure the overbalance.

The first test flight was made on 26th February l943. This flight was to ascertain the precise nature of the problem and, in effect, reproduce the manoeuvre which had caused the fatal crash to W7917, a fortnight earlier. Unfortunately the surviving A&AEE records at Boscombe Down do not contain the names of the very brave trials crew who conducted this dangerous flight, though even the cold print of the official report cannot mask the supreme skill and coolness of the unknown test pilot.

It is here reproduced:
4.1HR679
'4.11 This. . . test [was] made to. . . determine the subsequent behaviour if overbalance set in during sideslip.
At 150 mph ASI the pilot attempted to introduce sideslip by applying right aileron and opposite rudder, but the forces required were too high to make it possible for more than a very small amount of control to be used. The angle of bank was about 15° and the rudder was heavy with no tendency to overbaiance.
At 140 mph ASI the test was repeated and it was possible to apply a little more bank with more rudder movement, and the results were similar to those obtained at the higher speed.
At 130 mph ASI it was possible to apply full rudder with again about 15° of bank, and there was no tendency for the rudder to overbalance.
At 120 mph ASI the pilot moved the rudder bar to approximately 3/4 of its travel, and thereafter the rudders moved of their own accord to the full extent of their travel.The pilot was unable to centralise the rudder bar. The aircratt went into a spiral dive in the direction of the applied rudder [to port]. Opening the throttles fully on the port side failed to produce recovery, but, when the control column was moved forward the airspeed rose to about 150 mph ASI, the rudder bar could be returned to central, and straight flight was resumed.

During that test, the Halifax lost 4,000 ft. The reaction of those on board can well be imagined, especially as, in such a large aircraft in a spiral dive, it would be virtually impossible to move, due to centrifugal force, making it impossible to bale out. Having survived a condition of flight that had killed numerous other crews, the test pilot then climbed the Halifax back to 12,000 ft and tried a further test, this time at l l0 mph indicated airspeed. The same rudder locking occurred, though this time the pilot was able to assist the recovery by opening up the port engines to full take-off power: 2,850 rpm + 9 lb of boost. The report summarizes these first tests:

'When rudder locking takes place, the rudder overpowers the ailerons completely and the aircraft rolls over to the side in which rudder is applied. At the same time, the nose drops, and the aircratt enters a spiral dive. The recommended method of recovery is to remove the opposite aileron, move the control column forward until the speed has increased to at least 150 mph and then, after centralising the rudder, recover from the resultant dive. If [the report continues] the pilot pulls the control column back as the aircraft rolls over and drops its nose (as he would instinctively do) then the controls are set for a spin and, unless action is taken quickly . . . a spin may result. In any case there is a large height loss of anything up to 4,000 feet during recovery.'

The root cause of the many Halifax accidents was now apparent. The trouble was that the locking of the rudder was occurring at a speed likely to be encountered just when any spiral or spin would be disastrous; that is when near the ground. 120mph or less would be the speed of the bombers when approaching to land, when any coarse operation of the rudders, coupled with a sideslip, could provoke the fatal rudder locking; a not unlikely eventuality, particularly in making crosswind landings. Asymmetric flight, a common enough hazard on operational bombers with one or more engines inoperative due to enemy action, was another flight condition which could easily provoke the rudders to lock over; again, a Halifax flying on two engines would be forced to cruise in the dangerous low speed range.

Many Halifaxes which failed to return from operation could well have spun in, following evasive manoeuvres to escape from the increasingly effective radar-guided German night fighters, particularly when crews resorted to the desperate evasive measure of ‘corkscrewing’.

If a rear or upper gunner spotted a night fighter closing on his bomber, he would call on the intercom: ‘Corkscrew, Skipper’. The pilot would then slam shut the throttles of the two engines on the same side, at the same time applying full rudder, usually to the left (a fact well known to German night fighter pilots, who reported that nine out of ten heavy bombers broke left on attack). The resultant violent corkscrew usually ‘lost’ the fighter: it may well have lost a number of Halifax Mk.IIs. It was, in any event, a dangerous measure in heavy bombers since they often had sustained structural damage from flak, unknown to the crews, and ‘corkscrewing’ imposed severe additional strain on the weakened airframes.

As far as the A&AEE were concerned, it was now true that a skilled test pilot had reproduced the conditions that had caused so many fatal Halifax accidents and had further empirically devised a successful recovery technique. However, it was clearly one thing for an experienced test pilot to effect a recovery in daylight with adequate height and the knowledge as to the nature of the problem; for operational squadron pilots, with perhaps as little as 200 hours total time, exhausted, possibly wounded and flying damaged bombers at night on instruments, in bad weather, over enemy territory, it would be quite another case. Merely pinpointing cause and effect and recommending a difficult recovery technique was not going materially to reduce the losses, or indeed commend the Halifax to its crews.

At Boscombe Down, before any further flights were undertaken, a safety measure was introduced on both of the test Halifaxes. It was decided, in the light of the first A&AEE report, to fit a restrictor which was attached to the rudder bar, enabling the pilot to govern the total amount of rudder travel in flight. The nominal maximum travel of a standard production Halifax Mk.II’s rudder was a minute or two under 20°; the restrictor could be set up - on the ground - to limit the total angular movement to about 12°. In practice, due to losses in the control linkages, hinge play and flexing of the structure, the actual angle at the rudder was more than the nominal permitted by the restrictor. It was found that taking up this play acted as a damper and the rudder could no longer slam hard over, as had apparently happened to W7917. The restrictor on the rudder bar was calibrated in degrees, enabling the test crew to preselect the maximum rudder angle.

After the safety restrictor was fitted, the first proposition considered to prevent the locking of the rudders was a simple one: that of making them so heavy that no pilot could apply sufficient rudder to overbalance them in normal flight, yet leaving enough movement for control on take-off and compensating for asymmetric flight with dead engines. The first attempt to achieve this was a time-honoured method, well known to RAF riggers: ‘stringing’ or ‘cording’.

‘Cording’ was used in the days of fabric-covered biplanes to adjust for minor rigging anomalies. If a pilot reported that his aircraft was flying, say, left wing low, the airframe riggers, after checking that the aircraft was rigged as accurately as eye and trammels allowed, would dope a short length of cord, of about 1/8th inch diameter, along the trailing edge on top of the left aileron. This cord acted on the airflow over the control, pushing it down, thereby lifting the low wing; by adjusting the length or diameter of the cord, an accurate trim could be obtained.

The practice of cording continued into the era of all-metal monoplanes because many, including the Halifax, still had fabric-covered control surfaces. The cording of the Halifax was to be on both sides of the trailing edges of the rudders, with the object of making the control sufficiently heavy to prevent the fatal overbalance angle being achieved in flight.

With the cording doped into place, tests were flown with HR679 with rudder restricted flrstly to a total left/right travel of 12°, then with 12° left and 15° right. Some unexpected facts emerged from the test flight; the test pilots were surprised to find that, contrary to expectations, the cord made no difference to the rudder 'feel', no additional heaviness being apparent. No rudder overbalance occurred when sideslipping to starboard, even down to 105 mph indicated, at a maximum rudder angle of l4°; but when sideslipping to port, overbalance occurred at a 12° rudder angle, but only at the low speed of l05 mph.

The conclusions drawn from the tests flown with HR679, with the restricted rudder movement and 1/8 inch cord doped to the rudder, did not offer any appreciable hope of solving the problem, though the A&AEE report reveals that the 'cord' was still considered as a possible solution:

'. . . It was still hoped that a condition might be found in which the rudders would be too heavy for the pilot to apply sufficient control to reach the overbalance stage and yet in which the effectiveness of the rudders, when acted upon by the trimming tabs, would be sufficient to cater for the worst asymmetric flight case [i.e. two engines out on the same side].

To this end the 1/8 inch cord was removed from the trailing edges of the rudders and replaced by cord of 3/l6 inch diameter, but below the trimming tabs only. At the same time, the angular movement of the rudders was reduced from [a nominal] 20° each way to 17° each way.'

Other tests had shown that 17° each way was ample to cover the worst case of asymmetric flight.

Several test flights were made with HR679 in the condition described above. The aircraft was flown by a number of A&AEE pilots, a Handley Page test pilot and an experienced RAF captain from No. 4 Group which operated Halifaxes.
The report summarized the tests:

1. The rudders were considered too heavy for general flying.
2. The . . . cord did not improve the rudder locking characteristic.
3. The restricted angular movement provided ample rudder control for turns against two engines running at emergency power conditions [2,850 rpm and +9 lb boost] down to a speed of 140 mph ASI.

Since the 3/16 inch cord simply made the rudders unpleasantly heavy in flight, whilst contributing nothing to the central problem of rudder overbalance, the cord was removed and the aircraft test flown with just a restrictor fitted to the rudder bar.

The report concluded that:

' . . . It was anticipated that the rudder angle required to cater for two dead engines on the starboard side would be less than that required for the opposite side [due to the effect of engine torque] and, since no cure could be offered to the Service for rudder locking, it was hoped that a further restriction in angular rudder movement to port could be recommended, it being agreed that, provided sufficient rudder movement was left to allow turns to be made against two working engines, the smaller the angular movement available, the less violent would be the behaviour of an aircraft when rudder locking took place. '

The tests conducted were to be repeated with the second Halifax, HR727, with the factory modified rudder with the smaller balance areas. The results of the test were disappointing, as the report summarizes:

5.2 HR727 The modified rudders, with reduced aerodynamic balance, are more pleasant for general flying than the standard rudders because they are more effective, but, because they suffer also from overbalance troubles, and because, being more effective they overbalance at smaller angles, they cannot be recommended for fitment to Service aircraft. . . .

The report held out little hope of solving the basic Halifax problem, as stated in the 'Conclusions and Recommendations' of the report:

'Since no cure nor palliative can be suggested to stop Halifax rudders locking in Service, it is recommended that all existing rudders be restricted in angular movement to 17° each way. . . . A further restriction of 2° to port could be made if desired, but it is probably safer to keep the movement equal each way. Tests now being carried out at the Royal Aircraft Establishment [RAE Farnborough] should show whether the rudder locking characteristic is due to overbalance, tail stalling, or both. In any case, a cure can almost certainly be effected by the introduction of increased fin area, and it is strongly recommended that a substantial increase of fin area be provided.'

Modifications to the rudder limit stops were recommended and, as far as the existing squadron Halifaxes were concerned, that was combined with careful briefing of pilots at the operational training units (OTU) and No. 4 Group as to the possible consequences of inadvertently locking the rudders and the recommended recovery techniques; there the matter, for the moment, had to rest. However, the number of Halifax accidents did fall.

It was considered at A&AEE that the recommendations were only a palliative and in no way cured the rudder locking, which the RAE traced to complex fin and rudder stalling, due in part to turbulent air from the rather slab-sided Halifax fuselage. The final cure was a redesigned 'D' shaped fin with 40 per cent larger area. The new tail was tested by A&AEE on Halifax Mk.III, R9534.

The rudders on the new tail could be moved 20° either way and, though rather heavy, showed no tendency to overbalance in any condition of flight. They were adopted by Handley Page on all future Halifax production.

The A&AEE later tested a production Mk.V, DKI45 with the new ‘D’ type rudders and found them satisfactory, concluding that:

'The handling qualities of the Halifax Mk.II or Mk.V are satisfactory with the large D type rudder and fin combination. There is sufficient rudder for flight with two engines dead on one side, and turns can be made against the working engines. There is no tendency for the rudders to overbalance when sideslipping down to I20 mph ASI.'

The case was now closed.

The Halifax Mk.II with the revised ‘D’ type fins continued in second line service (mainly with training units) until the end of the war; it had been supplanted on the production lines by the B.Mk.III, which began its operational career with Bomber Command in February 1944. This bomber variant was the best of the Halifaxes. It was powered by four Bristol Hercules XVIs, fourteen cylinder sleeve valve radials, offering 1,615 hp for take-off which, with an increase of wingspan from the original 98ft I0in to 104ft 2in, substantially improved the operational ceiling of the type.

A final Halifax bomber, the B.Mk VI, was operational by October I944, but was too late to see extensive service though, had the war in the Pacific continued, the Mk VI would have been used in the Far East.

During the war years, in addition to service with Radio Counter Measure squadrons, Coastal, Transport and Training Commands, Halifaxes of Bomber Command flew on 75,532 sorties, dropping 227,610 tons of bombs.

A single Halifax Mk.III of 462 Squadron shared with Mosquitos the distinction of dropping the last bombs on Germany, with a sortie against Flensburg on 2 May 1945.

The total production of 6,176 Halifaxes, which included 1,966 Mk.IIs and 2,000 Mk.IIIs, were produced by Handley Page, English Electric, Rootes and Fairey Aviation. The last Halifax built, a Mk.IX (RT938), left the Handley Page factory at Cricklewood in London on 20 November 1946.

The later Halifaxes, Mks. VIII and IX, were used post-war for the training of parachutists and supply dropping, and numbers of them remained with the RAF in this role until finally superseded by the Handley Page Hastings in 1948.

The Halifax, in common with many of the aircraft of the fighting powers during the Second World War had its problems, but these were overcome to enable the only bomber produced in Greater London to make a considerable contribution to the RAF’s share of victory, in which the scientists and test pilots of the A&AEE played a vital, though hitherto unpublished, role.