No. 14

British European Airways Corporation, Vickers Viscount, G-ALWE, crashed while approaching to land at Ringway Airport, Manchester on 14 March 1957. Report released by the Ministry of Transport and Civil Aviation (UK) CAP 147

Circumstances

The aircraft was reaching the end of a scheduled passenger-carrying flight from Schiphol, Amsterdam, with a crew of 5 and 15 passengers aboard. Until the aircraft was roughly a mile from the threshold of the runway it was apparently making a perfectly normal approach, then it made a banked turn to starboard and continued to descend until the starboard wing tip struck the ground. With the starboard wing furrowing the earth and breaking up, the aircraft, obviously completely out of control, went on until it struck some houses, demolishing two of them (in one of which a woman and her infant son were killed). The aircraft came to rest in the ruins of the houses and immediately caught fire and set fire to the houses. All the crew members and passengers were killed in the accident. The position of the final crash was about 900 yards short of the runway and 200 yards to the right of its extended centre line.

Investigation and Evidence

The fire and rescue services arrived at the scene with the utmost promptitude but because of the fierceness of the fire there was no possibility of saving any lives, even if any of the occupants of the aircraft were not killed immediately on impact.

Although there were no survivors from the aircraft, it is clear from the evidence of eyewitnesses and from the communications which took place between the aircraft and the ground that all was apparently normal until, at the most, half a minute before the crash.

The captain and first officer on this last flight were experienced and highly competent pilots. The captain had flown with BEA 6 951 hours, 1 051 of which were on Viscounts. The first officer had flown a total of 7 314 hours with BEA of which 132 hours were on Viscounts.

The aircraft had been properly maintained and the load carried was comparatively light and was correctly balanced.

G-ALWE was the first 701 type Viscount to be manufactured and was used to a considerable extent for the training of pilots - that is to say for teaching experienced pilots how to handle aircraft of this new type. For this reason it had had by 14 March 1957 more flying hours than any other Viscount except one and more landings than any other Viscount except another one, i.e., 6 902 flying hours and 4 553 landings as compared with 6 948 flying hours and 4 951 landings which were the highest figures among other Viscounts.

Description of the Accident

At about 1334 hours on 14 March the aircraft passed into the control of the Manchester Approach Controller. At 1336 the Approach Controller received a call from the pilot and asked him to report passing Oldham Beacon and reaching 3 500 ft. The Approach Controller then gave him the latest weather observations - wind 250°/23 knots, visibility 10 nautical miles, cloud 5/8 at 3 000 ft and 8/8 at 10 000 ft. He also gave the aerodrome pressure. At 1341 the aircraft reported at Oldham Beacon still over 3 500 ft. (According to normal practice the pilot would start his pre-landing drills after

passing Oldham Beacon and this would include lowering the flaps.) The Approach Controller asked the pilot if he wanted an instrument let-down. The pilot said he would like GCA to give him a cloud break. This meant that he wished for the system of Ground Control Approach to be used so as to ensure a clear descent path, leaving him to make a visual approach after he had broken through the lowest cloud. He was, accordingly, handed to the GCA Director until he came below cloud and had the airfield in sight, when he asked to be transferred to the Aerodrome Controller. The pilot then gave a call meaning "finals", i.e. that he was in line of approach on to the runway in a position from which a landing would be made on his then present heading. The Aerodrome Controller told him he was clear to land and gave him the surface wind.

The Aerodrome Controller sighted the aircraft when it was 4-1/2 to 5 miles from the runway and the Approach Controller at 3 to 4 miles. Both watched it approach (though neither was watching it continuously) and neither saw anything unusual until it was, they thought, about 1 mile or a little more from the end of the runway. Then both saw it take a gradual turn (one of them described it as a "shallow diving turn") to the right, which looked like an intentional manoeuvre, perhaps to get into line with the runway, but very soon the turn tightened up and the angle of the bank increased so that both these witnesses realized that something was wrong and each separately gave the crash alarm. Neither saw the actual crash because their view was obscured by buildings. The time of the crash was 1346 hours. The time between the steep banking turn and the crash was estimated at something between ten seconds and half a minute. The airspeed at the critical time is estimated at 115 to 120 knots.

There were five eyewitnesses apart from the two control officers. There was general agreement that the aircraft was approaching normally (though perhaps rather lower than usual and perhaps on a heading which would have brought it rather to the left of the runway), until it reached a point about a mile from the threshold. It then banked to the right and maintained this bank for a few seconds. One witness thought it side-slipped and looked as if it was getting into difficulties but then put on full left rudder and got on to an even keel. No other witness observed this. If there was any recovery it must have been only momentary because to other witnesses the aircraft appeared to pass straight from what might have been a controlled banked turn into a steep and uncontrolled turn. (One witness, but only one, said the engine noise increased in loudness and rose in pitch.) The ultimate angle of bank was variously estimated at from 45° to 80° and then two of the witnesses saw the starboard wing tip touch the ground. From marks afterwards found on the ground and from pieces of wreckage collected, it can be stated positively that the starboard wing tip touched the ground about half a mile from the threshold and 150 yards to the right of the extended centre line of the runway. From that point a furrow in the earth made by the starboard wing went nearly straight (at an angle of about 45° with the extended centre line) but curving very slightly to the right for a distance of about 25 yards and then, after a break of about 10 yards, for about another 35 yards. The final crash into the houses was about 85 yards from where the wing tip first touched the ground.

One witness said that when the aircraft was over a point which is rather less than a mile from the threshold and was perhaps five hundred to six hundred feet high, he could see it from directly astern and observed that the two inboard starboard flaps appeared to rise above the wing (see Figure 12). It appeared to him that the centre joint between these flaps had come adrift from the wing. One moment the flaps were normal and the next they were bent. The angle of the flaps made it appear that they had risen above the trailing edge of the wing giving "a sort of roof effect". The port flaps remained

normal. It was immediately after the movement of the starboard flaps that the aircraft first banked to the right. He looked to see if the ailerons moved but could not see any movement. There was no evidence from any eyewitness that the ailerons were operated at all after the first turning and banking movement began. The witness estimated the time interval between the bending of the flaps and the final impact with the ground at only about five or six seconds. From evidence of other witnesses the Commissioner thought this to be an underestimate and that the period was probably about twenty seconds.

As will appear later in this report, a movement of the flaps such as was described by the witness would tend to cause the aircraft to make a banked turn to the right but not to such an extent that the movement could not be easily controlled by the ailerons if they were working normally. Witnesses with experience in the control of aircraft all agreed that a competent and experienced pilot would automatically use his ailerons in such circumstances, and that this movement would come so naturally to a pilot that it is unthinkable that he would not make it. This creates the impression that for some reason the ailerons must have been incapable of movement. If this was so, then the only possible hope of getting the aircraft righted was by use of left rudder and increased power from the starboard engines. There is, as indicated above, some evidence that the rudder was put to port and that there was some increase of engine speed. If these actions were taken in the very short time available then the pilot acted with great skill and promptitude but in all probability the bank was too steep and the aircraft too near the ground for these measures to be effective.

From the point of view of this report the important flap unit is starboard flap unit No. 2. The important fitting is the aft lower fitting of that unit (see Figure 13) and the important bolt is the larger bolt through that fitting. This was a 9/16 inch diameter bolt and the smaller bolt at the same fitting was 5/16 inch. In the wreckage were found the flap unit and the main part of the aft bottom fitting with the head and part of the shank of the 9/16 inch bolt (broken off so as to leave only one thread), while the lug of the fitting was still attached to the trailing edge member by the 5/16 inch bolt. The remainder of the 9/16 inch bolt together with its nut was never found, despite diligent search. The surface of the break in the 9/16 inch bolt showed on examination an appearance which left no doubt in the mind of an expert that the bolt had been subject to fatigue; about 20% of the area appeared to have had a fatigue crack spreading slowly across it, about another 70% showed a more rapid progress of fatigue, and the final 10% had suffered a sudden tension fracture. The break of the lug from the remainder of the fitting cannot be described with particularity because fire had so affected the broken surfaces as to destroy evidence of the metallurgical character of the fracture. When found, the flap unit was completely detached from the wing but the indications were that the top fitting had broken after the lower part of the unit had been detached from the wing, and it seems probable the top fitting broke only in the course of the final break-up of the aircraft.

At this point it is possible to draw prima facie conclusions as to how this accident may have happened. The 9/16 inch bolt was badly fatigued and the ultimate breaking of it may have been the first step in the chain of causation leading immediately to the accident. If it did break, the stress on the lug and the 5/16 inch bolt holding it would be considerable, and it was the lug that broke. Alternatively, the lug may for some reason have broken first and the stress so imposed on the 9/16 inch bolt would then have been more than in its fatigued condition it could bear. In one or other of these ways the lower part of the flap unit became detached from the wing. The air pressure on the lowered flaps caused them to lift the No. 2 unit so that it pivoted about its top fitting.

Fatigue in a piece of metal is caused by numerous alternations of stress in it. It is most liable to occur at a place of high stress concentration such as a sharp re-entrant corner, e.g. the bottom of a thread in a bolt. All the main bolts supporting flap units were subject to certain alternations of stress but it had not been supposed up to the time of this accident that stresses of sufficient magnitude could occur a sufficient number of times to bring about fatigue within the period in which this happened to this particular bolt.

According to the original design the larger bolt for the lower fitting of No. 2 flap unit was a 1/2 inch bolt. With the earlier Viscounts some trouble was experienced with the flaps. G-ALWE itself had some of these flap troubles but not to an exceptional extent, and there is no reason to suppose that any extra stresses on the supports of the flap units were caused by them. However, one thing that happened in a number of Viscounts was that the chain broke in the No. 2 flap unit, and it was decided to strengthen this chain. For valid technical reasons it was considered that the chain ought to be the weakest part of the unit (because a break in the chain was less likely to have serious results than a break in the structure), and so when the chain was strengthened it was decided to strengthen various parts of the unit, including the main bolt holding the lower fitting. After calculations as exact as the nature of the problem permitted, the decision was to increase the diameter of the bolt to 9/16 inch. The calculation involved assessing the load expected to be carried by the bolt, and applying a factor of 1.5 to arrive at the "fully factored load" and then applying another factor to give a further reserve of strength; for flap attachment bolts in Viscounts this second factor was at least 1.6 but for this particular bolt it was about 2.4, that is to say the fully factored load was about 6 tons and the strength of the bolt was sufficient for a static load of about 14 tons. The name of Mod. 799 was given to the whole modification including the provision of a stronger chain and a larger bolt with the associated work.

Examination of the fitting concerned on G-ALWE after the accident revealed certain unusual features as follows:

a) the marks of the bolt heads and nuts (both the original 1/2 inch one and the later 9/16 inch one) on the fittings were uneven, i.e. were more pronounced at one side than the other, indicating that either the bolt or the hole was out of true; and, consequently, the loading on the bolt would not have been truly axial; the position of the deepest impression of the nut of the 9/16 inch bolt corresponded approximately to the fatigue origin on the bolt; (something similar and even more pronounced, was found in the corresponding position on the port wing, and, on the assumption that in each case the shaft of the 1/2 inch bolt was true to its head, it appeared in each case that the 9/16 inch hole was not concentric with the 1/2 inch hole and that the axes of the original and the new hole were not parallel);

b) the front face of the fitting had been milled down by about 0.1 inch - one effect of this being that the lug was 0.1 inch thinner than as designed;

c) because the part of the trailing edge member of the wing against which the fitting had to rest had three snap rivet heads projecting from it, three small depressions had been made in the face of the fitting (see Figure 13); but the edge of two of these depressions had fouled their rivet heads so that the face of the fitting had not been lying true against the trailing edge member.

The wings of G-ALWE (apart from the flaps) were manufactured by Saunders-Roe. As to the parts relevant to this Inquiry, Saunders-Roe manufactured the trailing edge member, the forward fitting

and the after fitting and reamed holes for the 1/2 inch bolt. The holes in the trailing edge member and the forward fitting were originally left at 7/16 inch and were reamed to 1/2 inch on final assembly. After delivery of the wing to Vickers, for some reason a replacement for the forward fitting was asked for by Vickers, and was delivered separately by Saunders-Roe. This replacement was delivered with a 7/16 inch hole which was reamed by Vickers to 1/2 inch. Because of the modification which later took place it is impossible to tell whether it was the 1/2 inch hole or its bolt which was out of true. It appears from the evidence that it is quite possible that in the course of the successive reamings some malalignment of the hole came about. However, for the purposes of this report any malalignment of the 1/2 inch hole is irrelevant unless it led to the malalignment of the 9/16 inch hole.

Mod. 799 was performed on G-ALWE by Marshalls. They reamed a 9/16 inch hole which may not have been co-axial with the original 1/2 inch hole. In the result the axis of the 9/16 inch hole was not true. How this came about remains uncertain.

The machining of the face of the aft fitting was done in Vickers' workshops. There should have been a concession note for this work but it was not possible to find one and probably none was issued. The Commissioner was assured that the work would not have been done without obtaining the oral consent of the design department and that those responsible for the design believed and still believe that the fitting was still of adequate strength with this amount of metal removed. The reason for the alteration was probably that on assembly the flaps were found to be very slightly out of alignment and that the machining was done to get them properly aligned. The only possible materiality of the matter is that the lug might not have broken if it had been of the original thickness.

It was by an oversight in the original detailed drawings that snap-head rivets and not counter-sunk rivets were indicated. Only G-ALWE and one other aircraft had been fitted with these rivets when the error was discovered. Thereafter the rivets were countersunk but on G-ALWE it was considered unnecessary to remove perfectly good rivets which were already in place and the procedure adopted was to make depressions to accommodate the rivet heads. When the 0.1 inch of metal was removed the depressions remaining in the surface of the fitting would obviously be too small and would have to be enlarged. Again this work should have been covered by a concession note but apparently was not. However, it was obviously necessary to do it. For some reason which is unexplained, two of the depressions were not exactly in the right position and instead of completely enclosing their rivet heads the edge of each of these two rested on the edge of the rivet head. This meant that the forward face of the fitting was not in close contact with the trailing edge member. Two possible consequences would be

1) that when the two bolts were tightened up the fitting would be under stress which may have caused the lug to break off. (If this stress had directly caused such a fracture it would probably have happened at once, but it is possible that a minute crack was caused which led in time to some degree of corrosion followed eventually by fracture.)

2) that when the original 1/2 inch bolt was removed for Mod. 799, the fitting still held by the 5/16 inch bolt would slightly spring away at the other end of its face (though the attachments of the fitting to the flap unit would tend to reduce any such springing) so that it would be in a slightly different position when the reaming operation was performed from

the position it would take up when the 9/16 inch bolt was inserted and the nut tightened. This, therefore, is a possible cause or contributory cause of the faulty seating of that bolt. It must, however, be remembered that the seating of the corresponding bolt on the port wing was also faulty, although the fitting was there lying snugly against the trailing edge member.

A careful experimental investigation was made by the Royal Aircraft Establishment into the question of whether faulty seating of the bolt head or the nut had any effect on the incidence of fatigue. The results established that an inclination of a few degrees may drastically reduce the fatigue life of the bolt. Unless the inclination was so small that the bolt head or nut could bed down on the fitting, the effect on fatigue life was not related to the angle of inclination. Broadly speaking, the investigation showed that a bolt accurately seated could withstand about twice the alternating load of a bolt with inclined seating, but the effect of inclined seating on fatigue life in certain ranges of alternating load was found to be of a high order. The findings may be summarized as follows: with loads up to 4 tons to the square inch both well-seated and badly-seated bolts still had an indefinitely long life; between 4 and 8 tons to the square inch, well-seated bolts still had an indefinitely long life but badly-seated bolts had a limited life; from 8 to 12 tons to the square inch both had a limited life but the life of a well-seated bolt, expressed in alternations of load, was about 50 times that of a badly-seated one. It is now clear that the malalignment of both 9/16 inch bolts in G-ALWE is an important factor to be considered in relation to the high degree of fatigue which had developed in both of them. On the other hand it cannot be said that no fatigue would have occurred if the bolts had been accurately seated; for among the 28 bolts from other Viscounts found to be cracked were at least two which had cracks to the extent of about 2% of the cross-sectional area and which showed no signs of malalignment.

Other experiments were made by RAE and Vickers to discover what deformation of the flaps would be likely to result from the failure of the connection at No. 2 unit bottom fitting and what effect on the flight of the aircraft this would have. The conclusions reached were that in all probability the top fitting held and the unit pivoted about this point until the bottom of it came away to a distance of about six inches from the trailing edge member. The distortion of the starboard flap system which resulted (involving the closing of the slot between the fore flap and the upper falsework) would introduce sufficient asymmetry to cause the roll and turn which was observed, provided no corrective action was taken by the use of the ailerons. The rolling tendency would, however, be well within the corrective power of the ailerons. Vickers made a mechanical test on a wing, simulating the conditions believed to have affected G-ALWE and obtained a certain deformation of the flaps. They then calculated the aileron angle necessary to hold the resulting roll and concluded that it was probably 2.4° or at most 3.8°. RAE made flight tests and simulator tests and concluded that the deformation might have brought about a somewhat greater loss of lift than was found by Vickers and that to cause the roll described by witnesses, flap damage equivalent to about 4° of aileron would be needed. Ailerons, if working normally, could turn through an angle many times as great as this. (Simulator tests, checked by full-scale flights showed that control by the use of rudder alone, with the ailerons locked, would have been marginal and almost certainly impossible in practice under the conditions existing at the time.) It was then considered whether the ailerons were locked in some way.

The wire controlling the locking devices of the starboard aileron passed through a fair-lead on No. 2 flap unit.

Just inboard of the unit it passed in front of a fuel pipe. Geometrically it is clear that a movement of the unit such as has been described above would tend to pull on the wire (the extent of this pull being much magnified by the proximity of the fuel pipe) and so to lock the aileron. This would cause the port aileron also to be immovable. Tests which were made indicate that while the degree of movement obviously depends on the exact position of the wire (which cannot be ascertained), it would have been possible for the ailerons to be locked in this way, assuming a position for the wire within 1/4 inch of the fuel pipe which, though unusual (as shown by examination of a number of other Viscounts), does occur in a small proportion of cases. There are several indications in the wreckage that the ailerons were in fact locked.

There was also some indication in the wreckage that the elevators were locked or partially locked and the rudder was locked. It appears that the control lever which operated all the locks was not at the time of impact in the off position but was at least a quarter of the way towards the lock position. That would probably be sufficient just to cause the locks to begin to engage. This leads to the question - did the pilot operate the locking lever and if so, why? The most probable answer is as follows: the movement of the flap unit locked the ailerons; the pilot, when the roll began, at once tried to move his ailerons and found that they were locked; in desperation he (or the co-pilot on his instructions) seized the locking lever to see if he could free the ailerons and (it being at that time in the unlocked position) pulled it towards the locked position. This probably happened at a time when the aircraft was, in fact, irretrievably out of control. The locks would not necessarily engage immediately but would do so on any control surface which reached the neutral position while the lever was being pulled. An alternative possibility is that in the break-up of the aircraft something caught the main locking wire and pulled it; but no evidence of this having happened could be found in the wreckage.

Steps following the accident

On 18 March, Vickers sent instructions to all operators, to the following effect:

1) on aircraft which had not yet reached 1 500 landings all bolts from bottom fittings of flap units should be inspected for tightness at the next check nearest to 100 flying hours; loose bolts to be tightened and re-locked;

2) on aircraft which had exceeded 1 500 but not exceeded 2 500 landings not more than 20° of flap should be used and aircraft should return to base for immediate replacement of bolts at flap units 2 and 3;

3) aircraft with over 2 500 landings should immediately return to base using not more than 20° of flap and fit new bolts on all four units.

On 19 March, Vickers sent to Viscount operators a request for return of bolts with instructions for identification. It may be mentioned that no cracks were found in bolts from any aircraft which had had less than 1 500 landings but a small crack was found in a 9/16 inch bolt from an aircraft which had had only 1 462 landings since Mod. 799. On 22 March Vickers began drawings for a modification to strengthen the support of all the flap units (Mod. D 2175). On 23 March, Vickers sent to Viscount operators directions for the inspection of fittings (because although there was no evidence of fatigue in the fittings it was known that the lug had fractured from a fitting in G-ALWE).

The modification is described as follows:

The lower part of the flap unit had reinforcing gussets and angle plates added to it. A fishplate was added on the outside

of the wing surface so that there is now an additional and redundant structure for carrying the loads. These additional parts are designed to carry the full load as if the fittings and bolts were not there. In addition the designers worked to low stresses to ensure a good fatigue life. The fishplate reduces loads in the bolts to about half their original value. It is believed that this would extend the fatigue life of the bolts at least ten times. In addition, however, the bolts are to be examined periodically and replaced after specified periods. The examination is made in the laboratory and includes a development of the magnaflux test which development provides a very delicate test for small cracks. As a further safeguard the clearance of the locking lever has been increased so that even if the unit did become detached in the same way as on G-ALWE (which is considered to be practically impossible) the ailerons would not lock. Vickers have also introduced for themselves and their sub-contractors the practice of checking by a blueing test (which is a test for accurate seating) any bolts in an aircraft that take tension loads and any bolts in holes reamed out on assembly.

No criticism was made at the Hearing of the remedial measures adopted but it was suggested on behalf of the British Airline Pilots Association that, in addition, it would be desirable that the aileron control cable should not pass through any guide on a flap unit, so that if this unit did become detached, there would be no possibility of the aileron becoming locked. The Commissioner was satisfied that the modifications made as indicated in the last paragraph were sufficient for this purpose, and there was no practical reason for altering the position of the fair-lead. However, it appeared from the evidence that there would be no difficulty in having the fair-lead on the main structure of the wing rather than on the flap unit, and it would be worthwhile to make the alteration if it would give pilots a sense of greater security.

Another submission made on behalf of the BALPA was that it would have been desirable to cancel all flights, or at least all passenger flights, of Viscounts immediately there was reason to believe that a structural fault had caused the accident, until a judgment could be formed as to where the fault lay and whether it was something peculiar to G-ALWE or not. It was accepted that from 18 March onwards all necessary precautions were taken.

Conclusions

It was concluded that this accident happened because:

a) the lug broke;

b) the 9/16 inch bolt broke because it was badly fatigued;

c) the aileron became locked when the flap unit moved away from the trailing edge member.

The Commissioner was satisfied that this was the probable order of events, though it is not certain that the lug broke before the bolt.

The breaking of the lug was probably an indirect result of the fitting having been machined down to the extent of 0.1 inch and of the fitting not having been seated close against the trailing edge member. It was unfortunate that the 0.1 inch of metal was removed. The faulty seating of the fitting was a serious defect of workmanship. This was not discovered on inspection, and it may well be that because of the absence of a concession note for the work done on the fitting, attention was not directed to checking the accuracy of the seating. All these matters concern Vickers alone and have nothing to do with Saunders Roe or with Marshalls.

The view formed about the severe fatigue of the 9/16 inch bolt is that it was the result of a number of factors. The magnitude and number of alterations of stress to be expected at the bottom attachment of Nos. 2 and 3 flap units were underestimated by the designers. This is the only way in which the significant incidence of fatigue in bolts from both these units

can be accounted for. Secondly, the Commissioner was satisfied that the method of effecting Mod. 799 after delivery made it impossible to do the work with as much precision as when the modification was made in the course of manufacture. This would explain the substantial incidence of fatigue in main bolts from bottom fittings from units so modified by each of three highly reputable organizations. Thirdly, no doubt the larger number of landings performed by G-ALWE than by nearly all other Viscounts is one reason why there were bolts in it more severely cracked than in any of the others. Additional factors which may have operated in this connection are that as this was the first machine of its type, the manufacturing difficulties would be greater than for later models and (though this cannot affect the 9/16 inch bolts) that the use of this aircraft for the specialized training of pilots may have involved some additional stress. Lastly, the Commissioner was satisfied that the faulty seating of the head and nut of this particular bolt brought about the advanced state of fatigue that was present in it. Because the corresponding bolt on the port wing was also out of alignment it was not felt that the malalignment of the bolt in question could with any confidence be attributed to the faulty seating of the fitting. It is, however, possible that the fitting sprang slightly when the bolt was removed for enlarging the hole and that this led to the hole being reamed out of true. Whether this was so or not, it is fair to say that the state of knowledge of these matters at the time when the reaming was done was not such that those responsible could have been expected to know that a small error in the alignment could lead to a great acceleration of fatigue. If this had been realized the seating could have been submitted to a test known as a "blueing test" which would have disclosed the error; the normal practice did not require such a test.

As to the locking of the ailerons, nobody could have been expected to foresee this and neither the placing of the control wire nor the provision of a fairlead attached to the unit could be called a fault in design.

In coming to a final conclusion about the cause of this accident, it was considered that the fatigue of the bolt was really the effective cause. It was this bolt that was designed to carry most of the load and, even if the lug broke first, there was nothing to show that a major structural failure would have occurred if the bolt had not been severely fatigued. It was, in fact, in such a condition that it was bound to break sooner or later, and if when it broke the lug was still attached by the smaller bolt to the trailing edge member the lug and the small bolt had imposed on them a load which (although according to the evidence they were both deemed strong enough to carry it) it was not their function to bear. The locking of the ailerons is to be regarded rather as something which made it impossible to prevent an accident than as something which caused it.

Probable Cause

The cause of the accident was the fracture, due to fatigue, of the 9/16 inch bolt holding the bottom of the No. 2 starboard flap unit.

Recommendations

It was recommended

a) that reliance on a single bolt in tension for the support of a primary structure should be avoided if possible;

b) that where such bolts are used an ample margin of strength should be allowed (having regard to the material of which the bolt is made) so as to ensure that fatigue will not develop at any time in the life of the bolt;

c) that where such bolts are used the seating of the bolt and nut should be carefully checked.

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ICAO Ref: AR/499

PHOTO COURTESY OF "DAILY EXPRESS" (MANCHESTER)

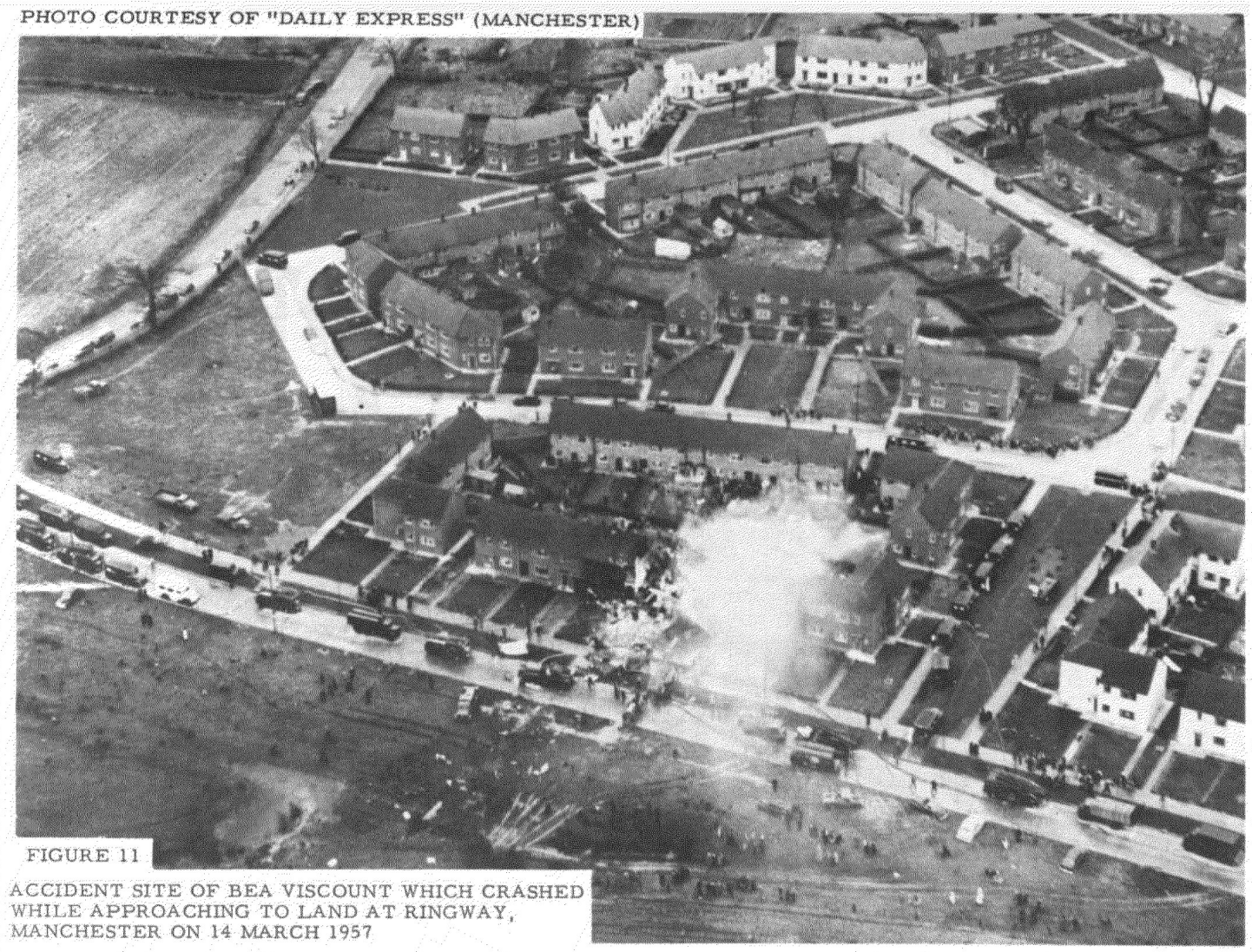

FIGURE 11

ACCIDENT SITE OF BEA VISCOUNT WHICH CRASHED WHILE APPROACHING TO LAND AT RINGWAY, MANCHESTER ON 14 MARCH 1957

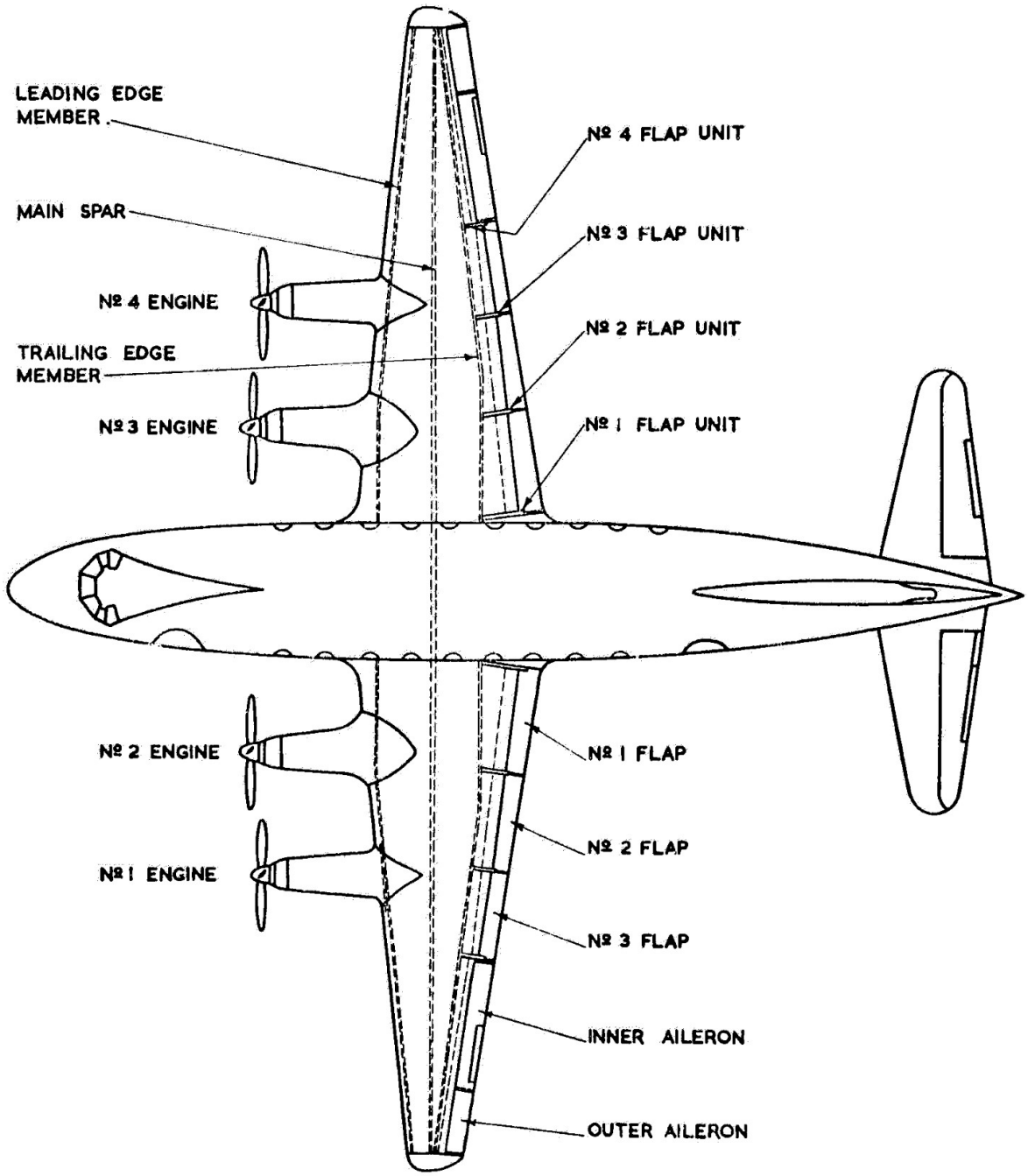

FIGURE 12

GENERAL ARRANGEMENT PLAN OF AIRCRAFT G-ALWE

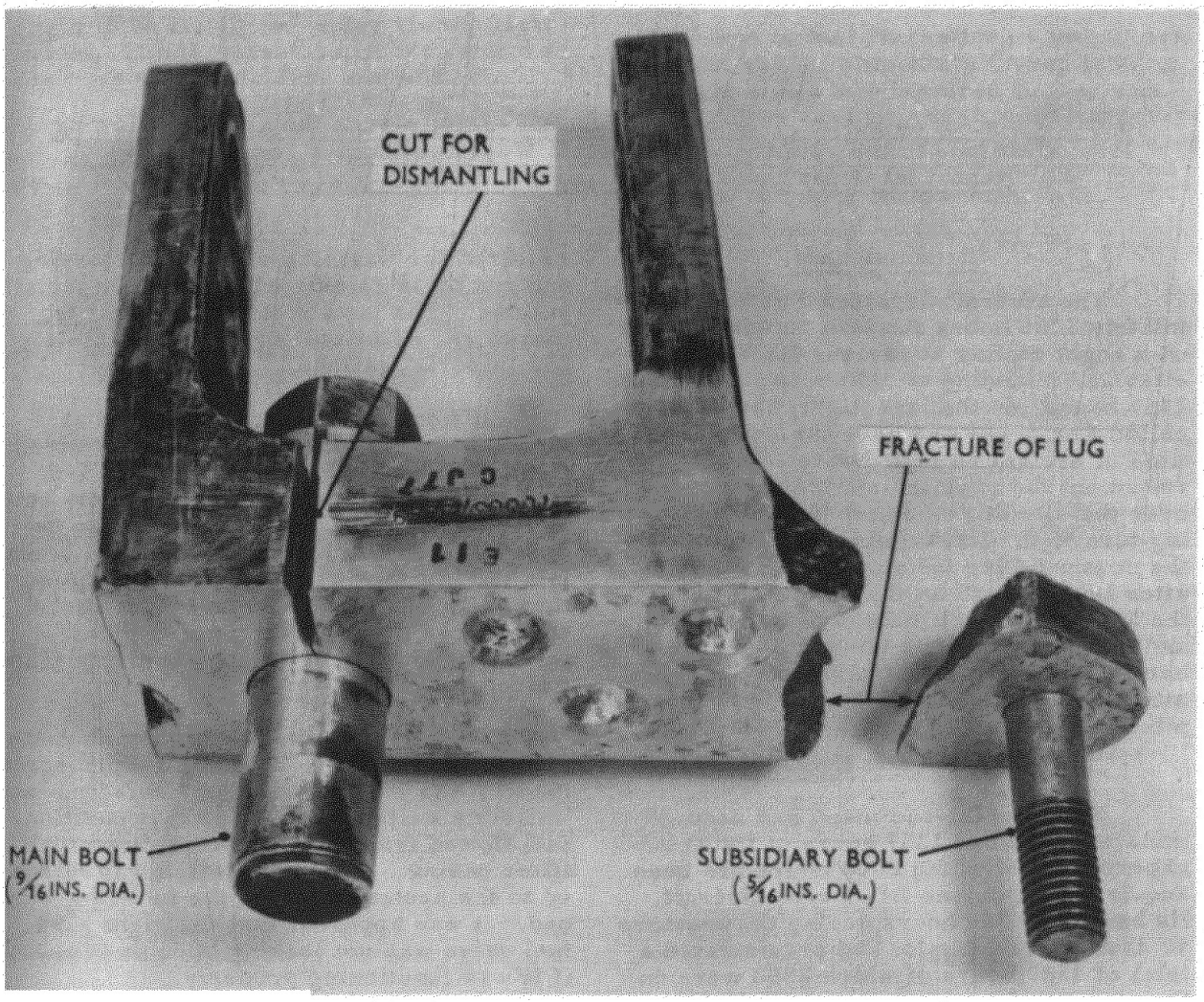

FIGURE 13

BOTTOM FITTING OF NO. 2 UNIT