DEPARTMENT OF TRANSPORT AND POWER

A.A.P. No. 4

ACCIDENT TO VISCOUNT 803 AIRCRAFT EI·AOF NEAR ASHBOURNE, Co. MEATH. ON 22nd. JUNE, 1967

REPORT ON AN INVESTIGATION
MADE UNDER REGULATION 7 OF THE
AIR NAVIGATION (INVESTIGATION OF ACCIDENTS)
REGULATIONS, 1957 (S.I. No.19 of 1957)

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DUBLIN:
PUBLISHED BY THE STATIONERY OFFICE.

To be purchased from the
GOVERNMENT PUBLICATIONS SALES OFFICE, G.P.O. ARCADE, DUBLIN 1
or through any Bookseller.

Price: Three Shillings and Sixpence.

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ACCIDENT TO VISCOUNT 803 EI-AOF NEAR ASHBOURNE, COUNTY MEATH, IRELAND ON 22 JUNE 1967

1. INVESTIGATION

1.1. Flight Details

Training flight for the purpose of conversion of Aer Lingus cadet pilots to Viscount aircraft.

Departed Dublin Airport 0644 G.M.T., 22 June 1967, with I.F.R. clearance from Air Traffic Control for training flight in the sector north-west of Dublin Airport. The pilot-instructor said his intention was to spend two hours in this sector and then to practise circuits and landings at the airport for one hour.

The aircraft climbed to its assigned flight level and obtained two revised clearances, for higher levels, from A.T.C. at 0656 and 0707 G.M.T. Its last transmission to A.T.C. was an acknowledgement of the last clearance, at 0708 G.M.T.

At 0743 G.M.T. a telephone call from Ashbourne post office informed A.T.C. that an aeroplane had crashed two miles north of Ashbourne. Immediate radio-telephone calls were made to EI-AOF, without response; and full emergency procedures were initiated. Another Viscount training flight practising circuits at the airport was despatched at 0746 G.M.T. to make a search. The pilot sighted the wreckage of EI-AOF at 0751 and information on its position was given to the airport Fire Service.

Eye-witnesses stated that EI-AOF had hit the ground in a nearly-vertical attitude after diving from comparatively level flight at a low altitude and that violent fire and several explosions followed impact. The three occupants—a training captain and two cadet pilots—were killed at impact.

Location: In a cornfield at Ballymadun:
53°31′40″ N. 06°25′30″ W.
Elevation approximately 320 feet A.M.S.L.

Time: 0735 G.M.T. (DAY).

1.2 Injuries to Persons

FATAL: 3 flight crew; no passengers or others.

1.3. Damage to Aircraft

The nose, forward parts of the fuselage, engines and wings were severely damaged by impact. Subsequent fire and explosions completed the virtual destruction of the nose and forward fuselage and affected both wings extensively.

1.4. Other Damage

Damage to corn over a small area of the field in which impact occurred.

1.5. Crew Information

1) Captain H. O'Keeffe:
   Age: 38 years.
   Licences held: A.L.T.P. number 123, first issued 7 July 1959.
   Type ratings for Chipmunk, DC.3, F.27, Viscount 808 and 803, Carvair ATL 98.
   Flying experience: total: 5,525 hours.
   Viscount: pilot-in-command: 950; co-pilot: 230; flight instructor: 31 January 1965 to 22 June 1967.

2) Cadet J. Kavanagh:
   Age: 19 years.
   Licence: British Commercial pilot licence, first issued February 1967, rated for single-engine aeroplanes (not over 12,500 lb. authorised maximum weight).
   Flying experience: total: 226 hours
   pilot-in-command: 143 hours
   under instruction: 83 hours
   Viscount: 0 hrs. 40 mins. (under instruction).

3) Cadet R. de Paor:
   Age: 20 years.
   Licence: British Commercial pilot licence, first issued March 1967, rated for single-engine aeroplanes (not over 12,500 lb. authorised maximum weight).
   Flying experience: total: 203 hours
   pilot-in-command 151 hours
   under instruction: 52 hours
   Viscount: 0 hrs. 40 mins. (under instruction).

1.6. Aircraft Information

(*a*) The aircraft EI-AOF was a Viscount type 803 which had flown a total of 17,447 hours since manufacture up to the date of the accident; 783 hours since last renewal of its Certificate of Airworthiness (which was valid up to 23 February 1968); and 227 hours since the last check requiring certification by a fully-licensed engineer (for issue of a Maintenance Release).

Records kept by Aer Lingus showed that all maintenance and inspection required by regulations and the requirements of the Department of Transport and Power had been satisfactorily carried out.

EI-AOF had been purchased by Aer Lingus from K.L.M. in 1965, starting service with Aer Lingus early in 1966 after overhaul by Scottish Aviation Ltd. It had been flown 3,064 hours by Aer Lingus.

(*b*) The aircraft weight and centre of gravity position were within limits for the flight.

(*c*) Fuel used for the flight was aviation kerosene J.P.1. Checks of the fuel installation used for re-fuelling showed that contamination of fuel is unlikely to have been a factor in the accident.

1.7. Meteorological Information

The weather situation in the area is summarised in Meteorological Service reports in appendix 2.

From these reports and from witnesses' statements it appears probable that in the whole of the area covered by the last flight of EI-AOF there was a varying but generally low cloud-base; that inland from the coast, in the particular localities in which the Viscount descended from training altitude and in which its last movements took place the visibility under the cloud-base was worsened by drizzle; and that the cloud base, especially over higher ground, was particularly low. These conditions would have made flight by visual reference extremely difficult.

1.8. Aids to Navigation

Aids available for landing at Dublin Airport were Instrument Landing System (ILS), precision approach radar (PAR), terminal area radar (TAR) and non-directional beacon (NDB). EI-AOF was equipped for use of all these aids. Aids to navigation were Automatic Direction Finder (ADF) (used in conjunction with the NDB), VHF omnidirectional range (VOR) (which was operating on "test" but radiating reliable signals) and TAR. The TAR was operating normally at the time of the accident but was withdrawn for maintenance at 0739 or 0740 G.M.T. Since its use as a navigation aid was not requested by EI-AOF, continuous attention by the radar controller to this aircraft's "echo" on the display was not demanded. However, contact with the aircraft was maintained by the radar controller by regular observation of its movements within the assigned sector from the time it reached altitude until approximately 0730 G.M.T. About this latter time it was essential to concentrate use of the radar on the separation (for air traffic control purposes) of other aircraft in the vicinity of the airport. The controller's last observation of EI-AOF, in the general direction of the position of impact, could not be related to an exact time and does not provide any significant information in relation to the accident.

Equipment in EI-AOF for use of the available navigation aids was shown by the appropriate records to have been serviceable at the commencement of flight. Investigation of this equipment after the accident indicates that the power source for it was available and operating at the time of impact. No conclusion can be made as to whether individual units were serviceable or actually being used; but there is no contrary evidence.

1.9. Communications

Radio-telephone communication equipment on the ground at Dublin Airport was not deficient in any way and the procedures used were adequate and efficient.

Investigation of remaining parts of the communication equipment after the accident indicates that it was capable of being used throughout the flight up to the time of impact. Details of air-to-ground communication which took place during the flight are given in paragraph 2.1.4. of this report.

1.10. Wreckage

Distribution of the wreckage was confined within a rectangular area 400 × 150 feet in the cornfield in which impact took place. All parts of the aircraft with the exception of metal fragments and some small components were within an area equivalent to that of the aircraft itself. Those parts outside this area are considered to have been displaced by explosion following impact.

The aircraft was found in an inverted position headed in a direction approximately opposite to that of the approach to the field. The position of the wreckage and its alignment are consistent with a nearly vertical impact in a spin.

A diagram of the scene of impact (figure III); and photographs of the wreckage layout (figure IV) and area of impact, looking back (westward) to the direction of approach (figure V) are in appendix 1.

1.11. Fire

The aircraft suffered violent but localised fire immediately after impact. This fire destroyed the nose, flight deck and centre section and affected all of both wings to a slightly lesser degree. The tail unit and extreme rear part of the fuselage were comparatively unaffected.

Fire-fighting equipment of the County Meath Fire Brigade was first to arrive at the scene of the accident. Units of the Dublin Airport Fire Service later joined in getting the fire under control. The circumstances of the accident were such that it is unlikely that damage by fire would have been lessened even if fire-fighting equipment had been close at hand.

1.12. Survival

Medical evidence shows that the occupants could not have survived the force of impact.

1.13. Tests and Research

After examination as far as was practicable at the scene of the accident, the fuselage parts were taken to Dublin Airport where further investigation, with the assistance of expert representatives of the aircraft manufacturer, was undertaken by engineers of the Department of Transport and Power.

Expert investigation was also carried out of engines, propellers, electrical and electronic units, and certain components whose operation might have had a bearing on the cause of the accident.

Reports on these items are included in appendix 3.

2.1. ANALYSIS

2.1.1. The Flight Crew

Captain O'Keeffe had been an Aer Lingus pilot since early in 1958; a captain since 1961; and a flight instructor on Viscount aircraft for about 2½ years. His record with the Company, especially as a captain, had been impressively good; assessments of his performance on flight checks (carried out periodically by training pilots in accordance with statutory requirements) had been consistently good throughout his service. He was exceptionally keen and meticulous in his approach to his job; set himself a high standard as a pilot; and was known to be demanding as an instructor. However, the opinion among pilots who had passed through his hands was that the high standard he demanded had been to their overall benefit.

Cadet Pilots Kavanagh and de Paor had joined Aer Lingus under the Cadet Training scheme in 1966 and had each spent one year at British flying schools, reaching the standard necessary to qualify for the Commercial Pilot licence. All flight training completed at these schools had been on aeroplanes which, by comparison with the Viscount, were light in weight, uncomplicated and easy to handle. School training records indicate that the standard they achieved on completion of the courses was satisfactory.

2.1.2. The Flight on 12 June 1967

Before the flight, on June 22, in which the accident occurred, the two cadets had had, on June 12, one initial flight with Captain O'Keeffe as instructor and in company with a third trainee pilot, who had considerably greater pilot experience than the cadets. For all three trainee pilots, it was their first experience under instruction in the Viscount and their first contact with the instructor. The Viscount used was not the one subsequently involved in the accident.

Cadet de Paor completed, under instruction, the exercises scheduled for the flight (listed in exercise 2 of the Conversion syllabus, appendix 4); his performance was criticised by the instructor. Cadet Kavanagh was then given instruction in the same exercises. After a demonstration of recovery from an approach to the stall by the instructor, the cadet pilot, whilst taking the appropriate recovery action, pushed the control column forward too quickly. This resulted in an unintended pitch-down of the nose and automatic feathering (stopping) of one of the four engines; it was later found that this engine had also suffered damage from over-heating resulting from the same manoeuvre. After recovery of normal flight conditions by the instructor, the aeroplane was brought back to Dublin Airport operating on three engines and a satisfactory landing was made by Cadet Kavanagh.

Captain O'Keeffe reported the incident to the Chief Flying Instructor and it was decided that the two cadets should complete a further course of instruction in the flight simulator (for which they had already been rostered) before continuing with flight training. His comments in flight training records make it certain he intended the training manoeuvres in exercise 2 to be repeated by the two cadet pilots.

2.1.3. The Flight on 22 June 1967

Evidence from air-to-ground radio communication indicates that the flight was normal from 0644 G.M.T. (take-off time) to 0708 G.M.T., at which time an amended clearance to fly between Flight Levels 100 and 150 (altitudes of 10,000 to 15,000 feet) was acknowledged by EI-AOF. During a period of probably 2 to 3 minutes after that time something happened which caused the aeroplane to descend, without requesting or getting Air Traffic Control clearance for descent, to an altitude very much lower than that for which it was cleared or at which, during any of the training exercises scheduled, the aircraft would normally operate.

EI-AOF appears to have been seen at a low altitude first at Rathdrinagh, near the Slane road about 10 miles north-west of Ashbourne and 4 miles south-east of Slane (witness No. 1). It was stated, by a twelve-year-old boy who watched it through the window of his house at about 8.10 I.S.T. (0710 G.M.T.) to be very low and loud, with undercarriage extended and engine sounding normal. It was going approximately northwards.

Very shortly after this time (between 0712 and 0714 G.M.T.) it was heard flying low in cloud in the vicinity of Collon, 9 miles north of Rathdrinagh (witnesses Nos. 2, 3, 4 and 5); and was seen by a witness (No. 2) at about 0720, flying just below a cloud-base, reliably estimated as only 200 feet above ground level. Manoeuvres at low altitude, but in cloud, appear to have continued until at least 0725 and at a time between 0727 and 0730 the aircraft was heard flying off, still very low, southward (witnesses Nos. 6, 7 and 8).

Evidence of the Viscount's movements from the area in the vicinity of Collon to the Ashbourne/Ballymadun neighbourhood is lacking, with the possible exception of the sighting of an aeroplane momentarily beneath cloud, flying south, by witness No. 9. In this case the time given is earlier than that at which EI-AOF is known to have been still near Collon and hence no certain conclusion can be made. The absence of evidence suggests that the Viscount was sufficiently under control to be climbed again at least to an altitude at which it would not arouse particular attention on the ground.

In the Ashbourne/Ballymadun area the Viscount was first seen at a time very soon after 0730 G.M.T. by two youths (Nos. 11 and 12) working at a farm in Adamstown, 2 miles north-east of the crash site. The sound of engine power going on and off erratically brought them out of their milking shed to get a number of fleeting sights of a big four-engined aeroplane flying close overhead and circling with landing gear up and some propellers stopped; flying erratically ("fluttering") and "gushing black smoke as the engines revved up." Both boys were insistent that two of the propellers were stopped, or turning very slowly; but the elder (witness No. 12, 17 years of age) said the two inner engines, whilst the other (witness No. 11 aged 15) said the two "on his right-hand side". Both said the aeroplane was flying so low that it very nearly hit roofs and telegraph poles. Statements by a road overseer (No. 30) and his companion (No. 31) appear to confirm the aircraft's movements in the Adamstown area and to indicate that a low cloud ceiling prevailed in the neighbourhood at the time. The Adamstown area is hilly, varying from 350 to 450 feet above sea level and is situated between higher points to the east and west; and it appears most probable that the pilot, whilst trying to maintain visual contact with the ground, was forced to re-enter cloud to avoid the possibility of collision with ground objects.

Three boys (witnesses Nos. 13, 14 and 15) on the road about 2 miles north of the impact site, also saw the aeroplane flying very low, some two minutes before the time of the crash, and going in and out of cloud. It was seen in a direction and at a distance identifiable with the Adamstown area and heard by one of the boys returning, this time obscured either by intervening higher ground or by its being in cloud, as if making a circuit of the area. This appears to agree with the evidence of the youths at Adamstown.

It has been assumed that the aircraft track from the vicinity of Adamstown took it south-west three or four miles, to the next point at which it was seen—on the opposite (S.W.) side of the impact site, and about 2 miles from it. Witness No. 17, working in a field between Ratoath and Ashbourne heard the loud noise of engines and saw a big four-engined aeroplane approaching very low from the north-east. It came down over the trees in the field beside him as if to land, then power was applied and it climbed away, turning right all the time and vanished behind trees to the north. He thought all propellers were turning and that the undercarriage was not extended.

From the point where the Viscount was seen by witness No. 17 there is evidence that a right-hand turn was made on to an easterly heading, approximately towards the Ballymadun area; still very low over the ground, but not at all times beneath the very low cloud base prevailing. Height over the ground in this final stage of flight cannot be established with certainty since there was probably considerable variation and the witnesses' capacity to estimate height in the circumstances is doubtful. However, witness No. 17 said the aeroplane was down to about 30 feet; witness No. 23, at Laurel Mount, about one mile from the crash site, on the final approach to it, said "it barely missed one of the high trees"; witness No. 38 (on the road beside the field in which the aircraft crashed)—"about 20 feet over me". The ground track appears to have been erratic and to have included a change in direction from E.N.E. (over the Slane road towards Laurel Mount) to S.E. just before a final turn E. at Ballymadun.

The aircraft appears to have approached Mangan's cornfield at Ballymadun from west-north-west, crossing the by-road bordering the field close overhead of Eugene Ryan's farm. (See appendix 1, figure III). Engines were throttled back, although there were probably occasional bursts of power, and she was descending. One witness (No. 38) thought the left wing was "drooping"—this was possibly left bank in an intended turn, since another witness (No. 41) on the road nearby said it was "zig-zagging". After crossing the field some 900 feet the aircraft appeared to drop down vertically in what seems from a majority of witnesses' accounts to have been an incipient spin. There was a sudden sharp roar of power which was probably coincident with this last manoeuvre; then silence until impact occurred.

The evidence of witnesses of the Viscount's final movements and of the crash, justifies a conclusion that the accident occurred at 0735 G.M.T. (Witnesses Nos. 26, 29, 31, 38 and 42).

2.1.4. Radio-Telephony contact between EI-AOF and Ground Stations

Evidence based on recordings of R/T exchanges between aircraft and air traffic control during the period of the last flight of EI-AOF and an investigation of Aer Lingus' procedures on the R/T channel used by them for service and commercial communication with their aircraft shows that communications (all with air traffic control) were normal from the time of departure (0644 G.M.T.) until 0708 G.M.T. During this period the following exchanges took place:

0646 : clearance from Tower (aerodrome control) to Centre (en route) frequency.

0646/7 : confirmation of clearance to operate at between 5,000 and 10,000 feet in "north-west sector".

0656 : change of clearance to operate between 5,000 and 12,000 feet (on request by EI-AOF).

0706/7 : request by EI-AOF for clearance to 15,000 feet; clearance given to operate between 10,000 and 15,000 feet; and routine instructions for procedure in the event of radio communication failure.

0708 : a normal brief acknowledgement of the foregoing message by EI-AOF.

After 0708 G.M.T., no further communication from EI-AOF was heard by any ground station. No call was made by any ground station to the aircraft from 0708 until 0743 G.M.T., just after A.T.C. had been informed (by telephone) that an aeroplane had crashed. It is regarded as normal procedure by A.T.C. not to initiate contact with an aircraft cleared for a training flight unless control requirements make it necessary. However, it is the normal procedure when radar is available to maintain contact by watching the progress of the flight on the radar display; and in this case the A.T.C. officer responsible for the airspace in which Viscount EI-AOF was flying states that he was watching the aircraft regularly on the display. Movements of the aircraft within that airspace would cause no concern if contained within the allotted area. Changes in altitude are however not reflected in the display and a descent from the normal flight altitude to the height at which EI-AOF is known to have been flying would not be apparent to the Radar controller.

2.1.5. The Aer Lingus pilot training arrangements

Since the accident occurred in the course of a training flight and involved two cadet pilots at an early and most important stage in training, the Company's policy and practices related to training were examined.

The main line of recruitment of pilots is and has been for the past five years through what is known as a Cadet Scheme. Under this scheme, youths are selected by open competition, after school-leaving age, on the basis of a minimum educational standard, interviews and aptitude tests. Those selected are given basic flying training up to the standard required for grant of the Commercial Pilot licence, this training being provided under contract either by the Air Corps school at Gormanston or an established and government-recognised British or United States civil pilot school. This training occupies a period of about one year, during which each pilot does at least 200 hours of flight, of which a substantial proportion is dual instruction, and receives class-room training in air navigation, meteorology and other subjects related to the profession of airline pilot. After satisfactory completion of this initial training, the cadet pilot joins the Aer Lingus training branch, receiving a class-room course of specialised instruction related to the aircraft type on which he is to be "converted"; courses using a flight simulator intended both to develop his knowledge of practical air navigation and to familiarise him with the use of cockpit equipment and instruments; and finally a flight training "conversion" course.

Planning and scheduling of Cadet courses is naturally based on the Company's requirements, related to crew replacement and expansion of operations. The necessity to plan ahead and difficulty in forecasting the extent of expansion lead at times to a demand for trained pilots in excess of the normal rate of supply. Enquiries revealed that the demand in early 1967, based on the expectation of an extremely busy peak season in the summer and autumn of that year, had led to unusual pressure being exerted on the training branch to make available as many Viscount flight crews as possible in time for the summer season. The group of cadets which completed initial training (in Scotland) and reported to Aer Lingus on 24 April 1967 were told that their training was to be completed in the minimum possible overall time. Since the two cadets involved in the accident were only at the very earliest stage of flight training when it occurred, the possibility that hasty or inadequate training can have been a factor seems to be relevant only to ground training. This possibility is therefore discussed in the succeeding paragraph.

2.1.5.1. Ground training

The syllabus of instruction, the instructors' methods and class-room time spent were examined. The syllabus and content of the courses given is subject to supervision by qualified technical officers of the Department and had satisfied them as to its adequacy. A further check on training standard is provided by the results of a difficult and searching written examination (two 3-hour papers) set and marked by the Department's Inspectors before endorsement of an aircraft type rating on a pilot's licence. Results in general of the courses including the two cadets were up to the normal standard; and the two cadets themselves achieved very good marks. It was concluded that these two cadet pilots' knowledge of the Viscount, as far as it could be derived from ground instruction, was up to the same standard as had obtained for all previous cadet courses.

Courses of instruction on flight simulators fall under three headings: an introductory course on general-purpose machine (the "Link", as already used by the Cadet during initial training); a course on the cockpit lay-out, instrumentation and emergency procedures of the Viscount; and a course on operation of the instrument flight system of the Viscount 803. The latter two courses are given on the same simulator. Cadets Kavanagh and de Paor had completed the introductory course but not the courses on the Viscount simulator, on the date (June 12) on which they were rostered for their first Viscount training flight. It was not, in fact, regarded by the Company as essential that simulator exercises should be completed before commencement of flight training. In support of this view, it was stated that experience has shown the amount of conversion flight training necessary for the average pupil was not significantly reduced by simulator training; and that giving simulator and flight training concurrently is a normal practice. However, it is considered that the completion to a satisfactory standard of a simulator course designed to secure a fixed minimum knowledge of normal and emergency procedures *before* commencement of flight training would lead to an improvement in efficiency and quality of flight training.

It appears that at the date (June 12) on which the two cadets were rostered to commence flight training, the flight instructors were under the impression that they had already been given the full simulator courses, although needing additional training to reach a satisfactory standard; whereas the simulator superintendent did not consider they had finished the courses. In view of the Company's accepted policy at the time, referred to above, the possible misunderstanding here cannot be regarded as a neglect of normal procedures. However, it does indicate absence of the liaison between simulator and flight training sections which is essential in an efficient organisation.

Since the accident, action has been taken to ensure full co-ordination between the various elements in the training organisation. Reports on pupils by the flight simulator superintendent are now given careful consideration by the chief flying instructor in conjunction with flight and simulator instructors before commencement of flight training.

Whilst the elimination of the minor deficiencies above referred to will make for an improvement in the overall safety of operation, it is considered that these deficiencies were not a factor in the particular circumstances of the accident on June 22.

2.1.5.2. Flight Training

Flying training is under the direct supervision of the chief flying instructor (C.F.I.) who is a permanently-appointed officer of the Company and who has occupied this position for some fifteen years. A number of instructors is allotted to each aircraft type in use by the Company. At the date of the accident, the Viscount flight training section consisted of a chief instructor and five others. Flying instructors are selected by the Flight Operations Manager and the C.F.I. on the basis of ability and temperament; sufficient incentive in terms of additional pay being provided to ensure competition for the posts.

Training of the selected pilots for the task of instruction has always been on an informal basis, there being no laid-down syllabus or written instructions. Uniformity of methods and standards is achieved by an induction course for each new instructor for which the chief instructor in each aircraft section is responsible; by informal but frequent meetings for discussion of syllabus items and student progress; and by progress checks on students by the chief instructor of each section. An additional check on instructional standards is provided by a system of allotting newly-trained pilots for duties with check pilots who are charged with observing and reporting on their ability and especially with bringing any deficiencies to the notice of the C.F.I.

The standard achieved is considered to be such as to ensure a high level of safety in public transport operation; and to be comparable with international standards generally obtaining. In this connection it is noted that the Company's training facilities have been availed of for many years by well-established airlines of many foreign States; and that the Company has in recent years been approved after inspection for the training of pilots employed by the British civil aviation administration.

The conversion training of a cadet pilot, whose total experience is some 200 flying hours on the comparatively simple type aircraft which suffices for qualification for the Commercial Pilot Licence, on to the Viscount involves greater difficulties and problems than that of converting an already experienced airline pilot from one type to another more advanced one. These problems have become more serious, in the period since the inception of the cadet scheme, as the basic airline aircraft has changed from F.27 to Viscount, involving an increase in weight and complexity of control and hence a widening of the gap between initial and airline flight training. One step taken to lessen this problem was the introduction of use of the Viscount flight simulator, on which every cadet is given courses totalling some 40 hours. The possibility of increasing the amount and scope of initial training and including in it training on somewhat more complex twin-engined aeroplanes has been discussed with the Department and the Air Corps, and with other contracting Schools used. So far such extended training has not been found practicable and conversion to the Viscount has been accomplished with reasonable success over the past eighteen months. There are indications, such as an increase in the average failure rate of cadet pilots on conversion courses during that period, that the Company's training policy, whilst not unsafe, is not the optimum; and it is under review with the object of devising a more regular graduation of the training programme.

As already noted above, the maintenance of adequate and uniform standards of flight instruction had relied on the informal methods and traditions built up over a long period in this particular branch of the Company under the influence of successive chief flying instructors and their colleagues. The continuing expansion of the training organisation, the consequent need for delegation of the chief instructor's responsibilities and the increasing problem of dealing with pilots of minimum experience and more complex aircraft make apparent the need for more detailed guidance in written form than has hitherto been available. Written training instructions for the Viscount appeared to be confined to somewhat sketchy syllabi for conversion training contained in Chapter 2 (section 2–7) of the Administration Manual, (part of the Company's Operations Manual), listing a series of Exercises to be completed in chronological order for each type. These syllabi are reproduced in the Conversion Course record for Cadet Pilots together with a form for recording dates and times of flights and instructors' assessments on the various exercises and are identical with those formerly used for conversion of more experienced Company pilots from one aircraft to a more advanced type. In order to amplify the material in these syllabi, the flight instructors use for reference purposes those parts of the Pilots' Technical Manual (another volume of the Operations Manual) which give detailed instructions on flight characteristics and handling, drills and emergency procedures, and operation of the various systems. Although this material is well produced and suffices for safe operation of the aircraft, it is intended for the use of pilots in the proper execution of their duties and is not considered appropriate as guidance material for instructors.

The syllabi referred to above were compared with training syllabi used by other operators, in which short notes as to methods of execution, limitations in varying circumstances and other explanatory matter which is always useful and sometimes essential, have been appended to the description of the manoeuvres listed. It was considered that the Company's operation could benefit from a review of training guidance material based on an examination of current methods in use by other operators.

A Viscount Training Manual has been produced by the Company since the accident and is now in use.

2.1.5.3. Cadet Pilot Proficiency

Enquiries during the investigation were directed towards ascertaining whether or not a cadet pilot at the earlier stage in flight conversion would be able to maintain control of a Viscount in the circumstances existing. It was concluded that even in the most favourable circumstances the average cadet would probably be working beyond the limits of his capabilities whilst flying on instruments (in cloud) if he were without guidance and psychological support of an instructor or other experienced pilot.

In relation to the proficiency of a cadet pilot on the Viscount's radio-telephony equipment, it was ascertained that the pre-flight instruction given would not enable him to use it without further instruction in flight. In fact, mastery of its use is "picked up" as flight training progresses, with assistance from the instructor. It was normal practice for Captain O'Keeffe, when instructing, to do all necessary operation of radio-telephony himself until the later stages in training—in the typical case, after about ten hours instruction. It therefore seems probable that, had a situation arisen in which Captain O'Keeffe was unable either to transmit or to tell the cadets what to do, they would be incapable, despite efforts to do so, of sending a message by radio-telephony.

Their courses in preparation for the Commercial Pilot licence had included expert instruction and plenty of practice in cross-country flight by map-reading. If either cadet had been flying a familiar aeroplane and using a suitable map in fair weather there is little doubt that he would have been capable of finding his way back to Dublin Airport from any part of the area in which the training flights took place. However, neither of them was familiar with the topography of that area since all previous flying experience (with the exception of the brief flight of June 12, from which very little local knowledge could have been gained) had taken place elsewhere. The weather prevailing on June 22 would not have allowed easy recognition of land marks even to a pilot who knew the area well; and the maps available to the pilots on this occasion were of such a scale that close-range map reading, at the low altitude necessary to remain below cloud, would have been a most difficult task. It was concluded that in the circumstances the cadet pilots, if without assistance from the instructor, would probably have been unable to find their way back to base.

The probability of the cadet pilots being able to maintain control of the Viscount in instrument flight conditions (in this case, in cloud) was also in question. Both cadet pilots had been given training in instrument flight at the Schools which had prepared them for the Commercial Pilot Licence, but not to the extent sufficient to qualify them for the grant of an instrument rating. In the case of Aer Lingus cadet pilots, the Irish licensing authority grants the Instrument rating only after the prescribed flight test had been passed on the type (in this case the Viscount) used for conversion training. Attainment of the standard necessary to pass this test requires considerable additional instrument flight training during the Aer Lingus conversion course. Both cadets had also been given the normal amount of Viscount flight simulator instruction in the period immediately prior to the accident. Whilst proficiency on a simulator (of the type used by Aer Lingus) enables the student pilot to progress faster in instrument flight training, it is recognised that it cannot be a substitute for such training in flight. It was considered that, at the very early stage reached in flight instruction, simulator training received by these cadets could not have compensated for their lack of experience on the aircraft.

It was concluded that the two cadets could not have obtained the ability in basic handling of the Viscount which is necessary for control in instrument conditions.

2.1.6. Medical Aspects

Post-mortem examination of the bodies of the flight crew was limited as a result of injuries sustained at impact.

However, there was no evidence in any of the three cases of any disease or abnormality likely to have been present before the accident or of the effects of carbon monoxide.

In view of the circumstances of the accident, elsewhere discussed, which point to incapacitation of Captain O'Keeffe before impact, attention was directed especially to possible signs of heart defects which might have permitted a sudden seizure. In this respect, whilst post-mortem examination gave no indication of abnormality, damage to the body did not allow certainty in opinion.

Captain O'Keeffe had been a pilot in the Air Corps from 1950 to 1957 and an Aer Lingus pilot from 1957 onwards. Records of the Irish Civil Pilots Medical Board were therefore available over seventeen years. No mention is made throughout these records of any physical defect or abnormality which might indicate the possibility of sudden seizure. His last medical examination by the Board was made on 26 April 1967.

Medical records on all pilots are also kept by the Aer Lingus medical officer. These records similarly give no indication of defect. The most recent medical examination was early in the month of December 1966, no defects being evident.

It was ascertained, however, that Captain O'Keeffe had been absent from duty through illness from the last week in December 1966 until early January 1967; that this illness had involved a week in a nursing home; and that he had not spoken of this illness to the State Medical Board examiner. Since the Company's requirements called for only one medical certificate from the pilot's own medical adviser, the necessity for investigation by the Aer Lingus medical officer of the reason for unfitness did not arise at the time. The illness was described by Captain O'Keeffe's doctor as a simple urinary tract infection which, although necessitating hospitalisation and tests to find a suitable antidote, cleared up rapidly and would not be in the least likely to cause sudden incapacity.

Both cadet pilots had been passed fit, for issue of the Commercial Pilot Licence, by a British Medical Board. Consequently there had been no requirement before the date of the accident for examination by the Civil Pilots Medical Board. There was no evidence that either suffered from any medical defect.

Since a possible explanation for the accident involves incapacitation of the instructor, it was established by experiment that removal of a dead or unconscious man from a pilot seat by two remaining crew members would not have been possible. It was also ascertained from the position of the bodies of the flight crew as found that the left-hand pilot seat was occupied by Captain O'Keeffe and the right-hand side by Cadet de Paor. A third flight deck seat located immediately behind the co-pilot (right-hand) seat may have been occupied at any time during the flight by the other cadet. However, it is normal practice for the second of two pilots under training to stand between and slightly behind the two front pilot seats, from which position almost all the instruments and controls can be seen, so as to benefit by instruction given to his co-pupil; and it is considered likely that this was Cadet Kavanagh's position during most of the flight. The likelihood of the instructor sustaining injury through striking his head on some object on the flight deck during an unintended manoeuvre resulting from the training exercises was also considered. It appears probable, from examination of the bodies of the flight crew and parts of the seat-belt and shoulder harness equipment, that the lap-straps but not the shoulder-harness of the pilots in the two pilot seats were fastened. It was concluded that a pilot with lap-straps fastened might sustain injury, if pitched forward suddenly, from contact with the control column, but not from any other part of the flight deck equipment. No conclusion can be made as to the possibility of such injury either from the bodies of the flight crew or from examination of the control column. Regarding use of the shoulder-harness, the Company's requirement is that pilots wear the shoulder-harness for take-off and landing.

2.1.7. Technical Evidence

2.1.7.1. Configuration

It is considered to have been established from examination of the wreckage that the Viscount, when it hit the ground, was in the "landing configuration"—i.e. the undercarriage was locked in the "down" position and wing flaps were at 40° (the normal position for final approach and landing).

2.1.7.2. Engines and Propellers

Many witnesses in the Ashbourne/Garristown area emphasised the "revving up and down" and unusual engine noises which made them think the aeroplane was in trouble; and the two youths at Adamstown (witnesses 11 and 12) were convinced that two propellers were stopped. A comprehensive and detailed examination of engines and propellers was therefore undertaken, with the full co-operation of the manufacturers (Rolls Royce and Dowty-Rotol). The investigation indicated that none of the four propellers was feathered (i.e. "stopped") at the time of impact; and that probably all engines were "lit" (i.e. that power was available on operation of the power levers). This latter indication, however, was not one which could be established with certainty owing to damage to engine components sustained as a result of the impact and subsequent fire.

2.1.7.3. Airframe

Examination of the airframe including control surfaces, flaps, undercarriage, pilot controls and hydraulic and fuel systems is reported in detail in the Airframe Assessment in appendix 3.

In relation to possible reasons for the descent of EI-AOF soon after 0708 G.M.T., the following conclusions derived from this examination were reached:

(*a*) there was no evidence of control surface malfunction; or of over-stressing in flight, of any airframe surfaces;

(*b*) no significant part of the airframe was missing;

(*c*) there was no evidence of fire in flight, all fire damage being attributable to impact;

(*d*) no evidence of explosion in flight could be found; however, damage to the flight deck and centre section sustained from the impact and subsequent fire does not permit exclusion of the possibility of a localised explosion affecting the flight deck and hence the flight crew;

(*e*) up to the time of impact, electrical power was available and both radio-telephony and radio navigation aids were capable of being used;

(*f*) there was no evidence of collision with any object before impact;

(*g*) there was no evidence of malfunction in hydraulic or fuel systems.

2.1.8. Summary of probabilities

2.1.8.1. Intention to make a forced landing

Both undercarriage and wing flaps were found to be in the landing position at the time of impact. If they had remained in this position from some abnormal occurrence at an earlier stage in the flight—for example, in the course of, or as a result of, emergency stalling procedures carried out at high altitude, and involving the use of the landing configuration—it would have to be presumed that they could not be retracted. Since inability to retract both undercarriage and flaps would involve the coincidental failure of two quite distinct aircraft systems, it appears much more probable that they were selected to the landing position during the final manoeuvres in the Ballymadun area. Eye-witness evidence as to the undercarriage position, although meagre, confirms this opinion.

2.1.8.2. Engine or Propeller trouble

There is considerable evidence from witnesses of unusual and distressing engine noises, yet engine and propeller investigation do not indicate any deficiency in these components. The technical investigation reports, however, are not considered sufficiently conclusive to eliminate the possibility that loss of power through unintended automatic feathering of propellers (leading to stopping of one or more engines) may have been a factor in the accident. Had there been engine trouble, it would be logical to presume that it occurred before the descent from the assigned altitude and was the reason for that descent. Automatic feathering (with consequent stopping of engine and propeller) could have occurred during the practising of recovery from stalls, as happened in the incident of 12 June (see 2.1.2.); through severe engine icing; or due to some malfunction in the propeller system. A malfunction would almost certainly have been apparent in subsequent examination; severe engine icing was unlikely in the meteorological conditions prevailing and, had it been likely to occur, could easily have been dealt with by correct use of the anti-icing equipment, with which the captain was thoroughly familiar and proficient. If some mishap in the course of stalling practices caused the stopping of, or even damage to, engines, the performance of the Viscount on reduced power (even with only one engine operating) is such that it is difficult to believe that an enforced descent could have been necessary without a skilled pilot such as Captain O'Keeffe being able to warn Air Traffic Control.

2.1.8.3. Airframe icing

Since at least two cases of loss of control in Viscount aircraft have been attributed to tail unit icing, serious consideration was given to this possibility in the existing circumstances. Airframe icing serious enough to cause any problem would only occur in cloud at temperatures below freezing point. Freezing level is estimated to have been between 7,000 and 8,000 feet but amounts of cloud above that level are difficult to determine, otherwise than from pilot reports. The pilot of an aircraft approaching Dublin from the east and reaching the coast a few minutes after the time of the accident, gave the cloud top level as 6,000 feet. Another pilot flying at 15,000 feet from Shannon to Dublin and reaching the Ashbourne-Dublin area about 1½ hours after the accident time, stated that he estimated cloud tops were in the region of 6,000 to 8,000 feet. Since surface weather in the Ashbourne area became worse in the period following the accident (increasing drizzle becoming steady rain), it is reasonable to infer that medium and upper cloud would increase in this same period; and hence that cloud at the time EI-AOF was climbing to his cleared altitudes did not in fact extend higher than 8,000 feet. On this assumption, ice accretion to an extent sufficient seriously to affect control is considered most improbable. Even if serious icing conditions had in fact been encountered to the extent that involuntary descent occurred, the long period during which the aircraft is known to have remained airborne (more than 20 minutes) below the freezing level makes it almost impossible to accept that icing of surfaces was a factor in the final disaster.

2.1.8.4. Inadvertent spin

There is no doubt that Captain O'Keeffe intended to repeat, on 22 June, the training exercises involved in the flight of 12 June. Of these, only the approaches to the stall might conceivably have made a spin possible; and then only if a full stall, rather than the normal approach to the stall, had been carried out. A spin in the Viscount would certainly be likely to engage the full attention of the pilot and prevent his using radio-telephony until recovery had been effected. It could also explain the extraordinary loss of height in the few minutes after 0708 G.M.T. However, several factors tend to discount its acceptance as a reason for the accident. Firstly, if a spin brought the aeroplane down to low altitude, recovery must have been achieved and the pilot (assuming Captain O'Keeffe in control) would then be able to warn A.T.C. of his predicament. Secondly, it appears very unlikely that a pilot of Captain O'Keeffe's ability, especially after his experience on the flight of 12 June, could allow the aeroplane to be put in a position which would make a spin possible. Thirdly, the aeroplane's manoeuvres during the long period between descent and impact, whilst indicating a large measure of control by the pilot, are not consistent with what was to be expected if the instructor remained in control.

2.1.8.5. Automatic Pilot malfunction

Impact damage did not allow a conclusion to be reached, derived from examination of the wreckage, on this possibility. However, if such a malfunction had caused a control problem sufficient to prevent a distress call, the apparent ability to sustain flight at low altitude for such a long period, after an enforced descent, would be very difficult to explain.

2.1.8.6. Incapacitation of Instructor

The likelihood of some occurrence in the normal course of the flight at assigned altitude which would compel descent (voluntary or involuntary) and at the same time preclude air-to-ground communication has already been discussed and the lack of evidence in support pointed out. Since it has been established that there was sustained flight at abnormally low altitude for a period of more than twenty minutes, which indicates a large measure of pilot control over aircraft manoeuvres, it is difficult to accept such an occurrence as the sole explanation for the accident.

A hypothesis which would be reasonably consistent with the ascertained facts is that the instructor pilot became incapacitated and that the cadet pilot at one of the two sets of aircraft controls found himself in consequence faced with the task of taking charge. If this occurred, either through injury or sudden illness, the cadet pilot left in control would not, especially in the extremely difficult circumstances of having a disabled man in a pilot seat beside him, be able to maintain control of the aircraft above (and possibly in) cloud. Being unable (through lack of familiarity with the aircraft's radio equipment) either to communicate with air traffic control or to use radio-navigational aids for a return to Dublin Airport, his most likely action would be to descend through cloud, fix his position by sight of the ground and so get back to base visually. In view of his very limited experience in such a large and complex aeroplane his capability would have been strained to its limits even if there had been good visibility under a cloud base allowing visual manoeuvre. However, the weather conditions over the whole area in which the descent and accident took place were so poor that visual flight would scarcely have been possible for a skilled pilot flying an aircraft with which he was thoroughly familiar. Meeting such conditions on breaking out of cloud, the cadet pilot would be likely to have to use engine power intermittently, in order to keep his speed down to a level which would allow him to manoeuvre visually and thus produce the strange engine noises which impressed so many of the witnesses. The task of trying to keep the aeroplane under control and beneath cloud whilst trying to find out where he was may have proved so much beyond him at this stage that the decision to attempt a landing was forced on him. This intention appears to be borne out by the aeroplane's movements in the final circuit when what seemed to be an overshoot from an attempt to land was made. The events immediately preceding impact are also considered to be consistent with an abandoned attempt to land in the cornfield—the approach over the road with engines throttled; a possible pull-up because the field proved too small or because the pilot became aware of the electric power lines in the field, converging with his line of approach; speed low enough to provoke a stall; and the sudden burst of power as control was being lost and the nose falling.

2.2. CONCLUSIONS

2.2.1. Findings

2.2.1.1. The aircraft descended from the altitude to which it was assigned for training flight manoeuvres about twenty-eight minutes after take-off and within a period of four minutes after its last communication with Air Traffic Control.

2.2.1.2. For reasons which cannot be determined, the aircraft entered an unintentional stall and probable spin at a low altitude from which recovery was not possible.

2.2.1.3. There is no evidence to indicate that either the descent from assigned altitude or the stall and spin were caused by any defect in the aircraft.

2.2.1.4. Low cloud-base and restricted visibility in the area in which both the descent and final impact occurred were probably a material factor.

2.2.1.5. The two cadet pilots under instruction had probably not reached a stage of proficiency in training at which they would have been able to maintain control of the aircraft, in the flight conditions existing at the time of the accident, without assistance from a more experienced Viscount pilot.

2.2.1.6. The pilot-in-command of the flight was authorised for instruction on Viscount aircraft; he had adequate experience in instruction and was competent and efficient in carrying it out.

2.2.1.7. The two cadet pilots under instruction were properly licensed as Commercial pilots. Their ground training had been completed in accordance with the Company's normal practice for cadet pilots.

2.2.1.8. The flight was undertaken in accordance with training procedures established by Aer Lingus.

2.2.1.9. The Company's training organisation showed minor deficiencies in relation to co-ordination of ground and flight training and to the provision of detailed guidance to flight instructors. There is no evidence that these deficiencies contributed to the accident.

2.2.1.10. The aircraft was in an airworthy condition at the commencement of the flight and had been properly maintained.

2.2.1.11. No communication was received from the flight crew by any ground station between 0708 G.M.T. and the time of the accident.

2.2.1.12. There was no failure or defect in ground communication equipment or procedure; nor was there evidence of failure of airborne communication equipment.

2.2.2. Probable Cause

The immediate probable cause of impact with the ground was an unintentional stall and incipient spin at a low altitude from which recovery was not possible.

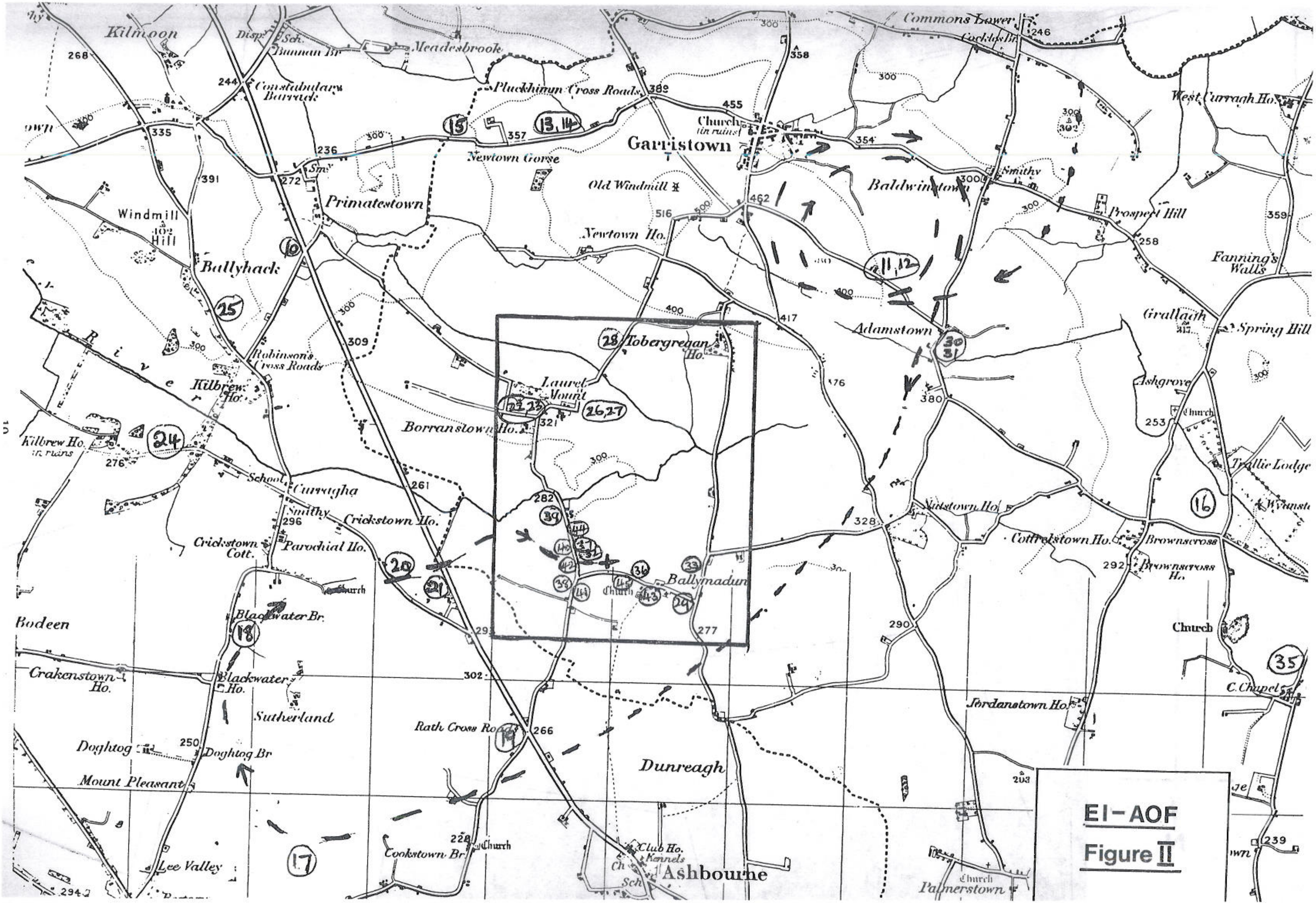
There is not enough evidence to determine the circumstances leading to the stall and incipient spin but the behaviour of the aircraft in the final stages was such as to indicate that it was not under the control of the flight instructor.

ROBERT M. REIDY,
Inspector of Accidents.
14 June, 1968.

APPENDIX 1.

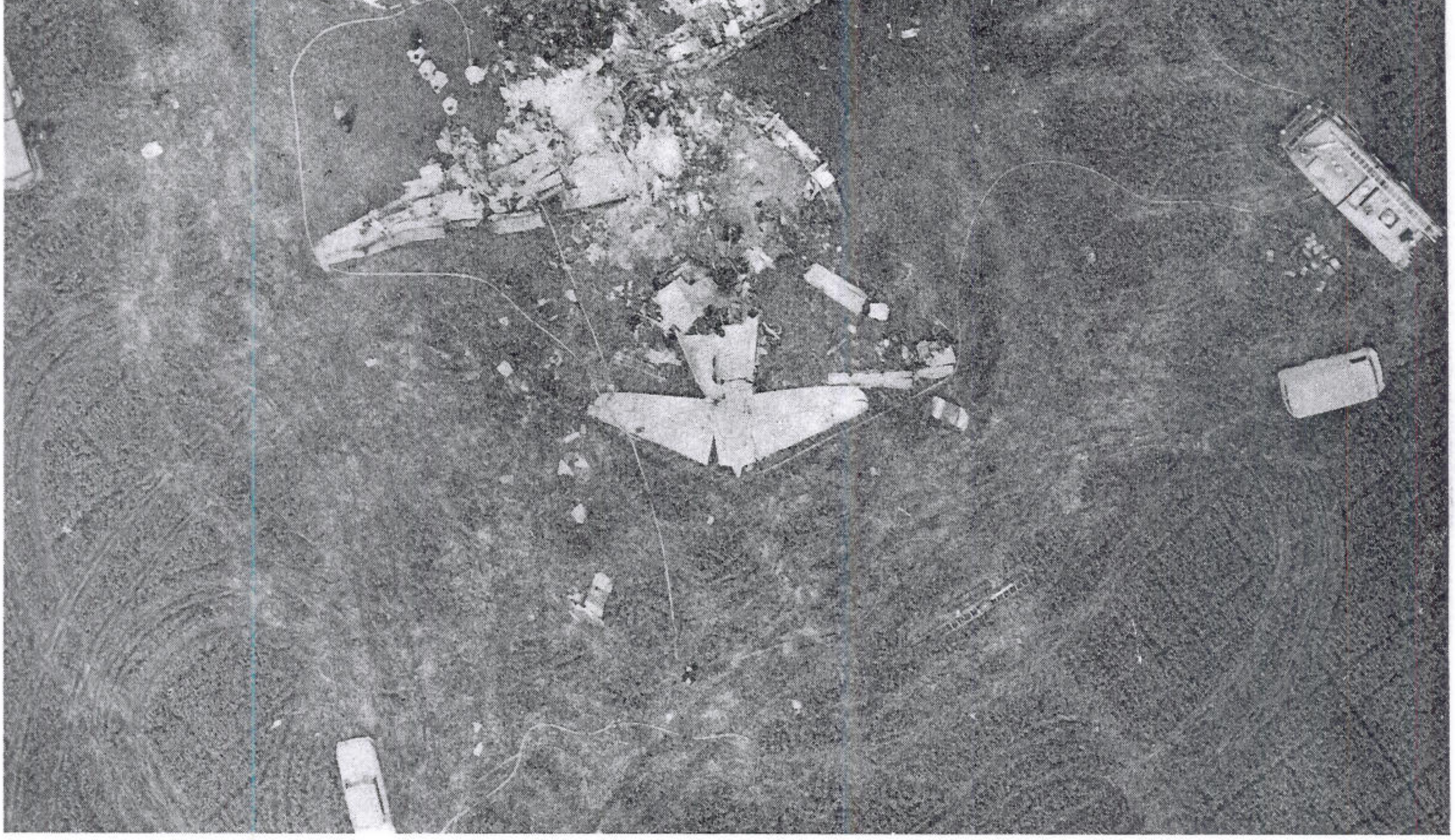
A possible flight path of EI-AOF from the first point (1), at which it appears to have been flying an abnormally low altitude up to the point of impact is shown by means of the broken line on figures I and II.

Arrows indicate the probable flight direction; numbers indicate the position of witnesses, referred to in the report.

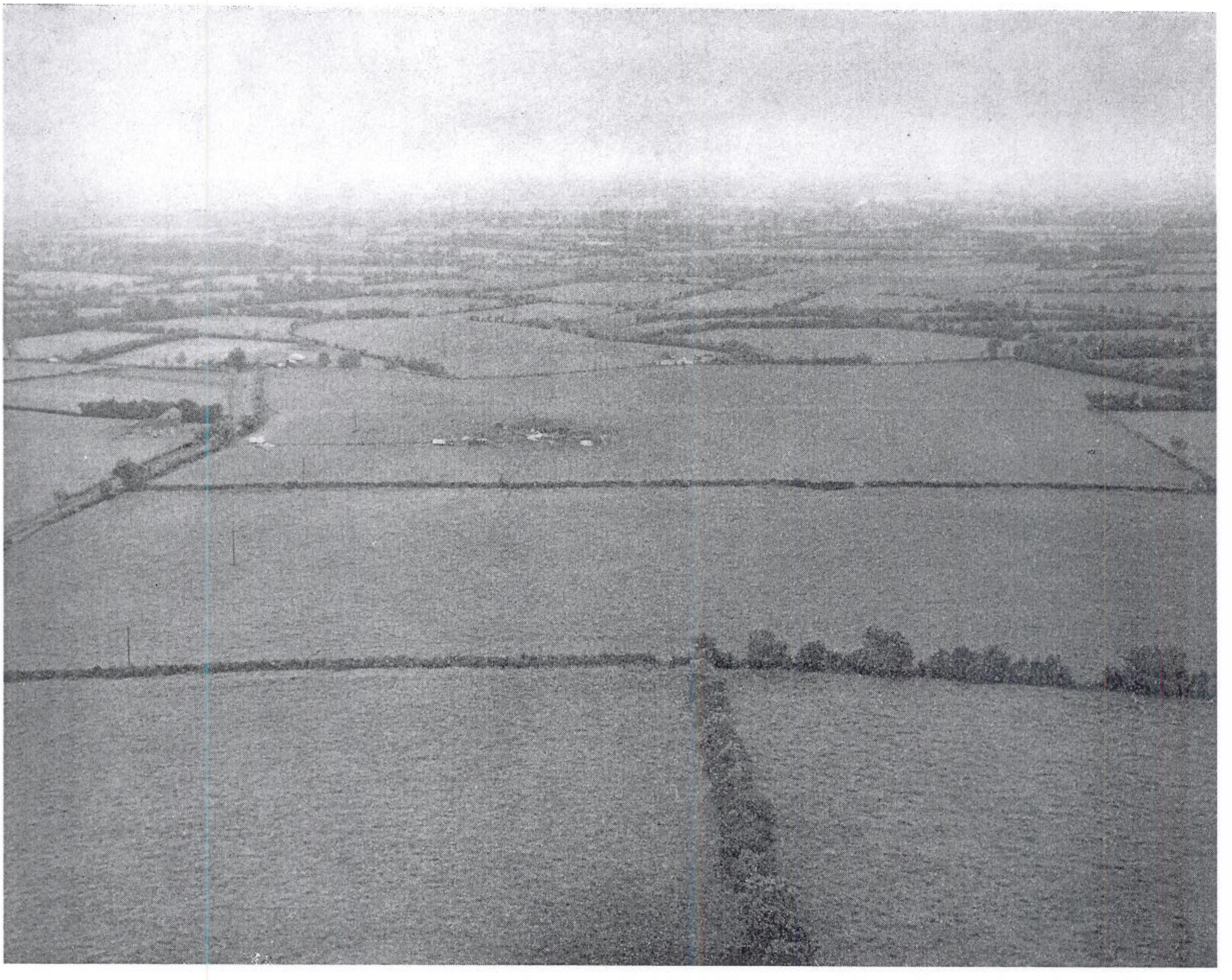


EI-AOF
Figure II
Garristown
Ashbourne
Kilmoon
Meadesbrook
Pluckhimm Cross Roads
Newtown Gorse
Primatestown
Old Windmill
Newtown Ho.
Baldwinstown
Prospect Hill
Fanning's Walls
Grallagh
Spring Hill
Adamstown
Ashgrove
Tobergregan Ho.
Laurel Mount
Borranstown Ho.
Ballymadun
Ballyhack
Windmill Hill
Robinson's Cross Roads
Kilbrew Ho.
Curragha
Crickstown Ho.
Parochial Ho.
Crickstown Cott.
Blackwater Br.
Blackwater Ho.
Bodeen
Crakenstown Ho.
Sutherland
Doghtog
Doghtog Br
Mount Pleasant
Lee Valley
Rath Cross Roads
Cookstown Br
Dunreagh
Palmerstown
Jordanstown Ho.
Cottrelstown Ho.
Brownscross
Brownscross Ho.
Trallie Lodge
West Curragh Ho.
Commons Lower
Cockles Br
Constabulary Barrack
Bunnan Br
Club Ho.
Kennels
Church
C. Chapel


N
EI AOF. SCENE OF IMPACT
O/H Power Cable.
AIRCRAFT TRACK
Eugene
Ryan's
Farm.



EI-AOF: Figure IV
Wreckage Layout

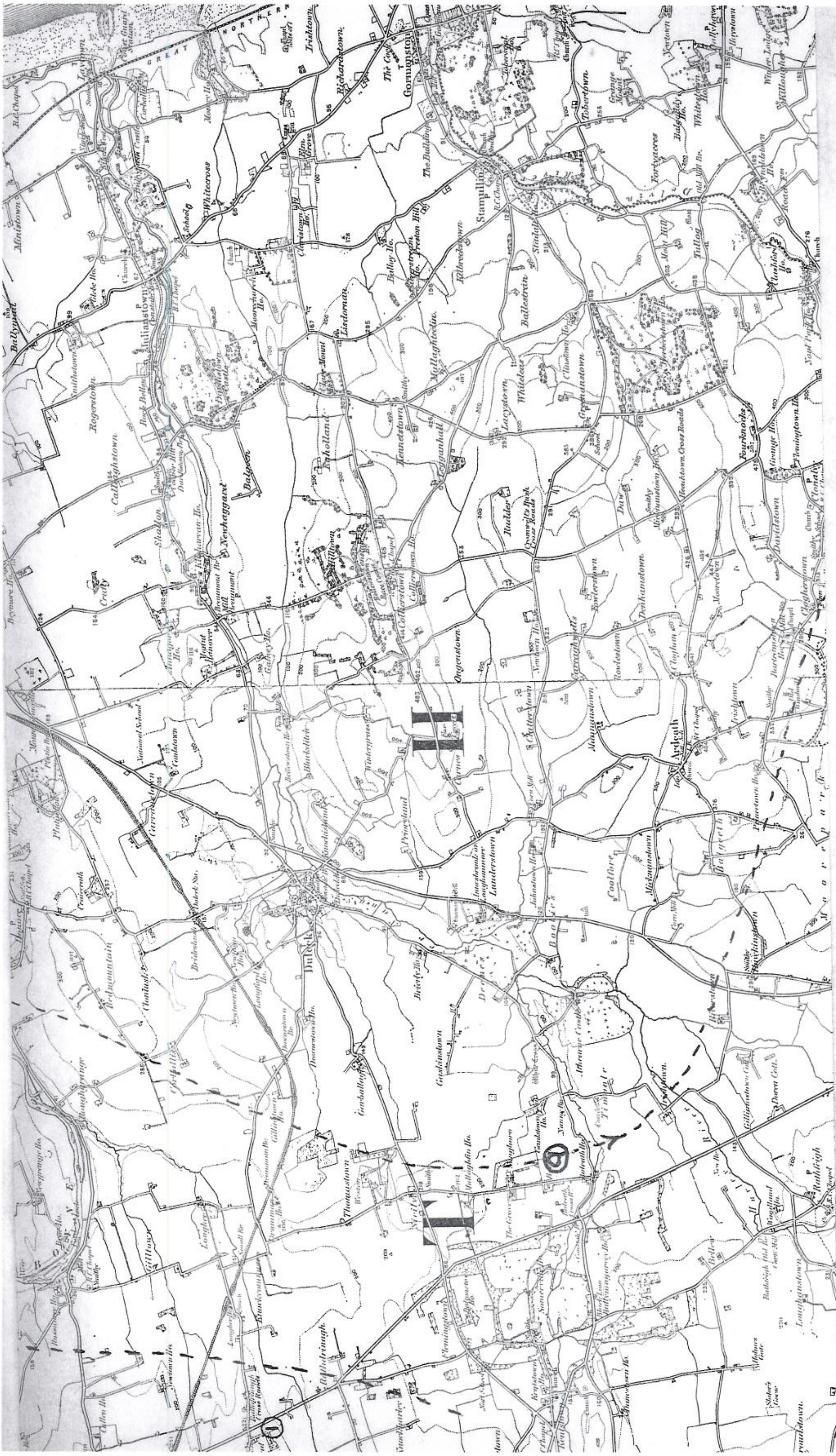


EI-AOF: Figure V
Area of impact looking west

PART A
DROGHEDA
Collon
Slane
Termonfeckin
Carrickbaggot
Castlelumny
Tullyallen
Mellifont
Monasterboice Ho.
Red Mountain
Hill of Rath
Mornington
Baltray
Donacarney
Colp
Canonstown
Belpatrick
Devlin River
Northern Railway
Red Gap
Glassallen
Broomfield
Mount Oriel
Dunmore
Oldbridge
Monknewtown
Rossin
Bryanstown
Tullyesker
Killineer
Ballymakenny

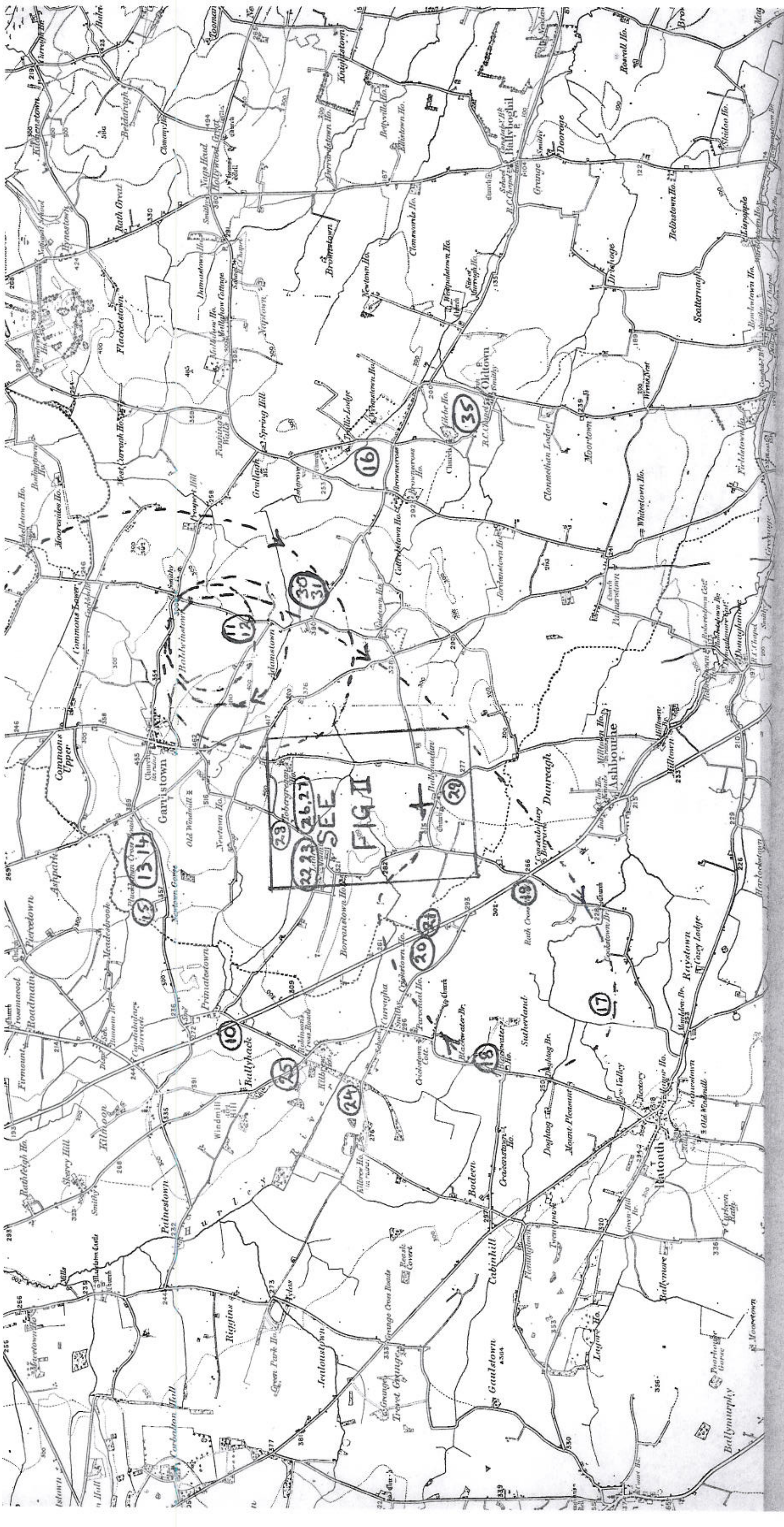
PART B

→



Gormanstown
Stamullin
Julianstown
Duleek
Ardcath
Whitecross
Clonalvy
Lisdornan
Ballestrain
Carnes
Primatestown
Fourknocks
Newhaggard
Balgeen
Dardistown Castle
Tobertown
Fortyacres
Rogerstown
Smithstown
Tullog

PART C



SEE FIG II
Garristown
Ashbourne
Oldtown
Ballyhack
Primatestown
Naptown
Flacketstown
Commons Upper
Commons Lower
Ballybwelstown
Adamstown
Dunreagh
Ratoath
Cabinhill
Gaulstown
Crazestown
Bodeen
Sutherland
Doghtog
Mount Pleasant
Raystown
Ballymurphy
Ballymore
Kilmoon
Palmerstown
Whitestown Ho.
Moortown
Spring Hill
Brownstown
Scatternagh
Belinstown Ho.
Doorage
Grange
Ballyboghil
Knightstown
Hollywood Great
Rath Great
Piercetown
Ashpark
Firmount
Rathleigh Ho.
Painestown
Riggins
Jealoustown
Borranstown Ho.
Curragha
Killegland
Rath Cross
Fieldstown
Priestown
Fanning's Walls
Gravallagh
Adamstown
Gallanstown Ho.
Cottrellstown Ho.
Brownscross
Clonmethan Lodge
Ballyboghil
Cobbinstown
10
13 14
15
16
17
18
19
20
21
22 23
23
24
25
26, 27
29
30 31
35
11 12

EI-AOF
PROBABLE FLIGHT PATH

FIGURE 1. ONE INCH TO A STATUTE MILE

PART D

APPENDIX 2.

TRANSCRIPT OF TAPE RECORDINGS OF R/T EXCHANGES, BETWEEN EI-AOF AND AIR TRAFFIC CONTROL

Frequency 118.1 Mc/s.

Time	*From*	*To*	*Text*
0634	OF	Tower	Dublin Tower this is EOF.
	Tower	OF	OF go ahead.
	OF	Tower	OF is starting up now for training and I'll be looking for the N.W. Sector operating between 50 and 100.
	Tower	OF	50 to 100 in the N.W., Roger, give us the number of souls on board, the elapsed time, and that, and endurance.
0635	OF	Tower	Roger we've got 3 on board; endurance is 4 hours, duration of detail is 3 hours, 2 hours in the N.W. and 1 in the circuit.
	Tower	OF	2 in the N.W. OK thanks.
0637	OF	Tower	Tower EOF taxi clearance.
	Tower	OF	OF make a 180 taxi down runway 30 to 17, the wind calm, QNH 1014.
	OF	Tower	014 Roger and could I have a time check.
	Tower	OF	Ah, correction to that I'll make that RW 35, I think that'll be handier, time 37.
	OF	Tower	37 Roger taxi for 35.
0638	Tower	OF	Straight ahead there for 35.
	OF	Tower	Roger.
0639	Tower	OF	OF you can move forward a bit more, QE is going for stand 7.
	Tower	OF	OF clear to line up and you are cleared to operate between flight levels 50 to 100 in the NW.
	OF	Tower	Understood cleared to operate 50 to 100 in NW and how long will the VOR be working.
	Tower	OF	Now that's a 6 mark question just; I couldn't really say; they say it's only on test; it goes off each morning. Standby I'll check.
0640	OF	Tower	The problem is once it goes off, I'll have to come back because I wouldn't be able to—I'd have no . . . (undecipherable).
	Tower	OF	I know it's possibly about half nine to ten I think.
	OF	Tower	Roger I'll keep going as long as I can any way.
0644	OF	Tower	OF is ready.
	Tower	OF	OF cleared take-off, cleared to the NW, the wind calm.
0646	Tower	OF	Away at 44 Call Centre 128.0.
	OF	Tower	Roger.

TRANSCRIPT OF TAPE RECORDINGS OF R/T EXCHANGES BETWEEN EI-AOF AND AIR TRAFFIC CONTROL

Frequency 128.0 Mc/s

Time	*From*	*To*	*Text*
0646	EOF	Centre	Centre, this is OF climbing out to the NW to operate between 5 and 10.
0647	Centre	EOF	OF Hold yours, between 5 and 10, listen out.
0655	EOF	Centre	Centre this is EOF, I wonder could you alter my clearance from 5 to 10, to 6 to 12.
	Centre	EOF	OF sorry, I missed the beginning of that, were you asking me, to operate between 6 and 12.
0656	EOF	Centre	Affirmative I'd like to go 2000 feet higher.
	Centre	EOF	Yes OK make it 5 to 12 and that's cleared to the NW area.
	EOF	Centre	Roger thank you.
0706	EOF	Centre	Centre this is EOF.
	Centre	EOF	Go ahead.
	EOF	Centre	OF, I'd like to be cleared to 150 in the NW if possible.
	Centre	EOF	Standby just a moment and I'll clear it for you.
0707	Centre	EOF	OF.
	EOF	Centre	OF.
	Centre	EOF	You're clear to operate now between FLs 100 and 150, is that OK.
	EOF	Centre	Affirmative 100 to 150.
	Centre	EOF	That's it and just . . . in case you have radio trouble. Expected Approach Time 0900 Flight Level 110 back to Rush ADF let down for Runway 17.
	EOF	Centre	EAT 0900 Rush 100 ADF let down to 17.
	Centre	EOF	Yes, make that 110 flight level.
	EOF	Centre	Flight level 110, 0900 to Rush ADF let down to Runway 17.
	Centre	EOF	That's it.
0708	EOF	Centre	Roger.
074356	Centre	EOF	EOF Dublin, how do you read.
074407	Centre	EOF	EOF Dublin.

GENERAL METEOROLOGICAL SITUATION ON THE MORNING OF 22 JUNE 1967

At 0800 GMT on 22 June, 1967, a weak warm front lay from Arklow to Limerick, moving northwards at 5 to 10 knots. West of Limerick the front was quasi-stationary.

South of the latitude of Dublin, the gradient at 2,000 feet, as deduced from the pressure field, was generally 210°/10 knots: north of that latitude it was generally 240°/12—15 knots.

During the preceding 5 hours (03—08) Dublin Airport, Birr and Mullingar reported intermittent, light precipitation (rain or drizzle, but mainly drizzle) and it is considered that similar conditions applied further north as far as the latitude of Drogheda. It would appear that the precipitation was continuous on hills to the south of this triangle and at low levels to the west of it.

The warm front passed Dublin Airport shortly after 1300 GMT.

METEOROLOGICAL DATA (*Supplied by Met. Office, Dublin Airport*)

ACTUALS 22 JUNE 1967

DUBLIN AIRPORT	*Wind*	*Vis.*	*Weather*	*Cloud*
0730 GMT	Calm	35 Km.	Drizzle	3/8 1700, 8/8 4000
0800 GMT	,,	35 Km.	,,	3/8 1000, 7/8 4000, 8/8, 10,000
0808 GMT	,,	35 Km.	,,	3/8 1000, 4/8 4000, 8/8 9,000
0824 GMT	,,	30 Km.	,,	2/8 1000, 4/8 4000, 8/8 9,000
CASEMENT				
0700 GMT	Calm	30 Km.	,,	1/8 1000, 8/8 3500
0800 GMT	270/05	20 Km.	Rain	1/8 700, 5/8 1500, 8/8 2400
MULLINGAR				
0700 GMT	280/05	11 Km.	Drizzle	3/8 500, 8/8 1100
0800 GMT	Calm	14 Km.	,,	3/8 700, 8/8 1300
GORMANSTON				
0800 GMT	200/05	45 Km.	Rain	3/8, 1200, 7/8 3500

FREEZING LEVEL (At Midnight) Aldergrove 6,500 feet Valentia 8,600 feet

CLOUD TOPS 13,000 feet (based on actual from aircraft at 0623 GMT)

APPENDIX 3

INDEX

ACCIDENT TO VISCOUNT EI—AOF ON 22 JUNE 1967—AIRFRAME ASSESSMENT

ACCIDENT TO VISCOUNT EI—AOF ON 22 JUNE 1967—AIRFRAME ASSESSMENT

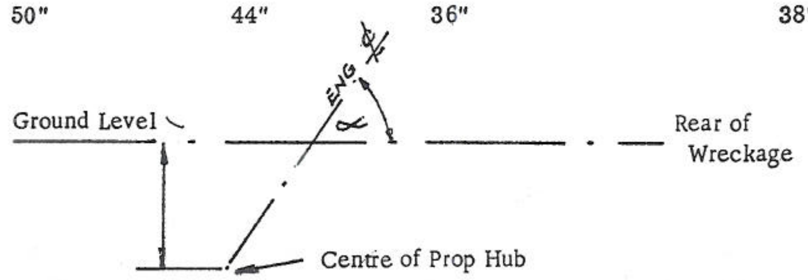
When reading these notes reference should be made to the aerial photographs taken soon after the crash.

SECTION I.—INTRODUCTION

The aerial photographs show clearly the general disposition of the wreckage. There were no marks in the vicinity of the crash or any evidence to suggest prior impact with the ground or any obstacle. The initial impact area is confined to within the outline of the aircraft as shown in the photographs and no skidding took place after impact.

The aircraft was found in the inverted position with the four engines angled into the ground. The angles and depths from left to right looking down on the wreckage were:

	1	2	3	4
Angle (α)	60°	50°	25° to 30°	30°
Depth (d)	50"	44"	36"	38"



The fin, rudder, and rudder tab were compressed sufficiently in a vertical direction to permit the outer area of the tailplanes to impact the ground. Fire damage was extensive particularly in the fuselage and port wing. The only portions of the airframe escaping were the rear fuselage, empennage, and the outer portions of the wing. It was estimated that the fuel on board at the time of the crash was about 1,100 gallons. Due to a slight slope on the ground (right side down) loose fuel would tend to gravitate to the right thus helping to explain the severity of the fire damage in the fuselage and port wing. Parts of the lower fuselage structure, port engine nacelles, bag tanks, and wing skinning were scattered up to a distance of 65 yards from the wreck generally in a forward and aft direction. The scattering of this debris was caused by explosions occurring in the port wing and fuselage. These may or may not have occurred simultaneously.

Examination of the airframe did not reveal any evidence of in-flight fire damage. The wings, flaps, ailerons, tail-plane, elevators, fin, rudder, and all tabs were accounted for at the wreckage site. Major structural failure in flight causing complete breakaway of any of the above components may therefore be ruled out immediately.

The wreckage was studied in detail in an attempt to establish if there was any partial failure or malfunctioning which may have caused or contributed to the accident. The results of this study are included in the following notes.

SECTION 2.—ASSESSMENT OF THE ATTITUDE AND MOTION OF THE AIRCRAFT AT TIME OF IMPACT.

Before beginning the study of the airframe it would seem appropriate to make some assessment of the attitude and motion of the aircraft at the time of impact.

Attitude of the Aircraft at initial impact.

The engines pierced the ground at angles varying from 60° to 30° as illustrated in Section 1 of this report. The damage to the canopy skin was symmetrical about the Centre Line and the damage to the nose undercarriage indicated very high inertia forces close to the nose.

These three facts suggest that the nose fuselage struck the ground first at some 20° or 30° over the vertical and that the impact was central on the fuselage with the wings presumably equally disposed relative to the ground.

Motion of the Aircraft at the time of Impact.

It is assumed that we are *looking down on the wreckage towards the nose.*

1. **Fore and aft Velocity small.**

There were no signs of any appreciable fore and aft movement after initial impact.

2. **Vertical velocity not very large.**

The depth the engines pierced the ground and the general impact damage is consistent with the Aircraft having descended a few hundred feet out of control rather than a few thousand.

3. **Small sideways velocity to the right.**

The position of the engines relative to the wing suggest that the Aircraft had some sideways velocity to the right.

4. **Yawing left wing forward.**

The position of the tail and the fact that the engines on the left of the wreckage were well driven back, suggests that the aircraft was yawing left wing forward.

5. **Rolling right wing down.**

The right tail plane was more severely damaged by ground impact than the left one and the right wing and engines suggested some slap in effect. Rolling right wing down would explain this.

6. **Pitching velocity was probably tail down.**

It is difficult to make any assessment of this since the nose fuselage impact loads would impart a high tail down pitch onto the aircraft and this alone might be high enough to explain the fin crushing.

SECTION 3.—WINGS

The wings were severely damaged by impact loads, fire and explosion. The stb'd wing components were located in approximately the correct spanwise position but the port wing was disrupted by an explosion occurring in the fuel tanks. This separated the structure spanwise just aft of the main spar, blowing the rear portion completely over and rearwards, displacing flaps, most of the ailerons and undercarriage and scattering bits of tank, nacelle and wing structure over a wide area.

Wing leading edges, leading edge member, top and bottom wing skins and ribs generally constructed of light alloy sheet were in a multiplicity of pieces all severely damaged by fire. No attempt was made to piece these items together since it was considered that no useful or relevant information could be obtained by doing so. The main spar and the trailing edge member including flap beams and aileron hinge supports were reconstructed as far as possible and the damage studied.

MAIN SPAR. (Ref. Fig. No. 2)

The main spar tip to tip was found in the correct spanwise position in the wreckage, thus eliminating any possibility of complete in-flight failure. Detailed examination of the fractures and general distortion revealed no evidence of fatigue or anything to suggest unusual in-flight wing distortion or overload condition prior to impact.

The wing root fractures and distortion illustrated were probably caused by rolling impact loads on fuselage and port wing.

Trailing edge member including flap beams and Aileron hinge Supports. (Ref. Fig. No. 3)

All the flap beam joints at the trailing edge member with the exception of No. 1 port side upper were intact with flap beams and portions of the trailing edge member and interspar formers still attached. No. 1 Port side upper is in compression under flight loads and the tear-away type of failure was caused by the crash. There was no evidence of pre-crash damage to the trailing edge member, flap beams, or aileron hinge supports.

SECTION 4.—ASSESSMENT OF DAMAGE TO FLAP SYSTEM

Flap gearbox setting established by B.A.C. was 40°.

FLAPS (Ref. Figs. No. 4 and 5)

On the port side the structure aft of the main spar in the region of the flaps was blown completely over and rearwards. Flaps section No. 1 stayed with the trailing edge structure but flaps sections 2 and 3 were blown clear, the No. 2 section to near the tail and the No. 3 section to mid-way between the wing and the tail. The Port flaps were all damaged at the ends and in some cases the end ribs were broken almost completely away. The No. 3 flap section was badly damaged and twisted at both ends.

The No. 1 flap section on the stb'd side was almost completely destroyed by fire, only the end ribs were left and these were attached to the chain assembly. Flap sections 2 and 3 had broken from their mountings and were lying to the rear of the wing structure. The impact damage to the stb'd flaps was less severe than that noted on the port side.

There was no overall bowing of the flap surfaces or any evidence to suggest that they had been subjected to abnormal flight loads prior to impact. The higher slap in forces on the port wing and the disruption by explosion afterwards probably explains the greater flap damage on the port side.

FLAP DRIVE SYSTEM (Ref. Figs. 4, 5, and 6)

The damage to the torque tubes, radius rods, drive shafts, chains and sliders and markings on the guide rails are recorded in detail in Figs. 4, 5 and 6. It is now proposed to discuss this damage. It is assumed that the flap setting was 40° and reference should be made to Section 2 of this report.

The important crash loadings on the flap system are estimated to be:—

(1) Inertia forces essentially in a forward direction giving compression loads in radius rods and tending to move the slider in a forward direction, and to force it against the top edge of the chain slider guide rail. The chains would also be loaded imparting torsional loads to the torque tube.

(2) The pitch over. A large pitching couple would be imparted to the aircraft after nose impact tending to pitch the aircraft tail down looking down on the wreckage. This pitching term would be translated to the flaps by forces in the radius rods and pressures between the bottom edge of the chain slider guide rail and the drive shaft and slider.

(3) Actual ground impact loads.

(4) Explosive forces, confined to the port wing.

The torque tube damage is quite similar on both wings and is consistent with having been caused by the above loadings in particular loadings (1) and (3). The torsion failures between flap beams 3 and 4 on both sides were almost certainly caused by unequal forward movement of the flap under loading No. 1 (i.e. inner ends moving in more rapidly than the outer).

The location of the markings discovered on the top edge of the chain slider guide rails provide definite proof that the flaps on both sides did in fact move forward initially under loading (1), probably by breaking the torque tube joints in the fuselage. The rolling and yawing of the aircraft would make the behaviour of both different, but the following sequence of events is suggested by the marking on the chain slider guide rails:

> Forward inertia forces at initial impact forced the sliders forward on both sides, the drive shafts marking the top edges of some of the chain slider guide rails.
>
> On the stb'd side the pitch over caused the damage to the bottom edge of the guide rails. The light markings on the top edge corresponded approximately with the damage to the lower edge, and both were at the slider position. This would indicate that no movement of the drive system took place after the initial forward movement.

On the port side the sliders were all found in the over-travel position with the exception of No. 4 which was forward of the $28\frac{1}{2}$° mark. The centrifugal forces arising from the pitch over, the explosive forces or a combination of both would tend to move the sliders aft and cause the damage to the slider guide rails. The fact that the stb'd sliders and the No. 4 slider on the port side did not move suggests that the explosive forces accelerated the flaps rearwards.

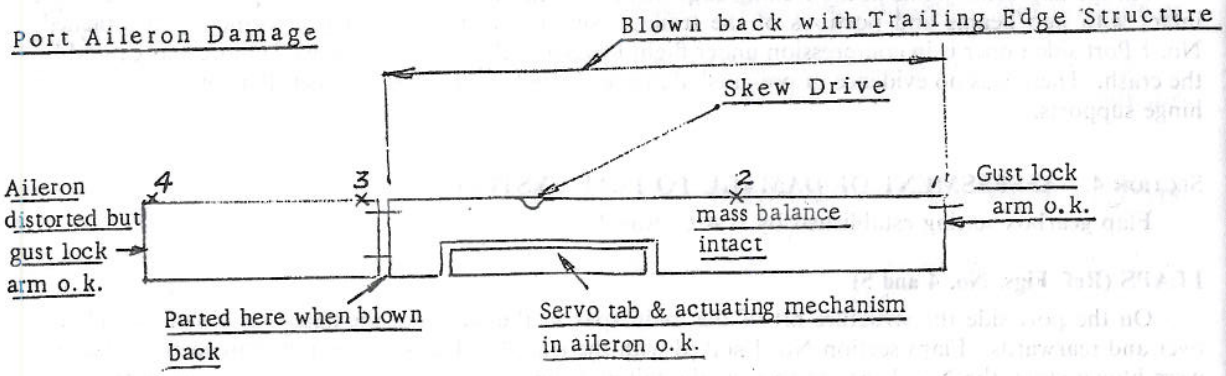
The damage to the radius rods was caused mainly by loadings (1) and (2) and the remaining damage is readily attributable to the crash.

Comments

A flap angle of 40° was established from the gearbox setting and examination of the wreckage did not reveal anything to contradict this.

There was no sign of fatigue failure, overload, or any sign of a malfunction having occurred in flight and the damage was readily explained as having been caused by the crash.

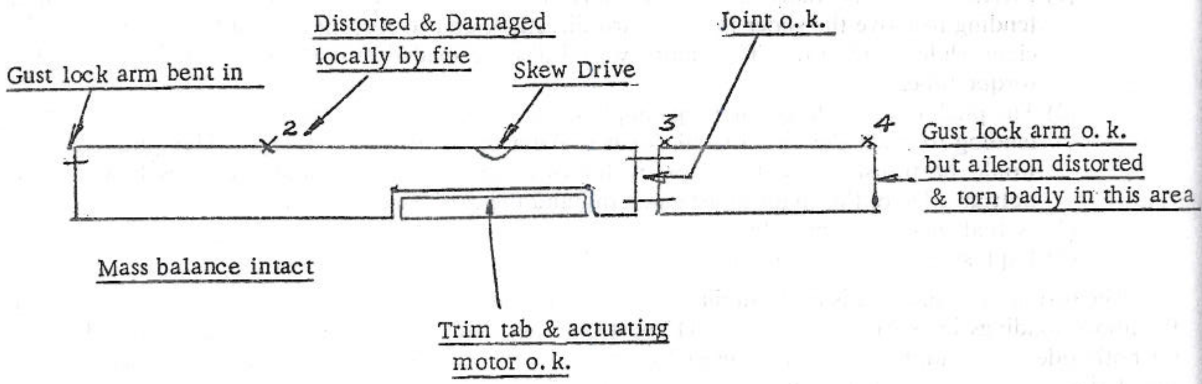
Port Aileron Damage



The aileron was slightly damaged by fire on lower surface, it was attached at all hinge points except No. 1 where the spigot had pulled out of the flap beam. The hinge structure was damaged and the aileron was distorted and cracked at hinge points 2, 3, and 4 and at the skew drive. The skew drive was still attached to the aileron and loosely attached to the trailing edge member which had broken at this point. There were impact marks on the top false work made by the forward part of the aileron.

The gust lock arms on the aileron were o.k. although the surrounding structure was damaged at the outbound end. The lock units and levers were all accounted for, and the surrounding structure at both ends was damaged. The inner assembly was loosely in position but the outer had fallen away, the locking lever was broken and the piston rod in locking unit was bent and forced towards the locked position.

Starboard Aileron Damage



Fire damage was generally slight, the aileron was attached at all hinge points except No. 1 where the spigot had pulled out of flap beam. The hinge structure was damaged and the aileron was distorted and cracked at hinge points 2, 3, and 4 and at the skew drive. The skew drive was attached to the aileron and to a small portion of the trailing edge member which was burnt in this area. The top false work had been lightly marked by the forward part of the aileron. The damage to the aileron gust lock arms is noted in the sketch. The lock units and levers were accounted for. The lock units were still attached to the locking levers but the supporting structure was damaged at both ends. The outboard assembly had broken from its mountings and the piston and actuating lever were found out of position and damaged.

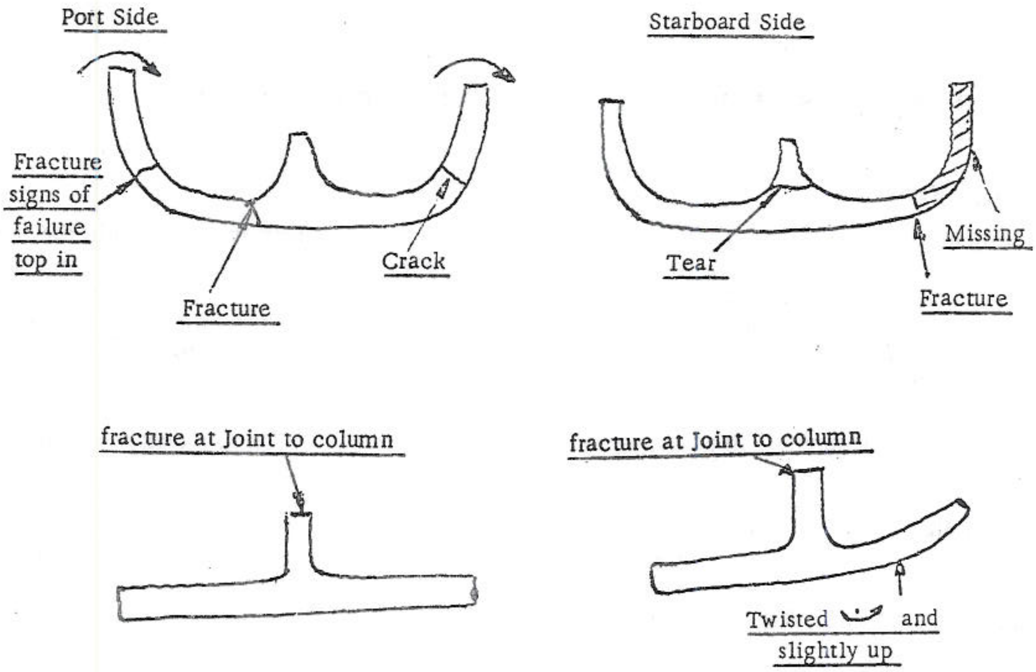
The stb'd aileron had been forced hard forward into the trailing edge structure.

Aileron Control Run

The aileron control run in the wings was broken and bent in numerous places and almost completely destroyed by fire inboard of the No. 2 flap beams on each side. The rods were pulled out of position between flap beams No. 2 and 3 on both sides and damaged by fire in this area on the starboard side. Outboard No. 3 flap beam the rods were in position but damaged by fire on the starboard side. Bearings and guide rollers were generally in position except where the trailing edge member was destroyed by fire.

Stops were in position and undamaged on both sides and control rod positions indicated that the rod on the port side had travelled outwards to $1\frac{3}{8}''$ of stop and that the rod on the starboard side had travelled inwards to $1\frac{1}{4}''$ of stop. Converted to aileron angle this gives approximately starboard aileron $\frac{1}{2}$ down, port aileron $\frac{1}{2}$ up.

The aileron control run in the fuselage was almost completely destroyed; only small portions were found. The aileron interconnecting chains were broken in several places and the chain wheel was badly damaged. Both hand wheels were broken off control column and damaged as shown below.



Comments

The trim tab was found in the neutral position and this was confirmed by the position of the motor and transmitter adjacent to motor. It is difficult to say what reliance can be placed on the aileron angle obtained from the control rod position relative to the stops. If the rod did not move after impact then obviously it gives the aileron angle prior to impact; it was not possible to establish if this was the case. There was no evidence to suggest any pre-crash damage to the ailerons or control run or that the gust locks had been forced on by fouling of the control cable.

SECTION 6.—FUSELAGE STRUCTURE

Brief Damage Report

The fuselage was fractured at the rear entry doors. The structure aft of the fracture including fin, tailplanes etc. was undamaged by fire and complete and although skewed slightly to the left looking down on the wreckage was the correct distance from the wings. The skin was torn longitudinally and circumferentially and the structure was damaged by fin impact loads. The rear entry doors were thrown clear to the left and right of the wreckage but the galley and rear freight door were still in position. Examination of the fracture indicated tension on the lower fuselage structure and tearing with signs of compression on the upper fuselage structure.

The structure from the rear doors to the nose was completely gutted by fire and portions of the lower fuselage structure were scattered over a wide area, presumably as a result of an explosion which occurred in the fuselage after impact. The seats made from magnesium alloy were all destroyed by fire.

The nose fuselage took the initial impact; it was not imbedded into the ground but the outline of the wreckage indicated that the fuselage structure forward of the wings had been compressed to near half its original length.

The fuselage structure forward of the rear doors was broken in numerous pieces and these were generally badly distorted and burnt. Some of the catenary floor beams were recovered and examined to study the disruption of the nose undercarriage. The canopy skin and windscreen surround were located in a large piece. The canopy skin was flattened and buckled in a rather uniform and symmetrical manner suggesting that the fuselage impacted centrally. The windscreen structure was completely flattened and the direct vision windows were found to be in the closed position.

Comments

Witness evidence has established that the aircraft was flying some 20 minutes at low altitude; pressure cabin failure is thus eliminated as a contributory cause. At major checks recently the fuselage was cleared from the corrosion point of view and indeed the portions of fuselage structure undamaged by fire showed no signs of corrosion.

The fuselage structure is not suspect as a contributory cause and no attempt was made to piece the structure together; indeed this would be very difficult if not impossible. The fracture at the rear doors and general tearing on the aft structure was most certainly caused by inertia and impact loads and to some extent by explosive forces.

Section 7.—TAILPLANES, ELEVATORS, TABS, AND CONTROL CIRCUIT

Brief Damage Report

High forward inertia forces at initial impact forced both tailplanes forward crushing in the fuselage frame at the front pick up points and impacting the inner ends of the tailplanes onto the stiff fin-post frame and also separating the elevators from the torque tubes. The root damage on both tailplanes and elevators was caused by these forward loads and they were more severe on the starboard assembly. The outer areas of the tailplanes and elevators were damaged by ground impact, this being heavier on the port side. The tailplanes were attached at front and rear pick-ups and the main spar in the fuselage was undamaged and in position. The elevator and tabs were attached at all hinge points.

The torque tube assembly, tab actuating mechanisms and the control run to a distance 8′ forward of the fuselage break were in position. Some levers and rods were broken but all components were accounted for up to this point. The trim cable system was complete up to the fuselage break, but was broken aft of the pressure bulkhead. The gust locks were in the off position and the cable was broken forward in the fuselage. The remainder of the control run up to the control column was almost completely destroyed and no attempt was made to piece it together. The elevator trim mechanism was removed from the pedestal and sent to B.A.C. Weybridge but they were unable to obtain a positive trim setting.

Comments

There was no evidence to suggest that the tailplanes or elevators had been subjected to unusually high loads prior to impact or that there was any failure or malfunction in the control circuit which may have contributed to the accident. It was impossible to establish the in-flight elevator angle prior to impact.

Section 8.—FIN, RUDDER, TAB AND CONTROL CIRCUIT

Damage

The fin, rudder, and tab were compressed vertically into a fraction of their original length. The forward inertia loads on the assembly at initial impact compressed and cracked the rear pressure bulkhead at the forward fin attachment point. Impact loads broke the forward attachment, fractured the fin post about 18″ from the base and forced in and twisted aft the fuselage pick-up frame.

The fin structure, rudder tab, fittings, control mechanisms including trim although damaged were all accounted for up to the fuselage break at the rear doors and the tab and rudder were loosely attached at all hinge points. The torque tube assembly was attached to the base of the rudder but had been forced into the fuselage and was extensively damaged. The control run from the rudder to a distance of about 12′ forward of the fuselage break although broken and damaged was loosely in position. The remainder was almost completely destroyed; only small portions were found. The structure around the gust lock was compressed and distorted; however the gust lock was in position and off and the operating cable was broken in the region of the fuselage break.

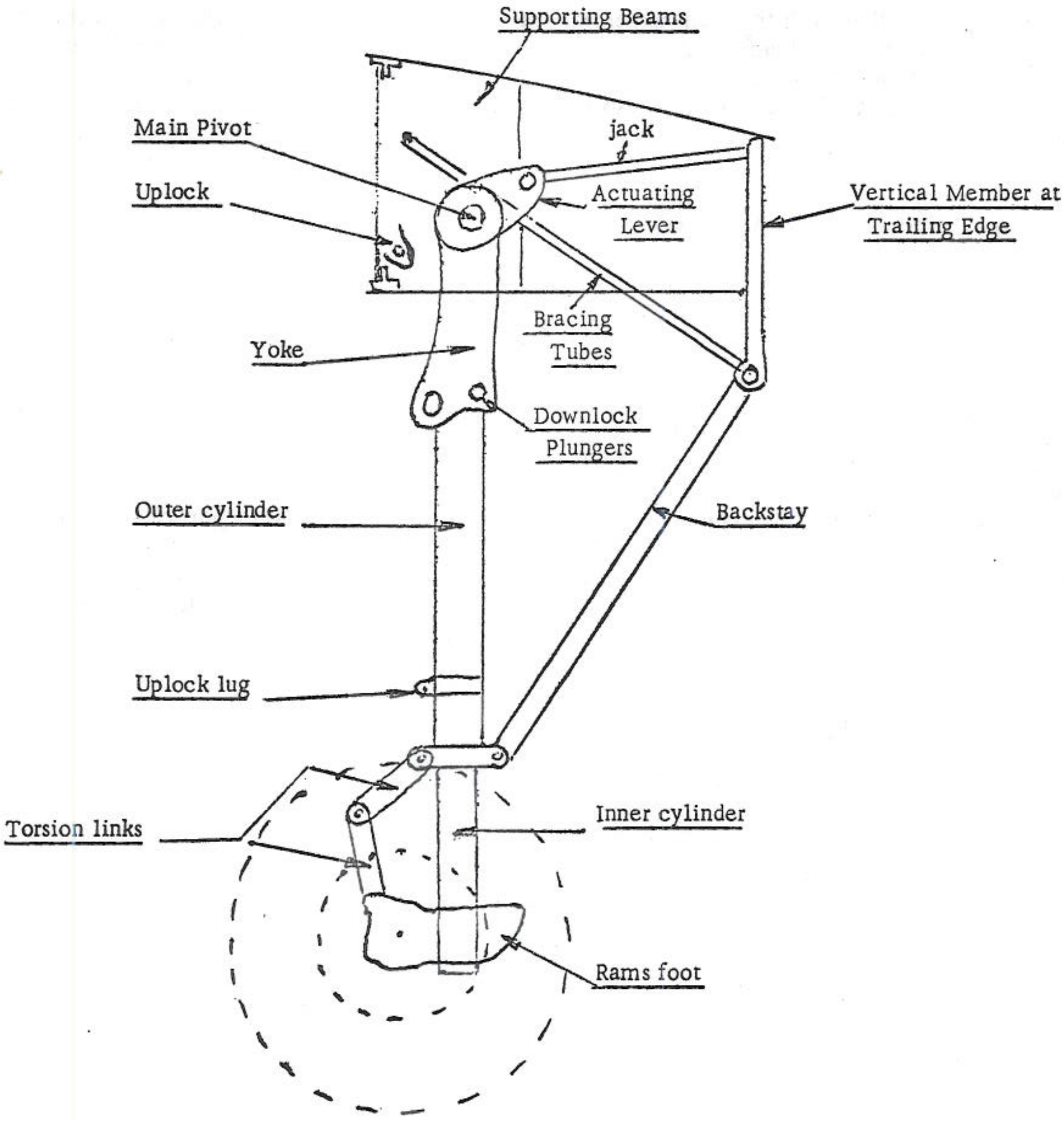
The starboard rudder pedal unit was damaged but still attached to a portion of the floor. The lower portion of both rudder pedals and the brake pedals were broken away and the lever under the floor was broken and burnt. The left rudder pedal had been forced hard forward and down, damaging attachments. The upper portion of the right pedal was broken away from arm but attached to the brake piston.

The port rudder pedal unit was more severely damaged; the brake pedals, rudder pedals and linkage had all broken away; the right bar was bent slightly forward and the lever under the floor was attached but broken and burnt.

Comments

The induced pitching after nose impact contributed to the high crushing loads on the fin. The structure and controls were examined as far as possible but there was no evidence to suggest any malfunction or failure which may have contributed to the accident. It was impossible to establish the rudder angle prior to impact but the rudder trim mechanism in the pedestal was examined and found to be close to the neutral position.

Main Undercarriage.



Damage to Port Main Unit

The undercarriage was found lying aft and slightly in and the oleo was complete, fully extended, and still attached to yoke with the downlock plungers engaged and the jack fully compressed. Fire damage was extensive at the lower end, the rams foot was completely burnt, the axle and brake units were badly damaged, the wheels and tyres were almost completely destroyed and the torque links were broken clear at the bottom.

The main pivot supporting beams, jack, vertical member at trailing edge backstay, and bracing tubes had broken away with the undercarriage. The bracing tubes were both bent and the main pivot support beams were damaged; the outboard beam was dislodged from the yoke assembly. The joints were all intact with the exception of the inner bracing tube top attachment and the backstay lower attachment. The lower half of the backstay was destroyed by fire. The uplock was recovered and the jaws were open.

Damage to Starboard Main Unit

The application of heat to the oleo leg boosted the air pressure in the shock absorber and blew out the retaining gland nut projecting the inner cylinder complete with the axle, wheels, brakes, and rams foot to a position near the rear fuselage. The tyres were partially destroyed by fire and the lower torque link was broken at the lower end.

The outer cylinder, yoke and the remainder of the aircraft support structure was located in the wreckage and the assembly had fallen forward after the vertical member had separated from the trailing edge which was badly burnt in the area. The outer cylinder was attached to yoke, the jack was fully compressed and still attached at the aft end and to the actuating lever which had been pushed forward to the downlock withdrawn position. The downlock plungers were withdrawn and the outer cylinder had moved forward relative to the yoke and away from the locked down position.

The supporting beams were still attached to the main spar but had been forced forward and damaged. The backstay and end attachments, and the bracing tube end attachments were intact but the bracing tubes were slightly bowed. The uplock was in position with the jaws open.

Comments

It is considered that both the main undercarriage units were locked down prior to impact and that the inertia forces and impact loads by changing the geometry tripped the downlock on the starboard unit.

The starboard unit did not collapse on impact but stayed upright at least until the inner cylinder was ejected. It is probable that the port unit also remained upright until heat and explosion disrupted the structure.

SECTION 10.—NOSE UNDERCARRIAGE

Damage

The nose undercarriage was thrown viciously forward and slightly to the right, looking down on the wreckage, tearing out the downlock in an aft and left direction. The torque links were broken by contacting the catenary floor beam where the forward end of the wheel pad brakes picks up. The steel strap and lower portion of the floor beam where the pad dampers are was distorted by impact of the nose wheels. These marks were right of the aircraft looking down on the wreckage. One inboard wheel rim was found completely undamaged by fire and was badly flattened at one point, all the remainder of the wheels, tyres and rims were destroyed; only some tyre reinforcing wires were found.

The support structure at the main pivot was complete on the port side with a portion of the bulkhead and the uplock surround still attached. It was badly distorted sideways in an outboard direction. Only one member was in position on the starboard side and the down lock beam was badly damaged and broken in numerous pieces. The oleo assembly and steering mechanism was complete with the exception of the torque links.

Comments

Being close to the initial impact point the inertia forces were very high and the downlock damage is a good indication that at time of impact the nose undercarriage was fully locked down. There was no evidence of previous impact prior to the crash.

SECTION 11.—PILOTS' CONTROL PEDESTAL

Damage

The control pedestal was severely damaged by impact and fire. The assembly had been moved during initial rescue operations but the levers, controls, etc., had not been disturbed.

The throttle levers were approximately ¼ way towards open position and were in alignment; the quadrant, however, was bent sharply downwards at the rear. The high pressure cock levers were in the closed position, all four having suffered fire damage. The landing gear selector lever showed a gear down selection. The parking brake levers were to the off position and the anti skid system was selected on. The top of the gust lock lever was broken off, the remaining portion of the lever being in the stowed position i.e. locks off. The flap selector lever was broken about mid-point, the stub of the lever was approximately 3″ from rear of locating gate, indicating a flap lever selection of between 20° and 40°.

The complete rudder trim mechanism was removed from the pedestal and a trim setting of approximately ½ unit aircraft nose left was established. The elevator trim hand wheels and trim indicators were extensively damaged particularly on the left hand side of pedestal. On the right hand side the trim indicator showed 1½ units aircraft nose down trim. The trim mechanism was removed from the pedestal and sent to B.A.C. Weybridge, but they were unable to obtain a positive trim setting. The emergency flap selector switch was in neutral position.

Comment

The positions of the throttle levers and the high pressure cock levers will be discussed in conjunction with the engine.

The flap lever must have been displaced on impact since a 40° flap angle was established from the gearbox setting.

The position of the gust lock lever and landing gear selector is as expected from the airframe analysis.

The rudder trim was close to the neutral position.

SECTION 12.—HYDRAULIC SYSTEM

Damage

The landing gear selector valve and electrical actuator were recovered and both were found selected to the gear down position. Otherwise the hydraulic system components and plumbing were destroyed or severely damaged by fire and no attempt was made to investigate the system.

Comment

The main hydraulic system is used to operate undercarriage, nose wheel steering, and brakes. It does not operate any item essential to the control of the aeroplane in flight and is thus not suspected as having any bearing on the accident.

SECTION 13.—FUEL SYSTEM

Damage

The fuel system bladder tanks and plumbing were destroyed by fire. The system control valves were, however, recovered and were positioned as follows:

L.P. Cock	– 4 off	– Open
Inter Engine Cock	– 2 off	– Open
Cross Feed Cock	– 1 off	– Closed
Power Drain Valve	– 1 off	– Closed.

Comments

All control valves were in the normal cruise position. During take-off and landing, inter engine cocks would normally be closed. Nothing else could be gained from the general fuel system but there was no evidence of inflight fire and the fuel supply local to the engines will be discussed in conjunction with the engines.

SECTION 14.—ELECTRICAL SYSTEM

Generators and other electrical components were so badly damaged by fire after impact that no conclusion could be reached as to their condition just before the accident. However, it was concluded from examination of the invertors, the communications equipment and the fuel booster pumps that both A.C. and D.C. power was available on the aircraft at the time of impact.

Prepared by J. McStay and M. Maxwell

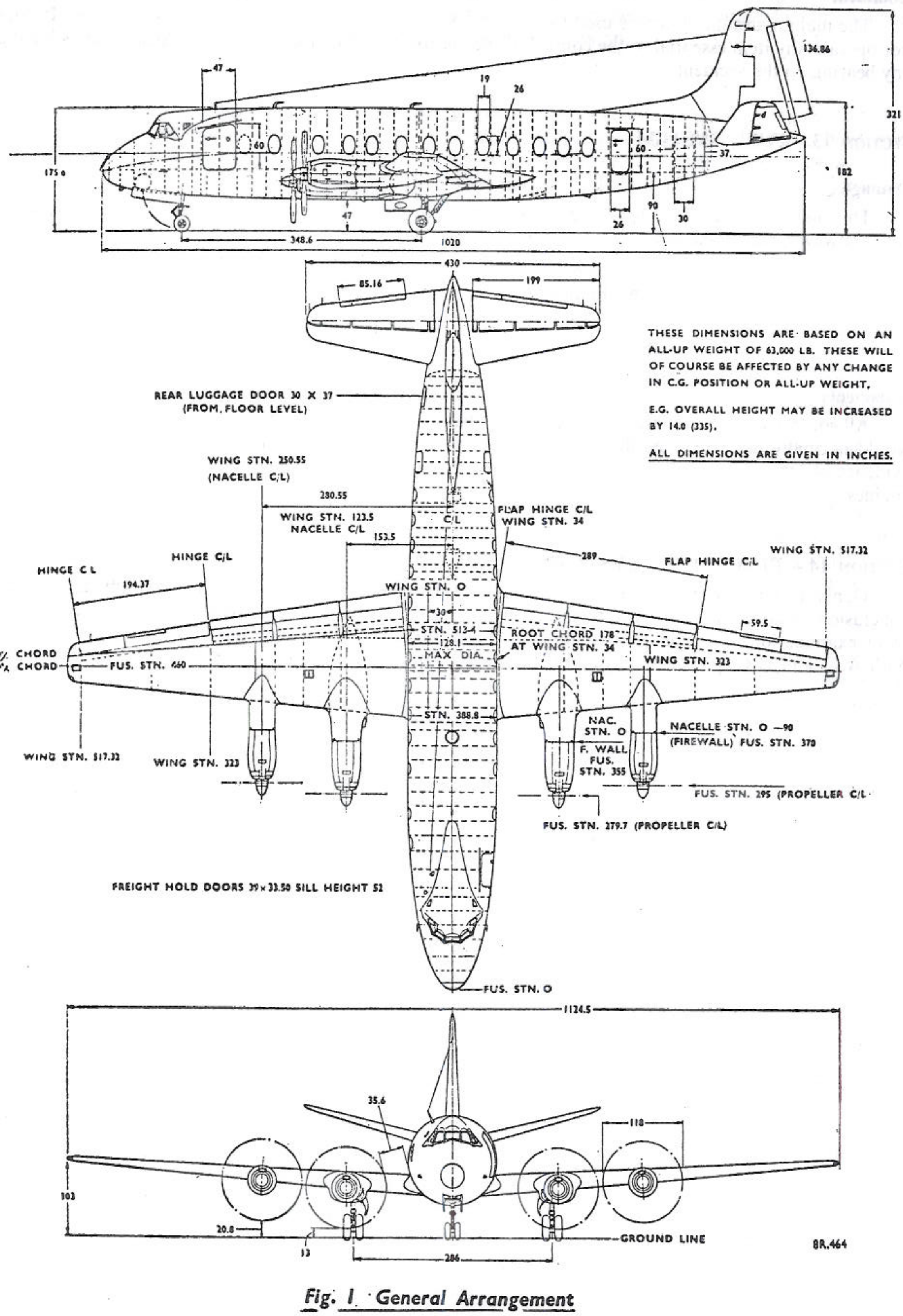


Fig. 1 General Arrangement

1

ΛAIN SPAR. View looking forward onto aft face [Wing top side up.]

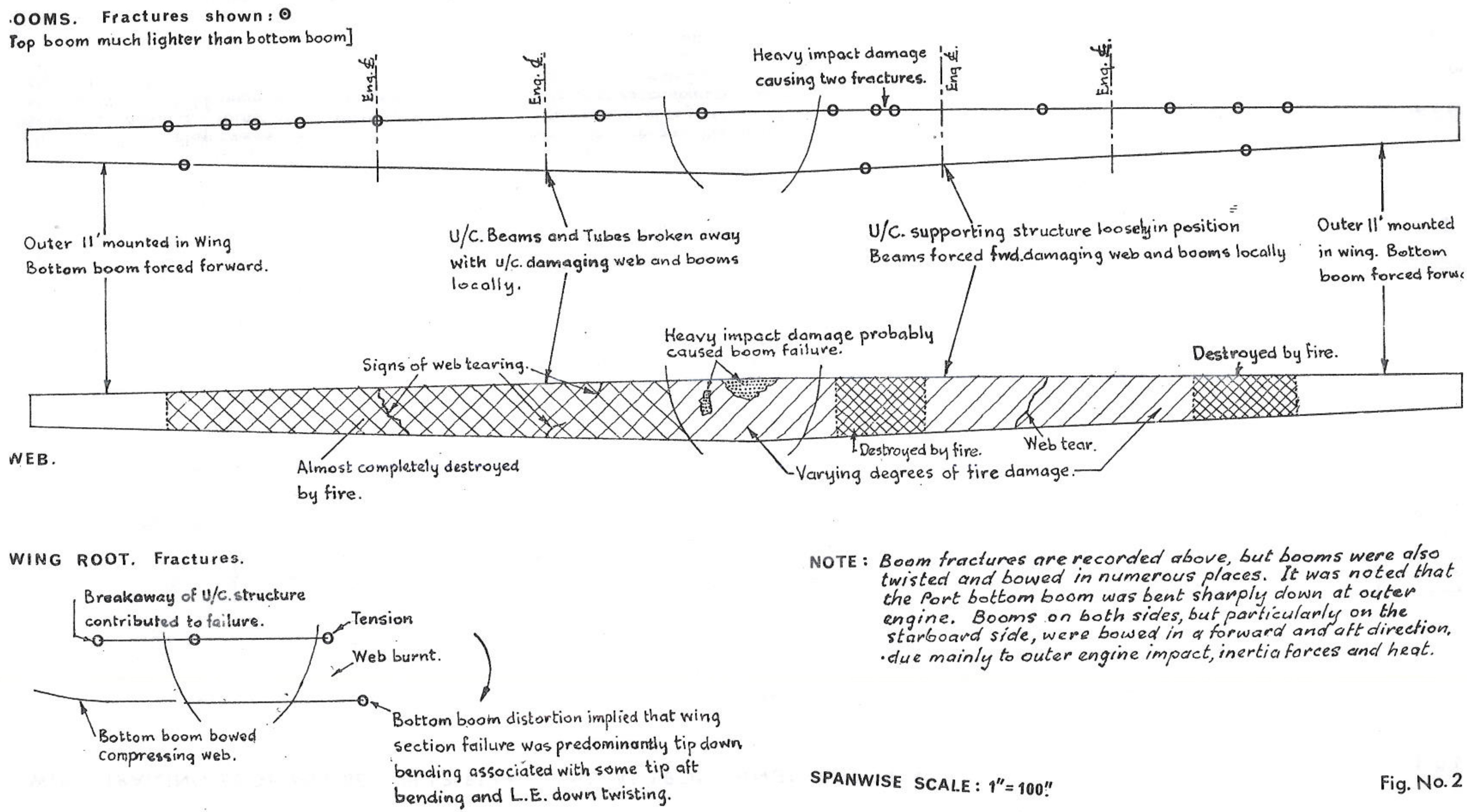


Fig. No. 2

WING TRAILING EDGE MEMBER · FLAP BEAMS AND AILERON HINGE SUPPORTS.

Areas destroyed by fire shown: [cross-hatched] **Remainder suffered varying degrees of damage [· more extensive on starboard side.]**

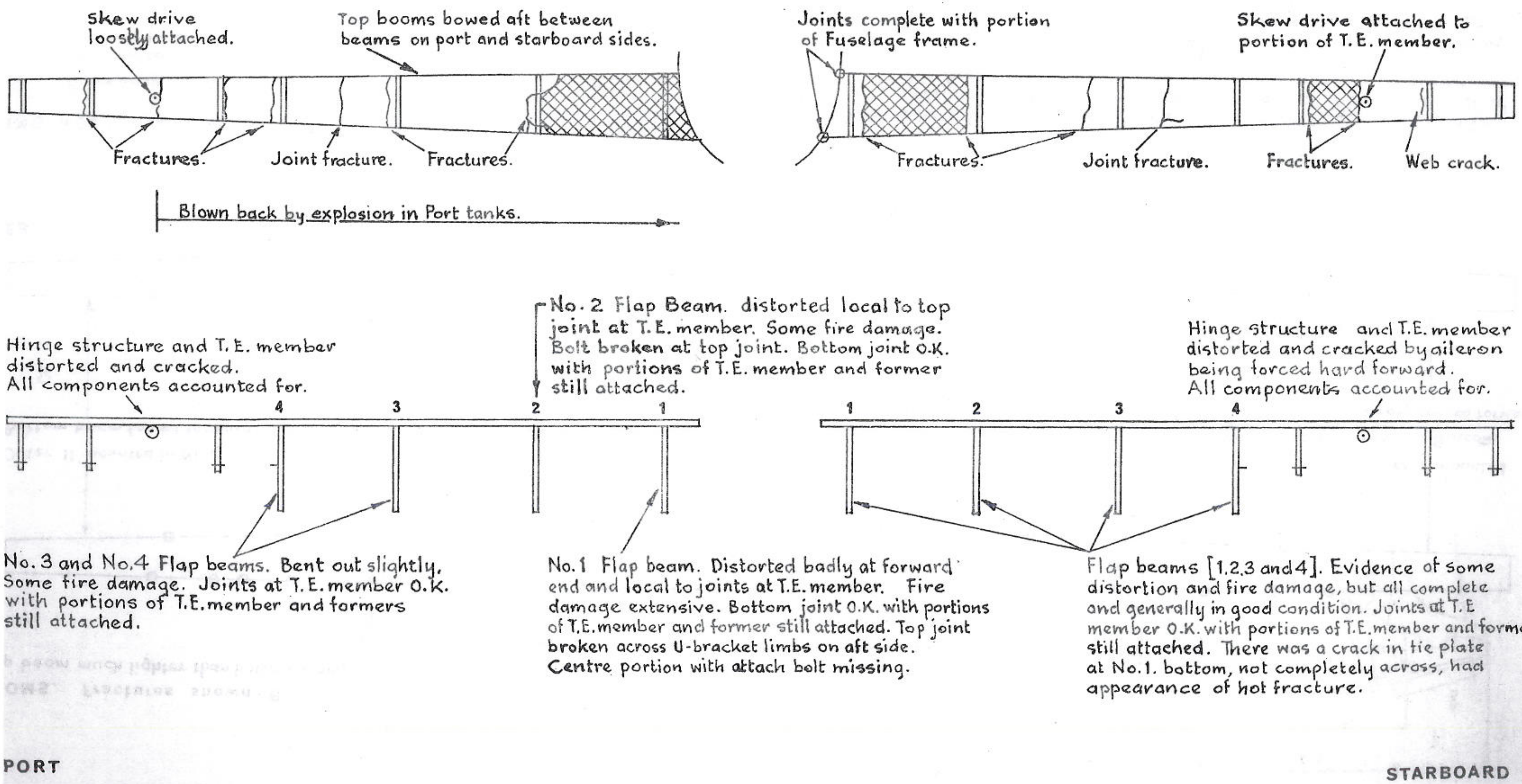


Fig No 3

FLAP SYSTEM. PORT SIDE.

DAMAGE TO RADIUS RODS :

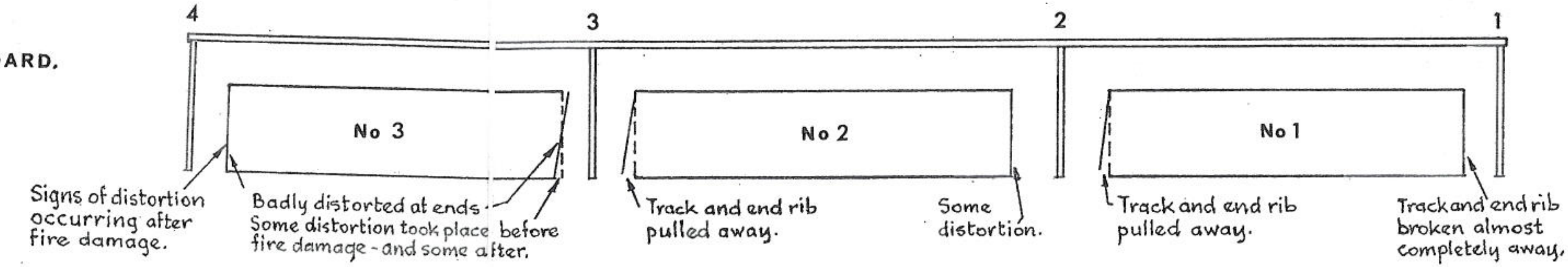
Broken in two places. End pieces still attached at forward end and at flaps.

Almost fully compressed. Bent but not broken. Attached at forward end, but broken away from flaps.

Lockable tie-rod. Bent and broken at lock coupling. Attached at forward end, but broken clear of outer flap, loosely attached to inner.

Extended bent but not broken. Still attached to flap but broken away at forward attachment.

OUTBOARD. INBOARD.



Chain boxes, complete with splined ends, Jockey sprockets and Guide rollers were in position and undamaged.

The lower surface of all flaps, L.E. slats, inner end of No.1 Flap and inner and outer ends of No.3 Flap slats were twisted and distorted out of position.

No.4.

Chain and slider O.K. Drive shaft broken out of slider and flap. Slider found in position forward of 28½° mark. Top edge of Guide rail badly marked at slider, caused by drive shaft being forced up and forward. Bottom edge slightly marked at slider position.

No.3. Outboard.

Chain unbroken. Drive shaft attached to slider and flap. Slider found in overtravel position at end of guide rail. The bottom edge of guide rail was bent down at aft end.

No.3. Inboard.

Chain broken at link aft of Slider. Drive shaft attached to slider but broken away from flap. Slider found in overtravel position at end of guide rail. Guide rail undamaged.

No.2. Outboard.

Slider broken away from chain but still attached to drive shaft which was loosely in position in flap. Slider found in overtravel position at end of guide rail. The bottom edge of guide rail was bent down at aft end.

No.2. Inboard.

Slider broken away from chain and drive shaft. Drive shaft loosely in position in flap. Slider found in overtravel position at end of guide rail — marking apparent on top edge of guide rail forward of 40° position

No.1.

Chain unbroken. Drive shaft attached to slider but broken away from flap. Slider found in overtravel position at end of guide rail. Slight marking apparent on top edge of guide rail forward of 40° position overtravel switch O.K.

Fig. No. 4.

FLAP SYSTEM. STARBOARD SIDE.

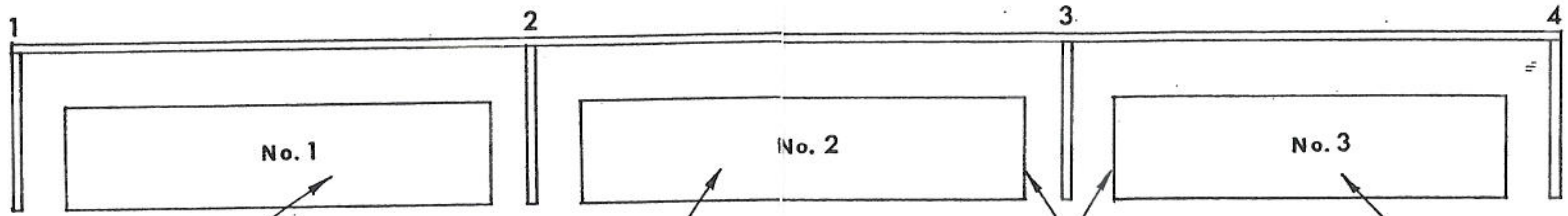
DAMAGE TO RADIUS RODS:

Bent and broken, attached at forward end, and loosely to flap.

Lockable tie-rod. Bent and broken at lock coupling and close to aft end. Established in lock-down position by X-ray at B.A.C. Attached at forward end and to inner flap. Broken away from outer flap.

Bent and fractured, attached at forward end but broken away from flaps.

Broken at forward end. Attached at forward end and at flap.



Almost completely destroyed by fire. - only end ribs left.

Some fire damage over most of flap.

Some local distortion.

Fire damage on lower surface and on slat.

Chain boxes, complete with splined ends, Jockey sprockets and guide rollers were in position and undamaged.

Slats on flaps Nos. 2 and 3 were crushed and distorted.

No. 1

Chain unbroken. Drive shaft intact in slider, but broken out of flap. Slider forward of 40° position. The lower side at guide rail was forced down and broken at aft end. The top and bottom edges of the guide rail were damaged at the slider position.

No. 2 Inboard

Chain unbroken, Drive shaft intact in slider and loosely in position in flap end rib. Slider forward of 40° position. The top and bottom edges of the guide rail were damaged at the slider position.

No. 2 Outboard

Chain unbroken, but slider fractured by drive shaft pulling out. Drive shaft loosely attached to flaps. Slider forward of 40° position. The bottom and top edges of the guide rail were damaged at the slider position.

No. 3 Inboard

Chain unbroken, but slider fractured by drive shaft pulling out. Drive shaft also adrift from flap. Slider forward of 40° position. The top and bottom edges of the guide rail were damaged at the slider position.

No. 3 Outboard

Chain unbroken, but slider fractured by drive shaft pulling out. Drive shaft loosely attached to flap. Slider forward of 40° position. The bottom edge of the guide rail was damaged at slider position.

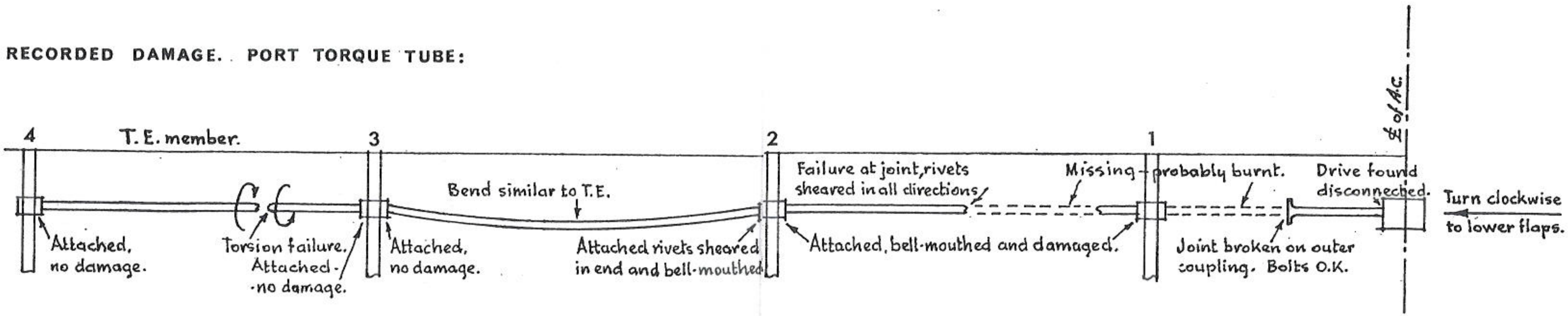
No. 4

Chain unbroken, but slider damaged and twisted down by drive shaft pulling out. Drive shaft adrift from flap. Slider forward of 40° position and guide rail damaged at slider position.

Fig No. 5

WING FLAPS. DAMAGE REPORT.

RECORDED DAMAGE. PORT TORQUE TUBE:



RECORDED DAMAGE. STARBOARD TORQUE TUBE:

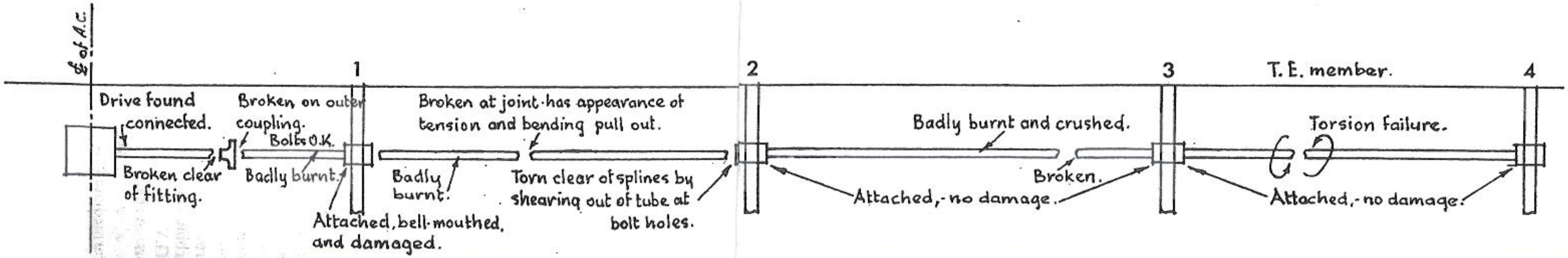


Fig. No. 6.

REPORT ON ENGINES AND PROPELLERS

On impact engines were found to have embedded between $5\frac{1}{2}$ feet on No. 4 engine to $3\frac{1}{2}$ feet on No. 1 engine. The engines were cleared by digging party and the control settings were then recorded as follows:

Engine No. 1

Feathering lever in "Run" position (Rod bent) R.P.M. lever 0.057" from max. R.P.M. Stop. H.P. cock was $\frac{1}{8}$" beyond "Open" position (Rod bent).

No. 2 Engine

Feathering lever in "Run" position (Rod bent) R.P.M. lever in max. R.P.M. position (Max. stop broken off). H.P. cock was in "Open" position.

No. 3 Engine

Feathering lever $\frac{1}{16}$" on "Run" side of U/F position. R.P.M. lever $\frac{5}{16}$" from max. R.P.M. position. H.P. cock in "Shut" position.

No. 4 Engine

Feathering lever $\frac{1}{8}$" on "Run" side of U/F position (bent). R.P.M. lever 0.043" from max. R.P.M. Stop. H.P. cock $\frac{1}{2}$ way between Open and Shut.

Engines were then removed from crash scene to No. 2 Hangar, Dublin Airport for further investigation on the 24 June 1967. The following observations were made:

No. 1 Engine

Main oil filter	white sludge
Wheelcase filter	sludge
Reduction gear filter	"
Fuel filter	Clean
Propeller	Flight Fine position 24° (approximately)
Turbines	Distorted due contact with exhaust case while turbines rotating. No excessive burning or overheating evident
Turbine shaft	Torsional break indicating engine rotating on impact
N.G.V.s	Normal relative to hours operated since overhaul
Torsion shaft	Torsional break
Hot air gate valve	Shut

No. 2 Engine

Main oil filter	Clean
Wheelcase filter	White sludge
Reduction gear filter	White sludge
Fuel filter	Burned. Still in bowl
Propeller	Flight Fine position 24° (approximately)
Turbines	Same as for No. 1 engine
Turbine Shaft	O.K. (no break)
N.G.V.s	Same as for No. 1 engine
Torsion shaft	Torsional break
Hot air gate valve	Shut

No. 3 Engine

Main oil filter	White sludge
Wheelcase filter	White sludge
Reduction gear filter	White sludge
Fuel filter	Burned out. Rivet head in bowl
Propeller	Flight Fine (24° approximately)
Turbines	Same as for No. 1 engine
Turbine shaft	Same as for No. 1 engine
N.G.V.s	Same as for No. 1 engine
Torsion shaft	Torsional break (Shaft broken into several pieces)
Hot air gate valve	Shut

No. 4 Engine

Main oil filter	Clean
Wheelcase filter	Clean
Reduction gear filter	Clean
Fuel filter	Burned
Propeller	Flight Fine (24° approximately)
Turbines	Same as for No. 1 engine
Turbine shaft	Torsion break
N.G.V.s	Same as for No. 1 engine
Torsion shaft	Torsion break
Hot air gate valve	Shut
Intermediate case	Case completely burned out

Report on the Condition of the Engines Involved in the Accident to Aer Lingus Viscount Aircraft EI-AOF at Ashbourne, near Dublin on 22nd June 1967

Conclusions

1) All four engines were turning at the time of impact.

2) There were no indications of any pre-impact failure within any of the four engines.

3) All drives to all engine accessories were intact at the time of impact.

4) From the type and extent of the rotating damage in each engine, and the propeller blade angles, all four engines are considered to have been operating under similar conditions at impact.

5) Contamination of the oil filters of the four engines was of magnesium corrosion products and fire extinguishant and had occurred after impact.

6) It is considered that all four engines were operating at a low power setting at impact.

7) It is considered that all fire damage to the engines had been caused after impact.

R. W. H. QUINTON
Assistant Technical Services Engineer
Rolls Royce Derby Ltd.

REPORT OF INDIVIDUAL ENGINE CONDITIONS

General

The aircraft was found nose down on its back near the centre of a 40 acre corn field. All four engines were buried to a depth of approximately 4 ft. at the propeller spinner. The "dig-in" angle of the engine was about 40° to the horizontal. Each engine was broken at the magnesium intermediate (A.G.B. drive) casing. The aircraft had burst into flames immediately after impact and fire had badly affected the engines rear of the fireproof bulkhead. Reduction gear and compressor assemblies were less affected by the fire. Two propeller blades on each engine were protruding upwards above ground level, whilst the others had been pulled out or bent backwards under the engine.

All four engines were subsequently removed from the site and taken to an Aer Lingus hangar at Dublin Airport for more detailed examination.

Condition of Engines

No. 1 *Position* *Engine No.* 5102—*Time since overhaul* 3,274 *hours*
Time Since New 14,052 *hours*

Reduction Gear Assembly

External Condition

The top surfaces of the reduction gear had been severely damaged by the impact, whilst the bottom side showed very little damage from impact although some of the magnesium pipes had been affected by fire.

The oil cooler had been wiped off and severely distorted, the reduction gear was badly broken and the starter motor broken off at the mounting flange. The propeller shaft was not broken.

Internal Condition

Internally the reduction gear had suffered damage to the support panels and front bearing housing; these had been broken in a number of places. The layshafts and bearings showed no defects associated with running.

Pressure and scavenge oil filters were checked and no metal deposits were evident. All three filters had been contaminated by a white sludge which had also entered the reduction gear casings.

The drives to the P.C.U., Fuel Pump and Oil Pump were found to be intact.

Compressor Assembly

Externally the compressor was badly damaged at the top position, the front compressor casing was very badly smashed and the first stage steel diffuser was bent backwards.

The first stage R.G.V. was bent backwards against the direction of rotation. The coupling drive shaft to the reduction gear had failed at a position adjacent to the rear splines on the compressor shaft. The failure was of a typical torsional overload type and the fracture was inclined at approximately 45° with associated spiral indication along the total length of the shaft. The first stage impeller was intact. The control shafts and cross shaft showed no breakages.

Intermediate (A.G.B. drive) Casing

The casing was broken at each end, and the mid section completely burned away. The steel cooling air tubes were badly bent but showed no distress from burning.

Combustion Assembly

The combustion assemblies were all broken from their mountings and had fractured either at the outlet elbow or the expansion chamber. The flame tubes and air casings were all severely distorted and crushed as the result of the impact.

Turbine and Nozzle Box Assembly

The nozzle box showed impact damage at the top position, and two nozzle outlets were almost closed off.

The H.P. nozzle guide vanes showed no distress, and their condition was commensurate with running time.

The H.P. turbine blades showed no evidence of any turbine overheat or distress.

The L.P. blades were bent over in the direction of rotation and the trailing edges rubbed, additionally the inner surface of the L.P. turbine wheel was rubbed by the exhaust unit collapsing on to it on impact.

The turbine shaft had sheared at the turbine end. Heavy indentation was noted on the inner surface of the bell coupling, this had been caused by impact of end face of the rear compressor shaft on impact.

Hot Air Gate Valve

The gate valve was found in the closed position.

No. 2 Position *Engine No.* 5820—*Time Since Overhaul* 2,091 *hours*
Time Since New 15,755 *hours*

Reduction Gear Assembly

External Condition

This was similar to No. 1 engine.

Internal Condition

The propeller shaft was bent but the condition otherwise was similar to No. 1 engine. The oil filters were free from any metallic deposits, but were filled with white sludge deposits similar to those found in the filters of the No. 1 engine.
The drives to the P.C.U., Fuel Pump and Oil Pump were intact.

Compressor

The condition was similar to that of the No. 1 engine.
The coupling drive shaft to the reduction gear had failed at a position adjacent to the front splines. Typical spiral lines associated with torsion overload were present.

Intermediate (A.G.B. drive) Casing

The condition was similar to that of the No. 1 engine.

Combustion Assemblies

The condition was similar to that of the No. 1 engine.

Turbine and Nozzle Box Assembly

The condition of this was similar to that of the No. 1 engine, except that the turbine shaft had not sheared.

Hot Air Gate Valve

The gate valve was found in the closed position.

No. 3 Position *Engine No.* 5220—*Time Since Overhaul* 3,831 hours
Time Since New 14,820 *hours*

Reduction Gear Assembly

External Condition

Generally similar to Nos. 1 and 2 engines. However, the propeller shaft had broken off at a position adjacent to the main diaphragm due to impact.
The oil filters were free from any metallic deposits, but they had also been contaminated with white sludge deposits similar to those of Nos. 1 and 2 engines.
The drives to the P.C.U., Fuel Pump and Oil Pump were found to be intact.

Compressor Assemblies

Externally the compressor casings were similarly damaged to those of Nos. 1 and 2 engines.
The first stage R.G.V. was bent back slightly against the direction of rotation. The coupling drive shaft to the reduction gear had failed and was broken into five pieces. The fracture surfaces all showed the 45° angle typical of a torsional failure.
The first stage impeller was intact, and the control cross shafts were not broken.

Intermediate (A.G.B. drive) Casing

The condition was similar to that of the Nos. 1 and 2 engines.

Combustion Assembly

Broken and distorted in a similar way to those from Nos. 1 and 2 engines.

Turbine and Nozzle Box Assemblies

The nozzle box casing showed impact damage similar to that on Nos. 1 and 2 engines.
The H.P. nozzle guide vanes showed no distress, and their condition was normal for running time.
The H.P. turbine blades showed no evidence of overheating or distress.
The L.P. blades were bent over in the direction of rotation, and the trailing edges were severely rubbed; three blades were broken in the aerofoil as the result of this damage.
The turbine shaft had sheared at the turbine end.

Hot Air Gate Valve

The gate valve was found in the closed position.

No. 4 Position *Engine No. 4747—Time Since Overhaul 2,154 hours*
Time Since New 10,868 hours

Reduction Gear Assembly

External Condition

This was similar to the other three engines.

Internal Condition

There was general damage similar to that shown on the other three engines; the prop shaft was bent. There was no sludge contamination of the filters from the engine. The drives on the various units were satisfactory as in the other three engines.

Compressor Assembly

External damage was similar to that on the other three engines.
No bending back of the first stage R.G.V. was noted. The coupling drive shaft to the reduction gear had failed at the engagement end with the high speed pinion. Associated spiral torsion indications were noted along the length of the shaft.
The first stage impeller was intact, and control cross shafts were not broken.

Intermediate (A.G.B. drive) Casing

The condition was similar to that of the other three engines.

Combustion Assembly

The combustion assemblies were in a similar condition to those from the other three engines.

Turbine and Nozzle Box Assembly

The nozzle box was damaged at the top positions similar to the other three engines.
The H.P. nozzle guide vanes and H.P. turbine blades showed no evidence of distress or overheating.
The L.P. blades showed a slight rub on their trailing edges as the result of exhaust unit contact with the exhaust unit inner cone.
The turbine shaft had sheared at the turbine end, additionally the turbine bell coupling shaft had sheared the splines off the rear compressor shaft.

Hot Air Gate Valve

The gate valve was found in the closed position.

R. W. H. QUINTON
Assistant Technical Services Engineer
Rolls Royce Derby Ltd.

J. TAYLOR
Dart Service Project
Rolls Royce
East Kilbride

Discussion

All four engines were extremely badly damaged by impact, but each engine was complete within its own impact area. This, and the general appearance of the aircraft wreckage, gave the impression that there was little or no forward speed at the moment of impact.

The fact that each propeller had two relatively undamaged blades protruding above ground level, whilst the other two were buried beneath their respective engines and bent under them, indicated that each engine had been stopped within half a propeller revolution. In each case two propeller blades were folded back under the engine, thus indicating a degree of forward motion. However, this is estimated to have been very small as they had scarcely moved back relative to the propeller hub even though detached from the latter.

Control positions on the engines were as shown in the following table.

	No. 1 Engine	*No. 2 Engine*	*No. 3 Engine*	*No. 4 Engine*
Shut off Cock	Fully Open	Fully Open	Closed	Half Open
Throttle Valve	Just off the slow running stop.	Just off the slow running stop.	Just off the slow running stop.	Half way between Open and closed.
Feathering Lever	Run Position	Run Position	0.050″ from unfeather.	$\frac{1}{8}$″ from unfeather.
RPM Lever	Fully Open	Fully Open	$\frac{1}{4}$″ from Fully Open	$\frac{1}{4}$″ from Fully Open

As none of these were still connected to the cockpit levers, as they were all free to move, and in view of the severe shock loading that the whole system had undergone, it is not felt that any real significance can be placed on the readings shown above.

All four engines had torsion failures of the main torque shafts, and each showed evidence both within their turbines and their compressors of turning motion (in the correct direction) at impact. It is therefore considered that all four engines were turning at impact.

All four sets of combustion outer casings and flame tubes were returned to Rolls-Royce for detailed laboratory examination with a view to establishing the temperature condition of the combustion equipment at impact. These tests have not proved entirely satisfactory as contradictory results have been obtained from flame tubes from the same engines, and even from the same flame tube. It is felt that these contradictory results are most probably due to the varying degree to which individual flame tubes were subjected to fire or increased temperature in the subsequent fierce aircraft fire.

Nevertheless, from the many individual "crash buckle" tests carried out the weight of evidence indicates that the temperature of the flame tube rear conical sections did not exceed 600° C at the time of impact.

All the other weight of evidence—propeller angles, internal engine condition, etc., etc., points to the fact that all four engines were operating at very similar conditions.

As this evidence shows that all propellers were at "flight fine" all engines were turning though not at great power, all fuel unit drives were intact, there was plenty of fuel on board as shown by the subsequent fierce fuel fire, it seems most probable that all four engines were alight.

In addition, as it is understood that the undercarriage on the aircraft was down and locked at the moment of impact and that some flap was selected down it would appear that it is most probable that the engines were at a low power setting, as if making an approach to land.

Samples of the sludge found in the oil filters of 3 of the 4 engines have been laboratory examined and the chemical analysis was found to be: 2% oil, 28% magnesium corrosion products, with the majority of the remainder being sodium carbonate and water. There were very slight traces of a number of base metals.

It is considered that this oil system contamination was undoubtedly caused after impact, primarily during the fire fighting operations. In any case the engines could not possibly have operated for the time that this aircraft had been airborne, with an oil system contaminated in this way, without showing considerable distress if not complete failure of all main line bearings.

R. W. H. Quinton
Assistant Technical Services Engineer
Rolls-Royce Limited, Derby.

DOWTY ROTOL LIMITED

DYNAMICS DIVISION

ACCIDENT INVOLVING THE AER LINGUS VISCOUNT TYPE 803, REGISTRATION No. EI–AOF, WHICH OCCURRED ON 22 JUNE 1967 NEAR DUBLIN, EIRE

Statement Relating to the Strip Investigation of the Dowty Rotol Propellers Fitted to Viscount EI–AOF at the Time of the Crash

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(This report describes the condition of the four propellers as found at the crash site and during examination after their removal to the overhaul base of Aer Lingus at Dublin Airport, and the conclusions derived therefrom)

Conclusions

1. The pitch angles at the moment of impact, as derived from the indentations produced by the blade bearing rollers on the roller tracks, the position of the main operating piston, indents in a cylinder bore and on a collet sleeve, and the condition of the abutment faces of the flight fine pitch stops and spring collets, were:

Port Outer Propeller (No. 1)	24°
Port Inner Propeller (No. 2)	24°
Starboard Inner Propeller (No. 3)	24°
Starboard Outer Propeller (No. 4)	24°

i.e. all the propellers were on the flight fine pitch lock.
(Note that all blade angles quoted in this report refer to a station at 0·7 of the tip radius).

2. All four propellers, which are left hand tractor, were rotating normally at impact, at a low revs/min. The line of flight had an associated large vertical component.

3. All the propellers were operating at a similar windmilling condition at impact. The specific condition, i.e. flight idling fuel flow or dead engine, cannot be determined in this instance from the condition of the propellers. (The attached graph H.0213 shows the values of windmilling drag and revs/min. for a dead engine and for an engine with idling fuel flow).

4. There was no evidence of fatigue failure on any of the failed surfaces.

5. No defects, other than through damage sustained during impact were found in the propellers to suggest that normal operation could not be obtained up to the moment of impact.

R. H. Barnfield
Investigation Engineer—Airworthiness
Dynamics Division
Dowty Rotol Limited.

9 October 1967.

Details of the Propellers Installed

Type R130/4–20–4/12E

Starting Pitch Blade Angle	0°
Flight Fine Pitch Stop Blade Angle	24°
Feathered Blade Angle	84° 24′

Installation	*Propeller Serial No.*	*T.S.N.*	*T.S.O.*	*Date Installed*
1	130/57/308	12,266	2,083	21.2.67
2	130/57/288	13,375	2,496	21.1.67
3	130/57/158	14,653	2,667	24.8.66
4	99796	—	—	21.2.67

Propeller Blades—Part No. RA25842

	Blade No. 1	*Blade No. 2*	*Blade No. 3*	*Blade No. 4*
Propeller No. 1	A93779	A93349	A94541	A95594
Propeller No. 2	A92640	A92612	A92686	A92688
Propeller No. 3	A93757	A92815	A93743	A92886
Propeller No. 4	A95251	A95243	A95221	A95227

1. General

1.1 Blade positions are as viewed from the front of the propeller hub:

No. 1 Twelve o'clock
No. 2 Three o'clock
No. 3 Six o'clock
No. 4 Nine O'clock

and the propeller is left hand tractor, i.e. the sequence of blade rotation is 4, 3, 2, 1. *N.B.* These blade positions are arbitrary and do not refer to blade positions as found in the wreckage.

1.2 Conversion of linear measurements taken throughout the propeller assembly are converted to relative blade angles by reference to Dowty Rotol Ltd. graph No. H.0050 attached.

2. Port Outer (No. 1) Propeller, Serial No. 130/57/308

2.1 *General*

2.1.1 During impact, No. 1 propeller had become detached from the engine, complete with reduction gear. Blades Nos. 1 and 4 had become detached from the hub, and No. 4 was recovered from underneath the engine with its root end immediately adjacent to its respective hub port. The propeller hub was approximately 3 ft.—4 ft. in the ground, and the engine/propeller axis was at an angle of approximately 30° with the horizontal.

2.1.2 The spinner support flange of the cylinder was broken between blade ports Nos. 1 and 4.

2.1.3 There were heavy witness markings on the flight fine pitch stop abutment faces from loading on the spring collet in the pitch lock mechanism. The collet fingers were severely distorted adjacent to No. 2 blade port due to over-riding of the flight fine pitch stop approximately 0.240 inches. The cylinder front cover was not unduly distorted, indicating that the relative motion producing the distortion was fine pitch twisting of the blades.

2.1.4 An indentation on the collet sleeve, positioned 0.800 inches from the front edge adjacent to No. 2 blade, is at an equivalent blade angle of 22°. (Ref. Graph No. H.0050). The sleeve was partially displaced in the hub retaining threads.

2.1.5 The cylinder barrel was not broken, and there were no indentations in the bore of the cylinder.

2.1.6 During the preliminary inspection, prior to dismantling it was noted that the flight fine pitch stop, which is attached to the main operating piston, was approximately 0.380″ forward of the front edge of the collet sleeve (equivalent to a blade angle of 18°).

2.2 *No.* 1 *Blade, Serial No. A93779 and its Associated Bearing Assembly and Operating Pin*

2.2.1 *Blade*

Impact loads had wrenched No. 1 blade out of the hub and had lightly indented the side faces of the blade root dogs in contact with the associated dogs of the blade bearing in a direction consistent with a relative fine pitch twisting of the blade.

2.2.2 *Blade Bearing, Serial No.* 33222

Both the preload and centrifugal tracks of the bearing were indented from the impact loads imparted through the rollers. By matching complementary indentations on the fixed and rotating tracks, an indication of the blade angle at the moment of major blade bending could be obtained.

Measurements taken from the preload tracks of this bearing indicate a blade angle of 20°, whilst measurements from the centrifugal tracks indicate a blade angle of 10°.

The operating pin dowel retaining hole in the centrifugal race had become elongated from a relative fine pitch twisting of the blade.

Witness marks of the bearing on the hub port indicate the centre race was wrenched out of the hub along a major axis 139° from the hub front centre line, measured in a clockwise direction.

2.2.3 *Operating Pin and Link Assembly*

The operating pin retaining bolts had all been sheared by a relative fine pitch twisting of the blade. The operating pin mounting flange was distorted consistent with a generally rearwards bending of the blade.

2.3 *No.* 4 *Blade, Serial No. A95594 and its Associated Bearing Assembly and Operating Pin*

2.3.1 *Blade*

Impact loads had wrenched No. 4 blade out of the hub, and had sheared the corners of the blade root dogs in a direction consistent with a relative fine pitch twisting of the blade.

2.3.2 *Blade Bearing, Serial No.* 17843

The preload tracks of both the preload and centre races were severely damaged, raised metal having been swaged over in a direction consistent with fine pitch twisting of the blade.

The matching of indentations on the fixed and rotating tracks of the centrifugal bearing indicate a blade angle of 5°.

Witness marks of the bearing on the hub port indicate the centre race was wrenched out of the hub along a major axis 165° from the hub front centre line, measured in an anti-clockwise direction.

2.3.3 *Operating Pin and Link Assembly*

The operating pin locating dowel, located in the operating pin mounting flange, had been sheared by a relative fine pitch twisting of the blade.

2.4 *General Analysis—Port Outer Propeller*

2.4.1 The condition of the four blades, the location of the two detached blades in the engine crater, and the direction in which each detached blade had been wrenched out of the hub is consistent with a low revs/min. associated with a line of flight containing a high vertical velocity.

2.4.2 It is a known feature that when the blade connecting linkage has failed significant changes in blade angle can occur before blade bending loads transmitted through the bearing rollers can produce indentations on the associated tracks. No significance is therefore attached to the low blade angles produced by matching bearing track indentations, other than as additional proof that the blades had sustained fine pitch twisting moments at impact.

2.4.3 The damage sustained by the spring collet fingers is indicative that the flight fine pitch stop was engaged at impact.

2.4.4 The failure of the operating pin retaining bolts and locating dowels of the detached blades was produced by fine pitch twisting of the propeller blades at impact, characteristic of a windmilling propeller.

2.4.5 Any tendency towards a large displacement of the main operating piston by loads from the propeller blades will be resisted by the resultant high pressure differential across the propeller control oilways if the loading is of short duration. This will tend to minimise any piston displacement resultant from blade loads in this propeller.

The indentation on the collet sleeve is at an equivalent blade angle of 22°, which is 2° below the flight fine pitch stop but was obviously produced as the stop over-rode the spring collet.

The propeller is therefore considered to have been at 24° (flight fine pitch stop) at the moment of impact.

2.4.6 There was no evidence of any type of pre-impact mechanical failure within the propeller.

3. Port Inner Propeller (No. 2), Serial No. 130/57/288

3.1 *General*

3.1.1 During impact, Nos. 1 and 2 blades were wrenched out of the hub and were recovered from underneath the engine, with their root ends adjacent to their respective hub ports. The propeller hub was approximately 3 ft.—4 ft. in the ground, with the engine/propeller axis at an angle of approximately 30° with the horizontal.

3.1.2 Removal of the propeller from the engine was extremely difficult, due to the severe distortion of the engine propeller shaft.

3.1.3 During the preliminary inspection, prior to dismantling, it was noted that the flight fine pitch stop was approximately 0.2" forward of the front edge of the collet sleeve.

3.1.4 The spinner support flange of the cylinder was broken adjacent to blade No. 2.

3.1.5 The cylinder barrel was intact and there were no imprints in the bore of the cylinder.

3.1.6 There were no significant marks on the barrel of the collet sleeve, which was partially displaced in the hub retaining threads.

3.1.7 There were no significant markings on either the flight fine pitch stop or the pitch lock assembly.

3.2 *No. 2 Blade, Serial No. A92612 and its Associated Bearing Assembly and Operating Pin*

3.2.1 *Blade*
Impact loads had wrenched this blade out of the hub, and had sheared the corners of the blade root dogs in a direction consistent with a relative fine pitch twisting of the blade.

3.2.2 *Blade Bearing, Serial No.* 14016

(*a*) The preload tracks of both the preload and centre races were severely damaged, metal being swaged over in a direction consistent with fine pitch twisting of the blade.

(*b*) The matching of indentations on the tracks of the preload races and the centre race indicate an equivalent blade angle of —25°.

(*c*) The matching of indentations on the fixed and rotating tracks of the centrifugal bearing indicate a blade angle of 24°.

(*d*) Witness marking in the bearing indicate the blade was wrenched out of the hub along an axis 173° from the hub front centre line, measured in a clockwise direction.

3.2.3 *Operating Pin and Link Assembly*

(*a*) The operating pin retaining bolts were all sheared by a relative fine pitch twisting of the blade.

(*b*) The link bush was crushed in a manner consistent with a rearward bending of the blade.

3.3 *General Analysis—Port Inner Propeller*

3.3.1 The condition of the four blades and the location of the two detached blades in the engine crater is consistent with a low revs/min., associated with a line of flight containing a high vertical velocity.

3.3.2 The failure of the operating pin retaining bolts was produced by fine pitch twisting of the detached blade, characteristic of a windmilling propeller.

3.3.3 The blade angles derived from the matching of bearing track indentations are a further indication of the fine pitch twisting of the blades. Although the maximum coarse pitch angle derived from matching the indentations on the centrifugal races was 24°, this cannot be considered proof of blade angle at impact for the reasons given in paragraph 2.4.2.

3.3.4 Since the main operating piston was found in approximately the flight fine pitch position and there was no displacement of the piston during transit of the engines from the accident site, for the reasons given in paragraph 2.4.5, with respect to displacement of the main operating piston under the specific conditions of this accident, the propeller is considered to have been at 24° (flight fine pitch stop) at the moment of impact.

3.3.5 There was no evidence of any type of pre-impact mechanical failure within the propeller.

4. Starboard Inner Propeller (No. 3) Serial No. 130/57/158

4.1 *General*

4.1.1 During impact, Nos. 1 and 2 blades were wrenched out of the hub, and were recovered from the engine crater. The propeller hub was approximately 4 ft.—5 ft. in the ground, with the engine/propeller axis at an angle of approximately 30° with the horizontal.

4.1.2 The engine propeller shaft was broken in the blending radius between the shaft and diaphragm.

4.1.3 During the preliminary inspection, prior to dismantling, it was noted that the flight fine pitch stop was approximately 0.2″ forward of the front edge of the collet sleeve.

4.1.4 The spinner support flange of the cylinder was broken between hub ports 1 and 2.

4.1.5 The cylinder barrel was intact but there was a light indentation in the cylinder bore, between hub ports 1 and 2, 1.920″ from the shoulder forming the ground fine pitch stop.

4.1.6 There were no significant marks on the barrel of the collet sleeve, which was partially displaced in the hub retaining threads.

4.1.7 There were no significant markings on the flight fine pitch stop, but the fingers of the spring collet had been over-ridden slightly in line with No. 1 blade.

4.2 *No.* 2 *Blade, Serial No. A*92815 *and its Associated Bearing Assembly and Operating Pin*

4.2.1 *Blade*

Impact loads had wrenched this blade out of the hub and had damaged the corners of the blade root dogs in a direction consistent with a relative fine pitch twisting of the blade.

4.2.2 *Blade Bearing Serial No.* 31612

(*a*) The preload tracks of both the preload and centre races were severely damaged, metal being swaged over in a direction consistent with fine pitch twisting of the blade.

(*b*) The matching of indentations on the thrust ribs of the preload race and on the tracks of the centre race which had been produced by a forwards Extrusion of rollers due to rearwards blade bending indicate an equivalent blade angle of 13°.

(*c*) The matching of indentations on the fixed and rotating tracks of the centrifugal bearing indicate a blade angle of —42°.

(*d*) Witness markings on the bearing indicate the blade was wrenched out of the hub along an axis 170—180° from the hub front centre line, measured in a clockwise direction.

4.2.3 *Operating Pin and Link Assembly*

(*a*) The operating pin retaining bolts were all broken by a combined shear/bend load, produced by a relative fine pitch twisting and rearwards bending of the blade. The operating pin locating dowel was bent in a manner consistent with the same directional forces.

4.3 *General Analysis—Starboard Inner Propeller*

4.3.1 The condition of the four blades, the location of the detached blades in the engine crater and the angular relationship of the broken spinner support flange relative to the detached blades hub ports is consistent with a low revs/min., associated with a line of flight containing a high vertical velocity.

4.3.2 Evidence obtained from the deformed blade bearing preload tracks, the blade angle derived from the matching of roller indentations on the centrifugal tracks, and the fracture faces of the operating pin retaining bolts is all indicative of fine pitch twisting of the detached blade, which is characteristic of a windmilling propeller.

4.3.3 Since there were no significant witness markings on the abutment faces of the flight fine pitch stop and the spring collet, the light impact indentation in the bore of the cylinder could only have been produced by the front land of the piston seal grooves, and is equivalent to a blade angle of 23°.

4.3.4 Since the main operating piston was found in approximately the flight fine pitch position, for the same reasons given previously in paragraphs 2.4.5 and 3.3.4 and with the additional evidence outlined in paragraph 4.3.3, this propeller is considered to have been at 24° (flight fine pitch stop), at the moment of impact.

4.3.5 There was no evidence of any type of pre-impact mechanical failure within the propeller.

5. Starboard Outer Propeller (No. 4) Serial No. 99796

5.1 *General*

5.1.1 During impact Nos. 2, 3 and 4 blades were wrenched out of the hub, and were recovered from the engine crater. The propeller hub was slightly deeper in the ground than the others, with the axis of the engine/propeller at approximately 30° with the horizontal.

5.1.2 The propeller was not detached from the engine although the engine reduction gear casings were cracked all round.

5.1.3 During the preliminary inspection prior to dismantling it was noted that the flight fine pitch stop was approximately 0.1″ forward of the front edge of the collet sleeve.

5.1.4 The spinner support flange of the cylinder was broken between hub ports 3 and 4.

5.1.5 The cylinder barrel was intact, and there were no imprints in the bore of the cylinder.

5.1.6 There were no significant marks on the barrel of the collet sleeve, which was partially displaced in the hub retaining threads.

5.2 *No. 4 Blade, Serial No. A95227 and its Associated Bearing Assembly and Operating Pin*

5.2.1 *Blade*

Impact loads had wrenched this blade out of the hub and had distorted the corners of the blade root dogs in a direction consistent with a relative fine pitch twisting of the blade.

5.2.2 *Blade Bearing Serial No.* 16500

(*a*) The matching of indentations on the fixed and rotating tracks of the preload bearing indicate an equivalent blade angle of 20°.

(*b*) There were no matchable indentations on the centrifugal bearing.

5.2.3 *Operating Pin and Link Assembly*

The operating pin locating dowel was bent in a manner consistent with a fine pitch twisting/rearwards bending of the blade.

5.3 *No. 3 Blade, Serial No. A95221 and its Associated Bearing Assembly*

5.3.1 *Blade*

Impact loads had wrenched this blade out of the hub and had broken the tip. The corners of the blade root dogs were sheared in a direction consistent with a relative fine pitch twisting of the blade.

5.3.2 *Blade Bearing Serial No.* 12949

(*a*) The matching of indentations on the fixed and rotating tracks of the preload bearing indicate an equivalent blade angle of 21°.

(*b*) The major axis of the indentations indicate the associated blade bending occurred along an axis of 155° relative to the front of the hub fore-aft axis.

(*c*) The matching of indentations on the fixed and rotating tracks of the centrifugal bearing indicate an equivalent blade angle of 9°.

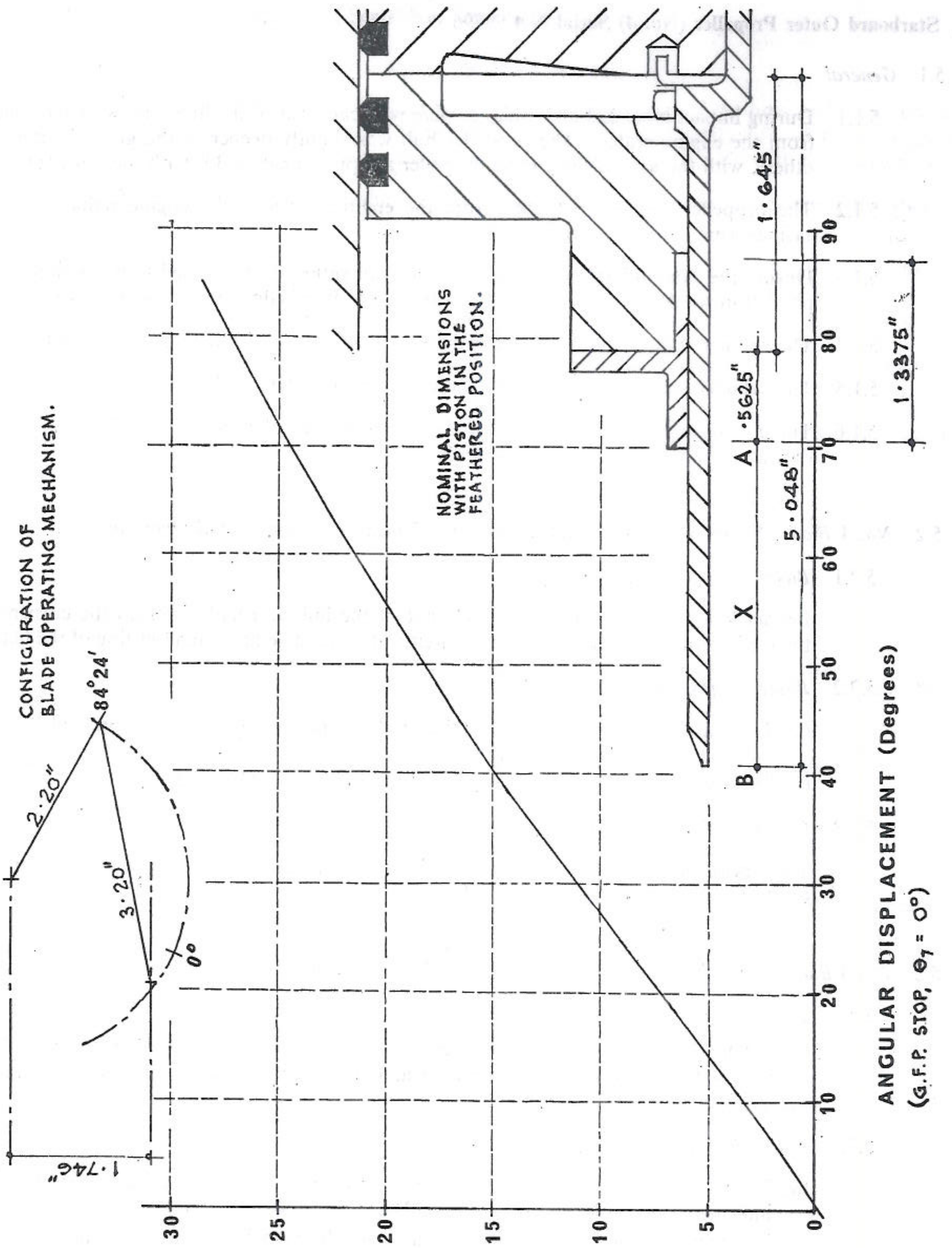
5.4 *General Analysis—Starboard Outer Propeller*

5.4.1 The condition of the four blades, the location of the detached blades in the engine crater and the angular relationship of the broken spinner support flange relative to the detached blades hub ports is consistent with a low revs/min., associated with a line of flight containing a high vertical velocity.

5.4.2 Evidence obtained from matching roller indentations on the bearing tracks and the bending of the operating pin locating dowel is indicative of fine pitch twisting of the detached blades characteristic of a windmilling propeller.

5.4.3 Since the main operating piston was found in approximately the flight fine pitch position, for the same reasons given previously in paragraphs 2.4.5 and 3.3.4 this propeller is considered to have been at 24° (flight fine pitch stop) at the moment of impact.

5.4.4 There was no evidence of any type of pre-impact damage within the propeller.

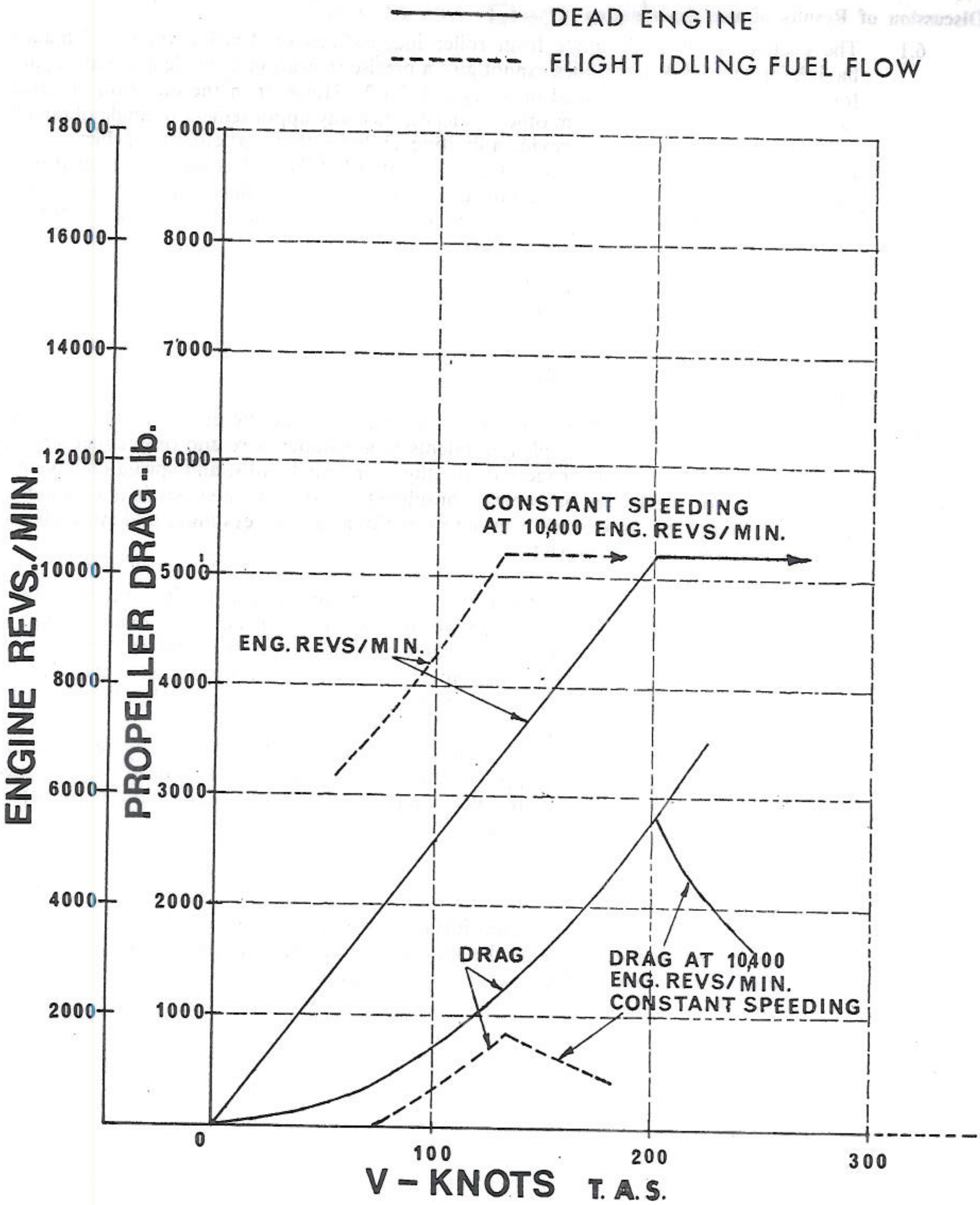


LINEAR DISPLACEMENT (Inches)
Also relationship 'X' between edge of
Piston Liner A and front edge of
Collet sleeve B.

TYPE R 130/4·20·4/12 E

4 BLADE - 20 ROOT PROPELLER. DART.

Graph No. H 0050



REF: PERFORMANCE OFFICE REPORT No.1011

WINDMILLING DRAG AND ENGINE REVS/MIN. WITH A DEAD ENGINE, AND WITH FLIGHT IDLING FUEL FLOW, AT 24° STOP ANGLE.

GRAPH No. H 0213

6. **Discussion of Results of the Examination**

6.1 The evaluation of blade angle from roller indentations on bearing tracks of blades having fractured link assemblies cannot give a precise indication of blade angle at impact for the reasons already outlined in paragraph 2.4.2. However, if the direction of blade twisting can be established from other evidence, then any appraisement of angle obtained from roller indentations will provide a limiting angle for that particular propeller.
Considering the subject propellers fitted to aircraft EI–AOF, it has been established that each of the detached blades had sustained a twisting towards a finer pitch during impact. the pitch angle of each propeller must therefore have been *at least* the angle indicated by the bearing indentations, viz:

Propeller 1 20°+
Propeller 2 24°+
Propeller 3 13°+
Propeller 4 21°+

6.2 In the analysis of the condition of the propellers, more specific evidence including the position of the main operating piston, indents in a cylinder bore and on a collet sleeve, the condition of the abutment faces of the flight fine pitch stops and spring collets and the condition of the blades have been considered. From this analysis it is concluded that the four propellers were all rotating normally at a low revs/min., and were all on the flight fine pitch stop at impact.

6.3 The twisting of the blades towards a finer pitch at impact is indicative that they were operating at a negative incidence angle, i.e. that all the propellers were windmilling.
The attached graph H.0213 shows the values of windmilling drag and revs/min. for a dead engine and for an engine with idling fuel flow, at steady state, sea level, I.S.A. conditions. (Any deviations of the aircraft from a normal flight path will obviously affect these theoretical values).
From this graph it will be seen that for the same forward speed V, the engine revs/min. with a flight idling fuel flow is approximately $2\times$the revs/min. of a dead engine, thus there would be approximately $4\times$the work done in stopping the rotation of the propeller and reduction gear in the former case.

$$\left(\text{Work done} = \triangle\ \text{K.E.} = \frac{I\omega^2}{2g}\right)$$

From the examination of the propellers it is not possible to determine the actual operating conditions of the engines, although the similarity of damage sustained by each propeller would suggest that the operating conditions were also similar.

Report on Electronic Units

ELECTRONIC UNITS

Invertor SN 3065

This unit was practically complete, and on investigation showed that it was stationary at time of impact.

Invertor SN 13529

This unit was badly damaged and showed every indication of turning at high speed at time of impact.

Emergency Invertor SN 6701

This unit was complete and on investigation showed that it was stationary at time of impact.

VOR RXRs No. 1 & No. 2 SN No. 1=2904; No. 2=1780

These units were very badly damaged and were beyond investigation, i.e. no useful information could be got from them.

ADF RXRs SNs No. 1=574870; No. 2=571219

These units were badly damaged and were beyond investigation.

Indicating Units (RMI) SN 51 and 3

These units were badly damaged and were beyond investigation.

VHF Tx Rx 618M-1D SN 66 No. 1

This unit prior to stripping showed a reading of two (2) on the monitor meter, located on the panel of the unit. The selector switch was selected to MODULATION I position. The frequency selected was 131.5 Mcs. This frequency selection was observed through the grilled cover of the unit.

On dismantling of the TxRx it was confirmed that:

(*a*) the frequency selected was 131.5 Mcs.;

(*b*) the power relay was in transmit position;

(*c*) the transmit relay was in the transmit position;

(*d*) the aerial change over relay was in transmit position.

NOTE—To get a reading of two (2) on the monitor meter with MODULATION I selected the R.F. carrier would have to be modulated.

The frequency selection, relay positions and monitor meter reading combine to indicate transmission at the moment of impact. However, transmission and modulation may well have occurred through contact (either a pilot's hand or other object) with the control column transmit switch at impact. This would produce a modulated carrier which, lacking speech into a microphone, would probably pass unnoticed as a transmission.

The Company's receiving station in Movement Control has the responsibility of monitoring this frequency and was doing so at the time of the accident. No transmission was heard.

VHF TxRx 618M-1D SN 89 No. 2

This unit when dismantled showed all relays in relaxed positions. The frequency selected was 129·00 Mcs. (this selection could be caused by impact) and on straightening up the Mcs. selector, which was badly bent, the frequency selection moved towards 128·00 Mcs.

The conclusion reached on further examination and consideration was that the selected frequency was probably 128·00 Mcs. This is the Dublin A.T.C. sector frequency on which communications are normally made between aircraft on training and A.T.C.

VHF Controller No. 1 SN 63

This unit was associated with TxRx No. 2 and it was found that the OFF/PWR/TEST switch was in PWR position. The volume control was fully clockwise and the frequency selected was 131·5 Mcs.

VHF Controller No. 2 SN 65

This unit was associated with TxRx No. 2 and it was found that the OFF/PWR/TEST switch was in the OFF position. The volume control was fully clockwise and the frequency selected was 128·00 Mcs. Damage to the unit was such that it cannot be concluded that the Controller switch was in the OFF position before impact.

APPENDIX 4

Conversion syllabus for Aer Lingus Cadets to Viscount Aircraft

1. Pre-departure check (instruction by Engineering Personnel).
2. Walk round check before entering aircraft.

EXERCISE 1.

1. Check list drills.
2. Familiarisation with flight deck and controls.
3. Fuel trimmer setting calculation for take-off.

EXERCISE 2.

1. Engine starting and blow out technique.
2. Taxying technique.
3. Pre-take-off W/M and oil pressure check.
4. Take-off.
5. Normal Climb.
6. Climbing turns.
7. Straight and level flight.
8. Level turns. Rate 1. 30°—45°.
9. Effect of trim tabs.
10. Effect of Undercarriage.
11. Effect of Flaps.
12. Stall—gear and flaps down—power off. (Stall Warning).
13. Stall—clean—power off. (Stall Warning).
14. Airspeed Control in various Approach Configurations.
15. Simulated overshoot procedures.
16. Emergency procedures on various Systems.
17. Emergency descent techniques (2).

EXERCISE 3.

1. Normal circuits and landings.
2. Overshoots.
3. Correction of Undershoots.

EXERCISE 4.

1. Cross wind take-offs and landings.
2. Low circuit.
3. Short landing.
4. Glide approach (Simulated total engine failure).

EXERCISE 5.

1. Collins I.F.S.
2. Sperry Flt. System.
3. General Instrument flying.
   - A. Straight and level flight.
   - B. Rate 1 Turns.
   - C. 30° Bank.
   - D. 45° Bank.
   - E. Recovery from unusual positions.
4. Limited Panel.

EXERCISE 6.

1. 3E Handling.
2. 2E Handling.
3. VMC_A.
4. VMC (Two Engines).
5. Feathering and Fire Drills.
6. Air Relighting.
7. Engine Failure on Instruments.

EXERCISE 7.

1. Line procedures.
2. Setting up pressurisation, etc.
3. Normal take-off and climb out (Check List).
4. Cruise Control (Check List).
5. Descent technique.
6. Holding technique.
7. Approach and Final Check Lists.
8. Landing (Runway and after landing check lists).

EXERCISE 8.

1. Radio Navigation and Airways procedures.
2. E.A.T.—Holdings en route—Clearances—Correct R/T Procedure.
3. Flight Levels—Transition alt. and level.
4. Emergency turn procedures.
   Compulsory turn procedures.
5. I.F.S. Failure procedure.
6. I.F.S. Rectification.

EXERCISE 9.

1. Engine failure on take-off after decision speed V_1.
2. 3.E. circuits and landings.
3. 3.E. overshoot.
4. Engine failure on take-off before decision speed.
5. Unfeathering and restarting on ground.
6. 2E Circuit and Landings.

EXERCISE 10.

1. Instrument take-off.
2. I.L.S. Let down and approach.
3. A.D.F. approach.
4. P.P.I. step down or G.C.A. approach.
5. Instrument take-off with engine failure.
6. V.O.R. (General procedures).
7. V.O.R. Let down and approach.
8. General A.D.F. (Tracking on QDMs, QDRs, Homings, time and distance from Beacon).

EXERCISE 11.

Night Flying;

1. Take-offs and landings at maximum R.T.O.W.
2. Overshoots.
3. Take-off with Simulated engine failure.
4. 3.E. Landings.

EXERCISE 12.

Final Check—to include;

1. Instrument Rating Test.
2. Periodic Check.

NOTE—A Progress Check will be carried out at the end of each week's flying programme, on exercises already completed by the Student Pilot.

ADDITIONAL EXERCISES

4751. H.57419. 6.6. 500. 1/69. Hely Thom Ltd.