No. 54

Aquila Airways Ltd., Short Solent flying boat, G-AKNU, crashed between Chessel and Brook on the Isle of Wight, on 15 November 1957. Report released by the Ministry of Transport and Civil Aviation (UK). CAP 149.

Circumstances

At approximately 2246 hours the aircraft took-off from Southampton Water on a scheduled flight to Lisbon, en route for Madeira, with 50 passengers and a crew of 8. It made a normal climb and three minutes later passed a routine departure message to Southern Air Traffic Control Centre, London. At 2254 hours, however, the radio officer called the Aquila base at Southampton and transmitted this message: "No. 4 engine feathered. Coming back in a hurry." Approximately one minute later the aircraft crashed into the face of a quarry between Chessel and Brook on the Isle of Wight. The wreckage caught fire and, despite the efforts of people who quickly came to the scene, none of the crew and only fifteen of the passengers survived.

Investigation and Evidence

The crew were properly licensed and adequately experienced for the flight.

The captain's total flying hours amounted to 11 000, of which 6 000 were in command. On Solent aircraft he had flown 783 hours as first officer and 445 hours as captain, and, in addition to this flying boat experience, he had flown 1 000 hours in command and 300 hours as second pilot on Catalina amphibians, and 786 hours as first officer on Hythe flying boats.

The Commissioner was satisfied that, on departure, the aircraft had a valid Certificate of Maintenance.

The evidence of what occurred on the last flight was provided by witnesses from the ground, two surviving passengers, and by evidence discovered on examination of the wreckage. The facts established were as follows:

At a time said to be not long after the take-off the passengers felt the aircraft dip and noticed a change in the engine noise.

The Hampshire ground witnesses thought the aircraft was flying unusually low south of Beaulieu, but they established that up to the time when it reached the coast it was approximately on course.

The aircraft was seen to cross the Isle of Wight coast on a southerly course, but about three miles east of the point where its previous course would have taken it. Again, the witnesses spoke of it as being low.

Shortly before the crash, the steward went around warning passengers to keep their safety belts fastened; the illuminated notice to this effect had never been switched off (it was the practice not to switch it off until an altitude of 1 000 feet was reached). One passenger witness said that the steward appeared tense and said that "Things were a bit sticky"; according to another passenger the steward said: "It is a bit bumpy; please keep safety belts fastened".... They both put the steward's visit at 3 to 5 minutes before the crash, which would be before crossing the Isle of Wight coast ..... The emergency message was transmitted at 2254 hours and so far as can be checked the crash took place at about 2255 hours - approximately one minute after the emergency message.

According to the Isle of Wight ground witnesses, the aircraft became progressively low, and the passenger witnesses stated that they felt dips as though the aircraft was descending and pulling up. For the last mile or two of flight the landing lights were on, in the "ahead" position.

There was no sign whatever of any fire on board before the crash.

Immediately before the crash, G-AKNU's landing lights illuminated the hill top ahead. At about the same time, the aircraft was seen to bank sharply to starboard. Until then, its course over the Isle of Wight had represented a slight but continuous starboard turn. The point of impact was approximately 300 feet above sea level.

The examination of the wreckage and ground marks established the following facts:

1) At the moment of impact the aircraft was banked 45° to starboard.

2) At impact both port engines were under power, but neither starboard engine was under power.

3) The starboard inner propeller was not feathered, and was, therefore, "windmilling".

4) The starboard outer propeller was fully feathered.

5) At impact the aircraft's speed was close to, if not at, the stalling point.

6) There was no mechanical defect in any engine.

7) The fuel cut-off actuators for both starboard engines were at the "stop" position.

8) The state of the ancillary equipment (magnetos, high-tension ignition harness, fuel injectors and fuel pumps) could not be ascertained owing to fire, but sufficient evidence was available to show that the driving system of the magnetos and the pump drives for the Nos. 3 and 4 fuel pumps had not failed.

From the above facts the following inferences were drawn: between Beaulieu and the Hampshire coast something out of the ordinary had happened, and over the Solent the aircraft made a turn to port followed by a turn to starboard. As the emergency message indicated, feathering drill had been carried out to the No. 4 (starboard outer) engine.

The cause of the accident was clearly the stoppage of both starboard engines, and the immediate question is why did each of them stop. As to the starboard outer (No. 4) engine, it is clear that the captain either had, or thought he had, some trouble with this engine. In the Commissioner's view, the turn to port over the Solent was, in the circumstances, consistent only with an intention to return to the base in Southampton Water, and it follows, therefore, that the trouble became apparent at or before the crossing of the Hampshire coast. A mechanical defect in the engine itself is ruled out by what was discovered from the wreckage, and the possibilities theoretically are that there was either

a) a defect in some ancillary apparatus, or

b) a defect in some instrument, giving the crew the false impression that the engine had developed a defect, or

c) that the engine had been stopped by an accident, or

d) that there was no defect in either engine or instrument but that some defect had occurred in the other starboard engine and had been mistaken for the starboard outer engine.

It was pointed out at the Inquiry that the pilots have no instrument before them indicating in the case of engine failure which of their four engines has become inoperative. They have an rpm indicator, but owing to the operation of the constant

speed unit a failed engine would automatically pick up speed and all that the indicator would show would be a momentary drop followed by recovery. The same applies to the boost indicator. The flight engineer, however, has to the top left of his station a set of four torque meters, and these provide an immediate and positive indication of the loss of power in any engine. It was not thought that a mistake by the pilot as to which engine had failed could persist for more than a minute or two at the outside; he would be bound to consult the flight engineer either over the inter-communication system or by sending the first officer back to ascertain what the flight engineer knew, and it is inconceivable that during the five minutes or so of flight left after leaving the Hampshire coast, the captain and flight engineer between them did not appreciate which engine or engines had initially failed. Some criticism was voiced at the Inquiry of the inter-communication system which required the captain to use a hand to draw his microphone towards him; if his hands were literally full in coping with an emergency, he would be unable to use the system. This criticism is not a new one, but it was not thought to have any bearing on this accident. The flight engineer could, at any time, use the inter-com, and the first officer was always available to assist. The fourth possibility can, therefore, be ruled out - that the starboard outer (No. 4) engine was mistakenly feathered after a defect in the starboard inner (No. 3) engine, and it was thought unlikely that the third possibility (accidental stoppage) took place. There was no evidence available to indicate which of the other possibilities may have caused the No. 4 engine to develop a real or apparent defect.

The failure of one engine on a four-engined aircraft is not serious. The flying boat could still climb and there was nothing in a single engine failure to stop a normal return to base which the Commissioner felt had been commenced by the turn to port over the Solent. The subsequent turn to starboard over the Solent indicated that at or before that time the starboard inner engine, as well as the starboard outer engine, had stopped. The real cause of this accident must be sought in the reason for the stopping of that engine. While the theoretical possibilities causative of this stoppage are the same as those given above, there is, as regards this engine, the important clue yielded by the examination of the wreckage, i.e. the position of the engine cut-off actuator.

In view of its importance to the Inquiry, it is necessary to describe the working of this fuel cut-off. It effects a positive interruption of the fuel supply and is mechanically operated by an actuator consisting of a screwed shaft which is driven either backwards or forwards by a split-field motor. The motor is controlled by a change-over switch on the controls roof panel. When the switch is turned from the upper or "run" position to the lower or "stop" position, electric current passes through the "stop" field and the motor moves the screwed shaft until, at the limit of travel, a limit switch interrupts the current. A diagram of the actuator circuit is given in Figure 34 and a photograph of the roof panel in Figure 35. The operation of this switch is part of the feathering drill.

Owing to their nature, it was impossible for the fuel cut-off actuators to have changed position as a result of the crash. All four actuators were found; both port ones were at the "run" position and both starboard at the "stop" position. In the case of the starboard outer engine, that position is consistent with the feathering of which the emergency message spoke, and is one of the grounds upon which it was found that the propeller had indeed been, as the message indicated, feathered. But the starboard inner propeller had not been feathered. Operating the cut-off is not performed until after the actual feathering of the propeller blades and there was no operational reason for this cut-off actuator to be in the position in which it was found. It is reasonable to infer, therefore, that this cut-off was not operated deliberately and advisedly, but preceded the engine stoppage and, in fact, caused it.

The investigation into the decisive cause of the accident is thus narrowed down to the question of what operated the actuator. It could only be so actuated by current flowing through the "stop" winding of the motor. In the circumstances of this case, that current could only have been caused to flow either by the accidental operation of the switch or by some electrical failure. Experiments conducted since the accident established that a short circuit between the two leads to the actuator would not cause it to move to the "stop" position. In fact, electrical failure could not occur unless there was, firstly, a break in the "run" lead; secondly, a breach in the insulation of the "stop" lead; and thirdly, a breach in the insulation of some other live conductor by which current passed by contact to the broken "stop" lead. The coincidence of these three separate failures is, to say the least, most unlikely.

As to the accidental operation of the switch, two possibilities were considered. The first was that the captain or first officer had determined to switch on the pitot head heaters and had, in error, operated the starboard cut-off switches instead. Reference to Figure 35 shows that the two pitot head heater switches are mounted to the right of the two switches controlling the starboard fuel cut-offs; the pitot head heater switches are up when off and down when on, and the cut-off switches are up for "run" and down for "stop".

The second possibility was that when the starboard outer cut-off switch came to be operated as part of the feathering drill for that engine, the starboard inner switch was accidently tripped in the course of the switching.

In favour of the first theory is the fact that it had happened before. Another captain had some years previously operated the cut-offs in mistake for the pitot head heaters and had lost considerable height before discovering what had happened. As a consequence of that mishap semi-circular metal guards had, in consultation with the Air Registration Board, been fitted outside the fuel cut-off switches. In the circumstances of this case, the repetition of this mistake is highly unlikely for the following reasons.

Firstly, in the prevailing climatic conditions the pitot head heaters would ordinarily have been switched on before take-off. Secondly, both pitot head heater switches would be operated at the same time, and this type of accidental operation would, therefore, cause both starboard engines to fail at the same time, and the fact that only one was detected as having failed and was feathered is on this hypothesis only explicable by a lack of liaison between the captain and the flight engineer, which was not believed to have happened. (This mistake could hardly have happened after the feathering of the starboard outer engine because the switches would then be in different positions, the inner one up and the outer one down and the error would immediately be apparent). Moreover, as will be indicated below, the course of the aircraft points to the view that one engine failed some time before the other.

The accidental switching of the starboard inner cut-off switch when operating the adjoining starboard outer switch is difficult to visualize as having occurred. The switches were reasonably stiff and they are one and a half inches apart. With a heavily gloved hand, it might be possible to effect this accidental operation, but this was regarded as something unlikely to occur.

A third possible cause of the accidental operation of the No. 3 fuel cut-off switch was suggested. It was that when, following the real or apparent failure of the starboard outer (No. 4) engine, feathering drill was carried out to that engine, the No. 3 fuel cut-off switch was operated in error for the No. 4 fuel cut-off switch. In consequence the starboard inner as well as the starboard outer engine would

be stopped and the behaviour of the aircraft would cause the captain sooner or later to call for a recheck of the feathering procedure by the first officer. In this recheck the latter would detect that the No. 4 fuel cut-off switch had not been operated and would move it to the "stop" position. In the emergency conditions then prevailing it is possible that this operation of the No. 4 switch would not lead the first officer to appreciate that he had previously operated the wrong switch, and the error, therefore, could go uncorrected. This again can only be described as an unlikely possibility.

The position thus is that the operation of the No. 3 cut-off actuator could have been effected in a number of ways, none of them proved, all of them unlikely. The aircraft's movements give a little assistance in assessing the comparative weight of these theories. The turn to port over the Solent, clearly to return to base, followed by the turn to starboard, which the Commissioner did not doubt was involuntary, pointed to the failure of the starboard inner engine occurring a minute or two after the failure of the starboard outer engine. This increases the unlikelihood of electrical failure by adding another coincidence, that of the time element, to the three already mentioned. It is also adverse to the pitot head heater switch theory but it is consistent with either of the other two theories.

It remains to consider whether the captain was in any way at fault in what he did when confronted with the emergency. The stoppage of the second engine created a real and very rare type of emergency. It would at once swing the aircraft to starboard and, whether he knew or not what had happened, the captain would find himself in this dilemma: he could only retain ability to turn to port by retaining speed, and speed he could only retain by putting the nose of the aircraft down and losing what height he had left. On the other hand, he could only retain the height which was so vitally necessary to survival at the expense of slowing the speed, and that, in turn, meant promoting an involuntary turn to starboard. He would know from his altimeter that he was dangerously low, and in the pitch black night in question, he probably did not know his precise position. Had he been certain of position he could have throttled back his port engines while over the Solent and glided down to make a landing on the water, and in daylight that is probably what would have happened. But in the darkness, and with what was described as a glassy sea, landing on the water was, although not a hazardous, a difficult task, and in fact, it may well have been that the involuntary turn to starboard took the aircraft over the Isle of Wight before a decision of any kind could be reached. It was suggested that he should have feathered the No. 3 propeller to reduce drag, but if (as is almost certain) he did not know the cause of the failure of the No. 3 engine, he was fully justified in keeping the engine turning, by keeping the propeller windmilling, in the hope that the engine would restart. The Commissioner did not find anything in the evidence giving validity to any criticism of the captain's handling of the aircraft in the emergency.

Probable Cause

The accident was caused by the stoppage of the No. 3 engine at a time when the No. 4 engine was stopped. The cause of the stoppage of the No. 4 engine is unknown. The cause of the stoppage of the No. 3 engine was either an electrical failure in the fuel cut-off actuator circuit or the accidental operation of the cut-off switch.

Observations and Recommendations

Fuel cut-off switch

The accidental operation of such a switch may endanger an aircraft and if not traced and rectified may lead to disaster. It is, therefore, important that steps should be taken to minimize the risk of accidental operation. On the Solent III this risk could arise from the

positioning of the starboard switches in proximity to the pitot head heater switches and from the lack of any guard to the cut-off switches. Such proximity should where possible be avoided in designing instrument panels, and where it cannot be avoided either the switches ought to be of such differing design as to make confusion with their neighbours impossible, or the switches should be effectually guarded. The Commissioner doubted whether the semi-circular metal strips fitted outside these switches on Solent III's after the captain's mishap were sufficient to eliminate the risk but was informed that since this accident Aquila have fitted the switches on their Solent III's with a shield between the two switches and a bridge over them, so that to operate them a finger has to be inserted under the bridge.

Maintenance

No evidence of any kind of defective maintenance was found on examination of the wreckage. Had it not been for evidence of the No. 2 gill motor being found disconnected no criticism could have been levelled at the quality of the maintenance and inspection. But the facts that the gill motor could have been installed without being coupled to its shaft, and that checks which should have disclosed that defect were said to have been carried out but did not disclose the defect, are bound to have raised doubts as to the quality of maintenance and inspection generally and as to the reliance to be placed upon maintenance check sheets initialled to show that checks have been performed. After consideration of all the evidence on maintenance it was not felt that this one instance of defective maintenance should vitiate the rest of the evidence. The Commissioner did not consider it necessary to make recommendations upon the tightening up of both maintenance and the documentation of maintenance. There was nothing wrong with the maintenance schedules or with the system of maintenance and inspection. Efficiency must depend on those who carry out the work and inspect it. It was a failure of the human element that led to the affair of the gill motor, and no recommendation can prevent such failure. Safety in the air demands that maintenance and inspection be conducted at an absolute level of integrity. This entails the observance of high ethical standards by those who take part in the work, and it is the duty of management to see that those standards are accepted and reiterated and never compromised.

Crew Training

The Commissioner was not concerned with a pilot's or engineer's training in the management of aircraft in general but with his training upon a particular type of aircraft. Different types vary in their characteristics and controls and it is obvious that a major function of training must be to fit the crew member to the particular type of aircraft with which he is to deal and to equip his mind not only with the knowledge but also with the reactions necessary to deal with the various situations that may arise. The instilling of procedures into a pilot's or engineer's mind so that his reactions are both instinctive and accurate must be part of normal training, and the instilling of emergency procedures must rank high in order of importance not only because the consequences of an emergency may be so serious but also because daily experience, which may be relied on to confirm normal procedures, does not produce experience of emergencies.

To these ends the current regulations impose two broad requirements as regards scheduled flight operators. Each crew member firstly must hold a valid licence entitling him to act in the position he occupies upon the type of aircraft he is called upon to operate, and secondly must have passed a competency check within a prescribed time before any given flight. The competency check is administered by the operators, but they have no legal responsibility for the tests required

for the obtaining of a licence, including the test required for the inclusion of an aircraft type rating in a licence. In practice, however, Aquila supplied both the aircraft and the services of a pilot to give a certificate for the purposes of the type rating tests relevant to this Inquiry.

The operation of the legal requirements as regards training upon a particular type of aircraft can be illustrated by reference to the history of the first officer. He came to Aquila with a commercial pilot's licence endorsed in Group 1 for Auster Variants. In order to be licensed to act as first officer on Solents he had to have that type included in the Group 2 type rating. To obtain this he was required by virtue of Regulations 101 and 104 of the Air Navigation (General) Regulations, 1954, and the handbook CAP 54 therein referred to, to pass a written examination upon the airframe and engine of this type (the syllabus for which includes emergency procedures) and to produce a certificate showing that he had performed satisfactorily the manoeuvres detailed in the handbook. The manoeuvres are, for a Group 2 rating, "six take-offs and six landings, by day or by night, as pilot in charge or as pilot under supervision". The certificate has to be given by a licence holder who has the relevant type of aircraft in his Group 1 rating. In the case of the first officer this meant that he qualified for a licence authorizing him to act as second pilot on a Solent aircraft after 45 minutes at the controls and without any practical, as opposed to written, test in emergency procedures.

Before permitting the first officer to fly as second pilot, however, the operators were required to administer the competency check above referred to, and were under the general duty imposed by Article 18 of the Air Navigation Order, 1954, to "ensure that every member of the operating crew.... is fully instructed in the duties and responsibilities to be discharged by him ...." and also to furnish a proper Operations Manual. The legal provisions thus envisage that responsibility for the practical, as opposed to theoretical, testing and training shall fall largely upon the operators and that, as regards second pilots, the practical tests required by the Ministry for inclusion of a type rating in the licence shall be merely introductory and partial. The amount of training adjudged by the operators to be necessary after the first officer had qualified for the Solent group rating can be measured by the fact that they required him to fly as supernumerary for 112 hours between taking his type rating test and his first competency check.

It is important that operators should appreciate the full nature of the burden which both the law and prudence casts upon them in the matter of crew training. In this case there were some shortcomings in Aquila's approach to the matter.

By Article 18 (5) of the Air Navigation Order and Regulations 46 of the Air Navigation (General) Regulations, 1954, an operator is required to furnish to crew members an Operations Manual containing inter alia "Emergency Flight Procedures". Prior to 1957, Aquila were using a manual dated 1952, which was, by 1956, recognized as being "hardly up to the job", and it was decided to compile a new manual. The old manual contained no feathering or unfeathering drill, and no engine fire drill. It was, however, supplemented in practice by making available to crews copies of a manual issued in respect of Solent III's and IV's by Tasman Empire Airways Ltd. Aquila possessed either two or three copies of this - one kept in the crew room at Southampton and the other, or others, available to crews. This manual did contain feathering procedures and engine fire drill. Engine fire drill was also printed on a card fixed to the gap in the centre of the roof instrument panel - see Figure 35. This drill included feathering procedure. Work on the new Aquila Manual progressed sufficiently for an incomplete manual to be issued to crews early in 1957. This took the form of duplicated sheets held in a loose leaf binder. In the new manual, provision was made for sections entitled

"Check Lists", "Emergency Operations (Technical)" and "Emergency Equipment". In the incomplete manual, these sections were described as "Not yet issued". One of these incomplete manuals was recovered from the wreckage of G-AKNU. No copy of the old manual was recovered from the wreckage, and whether any part of this was still in force is obscure - it was stated never to have been withdrawn.

Whether the provision of an obsolete manual plus a new incomplete manual plus another operator's manual is a compliance with the Regulations is not a question which the Commissioner was called upon to determine, but it was clearly a cumbersome and undesirable practice; and the delay in issuing the remaining parts of the new manual pointed to a lack of appreciation of urgency in the matter, an attitude which can also be detected in the failure to administer the six-monthly check to the first officer on or before the due date (5 November). It can further be said that the absence of any scheme of training or syllabus or training check lists placed a heavy burden on the flight captain's memory.

The Commissioner fully appreciated that small operators cannot adopt the elaborate training methods of big airline corporations; but, nevertheless, thought it reasonable to suggest for consideration that any operator, however small, should devise and commit to paper a scheme of crew training and the appropriate check lists, and that copies should be available for inspection and comment by the Ministry.

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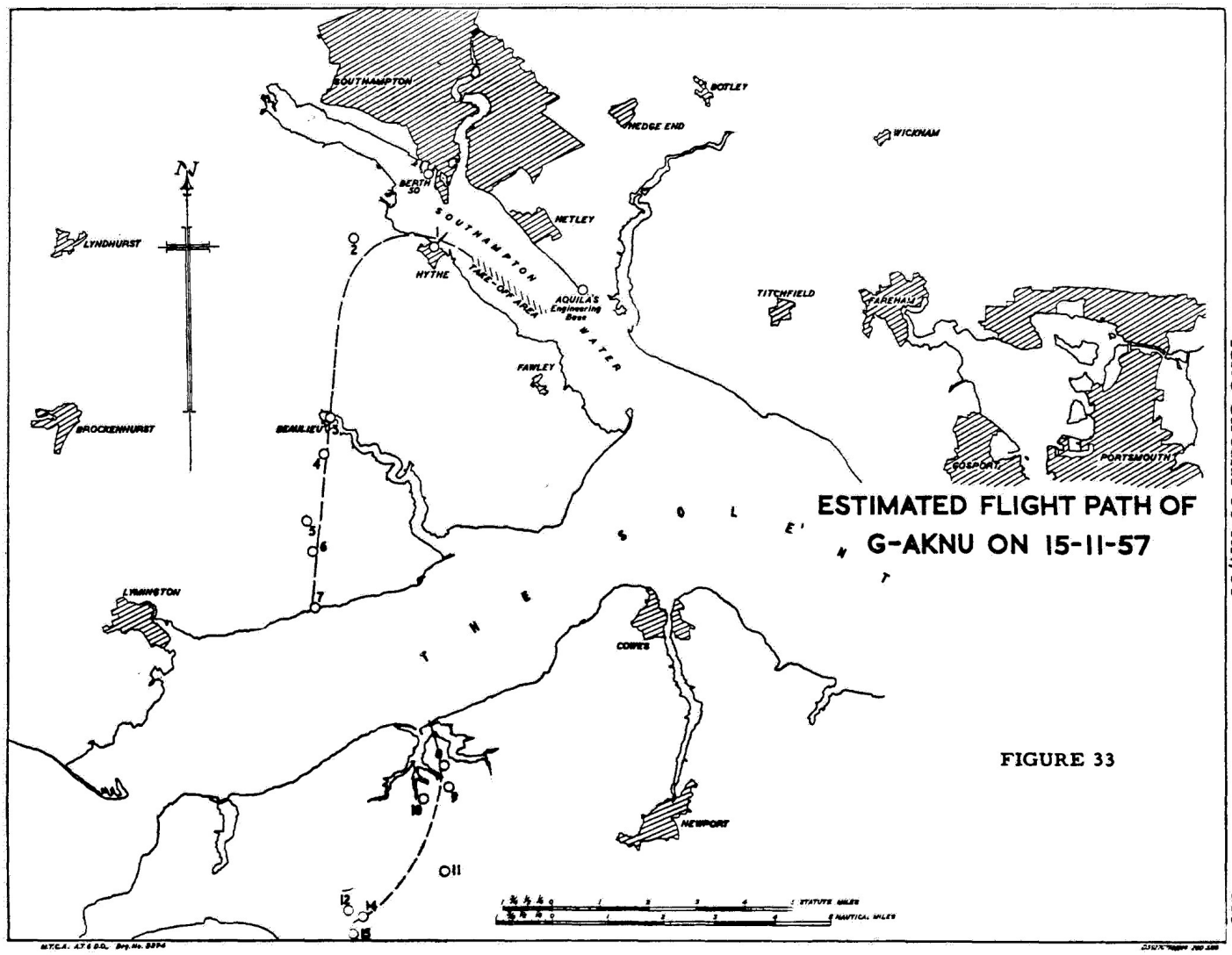
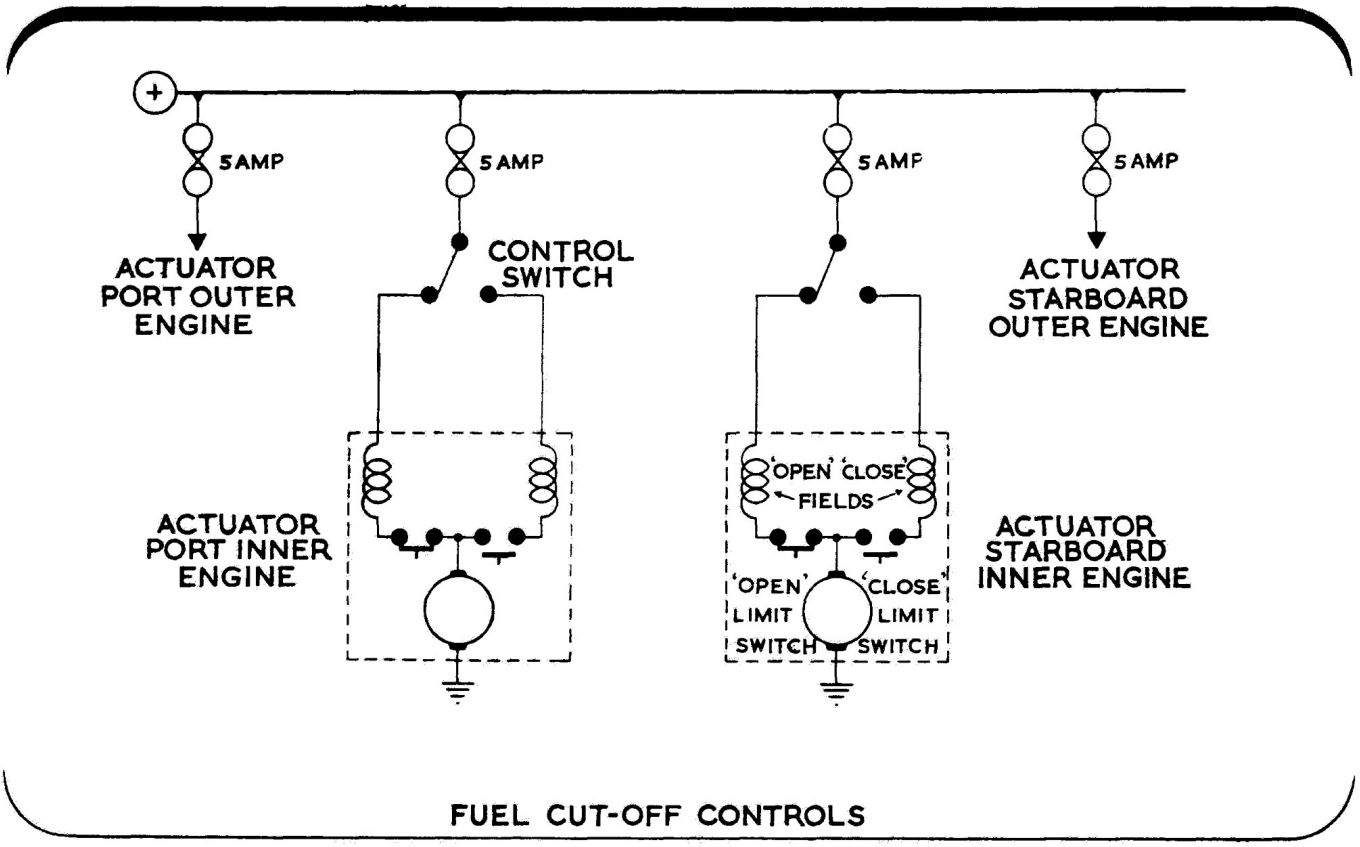
ICAO Ref: AR/522



ESTIMATED FLIGHT PATH OF G-AKNU ON 15-11-57

FIGURE 33

FIGURE 34 — FUEL CUT-OFF CIRCUIT DIAGRAM



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REPRODUCTION OF ROOF INSTRUMENT PANEL

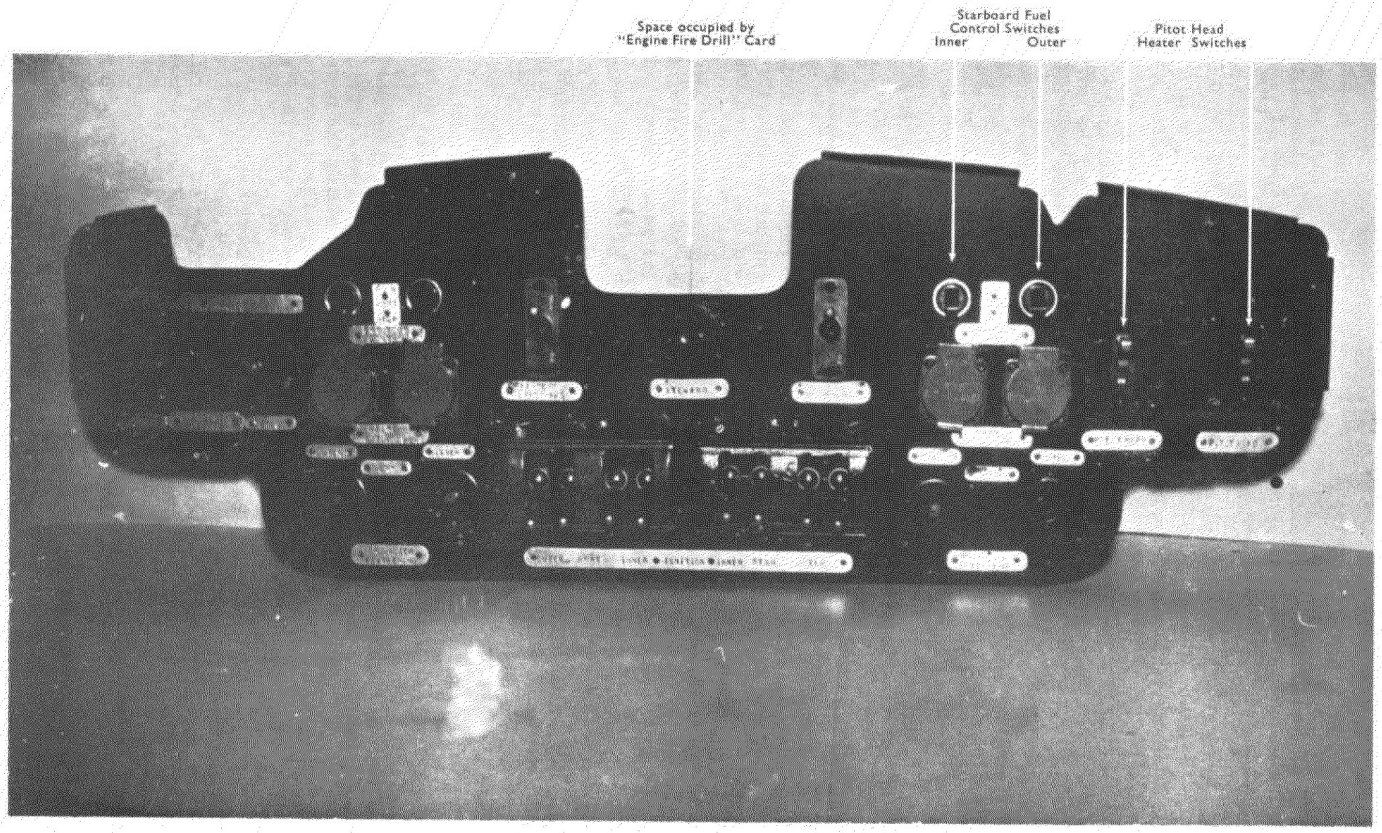

FIGURE 35