No. 9

Scottish Airlines (Prestwick) Limited, Avro York, G-ANSY, crashed at Zurrieq, Malta on 18 February 1956. Report of Court of Inquiry appointed by His Excellency the Governor of Malta.

Circumstances

On 18 February at 1221 hours Greenwich Mean Time the aircraft, which had arrived at Malta at 1046 hours on the same day, took off from Luqa Aerodrome, Malta on a flight to Stansted, England. The aircraft became airborne about two thirds of the way down the runway and the undercarriage was retracted. About this time black smoke was seen coming from the No. 1 engine. The aircraft instead of turning to starboard as instructed by the Ground Control appeared to drift to port. The port wing dipped steeply and at 1222-23 hours the aircraft nose-dived into the ground on the cliffs near Zurrieq and blew up on impact. The crew of 5 and 45 passengers were all killed.

Investigation and Evidence

Evidence confirms that the aircraft climbed in steps at a slow forward speed, flying in a tail-down, nose-up attitude and with a varying degree of smoke emanating from No. 1 engine. The climb continued in this manner until a maximum height of approximately 700 - 800 feet a.m.s.l. was achieved with a "crabbing" or "yawing" motion to port which was taking it towards higher ground. Meanwhile the smoke from No. 1 engine fluctuated in volume and colour until at maximum altitude it disappeared. Witnesses stated that at that time the engines of the aircraft had an unusual "booming" sound and the aircraft seemed to be in an unusual nose-up attitude. The aircraft reached its maximum height approximately half way in its flight, i.e. between Qrendi village and Zurrieq. Shortly after passing Qrendi village the aircraft began to turn to port towards the south-east where it passed over a ridge marked 400 feet a.m.s.l. At this point the aircraft was observed to be flying normally except that the engines seemed to have tremendous power and their vibration was felt by the driver of a car nearby. Shortly thereafter the aircraft was observed to falter in the air, its wings tilting both to port and starboard before finally dropping the port wing and turning over in a dive.

From the inspection of the wreckage it was determined that the aircraft was almost vertical at the time it struck the ground. The whole of the fuselage forward of the freight door aperture was destroyed by ground impact and all four engines had been torn from their mountings. On examination it was found that Nos. 2, 3 and 4 engines were functioning satisfactorily at the time of the accident. No. 1 engine had suffered an internal fire and all the induction flame trap elements had been severely burnt adjacent to the inlet valves of both cylinder blocks. The severe heat of the internal fire in the induction system had consumed the impeller. Moreover, the boost enrichment capsule was found to have two cracks.

The position of the piston in the remains of the flap hydraulic actuating jack indicated that the flaps were UP at the time of the ground impact and, as far as could be ascertained from the remains of the flap and flying control systems, no evidence of malfunctioning was found.

The propellers were also completely stripped and were all found to be in fine pitch setting.

The engine fuel master cocks for Nos. 1, 2 and 3 engines were found to be ON, but the master cock for No. 4 engine was not located.

The parties appearing at the Inquiry put before the Court all the circumstances which might have a bearing on or possibly disclose the cause or causes of the accident. The following causes were considered:

Sea gulls

No proof of damage from this source was forthcoming.

Sabotage

Having carefully considered all the facts the Court felt that, although there was undoubtedly opportunity for a sabotage device to have been planted in the aircraft at Nicosia by persons who, in view of the conditions prevailing at Cyprus, would presumably seek an opportunity, nevertheless the state of the evidence was certainly not such as to lead the Court to conclude that the cause, or one of the contributory causes of the disaster, was an explosive or incendiary bomb.

Excess of Weight

Examination of the Load Distribution and Trim Sheet appertaining to this flight and of the relevant evidence indicated that the aircraft was overloaded to the extent of 297 Kgs. The Court considered that this overload did not impair the take-off of the aircraft and was, therefore, of the opinion that the above-mentioned slight excess in weight should not in any way be considered as a contributory cause of the accident.

Engine failure

Evidence shows that there was a failure in No. 1 engine and it is considered that this was due to the failure of the boost enrichment capsule in the carburettor.

This capsule was found to have two cracks at the outside diameter or periphery of the second convolution from the top. These cracks were intergranular associated with corrosion and normal stresses, the stresses being those to which the convolutions were subjected under standard working conditions.

The failed capsule prevented the boost enrichment needle from moving to give the correct jet area during take-off power conditions, and resulted in weak mixture. This weak mixture gave rise to burning on the inlet side of flame traps, causing these to disintegrate but not to burn through completely. Particles of the burnt foils were trapped between the inlet valves and the seat inserts. This would intensify the burning, and, finally, the protective value of the flame traps would be overcome, and there would be a series of backfires or continuous burning through the supercharger. This burning would cause the supercharger rotor to disintegrate, and the engine would then cease to be a useful agent in the aircraft.

An investigation was undertaken by Rolls Royce Limited to ascertain whether normal ground and pre-flight checks would enable detection of a failed boost enrichment capsule, and this investigation was carried out on a York aircraft of the same type as G-ANSY. A simulated capsule failure was produced by blanking off the boost pressure supply to the carburettor chamber.

Under these conditions the engine was checked for R.P.M. response at standard boost up to +14 lbs./sq. in. Boost and single ignition checks were made at the same settings. The engine behaved in a standard manner and no evidence of irregular running could be detected.

Subsequently, Rolls Royce Limited carried out a further test on the same type of engine on a test bed with an assimilated failed capsule. The engine was subjected to +18 lbs. boost at 3 000 R.P.M. for half an hour and at the end of the test, after dismantling the engine, the flame traps and the supercharger were not damaged.

The Court was satisfied on the evidence that the failure of the boost enrichment capsule could not have been discovered by the normal exercise of vigilance reasonably expected from the Operators and their staff.

When the aircraft became airborne, it is conceivable that No. 1 engine was subjected to incipient pre-ignition due to partially burnt flame traps becoming incandescent together with the high charge temperature brought on by weak mixture at high boost pressure delaying the burning in the cylinders and leaving very hot gases, which would ignite the incoming charge when the inlet valve opened.

This would cause the incomplete combustion indicated by carbon particles of unburnt fuel accompanied by a proportion of burning oil, shown by smoke emanating from the exhaust stacks and would result in further burning of the flame trap matrix, particles being deposited on the inlet and exhaust valves and the seat inserts.

Continuous burning in the induction system would then occur, transmitting a heatwave to the supercharger rotor and the supercharger casing, and this would eventually cause the complete failure of the supercharger.

As G-ANSY became airborne the supercharger was subjected to extreme temperature, due to the fire in the induction system (shown by black smoke from the exhaust stacks) upsetting the internal combustion engine cycle. This would produce a considerable drop of power from the outset.

On a broad estimate the progressive loss of power available from No. 1 engine at the take-off stage probably corresponded to the spreading of the continuous burning taking place in the induction system, until the supercharger rotor was finally consumed by the internal fire. It is thought probable that the cessation of dense smoke coincided with the complete burning through of the supercharger rotor, causing a reduced airflow through the engine. It is estimated, with a reasonable degree of probability, that thirty seconds after the take-off the engine ceased to be a useful agent to the aircraft.

Thereafter, the propeller was windmilling. The gases were still burning in the induction system keeping the flame traps incandescent. Although the boost would then be reduced to more or less the zero reading, the pumping action of the pistons, consequent to windmilling, would maintain a reduced airflow through the engine and would eject particles of burnt flame trap elements or sparks through the exhaust stacks.

The developments of the failure of No. 1 engine, outlined in the foregoing paragraphs, go to show that the density of the smoke coincided and varied with the intensity of burning in the induction system. As the power of the engine diminished, the density of the smoke diminished, and, as the density diminished, the smoke must have appeared to onlookers at a distance to turn from a thick black colour to gray and vapourous. Moreover, the smoke was intermittent owing to the fact that particles of burnt flame traps were being deposited at intervals on the valves and seat inserts. This explains satisfactorily the apparent differences on the subject of smoke in the depositions of the witnesses of the flight.

A slight tendency to overspeed momentarily in No. 1 engine during take-off from Abu-Sueir was recorded in the technical log by the captain on the previous sector of the flight. His entry runs as follows:-

> "A slight tendency to overspeed momentarily in No. 1 engine during take-off. The engine surged up to 3150 R.P.M. but was immediately controllable by the pitch control lever and I recorded the defect on 18 February during the flight Abu-Sueir to Luqa. I had first noticed this slight surging tendency on the previous day during the take-off from Luqa."

This defect was recorded in the technical log as of the "deferred" category, which means that the aircraft was not thereby made unserviceable but the defect would be rectified on return to base at Stansted.

Judging by the subsequent events, the Court is inclined to think that the tendency to overspeed at take-off on the previous sectors, as reported by the captain, could have been the result of high induction temperature caused through weak mixture, and aggravated by partially burnt flame traps, momentarily upsetting the mixture strength and resulting in an engine revolution surge.

With regard to the 'B' Bank No. 6 cylinder rear exhaust valve causing the popping noise from No. 1 engine on the rundown check prior to the fatal flight, the evidence shows that when this defect was noticed the following action was taken by the Flight Engineer and the Station Engineer on duty: - the cowlings were removed as well as some of the exhaust stubs; the valve was examined through the exhaust port aperture and found to have stuck open; the propeller was turned by hand for the valve to be examined; it was scraped and a little thin oil was applied to it; the engine was then turned over and the valve freed itself; a check was carried out at 'O' boost; the R.P.M. which previously was 2200 now came back to 2350, and everything was normal after a complete run-up check.

It is considered unusual for carbon deposit in the area of the head of the valve and stem to restrict the function of the exhaust valve in the valve guide.

It is conceivable that the restriction that the Duty Station Engineer cleaned on the valve prior to take-off from Luqa Airfield could have been minute particles of flame trap elements, which caused the valve to stick in the open position. These particles would be consequent to the previous burning of the flame traps, particularly as the flame trap most affected by burning was located in 'B' Bank No. 6 cylinder area.

The pre-flight overspeeding and valve defect abovementioned would not, at the time, be related to the failure of a boost enrichment capsule and subsequent flame trap failure, unless the minute particles of flame trap elements were noticed. However, as these particles would be combined with carbon deposit, it would be most difficult to notice them.

The Court was therefore of the opinion that, in the circumstances, the rectification action taken with regard to the overspeeding and the valve was satisfactory.

The failure of No. 1 engine alone should not have caused the accident, because aircraft of the type York G-ANSY have a three engine performance. Normally, therefore, a pilot should be able to cope with that failure, particularly as, in his routine emergency check tests under the mandatory six monthly check system, he would be trained, as in point of fact the subject captain was trained, to take off when one engine fails.

Handling of Aircraft

As the aircraft took off with instructions from the Control Tower to turn right, it is clear that there was a partial failure of the critical (No. 1) engine, which failure became complete in a period estimated at thirty seconds. At the time of the take-off the speed of the aircraft would be between the minimum control speed of 108 knots and the safety speed of 125 knots. At this juncture the pilot should have felt a progressively heavy footload on the starboard rudder pedal and also a yaw to port. The pilot should have then:

a) obtained flying speed in the shortest space of time by depressing the nose of the aircraft and flying parallel to the runway or ground;

b) corrected the swing to port by means of the rudder and rudder trim tab control in order to keep the aircraft straight on course;

c) put the starboard wing slightly down in order to assist rudder control and offset the resulting asymmetric power as well as the natural wind drift, and

d) when No. 1 engine failed completely - after rapid consultation with his engine instruments, which would then be probably showing 2500 R.P.M. and a fluctuating boost, due to windmilling of the propeller, feathered the propeller in order to minimise the drag from its windmilling and ensure a better three-engine performance.

From the flight path of the aircraft, according to the evidence as assessed, this remedial action was not taken. In fact, the aircraft was not kept straight after take-off but was allowed to drift to port, the nose was not depressed to maintain flying speed, and the propeller was not feathered.

These omissions, in the opinion of the Court, ultimately led to the disaster. It appears that the pilot sacrificed speed for height. The evidence confirms that the aircraft climbed in steps with a nose-up attitude and with a slow speed, at the same time yawing to port, thus indicating lack of speed and consequent loss of directional control.

It is true that, by this method of a stepped climb, the aircraft eventually gained an estimated height of from 700 feet to 800 feet above mean sea level which, in that locality, would be 300 - 400 feet above ground level. As a matter of fact, from the evidence available it is certain that the aircraft cleared the high ridge in the Qrendi area at about 300 feet above ground level.

The height reached by the aircraft at this time was sufficient for manoeuvring, but here again the pilot failed to depress the nose of the aircraft in order to gain flying speed and directional control. Instead, he still kept the aircraft in a nose-up or level attitude getting thus dangerously close to the minimum control speed and to the stalling range. It is considered that, as, at this time, the aircraft was approaching the coast with reasonable ground clearance, if the pilot had depressed the nose of the aircraft, he would have been able to fly out to sea. By failing to depress the nose of the aircraft, and keeping it in a nose-up or level attitude, the pilot committed himself further to a turn to port and to an approach to higher ground.

As the turn progressed, it appears that the pilot retracted the flaps (found fully retracted when the wreckage was inspected) without depressing the nose of the aircraft. This action must have increased the stalling speed of the aircraft and brought it down under minimum control.

To add to the difficulties, stemming from this series of errors, the aircraft, at this stage of the flight, that is when it was flying almost parallel and near to the coast, would be affected to a greater degree by the turbulence which would be expected to be felt in that locality, due to the prevailing gusty conditions.

The Court has kept in mind the possibility that the captain may not have feathered the propeller because he was still hoping to get some power from No. 1 engine, but it is considered that, in any case, he should have felt the drag on the rudder and aileron controls, particularly as the drag was being progressively accentuated by the diminishing directional control and by the ever increasing approach to minimum control speed and stalling range. Moreover, the boost gauge should have indicated conclusively that no power was being derived from this engine. It should be added that even if it were to be assumed that the pilot, for some unaccountable reason, had been unable to feather the propeller, the aircraft would still have been capable of a three-engine performance with the associated conditions of a windmilling propeller and an all-up weight of 68 282 lbs.

The captain had been trained in his routine Emergency Check Tests to take off with an assimilated engine failure. This test, however, according to the evidence before the Court, was carried out, not at the all-up weight of 68 000 lbs., but at a lesser weight of from 55 000 - 57 000 lbs.

The Court appreciates that neither the captain nor any of his crew or of the passengers survived to give explanations but, after giving due weight to this circumstance, the Court is still of the opinion that there was an error of judgment on the part of the pilot, because, however much the Court applied its mind, making all allowances, to the possibility of some reason which might explain the faulty handling of the aircraft, no such reason could be possibly found without sacrificing evidence and facts to sheer speculation and mere conjecture.

Probable Cause

The probable cause of the accident was the failure of No. 1 engine. However, failure alone did not cause the accident, which was caused by loss of speed and consequent loss of control through an error of judgment of the pilot.

Recommendations

Weight of Aircraft

Sub-section 3 of Section 43 of the Air Navigation (General) Regulations, 1954, authorises a method of computation of the weight of the crew and passengers in terms of a table of average weights in respect of an aircraft having a total seating capacity of twelve persons or more. It may be desirable to enact some limiting provision to the effect that, when the aggregate load of the aircraft comes to within a narrow specified margin of the maximum take-off weight, this fact alone would render inoperative the computation of the assumed weight, and, in any such case, the actual weight of each person should be ascertained by individual weighing.

Pilot training

It is suggested that at each six-monthly check of pilots it would be more advantageous, in similated cases of engine failure at take-off, that the weight of the aircraft should not be less than the maximum landing weight.

Torque meters

It is desirable that a further aid be given to the pilot to make sure that he is at all times aware of the power output on each engine. It is, therefore, recommended that Torque Meters or some equivalent device be fitted to aircraft not already provided therewith.

Replacement of boost enrichment capsules

The Court was informed by the Repair and Development Engineer of Rolls Royce Limited that the Company is now replacing all boost enrichment capsules by new ones whenever a Merlin 502 engine is returned for overhaul, irrespective of whether its overhaul life of 1050 hours has been reached or not. The Court understands that the Air Registration Board has approved this action.

Fire-fighting hoses

Bearing in mind that in the present instance the Royal Navy fire-fighting hoses could not be joined to those of the Royal Air Force because of a difference in diameter, it is recommended that suitable adapters be made available in order that the hoses can be joined as occasion requires.

Safety device for boost enrichment capsule

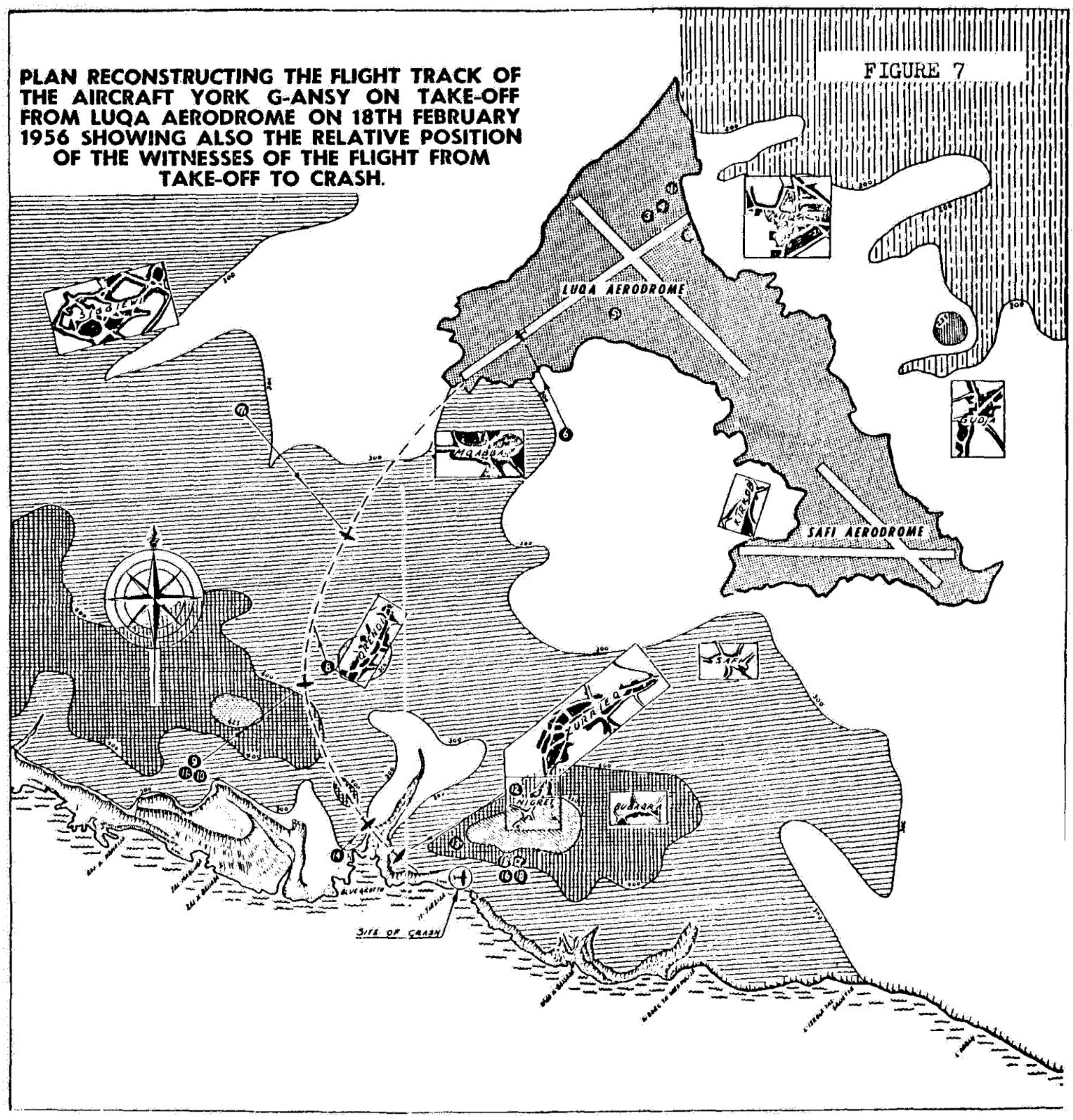
The balance effect of the boost enrichment capsule and the altitude capsule in the carburettor of a Merlin engine, through the medium of the two independent hinged connecting linkwork, controls the jet needle position in the jet orifice. The combined effect of both capsules is intended to provide suitable mixture correction for the engine at varying boost pressure and altitude conditions.

The starboard side capsule, controlling the altitude correcting jet needle in the event of a capsule failure, has a safety device which allows the jet to remain in the rich position at all altitudes above sea level. But the boost enrichment capsule, when punctured, will only allow the correct mixture to be maintained by the carburettor up to approximately +4 lbs. boost.

It is suggested that the boost enrichment jet needle be controlled by a spring balance device introduced into the linkwork mechanism, to allow the jet needle, when the capsule is punctured and expanded, to position itself in the jet orifice in a safe position, thus allowing a proportion of fuel to be delivered to the diffuser, and thereby creating a safety device also for the boost enrichment capsule in addition to the one already existing in respect of the altitude capsule.

- - - - - - - - - - - - - - -

ICAO Ref: : AR/474



PLAN RECONSTRUCTING THE FLIGHT TRACK OF THE AIRCRAFT YORK G-ANSY ON TAKE-OFF FROM LUQA AERODROME ON 18TH FEBRUARY 1956 SHOWING ALSO THE RELATIVE POSITION OF THE WITNESSES OF THE FLIGHT FROM TAKE-OFF TO CRASH.

Figure 8

BEFORE - This photo was taken just a few moments before Avro-York, G-ANSY, crashed into the ground on the cliffs near Zurrieq, Malta, on 18 February 1956.

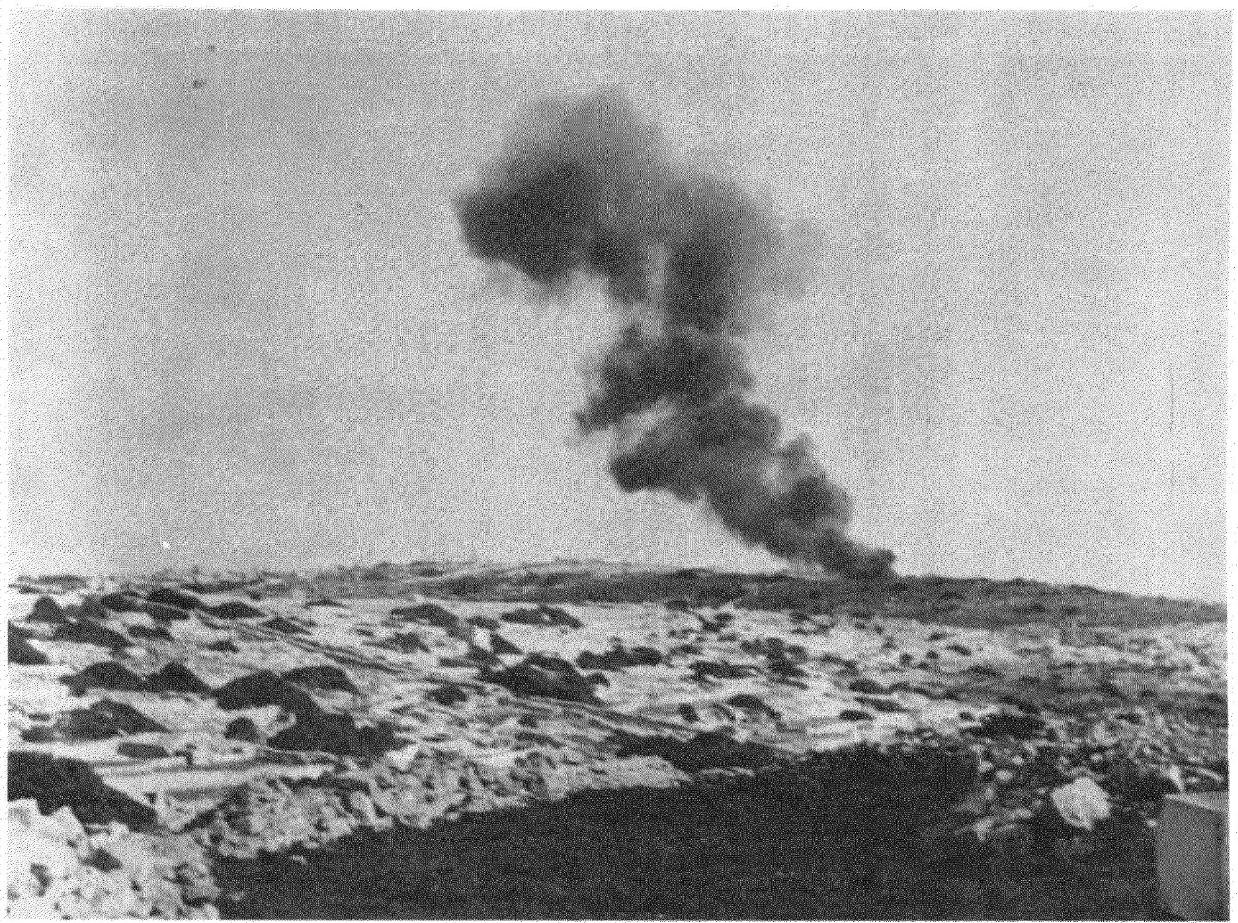


Figure 9

AFTER - The same Avro-York a few minutes later. It nose-dived into the ground and blew up on impact killing all 50 persons aboard.

Figure 10
General view of wreckage area of Avro-York, G-ANSY