

SCANNED COPY OF FINAL REPORT

Boeing 707 ZS-EUW

REPORT BY THE BOARD OF INQUIRY APPOINTED BY

THE HONOURABLE THE MINISTER OF TRANSPORT

UNDER SUB-SECTION (1) OF SECTION 12 OF THE

AVIATION ACT, 1962 (NO. 74 OF 1962)

TO INVESTIGATE AND REPORT ON THE ACCIDENT

TO

SOUTH AFRICAN AIRWAYS BOEING 707=344C AIRCRAFT

ZS-EUW, "PRETORIA", AT WINDHOEK ON

20TH APRIL, 1968.



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(i)

TO THE HONOURABLE THE MINISTER
OF TRANSPORT.

Sir,

We have the honour to report that we have completed our investigations into and our findings on the accident to South African Airways Boeing 707-344C aircraft ZS-EUW, "Pretoria", at Windhoek on 20th April, 1968.

We commenced our investigations with flight tests and ground studies during September 1968. On 25th September 1968 we held a pre-hearing for all interested parties at Johannesburg. Public hearings began at Windhoek on 1st October, 1968 and lasted there until 4th October, 1968, during which time we carried out inspections from the air and on the ground. The public hearings were continued at Pretoria from 7th to 9th October, 1968. Since then we have been engaged in conducting further investigations, obtaining additional evidence and consulting experts in various fields of aviation construction, maintenance, operation and accident investigation. These further duties have been carried out at Pretoria, Johannesburg, Jan Smuts Airport, Washington D.C. and London, in accordance with specific requirements.

In all, 82 witnesses testified viva voce in public; 22 made written depositions; 18 experts were consulted in the Republic, 12 in the U.S.A. and 1 in England. Approximately 250 documentary exhibits and records were studied, and also a large number of reports and technical publications.

We have personally investigated the wreckage

/and

(ii)

and the entire crash area. We have visited the observation points of all material eye-witnesses. We have examined the installations and services of J.G. Strijdom Airport. We have studied the relevant training and operational procedures of S.A. Airways. We have caused various investigations to be made on our behalf. We have from time to time engaged in air tests. We have done a comparative survey of the available reports of all other accidents having apparently similar characteristics. We have also considered possible improvements from the point of view of safety.

Our deliberations have now been completed and our findings on causation and responsibility are unanimous.

We now have the honour to submit our report, which has been compiled substantially in accordance with the recommended "Summary of Accident Report" contained in Appendix 3 to ICAO Annex 13, namely "International Standards and Recommended Practices on Aircraft Accident Inquiry", with certain additions and modifications.

Dated at Pretoria this day of November, 1968.

.....
CHAIRMAN.

Dated at Pretoria this day of November, 1968.

.....
MEMBER.

Dated at London this day of November, 1968.

.....
MEMBER.

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AIRCRAFT ACCIDENT REPORT. *

RELEASED ON THIS DAY OF 1968.

SUMMARY

- (a) Name of Operator:
South African Airways.
- (b) Aircraft : Boeing 707 - 344 C, registered
in the Republic of South Africa
as ZS - EUW, and known as
"PRETORIA".
- (c) Place and Date of Accident:
Aircraft crashed shortly after
take-off from runway 08,
J.G. Strijdom Airport, Windhoek,
South West Africa, on the night
of 20th April, 1968.

(d) /

* All times are given as G.M.T. Local time at
Windhoek is South African Standard Time (S.A.S.T.),
which is G.M.T. plus 2 hours.

(d) Brief Description of Accident :

On 20th April, 1968, at 18.49 the aircraft took off from J.G. Strijdom Airport on the second leg of a scheduled public service international flight from Johannesburg to London via Windhoek, Luanda, Las Palmas and Frankfurt.

Local weather conditions were fine : there was no cloud and no wind. The night was particularly dark: there was no moon and the horizon was indistinct.

The aircraft took off on runway 08 (i.e. towards the East) into conditions of complete darkness.

The aircraft climbed to an altitude which has been variously estimated, but which is believed to have been approximately 650 feet above the elevation of the airport.

The aircraft, instead of maintaining its climb, levelled off and then began to descend. Its heading of 080° magnetic was substantially maintained, though there was a slight veering to port. The levelling off and descent took an estimated time of some 30 seconds, at the end of which the aircraft flew into the ground at a point some 5,327 metres from the eastern extremity of runway 08 (i.e. from the threshold of the reciprocal runway 26). The level of the ground at the point of impact is 179 feet below the airport elevation or approximately 100 feet below the point of lift-off, so that the aircraft descended through approximately 750 feet. The impact occurred at a groundspeed of approximately 271 knots (312 miles per hour). The rate of descent at the time of impact is difficult to

/ estimate

estimate, but could have been as much as 2,000 feet per minute, and the mean rate of descent has been calculated as 1,500 feet per minute approximately.

The initial impact was in a slightly left-wing-down attitude. The hull and each of the 4 engine pods gouged deep trenches in the ground and the aircraft then began to break up as its momentum carried it onward. Wreckage and bodies were strewn over an area some 1,400 metres long and some 200 metres wide, and 2 separate fires broke out, presumably through the ignition of fuel on impact.

The entire flight deck crew of 3 pilots, flight engineer officer and navigation officer, were killed or mortally injured, as were the whole of the cabin crew, and all but 5 of the passengers. The total death roll of crew and passengers numbered 123 persons.

The last communication from the aircraft was the R/T acknowledgement of the control tower's permission to take off.

(e) Cause of the Accident :

- (1) The effective cause of the accident was the human factor, and not any defect in the aircraft or in any of the engines or flight instruments.
- (2) After a normal take-off and retraction of the landing gear, and while the aircraft was approaching an estimated height of 650 feet, the flaps were fully retracted and the engine output reduced from take-off

/ power

power to climb power. There is no reason to suppose that these steps were not taken in the correct sequence and at the prescribed indicated airspeeds. In that phase of flight these alterations in flap configuration and engine power would have caused the aircraft to level off and then lose height (a) unless the pilot checked that tendency and maintained a climbing attitude by appropriate action, or (b) until the aircraft gained much more speed.

- (3) The aircraft levelled off and lost height, and during the short period in which it did so the pilot appears to have acted as if he believed that the aircraft was still climbing. He appears to have altered the stabilizer trim to maintain the aircraft in its same pitch attitude, which he apparently believed was an attitude of climb, but which was in fact an attitude of descent. In that situation, which lasted for about 30 seconds, the aircraft lost approximately 750 feet* in height and flew into the ground.
- (4) The co-pilot failed to monitor the flight instruments sufficiently to appreciate that the aircraft was losing height.

The following causes probably contributed in greater or lesser degree to the situation described above:-

- (a) take-off into conditions of total darkness with no external visual reference;
- (b) inappropriate alteration of stabilizer trim;
- / (c)

* The ground at the point of impact is approximately 100 feet lower than the point on the runway at which the aircraft took off.

- (c) spatial disorientation;
- (d) pre-occupation with after-take-off checks.

The following causes might have contributed in greater or lesser degree :-

- (a) temporary confusion in the mind of the pilot on the position of the inertial-lead vertical speed indicator, arising from the difference in the instrument panel layout in the C model of the Boeing 707-344 aircraft, as compared with the A and B models, to which both pilots were accustomed;
- (b) the pilot's misinterpretation, by one thousand feet, of the reading on the drum-type altimeter, which is susceptible to ambiguous interpretation on the thousands scale;
- (c) distraction on the flight deck caused by a bird or bat strike, or some other relatively minor occurrence.

It has not been possible to determine whether the captain or the first officer was handling the controls at the relevant time.

(f) Responsibility for the Accident :

It was a fundamental requirement of safe operation of the aircraft in the conditions of darkness and lack of all external visual references, and especially in the phase of flight immediately after the take-off, that the pilot and co-pilot should have ensured that safe attitude and airspeed and a positive climb were maintained by continuous reference

to the relative flight instruments.

In the objective analysis of the occurrence, there was, as between the pilot and the co-pilot or either of them, a failure to observe this requirement in respect of the positive climb.

Various factors, operating individually or cumulatively on the pilot and/or co-pilot, probably caused or contributed to this failure, but there is nothing to suggest that any crew disablement or other emergency occurred which would have caused loss of control or which would have justified any departure from the said requirement. Responsibility for the accident accordingly falls on both the captain and the first officer, but primarily on the captain as the pilot-in-command, whether or not the first officer was doing the take-off.

Though in theory the third pilot's duties would have included monitoring the flight generally, in practice it was not possible for him to monitor flight instruments effectively. Besides, the evidence indicates that in this case he was responsible for the R/T. No responsibility for the accident therefore rests on him.

Apart from the foregoing, there is in relation to the accident no evidence of any neglect or breach of duty or other irregularity on the part of South African Airways, or the Department of Transport, or any person connected with the maintenance, operation or control of the aircraft, or with air traffic control, or search and rescue by the airport fire-fighting service, or with the licensing and flying proficiency

of the pilots, or with the medical examination of the crew members for the purposes of licence renewal.

I. INVESTIGATION

1.1 History of Flight.

On 20th April 1968, with Senior Captain Eric Ray Smith as the pilot-in-command, the aircraft left Jan Smuts Airport at 16.05 on flight number SA 228/129, carrying 105 passengers, mail, baggage and freight. Its immediate destination was J.G. Strijdom Airport, en route to London.

One of the passengers booked from Jan Smuts Airport failed to board the aircraft, though he had weighed-in, been cleared through customs and immigration, and his luggage was aboard.

The flight to Windhoek was uneventful. There is some evidence that the flight was "uncomfortable" for certain passengers, that the aircraft made a heavy landing at J.G. Strijdom Airport, and that its landing run was unusually short. Other evidence is to the contrary on each of these points. The Board is satisfied that the performance and handling of the aircraft during this leg of the journey were within normal limits.

Two of the survivors, who were passengers seated in the first class section, testified that on the journey from Jan Smuts Airport to J.G. Strijdom Airport, the electric lights over their respective seats flickered, but that the defect was rectified in each case by the flight engineer

/ officer

officer who was summoned by a member of the cabin crew. The Board has considered whether these defects indicate the possibility of a later malfunction of the illumination of the instrument panel or panels on the flight deck, but has discarded this possibility in view of the technical evidence.

At J.G. Strijdom Airport the captain and each of the other members of the flight deck crew were observed to be normal in appearance and behaviour.

Certain passengers disembarked at J.G. Strijdom Airport, and various items of mail, baggage and freight were unloaded. The aircraft was checked and refuelled, and further baggage and freight were loaded and secured. The eventual total number of passengers was 116. There were 12 crew members on board, and the total weight of passengers, mail, baggage and freight was 13,626 kilograms. The total weight of fuel was 26,762 kilograms. The actual take-off weight of the aircraft was 108,822 kilograms. The aircraft was correctly loaded and the c. of g. was within the prescribed limits at 27.7% MAC.

At 18.09 $\frac{1}{2}$ J.G. Strijdom Airport control tower, communicating with the aircraft on a radio frequency of 124.7 MHz, gave the QNH* as 1022 millibars and the temperature as 17 degrees centigrade; the QFE** was given as 24.53 inches and the surface wind as calm. Runway 08 was advised for the take-off.

The tower requested the aircraft to furnish a flight plan for its next leg. The full flight plan had been / filed

* QNH = the setting to be made on the subscale of the altimeter so that the instrument would indicate the official airport elevation if the aircraft were on the ground there.

** QFE = the present atmospheric pressure at the official airport elevation.

filed at Jan Smuts Airport, and the flight plan for the Luanda leg was furnished by R/T to the tower. There is nothing significant in the details of that flight plan, in which it was stated that the time to the top of the climb would be 24 minutes, and that the intended flight level was 350*. The aircraft was cleared by the tower for starting and taxi clearance and was then cleared "on-and-off" runway 08, left hand turn out, and unrestricted climb to flight level 350. The tower again advised that the wind was calm. The aircraft acknowledged these directions.

There were no further communications from the aircraft.

Having turned onto runway 08 the aircraft came to a halt and stabilised its engines before brake release and commencing its take-off roll. Runway 08 has a down slope of 0.8 per cent. The eastern end is 77 feet lower than the western end, and the highest point is 5,625 feet above mean sea level, that being the official airport elevation.

Various witnesses who observed the aircraft from observation points on the ground and the balcony of the airport building suggested that there were abnormal features in the take-off, such as unusual engine noises, an unusual glow in the tail pipe of No. 3 engine, an unduly prolonged take-off run, and a sluggish climb away. On the other hand, other witnesses, most of whom were better qualified to judge, considered that there were no abnormal features in the aircraft engines or in the take-off run or climb away up to at least 400 feet. Yet other witnesses

* Flight level 350 = a pressure altitude of 35,000 feet. / considered ...

considered that everything was apparently normal to a height of at least 700 feet.

The aircraft had taken off with all landing lights on, but there is some confusion among the eye-witnesses as to what occurred thereafter. Some witnesses claim to have observed only a red anti-collision beacon as it rotated. Others saw one or more of the navigation lights. Yet other witnesses saw "white" beams of light pointing forward from the aircraft. Some of the witnesses in this last category suggest that these beams came on after the aircraft had got into the air.

It is impossible to reconcile all the evidence on this question of lights, but it is clear that, in any assessment of the pre-crash conditions, account must be paid to the possibility that, while the aircraft was climbing away immediately after take-off, the fixed landing lights, or the runway turn-off lights, or the wing lights were switched on.

The assessment of heights by the various eye-witnesses, having only one or more lights in view against a dark sky, must be treated with caution. However, in subsequent tests, it was established that one of the eye-witnesses could not have seen the aircraft's lights (as she claimed to have done) unless the aircraft had attained a minimum height of 650 feet above the airport elevation.

It is evident that the landing gear was retracted immediately after lift-off, and it is also evident that the flaps were fully retracted thereafter. The precise
/height

height at which "flaps up" was selected cannot be determined. Prescribed procedure in South African Airways at this time required flap retraction on this model at an altitude of 700 feet above the ground. It is possible that the flaps were inadvertently retracted at an altitude of 400 feet above the ground, because of confusion with the procedure in the A model, which requires partial flap retraction at an altitude of 400 feet; but even if that were so, the speed would presumably have been correct, in which case the aircraft would have been able to continue to climb away.

At its maximum altitude, which has been assumed by the Board at approximately 650 feet, the aircraft levelled off and then began to descend.

Among the survivors was a passenger, Mr. Thomas Taylor, who is a U.S. State Department diplomatic courier, and who was seated in seat No. 1F in the first class section immediately aft of the galley. Mr. Taylor's evidence is that he at no time lost consciousness, and that there were no unusual occurrences or sensations prior to the impact.

The aircraft continued to descend until it struck the ground at a point 5,327 metres from the eastern extremity of runway 08. The impact was at a speed which has been established from 4 independent instrument sources at approximately 271 knots (312 miles per hour). The flight path angle of descent has been calculated at 5 degrees below the horizontal, and the probable attitude was one in which the nose and port wing were slightly down.

/ At

At the point of initial impact each of the four engine pods and the bottom of the hull gouged out deep trenches in the ground, and the aircraft then proceeded to disintegrate.

Two minutes and seven seconds after the aircraft had been cleared for take-off, two "click" or "pop" sounds were heard and recorded on the tape recorder in the airport control tower. These sounds were recorded on the frequency in use by ZS-EUW (i.e. 124.7 MHz), and there was no other aircraft in the area using that frequency at that time. It is thought that those sounds could have been made by the transmitter equipment of the aircraft being momentarily actuated by the impact, or by some electrical discharge phenomenon associated with the crash. The time at which these two sounds were recorded was 18.49 hours and 55 seconds. This agrees with the evidence of various witnesses who fixed the time at 18.50 and the Board accepts this as the probable time of impact.

1.2 Injuries to Persons

<u>Injuries</u>	<u>Crew</u>	<u>Passengers</u>	<u>Other</u>
Fatal	12 (5 flight deck crew and 7 cabin crew)	111	Nil
Non-Fatal	Nil	5	Nil
None	Nil	Nil	Nil

Lists of the passengers and of the crew are annexed as Annexures 1 and 2 respectively.

1.3 Damage to Aircraft.

The aircraft is a total loss.

/1.4

in regard to his blood pressure and cardiovascular system and was to have a report thereon submitted as soon as reasonably possible.

His total flying experience was 18,102 hours and 25 minutes, on numerous types of land aircraft. His flying time on all models of Boeing 707 aircraft amounted to 4,608 hours and 55 minutes, commencing in September, 1960. His total flying time on the 707-344C model, prior to the flight on 20th April, 1968, consisted of 1 hour of

/instruction

1.4 Other Damage

All mail, freight and baggage were either destroyed or severely damaged. Apart from the destruction of a certain amount of natural grazing by the impact and by the veld fires which were started afterwards, there is no evidence of damage to anything outside the aircraft.

1.5 Crew Information

1.5.1. Captain Eric Ray Smith, the pilot-in-command of "Pretoria", was 49 years of age. He was in possession of an Airline Transport Pilot's Licence No. 48(A), valid until 10th October, 1968.

His last medical examination had taken place on the 22nd March 1968, when he was passed fit for six months, with effect from 11th April 1968, with the following limitations:

- (a) he was to wear corrective lenses for near vision ;
- (b) he was to consult a specialist-physician in regard to his blood pressure and cardiovascular system and was to have a report thereon submitted as soon as reasonably possible.

His total flying experience was 18,102 hours and 25 minutes, on numerous types of land aircraft. His flying time on all models of Boeing 707 aircraft amounted to 4,608 hours and 55 minutes, commencing in September, 1960. His total flying time on the 707-344C model, prior to the flight on 20th April, 1968, consisted of 1 hour of

/instruction

instruction and conversion, in accordance with the practice of the Boeing Company. He had also attended lectures on the differences between the 707-344C and earlier models. During the six months preceding the accident his total flying time was 466 hours and 30 minutes, all on Boeing 707s. Of this, his total flying time during the previous 90 days was 222 hours and 25 minutes, and, during the previous 30 days 65 hours and 40 minutes. He had had a total of 5 days off since his last duty flight, but during that time he had undergone the conversion flight referred to above. His flying time from Jan Smuts Airport to J.G. Strijdom Airport on the day of the accident had been 1 hour and 45 minutes.

In the course of his career he must have carried out numerous take-offs under conditions of total darkness. As a Boeing 707 captain, he had experienced a total of 5 night departures from J.G. Strijdom Airport, at least 2 of which had taken place during the 6 months preceding the accident.

He underwent regular instrument rating renewal tests at 6-monthly intervals, and his proficiency in each test was assessed as "average" - i.e. satisfactory. He had also been subjected to 7 route checks, carried out by the South African Airways training captains and the overseas fleet captain, during his service as a Boeing 707 captain on overseas routes. In these checks too his proficiency was assessed as "average". The last route check was completed in July 1967, and his last 6-monthly instrument check was completed on 1st March 1968.

There is evidence from colleagues that Captain Smith had begun to accept that he was near the end of his flying career. There had been some deterioration of his general fitness, though he successfully passed the prescribed 6-monthly medical checks. He had indicated his intention to retire on his 50th (i.e. his next) birthday. He had begun to look forward to giving up flying, and it is believed that his general proficiency had begun to suffer, though the standard of his performance as a captain had remained satisfactory.

In Captain Smith's medical history there is evidence of successive episodes of otitis externa (involving inflammation of the outer ear). There is also a record of otitis media (involving the middle ear), but this cannot be verified, and there is reason to believe that it may have been recorded as such inadvertently. In addition, on the occasion of his last medical examination his blood pressure in successive tests was found to be slightly raised. He was required to submit himself to a full medical investigation in that regard, but the medical authorities did not consider this as urgent, and certainly did not regard his raised blood pressure as rendering him unfit for full flying duties. His heart, coronary vessels and aorta revealed a certain amount of deterioration at the post mortem examination. There was no evidence of any kind of cardio-vascular episode or seizure and though the Board has been advised by a specialist physician hereinafter referred to that the possibility of such an attack on the flight deck cannot be excluded, the circumstantial evidence of what was being done on the flight
/deck

deck at the time makes it most unlikely.

While the wreckage was being probed two yellow thephorin tablets (an anti-histamine) and one white paracetamol tablet (a mild pain-killer akin to an aspirin) were found on the floor of the flight deck. It is known that anti-histamines can produce, inter alia, dizziness and drowsiness, but these tablets are not necessarily to be associated with Captain Smith or any other member of the flight crew. Inquiries made in regard to Captain Smith and First Officer Holliday establish that neither was suffering from a cold or any other noticeable illness at any relevant time prior to the accident.

The Board decided to invoke the assistance of a specialist physician to conduct a full investigation into all matters which might have affected the health or flying proficiency of Captain Smith and First Officer Holliday. This specialist physician in turn invoked the assistance of an orthopaedic surgeon (whose opinion is referred to later in this report), an ophthalmologist and a psychologist. In regard to this aspect of the investigation :-

- (a) ~~The~~ evidence excludes a cardiac episode.
- (b) ~~Th~~ough a cerebral episode and/or a retinal haemorrhage cannot be excluded, the Board considers that any such event is highly unlikely, regard being had to circumstantial evidence of events on the flight deck.
- (c) ~~It~~ is believed that Captain Smith's blood pressure would not have resulted in his being grounded by a specialist physician.

(d) /

- (d) The opinion has been expressed that Captain Smith's vision was such that he would have had difficulty in seeing the instruments clearly at night, and that the particular glasses he was wearing at the time were not adequate to correct that deficiency. The Board has considered all the evidence and all the expert opinions with great care, and has come to the conclusion that it is most unlikely that Captain Smith would have continued to fly at night if his vision was such that he could not see the flight instruments adequately. According to his colleagues, he was meticulous in his approach to his duties, and the suggestion that a pilot of his experience and responsibility would have attempted to fly under instrument flying conditions without being able to see the instruments adequately is unacceptable. Nevertheless, it is clear that his vision had deteriorated as a normal consequence of his age, and that the glasses he was wearing might have made it necessary for him to strain at times, and perhaps to lean forward to get a better view of the instruments at times, and perhaps to require more intense cockpit lighting at times. These would not be unusual circumstances in a captain of his age, but might have contributed to difficulty in immediately locating the I.V.S.I. in the new instrument panel layout of the C model, to which layout he could not yet have become fully accustomed.

/ J.A.

/ J.A.

A thorough investigation into Captain Smith's previous performance as an aircraft captain, and into his habits on the various routes on which he flew, was conducted by a senior official of the Division of Civil Aviation and a senior training captain of South African Airways. This investigation involved the interrogation of all first officers and a number of other crew members with whom Captain Smith had flown during the past 6 months, and also involved journeys as far afield as the United Kingdom and Australia to interview persons who knew him at airports and hotels en route. The investigation revealed nothing which would reflect in any way on Captain Smith's proficiency or personal habits.

1.5.2. First Officer John Peter Holliday was 34 years of age. He held Airline Transport Pilot's Licence No. 383(A), valid until 28th July, 1968.

His last medical check was completed on 29th January 1968, when he was passed fit for 6 months.

His total flying experience, which was on various types of land planes, was 4,109 hours. His total flying time on Boeing 707 type aircraft was 229 hours, and in addition he had had 336 hours on Boeing 727 type aircraft. He converted onto Boeing 707 aircraft in January 1968, and his total flying^{time}/during the previous 6 months, 90 days and 30 days respectively were well within the prescribed limits. He had been converted onto the C model on 8th March, 1968, after a course of lectures on the differences between C models and the earlier models, and after 1 hour's flying instruction. He had performed /satisfactorily

satisfactorily in all previous tests and checks. In particular, he had successfully completed his last instrument rating check on Boeing 707s on 30th January, 1968. He had had 5 days off since his last duty flight.

There is nothing significant in First Officer Holliday's medical history. He passed all previous checks without difficulty.

First Officer Holliday had not previously experienced a night departure from J.G. Strijdom Airport, though he must have had considerable experience of dark night take-offs.

1.5.3. The third pilot, Mr. Richard Fullerton Armstrong was 26 years of age. He held Commercial Pilot's Licence No. 1198(C), valid with instrument rating until 9th September, 1968.

His last medical check had been completed on 30th November, 1967, when he was passed fit for 6 months.

He had a total of just over 1,000 flying hours, on various types of land aircraft. His total flying time on Boeing 707s was 79 hours and 40 minutes. He too had been converted onto the C model. His total flying times during the previous 6 months, 90 days and 30 days respectively, were well within the prescribed limits. His flight on 20th April, 1968 as a member of Captain Smith's crew was the first time had had flown as an independent member of a Boeing 707 crew.

/1.5.4

1.5.4. None of the 3 pilots had previously flown together as part of the same crew.

1.5.5. Flight Engineer Officer Phillip Andrew Minnaar was 50 years of age. He held Flight Engineer Licence No. 616, valid till 12th December, 1969, and rated for, inter alia, Boeing 707 - 344A, B and C models.

His last medical check had been completed on 14th December 1967, when he was assessed fit for the ensuing 12 months, but was required to wear corrective lenses for near vision.

He had extensive experience on Boeing 707s, and was fully qualified on the C model. His total flying time was 11,443 hours and 10 minutes, of which 2,688 hours and 55 minutes had been on Boeing 707s.

At the post-mortem examination on Mr. Minnaar, it was found that his heart had developed slight fatty infiltration and a certain amount of fibrosis. The possibility that he suffered some kind of cardio-vascular attack shortly before the accident cannot be excluded, although there was no direct evidence of this.

1.5.6. The navigation officer, Mr. Harry Charles Howe, was 44 years of age. He held Flight Navigator's Licence No. 34(N), valid until 22nd January, 1969. He had been passed fit at his last medical check on 23rd January, 1968. He had extensive experience of overseas service on Boeing 707 aircraft.

/1.5.7.

1.5.7. The cabin crew on board were as follows:-

Flight Traffic Officer - A.G. Manson.

Chief Flight Steward - J.A. Erasmus.

Senior Flight Steward - H.S. Louw.

Flight Stewards - Messrs. R.J. Bester and
J.W. Jesson.

Flight Stewardesses - Miss E. Janse van
Rensburg and Miss M. Nortier.

The cabin crew qualifications and documentation were all in order.

1.6 Aircraft Information

1.6.1. Boeing 707 - 344 C, serial No. 19705, was constructed by the Airplane Division of the Boeing Company, Renton, Washington, U.S.A. It was delivered to South African Airways at Seattle on 23rd February 1968 and it arrived in South Africa on 1st March 1968. It was registered on the South African register as ZS - EUW, in categories a, b, c, d, e and f, which included public transport and training. Four Pratt and Whitney JT.3D-7 engines were installed as follows:-

<u>Position</u>	<u>Serial Number</u>
No. 1	P.670656BG
No. 2	P.670657BG
No. 3	P.670658BG
No. 4	P.670659BG

The Certificate of Registration, No. 3007, was issued on 7th December 1967.

The Certificate of Airworthiness, No. 3007, was issued on

/ 17th

17th January 1968 valid until 3rd March 1969.

Airplane Flight Manual No. D6-1587 was approved by the Federal Aviation Administration of the U.S.A. for Boeing 707 - 344C series aircraft Nos. 19705 and 19706 on 21st February 1968 and was amended up to 1st March 1968. The original of the last certificate of safety for flight (maintenance release) was on board and is not available, but a copy of this certificate is included in the South African Airways maintenance records relating to a check A completed on 17th April 1968. The certificate of safety was valid at the time of take-off from Windhoek.

The aircraft flew regularly after its arrival in South Africa. On 20th April 1968 Senior Training Captain A.S. Britton used the aircraft for training and conversion flights at Jan Smuts Airport from 0500 to 0900. During that time the aircraft, engines and all systems functioned faultlessly. Captain Bain took over the aircraft for further training and conversion of crews, and was air-borne from 10.10 to 13.40. As before there were no faults, except that after the flight Captain Bain wrote in the technical defect log that No. 3 engine should be checked for slow acceleration. This is referred to hereinafter.

1.6.2. Airframe and Flight Instrument History

The airframe and all systems, including flight instruments, were maintained by South African Airways, a licensed aircraft maintenance organisation, in accordance with the approved maintenance schedules. These schedules require, inter alia, a check A to be done at intervals not / exceeding

exceeding 105 hours, and periodic inspections after every 500 hours of flying time. South African Airways records indicate that checks A were completed as follows:-

3rd March, 1968, at 37 hours since new;

3rd April, 1968, at 69 hours 20 minutes since new;

17th April, 1968, at 194 hours 45 minutes since new, which was the last.

This last check A was done 125 hours 25 minutes after the previous check A instead of after 105 hours, but the records of the Department of Transport show that an extension of 25 hours was granted to South African Airways on this occasion. The total flying time at the commencement of its last flight was, according to South African Airways records, 238 hours 20 minutes.

There were no outstanding inspections at the time of the accident.

The defects log and transit inspection record completed for a flight from Salisbury to Luanda on 17th April 1968, showed that the captain's flight instruments, which are fed by the air data computer, were unreliable above 30,000 feet, and that the warning flags showed intermittently. Nos. 1 and 2 air data computers were interchanged, and it appeared that, in the flight from Luanda to Las Palmas, the fault had transferred itself to the first officer's instrument panel. At the terminal check, done on 19th April 1968, after a total aircraft flying time of 229 hours 10 minutes, the faulty air data computer was replaced. The new air data computer was checked and found to be serviceable.

South African Airways records show that the

/ aircraft

aircraft was flown for a total of 7 hours 25 minutes on training on 20th April 1968, before it took off on the flight from the Jan Smuts Airport to J.G. Strijdom Airport. A pre-flight inspection was done on 20th April, 1968, prior to the departure of the aircraft for Windhoek.

The defects log and transit inspection record completed for the flight from Jan Smuts Airport to Windhoek is endorsed "no defects".

1.6.3. Engine History

All four engines were constructed by Pratt and Whitney Aircraft Corporation, East Hartford, United States of America, and were installed in ZS - EUW during manufacture of the aircraft. The total running time of each engine at the time of the last take-off was 238 hours 20 minutes. No overhauls or major repairs were carried out on any of the engines.

The engines were new and were maintained by South African Airways in accordance with the approved maintenance schedules.

On 7th April 1968, there was an entry in a minor check snag sheet to the effect that there was turbine rub on No. 3 engine. The second stage turbine rotor inner seal supports were checked, the main oil pressure filter was checked for metal contamination, and the engine was ground run. There was no evidence of rub.

During the last training flight on 20th April 1968, Captain Bain reported that No. 3 engine was slow in
/ acceleration

acceleration when compared with No. 2. These two engines were ground checked during the pre-flight inspection on 20th April 1968, prior to the departure of the aircraft for Windhoek. It was found that both engines were the same on acceleration, and the defects log and transit inspection record were inscribed accordingly.

A vibration log maintained by South African Airways shows no abnormalities in any of the engines.

The last entries in each of the engine log books are dated 17th April 1968, but subsequent maintenance is shown in other records kept by South African Airways.

1.6.4. Cabin Accessory and Equipment History

The aircraft was delivered to South African Airways without tourist class seats or galley installations.

Forty-one triple tourist class seats were installed during the conversion of the cabin to standard configuration. This was done on 29th March 1968 during the check A which was completed on 3rd April 1968. There is no specific record in the airframe log book relating to the fitment of these seats. Information supplied by South African Airways is that the seats which were installed were manufactured by Aircraft Furnishings Limited, Walton-on-Thames, England, and that they were designated model 507. The evidence is that these seats were manufactured to U.S.A. technical standards order No. 339 and that they were designed to fit into the standard Boeing seat attachment rails.

/ T.S.O. 339

T.S.O.339 prescribes strength requirements for seats used in U.S.A. aircraft, and the first class seats in ZS - EUW were manufactured to the same specification. The Board is satisfied, notwithstanding the absence of any specific record in the airframe log book, that the tourist class seats were properly installed, and that due account thereof was taken in determining the empty weight of the aircraft.

The installation of five galleys in the 707 - 344C model aircraft was approved by modifications No. 346, extended to cover the C model on 26th March, 1968, and No. 378, also dated 26th March, 1968. The galleys were manufactured in Western Germany and information supplied by South African Airways indicates that they were made to Boeing approved drawings. The incorporation of these modifications is reflected in the airframe log book, as LM/BOE/292A and LM/BOE/379 respectively.

One additional seat for the South African Airways traffic officer was also installed in accordance with approved modification No. DCA/379. This is reflected in the airframe log book as LM/BOE/370.

1.6.5. The maximum certificated all-up weight of the aircraft is 326,000^{lbs} (approximately 147,913 kilograms *) or 330,600 lbs (approximately 150,453 kilograms *) with "alternate" (i.e. alternative) fuel management. The take-off weight for its last flight from J.G. Strijdom Airport was 239,911 lbs approximately (108,822 kilograms). This was 3,000 kilograms below the maximum landing weight of

* 1 kilogram = 2.204 lbs approximately.

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this model. The centre of gravity limits shown in the flight manual for the relative take-off weight are 19.0 per cent to 35.0 per cent of mean aerodynamic chord (MAC), and the actual centre of gravity at the time of take-off was 27.7 per cent MAC, which was well within prescribed limits.

The Board is satisfied that the aircraft was properly and safely loaded, although there were certain minor errors in the basic load data and in the calculated trim setting. In particular the trim setting was calculated as $2\frac{3}{4}^{\circ}$ nose-up, but should have been $3\frac{1}{4}^{\circ}$ nose-up. None of these errors has any significance in relation to the accident.

1.7 Meteorological Information

Weather conditions in the vicinity of J.G. Strijdom Airport at the time of the accident are not significant. There was no wind and no cloud. The QNH was 1022 millibars and the QFE was 24.53 inches. The ground temperature at the airport was 17 degrees centigrade. Visibility was good, but it was a particularly dark night, with no moon, and there were few (if any) lights on the ground beyond the eastern extremity of runway 08. The aircraft therefore took off into what has been described as a "black hole".

1.8 Aids to Navigation

The accident was not related to any navigation problems.

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In any event, J.G. Strijdom Airport was equipped with VDF, VOR and NDB facilities, all of which were fully serviceable.

The aircraft was fitted with ILS, VOR, DME, marker beacon receiver, radio compasses, weather radar, and A.T.C. transponder. There is no reason to suppose that any of these were unserviceable. In addition the aircraft was fitted with 2 independent dopplers, both of which were functioning normally.

1.9 Communications

Two-way R/T air to ground was available between the aircraft and air traffic control at J.G. Strijdom Airport on 118.1 and 124.7 MHz, and on 2966, 5680, 6552, 6777 and 8879 KHz.

In addition, all R/T conversations between the aircraft and air traffic control were recorded on the tape installed in the tower. The Board listened to the playback of this tape, and have also studied the typed transcript thereof.

1.10 Aerodrome and Ground Facilities

The main runway used at J.G. Strijdom Airport, runway 08, is 9,000 feet (approximately 2,743 metres) long, and has a downhill slope of 0.85 per cent. The elevation of the Airport is 5,625 feet AMSL. The runway surface was relatively new, well maintained and in excellent condition. Visual approach slope indicators were installed

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on runway 08 and on its reciprocal, runway 26. The Airport itself was equipped with full aerodrome and ground facilities insofar as any of the same are material to the present Inquiry.

J.G. Strijdom Airport was equipped with three fire tenders, one of which carried foam and another of which carried equipment enabling it to vaporise water under high pressure. The third fire tender carried water. Two of the tenders were equipped with 2-way radio, and all were equipped with searchlights. These tenders were continuously manned during operations at the airport.

1.11 Flight recorders.

Neither a flight data recorder nor a voice recorder was carried on the aircraft. The current South African Air Navigation Regulations 1963, as amended, do not require a flight data recorder to be installed in aircraft such as the Boeing 707. However, on 29th June, 1966, South African Airways were advised by the Department of Transport that it was intended to make the installation of flight data recorders, recording time, altitude, air-speed, vertical acceleration and heading, mandatory for all Boeing 707 and 727 aircraft as from 1st January 1968. South African Airways advised on 18th August, 1966 that they were in the process of implementing these requirements. However, delays were experienced in the procurement of suitable flight data recorders, with the result that all Boeing 707 aircraft could not be fitted with this equipment by due date, and ZS-EUW was one of these which was not so fitted.

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1.12 Wreckage

A widespread search was carried out on runway 08 itself, and from the threshold of the runway to the point of initial impact, and thereafter over and beyond the entire area covered by the wreckage. The search failed to yield anything, before the initial point of impact, that could be related to the aircraft. Nor were any signs detected that the aircraft had struck bushes, fences or telephone wires prior to striking the ground at the initial point of impact.

The wreckage of the aircraft and its contents were scattered over an area some 1,400 metres long and some 200 metres wide. A general idea of the ground marks, and of the area over which the wreckage was distributed, may be obtained from the composite aerial photograph (Annexure 3). The location of individual items of wreckage, and the reconstruction of the sequence in which disintegration occurred, appear from the diagram and key (Annexures 4 and 5 respectively).

The investigation on the crash site accounted for all the primary structure and main components of the aircraft and engines, and also enabled a reconstruction to be effected from which the inference is clear that the aircraft was intact when it struck the ground at the initial point of impact.

Fire broke out at two points, and it is probable that each fire occurred initially when each of the respective main planes came to rest, with a flashback

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of fire along the trail of fuel spilt as each wing moved forward along its respective line of momentum.

At the point of initial impact No. 2 engine was the first to touch the ground, the aircraft having been slightly left wing low. Each of the four engine pods and the bottom of the hull gouged out deep trenches in the ground, and the engines and the aircraft then proceeded to disintegrate. The sequence of disintegration of the aircraft, as subsequently reconstructed, was that initially Nos. 1 and 2 engines broke away, followed by the port wing. The starboard wing then broke away, tearing open the fuselage and so allowing the nose section to break free. The nose section carried on straight ahead until it topped a rise, when it deflected to the left, tumbling and skidding until it came to rest.

All the eventual survivors were seated in the nose section, and the reason for their survival is probably that this portion of the aircraft, having broken away, decelerated less rapidly than the rest of the aircraft. This portion of the aircraft was not involved in any fire. The fuselage aft of the nose section tended to dig into the ground, and ejected passengers and its other contents along the general line of momentum. Certain of the installations which broke free from the aircraft followed on and crushed some of the bodies which had been ejected. Most of the bodies were flung up to 150 metres beyond the point where the aft portion of the fuselage eventually came to rest. The tail broke free fairly early on.

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The port wing, having torn free, continued for approximately 1,400 metres, veering slightly to the right side of the general line of momentum. As it travelled fuel spilled from it, and it appears that on its final impact ignition took place with a flashback of fire along the line of the spilt fuel.

The starboard wing was deflected to the left of the initial point of impact, probably because it rotated over the cabin as it broke away from the aircraft. Fire broke out in this wing as well, also with a flashback along the line of spilt fuel.

From examination of the wreckage, it is evident that the landing gear, landing gear doors and flaps had been fully retracted prior to impact, and that at least one of the retractable landing lights had also been fully retracted. The other retractable landing light was not recovered.

The structure of the cabin floor sections of the aircraft remained virtually intact.

Other evidence obtained in the wreckage is discussed in the Analysis in section 2.1 of this Report.

1.13 Fire

The crash was observed almost immediately from the airport because of the fire which broke out.

Action was taken immediately by the air traffic controller and the three fire engines at once set off for the crash site. Two of the fire engines attempted

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to drive directly to the scene of the crash, and, when they reached the aerodrome boundary, drove through the perimeter fence, and then drove through farm fences beyond it in their determination to reach the crash site. They ran into obstacles in the form of ditches and dongas which held them up. They finally reached the area of the crash after being led there by a farmer. The other fire tender turned back from the perimeter fence, and travelled along the Gobabis Road, south of the Airport; it reached the crash by turning off that road.

In the event, there was a delay of up to 40 minutes in the arrival of the respective fire tenders at the site of the crash.

The fires at the site caused considerable additional damage to the wings and to other portions of the wreckage.

In addition, a number of the deceased passengers sustained burns.

The Board inspected the fire fighting services at the airport, and scrutinized narrowly every aspect of the operation of the fire tenders. The Board is satisfied that these services were alerted immediately and that all reasonable steps were taken promptly and efficiently to reach the scene of the crash.

1.14 Survival Aspects

Nine passengers survived initially, but 3 died shortly after and 1 (Dr. van der Wath) some days later.

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The remaining five are alive today. They are Messrs. Taylor, Rooke, Derbyshire, Arntzen and Williams. All these and Dr. van der Wath were seated in the nose section, and the probable reason for their survival has already been referred to above under "Wreckage".

It is believed that if the first officer had been wearing his shoulder harness, and not merely the belt, he might have survived.

All the crew perished.

All bodies were identified except for those of 11 passengers.

An analysis of the injuries sustained by passengers and crew shows that 94% suffered severe injuries to the pelvis and lower half of the body, and 84% suffered head injuries.

No pattern could be determined from these injuries, though the position of almost every occupant was plotted and the particular injuries suffered by each of the crew and by each of the identified passengers were analysed by 2 pathologists and an orthopaedic surgeon.

Despite the large number of pelvic injuries, examination of the passenger seat belts indicates that 67 were unfastened and undamaged by stress, whereas only 23 seats were unoccupied. The inference is that at least 44 of the passengers had already unfastened their seat belts when the impact occurred.

The evidence indicates that the helicopter service established between the scene of the crash and

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the Windhoek hospital played an important part in ensuring rapid treatment for the few survivors.

The scene of the crash was difficult to reach by ground transport, but numbers of civilian helpers aided the fire tender crews and the police. Among these was Mr. Trumper, a farmer, on whose lands the accident occurred, and who rendered valuable assistance.

All the bodies were removed from the scene before the investigating team could establish the exact positions in which they were found.

1.15 Tests and Research

The following investigations were undertaken -

- (a) Within hours of the crash a team of investigators arrived. During the subsequent weeks searches and investigations were carried out with great thoroughness. These operations were conducted under the direction of the Director of Civil Aviation, aided by officials of the Department of Civil Aviation and of South African Airways, and by a senior official of the United States National Transportation Safety Board, with a team of representatives from the Boeing Company and the Pratt and Whitney Company.
- (b) Flight tests were carried out by South African Airways at the scene in an attempted simulation of the flight. The aircraft used was a sister ship, ZS - EUX, and certain eye-witnesses were posted in
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their original positions and their observations noted.

- (c) All flight instruments were sent to their respective manufacturers for complete investigation and testing.
- (d) Members of the Board participated in actual flight tests and observations at night and also in daylight.
- (e) In addition the Board visited J.G. Strijdom Airport, the scene of the crash and the observation points of the main eye-witnesses, and also inspected the wreckage, the air traffic control and fire fighting services at the airport.
- (f) The Chairman conducted investigations in Washington, D.C., with the collaboration of the National Transportation Safety Board, the Federal Aviation Administration and the Boeing Company. These investigations lasted 3 days, and were carried out with the assistance and participation of the following:-

N.T.S.B. Bureau of Aviation Safety.

- (i) Marion F. Roscoe - Deputy Director.
- (ii) Robert L. Froman - Assistant Director (Inter-Department).
- (iii) Martyn V. Clarke - Assistant Chief of Central Investigation Division and a specialist in take-off accidents.
- (iv) W.L. Lamb - Supv. ASI of Operations Branch of Central Investigation Division.
- (v) John H. Pahl - Chief of Safety Analysis and Promotion Division.
- (vi) Bernard C. Doyle - Assistant Chief of Safety Analysis

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and Promotion Division and till recently Chief of Human Factors Branch of Central Investigation Division.

- (vii) Coe M. Anderson - Chief of Technical Services Branch of Safety Analysis and Promotion Division.
- (viii) P. Alexander, of the Aeronautical Engineering Section, Technical Services Branch, Division of Safety Analysis and Promotion.
- (ix) Accident Data Branch, Safety Analysis and Promotion Division.

Federal Aviation Administration.

- (i) Richard S. Sliff - Deputy Director of Flight Standards Service.
- (ii) Donald E. Kemp - Chief of Accident Investigation Staff, Flight Standards Service.

Boeing Company.

- (i) D. Knutsen - Chief Test Pilot.
- (ii) W. Hansen - Accident Investigation Department.

The investigation covered the following aspects, inter alia :-

- (A) A computer analysis of all available data on all known Boeing 707 and 727 take-off accidents and near-accidents.
- (B) A comparative examination of numerous other take-off accidents involving other types of aircraft and resembling the Windhoek accident in material aspects.
- (C) A critical analysis and evaluation of all the

/ evidence

evidence collected on the Windhoek accident, including consideration of possible sources of additional evidence.

- (D) A systematic study of various suggested causes of the Windhoek accident, including, inter alia :-
- (i) runaway or jammed horizontal stabilizer trim;
 - (ii) wrong horizontal stabilizer trim setting;
 - (iii) wrong flap setting for take-off, or premature retraction of flaps;
 - (iv) malfunction of one or more basic flight instruments through intrinsic defects or extrinsic influences;
 - (v) development of a flight situation "on the wrong side of the power curve";
 - (vi) crew disability involving the whole crew or only one pilot;
 - (vii) combinations of circumstances leading to loss of concentration on or misinterpretation of flight instruments.
- (E) A study of a series of flying aberrations recorded on scheduled airline flights in the U.S.A., including post take-off aberrations.
- (F) The adequacy and safety standards of the Boeing Company's recommended take-off procedures (with particular reference to flap operation) as adapted and applied by South African Airways.
- (G) The adequacy of the Boeing Company's recommended conversion training from the B to the C model of the Boeing 707-344 type, as adapted and applied by South African Airways.

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- (H) A comparative study of take-off procedures in a number of other airline companies operating Boeing 707 and 737 type aircraft.
 - (I) A comparative study of flight instrument panel layout and standardization in other airline companies.
 - (J) The value of flight recorders and voice recorders as established in aircraft accident investigation in the U.S.A.
 - (K) Additional evidence which might have been recovered after the Windhoek accident through more elaborate post-mortem procedures and/or through timeous interrogation by medical experts of the survivors suffering from post-traumatic retrograde amnesia.
- (g) The Board conducted an investigation in London with Mr. D.P. Davies, Chief Test Pilot, Air Registration Board, and author of a standard work on flying large jet aircraft. This investigation lasted approximately 2 days, and covered inter alia :-
- (i) A.R.B. testing of and requirements for Boeing 707 aircraft for airline operation.
 - (ii) A critical survey of the evidence adduced in regard to the Windhoek accident.
 - (iii) A survey of all circumstances and considerations relevant to the operation and function of the stabilizer trim and of the flaps on "Pretoria's" last flight.
 - (iv) A general assessment of probability in respect

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of each item in the range of possible causative factors.

- (v) A comparative study of all flight instrument failures and malfunctions in another Boeing 707-344C over the period of six months since manufacture.

- (h) An investigation was conducted by a specialist physician, assisted at times by an orthopaedic surgeon, ophthalmologist and a psychologist into:-
 - (i) the respective medical backgrounds of the captain, first officer, second officer, flight engineering officer and navigator;
 - (ii) whether any human factors were operative in relation to the accident;
 - (iii) whether the pills or tablets found on the flight deck after the accident played any part in the accident;
 - (iv) whether the aircraft was being flown by the captain or the first officer.

- (i) An inconclusive attempt was made to correlate the seating positions of the crew, and of those passengers who could be identified, with the respective injuries suffered by each such person.

- (j) The Professor of Land Surveying in the University of the Witwatersrand investigated the angle of descent and the attitude of the aircraft at impact.

- (k) The Boeing Company calculated the range of possible flight profiles.

2. ANALYSIS AND CONCLUSIONS.2.1 Analysis

2.1.1. The Board finds itself able, on the evidence, to exclude the following :-

A. Engine Failure.

The reasoning here is as follows:

- (i) The engine pressure ratio was determined after the crash as having been, in the case of each engine, appropriate to that for climb power. This evidence has determined beyond all reasonable doubt that all four engines were delivering satisfactory power. Furthermore, all fuel pumps and filters were found to be serviceable on examination after the impact.
- (ii) There was evidence in the wreckage that the engine components, at the time of impact, were under temperatures consistent with power delivery; some of the sand scooped up by the engines on impact had actually been glazed into the metal by this heat.
- (iii) There was no radio or other signal from the aircraft indicating engine failure.
- (iv) All the evidence is conclusively against any suggestion of returning to the airport for a landing or for any attempt to do an emergency landing.
- (v) It is probable that the flight crew were actually engaged in routine procedures when the crash occurred, with which they would not have been occupying themselves if there had been an emergency such as engine failure after take-off. The evidence here includes
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the following, inter alia :-

- (aa) One of the retractable landing lights was found fully retracted.
- (bb) The landing gear selector lever had been returned to the "off" position.
- (cc) The radio altimeters had been switched off.
- (dd) The heading for the sector Windhoek-Luanda had been selected on the radio direction indicator. (A senior training captain testified that normal South African Airways procedure would be to use the runway heading for take-off, and only to select the sector heading thereafter).
- (ee) The engines had been adjusted to climb power.
- (ff) The horizontal stabilizer trim had been reduced from $2\frac{3}{4}$ units nose-up to 0.
- (gg) The flight engineer officer had logged the time of take-off.
- (hh) The aircraft had only been in the air for approximately 57 seconds, of which approximately 30 seconds were involved in the levelling out and descent to the point of impact, and during which 30 seconds the foregoing procedures must have been carried out.

B. Fuel Inadequacy and/or Contamination.

The evidence establishes that the fuel on board was adequate and that there was no contamination, and in any event all engines were functioning at climb power at the time of impact.

/ C. Airframe

C. Airframe Failure.

The evidence is against any failure of airframe structure in that :-

- (i) A careful search revealed no portions of the aircraft on runway 08 or in the area between that runway and the point of impact.
- (ii) No unusual attitudes on the part of the aircraft were observed by any of the eye-witnesses, and the marks of impact support this.
- (iii) Mr. Thomas Taylor testified that he experienced no unusual movements or G-forces.
- (iv) The primary components of the aircraft structure have been satisfactorily accounted for in the crash area.
- (v) The considerations referred to in regard to engine failure, in paragraph A (v) above, apply equally here.

D. Failure of Control Surfaces and/or
Control Mechanisms.

Much of the reasoning which excludes engine and airframe failure applies here too. In addition :

- (i) All control surfaces were accounted for in the crash area, with no evidence of any pre-impact malfunction or failure, except that the spoilers were not found and were presumed to have been burnt in the subsequent fire. The Board attaches no significance to the missing spoilers, regard being had to all the surrounding circumstances, and in particular to the speed at which the impact occurred.

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(ii) Though the rudder and aileron trim indicators appeared to have been knocked out of position on impact, all material components of the several control actuating mechanisms were found in the wreckage and provided every evidence of normal function up to the time of impact. In particular, the horizontal stabilizer trim indicator, showing 0° , coincided with the actual setting of the trim jack in the horizontal stabilizer, and with the stabilizer position in the fuselage aft of the pressure bulkhead. Furthermore, examination of all components revealed no electrical failure, and that the friction clutch mechanism had functioned satisfactorily.

E. Failure of Aircraft Systems.

- (i) Electric power. All the evidence is against total failure of electric power. In this regard :-
- (aa) The lights of the aircraft were visible to eye-witnesses while it was descending.
 - (bb) There is convincing technical evidence that the flight director system and the air data computer were under electric power at the moment of impact.
 - (cc) Alternative sources of power were available from the respective generators of each engine, apart from which an emergency power supply would have been provided from the batteries in the event of total generator failure.
 - (dd) Examination of the J6 Main AC power shield after impact showed that all the Bus Tie Breakers

/ (BTBs)

(BTBs) and Generator Circuit Breakers (GCBs), with the exception of the GCB for No. 2 engine, were closed. The tripping of the No. 2 engine GCB was probably caused by the breaking away of the current transformers and associated leads on impact (No. 2 engine was the first to touch the ground).

(ii) Electrical Illumination of Instruments. There are three independent systems for the illumination of aircraft instruments, and, in view of the clear evidence against there having been any electrical power failure, it is considered extremely unlikely that any failure occurred of the illumination of the flight instruments.

(iii) Instruments. In regard to the instruments necessary for flight under I.M.C., virtually conclusive evidence was obtained that there had been no malfunction or failure, prior to impact, of the airspeed indicators, the altimeters and the co-pilot's inertial-lead vertical speed indicator. This evidence consists of readings left or impressed on the respective instruments at impact, which give substantially correct values for airspeed, altitude and attitude, and which are consistent among the various instruments. The flight director systems, the air data computers, the airspeed indicators and the altimeters, all provide this evidence. In addition, the 2 dopplers and the true airspeed indicator independently provide corroborative evidence of the airspeed and ground-speed.

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The Captain's I.V.S.I. was found after the impact to be defective in a minor respect which would not have affected its efficient operation as an ordinary V.S.I.

(iv) Air Conditioning. The phase of flight which had been reached would have made any failure on the part of the pressurization system immaterial. The emission of smoke by the system, which has been known to occur in other cases through overheating of electrical components, can be ruled out in the present case because of the evidence of Mr. Taylor, who remained conscious throughout and who testified that there was no such occurrence. Mr. Taylor impressed the Board as an intelligent and reliable witness, and moreover was a very experienced air courier.

(v) Hydraulic System. Consideration has been given to the possibility of an explosion of an hydraulic component under pressure. However, all the accumulators were recovered, and though some of them had been burnt, there was no evidence of an explosion. Mr. Taylor's evidence is also against an explosion. The complete retraction of the landing gear and flaps within the relatively short time that the aircraft was in the air provides some evidence that the hydraulic system was serviceable.

(vi) Oxygen System. The Board has considered the possibility of an explosion in an oxygen bottle under pressure. All 6 of the main oxygen bottles were recovered, as were 8 out of the 9 "walkabout" bottles, including the bottle stowed on the flight deck. There was no evidence

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of an explosion in any of these. Careful examination of the flight deck further indicated that, though there was heavy damage from the impact, there were none of the usual marks of an explosion.

F. Fire.

There is no evidence of fire having occurred in the air. The aircraft was under observation by a number of eye-witnesses until it crashed. None of them has suggested that it was on fire while still in the air. Nor was there any signal from the aircraft. Mr. Taylor's evidence is again relevant here.

G. Adverse Weather.

There was nothing in the weather conditions which had any bearing on the accident.

H. Bird or Animal Strike.

A careful search was made on the runway and beyond it, and in the wreckage of the aircraft, for evidence of a collision on the runway with a kudu or other animal. This investigation was completely negative. The possibility exists that there was a bird strike after take-off, though the opportunity for this was reduced by the fact that very few birds fly at night. The windscreens were in place, and there was no evidence within the engines suggestive of ingestion of a bird or bat. Any bird strike which might have occurred did not affect the airworthiness or control of the aircraft, or the power output of the engines.

/ I. Sabotage

I. Sabotage.

The question of sabotage was thoroughly investigated by the South African Railway Police under Colonel Matheson. An explosives expert was also called in to examine whatever portions of the wreckage might possibly have yielded evidence of an explosion. His findings are completely negative. Other possible forms of sabotage (which it is not necessary to detail in this Report) have been considered by the Board, and rejected as highly improbable. The Board is satisfied that suitable steps were taken to protect the aircraft from access by unauthorised persons both at Jan Smuts Airport and at J.G. Strijdom Airport.

The possibilities suggested by the fact that one passenger had somewhat inexplicably missed the aircraft at Jan Smuts Airport, though his luggage was already aboard, have been fully investigated by the Police, who are satisfied that no sinister inference can be drawn. Mr. Taylor's evidence again confirms that there was no explosion or other episode suggestive of sabotage.

2.1.2. The analysis so far excludes all causes other than failure on the part of the crew to maintain proper control of the aircraft. The following factors are important:

(i) Having regard to the serviceability of the aircraft, engines, instruments, etc., there is no

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mechanical reason why the aircraft should have descended, or should not have been pulled out of its descent in good time.

(ii) The after take-off checks which had already been completed, according to the evidence left in the wreckage, strongly suggest that one or more members of the crew must have been engaged in these checks during the time that the aircraft was descending; it would be most unlikely that all these particular checks would have been completed prior to the aircraft attaining its maximum estimated altitude of approximately 650 feet.

(iii) There is no evidence of any emergency on the flight deck, in that there was no distress call or signal.

(iv) The flap retraction and the reduction in engine power, coupled with the change in trim, would ordinarily have resulted in loss of height, unless other steps were taken to check it.

(v) The take-off trim should have been $3\frac{1}{4}$ units nose-up instead of $2\frac{3}{4}$ units nose-up; this by itself is not significant, but the reduction of nose-up trim after take-off to 0 appears to have been excessive for the prescribed climb in that phase of flight.

2.1.3. Presupposing airworthiness and serviceability in all material respects, as demonstrated by the evidence already analysed above, the Board considers that the

/ fundamental

fundamental requirement on the part of the pilot was that he should have maintained proper control of the aircraft's attitude, heading, airspeed and climb, all by reference to his flight instruments, and that the co-pilot should have monitored this requirement by reference to his own flight instruments and by cross-checking. In all the circumstances, the fact that the aircraft was allowed to level off and then descend, gaining much more speed than was appropriate to the prescribed climb procedure in that phase of flight, leads to but one conclusion, namely that the pilot failed to maintain the prescribed climb and control of height and airspeed by reference to his flight instruments, and that the co-pilot failed to monitor his instruments in those respects, and/or failed to alert the pilot to the changes in altitude and airspeed.

2.1.4. Numerous possibilities have been considered as to why these failures should have occurred, such as :

(aa) Crew Incapacity:

The post-mortem findings on First Officer Holliday and on Mr. Armstrong, indicate that they had both been in good health. The post-mortem findings on Navigation Officer Howe are not available. The post-mortem findings on the captain, and on Flight Engineer Officer Minnaar, indicate that each had suffered a certain measure of arterial disease. Disability on the part of Mr. Minnaar would not

/ have

have affected control of the aircraft, though it might have caused a serious distraction. On the other hand, a sudden disability on the part of the captain would undoubtedly have caused a serious situation on the flight deck, though even then, the third pilot and engineer officer would have been there to assist, and the first officer should have taken all necessary steps to maintain full control.

The post-mortem findings on the captain indicate that his heart was still beating at the moment of impact. The indications are therefore, at least prima facie, against a fatal heart attack.

On the other hand, Captain Smith's medical history indicates that, though he was fit for flying, he was not as fit as he had been previously. One of his senior colleagues advised the Board that he appeared to have aged prematurely, and that he was looking forward to retiring soon, when he reached the age of 50. His flying proficiency had deteriorated with the general deterioration in the level of his physical fitness, though he had performed satisfactorily during all flight and route checks.

The anti-histamine and pain killing tablets found on the floor of the flight deck, were not necessarily associated with Captain Smith, and there is no evidence to establish that Captain Smith was taking drugs or any other form of medication. However, his raised blood pressure may have caused some anxiety on his part in regard to his immediate future, and the possibility cannot

/ be

be ignored that he may have been induced to seek treatment privately or to treat himself in an effort to overcome the clinical signs. The Board has consulted with specialist medical opinion on this aspect of the case, and, while it can make no findings, recognises as a possibility that Captain Smith might have been taking treatment privately and that this might have had some effect on his performance as a pilot on the night of 20th April, 1968.

Captain Smith's eye-sight required correction by the use of suitable lenses for near vision. His glasses were not found in the wreckage or at the site, but there is evidence that he took a pair of glasses with him when he left his home. The position in regard to his vision has been referred to in paragraph 1.5.1. of this report.

(bb) Escape of CO₂

Cases of crew intoxication by CO₂ have been reported. The Board has examined these instances, and has come to the conclusion that the evidence in the present case really excludes any such occurrence.

(cc) Vertigo and/or Spatial Disorientation

Either or both of these could have occurred in one or both of the pilots.

(dd) Distractions other than Crew Incapacity.

There is no evidence of any distraction, whether from internal or external causes. Mr. Taylor noted nothing untoward, but his evidence would not be conclusive of what

/ might

might have been happening on the flight deck.

Whatever the position in regard to distractions, it is impossible to escape the conclusion that a duty rested on the pilot and/or co-pilot (according to the circumstances of any distraction) to maintain proper control of the aircraft by continuous reference to the flight instruments. The existence of some serious distraction of attention could only mitigate the failure of the pilot and/or co-pilot to maintain such control. In the absence of information on any possible distraction, the Board finds itself unable to evaluate the extent of any such mitigation.

Among the possible distractions which have been considered are the following :-

- (i) Smoke through overheating of electrical equipment on or under the flight deck.
- (ii) Smoke through overheating in the air conditioning system.
- (iii) Bird or bat strike. In this regard the fact that the wing lights (if such were indeed the lights seen by the eye-witnesses) were put on would suggest that the crew wished to examine the leading edges of the wings for possible damage. However, the evidence is against a strike of such magnitude as would have affected the airworthiness or the control of the aircraft.
- (iv) Lighting failure (see paragraph 2.1.1. E (ii) above).
- (v) Some startling noise, such as that of crockery
/crashing

crashing in the galley.

- (vi) The suspected presence of another aircraft in the area: in fact a light aircraft was engaged in local night flying training while "Pretoria" was on the ground, but at the time of take-off was well South of the airport.

The evidence does not appear to support any of these possibilities, though some of them cannot be excluded.

(ee) Errors

The possibility exists that, since this was the first overseas flight on a C model aircraft by each of the crew members, and since the crew had not previously flown together, the pilot and the co-pilot did not integrate their respective efforts in strict conformity with prescribed procedures, and that :-

- (i) "Flaps up" might have been selected at 400 feet. The minimum height then prescribed was 700 feet, but in the A model flaps are reduced from 30° to 20° at 400 feet, whereas in the B and C models flaps were at the time fully retracted from 14° to 0° at 700 feet. Premature selection of flaps to 0° at 400 feet, at $V_2 + 10$ knots, with reduction of engine output to climb power, would have tended to bring the nose down. However, the engines were left at climb power, which suggests that no emergency developed on this score.
- (ii) There is ground for believing that there was a premature pre-occupation on the part of the co-pilot / with

with the after take-off check list items.

- (iii) The first officer might have been doing the take-off, and, in view of his previous experience on 727s (which require fairly considerable reduction of nose-up trim after take-off) might have applied excessive reduction of nose-up trim.
- (iv) The rapid increase in airspeed might have been ascribed by the pilot to the improved performance of the C model, coupled with the relatively low all up-weight on this occasion, and the pilot and the co-pilot might have regarded this as acceptable because of the sensation of climb induced by acceleration, and because of possible other temporary spatial disorientation.
- (v) There might have been a misreading of the drum-type altimeter, other instances of which have been reported. The effect of such misreading in the present case might have led the pilot to believe that the aircraft was approximately 1,000 feet higher than in fact it was. It is noted that the QNH setting found on the captain's altimeter was 1025 millibars and that on the first officer's was 1022 millibars. The discrepancy is attributed to the impact, and is not regarded as significant. The use of a QNH and not a QFE is normal practice in South African Airways, whose pilots are familiar with high altitude airfields.
- (vi) There might have been some pre-occupation on the

/ part

part of the pilot with trying to locate the other aircraft in the area at the time.

- (vii) There might have been some temporary confusion on the part of the pilot and/or co-pilot as to the position of the I.V.S.I., which was located differently on the C model. This confusion could have arisen because these pilots were accustomed to the A and B models, and in the captain's case, because of his vision, as discussed in paragraph 1.5.1.(d) above.

2.1.5. As a counsel of perfection, the same crew members should always be limited to flying one type of aeroplane, but in practice this situation cannot always be achieved. In many airlines, however, elaborate steps are taken to standardize instrument panel layout.

2.1.6. The Board has considered the adequacy of the training and conversion programmes applied by South African Airways in the present case, and has noted that South African Airways prescribed a conversion programme in the air of the same duration as that recommended by the Boeing Company itself.

2.1.7. The Board has not been able to determine with certainty who was actually flying the aircraft. The evidence of practice in the airline, and of this captain's normal procedures, indicates that the first officer was probably the pilot for this take-off. Certain evidence

/ of

of injuries has led to medical opinion that the captain was flying the aircraft, but the factual premise upon which this opinion is based is doubtful.

2.2 CONCLUSIONS.

- 2.2.1. (a) The aircraft was properly certificated and licensed. ✓
- (b) It was below maximum permissible all-up weight, below regulated take-off weight, and in fact at the time of take-off was below maximum landing weight. ✓
- (c) It was properly loaded and the c. of g. was within prescribed limits at 27.7% MAC. ✓
- (d) It was maintained according to prescribed requirements and was fully airworthy. ✓
- (e) It had sufficient fuel (JP-1) of the correct grade, specification and quality on board. ✓
- (f) The aircraft, engines, instruments and all other systems were functioning normally at the time of impact. ✓
- (g) There was no fire or explosion in the air. ✓
- (h) There is no evidence of sabotage. ✓
- (i) The aircraft flew into the ground some 57 seconds after take-off at a speed of approximately 271 knots (312 miles per hour), and disintegrated after impact. Fire thereafter broke out in each of the wings and flashed back along the line of spilt fuel. ✓

/2.2.2.

2.2.2. Each member of the flight crew held a valid and current licence as prescribed, and was properly qualified on the Boeing 707-344C. ✓

2.2.3. The weather was fine and did not contribute to the accident. ✓

2.2.4. South African Airways applied the conversion and flying training programme recommended by the Boeing Company and it also applied the take-off technique and procedures approved by that company at the time of the accident, but with an added margin of safety in that the flap retraction was delayed from a minimum altitude of 400 feet to a minimum of 700 feet. ✓

2.2.5. In regard to the cause of the accident :

- (1) The effective cause of the accident was the human factor, and not any defect in the aircraft or in any of the engines or flight instruments. ✓
- (2) After a normal take-off and retraction of the landing gear, and while the aircraft was approaching an estimated height of 650 feet, the flaps were fully retracted and the engine output reduced from take-off power to climb power. There is no reason to suppose that these steps were not taken in the correct sequence and at the prescribed indicated airspeeds. ✓
In that phase of flight these alterations in flap configuration and engine power would have caused the aircraft to level off and then lose height

/(a)

- (a) unless the pilot checked that tendency and maintained a climbing attitude by appropriate action, or (b) until the aircraft gained much more speed. ✓
- (3) The aircraft levelled off and lost height, and during the short period in which it did so the pilot appears to have acted as if he believed that the aircraft was still climbing. He appears to have altered the stabilizer trim to maintain the aircraft in its same pitch attitude, which he apparently believed was an attitude of climb, but which was in fact an attitude of descent. In that situation, which lasted for about 30 seconds, the aircraft lost approximately 750 feet* in height and flew into the ground. ✓
- (4) The co-pilot failed to monitor the flight instruments sufficiently to appreciate that the aircraft was losing height. ✓

The following causes probably contributed in greater or lesser degree to the situation described above:-

- (a) take-off into conditions of total darkness with no external visual reference; ✓
- (b) inappropriate alteration of stabilizer trim;
- (c) spatial disorientation;
- (d) pre-occupation with after-take-off checks.

The following causes might have contributed in greater or lesser degree :-

- (a) temporary confusion in the mind of the pilot on ✓

/the

* The ground at the point of impact is approximately 100 feet lower than the point on the runway at which the aircraft took off.

- the position of the inertial-lead vertical speed indicator, arising from the difference in the instrument panel layout in the C model of the Boeing 707-344 aircraft, as compared with the A and B models, to which both pilots were accustomed;
- (b) the pilot's misinterpretation, by one thousand feet, of the reading on the drum-type altimeter, which is susceptible to ambiguous interpretation on the thousands scale;
 - (c) distraction on the flight deck caused by a bird or bat strike, or some other relatively minor occurrence.

2.3 RESPONSIBILITY FOR THE ACCIDENT.

2.3.1. It was a fundamental requirement of safe operation of the aircraft in the conditions of darkness and lack of all external visual references, and especially in the phase of flight immediately after the take-off, that the pilot and co-pilot should have ensured that safe attitude and airspeed and a positive climb were maintained by continuous reference to the relative flight instruments.

In the objective analysis of the occurrence, there was, as between the pilot and the co-pilot or either of them, a failure to observe this requirement in respect of the positive climb.

Various factors, operating individually or cumulatively on the pilot and/or co-pilot, probably caused or contributed to this failure, but there is nothing to

/ suggest

suggest that any crew disablement or other emergency occurred which would have caused loss of control or which would have justified any departure from the said requirement. Responsibility for the accident accordingly falls on both the captain and the first officer, but primarily on the captain as the pilot-in-command, whether or not the first officer was doing the take-off.

2.3.2. Though in theory the third pilot's duties would have included monitoring the flight generally, in practice it was not possible for him to monitor flight instruments effectively. Besides, the evidence indicates that in this case he was responsible for the R/T. No responsibility for the accident therefore rests on him.

2.3.3. Apart from the foregoing, there is in relation to the accident no evidence of any neglect or breach of duty or other irregularity on the part of South African Airways, or the Department of Transport, or any person connected with the maintenance, operation or control of the aircraft, or with air traffic control, or search and rescue by the airport fire-fighting service, or with the licensing and flying proficiency of the pilots, or with the medical examination of the crew members for the purposes of licence renewal.

3. RECOMMENDATIONS.

3.1 At the time of the accident the minimum height for flap retraction as laid down by the F.A.A. was 400 feet. In the opinion of the Board, the minimum height in standard airline operation for full retraction of flaps on the B and C models should be of the order of 1,000 feet, and the normal height for such retraction should be 2,000 feet. The Board finds that South African Airways acted properly in laying down take-off procedures in accordance with the then recommended practice of the Boeing Company, which was approved by the F.A.A., and in prescribing a minimum which was in fact higher than the Boeing Company's minimum. It is noted that, since the accident, the Boeing Company recommends flap retraction at an altitude of 800 feet, as compared with the F.A.A. minimum of 400 feet (see "707-300B (ADV)C, Instructor Pilot Guide" Ref. 707 Pilot T.M. 4-1, of 15th May, 1968, at page 15, as compared with the F.A.A. minimum referred to on page 14), and that South African Airways has also increased its former minimum height.

3.2. The Board recommends that the whole system whereby the co-pilot monitors take-offs under I.M.C. should be revitalized so as to avoid the dangers arising from loss of concentration on flight instruments.

3.3. The Board draws attention to the desirability, from a safety point of view, of standardizing the layout of flight instrument panels, as is done by many other airlines.

/3.4

3.4. The Board notes that the checking of South African Airways' Pilots is done by South African Airways themselves. Without reflecting at all on the standards of South African Airways' flying instruction, the Board draws attention to the desirability of having a proportion of the flying checks conducted by an entirely independent inspectorate, as is done elsewhere.

3.5. The Board recommends that fire tender crews at airports should, as part of their duties, acquaint themselves with the terrain on extended centre lines of the runways and with the best methods of access to such terrain.

3.6. The Board recommends that the fitting of flight data recorders to all jet and turbo-propeller aircraft in passenger airline service be expedited, and that voice recorders be included in this requirement. The Board notes the valuable part played by voice recorders in the determination of the causes of numerous accidents in the U.S.A., not only in recording speech but also in recording all sounds associated with various operations of engines and aircraft.

3.7. In view of the evidence by a senior training captain in South African Airways that drum-type altimeters have in several cases led to misreading of altitude by 1,000 feet, which evidence is supported by similar instances reported to the Chairman by the N.T.S.B. in Washington, and reported to the Board by the Chief Test Pilot of the

/A.R.B.

A.R.B. in London, and by the personal experience of one of the members of the Board, the Board recommends that existing drum-type altimeters in public transport aircraft be substituted by 5-digit counter type altimeters.

3.8. The Board recommends that :

- (a) post-mortem examinations in fatal air accidents should be extended to include the fuller forms of investigation necessary to establish or eliminate cardio-vascular failure (such as microscopic study of the heart muscle), retinal haemorrhage, inhalation of suffocating gas, and to determine, if possible, from limb injuries, which pilot was handling the controls;
- (b) consideration be given in future to the interrogation under medically approved conditions, of survivors suffering from retrograde amnesia, in those cases where it would be proper to do so and where helpful evidence may be obtained from such procedures.

3.9. The Board recommends that the attention of all pilots be drawn to the medical opinion expressed in this case that the first officer would probably have survived if he had been wearing his shoulder harness.

3.10. The Board has given careful consideration to possible methods of improving the survival rate in this class of accident, but is unable on the information available to
/venture

into recommendations affecting aircraft design, stronger seats and securing devices, or methods of cushioning impact.

LOCALITY PLAN

ANNEXURE 3

SCALE 1:25000

0 500 1000 2000 3000 METRES



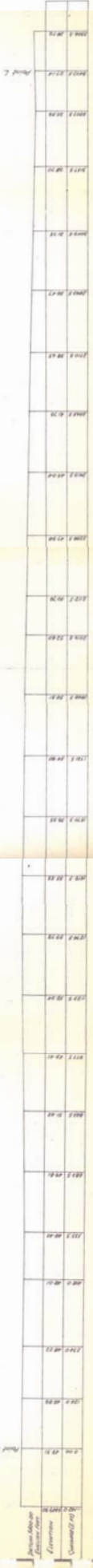
PART OF DWG. No.

0 85 UWH

SITE PLAN



LONGITUDINAL SECTION



Scale: 1:1000
Date: 10/10/2000
Author: [Name]
Checked: [Name]

ANNEXURE 1.LIST OF PASSENGERS.SURVIVORS

B.R. Arntzen^m
A. Derbyshire
W.E. Rooke
T.W. Taylor
P.T. Williams

DECEASED

E.W. Avery
G.A. Avery
E. Bachmann
F. Bachmann
D.A. de O. Barbosa
I. Bartels
A.E. Begley
C.E. Blackwood
I.H. Böhm
S. Böhm
H.A. Brand
E.A. Brandt
T.A. Brandt
K.G. Brock
R.B. Brockbank
H.W.F. Brons
W.H. Brons
F.K.W. Burzlaff
H.E. Burzlaff
S.G. Cheal
P.K. Coates

/Annexure 1 cont.

ANNEXURE 1 - LIST OF PASSENGERS (cont.)DECEASED

M.P. Collins
F.J.M.T. de C. de Chamarel
J.H. de Groot
P.A. de Kok
E. de Rauville
M.E. de Rauville
P. de Rauville
V.E. Engelbert
A.C. Ferguson-Davie
E.W. Fitze
J. Forrest
H.A. Fussenegger
L.P. Geldenhuys
J.L. Gilbert
W. Hanisch
E. Heinz
H.W.R. Hinsch
T.P. Hooper
M.W. Hooper
Y. Jooste
I.H.J. Kannegieser
K.H. Keck
I.D.M.A. Kirsten
L. Knispel
G. Krommenhoek
M. Krommenhoek
V.E. Krufinski
G.J.G. Langermann
J. Langermann

/Annexure 1 cont.

ANNEXURE 1 - LIST OF PASSENGERS (cont.)DECEASED

M. de B. Lobo
F. Lorentz
J.W. Loubser
S.L. Louw
F.G. Magee
H.U. Materne
R. Materne
S.A. Materne
W. Materne
I.M.I.S. Merz
K.L. Merz
R. Mininberg
E.A.C.D. Notzon
G.A.R. Notzon
J.S. Notzon
K. Notzon
R.M. Ose
K. Ostmann
L.A. Ostmann
H. Pack
H.W. Pack
R. Pack
W. Pack
M.A. Parker
K.M. Patterson
W.A.G. Patterson
M.A.J. Peters
D. Petrick
H.E. Pohl

/Annexure 1 cont.

ANNEXURE 1 - LIST OF PASSENGERS (cont.)DECEASED

V.M. Purcocks
M. Radovanovic
K.M. Richards
I. Roberts
P. Roch
S.M. Rooke
G. Rummel
E.M. Salters
R.M. Salters
C. Sattler
W. Sattler
E. Schnieber
B.W. Sewell
H.J. Sigsworth
D.G. Simpson
J. Smit
R. Smith
M.R. Staiger
B.H.E. Stalman
W.R. Stern
B. Thomas
E. Thomas
P.M. Thomas
E.N. Thompson
B. Tigner
J. De O. Trindade
D.F. Usher

/Annexure 1 cont.

ANNEXURE 1 - LIST OF PASSENGERS (cont.)

DECEASED

J.G. van der Wath

F.C. van Elten

C.H. Wichert

A.T. Williams

J.D. Wylie

ANNEXURE 2.

LIST OF CREW.

Captain E.R. Smith
Flight Officer J.P. Holliday
Second Officer R.F. Armstrong
Flight Engineer Officer P.A. Minnaar
Navigation Officer H.C. Howe
Flight Traffic Officer A.G. Manson
Chief Flight Steward J.A. Erasmus
Senior Flight Steward H.S. Louw
Flight Steward R.J. Bester
Flight Steward J.W. Jesson
Flight Stewardess M. Nortier
Flight Stewardess E. Janse van Rensburg

ANNEXURE 5.KEY TO SITE PLAN OF WRECKAGE.

(Numbers on this list refer to those shown on plan.
Items 1 to 126 are contained inside fenced area).

<u>Item No.</u>	<u>Description.</u>
1	Water drain mast tag.
2	Water drain mast and fragments of rotating beacon glass.
3	Top hat section P/N 90/9195/856.
4	Aircraft bay door latch 105755/5.
5	Sheet metal cover 901478/3002
6	Distance piece and portion of main landing gear wheel hub 9525654.
7	Forward thrust reverser.
8	Triangular steel plate 40/57511.
9	Heavy steel beam structure.
10	Heavy steel beam structure.
11	Timkin bearing plus wheel hub piece with tyre beading imprint.
12	Heavy structure piece 6510065/40 keel beam. Fabric rubber piece 22412121.
13	Casting rod end bearing 691673?9.
14	6910872/8 plate.
15	Extruded angle rivetted to plate alloy 50/7966/?6.
16	Blocker door actuator 69/14928.
17	Bulb seal and angle 5/86308/2050.
18.	Secondary air inlet door 69/33605/1.
19	Forward thrust reverser track A.D.C.N.552.
20	Main landing gear hub section and bolt.
21	Small piece inlet guide vane case.
22	65/2020/7 Support strut.
23	Portion engine cowl.

/Annexure 5 cont.

ANNEXURE 5 (cont.)

<u>Item No.</u>	<u>Description.</u>
24	Air research check valve 107234. Serial No. P.2639.
25	Suspected engine cowl debris.
26	Sheet metal structure 65/23446/2.
27	Inlet guide vane case.
28	65/6369/48 Sheet strip alloy.
29	Secondary air inlet door.
30	Part of C.S.D. casing.
31	Side cowl lower fastener.
32	2nd stage stator vane.
33	Inlet guide vane case.
34	Control service tab section 65/5347/14 - elevator tab.
35	Blocker door.
36	Nose gear inflation chart.
37	Portion fuel line.
38	Forward thrust reverser air tube fitting.
39	Casting control quadrant 65/11868/2.
40	Section of fan blade; 2nd stage.
41	Section N2 gearbox case.
42	Forward thrust reverser track.
43	Strut blow-out panel 65/22950/1.
44	Portion N2 gearbox.
45	2nd stage inlet guide vane.
46	Portion fan blade.
47	Portion main wheel hub.
48	Engine cowl fastener.
49	4th stage compressor blade.
50	Engine cowling.
51	Water injection manifold.
52	Fuel line.

/Annexure 5 cont.

ANNEXURE 5 (cont.)

<u>Item No.</u>	<u>Description.</u>
53	2nd stage fan blade.
54	Portion turbine blade.
55	4th stage turbine nozzle guide vanes.
56	Portion forward thrust track and N2 gearbox.
57	Turbo compressor air filter assembly.
58	Section of accessory components.
59	Engine component filter section.
60	Two pieces of engine cowling at impact.
61	Fan inlet guide vane.
62	Forward thrust reverser actuator end cap.
63	Section turbine blade shroud.
64	Suspected inlet guide vanes.
65	2nd stage inlet vanes.
66	Inlet guide vanes.
67	Section main landing gear wheel hub.
68	1st stage fan blade.
69	Outer race ball bearing piece.
70	Engine side cowling (small cowl).
71	Forward thrust reverser actuator fitting.
72	Engine cowl stay.
73	Section fuel control unit.
74	Section inlet guide vane case.
75	Fan inlet guide vanes.
76	Engine cowl fastener.
77	Main landing gear wheel hub.
78	1st stage fan blade.
79	Engine component.
80	Large portion inboard side cowl (small).
81	Forward thrust reverser track.

/Annexure 5 cont.

ANNEXURE 5 (cont.)

<u>Item No.</u>	<u>Description.</u>
82	Secondary air inlet door (portions).
83	2nd stage fan blade piece.
84	Main landing gear door attached to keel beam.
85	Fan blades (1st stage).
86	Forward thrust reverser track.
87	Turbine blade pieces.
88	Section engine cowling.
89	Section inlet case.
90	Engine component elbow.
91	Piece engine cowling.
92	Nozzle guide vane section.
93	Pieces 4th stage turbine blades.
94	Section starter motor.
95	4th stage turbine blades.
96	1st stage fan blades.
97	Secondary air inlet door.
98	Main landing wheel bearing cage.
99	2nd stage compressor stator.
100	Piece accessory component.
101	4th stage turbine blade.
102	Nose wheel landing gear hub.
103	Pieces engine cowlings 4th stage turbine blades and forward thrust reverser actuator.
104	Pieces of fan blades.
105	Piece forward thrust reverser actuator.
106	Inlet guide vanes.
107	Pressuring and dump valve cap.
108	4th stage turbine blade.
109	Inlet guide vane.

/Annexure 5 cont.

ANNEXURE 5 (cont.)

<u>Item No.</u>	<u>Description.</u>
110	Piece of engine injection system.
111	Piece of accessory engine component.
112	1st stage fan blade.
113	Pieces of turbine blade and fixture of 4th stage turbine blade.
114	Piece of inlet case.
115	2nd stage compressor blade lock.
116	Section of 4th stage turbine blade and 2nd stage compressor stator.
117	Secondary inlet door and turbine blade.
118	T.C. cowl lock.
119	Piece engine cowl.
120	2nd stage compressor blade lock.
121	Thrust reverser ducting.
122	Pieces engine cowling.
123	T.C. oil line and pieces turbine blade.
124	Inlet guide vane and compressor fan blade.
125	Fixture 4th stage turbine blade and piece 1st stage fan blade.
	Route 2nd stage fan blade.
126	Main landing gear door.
127	Fan blade turning. L.150.
128	Fan blade 1st stage. L.300.
129	Fan inlet guide vane. L.50.
130	6th stage N1 compressor.
131	Radio altimeter box cover. R.J.20.
132	Left 30 lower wing primary structure.
133	Left 30 left hand cove door 6518894.
134	Left 15 engine cowling 6541416.
135	Fuel oil cooler (B400?).
136	Inlet case outer.

/Annexure 5 cont.

ANNEXURE 5 (cont.)

<u>Item No.</u>	<u>Description.</u>
137	5th stage compressor blade.
138	Forward section turbo compressor.
139	Forward thrust reverser actuator.
140	Forward thrust reverser actuator.
141	1st stage fan blade.
142	Inlet guide vane case (inner).
143	4th stage nozzle guide vane.
144	1st stage fan blade.
145	Pressurising and dump valve.
146	Compressor stator.
147	Inlet guide vane case (northern side end).
148	Inlet guide vane case (southern side end).
149	4th stage turbine blade and T.C. strap bearing.
150	No. 4 engine side cowl panel. Right hand 36.
151	Right hand 36 No. 4 engine main side cowl and No. 4 engine bearing outer vane.
152	Lower cargo compartment door.
153	No. 3 engine main side cowl.
154	Fan blade (turning) E?
155	No. 4 engine forward thrust reverser translating sleeve.
156	Turbo compressor cowl.
157	Vertical gyro metal case.
158	Section of keel beam.
159	Corner of hole 4' x 9" deep.
160	Corner of hole 2' x 9" deep.
161	Corner of hole 22' x 1' deep.
162	Nose dome No. 4 6542388/2.
163	Lower cargo compartment shelf fibre glass.
164	Main landing gear wheel CR.S.126.

/Annexure 5 cont.

ANNEXURE 5 (cont.)

<u>Item No.</u>	<u>Description.</u>
165	Corner of hole 12' x 18" deep.
166	No. 1 bearing cage.
167	Fan inlet case.
168	4th stage compressor disc.
169	Landing gear ground lock pin.
170	Landing gear strut inner sleeve.
171	Air conditioning bung.
172	V.O.R. localizer unit.
173	Thrust reverser cascade vane.
174	Fan inlet case inner circumference.
175	Fin tip probe.
176	Control cabin roof lining.
177	External power receptacle.
178	Vertical gyro fibre glass cover.
179	Brake lockout deboosters.
180	Side cowl No. 1 engine.
181	Fan stage outer shroud.
182	Portion top fuselage skin.
183	1st stage turbine outer air seal.
184	Main landing gear oleo door.
185	No. 4 engine side cowl.
186	Flap jack fillet clasp.
187	Two spring air inlets.
188	Inboard flap fuselage track; left side.
189	Rudder debris.
190	Fan blade.
191	No. 3 engine inboard main cowl.
192	Left hand fillet flap.
193	Corner of hole 9' x 12" deep.

/Annexure 5 cont.

ANNEXURE 5 (cont.)

<u>Item No.</u>	<u>Description.</u>
194	Portion rudder, T.A.V.
195	No. 2 engine gear case.
196	4th stage compressor disc (piece).
197	5th stage disc.
198	Piece 5th stage compressor disc.
199	Vertical gyro (piece of).
200	Fan exit vane.
201	Compressor section less fan stages.
202	$\frac{1}{2}$ thrust reverser tail cone.
203	Fan exit vane.
204	Piece No. 2 gearbox.
205	Portion of lower keel beam and skin of forward air conditioning bay with heat exchanger.
206	Turbo compressor.
207	Inner right hand wing.
208	No. 2 engine oil cooler L.150.
209	Right wing leading edge flap.
210	Point of impact - right wing.
211	Point of impact - right wing.
212	Point of impact - right wing.
213	Point of impact - right wing.
214	Engine hole 18' x 18" deep.
215	Water injection pump.
216	15' long keel beam forward baggage compartment with cargo floor and track.
217	M.L.G. lock-out deboosters.
218	6th bearing exhaust strut.
219	Engine F.C.U.
220	Turbo compressor complete.
221	Portion of fin with lightning arrestor.

/Annexure 5 cont.

ANNEXURE 5 (cont.)

<u>Item No.</u>	<u>Description.</u>
222	Dorsal fin.
223	Right hand trailing edge fillet flap.
224	Piece of compressor disc.
225	Compressor spacer.
226	6th and 7th compressor discs.
227	Water injector pump.
228	Left hand wing tip.
229	Pressure bulkhead and thin vertical attachment piece.
230	Fan exhaust stator and low compressor outer case.
231	Vertical fin and portion of rudder.
232	Compressor bleed valve.
233	No. 4 engine.
234	Engine oil tank.
235	Fuel P & D valve engine.
236	Portion of lower skin right wing (burnt).
237	Portion of right outer aileron.
238	Portion right hand inboard wing flap.
239	Main strut left landing gear.
240	Fuel pump engine-driven 676 AAU 1221.
241	Hole caused by landing gear strut 30' x 2'6" deep.
242	Hole 6' x 2'6" deep.
243	Suspect No. 3 engine strut.
244	Stabilizer (tail unit).
245	Tail unit stabilizer.
246	Constant speed drive 6874.
247	Thrust reverser assembly 6516032 SN.C 318.
248	Spindle flap jack (unidentified position).
249	Turbo compressor.

/Annexure 5 cont.

ANNEXURE 5 (cont.)

<u>Item No.</u>	<u>Description.</u>
250	Fillet flap jack. 150' left.
251	Fuel control unit 59410.
252	Main wheel hub.
253	No. 6 bearing housing.
254	Engine oil tank.
255	Main oil pressure filter.
256	Left wing outboard section. No. 1 aux. fuel tank.
257	Engine strut No. 2.
258	Engine strut No. 1.
259	Directional gyro.
260	Right hand main landing gear outer cylinder assembly.
261	Flap transmission assembly F/1060.
262	Right hand main landing gear cylinder assembly.
263	Right hand inboard aileron.
264	1st and 2nd stage fan discs.
265	2nd stage compressor disc.
266	Turbo compressor shut-off valve.
267	6' x 1'6" deep hole.
268	Water injection pump.
269	Rear back door.
270	No. 3 engine strut.
271	1st and 2nd stage fan discs.
272	Engine fuel pump.
273	Water injection pump.
274	Portion of flap section in track - right wing.
275	Wing flap jack screw (unidentified position).
276	Cabin flooring over M.L.G. wheel well - unknown whether left or right.

/Annexure 5 cont.

ANNEXURE 5 (cont.)

<u>Item No.</u>	<u>Description.</u>
277	8th and 9th stage compressor.
278	Fuel control unit.
279	Floor section (cabin).
280	5th, 6th and 7th stage compressor.
281	8th and 9th stages compressor discs.
282	1st and 2nd fan discs.
283	Engine No. 1.
284	Starter motor.
285	Burnt out inboard portion of right wing.
286	Burnt out inboard portion of right wing.
287	Aft lower cargo compartment.
288	Fuselage section over centre wing.
289	Fuselage section over centre wing.
290	1st and 2nd stage compressor.
291	Nose landing gear assembly.
292	Right wing lower skin No. 4 engine area.
293	Constant speed drive.
294	Portion of galley.
295	Main landing gear truck wheel Nos. CRS.121, CRS.131, CRS.132.
296	No. 2 engine.
297	Hole 4' x 3' (engine ?).
298	Hole 9' x 1' deep.
299	Portion of aft galley.
300	Aft section main fuselage.
301	Aft section main fuselage.
302	Landing gear side strut.
303	No. 3 engine.
304	Hole 3' square 1' deep (made by engine).
305	Hole 5' x 3' x 1'6" deep.

/Annexure 5 cont.

ANNEXURE 5 (cont.)

<u>Item No.</u>	<u>Description.</u>
306	1st class passenger cabin section and cockpit.
307	1st class passenger cabin section and cockpit.
308	1st class passenger cabin section and cockpit.
309	Forward main entry.
310	Forward galley.
311	Main landing gear inner cylinder.
312	Fuselage overhead structure approximately navigator's station.
313	Main landing gear wheel and axle assembly (forward) CRS.133.
314	Forward portable water tank.
315	Part of left main landing gear.
316	Part of economy class seat assembly.
317	Portion of lower skin centre wing tank.
318	Hole 12' x 6" deep.
319	Hole 12' x 4" deep.
320	N.W. Corner of temporary fence.
321	S.W. Corner of temporary fence.
322	S.E. Corner of temporary fence.
323	N.E. Corner of temporary fence.
324	Direction of fuselage track.
325	No. 2 engine gear case (same as 195).
326	Fuss S.T. 820 left hand wheel well and floor tracks.
327	Left wing.
328	Left wing.
329	Left wing.
330	Left ML 6 aft axle and wheel assembly.
331	Left hand wing leading edge with taxi and landing lights.
332	Wheel mark. *****

APPENDIX A.LIST OF WITNESSES WHO TESTIFIED VIVA VOCE.PASSENGERS FROM JAN SMUTS TO J.G. STRIJDOM AIRPORTS:

W.A. Dreyer
J.H. Esterhuyse (Dr.)
K.J. Howes
H.J. Pack

SURVIVORS:

B.R. Arntzen
W.E. Rooke
T.W. Taylor
P.T. Williams

EYE-WITNESSES OTHER THAN OFFICIALS:

N.J. Bester
A.J. Boucher
R. Bozetti (Miss)
J. Collins
R.L. Kuhn (Mrs.)
W.R. Kuhn
J.H. Leijenaar (Mrs.)
H.J. Lorenz
Z. Maharokua
J.G. Maritz
A.E.B. Pfeiffer (Miss)
J.D.J. Roux
A.H.A. Trümper
B. Trümper
K.H.K. Wiese

/Appendix A cont.

APPENDIX A - LIST OF WITNESSES WHO TESTIFIED VIVA VOCE. (cont.)OFFICIALS EMPLOYED AT J.G. STRIJDOM AIRPORT:

M.E.J. Bezuidenhout, Clerk, S.A.A.

A.D. Clayton, Works Superintendent,
S.W.A. Administration.

J.H. Cocklin (Sgt.) S.A. Police.

J.G. Coffee (Sgt.) S.A. Police.

H.C. Doman, Assistant Station Manager, S.A.A.

S.W. Fouche, Aircraft Technician (Mechanics),
S.A.A.

M.B. Loubser, Port Steward, S.A.A.

S.W.P. Nel, Airport Assistant, Department
of Transport.

A.P. van Niekerk, Senior Assistant, S.W.A.
Administration.

N.H. Robson-Garth, Senior Aeradio Operator.

H. Rossouw, Airport Maintenance Superintendent,
S. W.A. Administration.

C.J. Schutte, Aircraft Technician (Mechanics),
S.A.A.

M. van der Watt, S.A.R. Police.

L.P. Weyers, Passport Officer, Department
of the Interior.

W.F.N.J. Willemse, Senior Air Traffic
Controller.

I.F.J. van Zyl (Sgt.) S.A. Police.

G.W. van Zyl, Airport Assistant,
Department of Transport.

OFFICIALS EMPLOYED AT JAN SMUTS AIRPORT:

L.P. van As, Assistant Workshop Foreman
(Production) S.A.A.

K.H.A. Bain, Senior Training Captain, S.A.A.

A.J.J. Bell, Foreman Inspector (Electrical)
S.A.A.

V.J. Benjamin, Engineering Assistant, S.A.A.

A.S. Britton, Senior Training Captain, S.A.A.

/Appendix A cont.

APPENDIX A - LIST OF WITNESSES WHO TESTIFIED VIVA VOCE.(cont.)OFFICIALS EMPLOYED AT JAN SMUTS AIRPORT

I.G. Caldwell, Aircraft Maintenance Engineer, S.A.A.

D. Davidson, Engineering Assistant, S.A.A.

E. Hartwell, Aircraft Maintenance Engineer, S.A.A.

D. Hoogewind, Senior Air Traffic Controller.

R.J. Hoole, Workshop Foreman (Production), S.A.A.

N.J. Joubert, Trim Clerk, S.A.A.

P. Mileham, Assistant Foreman (Instrument Maintenance) S.A.A.

R.J. O'Brien, Assistant Workshop Foreman, S.A.A.

T.B. Phillips, Production Manager, S.A.A.

J.G. van Rensburg, Traffic Controller, S.A.A.

H.V.G. Rogers, Principal Clerk, S.A.A.

A.A. Rossouw, Senior Outdoor Officer, Department of Customs and Excise.

L.E. Sandow, Supervisor (Electronics) S.A.A.

A.B. Swanepoel, Senior Clerk, S.A.A.

E. Trevaskis, Senior Air Traffic Controller.

C.E. Turner, Instrument Technician, S.A.A.

V.J. Viljoen, Foreman Inspector, S.A.A.

P.J. Visser, Assistant Foreman (Electronics), S.A.A.

A.N. Vorster, Assistant Workshop Foreman (Production), S.A.A.

E.H. Wahl, Assistant Workshop Foreman (Production), S.A.A.

F.A. Warder, Foreman, Instrument Overhaul Department, S.A.A.

H. van Wyk, Clerk, S.A.A.

OFFICIALS OF THE DIVISION OF CIVIL AVIATION:

R.P. Channer, Control Technician.

C.J. Dippenaar, Acting Chief, Airworthiness Section.

/Appendix A cont.

APPENDIX A - LIST OF WITNESSES WHO TESTIFIED VIVA VOCE. (cont.)OFFICIALS OF THE DIVISION OF CIVIL AVIATION:

J.J.S. Germishuys, Chief of the Flying Section.

J.J. Granzier, Assistant Director of Technical Services.

P.A. Peens, Inspector of Accidents.

A.G. Swan, Airworthiness Inspector.

MISCELLANEOUS:

E.P. Bedford, Aviation Manager, Mobil Oil Southern Africa (Pty) Limited.

Dr. H. Bukofzer, Principal District Surgeon, Johannesburg.

Dr. V.D. Kemp, Principal District Surgeon, Johannesburg.

Prof. G.B. Lauf, University of the Witwatersrand.

Col. K.W. Matheson, Deputy Commissioner, S.A. Railways Police.

Brig. N.J. Nieuwoudt, Director of the Military Medical Institute.

T. Saunders, Accredited Representative of the U.S.A. Government.

Dr. M.A. van der Spuy, Assistant Director of Health Services, S.A.A.

M.J. van Vuuren, Local Manager, Mobil Oil Southern Africa (Pty) Ltd., Windhoek.

APPENDIX B.WITNESSES WHO MADE WRITTEN STATEMENTS ONLY OR WHO
GAVE ADDITIONAL EVIDENCE IN WRITING.

E. P. Bedford, Aviation Manager, Mobil Oil of Southern Africa (Pty) Limited.

A. J.J. Bell, Foreman Inspector (Electrical), S.A.A.

H. Bukofzer (Dr.), Principal District Surgeon, Johannesburg.

R.P. Channer, Control Technician, Division of Civil Aviation.

A. Derbyshire, Survivor.

C.J. Dippenaar, Acting Chief, Airworthiness Section, Division of Civil Aviation.

H. van Dyk, Principal Inspector of Explosives, Department of Commerce.

J.J. van Dyk, Pupil Technician, Weather Bureau.

M. Freiman (Dr.), Senior Professional Officer, Department of Health.

J.J.S. Germishuys, Chief, Flying Section, Division of Civil Aviation.

J.J. Granzier, Assistant Director of Technical Services, Division of Civil Aviation.

K.M. Jones (Miss), Receptionist, S.A.A.

V.D. Kemp (Dr.), Principal District Surgeon, Johannesburg.

Prof. G.B. Lauf, University of the Witwatersrand.

Col. K. Matheson, Deputy Commissioner of S.A. Railway Police.

G. Paul, Head, Metal Mechanics Division, Council for Scientific and Industrial Research.

P.A. Peens, Inspector of Accidents, Division of Civil Aviation.

T.B. Phillips, Production Manager, S.A.A.

S. Pienaar, Chief Training Captain, S.A.A.

A.G. Swan, Airworthiness Inspector, Division of Civil Aviation.

S.S. Troskie (Miss), Lady Supervisor, S.A.A.

V.J. Viljoen, Foreman Inspector, S.A.A.

APPENDIX C.PERSONS CONSULTED BY THE BOARD:IN THE REPUBLIC -

J. Adam, Deputy Chief Executive, S.A.A.
 A.S. Britton, Senior Training Captain, S.A.A.
 J.J.S. Germishuys, Chief of Flying Section,
 Division of Civil Aviation.
 W. Hansen, Accidents Investigation Department,
 Boeing Company.
 D. Knutsen, Chief Test Pilot, Boeing Company.
 Prof. G.B. Lauf, University of the Witwatersrand.
 Col. K.W. Matheson, Deputy Commissioner of the
 South African Railways Police.
 F. Mosher, Federal Aviation Administration of the U.S.A.
 C.P.C. Pechey, Senior Captain, S.A.A.
 T.B. Phillips, Production Manager, S.A.A.
 J.A.G. Rademan, Fleet Captain, S.A.A.
 D.B. Raubenheimer, Senior Captain, S.A.A.
 F. Retief, Captain, S.A.A.
 F.A. Rouse, Senior Captain, S.A.A.
 T.R. Saunders, National Transportation Safety Board
 of the U.S.A.
 L.C. du Toit, Director of Civil Aviation.
 Dr. J.T. Marquard de Villiers, Specialist Physician (who
 provided in addition written reports from Prof. G.T. du
 Toit, Dr. H. Meyer and Prof. Dr. B.J. Schlebusch).
 A. Zollin, Representative in South Africa of the Pratt
 and Whitney Division of United Aircraft Corporation.

IN THE U.S.A. -N.T.S.B. Bureau of Aviation Safety.

Marion F. Roscoe - Deputy Director.
 Robert L. Froman - Assistant Director (Inter-
 Department.
 Martyn V. Clarke - Assistant Chief of Central
 Investigation Division and a specialist in
 take-off accidents.

/Appendix C cont.

APPENDIX C - PERSONS CONSULTED BY THE BOARDN.T.S.B. Bureau of Aviation Safety. (cont.)

W.L. Lamb - Supv. ASI of Operations Branch of
Central Investigation Division.

John H. Pahl - Chief of Safety Analysis and
Promotion Division.

Bernard C. Doyle - Assistant Chief of Safety
Analysis and Promotion Division and till
recently Chief of Human Factors Branch of
Central Investigation Division.

Coe M. Anderson - Chief of Technical Services
Branch of Safety Analysis and Promotion
Division.

P. Alexander, of the Aeronautical Engineering
Section, Technical Services Branch,
Division of Safety Analysis and Promotion.

Federal Aviation Administration.

Richard S. Sliff - Deputy Director of Flight
Standards Service.

Donald E. Kemp - Chief of Accident Investigation
Staff, Flight Standards Service.

Boeing Company.

D. Knutsen - Chief Test Pilot.

W. Hansen - Accident Investigation Department.

IN THE UNITED KINGDOM -

D.P. Davies, Chief Test Pilot, Air Registration Board.

APPENDIX D.PARTIES REPRESENTED AT THE HEARING.

<u>PARTY.</u>	<u>REPRESENTED BY.</u>
Government of the United States of America.	Mr. T.R. Saunders and technical advisers Messrs. W. Hansen, D. Knutsen, F. Mosher and A. Zollin.
Consul-General of the Federal Republic of Germany, Johannesburg.	Mr. Advocate E. Weber.
Consul of the Federal Republic of Germany, Windhoek.	Mr. Attorney Pfeiffer.
South African Airways.	Mr. Advocate W.S. McEwan S.C., and Mr. Advocate J. Conradie.
Boeing Company.	Mr. Attorney B.R. Turnbull.
South African Airways Pilot's Association.	Mr. Attorney A.M. Wise and Mr. R.B. Truter.
Estates late W.H. and H.W.F. Brons, M.R. Staiger, V.E. Krupinski and W. Hanisch.	Mr. Advocate E. Weber.
Estates late H.W.R. Hirsch, G. Rummel, I.H. and S. Böhm and K.L. Merz.	Mr. Attorney Pfeiffer.
Estate late E.R. Smith.	Mr. Attorney A.M. Wise.
Estate late D.A. De O. Barbosa and J. de O. Trinidade.	Mr. Attorney D. Lombard.
Estate late M.P. Collins.	Mr. J. Collins.
Estate late P.M. and E. Thomas.	Mr. Attorney H. Brigish.
The evidence was led by Mr. P.L. Erasmus, Legal Officer of the Department of Transport.	

APPENDIX E.EXHIBITS.

1. Site plan of crash showing positions of eye-witnesses.
2. Photographs showing views from Seeis and Oupenbamewa where eye-witnesses stood.
3. Defect log and transit inspection record.
4. Aircraft fuel and oil state.
5. Document found in cockpit after accident showing take-off data.
6. Instrument readings log found at scene of accident.
7. Flight Engineer's log found at scene of accident.
8. Vibration log found at scene of accident.
9. Passenger list compiled at Windhoek.
10. Passenger manifest.
11. Load Distribution Sheet.
12. Cargo manifest.
13. Passenger list : Jan Smuts - J.G. Strijdom.
14. Crew list : Jan Smuts - J.G. Strijdom.
15. Weather report : J.G. Strijdom : 20th April 1968.
16. Anemogram : J.G. Strijdom.
17. Transcript of recordings made automatically on the tape monitoring system at J.G. Strijdom Airport on the night of 20 April 1968.
18. J.G. Strijdom Airport action report on fuel, prepared by Mobil Oil Southern Africa (Pty) Limited.
19. Gravimetric millipore sample taken from Hydrant Cart 58/88.
20. Gravimetric millipore sample taken from Hydrant Cart 57/68.
21. Monitor for visual millipore test on equipment 57/68.
22. Monitor for visual millipore test on tanker 1138.
23. Rear hose nozzle fuel sample taken at Jan Smuts Airport on 21 April 1968.
24. Front hose nozzle fuel sample taken at Jan Smuts Airport on 21 April 1968.
25. Jan Smuts Airport action report on fuel, prepared by Mobil Oil Southern Africa (Pty) Limited.

/Appendix E cont.

APPENDIX E - EXHIBITS (cont.)

26. Site and wreckage distribution plan.
27. Legend of site and wreckage distribution plan.
28. Report by Mr. P.A. Peens, Inspector of Accidents, Division of Civil Aviation, indicating the order in which the aircraft broke up after initial impact.
29. Report by Mr. P.A. Peens on examination of crew seats.
30. A, B and C. Photographs of Captain's chair.
31. A to F. Photographs of First Officer's chair.
32. Photograph of Second Officer's chair.
33. A and B. Photographs of Navigation Officer's chair.
34. Photograph of Flight Engineer Officer's chair.
35. Report of the investigation into an aircraft accident (ICAO format) by Mr. J.J. Granzier, Assistant Director of Technical Services, Division of Civil Aviation.
36. Aerial photograph of crash site.
37. Album of photographs.
38. Report on post-mortem examination of E.R. Smith.
39. Summary of report at 38.
40. Report on post-mortem examination of J.P. Holliday.
41. Summary of report at 40.
42. Post-mortem photograph of J.P. Holliday.
43. Report on post-mortem examination of R.F. Armstrong.
44. Summary of report at 43.
45. A and B. Post-mortem photographs of R.F. Armstrong.
46. Report on post-mortem examination of P.A. Minnaar.
47. Summary of report at 46.
48. Post-mortem photograph of P.A. Minnaar.
49. Accident Investigation : Summary of report by Mr. T.B. Phillips, Production Manager, S.A.A.
50. Report on Field Work by Mr. T.B. Phillips.
51. Plan showing sectional breakdown.
52. Sworn statement by Mr. A. Derbyshire, survivor.
53. Cargo manifest : Johannesburg - Frankfurt.

/Appendix E cont.

APPENDIX E - EXHIBITS (cont.)

54. Cargo manifest : Frankfurt - London.
55. Cargo manifest : Luanda - Las Palmas.
56. Mail manifest : Luanda - Las Palmas - Frankfurt - London.
57. Load distribution sheet : Jan Smuts Airport.
58. Fuel flight plan : Jan Smuts Airport.
59. Sworn statement by Miss S.S. Troskie, Lady Supervisor, SAA.
60. Sworn statement by Miss K.M. Jones, Receptionist, Jan Smuts Airport.
61. Passenger list : Jan Smuts - Windhoek - Luanda - Las Palmas - Frankfurt - London.
62. List of persons who lost their lives and who were identified.
63. Affidavit by Mr. H. van Dyk, Principal Inspector of Explosives, Department of Commerce.
64. Affidavit by Dr. M. Freiman, Senior Professional Officer, Department of Health.
65. Affidavit by Dr. V.D. Kemp, Principal District Surgeon, Johannesburg.
66. Passenger seating positions.
67. Report by Mr. A.G. Swan, Airworthiness Inspector, Division of Civil Aviation.
68. Appendix A to Exhibit 67.
69. Appendix B to Exhibit 67.
70. Appendix C to Exhibit 67.
71. Appendix D to Exhibit 67.
72. Appendix E to Exhibit 67.
73. Portion of bone removed from No. 2 compressor of engine No. 4.
74. Chart showing break-up order of aircraft - Annexure to Exhibit 50.
75. Diagram of aircraft correlating injuries with seating positions of passengers submitted by Dr. H. Bukofzer.
76. A to W. Post-mortem reports and photographs of bodies of passengers submitted by Dr. H. Bukofzer.
77. A to CC. Post-mortem reports and photographs of bodies of passengers submitted by Dr. V.D. Kemp.

/Appendix E cont.

APPENDIX E - EXHIBITS (cont.)

78. Copy of Certificate of Registration.
79. Copy of Certificate of Airworthiness.
80. Record of check A to which is attached a copy of the Certificate of Safety.
81. USA Export Certificate of Airworthiness.
82. Record of Terminal Check.
83. Pre-flight Inspection Record.
84. Airframe Logbook.
85. Report on Slow Acceleration of No. 3 engine.
- 86.A Engine Logbook - No. 1 Engine.
B Engine Logbook - No. 2 Engine.
C Engine Logbook - No. 3 Engine
D Engine Logbook - No. 4 Engine
87. Report on Slow Acceleration on all engines.
88. Minor Check Snag Sheet : Turbine rub on No. 3 engine.
89. Folder containing history sheets.
90. Preflight Inspection Report.
91. Schedule of Modifications incorporated in ZS-EUW.
92. Various papers dealing with computer calculations.
93. Copy of aircraft Radio Station Licence.
94. Report on the control cabin circuit breaker panels.
- 95.A Report on No. 1 Engine.
B Report on No. 2 Engine
C Report on No. 3 Engine
D Report on No. 4 Engine
- 96.A Report on fuel control unit of No. 1 engine.
B Report on fuel control unit of No. 2 engine.
C Report on fuel control unit of No. 3 engine.
D Report on fuel control unit of No. 4 engine.

/Appendix E cont.

APPENDIX E - EXHIBITS (cont.)

- 97.A Report on fuel pump of No. 1 engine.
 - B Report on fuel pump of No. 2 engine.
 - C Report on fuel pump of No. 3 engine.
 - D Report on fuel pump of No. 4 engine.
- 98. Trim Sheet ex Jan Smuts.
- 99. Trim Sheet ex Windhoek.
- 100. Photographs of Instruments taken before despatch to USA.
- 101. Summary of Reports concerning investigation of instruments and equipment.
- 101A. Manufacturers Reports on instruments.
- 102. Report by CSIR on testing of lamps.
- 103. Diagram showing Boeing Landing Gear Control Cable System.
- 104. Diagram showing Boeing Left Wing Structure.
- 105. Diagram showing Boeing Right Wing Structure.
- 106. Report by Chief Training Captain S. Pienaar, S.A.A.
- 107. Diagram of Rate of Climb Indicator.
- 108. Report on Crew Members by Mr. J.J.S. Germishuys, Chief of the Flying Section, Division of Civil Aviation.
- 109. Pilot's Logbook of Capt. E.R. Smith.
- 110. Boeing 707 and 720 Pilot Training and Flight Check Record issued by the Boeing Company in respect of Capt. Bird.
- 111. Operating Instruction 3/68 issued by SAA indicating differences between Boeing 707/344 B and C models.
- 112. Copy of Certificate by SAA's Chief Training Captain regarding conversion course to Boeing 707-344C aircraft done by Capt. E.R. Smith.
- 113. Pilot Licence of Mr. J.P. Holliday.
- 114. A and B. Pilot Logbooks of Mr. J.P. Holliday.
- 115. A and B. Pilot Logbooks of Mr. R.F. Armstrong.
- 116. Logbook of Flight Engineer Officer P.A. Minnaar.
- 117. Statements by Personnel of SAA on their impressions of Captain Smith.
to
157.
- 158. Statement showing flight times of crew members.

/Appendix E cont.

APPENDIX E - EXHIBITS (cont.)

159. Sketch Plan showing gouge marks submitted by Prof. Lauf.
 160. Box containing cloth, playing cards and toothache drops found beyond threshold of runway 08, J.G. Strijdom Airport.
 161. Aerodrome Forecast: Jan Smuts Airport: 20 April 1968.
 162. Captain's conversion from Boeing 707-300 B to C applied by four International Airlines.
 163. Boeing 707 International Flight Manual.
 164. Personal Flying Logbook of H.C. Howe, Flight Navigator.
 165. Weight and Balance Modifications: ZS-EUW.
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 - 167A. Letter dated 25th September 1968 from Epsilon Industries Limited, Feltham, Middx, England.
- B to F. Flight Data Recorder Readouts and Transducer Output Graphs attached to Exhibit 167A.

APPENDIX F.BIBLIOGRAPHY.

1. I.C.A.O. Manual of Aircraft Accident Investigation.
2. I.C.A.O. Annex 13.
3. I.C.A.O. Accident Digests.
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6. Boeing Company's "707 Flight Patterns".
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8. Boeing Company's 707 Pilot Training Manual.
9. B.O.A.C. Flight Manual for Boeing 707s.
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17. Bioastronautics Data Book - N.A.S.A.
18. Medical Investigation of Aviation Accidents - William J. Reals.
19. Aircraft Accident Investigation Through Time-Regression of the Subconscious - Address by Bernard C. Doyle of N.T.S.B.
