REVISION 2: June 7, 2023
Original Document July 2021

AN ANALYSIS OF THE EVIDENCE CONTAINED IN RHODESIAN REPORT'S ANNEXES II AND III AND THE UN GENERAL ASSEMBLY REPORT A/5069 PERTAINING TO THE CRASH OF DOUGLAS DC-6B SE-BDY S/N 43559 ON SEPTEMBER 17-18, 1961

By Joseph Majerle III

AUTHOR'S NOTE ON REVISION

This revision is based on information found in the personal files of the late Bo Virving, Chief Engineer of Transair Sweden, A.B., made available courtesy of his son, Bjorn Virving. The majority of the new information came in the report titled "Confidential Copy No. 009, Rhodesia and Nyasaland Federal Department of Civil Aviation, CIVIL AIRCRAFT ACCIDENT, Report by the Investigating Board on the accident to Douglas DC6B aircraft SE-BDY, which occurred near Ndola Airport during the night of 17th September 1961".

Another significant part came in the form of the Commission interview of Transair Captain Lars Eric George Starck, section C/16, pages 10 thru 31, document title unknown, not found in the Board, Commission, or UN reports.

Additional information was found in a "CONFIDENTIAL" marked copy A/AC.107/Hearing/10, 5 February 1962., of an interview with Wing Commander Evans, Air Adviser to the British High Command, the Federation of Rhodesia and Nyasaland. Altogether, these documents clearly explained the premises that were summarized in the final reports.

PREFACE

I AM NOT a professional aircraft accident investigator. I am writing this account because after reading the reports of the crash, the professional aircraft accident investigators that were tasked with determining the facts of this tragedy, or for that matter, anyone else that has viewed the evidence contained in the above–mentioned files, have not come forward and pointed out the glaring misperceptions, dismissiveness of obvious real evidence, and inappropriate focus on irrelevancies that shaped the conclusions of the reports.

In addition, there is at least one aspect that I can only describe as a deliberate inaccuracy that I consider to be of decisive importance. The Annex III and UN A/5069 reports, following the original Board report, did not effectively question the basic premises of the Investigating Board report which, presumably, would have been their purpose, and is why nearly 60 years after the crash this subject is still very unresolved for a surprising number of people.

I AM PRIMARILY, an aircraft mechanic. But I earned a private pilot's license and had begun commercial and instrument flight training before earning any of my mechanics ratings. Before I had any ratings at all, I had already built and flown my first airplane out of salvaged, crashed, repaired and new parts. At this point, I was already self-employed in the aircraft maintenance, salvage and rebuild business.

I started salvaging airplanes from crash sites in 1974, studying whatever evidence was left at the scene in an effort to understand what and how the accident happened. With the advent of the Internet and the posting of Civil Aeronautics Board (CAB) and National Transportation Safety Board (NTSB) accident reports online, I have been able to read many reports going back to at least to the mid 1930's because I was interested in learning what was known about particular incidents that I had heard about as a youngster, and for well into adulthood.

I decided to abandon thoughts of becoming a professional pilot because at the time there were probably ten newly qualified commercial and airline transport pilots competing for every available job opening, and operators had their pick of the best. In the maintenance field, however, it was the opposite story; at the flight school there was only one mechanic, recently licensed, and not very confident at all in his abilities. As an experienced, but not yet licensed mechanic, I assisted him in getting the flight school's grounded aircraft operational again. For all intent and purpose, I have never been without work since.

I do not think it is inappropriate that I should be the person to write this report. What is required here is a broad-based, general knowledge of aviation, aircraft, their operations. I do not think an investigator has to have a DC-6 type rating to know how they are operated; provided one consults pilots with the rating to confirm what published documents like airplane flight manuals and Approved Type Certificate (A.T.C.) specifications say. Here in Alaska, it is very possible that we currently have the largest base of DC-6 experience operating, on a daily basis, in the world. I have known a great many DC-6 type rated pilots in my lifetime, to say nothing of having been related to one by marriage.

Any reader who wants to challenge what I state in this document is urged to consult with their own "expert(s)". I do not claim to be an expert on any aspect of this; however, every DC-6 expert that I consulted throughout this process confirmed readily what I thought to be the case when I presented them with the evidence. So that is why I think that it is time to reexamine what actually happened during the crash, as opposed to what most of the world thinks happened. Because the two are very different.

It is not within my area of expertise to speculate on the "why" of what caused the precipitating action of this accident. I have read a number of reports and books over recent years that attempt to tackle that subject, but I have nothing to contribute to what other researchers, with apparent objective credibility, have amassed.

I am, however, bothered enough by the acceptance of the original Rhodesian premises by the world at large and former UN officials, and the effect these misconceptions have had on the descendants, relatives, and friends of the victims, crew and passengers, that I am submitting this document to whom it may concern.

PREMISES

The Annex II report sets a number of premises that have gone unquestioned. They are, and I will attempt to order them in terms of occurring chronology, as follows:

01. That the aircraft crashed during the course of making a “normal instrument approach”.
02. That the aircraft was not on fire prior to its collision with the anthill on the ground.
03. That the crew could be faulted for not having transmitted a declaration of emergency during the approach.
04. That the crew could be faulted for the wreckage being found with the landing lights in the off position.
05. That the captain could be faulted for not having broadcast all his intentions to the destination airport, especially in an area known to be hostile to UN personnel.

These points, in addition to others, are where I will begin.

THE INSTRUMENT APPROACH

Annex II, part 3, par. 12.6: “. . .hit trees and the ground at a shallow angle of 5 degrees or less, at what appears to have been normal approach speed, at an altitude of 4357 feet MER (above mean sea level) with its undercarriage locked down, flaps partially extended, and with all four engines developing power and all the propellers in the normal pitch range, heading towards the Ndola radio beacon on a landing approach.”

There are four main parts of this statement to be addressed. They are to be considered in light of the aircraft's position in relation to the Ndola airport, which according to Annex II Part 1 par. 1 item 1.1 was “From Ndola aerodrome control tower 8.05 nautical miles on a true bearing 279 degrees.” 8.05 nautical miles is over 9.25 statute miles, from the airport at which it was intending to land.

01. “Normal approach speed” in my experience is based upon the aircraft’s stall speed, landing speed, and minimum control speed in multi-engine aircraft. It varies with combinations of all of the above and is normally calculated in percentages above the stall speed, which itself varies with differing weights, centers of gravity, bank angle, flap/high-lift device deployment, etc. In a standard airport traffic area, there is also a speed limit of 156 knots (180 mph.) Since the beginning of the age of the jumbo jets and the airports from which they operate, the speed restrictions have been raised because many of that class of aircraft have higher stall speeds than 156 knots (180 mph.), so for them, there is only the 250 knots (288 mph.) below 10,000 feet rule, which I believe applies to all airspace complying with ICAO rules.

Normal approach speed, at that stage of the approach, should have been 160 knots (184 mph.) or even more in this case, with this captain concerned about the possibility of armed, hostile aircraft in the general area. In consultation with a DC-6 captain, he said except in very unusual circumstances the standard instrument approach speed up to the final approach fix, which in this case was the Ndola NDB, 2.5 nautical miles, 2.875 statute miles from the runway end, would be 160 knots (184 mph.) Maximum flap extension speed is 139 knots (160 mph.)

The point that needs to be made here, and clearly with no ambiguity, is that there would have been no reason whatsoever in a normal instrument approach, especially in good weather conditions, to have had the aircraft slowed down to landing configuration while over 9 miles away from the airport. Standard procedure would be to begin deploying landing flaps and landing gear upon reaching the final approach fix, which in this case was the Ndola NDB (non-directional beacon), approx. 3 miles from the runway, an average distance for an NDB or a VOR (very high frequency omni-directional range) to be situated to a runway. That the aircraft was found configured for landing at the farthest point it was going to reach, away from the airport during its instrument approach, meant that the pilot would have had to slow-fly it throughout the rest of the approach procedure to a landing at the airport. This was the very first thing that struck me when I initially read the report. It is indicative, however, OF A LANDING ATTEMPT AT THE LOCATION WHERE IT CAME TO REST.

02. “. . .with its undercarriage locked down, flaps partially extended, . . .”

The DC-6 series aircraft have a stall speed of approximately 80 knots (92 mph.), and consequently a lower approach speed than the jet airliners that replaced them beginning in the 1960’s. The closest replacement is the Boeing 737 series, which like the DC-6 have an approximately 30,000 lb. payload and were generally intended to operate from the same runways that the DC-series used. While the Boeing will neither take off or land and stop in as short a distance as a DC-6 due to its higher stall and approach speeds, the differences are not gigantic. For this project I consulted a Boeing 737 captain whose career spanned the 737-200 series thru the 900 series, and was told, again, that landing gear and landing flap settings were deployed upon reaching the final approach fix, which is generally approximately 3 miles from the end of the runway. This, in an aircraft with higher approach and landing speeds.

Wing flaps increase both lift and drag and were originally developed to enable an aircraft to make steeper approaches to land without increasing speed that would need to be bled off during rollout after touchdown, in other words to shorten the landing to a stop distance. That they would also reduce the takeoff distance and improve the climb performance was a secondary consideration.

Annex II part 10 par. 10.3.4.2 states that all indications were that the flaps were in the 30-degree position. I would estimate that this is approximately optimal for lift and slow flight, which would be desirable for the lowest approach and landing speed based upon experience with numerous different types of aircraft. I have flown a number of different airplanes with flap deployment angles beyond 35 degrees and noticed that at angles much beyond 35 resulted in much higher drag components than lift components and engineering books generally support that observation based on wind tunnel testing. The higher angles of extension were generally useful only for bleeding off excess altitude quickly in situations where a pilot wanted to get a lot closer to the ground in a hurry. To my experience, 30 degrees was optimal landing flap in many, but not all, types. Again, it is indicative OF A LANDING ATTEMPT AT THE LOCATION WHERE IT CAME TO REST and not the airport itself.

What I have just described is what operators in the USA and at least some foreign operators have written into their operating manuals and is still standard operating procedure in the USA to this day. Transair Sweden A.B., however, wrote their operations manual differently.

Transair Captain Lars Eric George Starck, interviewed by the Commission, stated that the Transair Flight Operations Manual instructed their crews to slow the aircraft to 140 knots upon leaving the NDB outbound on the instrument approach procedure. Upon slowing below 200 mph (174 knots) up to 30 degrees of wing flaps were to be extended and left extended for the remainder of the approach until at least the final approach leg (from the NDB to the runway), where they could be further extended if desired. Upon reaching the location where the procedure turn [back toward the NDB and the runway) was to begin, the captain was to call for landing gear down so that by the time the aircraft was at its furthest point away from the runway in the instrument approach procedure the landing gear would be down and locked and approach flaps already set.

So, this explains why the investigators considered this to be a "normal" approach in their final reports. It is evident that they were as surprised as I was that the Transair operations management wrote their manuals this way.

In the Commission interview with Wing Commander Evans, he tells the Commission : "the nose of the aircraft wiped across the anthill and left the radar nose cone undamaged and I picked this up and showed it to Group Captain Blanchard-Sims, another member of the investigating team, and I remarked that it was strange that an aircraft which had crashed through the trees at something like 140 knots had a completely undamaged radar nose cone on it and this is fairly fragile. I put the nose cone back. It had of course been burnt in the subsequent fire and had become brittle so that movement of it could easily break holes in it or break it up. I cannot say now whether I picked up the entire nose cone or not. It is now in several pieces, but I certainly picked up the main curved centre piece which was absolute nose of the aircraft".

There was no further discussion of this topic, question, or suggestion as to whether the reason for this could have possibly been because the aircraft was not in fact traveling at 140 knots. I have not found anywhere in the three reports or the subsequently surfacing interviews and documents where an attempt was made to determine the velocity of the aircraft when it entered the trees or struck the anthill. All discussion appears to assume and be generally agreed upon, presumably based on Captain Starck's testimony, that the plane impacted at 140 knots.

03. “. . .with all 4 engines developing power . . .”

10.1.4 states “. . . the four engines were broken from their mountings and severely damaged by impact and subsequent fire . . . .” Examination of photographs in the appendix of the report reveals that engines #1, 2, and 3 had fallen to the ground after the aluminum nacelle structures melted away in the fire subsequent to coming to rest. The straight steel tube struts of the actual engine mounts are still straight and attached to the engines. Furthermore, the above mentioned engines are all still in the approximate positions they would have occupied on the wing with only the #4 engine having detached in the crash sequence, and it is laying in probably very close proximity to where it was wrenched from the wing during the cartwheel arc.

The second thing that struck me upon first viewing the wreckage plan is that almost the entire aircraft is still in one place.

10.2.1 "The main wreckage was contained in an area approximately 60 feet by 90 feet . . . ."

The DC-6 is almost exactly 100 feet long with a 117'6" wingspan, which means after it came to rest and cooled down the whole of the main wreckage would fit within the same rectangle as its original size. The wreckage plan, as surveyed, indicates that the vast majority of its original parts ended up oriented in the approximate positions that they occupied prior to the crash. In other words, throughout the crash sequence, very little of the aircraft was displaced from itself until very close to the end of its movement. This indicates a low energy crash with a very slow speed impact, at least relative to even minimum flying speed, to say nothing of a 140-knot instrument approach speed. 140 knots (161 statute mph.) is a velocity of 236 feet per second. The wreckage plan length of 760 ft. from first point of treetop contact to ground strike of the fuselage nose (10.1.1) is approximately one half of what I have observed to occur in unintentional controlled flight into terrain (CFIT) crashes during my time in this business. It is, however, in addition to viewing the appendix photographs of the site that were taken from the ground and from the air, completely consistent with the path of an aircraft with an 80-knot stall speed being intentionally landed.

Aircraft that are only capable of even 120 knots in unintentional CFIT crashes generally never resemble an airplane by the time all of the parts come to a stop, their propellers are almost never still attached to the engines, their landing gear are almost never anywhere near where they were originally attached, and their tail groups when broken off have usually broken the control cables in overload displaying a "broomstraw" effect. In this case, when the tail cone broke off in the cartwheel there wasn't enough energy left to pull the cables apart. If I had to estimate the minimum speed required to disintegrate the nose section of the fuselage such as is displayed in the wreckage plan and what can be seen of the remains in the photographs, I would say that it would require at most only about 50 to 60 knots to do that kind of damage. It was explained to me in 1986 by a good friend that was a DC-6 captain at that time, that the 4-engine DC-series had a somewhat fragile nose landing gear structure but not unusually so compared to other makes in its class. But when they were torn out of the fuselage it often did a lot of other damage and could possibly make the incident beyond economic repair. I saw an example of that just last fall (2020) where a DC-4 had its nose landing gear torn out in a ditch at barely more than walking speed; the damage extended through both sides of the factory break joint where the nose (flight deck, cockpit) section attaches to the forward fuselage section and the operator decided that it was beyond economical repair, according to a conversation with his director of maintenance. This should reflect no discredit on the part of the designers; from personal experience repairing nose landing gear damage on many different types of nosewheel type airplanes it is generally a fragile part of all of them.

I have been asked what I would estimate the rollout to a stop distance of the Albertina had it not hit any of the anthills in that immediate area, slowing to a stop on its own. It's a question with many variables and is a difficult one to answer. To my observation, aircraft with an 80-knot landing speed without reversing propellers seem to take 1700 to 1800 feet to get stopped, whether heavily loaded with heavy braking or lightly loaded and not using the brakes to stop. In this case of an unbroken field of sapling trees with occasional noticeably larger trees interspersed acting as an arresting net, the more it slowed the stronger the arresting action would become. My guess would be approximately half of that distance, additional from the point where all three landing gear were on the ground, provided that the nose landing gear remained in place.

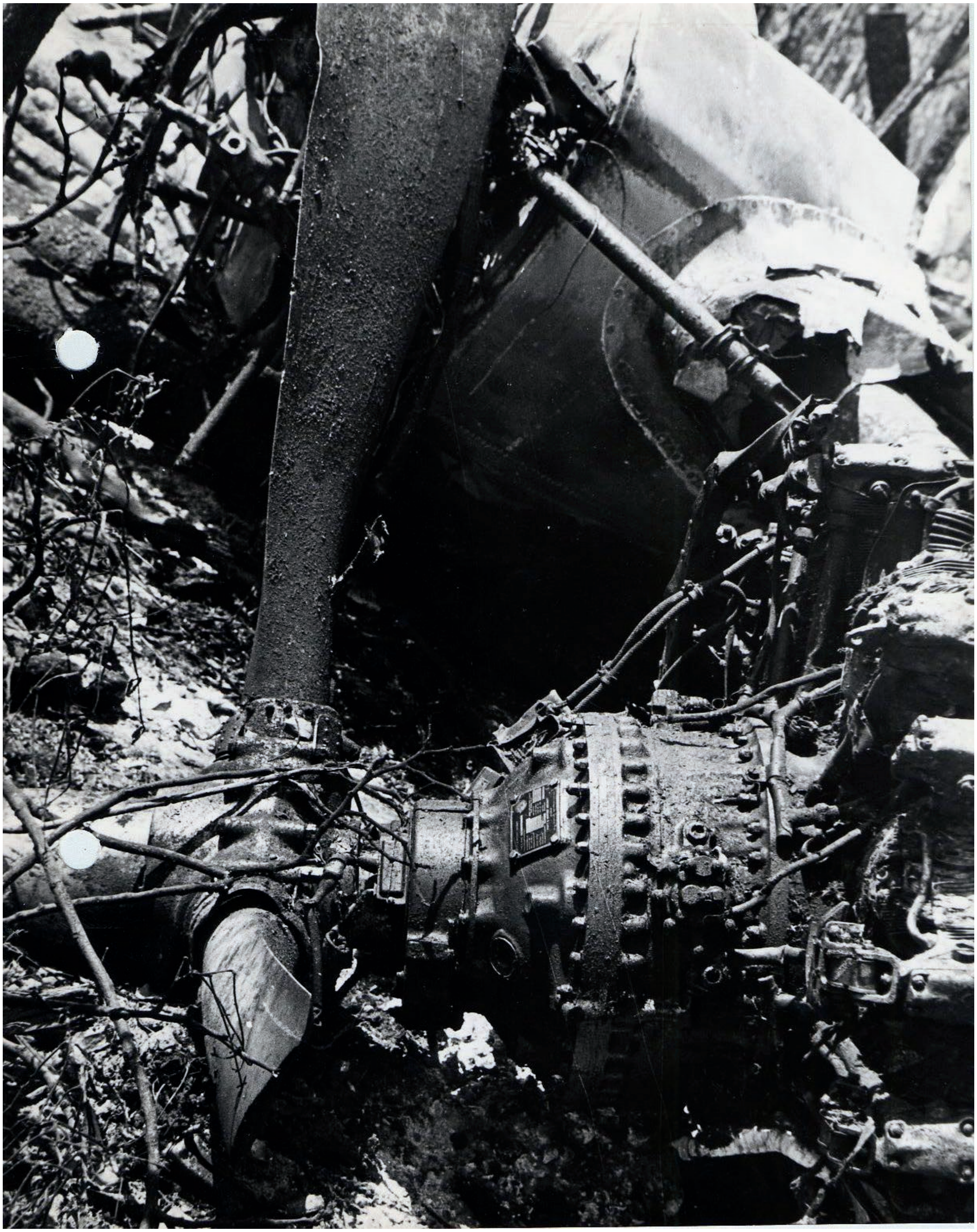
04. "...and all the propellers in the normal pitch range, ..."

The Hamilton Standard 43E60/6895A-8 propellers such as were installed on SE-BDY (of which I have owned several sets and still possess a crate full of hub and dome parts) has a normal pitch range of 96 degrees from neutral for feathering and forward thrust and 8 degrees aft of neutral for reverse thrust. 10.3.4.4 states: "Inspection of the propeller stop ring assemblies confirmed that the angular setting of all propellers was in the constant speed range."

First, the stop rings do not determine the constant speed range; they are only the outer limits of the blade travel, at full feather and full reverse. The constant speed range is a function of the engine driven governor and the distributor valve assembly, known on reversing models as the low pitch stop assembly, housed within the hub and dome and is sensed with electrical switches attached to the hub, sensed by the blades and actuated with an electric motor driven oil pump mounted on the engine reduction gear nose case immediately behind the propeller hub, with a rubber/spring lip seal interfacing the parting surfaces. The only way to externally determine the angular setting of the blades in this installation is to measure with a propeller protractor against the rotational axis (plane of rotation).

Second, the constant speed range is also a function of the engine turning at a high enough RPM for the governor to supply enough boosted oil pressure to operate the distributor valve to keep the blades off the low pitch stop, which in reversing propellers such as these is again a function of the distributor valve/low pitch stop assembly. But for the purposes of this analysis, that is not important.

Third, the photographic evidence, is what is important. Below are photos (photos 1-4) of all of the engine/propeller assemblies, and I will reference the individual blades in clock face numbers, as viewed from the rear of the engine looking forward as is standard practice.



1: #1Engine/Propeller. (# S-0727-0004-01-00041 UN website file.)

2: #2 Engine/Propeller. (# S-0727-0004-01-00021 UN website file.)

3: #3 Engine/Propeller. (# S-0727-0004-01-00039 UN website file.)

4: #4 Engine/Propeller. (# S-0727-0004-01-00016 UN website file.)

"Confidential Copy No. 9 Appendix 1.8 Detailed Technical Report" pages 4 to 9 contain the findings of Mr. Harry Apthorp, propeller inspector for Central African Airways (presumably hired and paid by the Commission) and form the basis of the propeller summary found in all of the reports. I will begin with Mr. Apthorp's "Conclusions" on page 9:

"With the exception of No. 1 blade of No. 4 propeller, it is considered that the angular position of the propeller blades after the aircraft came to rest may be ignored due to the failure of the blade centre bush drive pins and retaining screws and consequent movement of the propeller blades. Whilst no physical check of the drive pins and retaining screw of the number 2 and 3 propellers was possible, it is probable that these items had also failed. "

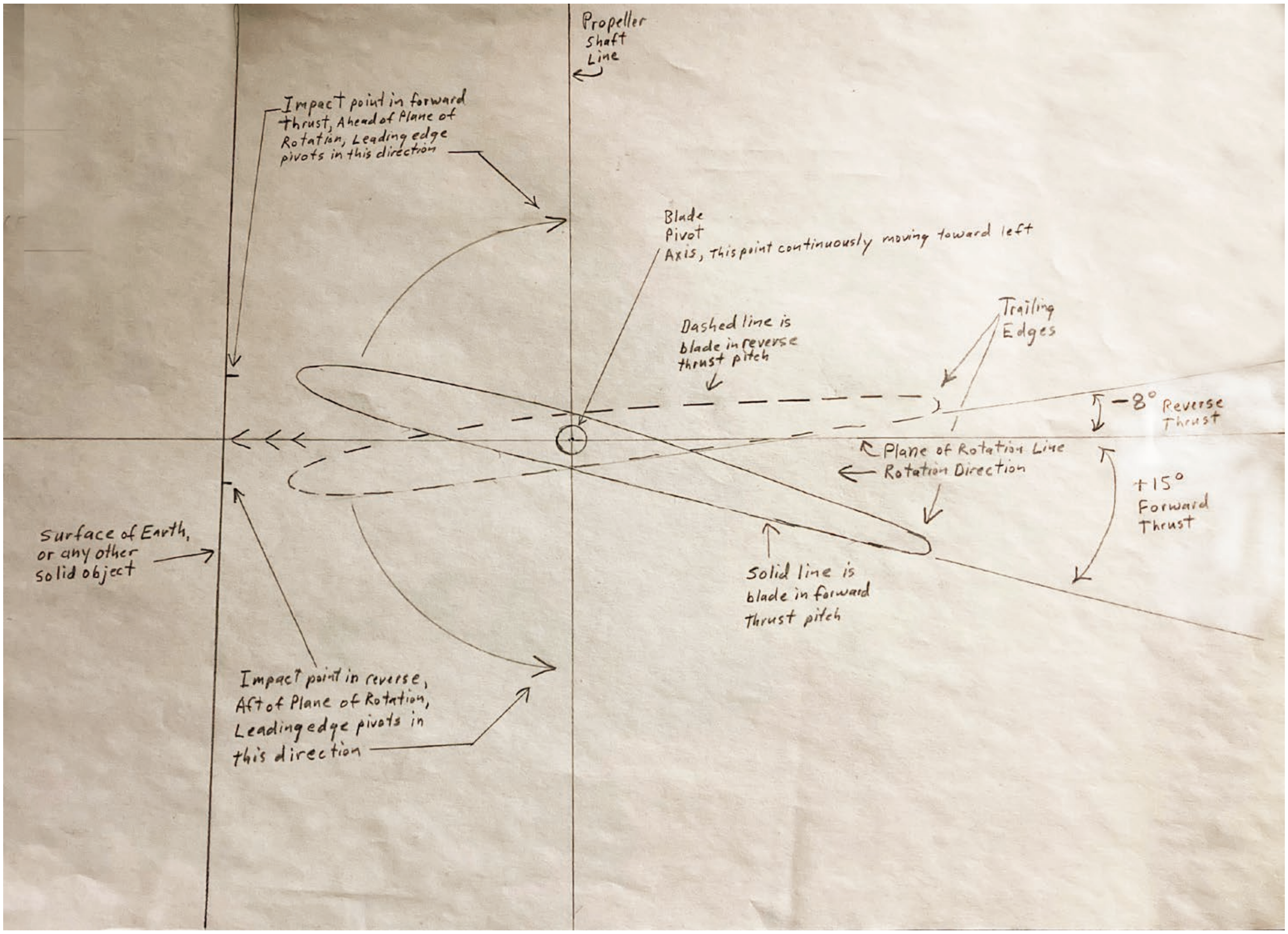
"It is also considered that the shearing moment exerted on the centre bush drive pins and retaining screws at the time of the initial impact would not have overcome the hydraulic lock existing in the propeller domes. For this reason, the angular readings obtained from the dome stop rings may be taken as accurate, within the blade angle tolerances laid down by the manufacturer."

"The damage sustained by the number 4 propeller was considerably less than that sustained by the other three propellers."

"During the investigation no evidence of mal-assembly or mal-functioning of the propellers was apparent and, it is considered that all of the propellers were operating in a normal manner up to the moment of first impact."

Mr. Apthorp based his conclusions on the findings of one out twelve blades, attached to the least damaged of the four prop assemblies. To my way of thinking, ignoring the evidence of eleven out of twelve in favor of one out of twelve is a questionable judgement, especially when the condition of the other eleven are dramatically different.

Mr. Apthorp's determination that sheared drive pins and retaining screws constitutes complete dismissal of their blade's actual angle at moment of strike is not borne out in my experience. I have on numerous occasions found sheared drive pins and screws with virtually no discernable rotation of the blade on the bushing, or in some cases very little, and in no cases did the blade then rotate toward reverse. In most cases they had moved toward feather at a positive angle, with the leading edge forward, as is logical when they strike at a positive, forward thrust angle. The following diagram (photo 5) illustrates the basic physics of the result of a blade striking the ground or an object.

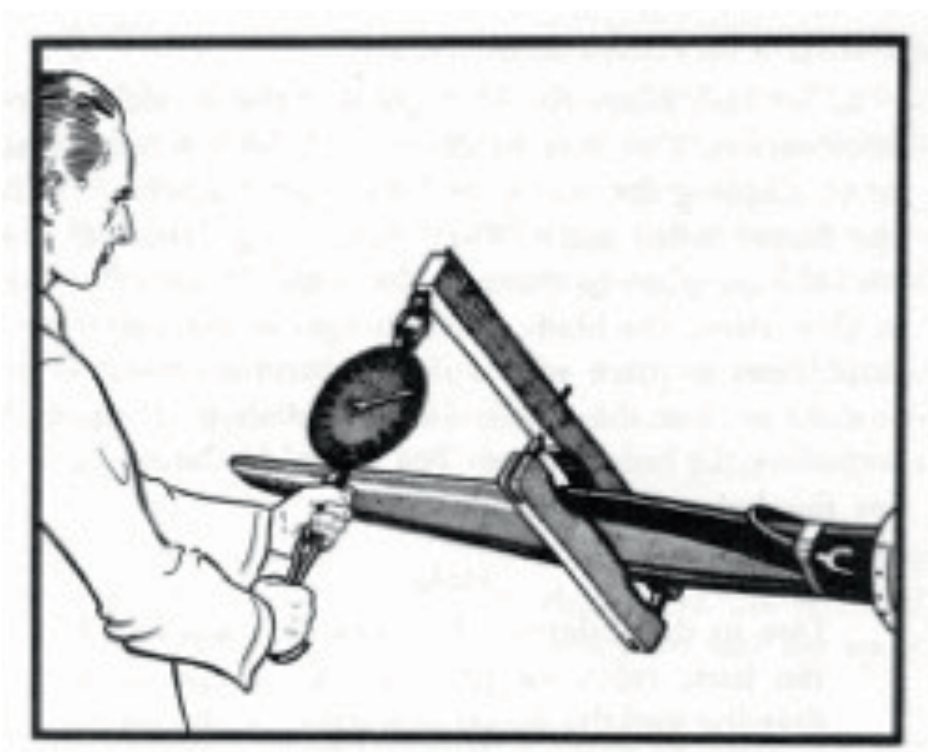


5: Blade strike diagram. (Drawing by J. Majerle.)

Note on the drawing that the blade pivot axis /propeller shaft line is not centered on the blade chord line; it is universally somewhat closer to the leading edge than the trailing edge on modern propeller blades. And by modern, I mean since before World War I, before even the invention of the variable-pitch propeller. While the fact that there is more surface area aft of its pivot axis contributes in some measure toward its tendency for the leading edge to twist forward (positive angle) if contacted on its camber (front) face, the strike angle of the leading edge forward of its pivot axis is the primary factor determining the direction that a propeller blade will stop at when rotating under engine power.

"...and consequent movement of the propeller blades." page 9. Mr. Apthorp, throughout, makes no suggestion of what possible force or forces could have moved, consistently with at least 10 and probably 11 out of 12 blades, "toward reverse". At least two out of three blades on all four propeller assemblies stopped in reverse angles, by his own admission.

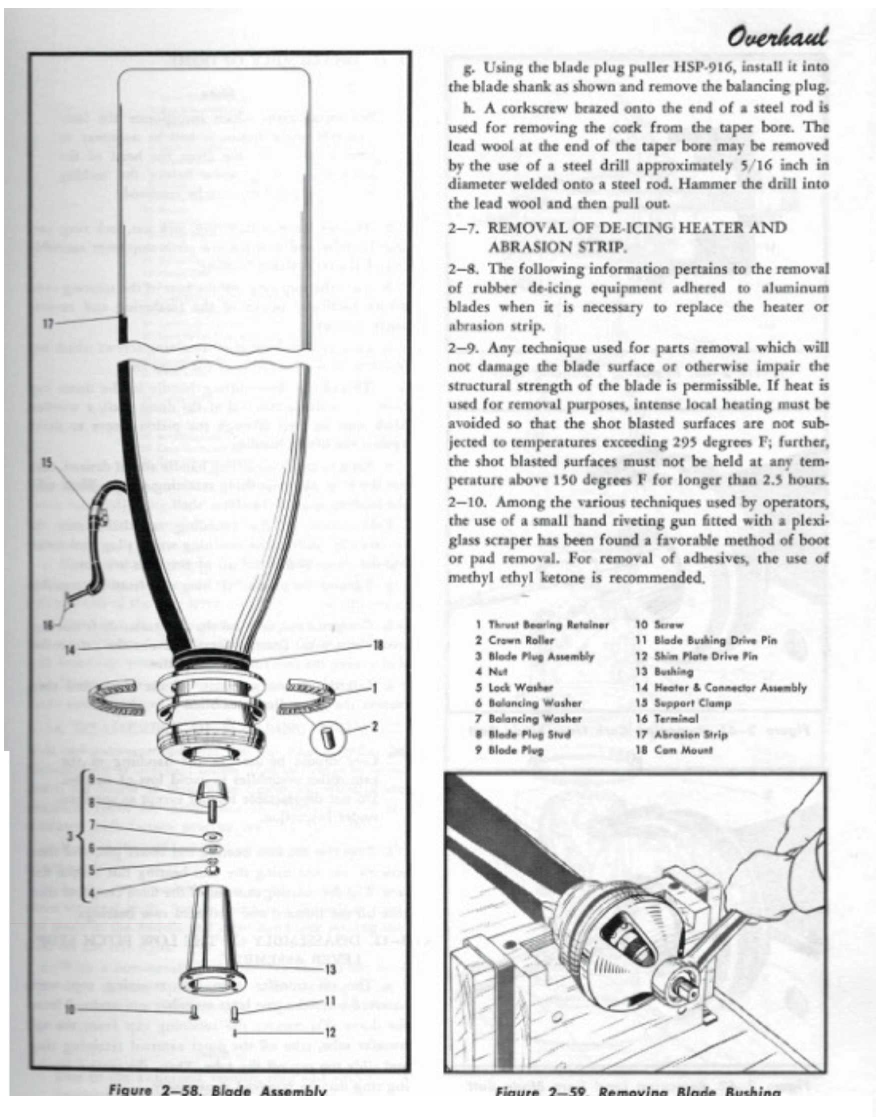
Per Hamilton Standard Propeller Overhaul Manual 163B, par. 2-159, the required blade pre-load is 100 plus or minus 10 lbs., break-away torque. This means that a force of optimally 100 lbs. is required 12" away from the center pivot line, just to begin to twist the blade on its center bushing surface and its roller bearings. This is without the resistance of the pitch-change system contained within the hub. For another perspective, this is the same force required to properly tighten or loosen the wheel bolts on my Volvo car. Figure 2-128 below (6), the man in the illustration is pulling down 45 to 55 lbs. on the spring scale with a 24" bar, just to get the blade to move.



6: Blade torque check. (Figure 2-128 of Hydromatic Reversing Propellers, Overhaul Manual.*)*

Another factor not explained in Mr. Apthorp's conclusion is the friction of the taper interference fit of the blade bushing to the blade shank bore, which is the primary attachment of the bushing to the blade. The drive pins are primarily an indexing device to assure uniformity of blade angle to the blade gear segment, and the retaining screws are mainly to assure that the parts stay together while being assembled. A single 5/16" or 3/8" steel pin and the same for a single steel screw, is not the primary power transfer system for 2500 horsepower to be transmitted through three blades. In other words, without the screws and pins the blades don't just roll around freely on the bushings. Fig. 2-59 below (7) gives an idea of the force required to loosen and remove the bushing from the blade shank bore.

These teeth on the blade bushing (item 13) mesh with the teeth on the blade gear segment (fig, 2-57 below.)



Overhaul

g. Using the blade plug puller HSP-916, install it into the blade shank as shown and remove the balancing plug.

h. A corkscrew brazed onto the end of a steel rod is used for removing the cork from the taper bore. The lead wool at the end of the taper bore may be removed by the use of a steel drill approximately 5/16 inch in diameter welded onto a steel rod. Hammer the drill into the lead wool and then pull out.

2—7. REMOVAL OF DE-ICING HEATER AND ABRASION STRIP.

2—8. The following information pertains to the removal of rubber de-icing equipment adhered to aluminum blades when it is necessary to replace the heater or abrasion strip.

2—9. Any technique used for parts removal which will not damage the blade surface or otherwise impair the structural strength of the blade is permissible. If heat is used for removal purposes, intense local heating must be avoided so that the shot blasted surfaces are not subjected to temperatures exceeding 295 degrees F; further, the shot blasted surfaces must not be held at any temperature above 150 degrees F for longer than 2.5 hours.

2—10. Among the various techniques used by operators, the use of a small hand riveting gun fitted with a plexiglass scraper has been found a favorable method of boot or pad removal. For removal of adhesives, the use of methyl ethyl ketone is recommended.

1 Thrust Bearing Retainer
2 Crown Roller
3 Blade Plug Assembly
4 Nut
5 Lock Washer
6 Balancing Washer
7 Balancing Washer
8 Blade Plug Stud
9 Blade Plug
10 Screw
11 Blade Bushing Drive Pin
12 Shim Plate Drive Pin
13 Bushing
14 Heater & Connector Assembly
15 Support Clamp
16 Terminal
17 Abrasion Strip
18 Cam Mount

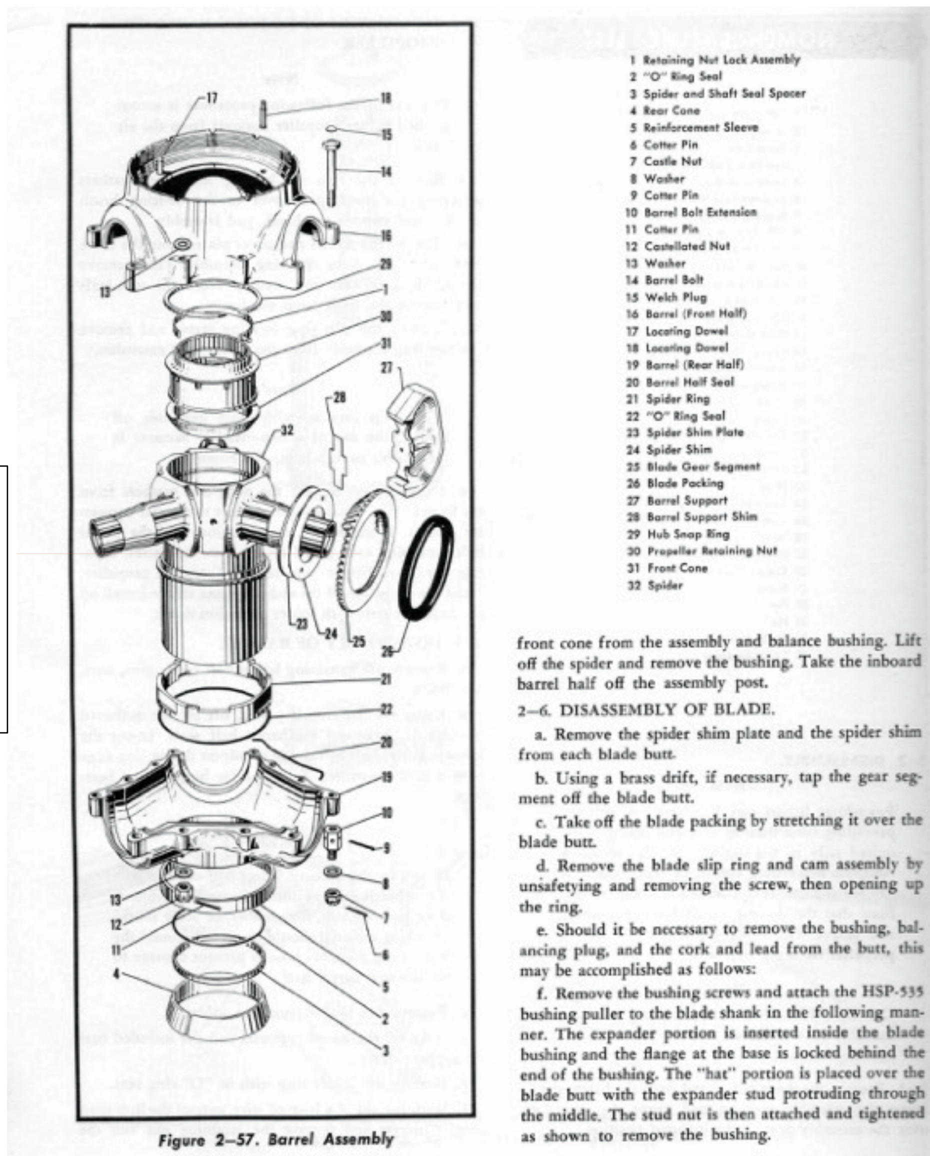
Figure 2—58. Blade Assembly

Figure 2—59. Removing Blade Bushing

7: Left -Blade Assembly (Figure 2-58) and right - Removing Blade Bushing (Figure 2-59, both from Hydromatic Reversing Propellers, Overhaul Manual.*)*

Yet another factor not explained in Mr. Apthorp's conclusion is the findings of the blade gear segment/blade bushing serrated drive teeth interface, of the two propellers that he did manage to disassemble to that stage. As can be seen in figure 2-57 below (8) and figure 2-58, above (7), the very finely cut teeth on the inside diameter of the blade gear segment (item 25), made from hard tempered steel, and the outside diameter of the blade bushing flange, made from brass (item 13) mesh together, allowing for a very finely adjustable angular relationship between the blade gear segment and the blade bushing. For propellers #1 & #4 Mr. Apthorp claims that "all blade gear segments were fitted with index angle 29 deg. in line with "A" reference line on blade center bushings". Which, according to the HSP manual, is the correct index angle for the +96 to -8 spec. for the DC-6 series installation. His statement would indicate that the steel/brass interface remained intact.

These teeth on the blade gear segment (item 25) mesh with teeth on the blade bushing (fig. 2-58 above).



1 Retaining Nut Lock Assembly
2 "O" Ring Seal
3 Spider and Shaft Seal Spacer
4 Rear Cone
5 Reinforcement Sleeve
6 Cotter Pin
7 Castle Nut
8 Washer
9 Cotter Pin
10 Barrel Bolt Extension
11 Cotter Pin
12 Castellated Nut
13 Washer
14 Barrel Bolt
15 Welch Plug
16 Barrel (Front Half)
17 Locating Dowel
18 Locating Dowel
19 Barrel (Rear Half)
20 Barrel Half Seal
21 Spider Ring
22 "O" Ring Seal
23 Spider Shim Plate
24 Spider Shim
25 Blade Gear Segment
26 Blade Packing
27 Barrel Support
28 Barrel Support Shim
29 Hub Snap Ring
30 Propeller Retaining Nut
31 Front Cone
32 Spider

Figure 2–57. Barrel Assembly

front cone from the assembly and balance bushing. Lift off the spider and remove the bushing. Take the inboard barrel half off the assembly post.

2–6. DISASSEMBLY OF BLADE.

a. Remove the spider shim plate and the spider shim from each blade butt.

b. Using a brass drift, if necessary, tap the gear segment off the blade butt.

c. Take off the blade packing by stretching it over the blade butt.

d. Remove the blade slip ring and cam assembly by unsafetying and removing the screw, then opening up the ring.

e. Should it be necessary to remove the bushing, balancing plug, and the cork and lead from the butt, this may be accomplished as follows:

f. Remove the bushing screws and attach the HSP-535 bushing puller to the blade shank in the following manner. The expander portion is inserted inside the blade bushing and the flange at the base is locked behind the end of the bushing. The "hat" portion is placed over the blade butt with the expander stud protruding through the middle. The stud nut is then attached and tightened as shown to remove the bushing.

8: Barrel Assembly. Note #25 showing the Blade Gear Segment. (Figure 2-57 of Hydromatic Reversing Propellers, Overhaul Manual.*)*

Really?

In my experience, in high-powered, hard blade-strikes on these Hydromatics, the blade gear segment drive interface system, whether it was the serrated teeth system or the spring-pack system, was the obvious first thing to shear, allowing the blade to then twist toward or to a positive-angle near-feather position. I have seen where both the drive teeth and the bushing pins/screws had sheared, with the bushing barely noticeably rotated in the blade shank bore, and I remember one instance where the sheared pin and screw head both fell to the floor upon sliding the blade off the spider, and then noticed that their shanks were still directly in line with the bushing holes; there was no visible rotation of the bushing within the blade. But the outer diameter of the blade bushing flange was mangled. The hardened steel blade gear segments are incomparably stronger than the brass teeth of the blade bushing. The displaced brass, still contained between the two parts and between the blade root and the spider shim, had bound up the blade gear segment tightly additionally binding up the blade.

Mr. Apthorp indicates that he did not have available all the tools necessary to fully disassemble the propellers. If I was tasked with determining at which angle the blades were at upon striking the ground on a reversing Hydromatic, particularly if there was suspicion of being in reverse thrust mode, I would ascertain that the low pitch stop levers had not unlocked to allow the blades to travel past the plane of rotation into negative angles. I would also ascertain that the locating dowels on the front hub barrel-half that index the fixed-cam portion of the pitch-change mechanism were intact. These are effectively the heart of the system, the very starting point of all the many parts of the pitch-change system. While in my limited experience with these propellers (compared to those that made careers out of them) I don't recall having seen the locating dowels sheared, I have never seen anything quite like this case, either. Mr. Apthorp never mentioned any attempt to accomplish this on any of the four propellers. He did mention viewing, on the melted-through dome shells of #2 & #3 propellers, that the cam slot rollers were .5" and .6" away from the reverse angle ramps, which would put them within the forward thrust normal operating range slot. But I think that would be meaningless if the fixed cam was displaced from the original location.

There is one other possible explanation for the alleged finding of the cam rollers in the constant speed (positive angle, forward thrust) slots of the fixed cam, and that is the stop return spring, in combination with the other two springs in the low pitch stop lever assembly, figure 2-64 below (9). However improbable in my mind, I cannot say that the springs in combination with the fact that the oil in the dome/piston chambers being super-heated by the external fire couldn't have returned the low pitch stop levers to the stops. It would have required overcoming the friction of the displaced blade gear segments/blade bushings, on all four propellers, but again I don't know if that would be impossible. I do, however, think it unlikely. That is a question, among all of these, for an experienced, reversing-qualified HSP Repairman.

d. Remove the slip ring insulator and the sleeve insulators from the studs. Insert an allen wrench in the mounting stud head and turn while applying pressure on the thread end to remove the studs.

e. Separate the two drum type rings and insulators from the adapter and remove the adapter insulator.

f. Remove the nuts and washers from the remaining terminal studs in the terminal housing box and separate the housing, insulators, and slip rings.

2–14. DISASSEMBLY OF CONTROL SWITCH ASSEMBLY.

a. Remove the two castellated nuts and washers from the switch mounting studs and remove the studs. Separate the cover group from the switch body group. Remove the spring and the "O" ring seal from the switch body and the seal retention plate from the switch boot flange.

b. Remove the boot from the plunger by any means possible. It is recommended that both the boot and plunger be replaced at overhaul.

c. It will not be necessary to press out the contact seat from the switch body housing unless corrosion or damage is evident.

d. Remove the hex nut, and washer from the terminal post and remove the lead and stud insulator and the terminal stud from the cover.

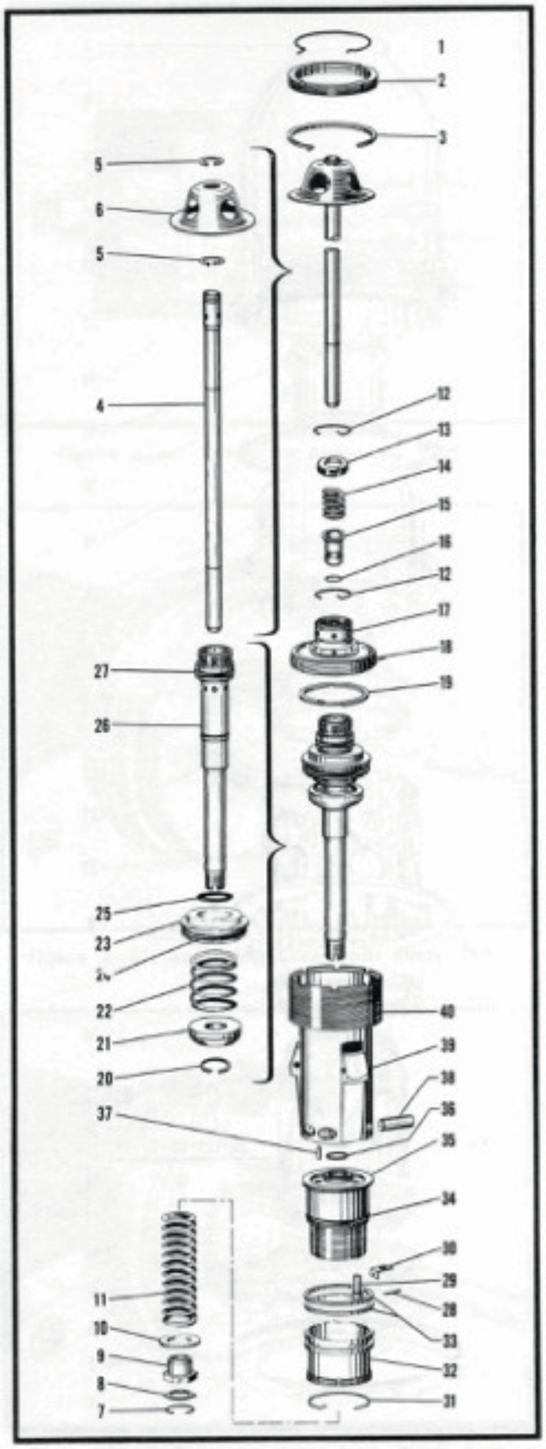


Figure 2–64. Low Pitch Stop Lever Assembly

1 Lock Wire
2 Cam Retaining Nut
3 Snap Ring
4 Oil Transfer Tube
5 External Retaining Ring
6 Tube Retaining Cap
7 Snap Ring
8 Lock Ring
9 Stop Return Spring Seat
10 Washer
11 Stop Return Spring
12 Lock Ring
13 Valve Spring Adjusting Nut
14 Servo Valve Spring
15 Servo Valve
16 Servo Valve Seal
17 Servo Piston
18 Servo Piston Ring
19 Internal Retaining Ring
20 External Retaining Ring
21 Lever Wedge
22 Spring
23 End Plate
24 End Plate To Lever Sleeve Seal
25 Shaft To End Plate Seal
26 Piston Shaft Assembly
27 Shaft To Piston Seal
28 Cotter Pin
29 Screw
30 Lock Clip
31 Piston Sleeve Lock Ring
32 Reverse Stop Adjusting Sleeve
33 Oil Seal Ring
34 "O" Ring Seal
35 Lever Sleeve End Cap
36 End Cap To Shaft Seal
37 Lock Pin
38 Lever Pin
39 Piston Stop Lever
40 Lever Sleeve

9: Springs in Low Pitch Stop Lever Assembly. (Figure 2-64 of Hydromatic Reversing Propellers, Overhaul Manual.*)*

Returning to Mr. Apthorp's conclusions regarding the "...consequent movement of the propeller blades", to my experience, when a piston-engine propeller strikes something suddenly, solidly, and hard enough to break a blade or blades off, (aluminum blades) it stops the engine's rotation within one or two or a very few more revolutions. The engine generally does not keep running. In the case of the Albertina, #2 & #3 clearly struck the most solidly, at obviously very high power settings, breaking off all six blades somewhere along their length. This is not surprising from the standpoint that they are naturally closest to the ground. In the case of #1, the only unbroken blade is obviously the last of the blades to strike because the drivetrain (power section, reduction gearing etc.) momentum was reduced by the energy absorption of the preceding breaking blades. It stopped at approximately the one o'clock position, almost straight up, so engine rotation stopped about 180 degrees after that blade last contacted the ground. If it had rotated further to the point of ground contact again and continued it would have bent it in a manner similar to that of the lowest blade on #4. Of the nine blades on engines #1, 2, and 3, there was only one full-length blade remaining for any external force to contact it and be "rotated on it's bushing". The stubs of the other eight would have provided extremely little contact area for whichever force could have rotated them.

On the same subject, the #4 propeller/engine is its own case. All indications throughout are that the right wing rode higher, struck fewer and smaller trees, and relatively speaking, sustained the least damage. The condition of #4 is, again relatively speaking, reflective of the right wing itself. The engine was not developing enough power to break any of the blades, which also didn't penetrate the ground as deeply as all the others. In my view the most likely explanation for this is that the ignition was stopped by grounded primary (p-lead) wiring in the cockpit breakup event. The power section/drivetrain momentum would have kept the propeller rotating throughout the cartwheel sequence and until it hit the ground where it and the nacelle were torn from the wing. Per Mr. Apthorp's report, the #3 propeller blade of #4 engine bore the weight and bent beneath the engine/nacelle until it came to a stop. But as to why it and the #2 blade were reversed if the #1blade was in fact not reversed is a phenomenon for which I have found no answer. The movement of the rotating cam within the dome assembly actuates all blades equally and simultaneously. Possibly the locating dowels of the fixed cam were sheared by the striking of the #2 & #3 blades prior to the #1 blade's contact, and the #1 just followed wherever the fixed cam stopped. Again, I have no recollection of having heard of that happening but can't rule out its possibility. Another question for the HSP Repairman.

My final thought on the propellers: Mr. Apthorp claims that the established blade angles were 36, 36, 34, and 45 respectively. For engines supposedly powered up for low cruise speed, it seems to me that a 2-degree difference in blade-angle is a rather large difference, to say nothing of a 9-to-11-degree difference for engine #4. The RPMs would have been quite unsynchronized, to say the least.

I have thought long and hard about how to estimate how much power the engines were developing at the moment the propellers struck the ground, and it is a difficult question to answer. The propeller blades were group 4, an early post-war development and were the strongest of all the Hamiltons ever built for piston engines, generally used only on the latest and most powerful post-war radial engines. I am not aware of any empirical strike strength tests, which is not to say that Hamilton Standard didn't conduct any, I just haven't heard about them. If I had to guess I would estimate that it would require a high-cruise manifold pressure setting to shear off and break them through the blade bore bushing hole as is evident in the photos. The captain clearly had gotten the throttles well forward and was making a lot of reverse thrust before the nose landing gear collapsed and the nose and propellers hit the ground.

THE WRECKAGE PLAN

The Annex II wreckage plan and the photographs of the descent path appear to show a deliberate, controlled descent with directional control maintained all the way to the anthill, as though it was intentional, and I am suggesting that it was.

I had difficulty scaling the exact measurements of where the small parts that were torn from the aircraft came to rest relative to the initial tree contact, and varying figures are given for the height of the anthill from 9 to 12 feet, which I would have thought would be consistent with the whole site having been charted by professional surveyors, but in reality this is not important.

What is important is to realize that only 760 feet from initial treetop contact the aircraft was rolling with all three landing gear on the ground, right side up, travelling in a straight line, directionally under control.

At some point not far from the anthill the left wing bottom skins were breached, presumably by a tree trunk, the top of which would have been broken off by the wing leading edge and spar(s), opening up one or more fuel bays and dumping their contacts to the ground in a concentrated area, which fueled the incinerated area shown at that location in the wreckage plan. As stated earlier, this would contribute to the reason that the #1 and #2 engines on the left side of the aircraft were less heavily fire damaged post-crash than the engines on the right side. However, the overall strength of the main wing box structure remained adequate to retain its basic shape to provide the arm around which the entire aircraft would pivot upon striking close to the base of the anthill, leading edge down, and not be sheared off at that point. Obviously, the wing leading edge outboard of the engines is what contacted the anthill, and initiated the cartwheel, as both of the left-hand engines stayed with the wing and came to rest close to their original positions on the wing.

At some point close to the anthill, there is no indication of where, the nose landing gear structure was overloaded in the undisturbed forest terrain and collapsed. Which is to say that the oleo strut and its retraction/extension linkage was torn from its mounting structure and its broken pieces were spread along the ground from forward movement of the rest of the aircraft behind it. I looked long and hard in the wreckage plan to find the exact point where the nose gear departed but could only find reference to a "steel shaft" alongside the base of the anthill and couldn't find it in the photos. Presumably, the "steel shaft" was the nose strut piston tube, which is a steel tube approximately 5" in diameter, and it was about where I would have expected it to be in this case. Other associated parts of the nose gear system were a little farther along the path, again where I would have expected them to be. I could find no reference to where the nosewheel and tire came to rest, which is important from the standpoint of knowing how long it was on the ground before failing, which was in some measure the fate sealer for the crew and passengers. I did find reference to an unidentified portion of wheel rim on the right-hand side of the path and well before the anthill, but whether it was from the nosewheel or one of the dual main wheels may never be known. Below (10) shows one of the main landing gear assemblies with the remains of both tires and wheels in place and photo (11) shows the same for the other main landing gear, so it is certain that all of the main wheel tires stayed in place throughout. While on the subject of the main landing gear, the DC-6 MLG units retract forward into their nacelle bays, and their retraction/extension links for normal operation on the ground loads the links in tension, which for metallic structures allows them to be at their strongest, especially in terms of retaining their shape when loaded. Photo (11) shows that the links had failed in compression and had bent, which would be expected to happen upon the main wheels striking the ground while traveling backwards during the cartwheel, and partially retracting back into their nacelle bays. But effectively, they stayed in place throughout the crash, again indicative of a relatively low speed occurrence.

10: The main landing gear with both tires in place. (# S-0727-0004-01-00019 UN website file.)

11: Compression-bent retraction links on main landing gear. (# S-0727-0004-01-00018 UN website file.)

As stated above, shortly after landing with all three landing gear on the ground, close to the anthill, at probably the worst possible location and time, with all four engines evenly at fairly high power settings in reverse thrust in what would have been a desperate attempt to slow the momentum of the aircraft and get it stopped, (but what is in reality standard operating procedure), the nose landing gear collapsed, instantly dropping the nose section of the belly and fuselage to the ground, pivoting on the main wheel axles. When this happened, the propeller blades began contacting the ground, bending, and breaking them off, and the wing leading edge from end to end rotated downwards, drastically lowering its height. As the fuselage nose belly skins, stringers, formers etc. began crushing and tearing away it allowed the wing leading edge to get even closer to the ground, until the left side contacted the anthill nearer the base than the top, which initiated the cartwheel. If the nose gear had remained in place, there is at least a chance that a relatively level wing might have been able to ride up and over it and the aircraft's momentum to remain linear. With even a few more seconds of reverse thrust as braking action, the survival odds would have increased dramatically. The noted fragment of wheel rim found along the glide path, if from the single nosewheel, and if large enough to have allowed the tire to depart from the wheel, I think in this terrain would have guaranteed the failure of the nose gear assembly.

I think a further word here about center of gravity is appropriate. SE-BDY as it departed Leopoldville was handicapped with a forward C.G. (center of gravity), with little or no aft cabin load. The DC-6, as with all large airliners, was designed to carry its nominal 15-ton payload distributed throughout the cabin from end to end and, as with most aircraft, have the load approximately centered on the wing, since that is what is supporting everything. In this case, with the passengers and their gear in the forward part of the cabin, the C.G. would have been well toward its forward limit, known as nose heavy. This means that the pilot, under any circumstance, would have a harder time holding the nose off the ground with the elevators than if there was weight in the fuselage behind the main wheels assisting him with the balance.

I have flown airplanes with only the pilots in the front seats and nothing in the aft cabin where the nosewheel could not be held off the runway whatsoever upon landing. With power at idle, when the main wheels touched the nosewheel slammed to the runway instantly because the C.G. was well forward of the mains. At least three different DC-6 pilots I have known over the years have told me that they much preferred flying them with a somewhat aft C.G. because of the better balance. In this case however, I think it could be listed as a contributing factor to the deadliness because after getting the main wheels to the ground, with the propellers in reverse and no accelerated air flow over the elevators, the captain was unlikely to have been able to keep the nosewheel from slamming to the ground immediately and beginning the sequence of breakup of the forward fuselage structure.

ABOUT THOSE ALTIMETERS . . .

There are numerous references throughout the reports about the barometric altimeters, three each, forming one of the major premises upon which the reports conclusions are based. So many, in fact, that I am not going to bother referencing them here. The Board (Annex II) and the Commission (Annex III) both spared no expense to prove beyond any shadow of doubt that their Air Traffic Control (ATC) had properly informed the crew of the altimeter setting and that Transair had properly maintained their instruments and aircraft, as well, and that there should be no discredit reflected upon the servants of and the country hosting the visitors. If those visiting aircrews could not pay attention to their altimeters and keep from flying into the ground while executing an otherwise exemplary instrument approach it was not the host's fault.

There is one very major problem with this.

According to "Confidential Copy No.9", pp.29 and 33 of sec. 1.8, there were a total of seven altimeters recovered from the site. Five of these were barometric altimeters: one each for the captain, first officer, and navigator/flight engineer, and two others that the investigators speculated were spares due to the presence of tag wires through one of the mounting screw holes in each of them. I would speculate that these may have been in use as cabin pressurization monitors rather than as spares, and not plumbed into the static system. The final two were "Radio Altimeter Model AVQ9. Ser. No. 710. Transmitter Receiver M1-19659" (primary unit for captain's instrument panel) and

"Radio Altimeter Model AVQ9. Ser. No. 824. Indicator M1-19672" (secondary for co-pilot's instrument panel).

Radar altimeters. They were decisively important.

Mankind had long awaited a means to know exactly how far the ground was below you and how far away an obstacle was in front of you while making instrument approaches. Barometric pressure gauge instruments were reliable but didn't give you all the information you really wanted and needed for making truly blind instrument approaches. With the WWII British development of the cavity magnetron, which made radar small enough to be carried aboard aircraft, it was a short step away to build an accurate radar altimeter. The DC-6 was among the very first of the postwar civil aircraft to be fitted with them. By then, airlines couldn't afford not to have them. All of the pilots that I have ever known use them, when they have them, during instrument approaches especially when near the ground. They tell me that they are a very reassuring and confidence-building device.

It is inconceivable that captain Hallonquist was not using the radar altimeter, if he needed an altimeter at all, throughout the portion of the instrument approach that the aircraft completed. Barometric altimeters are fine for flight where there are large safe heights above ground level and sufficiently accurate for keeping airplanes at known levels relative to each other but when you start getting close to the ground in conditions of poor or no visibility the radar altimeter is what is going to tell you where the ground or a solid object is in front of you.

I mentioned above about needing an altimeter at all. In the USA, in order to qualify for a private pilot certificate, a student must accomplish a certain number of landings and fly a certain number of hours at night during official after-sunset periods, (night time). This must be accomplished visually, under official VFR (visual flight rules) conditions. I am fairly certain that the rules to qualify for airman certificates in Sweden or the UK would be pretty similar, and in fact for all ICAO (International Civil Aviation Organization) countries. Without access to his logbooks, it's a foregone conclusion to assume that with over 7800 flight hours captain Hallonquist was competent and comfortable with night VFR landings. On the night in question, the weather 38 minutes before the crash, per Annex II chap. 5 par.5.3 page 14, the visibility was 5 to 10 miles with slight smoke haze, with ceiling not given, but presumably nil cloud cover from the last prior routine weather observation, 3-1/2 hours before. So, there is no reason to assume that the crew couldn't see where the ground was.

Prior to the advent of aircraft with auto-land capability, which was probably not until at least the mid-1970's and to my knowledge didn't come into service until the early 1980's, all, at least all civilian airplane landings were made visually by the human pilot. Even instrument landings were made visually, even when the approaches were made coupled to an autopilot. If at some minimum height above the ground at some certain distance from the end of the runway, and these numbers varied with different airports and with differently equipped aircraft, the pilot could not see the end of the runway to land the approach was called missed, power was applied and the aircraft climbed away to either try the approach again or proceed to an alternate airport where the weather was hopefully better. But all landings required the pilot, at some point, to see the runway visually. In all cases the pilot was only using the altimeter to know where to not descend below. To this day, the vast majority of airplane landings worldwide are still done this way.

Upon reaching Ndola, the aircraft established communications with the tower informing them that they had the airport in sight. At that point the captain could have made a VFR landing within the airport traffic area (ATA) without following the instrument approach procedure. Transair company policy was that if the crew was unfamiliar with an airport, and captain Hallonquist had never been to Ndola before, an instrument approach was to be made. The captain could have ignored this but he was obviously the type of person that would rather follow the rules and go by the book than ever have to explain in the future why he did not. I fully understand this philosophy, it is how I've tried to live my own life. It can be well imagined that for an instant it crossed his mind that he could just set up and land while he was right there, but he knew that an instrument approach was just a few minutes more, no big deal, we can see the ground, no appreciable weather. In other words, he didn't really need an altimeter to tell him where the ground was. He could see the ground. And the radar altimeter told him exactly how high above the ground he was.

THE PRECIPITATING EVENT

To my observation, in the study of aircraft accidents throughout the course of my life, there is almost always a precipitating event that sets off a chain of actions, reactions, counteractions, etc. that results in the crashed aircraft somewhere on the surface of earth. In this case, it is known from Annex II that the captain communicated to Ndola tower that all was well and within minutes the aircraft was being incinerated with its own wing fuel and that fifteen of the sixteen occupants' lives had ended, and that the last would succumb in less than a week. That person, Sgt. Harald Julien, was the only eyewitness to the crash.

To my experience, eyewitness testimony is considered evidence in a court of law, at least in this country. I am unfamiliar with Rhodesian law in the 1960's, but in the USA in the 1960's Sgt. Julien's statements would have been considered evidence in a crash investigation. Since there is no other actual evidence to the contrary, and testimony of ground observers about the airport over-flight and entry to the instrument approach procedure are insufficiently conclusive to determine externally what the precipitating event was, it seems logical to me that Sgt. Julien's statements, as brief as they are, are the only thing that can be considered as evidence in a search for the cause of the chain of events leading to the crash.

In the UN Commission report, par. 129., Senior Inspector Allen testified to the UN Commission that he spoke with Sgt. Julien and asked him three questions; 1. "What happened? He said: 'It blew up'." 2. "Was this over the runway? And he said 'Yes'. 3. "What happened then? And he replied: 'There was great speed—great speed'."

"It blew up—"

"—over the runway"

I have read all three of these reports several times and still don't understand the reluctance of the investigators, including the UN and the Swedish observers, to not make those six words the central point, the number one item on the list of where to begin to find the truth about what happened. Especially from the standpoint of determining whether or not there is fault to be assigned to the flight crew.

Assuming Sgt. Julien was belted into any seat in the forward cabin, looking out the side window on whichever side he was sitting on, he may or may not have had a view of the lighted runway and the town of Ndola but it is likely that the captain would have informed the passengers that they had arrived overhead Ndola and would be setting up to land there. It would have been the last thing he could identify location-wise and anywhere in that vicinity for him would be "over the runway". I don't know if Inspector Allen was deliberately trying to trip him up or why he asked him if it was over the runway when he knew that the aircraft had overflown the runway and not blown up there, but, it seems to me, it was an unusual question to ask a person in Sgt. Julien's condition. What I am getting at here is that Sgt. Julien knew where the runway was and that the aircraft had blown up. They sound like lucid answers to me, and not as though he was thinking about horses or submarines, for example.

In my view, in light of all of the data and evidence of all of the pages of all of the reports and the information displayed in all of the images of all of the photographs in the UN file, the only thing I can see that qualifies as a precipitating event is Sgt. Julien's: "It blew up".

And he was the only one left that was there when it happened.

Airplanes have been blowing up for a long time, in fact for almost as long as they've been in existence. There is a lot of video of it happening; I can think of footage that I've seen going back to the 1920's. And I've been on-scene to ones within seconds to minutes after the explosion. I've salvaged wrecks after the fact, and studied the effects of explosions on structures and materials.

To my experience and observation, on metallic structures, if some event ignites the fuel vapors, it is the vapors that explode and the still-liquid fuel then burns, but the explosive event is by then over. During the explosion some weak area in or near a seam will give way and tear open, leaving, in effect, a chimney from which the burning fuel would exhaust. In aluminum stressed-skin wet wing or bladder tank explosions, there is usually a torn section of skin along a rib or a stringer or even a spar, (weakened because of the drilled holes for rivets) that has opened up and from which the fire burned upward out. I have never seen an example where the fire burned downward; only upward. Presumably, because heat rises.

In viewing video of air combat, of which many hours exist of footage of most of the combatant countries back to at least WWII, when an airplane being shot at catches fire and smoke begins trailing behind, it is subtle but noticeable that the flames are still burning upward and the smoke is trailing slightly upward.

Another thing that struck me when I was standing near a burning airplane at night, while the fire department was trying to extinguish it with water, which was rather ineffective, was how brightly a gasoline fire lit up the sky in the dark.

As stated earlier, aircraft fuel tanks have been blowing up resulting in the destruction of the aircraft for a long time, for a number of reasons. The incendiary (tracer) bullet was developed during WWI to ignite the hydrogen gas in enemy airships and observation balloons, and was very effective, not only for that purpose but also to ignite the fuel in airplane fuel tanks. As TWA 800 proved in 1996, chafing electrical wiring after arcing long enough could blow a hole through an aluminum alloy sheet and ignite fuel vapors that would explode the tank so violently that it initiated an inflight breakup. About two weeks after that, right here in Alaska an engine failure on a DC-6 led to a chain of events that resulted in ignition of one of the wing fuel tanks which was left to burn long enough to result in the wing folding up and an inflight breakup. Electrostatic discharge (ESD)(static electricity) igniting empty or only partially full fuel tanks was known to have damaged or destroyed (I am going by memory here) about 25 civilian turbojet airliners and comparable heavy military aircraft (bombers, tankers, transports) combined since the introduction of the jet age. For that reason, after an airliner lands at an airport and taxis to its gate and shuts down, along with chocking the wheels a ground cable is attached to a fitting in the structure to remove the static charge it has built up while flying through the air. An airline line mechanic colleague tells me that he has measured as much as 50 volts upon making that connection.

But ESD is unlikely to have been the cause of the explosion that SE-BDY experienced. However, the explosion that Sgt. Julien described is most likely to have been the precipitating event that caused captain Hallonquist to make the decision to get the airplane on the ground, now, immediately if not sooner.

FORCED LANDINGS

Forced landings have happened throughout history for nearly countless reasons, but several of the reasons account for the vast majority of the occurrences. Topping the list besides fuel exhaustion/starvation would be engine failure; if your engine fails you have no choice but to put it down wherever you happen to be. That would be in the involuntary forced landing category. In the voluntary forced landing category, and some statistical database could prove me wrong, but to my experience inflight fire would be at the top. I have before me a list of seven airplanes that I had some thread of connection to in some form or other that were force landed by their pilots into whatever terrain was below them at that moment because it was the only chance they had to stay alive. One of the seven, the aforementioned DC-6, technically doesn't qualify as an attempted forced landing, because of the captain's indecision, but all of them resulted in aircraft that never flew again, and in five of the seven all survived, but with some minor injuries. In the other two, there were no survivors. The incidents I am referring to here all occurred in Alaska since 1977, and it is likely that there have been others that never came to my attention. All seven of them were due to inflight fires. One of the seven was a new customer of mine, but the aircraft was one I had never and was destined to never work on.

After almost fifteen months of examining these reports, the conclusion I would draw is that the case of SE-BDY fits into the category of a voluntary attempted forced landing due to an inflight explosion and fire that was successful until its final seconds, and then an unseen and un-seeable solid object ended its chance for a successful termination.

THE LAST ACTIONS

I will attempt to re-create the final minutes of the flight of SE-BDY based on the information in the reports, as I would visualize it to have to have occurred. I want to remind the reader that the largest airplane that I have ever steered through the sky was a DC-3, which is for all practical purposes not all that different from a DC-6. The ancillary control systems in the DC-6 were substantially different in being mostly electrical relay controlled, it had two more engines, and there were more systems in general such as anti-detonant injection (water/methanol) for the engines, reversing propellers, BMEP gauges for fine-tuning engine power and fuel mixture, etc.; it is a considerably more complex machine. But for the purposes of understanding what actions were taken and their results, it would have been basically as follows:

01. The aircraft has descended from the east toward Ndola from its reported maximum cruise altitude of 16,000 ft. and establishes communications with the control tower. It has just flown a long trip, far out of its way to avoid aircraft hostile to UN personnel and has avoided radio transmissions as much as possible to avoid detection. The captain states his intentions to enter the NDB instrument approach and is told to report reaching 6000 ft. There are no further communications with the tower.
02. It is likely that at last communication with the tower that the aircraft was already at 6000 ft., based on airport personnel statements and the extreme likelihood that the captain already had the Ndola approach plate in front of him, and had based his descent rate into Ndola to arrive near the minimum descent altitude (MDA) for the area.
03. The aircraft turns onto the outbound course leg and airspeed adjusted to at least 140 knots indicated airspeed. The Ndola approach plate in the UN report appendix gave times for approaches at 180 and 200 knots in addition; there is no way to ever know what speed was actually used. My best guess is that it would have been 140 knots.
04. At some point approximately but probably more than halfway on the outbound leg course the precipitating event occurs. This is probably nearly simultaneous with calling for landing gear down and 30 degrees flap. There is a bang, a flash of light, and then a constant partial illumination of the night sky on the left side of the aircraft.
05. The captain looks out the left cockpit window and sees a section of the upper wing skin torn open upwards, with bright yellow flames billowing rearward behind that area. It is possible that he can feel some diminished lift component from the spoiler-effect of the damaged wing skin on that side and may have moved the aileron trim to compensate.
06. Seeing this, the captain realizes quickly that they cannot expect the wing to last long enough for them to make it the three or more minutes it would take to get back to the Ndola runway; that they probably have only some number of seconds to live. He determines that he is going to land the airplane onto the ground in front of him, whatever that looks like, before the airplane breaks up. He is not

going to waste the time it takes to inform Ndola tower of the situation; flight crews generally never do. Investigators wish they would.

07. With his right hand he reaches up and pulls the throttles back; with his left he holds some back pressure on the elevators and with his right hand then starts trimming the elevators nose up. Airspeed begins to decrease, heading toward flap extension speed.
08. The captain has already told the first officer and flight engineer his intentions; they are assisting him in the other physical actions necessary to configure the aircraft for slow flight and landing. It's possible that the first officer is also assisting him in holding pressure on the ailerons to keep the wings level.
09. The aircraft is slowing down, beginning to descend, the captain is trimming the nose up on and off, trying to bleed off the excess altitude. The captain is nominally staying on the turn-back arc of the instrument approach.
10. With the aircraft slowed well down, in an effort to speed the descent and get rid of the excess altitude, the captain pushes the nose down with the elevators. The wind noise increases, and with the nose down attitude the occupants get a sense of "great speed", but in reality, the DC-6's landing profile is comparatively steeply nose down in normal conditions, opposite that of jet airliners, that land steeply nose up. The large double-slotted wing flaps, and modest wing loading allow for impressively steep descents at comparatively low airspeeds.
11. Seeing and sensing the proximity to the treetops, the captain begins putting back pressure on the control column, judging the round-out with the experience of 1445 hours in DC-6's, and rolls out of the procedure turn onto the return course to the NDB. He is possibly helped in his depth perception sight picture by some of the small campfires that the local charcoal makers have burning sprinkled around the general area. He probably doesn't need landing lights; they are useful for illuminating reflective objects and lighter colored areas/objects but can be only distracting if there is nothing light to reflect.
12. Having leveled off just above the treetops, the captain retards the throttles to idle and holds back pressure on the elevators and adds more nose up trim to relieve the pressure, bleeding off more speed toward the stall. It is possible that the thought occurs to him for a few thousandths of a second that if he makes it through this, in the future he will insist on having some ballast in the tail on these otherwise fairly empty charter trips. Now would be a good time to be a bit tail-heavy.
13. The aircraft is gently settling, the treetops are beginning to brush the belly, the propellers are chopping off twigs, there are probably some unfamiliar sounds resulting from this.
14. The ever-increasingly sized tree branches are clattering off the sides of the fuselage from the propellers now, the sounds of tree trunks snapping off beneath the belly and wings can be heard clearly. A somewhat larger tree trunk contacts the left-wing leading edge a little inboard of the tip rib and shears through the light skin, stringers, etc. and the wing tip falls away to the ground. That left wing just can't be held up quite level, but the aircraft is still traveling straight, into a little darker darkness.

15. The captain throws the propeller switch group into the reverse thrust position with his right hand and when the propellers start translating, he begins advancing the throttles forward.
16. The aircraft is halfway or more to the ground from treetop height and the trees are breaking off lower and lower. The manifold pressures are coming well up and the engines are roaring, the propellers are chopping off ever-increasing sizes of limbs and trunks. The reverse thrust in addition to the arresting effect of the bending and breaking trees are having an effect; the aircraft is well below stall speed now. Landing gear doors are being battered and tearing off, as well as pieces of wing skin, wing flap skin, and possibly horizontal stabilizer leading edge skin.
17. The aircraft has made it to the ground; all three landing gear are on the forest floor. The burning left wing has not had enough time to shed molten sections of skin yet, due to the occurrence at pattern height and the captain's immediate decision to get the airplane on the ground.
18. The left wing pushes over a larger tree, probably just outboard of the main wheels that doesn't surrender easily and tears a sizeable hole through the bottom wing skins, instantly dumping a significant quantity of already burning fuel onto the ground.
19. Some or all of the flight deck crew could possibly, for some very small fraction of a second, think that this might turn out OK. They are on the ground, upright, still largely in one piece, all still strapped into their seats, uninjured.
20. The aircraft at this time is effectively a 38-ton bulldozer, mowing down trees on a forest floor that has probably been undisturbed for centuries, if not millennia; I don't know the history of that area. Except that it's not built like a bulldozer, and I doubt that one has ever been built that would move at whatever speed it was going at this moment on its own. The nose landing gear at this time cannot withstand the combination of ground roughness, imposed weight, speed, possibly flat or even missing tire, and/or other unknown factors, and collapses, tearing out and further weakening the surrounding structure. The forward fuselage and nose section have pushed the nose gear down to its collapse, and relieved of its resistance continue to plunge downward, crushing and tearing the light aluminum structure to pieces as the forward shifting center of gravity exacerbates the situation even further, as it is effectively standing what originally was a 100 ft. long fuselage on its end.
21. Simultaneously with the nose section containing the flight crew and some observers disintegrating, the wing leading edges rotated downward, and well powered-up engines and propellers sliced the ground. The left wing leading edge contacted near the base of the anthill, and the 38 ton mass, with still considerable momentum, rotated around it, side-loading the second fuselage section, ultimately severing it from the rest of the fuselage.

For the aircraft to have been found as described and photographed in the reports, it would have had to happen generally as I have described. A type-rated DC-6 captain could certainly provide more and better detail of the specifics of operations and actions, and a mechanic with a lot of DC-6 experience could provide more and better detail of how things worked in this case, and here in Alaska there is and has been a lot of DC-6 experience, but to my knowledge none have researched this case and come forward with their observations. I suspect that most who are currently alive are unaware of it. I don't think I had heard of it until maybe ten years ago at the most. But those who were aware of it at the time, even as children, have kept the account of the crash alive, and rightfully so, as it is an injustice to the memory of those whose lives were cut short.

In my view, the flight crew did everything right. I can't see a single place where I wouldn't have done the same thing in that situation. I can't imagine that approach through the trees and the touchdown on the forest floor to have been accomplished more skillfully by anyone I've ever heard of, Eric Brown or Bob Hoover, anybody. I can only hope that I would instantly swallow my fear and act decisively in a similar situation, as this captain and crew did. They are as shining an example to all that it can be done, as others I have known and have heard of have done, as there is.

To me, it is really, and I mean really, obvious what happened there.

I have written this for the offspring, the relatives, and friends of the victims, in hopes that the dark cloud of implication that has surrounded this crew, completely unreasonably I believe, for some six decades now, can finally be lifted.

Joseph (Joe) Majerle III
Anchorage, Alaska
July 2021
Revised June 2023