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"THE DEVELOPMENT OF CIVIL AIRCRAFT ACCIDENT INVESTIGATION IN THE U. S. A."

A

L E C T U R E

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by

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At the outset I should like to express my appreciation to your General Secretary Salvatore Tomasino and to the Centro Per Lo Sviluppo Dei Trasporti Aerei for the honor of inviting me to appear before you.

Your General Secretary has suggested to me that my talk to you concern itself with the development of civil aircraft accident investigation in the United States. I shall further limit my remarks to accident investigation concerned with American air carriers.

As in all countries of the world commercial air transportation in the U. S. inaugurated service and began its first technical and economic growth in the years following World War I, and particularly following the momentous Lindbergh flight in 1927 from New York to Paris. For the next decade American aviation developed vigorously but haphazardly, with new designs and technical equipment following one after the other, and sometimes at the expense of public safety. In a parallel sense the economic growth of civil aviation skyrocketed in the late 1920's and then, following the worldwide depression, slumped to an all-time low in the mid 1930's.

Finally, amid newspaper headlines of forced mergers and airline bankruptcies appeared the tragic story: "U. S. Senator Bronson Cutting killed in an airline crash." As a consequence of these accumulating developments, and continuing turmoil over rates and methods of airmail subsidies, the attention of Congress was focused on the chaotic problem of U. S. aviation, and the result, in 1938, was passage of the Civil Aeronautics Act of that year.

The physical nature of aviation, which made possible the crossing of several States on a single flight, made it mandatory that the new law be national in scope, applying equally to all 48 States. Thus, for the first time in the United States the Civil Aeronautics Act brought all segments of civil aviation under one general Federal law, established uniform regulations that pertained both to the safety and economic health of the burgeoning industry and promised to aid in the encouragement and development of civil aviation in the future.

For the next twenty years the Civil Aeronautics Act served as the great charter of American civil aviation development. During its existence it helped to make possible an aircraft manufacturing industry, a national air transportation system, and a private flying business unequalled by any other nation of the world. Then, in 1958, and again partly as the result of a series of major air disasters, Congress reexamined the needs and the posture of our civil aviation. Under the understanding leadership of U. S. Senator Mike Monroney, public hearings were held to evaluate the need for new legislation to replace and modernize the old Act. Thus was born the Federal Aviation Act of 1958 under which all civil aviation in the United States now operates.

To carry out the mandates of the 1938 Act, Congress had originally created a three-part Federal agency known as the Civil Aeronautics Authority. However, after nearly two years of practical working experience, this cumbersome body was reorganized in 1940 and forged into two separate Federal agencies, and in much the same form that they exist today. The largest of these is the Federal Aviation Agency, (FAA) which is part of the executive branch of the U. S. Government; while the other is the Civil Aeronautics Board, (CAB) an independent agency of the Congress.

The FAA consists of some 42,000 employees headed by a single Administrator who is appointed by the President with the consent of the Senate. The principal duties of the FAA include the licensing of airmen and aircraft, the issuing of safety and airworthiness certificates, the promulgation of the U. S. Civil Air Regulations, and the development and operation of the air traffic control system, which function absorbs the largest single group of its personnel.

The CAB, on the other hand, comprises about 800 employees, headed by five Members appointed by the President with the consent of the Senate. The largest part of the Board's functions are quasi-judicial and legislative in nature: such as authorizing air carrier operations by specific applicants over specific routes; setting rates for the carriage of mail, domestic passenger tariffs and air freight; establishing and paying subsidies for scheduled air transportation; governing mergers and interlocking relationships; and ruling on other economic matters, as well as serving in its quasi-judicial capacity as the agency of review and appeal of FAA actions affecting safety certificates.

Last but not least of the functions delegated to the Board by Congress is its independent responsibility in the field of civil air safety.[1/] This is a broader responsibility than some aviation people seem to realize. Over the years, moreover, the Board's dramatic and widely publicized work in the investigation and cause determination of civil aircraft accidents, which is only one specialized form of its safety activities, has overshadowed some of its other equally important but lesser known safety functions.

For instance, the Federal Aviation Act of 1958 specifically charges; It shall be the duty of the Board to:

> "Make such recommendations to the Administrator(FAA) as in its opinion, will tend to prevent similar accidents in the future;
>
> Ascertain what will best tend to reduce or eliminate the possibility of, or recurrence of, accidents by conducting special studies and investigations on matters pertaining to safety in air navigation and the prevention of accidents."

1/ Section 701-703 of the Federal Aviation Act of 1958 (72 Stat 781-782, 49 U. S. C. 1441-1443.)

I cite these two paragraphs from the Act here because they are becoming increasingly important to the subsonic present and the supersonic future of commercial air transportation. Indeed, the cost in lives and money in connection with any disaster involving jet-age transportation has nearly reached the point where we can no longer afford to have accidents. Consequently, it has become more and more important that we direct more and more of our technical knowledge and safety efforts towards developing ways and means that will prevent accidents before they happen.

It might interest you to know that over the past four years the Board has made 165 formal recommendations directed at preventing accidents. The majority of these recommendations have been made to the FAA, and the balance to the U. S. civil aviation industry. All were based on factual evidence developed by the Board's Bureau of Safety through specialized studies or obtained in the course of an investigation of an accident. I am pleased to report that approximately 80 percent of these recommendations were accepted and corrective action found possible.

But we are interested here today in the Board's specialized work in the field of civil aircraft accident investigation, in which its Bureau of Safety has been engaged continuously since 1938. In this time the Board has found the cause of more than 93 percent of all air carrier accidents it investigated. Since the end of World War II air safety technicians from more than 16 countries, including Soviet Russia, have come to America to visit and study the Board's method of operation in air crash investigation.

Initially, however, without precedence or guidance, the Bureau of Safety was forced to invent and develop many of the techniques it uses today as standard practice. It pioneered in using X-ray in search of metal fatigue; in assigning physical items and wreckage clues to medical, metallurgical, and other research laboratories; and with only scant evidence available it worked out its own ways and means to uncover meaningful facts relating to the cause of a crash, such as determining the power setting of an engine and the speed of an aircraft at impact.2/

2/ "It seems that impact of an aircraft propeller assembly with the ground or other substantial object causes sufficient distortion and movement of the blade within the propeller hub assembly to cause impact marks with the aid of a simple protractor device, and the result gives us the relative blade angle at impact. We find that we can determine this blade angle to at least an accuracy of + or - two degrees. Disassembly of the propeller governor and measurement of the speeder rack spring usually gives us information as to the RPM of the engine, we can then determine the power setting of the engine. Propeller slash marks are also searched for and carefully examined and measured." (more)

Now after more than 22 years of operation, the Board's Bureau of Safety has acquired a fund of concentrated knowledge in a technically specialized area of civil aviation. Through the years it has brought together and trained its current professional staff of about 100 pilot-engineer-technicians who are known as CAB Air Safety Investigators. The Director of the Bureau, Melvin N. Gough, active in aviation research and air safety for more than 30 years, is a nationally known engineering test pilot. Indeed, under Federal Civil Service minimum entrance requirements CAB Air Safety Investigators must generally hold Commercial Pilot Certificates or Air Transport Ratings, an Instrument Rating, and have 10 years experience in aviation.

The Bureau of Safety is composed of a total of some 150 employees, the majority of whom are based at CAB headquarters in Washington, D. C. About 50 persons, 40 of whom are Air Safety Investigators, are assigned to ten area field offices across the nation. Whenever a crash occurs the office nearest the accident scene takes over immediate responsibility.

I have decided to outline in some detail the method of operation we follow from the time an airplane accident occurs to the actual issuance of the Board's final report listing the cause of the accident. I have chosen the tragic bombing case of a National Airlines' DC-6B, which occurred over Cape Fear, North Carolina, one rainy night in January 1960. I know that many of you may recall this case from newspaper stories.

National Flight 2511 was south-bound out of New York nonstop to Miami, Florida, and departed at 2334 with 29 passengers and a crew of five on board. All position reports were routine including one made over Wilmington but from then on there was silence.

2/(cont'd.) "Either due to the measurement of the speeder rack spring in the prop governor or, in other instances, by assuming an RPM which would be normal for a particular phase of flight or flight condition, we can by computation arrive at the speed of the aircraft at contact with the ground or the relative speed of two aircraft which collide in flight. If you are interested in the formulas for determining engine RPM or aircraft ground speed, they are as follows:

(1) To determine Ground speed in knots when engine RPM is known:

$$\frac{\text{Engine RPM} \times \text{number of propeller blades} \times \text{distance between slashes (ft.)}}{\text{Gear ratio (engine to Prop)} \times 101.3}$$

(2) To determine Engine RPM when Ground speed is known:

$$\frac{\text{Ground speed (knots)} \times \text{gear ratio (engine to prop)} \times 101.3}{\text{Number of blades} \times \text{distance between slash marks (ft.)}}$$

(101.3 equals feet per minute at speed of 1 knot per hour)

2/"Airplane Accident Investigation" by John L. McWhorter, Air Safety Investigator, Civil Aeronautics Board.
28 Tennessee Law Review 122,128: (1961).

This failure of Flight 2511 to make its next position report resulted in FAA air route traffic control calling the flight repeatedly but without response. At this point FAA airways communications at the Washington control center automatically notified the Civil Aeronautics Board of a possible accident.

Following the call concerning Flight 2511, the Chief of our Investigation Division immediately telephoned two air safety investigators in our New York office to proceed immediately via airline to the Wilmington area. On arrival they found that the North Caroline State Police had established security measures at the accident scene--a level, half-swampy field partially covered by scrub pine--and were awaiting the arrival of the CAB Investigator-in-Charge.

It was still raining when our men first inspected the wreckage of the DC-6B which had fallen in a fairly compact area, with most of the fuselage broken into fairly large sections. Our senior investigator immediately called on the nearest military establishment, which happened to be the U. S. Marine Corps base at Cherry Point, North Carolina, and requested assistance from the base helicopter search squadron. By noontime the rain had stopped and it was possible to view the accident scene from the air and ascertain if all the wreckage was in one general area.

In this case, however, utilizing several helicopters, and private aircraft, we found two large pieces of fuselage skin and a 3-seat unit from the cabin at Kure Beach on the edge of the Atlantic Ocean 18 miles from the main wreckage. Thus, it was evident that the airplane had begun to come apart in the air considerably prior to reaching its final impact point. Consequently, upon completion of his appraisal at the accident scene, our investigator telephoned the CAB headquarters in Washington and reported that his preliminary findings indicated some type of structural failure.

On the basis of this information a technical staff was quickly assembled to assist the CAB senior investigator at the scene of the accident. Using the Board's Aero-Commander executive aircraft we dispatched from Washington two aeronautical-structural engineers, one powerplant specialist to check the engines, and one air-carrier specialist to review the operation of Flight 2511 up to the time of the crash. With the arrival of this group the Investigator-in-Charge began organizing separate investigative groups and detailing to each group one specialized function. This Group Method is an investigative technique developed by the CAB over the years, and I believe warrants a word of explanation here because it represents an example of cooperation that is unparalleled by any other industry.

The way it works is this: the senior investigator invites top technical representatives from all aviation sources that are directly concerned with a major accident to participate in the investigation. In the case at Wilmington, he invited representatives from Douglas Aircraft, manufacturer of the airplane; Pratt & Whitney, manufacturer of the engines; Hamilton

Standard, manufacturer of the propellers; National Airlines, owner of the airplane; Air Line Pilots Association and Flight Engineers International Association, whose members composed the flight crew; and the FAA, who had certificated the aircraft and flight crew, and operated the air traffic control system used by Flight 2511.

In every instance all of these organizations cooperated immediately by sending several of their top technicians to Wilmington to assist the CAB. Thus, on the morning of the day following the accident, our senior investigator had organized four specialized CAB investigative groups, each numbering about eight specialists, and headed by a CAB Air Safety Investigator who directed the group operation. The five Groups included the following:

1. Structures Group:

This Group was directed by the assistant chief of the Engineering Division of the CAB Bureau of Safety and was concerned solely with collecting, identifying, and analyzing the airframe wreckage.

2. Powerplants and Propeller Group:

This Group was directed by a CAB Air Safety Investigator from Washington, an engine and propeller specialist, who was responsible for removing the four engines and propeller assemblies from the crash scene to a hangar at Wilmington Airport in order to conduct a preliminary teardown analysis of the engines, and prepare a layout study of the propeller hubs and blades.

3. Human Factors Group:

This Group, under the leadership of a CAB aeronautical engineer-attorney, was responsible for arranging necessary autopsies and analyzing and studying the breakup of the wreckage for future use in cabin safety design.

4. Operations Group:

The Operations Group directed by two CAB operations specialists reviewed all factors related to the last flight of National 2511, including flight plans, all recordings of radio contacts, and a complete review of aircraft maintenance records and crew proficiency records.

These four Groups met and exchanged progress reports each morning with the CAB Investigator-in-Charge, who had established his headquarters at the Cape Fear Hotel, which was equipped with a short-wave radio that connected him with both the main wreckage site and the Wilmington Airport, where the CAB Structures Group had decided to move the wreckage and reconstruct a mockup of the fuselage.

Before telling you something about this mockup I would like to fill you in on a few details that occurred three days after the accident. At this time a light aircraft pilot reported locating the body of a man on the west bank of the Cape Fear River, some 18 miles from the main wreckage site, in the vicinity where the fuselage skin and cabin seat had been found earlier. This body was identified as a male passenger by the name of Julian Andrew Frank.

There were two unique factors of interest concerning passenger Frank that did not exist in the case of all other occupants of the airplane: the first was the fact that passenger Frank was carrying insurance in excess of one million dollars; and, secondly, both legs had suffered an unusual shredded type of amputation. Because of this, and because of other unusual puncture wounds on the body it was decided that an autopsy should be performed.

Concurrently, additional small pieces from Flight 2511 were being found in the Kure Beach area adjoining the Cape Fear River. The investigators now felt strongly that an explosive force of unknown origin had ruptured the right forward cabin wall of Flight 2511 and caused the ejection of a 3-seat unit and the body of passenger Frank. It was at this point that the CAB Structures Group decided that they would reconstruct a mockup of the fuselage of Flight 2511 in order to determine the origin of breakup, the progression of structural failure, and the cause of both.

The mockup was built in an old hangar on the Wilmington Airport. The Structures Group used 2 x 4 timbers conforming in outline to the size and shape of the DC-6B fuselage and over this wooden skeleton framework they tacked chicken wire. On this wire, slowly and meticulously, they secured piece after piece of the fuselage skin collected at the main accident scene, where most segments had been photographed and identified prior to being moved to the mockup. A considerable amount of muscle was necessary for this operation and our men were glad to welcome the assistance of some two dozen convicts, who were temporarily released from a nearby prison, who gave most willingly of their services.

Now, as you well know, anyone having anything to do with an airline accident--and this is especially true of the press--is always trying to be the detective who finds the cause. In this case newspapers in Florida were headlining that the Wilmington crash was the result of a faulty propeller blade that had snapped off in flight and cut open the cabin. In the meantime, our CAB investigators, who are trained never to speculate or discuss the cause of an accident during investigation, were quietly working to eliminate one suspected area after another. By the fourth day our Investigator-in-Charge had narrowed his attention to four possibilities:

1. That Flight 2511 had been struck by another airplane, or a missile, which caused it to crash;

2. That Flight 2511 had suffered structural fatigue in the fuselage wall which resulted in explosive decompression;

3. That Flight 2511 had thrown a propeller blade through the right side of the cabin wall which caused explosive decompression severe enough to expel a seat unit and the body of a passenger;

4. That the right forward cabin wall of Flight 2511 had been shattered from an inside explosive force of unknown origin.

In the first instance the CAB Operations Group made a careful check of all aircraft airborne in the North Carolina vicinity at the time of the accident in order to check out the possibility of air collision. They also checked to see if any military aircraft or ground stations had fired missiles during the same period. All findings were negative.

At this point the CAB Structures Group reported that the size of the rupture in the cabin wall of Flight 2511 was much too large to have been caused by explosive decompression alone. Corrective construction following previous cases of explosive decompression had developed a cross-webbing type of wall structure, which was used in the DC-6B, and would have prevented a large rupture.

The third possibility, that of a propeller blade breaking off and ripping through the fuselage, had been favored by a number of aviation authorities as well as the press. This theory was soon eliminated, however, when the CAB Powerplant and Propeller Group recovered all propeller blades buried in the earth near the four engines at the wreckage site.

This left us with the number four possibility, which was studied with considerable scepticism. Any explosive force from within an airplane cabin, after the elimination of the possibilities enumerated, would mean sabotage by bombing. And in all the history of American air transportation there are only two other proven cases where a bomb has been used to destroy an airplane; and only one of these resulted in a fatal crash.

The autopsy on passenger Frank, in the meantime, had been completed and various metal particles removed from his body were undergoing laboratory analysis in Washington and New York. Nothing conclusive had yet been found. Out at the Wilmington Airport the fuselage mockup was progressing satisfactorily--so well indeed that from a distance the fuselage appeared to be intact and real. From the mockup hundreds of small pieces of metal, rug fabric from the floor of the cabin, seat material, and other areas near the ruptured side wall were also undergoing laboratory inspection looking for evidence of explosion. But none was found.

I will not bore you with the details of the next few weeks but suffice it to say that our investigators gradually became convinced from structural evidence that the damage had been caused by a highly explosive substance. Almost simultaneously, evidence was discovered in passenger Frank's body that indicated the presence of nitrate, which was also beginning to turn up in the mockup at the Wilmington Airport. More than that, evidence of manganese dioxide was located in the fuselage structure which indicated that electric dry cell batteries were in juxtaposition to the nitrate residue of dynamite.

Finally, two weeks before the Board convened its public hearing at Wilmington, our investigators located the amputated lower leg bone of passenger Frank in one of the hat rack compartments opposite the rupture in the mockup fuselage wall. This bone contained a portion of the mechanism of an alarm clock imbedded in it and cloth around it that was definitely identified as coming from the trousers of the suit worn by passenger Frank, and there was no doubt that this was part of his leg because no other passenger or crew member had suffered leg amputation.

In this case the CAB investigation had developed along two separate technical lines: one involving clinical analysis in the field of medical pathology, and the other involving aeronautical engineering reconstruction and laboratory analysis of portions of the airplane involved. Both these avenues of investigation basically resulted from clues developed by two CAB Investigative Groups: Human Factors and Structures.

As in most major air carrier accidents the Board convened a public hearing in this case, in which all the findings of technical fact originally developed at the scene of the crash by the various CAB Groups were entered in evidence as sworn testimony before a CAB Board of Inquiry. Six months later the Board issued its formal public report[3/] summarizing as follows:

> "It is the Board's conclusion that Flight 2511 proceeded in a normal manner without operational difficulty, mechanical failure, or malfunction until shortly after passing the Carolina Beach "H" facility a short distance south of Wilmington, North Carolina.
>
> At approximately 0233 a dynamite charge was exploded, initiated by means of a dry cell battery within the passenger cabin and at a point beneath the extreme right seat of seat row No. 7.
>
> Mr. Julian A. Frank was in close proximity to the dynamite charge when the detonation occurred.
>
> The dynamite explosion severely impaired the structural integrity of the aircraft and after making a wide descending right turn, it experienced inflight disintegration and crashed 1-1/2 miles northwest of Bolivia, North Carolina, at 0238."

3/ CAB Aircraft Accident Report, National Airlines, Inc., nr. Bolivia, North Carolina, N. C., January 6, 1960: Docket No. SA-352.

The Board has never determined whether or not passenger Frank committed suicide or was murdered. The Board's responsibility and jurisdiction in civil aircraft accident investigation is concerned with finding the cause of the accident so that with this knowledge remedial actions may be undertaken to prevent similar accidents. The criminal aspects of this tragic case, therefore, were referred for future action to the U. S. Department of Justice through its Federal Bureau of Investigation.

It is my hope that this brief description of the procedures followed by the CAB in its accident investigation work will provide you with some idea of how we operate in this field.

We have come a long way in American civil aviation since the Civil Aeronautics Act of 1938 was passed by the Congress. Our airlines, in those days, operated some 300 twin-engined transports, none of which were pressurized for altitude flying. Today, in scheduled flying, we have a fleet of 2,000 airliners, most of which are four-engined and pressurized; and more than 450 of them are jet-powered.

(Even though I have limited my general remarks to air carrier accident investigation, I believe I would be remiss as an information officer if I failed to pass along the additional civil aviation fact that our American private flying business, which we refer to as General Aviation, has also grown from a few thousand small airplanes in 1938 to a huge and active fleet of 70,000 today, of which more than 6,000 are multi-engine aircraft.)

And finally it is of interest to note the nation-wide acceptance of air travel as an American transportation utility. In 1938 our scheduled airlines transported more than 1.3 million passengers--in 1960 they carried 53 million passengers!

These figures, the number of airline aircraft and general aviation aircraft, and the number of people carried in scheduled air commerce, will give you some idea of the present-day size and scope of American civil aviation. Its continuing economic and technical growth, and its existence as a public transportation service, depend on maintaining and improving its operational safety.

It was for this reason that the Congress of the United States delegated to its own agency, the independent Civil Aeronautics Board, certain specific duties, including, among others, responsibility for the investigation and cause determination of civil aircraft accidents; for making recommendations to the FAA that will tend to prevent similar accidents; and to ascertain what will best tend to reduce or eliminate accidents by conducting special studies and investigations pertaining to safety in air navigation and the prevention of accidents.

This, then, is the area of operations, and the degree of responsibility, for U. S. air safety, fulfilled by the Civil Aeronautics Board and its Bureau of Safety.

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