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The Shaping of Things That Are: How Airplane Windows Took Their Shape

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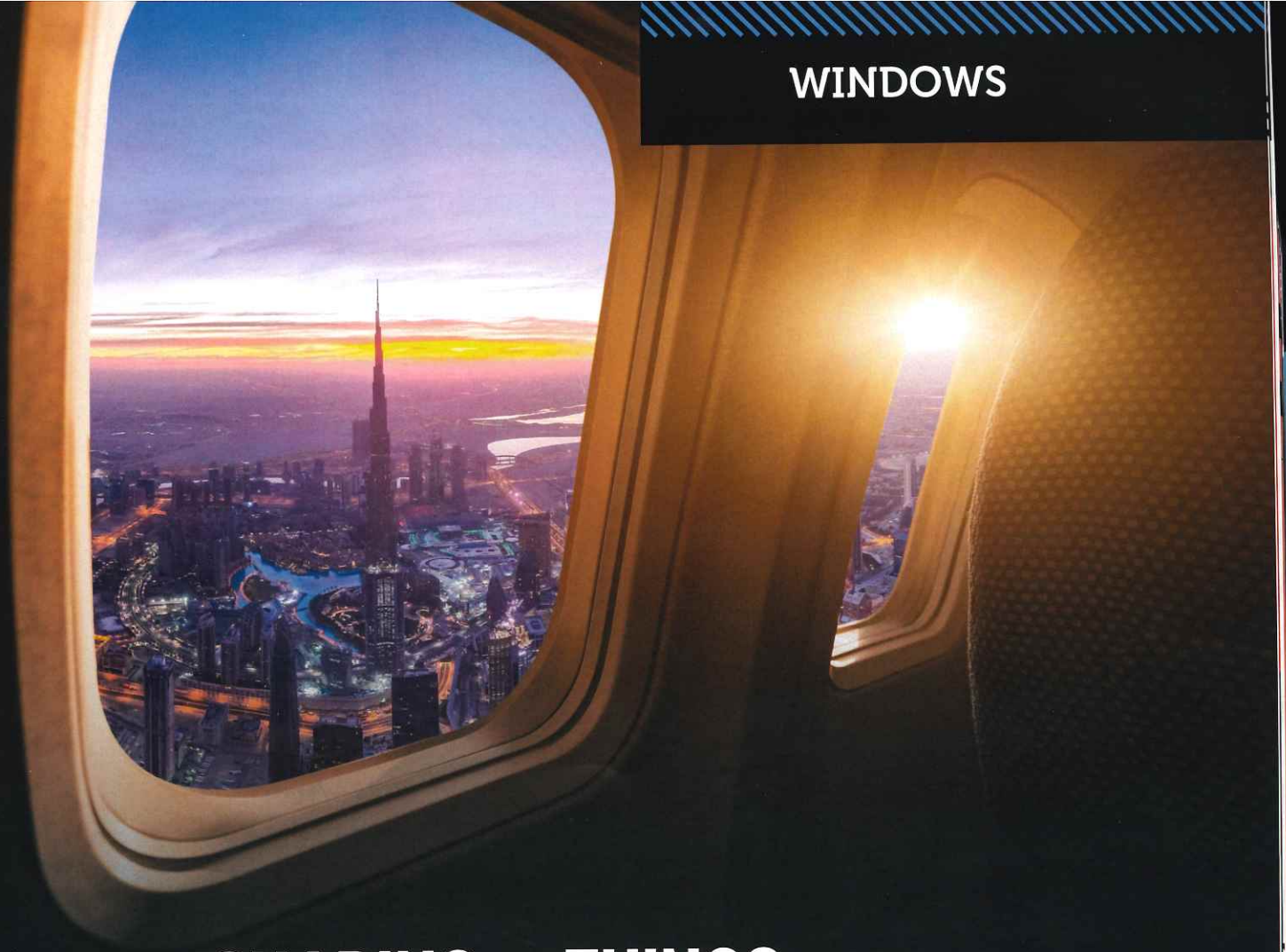

THE SHAPING OF THINGS THAT ARE

HOW AIRPLANE WINDOWS TOOK THEIR SHAPE

By MORGAN LOPEZ

Have you ever wondered why your airplane's windows are rounded? *It is not for aesthetic appeal.*

The first commercial jetliner windows' sole purpose was appearance; a squared window afforded an impressive view of the earth, but the view was not without consequence.

WORLD WAR II

Flying at 28,000 feet over Munich on July 26, 1944, an unaccompanied Royal Air Force (RAF) Mosquito, a de Havilland aircraft of remarkable design, spotted an extremely fast enemy aircraft with no propellers. Despite the Mosquito's own speed, the extraordinary aircraft closed in on the Mosquito surprisingly quickly. The Germans had created the Messerschmitt Me 262, the world's first successful jet fighter, which now encountered the enemy for the first time. Fortunately, quick thinking by the British crew allowed them to use the jet's momentum to their advantage so that they could escape and report their discovery. Less than ten years later, the enterprising Sir Geoffrey de Havilland would produce a jet designed for elegant travel, not combat. This jet, just like the Me 262, was also intended to transform aviation.

THE COMET

The world's first commercial jet engine, the British de Havilland Comet 1, entered service on May 2, 1952. The power of jet engines flew higher, farther, and faster than ever before. This revolutionized air travel and launched the Jet Age. The Comet was effectively vibration free, which created a smooth ride. Since the Comet flew at a high altitude (cruising altitude 35,000 feet), the cabins were pressurized. A futuristic jet design with square windows provided passengers an unmatched outlook of the earth below.

BRITISH AVIATION

On June 30, 1953 Sir Geoffrey de Havilland invited the recently crowned Queen Elizabeth II, the Queen's mother, and Princess Margaret on a Comet flight, making them the first members of the British Royal Family to fly on a commercial jetliner. De Havilland once said, in regard to his approach to design, "I like a thing to look right... if it does not, although I may not be able to prove it wrong scientifically, I have often found out later that it is."

The Comet was a triumphant achievement for British commercial aviation. The British Overseas Airways Corporation (BOAC) was a main operator of the Comet, making it the first airline to service passenger jets. BOAC merged with British European Airways (BEA) in the 1970s to form British Airways.

THE COMET ACCIDENTS

By April 8, 1954 the de Havilland Comet killed 99 people. The first accident occurred exactly one year after the Comet commissioned service: May 2, 1953, BOAC Flight 783 from Calcutta Airport to Delhi. Radio communication abruptly cut out while the aircraft rose 7,500 feet in the air. The aircraft set ablaze and fell to the ground near Calcutta, India. Forty-three people perished. The accident inquiry attributed the crash to structural airframe failure due to extreme turbulence from a severe thunderstorm squall. The second accident took place on January 10, 1954, BOAC Flight 781 from Ciampino Airport in Rome to London. Nearing 27,000 feet, communication with the crew unexpectedly ceased. The aircraft burst into flames and plunged into the ocean near Elba off the coast of Italy. Thirty-five people died. After this second accident near Elba, the Comet fleet was taken out of service. De Havilland made many modifications while the Elba wreckage was still being retrieved. British aviation authorities determined there was no definitive cause of the accidents. The Comet fleet resumed service on March 23, 1954. The third accident, South African Airways (SAA) Flight 201 (contracted by BOAC) took place on April 8, 1954 after a departure from Ciampino Airport in Rome en route to Ciaro. While ascending 35,000 feet, the aircraft suffered a calamitous inflight structural failure and crashed into the ocean near Naples, Italy. Twenty-one people died. The Comet fleet was grounded indefinitely. All Comet aircraft airworthiness certificates were revoked. Britain's aviation industry credibility was in jeopardy.

INVESTIGATION

The Elba crash investigation would prove to be the most revealing of the underlying causes of the Comet accidents. Underwater television cameras were used for the first time to search for debris from Elba submerged on the ocean floor. The Calcutta crash was mainly attributed to weather. The debris of the Naples crash sunk too deep in the ocean for retrieval. The causes of the Comet accidents lay in the Elba wreckage.

Professor Antonio Fornari of the Institute of Forensics Medicine at Pisa University performed autopsies on 15

of the passengers from BOAC Flight 781 and found passenger's sustained broken limbs after death, fractured skulls, and ruptured lungs. Ruptured lungs indicated a sudden decrease in cabin pressure. Professor Forani ascertained the causes of death were fierce movement of bodies and instantaneous impingement upon parts of the aircraft and volatile decompression. The bodies were burned. There was suspicion that a bomb had caused an explosion in the cabin. However, it was believed that the burns were acquired postmortem from burning kerosene on the water.

"By April 1954 the de Havilland Comet killed 99 people."

The British Minister of Transport and Civil Aviation designated Sir Arnold Hall, the director of the Royal Aircraft Establishment at Farnborough, to carry out an extremely thorough investigation into the causes of the Comet accidents. At the time of the de Havilland Comet incidents, there was no established aircraft accident investigation board or process, so new investigation techniques were created along the way.

Pressure tests were conducted on Comet G-ALYU (from the Comet fleet and unrelated to the accidents) fuselage that used water instead of air to preserve as much of the fuselage as possible for future testing and repairs. The fuselage was submerged in a water tank and water was pumped into the cabin to simulate the pressure experienced during flight. After 1,830 cycles in the water tank, a section of the fuselage failed-- a corner section of a square escape hatch window-- leading the investigation towards fatigue failure. Fatigue failure is when a structure may fail under its normal working load after a certain amount of time. This led to a new mapping of the crash site at Elba and the retrieval of the aircraft's two square Automatic Direction Finder (ADF) windows. The ADF windows, located on the top of the fuselage forward of the wings, bore signs of fatigue and were determined to be the principle source of inflight structural failure.

The de Havilland Comet was a pioneering endeavor. No one was aware of the issues of pressurized flight. The British Civil Aircraft Requirements (BCARs) and International Civil Aviation Organization (ICAO) regulations for pressurized and unpressurized aircraft fatigue were the same. By 1953, new regulations demanded additional fatigue testing for pressurized fuselages; the Comet was already servicing commercial passenger flights. De Havilland conducted pressurization tests on a Comet prototype fuselage where the fuselage lasted 16,000 pressurization cycles before succumbing to fatigue cracks at the corner of a square cabin window, making it obvious that stress concentrated at the corners of the square windows. The Federal Aviation Administration (FAA) describes the difference between modern rounded windows and the Comet's square windows, "With modern windows, the stress flows freely around the curved edges with minimal build up. But with the Comets' square windows, stress cannot smoothly flow around the abrupt corners. This creates stress concentrations." When the pressure load increased in combination with the high stress concentration, the material properties of the aircraft would gradually alter. This is called cold-working. The Comet prototype fuselage was able to tolerate 16,000 cycles before fatigue failure because the material changed due to cold-working near the corner windows. The testing was biased since the prototype fuselage fatigue areas were strengthened.There was a false notion of fatigue vulnerability in the production Comets. None of the production Comets involved in Calcutta, Elba, Naples, or the G-ALYU (used in the water tank) were ever exposed to the stringent pressurization testing. Thus, the airframes never improved from cold-working. These Comets reached their fatigue lives sooner than expected. Ultimately, these Comets exhausted their airframe, forcefully fractured the fuselage from explosive decompression caused by window design, and a fatal inflight structural failure crashed the jet.

WHAT HAPPENED TO DE HAVILLAND?

It took de Havilland four years to run another Comet commercial airline flight. By the time the Comet 4 was produced, the United States aerospace company Boeing had surpassed de Havilland. The Boeing 707 commenced service for Pan American World Airways on October 26, 1958. It ascended to the position of the first truly successful commercial jet airliner and dominated the industry until the late 1970s.

CONTEMPORARY

The de Havilland Comet accidents serve as an example of the long history of aviation safety. Accidents lead to increased flight safety and improved flight technologies. Today in aviation, human error presents a greater threat than mechanical failure to the safety of passengers. Mechanical failures have effectively been eliminated through technological advancement. The progress of technology and safety in aviation allows innovative private jet aircraft companies to experiment with window design. The Brazilian aerospace conglomerate, Embraer, created an interior concept design for the Lineage 1000E, Kyoto Airship. This business jet contains expansive door-sized windows offering a sweeping view of the landscape below. What would Sir Geoffrey de Havilland think if he could see the windows of the Kyoto Airship? This would be the first time a business jet, with a pressurized cabin, would have door-sized windows. The cautionary tale of the de Havilland Comet must be remembered; the progress of science always comes with risk.