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INTRODUCTION

The de Havilland D.H.106 Comet was the first production commercial airliner. Developed and manufactured by de Havilland Company at Hatfield, Hertfordshire, in the United Kingdom, the Comet Mark 1 prototype first flew on 27 July 1949. It featured a very aerodynamically clean design with four de Havilland Ghost jet engines buried in the wings, a pressurized fuselage and large square windows. In comparison to noisy propeller-driven airliners of the same era, this new design offered a quiet and comfortable passenger cabin and consequently showed signs of already being a commercial success at its 1952 debut. But not only were commercial airlines interested, various militaries around the world also took notice. The Royal Canadian Air Force (RCAF) had formulated a requirement for two aircraft for high-speed transport and VIP use. An inspection of the Comet by the RCAF in 1952 culminated in an order for two aircraft. When the de Havilland Comet was introduced into RCAF service in early 1953, it gave the RCAF the distinction of being the first air force in the world to operate jet transports.

However, just a year after entering commercial service, the Comet began suffering mysterious catastrophic and fatal accidents, with three of the aircraft breaking apart in mid-flight. Consequently, the Comet was withdrawn from service and further extensively tested to discover the true cause of the accidents; the first incident being incorrectly blamed on adverse weather. The real culprit turned out to be metal fatigue. Design flaws including the fuselage window shape and their installation methodology were ultimately identified. Consequently the Comet had to be extensively redesigned with oval windows, structural reinforcement and many other changes.

The RCAF’s Comets fortunately never suffered any serious in-flight problems prior the grounding of the design. In August 1956, the two aircraft were flown to Britain for modifications to resolve the metal fatigue problems and, the following month, they returned to Canada and resumed operational service.

Although commercial sales for the design never fully recovered, the redesigned Comet Mark 2, Mark 3 and Mark 4 series designs enjoyed a productive career of over the next 30 years. The Comet was also
adapted for a variety of military roles such as VIP, medical and passenger transport, as well as surveillance; the most extensive modification resulted in a specialized maritime patrol variant for the Royal Air Force (RAF) known as the Nimrod. Outlasting the Comet series, the Nimrods remained in service with the RAF until they were retired in June 2011, over 60 years after the Comet's first flight.

AIRCRAFT DESIGN EVOLUTION

Design Origins

With a great degree of foresight, in 11 March 1943, the British Government formed the Brabazon Committee to determine Britain’s airliner needs after the Second World War. In this same year, de Havilland had flown their first jet aircraft, the Vampire. This twin-boom fighter was powered by a de Havilland Goblin turbojet. One of the Brabazon Committee’s recommendations was for a high-speed, pressurized, transatlantic mail-plane that could carry six passengers and a half-ton of mail at a cruising speed of 640 km/h (400 mph). Challenging the widely held skepticism of the early jet engines were too fuel-hungry and unreliable, committee member Sir Geoffrey de Havilland, the head of the de Havilland company, used his personal influence to have the committee further specify a turbojet-powered design. The committee accepted the proposal, calling it the “Type IV” (of five designs) with the other designs being turbo-prop or piston-powered aircraft. In February 1945, de Havilland was awarded a production contract to bring a Type IV specification aircraft into service under the designation “Type 106”. The development of the DH.106 consequently focused on short / intermediate range mail-plane designs with a small passenger compartment and as few as six seats, before evolving into a longer range airliner with a capacity of 24 seats. Out of all the Brabazon designs, the DH.106 was seen as the riskiest both in terms of introducing untried design elements and for the financial commitment involved. Nevertheless, the British Overseas Airways Corporation (BOAC) found the Type IV’s specifications attractive, and initially proposed a purchase of 25 aircraft but, in December 1945, when a firm contract was laid out, the order total was reduced to just 10 aircraft.

The de Havilland design team was assembled in 1946 under the leadership of chief designer Ronald Bishop, who had been responsible for the Mosquito fighter-bomber. As the Type IV was intended as the premiere project for the United Kingdom, the Ministry of Supply decided that further research was required to better evaluate some the design ideas being put forward. A number of unorthodox configurations were considered, ranging from canard to tailless designs. The Ministry of Supply was,
however, interested in the most radical of the proposed designs and ordered two (later three) experimental tailless DH.108 Swallows to serve as proof of concept aircraft for testing swept-wing configurations in both low-speed and high-speed flight. The DH.108 Swallow was based on the Vampire jet fighter, using that aircraft’s fuselage design. During subsequent flight tests, the DH.108 gained a reputation for being both accident-prone and unstable, leading de Havilland and BOAC reconsider more conventional configurations for the DH.106 with less technical risk. The DH.108s were later modified to test the DH.106's power controls.

In September 1946, prior to the completion of the DH.108s, BOAC had also requested a redesign of the DH.106 from its previous 24-seat configuration to a larger 36-seat version. With no time to develop the technology necessary for a proposed tailless configuration, Bishop’s team opted for a conventional 20-degree swept-wing design with unswept tail surfaces, married to an enlarged fuselage accommodating 36 passengers in a four-abreast arrangement with a central aisle. Replacing the previously specified Goblin turbo-jet engines, four new, more powerful, Rolls-Royce Avons were to be incorporated in pairs buried in the wing roots. De Havilland Ghost engines were eventually installed in the first Comets as an interim solution while the Avon engines completed certification trials. The redesigned aircraft was named the DH.106 Comet in December 1947. Revised first orders for the type from BOAC and British South American Airways totaled 14 aircraft with deliveries projected for 1952.

Testing and prototypes
Because the Comet represented a new category of passenger aircraft, extensive testing was deemed a development priority. From 1947 to 1948, de Havilland conducted a comprehensive research and development phase, including the use of several test rigs at Hatfield for the stress testing of both small components and large assemblies alike. Sections of pressurized fuselage were tested to failure in a large decompression chamber simulating high-altitude flight conditions. However, finding the precise fuselage failure points proved difficult with this method, and de Havilland ultimately switched to conducting structural tests with a water tank that could be used to increase pressures more gradually.

The entire forward fuselage section was tested for metal fatigue by repeatedly pressurizing to 19.0 kPa (2.75 pounds per square inch (psi)) overpressure and then depressurizing through more than 16,000
cycles, equivalent to about 40,000 hours of airline service. The windows were also tested under a pressure of 83 kPa (12 psi), which was 32.8 kPa (4.75 psi) above expected pressures at the normal service ceiling of 11,000 m (36,000 ft).

In light of subsequent events, it is therefore perhaps surprising that these tests did not reveal any trace of the impending disasters that would overtake the Comet design.

The first prototype DH.106 Comet was completed in mid-1949, and was initially used to conduct ground tests including some tentative "hops" down the runway. By 25 July, the ground tests had been completed and the prototype's first true maiden flight took place on 27 July 1949 from the Hatfield airfield lasting just 31 minutes. The ensuing flight tests proceeded smoothly with over 200 hours being flown in the first five months.

The prototype was registered "G-ALVG" just before it was publicly displayed at the 1949 Farnborough Airshow in September 1949. A year later, the second prototype made its maiden flight. The second prototype was registered "G-ALZK" in July 1950 and it was used by the BOAC from April 1951 to carry out 500 flying hours of crew training and route proving. Qantas, the Australian airline, also sent its own technical experts to observe the performance of the prototypes, seeking information for its prospective Comet purchase. Both prototypes could be externally distinguished from later Comets by the large single-wheel main landing-gear units which were replaced on production models by sets of four-wheeled bogies.

DESIGN OVERVIEW

The Comet was an all-metal, low-wing, cantilever monoplane powered by four jet engines. The design featured a four-place cockpit occupied by two pilots, a flight engineer, and a navigator. For ease of training and fleet conversion, de Havilland designed the Comet's flight deck layout with a degree of similarity to the Lockheed Constellation, an aircraft that was in service at the time with key potential customers such as BOAC. The cockpit included full dual-controls for the captain and first officer, while a
flight engineer controlled various key systems, including the fuel, air conditioning, and electrical systems. The navigator occupied a dedicated station with a table across from the flight engineer.

The clean, low-drag design of the aircraft featured many new design elements including a swept-wing leading edge, integral wing fuel tanks, and four-wheel bogie main undercarriage units. The two pairs of de Havilland Ghost 50 Mark 1 turbojet engines were completely buried into the wings.

Large picture windows and table seating accommodations for a row of passengers afforded a higher degree of comfort and luxury as compared to other airliners of the period. Amenities included a galley that could serve hot or cold food and drinks plus a bar along with separate men's and women's toilets. Emergency provisions included several life rafts stored in the wing roots near the engines along with individual life vests stowed under each seat.

One of the most striking aspects of Comet travel was the quiet, "vibration-free flying" as later touted by BOAC. For passengers previous used to propeller-driven airliners, the combined smoothness and quietness of "jet flight" was a novel experience.

Onboard systems

Several of the Comet’s onboard systems were also new to civil aviation. One such feature was irreversible, powered flight controls, which increased the pilot's ease of control and the safety of the aircraft by preventing aerodynamic forces from changing the directed positions and placement of the aircraft's control surfaces. Additionally, the primary control surfaces, such as the elevators, were equipped with a complex gearing system as an extra safeguard against accidentally over-stressing the surfaces or airframe at higher speed ranges.

The Comet had a total of four hydraulic systems: two primary systems, one secondary system, and a final emergency system for basic functions such as lowering the undercarriage. The undercarriage could also be lowered in the event of an emergency by a combination of gravity and hydraulic hand-pump actions. Power was syphoned from all four engines for the hydraulics, cabin air-conditioning, and the deicing system; these systems had operational redundancy in that they would keep working even if only a single
engine was active. The majority of hydraulic components were centered in a single avionics bay. A pressurized refueling system also allowed the Comet's fuel tanks to be refueled at a far greater rate than previous methods.

**Fuselage**

The design requirements for the Comet demanded the use of a high proportion of alloys, plastics, and other materials new to civil aviation across the aircraft in order to meet certification requirements. The Comet's high cabin pressure and fast operating speeds were unprecedented in commercial aviation, making its fuselage design an experimental process. At its introduction, Comet airframes would be subjected to an intense, high-speed operating schedule which included simultaneous extreme heat from desert airfields and frosty cold from the kerosene-filled fuel tanks.

The Comet's thin metal skin was consequently composed of advanced new alloys and was both riveted and chemically bonded, which saved weight and reduced the risk of fatigue cracks spreading from the rivets. The chemical bonding process was accomplished using a new adhesive known as Redux which was liberally used in the construction of the wings and the fuselage of the Comet; it also had the advantage of simplifying the manufacturing process.

When several of the fuselage alloys were discovered to be vulnerable to weakening via metal fatigue, a detailed routine inspection process was introduced. As well as thorough visual inspections of the outer skin, mandatory structural sampling was routinely conducted by both civil and military Comet operators. The need to inspect areas not easily viewable by the naked eye led to the introduction of widespread radiography examinations; this also had the advantage of detecting cracks and flaws too small to be seen otherwise.

Operationally, the design of the cargo holds led to considerable difficulty for the ground crew, especially baggage handlers at the airports. The cargo hold had its doors located directly underneath the aircraft, so each item of baggage or cargo had to be loaded vertically upwards from the top of the baggage truck, then slid along the hold floor in order to be stacked inside. The individual pieces of luggage and cargo also had to be retrieved in a similar, slow manner at the arriving airport.

**Propulsion**

The Comet was powered by two pairs of turbojet engines buried in the wings close to the fuselage. Chief designer Bishop had chosen this embedded-engine configuration because it avoided the drag of podded engines and allowed for a smaller fin and rudder since the hazards of asymmetric thrust were reduced. The engines were outfitted with baffles to reduce noise emissions, and extensive soundproofing was also implemented to improve passenger conditions.

Placing the engines within the wings had the further advantage of a reduction in the risk of foreign object damage which could seriously damage jet engines. The low-mounted engines and good placement of service panels also made aircraft maintenance easier to perform. However, the Comet's buried engine configuration also increased its structural weight and complexity. Armour plate had to be placed around the engine cells to contain debris from any serious engine failures. Placing the engines inside the wing also required a more complicated internal wing structure.

The Comet 1 featured 22.5 kN (5,050 lbs) de Havilland Ghost 50 Mk1 turbojet engines. Two hydrogen-peroxide powered de Havilland Sprite booster rockets were originally intended to be installed to help boost the take-off under “hot and high” altitude conditions from airports such as Khartoum and Nairobi. These booster rockets were tested on at least 30 flights, but the Ghost engines proved to be powerful enough by themselves and the use of these booster rocket motors was discontinued although the Sprite
fittings were retained on production aircraft. *Comet* 1s subsequently received more powerful 25 kN (5,700 lbs) *Ghost* DGT3 series engines.

From the *Comet* 2 onwards, the *Ghost* engines were replaced by more powerful 31 kN (7,000 lbs) Rolls-Royce *Avon* AJ.65 engines. To achieve optimum efficiency with these new powerplants, the air intakes had to be enlarged to increase the mass air flow. Further upgraded *Avon* engines were introduced on the *Comet* 3 and *Comet* 4 series, and the aircraft type was subsequently highly praised for its take-off performance from high altitude locations such as Mexico City's airport.

**OPERATIONAL HISTORY**

**Introduction**

The earliest production aircraft, registered G-ALYP (and commonly “phonetically” referred to by its last two registration letters as “Yoke Peter”), first flew on 9 January 1951. It was then loaned to BOAC for development flying. On 22 January 1952, the fifth production aircraft, registered G-ALYS, received the first Certificate of Airworthiness awarded to a *Comet*, six months ahead of schedule.

At this time, the *Comet* was already a clear commercial success for de Havilland. Orders began pouring in from airlines including from Canadian Pacific Airlines (2 aircraft), Air France (3 aircraft), and Union Aéromaritime de Transport (UAT) (3 aircraft). And not only did the aircraft attract just commercial operators; the Royal Canadian Air Force (RCAF) became the first military in the world to introduce jet transports when it placed an order for two *Comet* 1s.

On 2 May 1952, as part of BOAC’s route-proving trials, G-ALYP took off on the world’s first jetliner flight with fare-paying passengers and inaugurated scheduled service from London to Johannesburg. The first flight of a Canadian Pacific Airlines *Comet* occurred later that same year on 11 August 1952.

The *Comet* was an immediate hit with passengers including Queen Elizabeth, the Queen Mother and Princess Margaret, who were guests on a special flight on 30 June 1953 hosted by Sir Geoffrey and Lady de Havilland, and becoming the first members of the British Royal Family to fly by jet. Flights on the *Comet* were at least 50 percent faster than advanced piston-engined aircraft such as the Douglas DC-6 (789 kph (490 mph) for the *Comet* as compared to the DC-6’s 507 kph (315 mph)) and they had a faster rate of climb which further cut flight times. For example, in August 1953, BOAC scheduled an eight-stop
London to Tokyo flight by Comets for just 35 hours, as compared to 85 hours and 35 minutes on their Argonaut piston-engined airliner.

In their first year of service Comets carried 30,000 passengers. As the aircraft type could be profitable with a passenger load factor as low as 43 percent, commercial success was expected from the airline's perspective. The Ghost engines enabled the Comet to operate above weather competitors had to fly through. In addition, they ran smoothly and were less noisy than piston engines, had low maintenance costs, and were fuel-efficient above 9,000 m (30,000 ft).

But, the projected bright future for the Comet design quickly ran into trouble.

Early Accidents

On 26 October 1952, the Comet suffered its first accident when a BOAC Comet 1A, registered “G-ALYZ”, departing Rome's Ciampino airport failed to become airborne and ran onto rough ground at the end of the runway. The captain had experienced a control shudder upon rotation and elected to abandon the takeoff. Only two passengers sustained minor injuries, but the aircraft was damaged beyond repair.

Then, on 3 March 1953, a brand new Canadian Pacific Airlines Comet 1, registered “CF-CUN” and named Empress of Hawaii, also failed to become airborne while attempting takeoff from Karachi, Pakistan, on a delivery flight to Sydney, Australia via Honolulu. Unfortunately, the aircraft plunged into a dry drainage canal and then collided with the embankment, fatally injuring all five crew and the six passengers on board. The accident was the first fatal jetliner crash, as well as the Comet's first major accident. In response, Canadian Pacific Airlines cancelled the remaining order for its second Comet 1A and never again operated the type in commercial service. Their second aircraft, “CF-CUM”, was instead converted to Comet 1A standard and was re-registered as “G-ANAV” for BOAC service.

The ill-fated Canadian Pacific Comet “CF-CUN”, see here at the de Havilland Hatfield plant, became the first fatal jet airliner crash - (de Havilland Photo)
Then, the fleet suffered yet another fatal accident on 2 May 1953, when a BOAC Comet 1, registered “G-ALYV” (“Yoke-Victor’), crashed in a severe thunder storm just six minutes after taking off from Calcutta’s Dum Dum Airport, in India, killing all 43 persons on board. Witnesses had observed the wingless Comet on fire plunging to the ground and the ensuing wreckage covered an area of 21 square kilometers (8 square miles).

Finally a fourth non-fatal accident occurred with a UAT Airlines Comet, registered “F-BGSC”, when it crashed on landing at Dakar Airport in Senegal on 25 June 1953. Although the aircraft was not totally destroyed, it was deemed beyond economical repair and was subsequently scrapped.

Except for “G-ALYV”, these early accidents were all originally attributed to pilot error. But subsequent reviews also suggested that further modifications were needed to the design in order to improve on the tight handling margins that pilots were experiencing during take-off and landing. On take-off, it appeared that over-rotation by the pilots had led to a loss of lift from the leading edge of the aircraft's wings. It was later determined that the Comet's wing profile experienced a loss of lift at high angles of attack and its engine inlets also suffered a lack of pressure recovery in these same conditions. As a result, de Havilland re-profiled the wings' leading edge with a pronounced "droop", and wing fences were added to control span-wise flow.

India Court of Inquiry

After the loss of “G-ALYV”, the government of India convened a court of inquiry to examine the specific cause of the accident. A large portion of the aircraft was recovered and reassembled at Farnborough in the UK. The break-up of the aircraft was found to have been caused by the failure of the spar in the left-hand elevator followed by structural failure of the wings due to an over-stress condition.

The inquiry further concluded that the aircraft had encountered an extreme wind gust during takeoff causing the elevator spar to fail; this severe turbulence was then determined to have induced excessive loads leading to the loss of the wings. Examination of the cockpit controls also suggested that the pilot may have inadvertently over-stressed the aircraft when pulling out of a steep dive through over-manipulation of the fully powered flight controls. The Investigators never considered metal fatigue as a contributory cause for the accident.

The inquiry's recommendations revolved around the enforcement of stricter speed limits during turbulence, and two significant design changes also resulted: all Comets were equipped with weather radar and a "Q feel" system was introduced, which ensured that control column forces (invariably called stick forces) would be proportional to control loads. This artificial feel was the first of its kind to be introduced in any aircraft.

De Havilland and BOAC both ultimately concluded that the circumstances surrounding the loss of “G-ALYV” were unusual and that the basic design was sound. The Comets already in service then resumed normal flying.

Comet disasters of 1954

Two further accidents were to befall the Comet 1 fleet before the type was finally permanently withdrawn from service.

The first occurred on Sunday, 10 January 1954. BOAC aircraft, “G-ALYP” (“Yoke-Peter”), which was the first production aircraft, was enroute from Singapore to London. The aircraft, operating as BOAC Flight #781, took off from Rome's Ciampino airport, the site of the first Comet accident. Twenty minutes after taking off from Ciampino, while flying at approximately 8,230 meters (27,000 feet), the aircraft broke up in mid-air and plunged into the Mediterranean Sea off the Italian island of Elba with the loss of all 35 souls (29 passengers and 6 crew) on board. With only partial radio transmissions, there appeared to be no
immediate obvious reason for the crash. Two local fisherman had heard the whine of jet engines in the cloud over their heads and heard what sounded like three explosions in quick succession then silence. They then described seeing a flaming mass plunge into the sea several kilometers away. By nightfall, salvage operations had recovered fifteen bodies, a few seat cushions, some mailbags, a scattering of personal effects and just a few fragments of wreckage. Engineers at de Havilland immediately recommended 60 further modifications aimed at any possible design flaws while the British government commissioned the Abell Committee as a formal Court of Inquiry to determine the likely causes of the crash. BOAC also voluntarily grounded its Comet fleet pending investigation into the causes of the accident.

**Abell Committee Court of Inquiry**

Media attention centered on sabotage, while other speculation ranged from clear-air turbulence to an explosion of vapour in an empty fuel tank. The Abell Committee focused on six potential aerodynamic and mechanical causes: control flutter (which had led to the loss of DH 108 prototypes), structural failure due to high loads or metal fatigue of the wing structure, failure of the powered flight controls, failure of the window panels leading to explosive decompression, or fire and other engine problems.

There was some preliminary evidence from the Italian pathologist team that the passengers had experienced an explosive decompression and collision with structure. But this was deemed surprising and was dismissed since the airframe had only flown 3,681 hours since entering service and de Havilland had previously conducted rigorous fatigue tests.

The committee concluded that fire was the most likely cause of the problem, and a number of changes were recommended to the design in order to protect the engines and wings from any damage that might lead to another fire.

During the investigation, the Royal Navy was continuously conducting recovery operations. The first pieces of wreckage were discovered on 12 February 1954 and the search continued until September 1954, by which time approximately 70 percent by weight of the main structure, 80 percent of the power section, and 50 percent of the aircraft's systems and equipment had been recovered. The overall forensic reconstruction effort had only just begun when the Abell Committee delivered its findings.
No apparent obvious fault in the aircraft was found, and the British government decided against opening a further public inquiry into the accident. The prestigious nature of the Comet project, particularly for the British aerospace industry, and the financial impact of the aircraft's grounding on BOAC's operations, both served to pressure the inquiry to end without further investigation. Comet flights consequently resumed on 23 March 1954.

Another Fatal Accident

Almost immediately after the resumption of flying, on 8 April 1954, BOAC Comet “G-ALYY” (“Yoke Yoke”), on charter to South African Airways, departed London for Rome en route to Johannesburg, South Africa. The aircraft was near Naples, at an altitude of approximately 9,144 meters (30,000 feet), when it suddenly disappeared with the loss of all 14 passengers and 7 crew on board. This aircraft had flown only 2,704 hours since delivery. Salvage operations recovered only five bodies and some flotsam. A sixth body later washed up on shore. Unfortunately, the wreckage had plunged into the sea to a depth of 1,067 meters (3,500 feet) beyond the reach of all available diving equipment. The Comet fleet was immediately grounded once again and a large investigation board was formed under the direction of the Royal Aircraft Establishment (RAE). British Prime Minister Winston Churchill tasked the Royal Navy with helping to locate and retrieve the wreckage so that the cause of the accident could be determined. The Comet's Certificate of Airworthiness was revoked and the Comet 1 line production was suspended at the de Havilland Hatfield factory.

Cohen Committee Court of Inquiry

On 19 October 1954, the Cohen Committee was established to examine the causes of both previous Comet crashes. Chaired by Lord Cohen, the committee tasked an investigation team led by Sir Arnold Hall, the Director of the RAE at Farnborough, to perform a more detailed investigation. Recovery of the wreckage from “G-ALYY” would ultimately prove almost impossible due to the depth of the sea at the crash site. Any hope for solving the cause therefore lay with re-examination of the “G-ALYP” wreckage and through further destructive testing. Hall's team began considering fatigue as the most likely cause of both accidents, and initiated more research into the measurable strain on the aircraft's skin. This had been prompted by the on-going recovery of large sections of the “G-ALYP” airframe from the Elba crash.

The entire BOAC Comet fleet including “G-ALZK” shown here was grounded following the loss of its sisters-ship “G-ALYY” near Naples - (Canadian Forces Photo PL-52891)
In-depth inspections by the RAE team eventually detected paint fleck traces on the port tailplane which were consistent with the skin on the forward fuselage being thrown backward by some catastrophic force.

BOAC donated one of its Comet 1 airframes, “G-ALYU” (“Yoke Uniform”), for a comprehensive fatigue test. This time, the entire fuselage was tested in a dedicated water tank that was built specifically at RAE Farnborough to accommodate its full length. In water tank testing, engineers subjected “G-ALYU” to repeated re-pressurization and over-pressurization. In early June, the internal pressure of the fuselage dropped to zero and an inspection of the fuselage revealed a crack in the skin emanating from a passenger window. The crack was then repaired and the testing resumed. Then on 24 June 1954, after 3,057 flight cycles (1,221 actual and 1,836 simulated), “G-ALYU” literally burst open. When the water tank was drained, the fuselage was found to have ripped open at a corner of the forward, port-side escape hatch cutout. The damage measured more than 2.45 meters (8 feet) in length and 0.91 meters (3 feet) in width. Signs of fatigue failure were again found in the corners of the passenger windows. A further subsequent test reproduced the same results.

Stress around the hatch and window corners was found to be much higher than expected, while stresses on the skin were also higher than previously expected or tested. These higher values were due to “stress concentration”, a consequence of the windows' square shape, which generated levels of stress two or three times greater than across the rest of the fuselage.
Based on these findings, Comet 1 structural failures could be expected at anywhere in a range from 1,000 to 9,000 cycles. Before the Elba accident, “G-ALYP” had made 1,290 pressurized flights, while “G-ALYY” had made only 900 pressurized flights before crashing.

The RAE also finally reconstructed about two-thirds of “G-ALYP” at Farnborough and eventually found fatigue crack growth from a rivet hole around the Automatic Direction Finder (ADF) antenna, which ultimately had caused a catastrophic explosive decompression and breakup of the aircraft at high altitude flight. The punch rivet construction technique employed in the Comet's design had also exacerbated its structural fatigue problems; the aircraft's windows had been engineered to be glued and riveted, but had been “punch” riveted only. Unlike drill riveting, the imperfect nature of the hole created by “punch” riveting could cause the start of early fatigue cracks around the rivet.

The investigation team ultimately concluded that these design and construction flaws in the Comet 1 were the most likely explanation for “G-ALYU’s” structural failure after just 3,060 pressurization cycles. The Cohen inquiry closed on 24 November 1954, and although the inquiry had again “found that the basic design of the Comet was sound”, de Havilland nonetheless began a refit program to strengthen the fuselage and wing structure, employing thicker gauge skin and replacing all square windows and panels with rounded oval versions.
Resumption of service

With the discovery of the structural problems of the early series, all remaining Comets were withdrawn from service, while de Havilland launched a major effort to build a new version that would be both larger and stronger. All outstanding orders for the Comet 2 were cancelled by airline customers. The square windows of the Comet 1 were replaced by the oval versions used on the Comet 2, which first flew in 1953, and the skin sheeting was thickened slightly. The remaining Comet 1s and 1As were either scrapped or modified with oval window rip-stop doublers (a thick, structurally strong ring of material that prevented a crack from spreading further). All production Comet 2s were also modified to alleviate the fatigue problems (most of these served with the RAF as the Comet C2), while a program to produce a Comet 2 with more powerful Avon jet engines was delayed. The prototype Comet 3 first flew in July 1954, and was tested in a non-pressurized state pending completion of the Cohen inquiry. Commercial Comet flights would not resume until 1958.
Development flying and route proving with the Comet 3 allowed accelerated certification of what was destined to be the most successful variant of the type, the Comet 4. All airline customers for the Comet 3 subsequently cancelled their orders and switched to the Comet 4, which was based on the Comet 3 but with improved fuel capacity. BOAC ordered 19 Comet 4s in March 1955, while American operator Capital Airlines ordered 14 Comets in July 1956. Capital's order included 10 Comet 4As, a variant modified for short-range operations with a stretched fuselage and short wings, lacking the pinion (outboard wing) fuel tanks of the Comet 4. However, due to financial problems and a subsequent takeover by United Airlines, Capital would never actually operate the Comet.

The prototype Comet 4 completed its first flight on 27 April 1958, received its Certificate of Airworthiness on 24 September 1958, and was then delivered to BOAC the following day. The Comet 4 enabled BOAC to inaugurate the first regular jet-powered trans-Atlantic services on 4 October 1958 between London and New York (although it still required a fuel stop at Gander International Airport, Newfoundland, on west-bound North Atlantic crossings). While BOAC gained publicity by being the first to provide trans-Atlantic jet service, by the end of the month, rival Pan American World Airways was flying the Boeing 707 along the same route, and, by 1960, the Douglas DC-8 as well. The American jets proved to be larger, faster, longer-ranged, and significantly more cost-effective to operate than the Comet. After analyzing effective route structures for the Comet, BOAC reluctantly began looking for a successor to the Comet and, by 1958, had already entered into an agreement with Boeing to purchase the 707.
The Comet 4 was however ordered by two additional customers: Aerolineas Argentianas took delivery of six Comet 4s from 1959 to 1960, using them between Buenos Aires and Santiago, while East African Airways received three new Comet 4s from 1960 to 1962 and operated them to Kenya, Tanzania, and Uganda destinations. The Comet 4A model initially ordered by Capital Airlines were instead delivered to British European Airways (BEA) as the Comet 4B, after being modified with a further fuselage stretch of 97 cm (38 in) to accommodate seating for 99 passengers. The Comet 4B first flew on 27 June 1959 and BEA began Tel Aviv to London-Heathrow services on 1 April 1960. Olympic Airways was the only other customer to order the type.

The last Comet 4 variant, the Comet 4C, first flew on 31 October 1959 and entered service with Mexicana Airlines in 1960. The Comet 4C featured the Comet 4B’s longer fuselage combined with the longer wings and extra fuel tanks of the original Comet 4, which gave it a longer range than the 4B. Ordered by East African Airways, Kuwait Airways, Middle East Airlines, Misair (later United Arab Airlines), and Sudan Airways, this variant was the most widely used of all the Comet types.
Later service

Besides the Boeing 707 and Douglas DC-8, the introduction of other jet-powered airliners, such as the Vickers VC-10, allowed various airlines to assume the high-speed, long-range passenger service role pioneered by the Comet.

Consequently, in the 1960s orders for the Comet declined, with a total of only 76 Comet 4s being delivered between 1958 to 1964. BOAC retired its Comet 4s from revenue service by the end of 1965 but other operators continued commercial passenger flights with the Comet until 1981. In particular, the Danish airline, Dan-Air played a significant role in the type's later history and, at one time, owned all 49 of the remaining airworthy civilian-registered Comets.

On 14 March 1997 a Comet 4C, registered XS235 and named Canopus, which had been acquired by the British Ministry of Technology and used for radio, radar and avionics trials, made the last documented flight of a production Comet.

Legacy

The Comet was widely regarded as both a bold step forward and a supreme tragedy. The aircraft's design and experiences drove numerous advances not only in aircraft construction but also in accident investigations. The inquiries into the accidents that plagued the Comet 1s established many important precedents in accident investigation; many of the salvage and meticulous accident reconstruction techniques developed at the time remain in use within the aviation industry.

In spite of the Comet design having been subjected to more rigorous testing than any other contemporary airliner, it was clear that the both pressurization and dynamic stresses involved were not thoroughly
understood at the time of the aircraft's development, nor was the concept of metal fatigue. While these lessons could be implemented on the drawing board for future aircraft, the corrections could be only retroactively applied to the Comet design. The fuselage skins on all subsequent airliners were of a greater thickness than the skin of the Comet.

Aeronautical engineering firms were quick to respond to the Comet's commercial advantages, design innovations and technical flaws alike; other aircraft manufacturers learned from, and profited by, the hard-earned lessons made by de Havilland.

The de Havilland Company eventually faded from existence, having been acquired and subsumed by the Hawker Siddeley Aviation in 1960. Hawker Siddeley, in turn, became part of the British Aerospace Corporation (BAe) in 1977.

VARIANTS

Comet 1

The square-windowed Comet 1 was the first model produced and a total of 12 aircraft entered service. The only noticeable change from the first two prototype aircraft was the adoption of four-wheel bogie main undercarriage units, replacing the original single main wheels. Four Ghost 50 Mk 1 engines were fitted (later replaced by the more powerful Ghost DGT3 series engine). The wingspan was 35.05 meters (115 ft), and the overall length 28.35 meters (93 ft). The maximum take-off weight was over 47,628 kg (105,000 lbs) and up to 44 passengers could be carried.

Sub-variants

- An updated Comet 1A was offered with higher-allowed weight, greater fuel capacity and water-methanol injection for the engines and ten Comet 1As were produced. In the wake of the 1954 disasters, with the exception of the RCAF aircraft, all Comet 1s and 1As were brought back to Hatfield. They were first placed in a protective cocoon and then retained for further testing / disposition. Most of these remaining aircraft either damaged beyond repair in further testing or were ultimately scrapped; and
- Comet 1XB: The two RCAF Comet 1As were rebuilt with heavier-gauge skins to a Comet 2 standard for the fuselage only, and were re-designated as Comet 1XBs; and four other Comet 1As were upgraded to a 1XB standard with a reinforced fuselage structure and oval windows. The 1XB series were also further limited in the number of allowable pressurization cycles.

Comet 2

The Comet 2 had a slightly larger wing, higher fuel capacity and more powerful Rolls-Royce Avon engines, all of which improved the aircraft's range and performance; its fuselage was also 0.94 meters (3 ft 1 in) longer than that of the Comet 1. Further design changes were made to make the aircraft more suitable for trans-Atlantic operations. Following the Comet 1 disasters, these models were rebuilt with heavier gauge skin and rounded windows, and the Avon engines featuring larger air intakes and outward-curving jet tailpipes. A total of 12 of the 44-seat Comet 2s were ordered by BOAC for the South Atlantic route. The first production aircraft (G-AMXA) flew on 27 August 1953. Although these aircraft performed well on test flights on the South Atlantic, their range was still not suitable for the North Atlantic. All but four Comet 2s were consequently allocated to the RAF with deliveries beginning in 1955. Modifications to the interiors allowed the Comet 2s to be used in a number of different roles. For VIP transport, the seating and accommodations were altered while provisions for medical equipment were also incorporated. Some
airframes later had specialized ELINT and electronic surveillance capabilities incorporated in the fuselage.

Sub-variants

- **Comet 2X**: Limited to a single modified Comet Mk 1 powered by four Rolls-Royce Avon 502 turbojet engines and used as a development aircraft for the Comet 2 series;
- **Comet 2E**: Two Comet 2 airliners were fitted with Avon 504s in the inner nacelles and Avon 524s in the outer ones. These aircraft were used by BOAC for proving flights during 1957–1958;
- **Comet T2**: The first two of 10 Comet 2s for the RAF were fitted out as crew trainers, with the first aircraft (XK669) flying for the first time on 9 December 1955;
- **Comet C2**: Eight Comet 2s originally destined for the civil market were completed for the RAF as transports and assigned to No. 216 Squadron; and
- **Comet 2R**: Three Comet 2s were modified for use in radar and electronic systems developments, and were assigned to No. 192 and No. 51 Squadrons. The 2R series was also equipped to monitor Warsaw Pact signals traffic and operated in this SIGINT role from 1958.

**Comet 3**

The Comet 3, which flew for the first time on 19 July 1954, was effectively a Comet 2 lengthened by 4.70 m (15 ft 5 in) and powered by Avon M502 engines which developed 44 kN (10,000 lbf). This variant also added wing pinion tanks which offered greater capacity and range. The Comet 3 variant was to remain a development only series since it did not incorporate the fuselage-strengthening modifications of the later series aircraft, and was not capable of being fully pressurized. Only two Comet 3s were ultimately built, with “G-ANLO”, the only airworthy Comet 3, being demonstrated at the Farnborough Airshow in September 1954. The other Comet 3 airframe was not completed to production standard and it was instead used primarily for ground-based structural and technology testing for the development of the Comet 4 series. “G-ANLO” became a flying testbed and it was later modified with Avon RA29 engines. In 1961, it was assigned to the Blind Landing Experimental Unit (BLEU) at RAE Bedford for use in automatic landing system experiments. When finally retired in 1973, the airframe was then used for foam arrester trials before the fuselage was salvaged at BAE Woodford to serve as the mock-up for the Nimrod variant.

**Comet 4**

The Comet 4 was a further improvement on the stretched Comet 3 with even greater fuel capacity. The design had progressed significantly from the original Comet 1, growing by 5.64 m (18 ft 6 in) and typically seating 74 to 81 passengers as compared to the Comet 1’s maximum of 44. Eventually up to 119 passengers could be accommodated in a special charter seating package developed for the the later 4C series. The Comet 4 was considered the definitive series, having a longer range, higher cruising speed and higher maximum takeoff weight. These improvements were possible largely because of Avon engines possessed twice the thrust of the Comet 1’s Ghosts.

Sub-variants

- **Comet 4B**: A short-haul variant originally developed for Capital Airlines as the 4A, the 4B featured greater passenger capacity (up to 101 seats) and a shorter wingspan with no wing mounted “slipper tanks”. A total of 18 aircraft were produced;
- **Comet 4C**: This variant featured larger wings (with wing mounted “slipper tanks” for additional fuel) plus the 4B’s added capacity. 23 of this variant were produced; and
- A single VIP Comet 4C (SA-R-7) was ordered by Saudi Arabian Airlines with eventual disposition to the Saudi Royal Flight for the exclusive use of King Saud bin Abdul Aziz. Extensively modified at the factory, the aircraft included a VIP front cabin, a bed, special toilets with gold fittings and
was distinguished by a resplendent green, gold and white colour scheme with polished wings and lower fuselage that was commissioned from aviation artist John Stroud. Following its first flight, the special order Comet 4C was then described as “the world's first executive jet.” After flying just 168 hours, on 20 March 163 while enroute from Nice to Geneva, sadly this aircraft crashed into the Alps killing all the crew onboard.

**Hawker Siddeley Nimrod**

The last two Comet 4C aircraft produced were extensively modified as prototypes (XV147 & XV148) to meet a British requirement for a maritime patrol aircraft for the RAF, initially named “Maritime Comet”, the design was designated Type HS 801. This variant eventually became the Hawker Siddeley Nimrod and production aircraft were built at the Hawker Siddeley factory in Woodford, England. The fuselage was significantly altered in this variant to incorporate an unpressurized lower half required for a bomb bay. First entering service in 1969, a total of five Nimrod variants were produced. The final Nimrod aircraft were retired from RAF service in June of 2011.

A Nimrod maritime patrol aircraft clearly showing its de Havilland Comet roots - (Bill Upton Photo)

**ROYAL CANADIAN AIR FORCE OPERATIONS**

In the late 1940s and early 1950s, the RCAF was looking for a high speed, high altitude aircraft that could simulate a bomber profile while at the same time looking for an aircraft to augment its air transport resources. A high speed aircraft was required to test Canada's home-based fighter forces and radar chains. At the time, there were no large aircraft in RCAF service that could fly at an altitude of 12,192 m (40,000 feet) or at 724 kph (450 mph). At the same time, the Korean airlift (Operation HAWK) had placed a considerable strain on Air Transport Command. The Canadair North Stars were providing yeoman service but couldn’t meet the full demand.
Avro Canada had hoped to sell its jet-powered airliner, the Jetliner, to both Trans-Canada Air Lines (TCA) and the RCAF. Ahead of its time, the Jetliner actually flew thirteen days after the de Havilland Comet. But the original Jetliner design had depended on using two Rolls-Royce Avon jet engines and when these engines ultimately were not available in time, Avro Canada was forced to revert to using four smaller, less powerful Rolls-Royce Derwent jet engines. In the end, the president of TCA would have nothing to do with the revised Avro Canada design and in early 1951, the RCAF decided that the de Havilland Comet could better fulfill all its required roles and an order being placed with de Havilland for two 40 passenger aircraft in October 1952.

In November 1952, more than 60 air and ground crew from 412 Squadron were sent to England to receive familiarization training on the Comet aircraft. The first RCAF aircraft to fly was RCAF #5301 (construction number (c/n) 06017) on 21 February 1953. Then on 25 March, the second aircraft RCAF #5302 (c/n 06018) made its maiden flight. The aircraft were officially handed over to the RCAF on March 18 and April 13 respectively. A typical RCAF flight crew consisted of seven personnel including the pilot, co-pilot, navigator, flight engineer and radio officer and two cabin crew. The two RCAF flight crews involved subsequently flew over 100 training hours, including international flights to Johannesburg and Singapore. In the process, an RCAF crew set a speed record flying from London to Beirut, Lebanon in just five hours and fifteen minutes. By late May 1953, the first aircraft and crew were ready to return to Canada.
Two views of a RCAF inspection of the de Havilland Comet at RCAF Station North Luffenham in England in January 1952. (Left to Right) Squadron Leader (S/L) J.A. “Andy” Anderson, Mr Lloyd (de Havilland Commercial Sales Manager), and Group Captain (G/C) Z.L. Leigh pose in front of the aircraft and then examine the cockpit. S/L Anderson was the Training Officer for Air Transport Command and test flew the Comet. G/C Leigh was the Chief Operations Officer for Air Transport Command. - (Canadian Forces Images PL-62095 and PL-62092)

The sleek lines of the RCAF Comet are apparent in this image from its delivery flight 18 March 1953. - (Canadian Forces Image PL-62843)
On Friday, 29 May 1953, the first of the de Havilland Comets #5301 landed in Ottawa. With the arrival of this aircraft, the RCAF became the first air force in the world to operate jet transports and the first jet operator to make a scheduled trans-Atlantic crossing.
A large crowd turned out at RCAF Station Uplands for the arrival of *Comet* #5301. The jet had made the trans-Atlantic crossing in just 10 hours and 20 minutes, with stops in Keflavik, Iceland, and Goose Bay, Labrador. The *Comet* then went on a cross-Canada tour, demonstrating its speed and sleek lines.

The *Comet* was a vast improvement in terms of comfort for the passengers. No longer did they have to sit in a vibration-filled, noisy cabin. The ability to fly above rough weather also improved the ride. The flights were advertised as being so smooth that “you could stand a pencil on end or have a full glass of water and not spill it.”

The *Comets* were soon lauded for their speed. On short flights, they cut the normal air travel time by at least one third. On longer flights, travel times were reduced by over 50 percent. One popular comparison against piston-engined airliners is illustrated in this anecdote.
One night a RCAF Comet flying from Gander to Paris passed a RCAF North Star over the mid-Atlantic. The North Star had left two hours earlier, headed for London. The Comet flew to Paris and after a brief stop, took off for London, arriving shortly before the North Star.

With its greater speed and altitude, the Comet was able to fly great circle routes at a time when other airliners were flying commercial air corridors. Its comforts were a pleasant surprise for travelers used to the noise and vibration of commercial airliners of the time. The Comet ushered in the age of the jet airliners, and the RCAF was at the forefront.

Normal Operations

A normal trans-Atlantic crew complement consisted of the following: Captain, First Officer, Navigator, Radio Officer, Flight Engineer, Steward (usually a qualified cook) and a transportation technician to handle load details. Sometimes, an extra (male) flight attendant was also on the crew.

At any given time, 412 Squadron operated with four complete Comet crews. New pilots were trained and operated as First Officers for a time and were then upgraded to Captain. Crews did not fly together as a unit for any length of time. Each trip was assigned the crew personnel by the Flight Dispatcher, who kept records of the various assignments to ensure fairness.

In normal configuration, the RCAF Comet carried 37 or 39 passengers in very comfortable fully reclining chesterfield type chairs. There was no music or movies available on board during the flights. Meals were usually delivered to the aircraft precooked and then heated up by the Steward and served to the passengers on real plates with real cutlery. The crew meals were excellent and were cooked right in the galley. The main meals were always steak or roast beef with all the trimmings; the Captain and First Officer being given different choices in the interest of safety. Breakfast consisted of bacon or ham and eggs cooked fresh by the steward in the galley and served in the 8-seater crew compartment.

Two views of the comfortable Comet interior. Note both the reclining chairs and the square windows. - (Canadian Forces Images PL-67927 and PL-67797)
The original purpose for the purchase of the Comets was to help provide high altitude target interception services for Canadian fighter aircraft in Canada and this role continued for a limited extent for several years. The main missions however came in the form of flying Canadian military personnel and their dependents to and from Europe. Because of the limited space available, military personnel had to have some higher level priority for a Comet ride. Otherwise they would have to go on a North Star transport or by sea.

A second primary role was to fly both civilian and military VIP's any place in the world. For this purpose, there was a VIP compartment that could be installed in the back end of the airplane complete with chesterfields, sleeping facilities and washrooms. The installation was very comfortable and was used for Royalty, the Prime Minister, Cabinet Ministers and many Foreign Dignitaries. When this aircraft arrived at a foreign airport with the Canadian Flag flying from the top of the flight deck, local people watched and were usually highly impressed. The Comet also participated in various major air shows such as Toronto and Ottawa. Typically, the Comet did a slow fly past with an F-86 Sabre tucked up under the tail of the aircraft in very tight formation.

The Comets were able to perform all roles admirably, with their maximum altitude of 12,192 meters (40,000 feet) and cruising speed of 732 kph (455 mph) achieved by four de Havilland Ghost turbo-jet engines, each rated at 49 KN (5,000 lbs) thrust. The Comet had a range of about 4,023 kilometers (2500 miles) with a capacity payload and fuel allowances for headwind and stand-offs.

Withdrawal from Service

Following the series of disastrous crashes of the Comet fleet while in commercial service, as a precaution the RCAF Comets were then withdrawn from military service in January 1954. The RCAF Comets were initially put into storage at de Havilland's Canadian factory at Downsview, Toronto in April 1954. When the trouble had finally been pinpointed by British Court of Inquiry, the ensuing recommendation was that the
Comet pressure hulls should be re-built with heavier gauge skins. The RCAF Comets were therefore ferried unpressurized back to England for these changes to be incorporated at Broughton, Chester. The first of the aircraft arrived on 24 May 1956 after an overnight-stop in Goose Bay. The most obvious external change was the incorporation of oval-shaped windows in lieu of the original square windows. The fuselage structure was also further reinforced and the leading edges of the wings were modified. Other changes included uprated Ghost Mk 4 engines and the jet tail pipes were swept outward to further reduce buffeting on the fuselage. These modified Mk1As were then re-designated as Mk 1XBs. The cost of the work was put at £142,000.

In August 1957, crews from 412 Squadron proceeded to Hatfield for re-familiarization and flight training. These included: Flight Lieutenant (F/L) Dean Broadfoot (senior pilot), F/L Bill Carss, F/L Paul Major, F/L Paul Lemieux, F/L Stan Jenkins, F/L Gord Maclinchin, Flying Officer (F/O) Dwayne McBride, F/O Robert Glover, F/L Harry Morrison (Navigator), F/O Dick Brown (Navigator), F/O Garth Thomson (Navigator), F/L
Paddy Maclintock (Navigator), F/L Hugh Filleul (Radio Officer), F/L Bob Rose (Radio Officer), F/O Bob Mackenzie (Radio Officer) and F/L Jerry Savard (Navigator).

These crews completed flying training with initial flights throughout the United Kingdom and into Germany. Then, on 16 September 1957, the two aircraft departed Hatfield enroute to Rome, El Adem, Khartoum, Entebee, Salisbury, and Johannesburg, where the crews were royally greeted by de Havilland staff and enjoyed their hospitality for three days. The return flights followed the same route arriving back in Hatfield on 23 September. On 26 September, both aircraft departed Hatfield, returning to Canada via Lages AFB in the Azores, and RCAF Station Chatham, New Brunswick before arriving at Ottawa, Ontario.

The RCAF Comets finally resumed service in the roles for which they had been intended, on 1 November 1957, officially as Mark IXBs. The two Comets, besides their role as VIP transport, were used for unscheduled domestic flights and for regular runs from Ottawa to Marville, France. They also continued exercising Air Defence Command.

Typical Air Defence Mission

Comet crewmember, Hugh Filleul, later described a typical air defence mission as follows:

*When 412 squadron in Ottawa received the two refitted Comets back from De Havilland in 1957, one of their roles was to fly as practice targets for the air defence system. After takeoff from Ottawa, we would fly north until we crossed the Mid-Canada Line [radar chain]. Then we would head south on a predetermined track so as to trigger the Mid-Canada Line alarm system. Our predetermined tracks would bring us into the Pine Tree radar system area covered by CF-100 fighters at North Bay or Ottawa.*

*The main object of the exercises I flew on was to give the CF-100s a chance to practice a “lead collision course” interception. We were not allowed to vary from our predetermined course, or altitude. The speed of the Comet was predetermined at 0.8 Mach (about 400 knots) and the altitude was always 30,000 feet even though we could have easily flown at over 40,000 feet. There was no evasion. We were always “sitting ducks”.*
These flights of about five hours were a real bore until it came time to be intercepted. It could then get exciting when we would watch as many as 12 fighters come at us from a bit above and off the beam on a collision course. The attacks were all radar controlled, both from the ground and from the Air Intercept operator in the aircraft. To me it was some miracle of control to get that many fighters in attack position at a closing speed of about 1,000 miles per hour. The CF-100s were supposed to break of automatically after they had completed their simulated rocket firing. Some crews had to have their kicks, however, and they would roar right over the top of us, a thrill for them and more so for us. We did not think that playing chicken at a closing speed of 1,000 miles per hour at 30,000 feet was that much fun. They always denied that they were doing it but after we threatened to take our airplane and go home the roaring went away.

Some brain in NDHQ had ordered that we carry parachutes on these flights. We followed orders and chucked them under the seats at the back of the aircraft as soon as we boarded. Can you imagine the explosion if one of those birds holed us at altitude? Never mind that. If anyone were still alive to jump from the rear door, the tail plane would slice him in half. Eventually, our CO got the order rescinded, perhaps by offering free jumps to anyone in NDHQ.

Sometimes we also played target for the USAF interceptors. They always requested permission. On one occasion we had an F-5 9 Dart pilot waving alongside us six minutes after a launch from their base at Sault St. Marie. Who knows, perhaps they cheated.

Although we made a nice blip on the AI operator’s radar screen, the Comet was not designed for this role. Eventually the role was taken over by specialized aircraft. This did not make us sad although we lost the ability to tease the CF-100 crew in the Uplands mess that the Russians would not necessarily maintain a fixed track at an altitude of 30,000 feet.

The RCAF Comet’s silhouette and performance nicely simulated a jet-powered bomber - (CF Image PCN-518)
VIP Missions

The *Comet* was used extensively for VIP missions flying the Minister of National Defence and other military officials to various destinations. The aircraft would be reconfigured with a VIP compartment at the back of the cabin for some of these missions.
Comet pilot, Jim Rittenger, described a typical flight from Ottawa to Marville, France as follows:¹⁰

*First, a few statistics:*

<table>
<thead>
<tr>
<th>Maximum Takeoff Weight</th>
<th>117,000 pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Landing Weight</td>
<td>80,000 pounds</td>
</tr>
<tr>
<td>Maximum Fuel Load at Takeoff</td>
<td>54,000 pounds</td>
</tr>
</tbody>
</table>

This provided about 6 hours 45 minutes endurance at about 8,000 lbs per hour average consumption. The Comet normally carried 37 passengers in very comfortable, well-padded, fully-adjustable seats. The cruise speed was 0.72 Mach or about 400 mph. The departure from Ottawa was usually around 1900 hrs local time (or about 0100 hrs Marville time) following an operations and weather briefing some 90 minutes prior to departure. There was always at least one fuel stop enroute due to limited range, so either Gander normally and sometimes Goose Bay were chosen depending on forecast winds at cruising altitude. Because less fuel was
required on this first leg, the Comet would fly fairly fast and fairly high, usually 33,000 ft which in turn provided a pretty good fuel consumption rate. Unlike present day jet passenger aircraft that have "fan-jet" engines and an optimum cruise altitude of between 31,000 and 37,000 ft, the Comet had "Centrifugal" flow jet engines. Therefore the higher the altitude flown considering aircraft weight, the better the fuel consumption. For example, when taking off at the maximum take-off weight of 117,000 lbs and reaching the initial cruise altitude, the fuel consumption could be 10,000 lbs per hour. After the fuel burned off and the aircraft gradually climbed higher, the fuel consumption could go down to as low as 5,000 lbs per hour at 42,000 ft.

So the aircraft would depart Ottawa arriving normally at Gander about 0345 Marville time. It was typically a quick turnaround stop where the aircraft would take on a maximum load of JP1 fuel, which was generally about 54,000 lbs. The crew would check the weather, calculate the take-off details for the aircraft and, if all was in order, file a Flight Plan to Marville. All items had to be considered down to the last detail i.e. take-off distance, time enroute, cruising altitudes, landing conditions and forecast weather. All conditions had to be favorable in order to flight plan to Marville using either Etain or Luxembourg as alternate airports if required. With the limited amount of fuel that the Comet could carry, the alternate had to be within 15 minutes flight time of Marville.

The total flight time to Marville, France was generally 6 hours and 15 minutes. The Comet would depart from Gander using all of the takeoff runway available. A long slow climb would be used to an initial cruise altitude of 29,000 ft where the aircraft would level off with an initial cruise speed of Mach 0.69. As the fuel burned off, the flight crew would gradually climb as high as they could and increase speed to Mach 0.73. Generally, the crew would arrive over Marville at about 37,000 ft. In the earliest days of service, because the Comet had the upper flight levels to itself, there being no other pure jet traffic, the flight crew could cruise and climb from 29,000 to 37,000 ft with no concern for other traffic. As time went by, the Comet crews encountered more and more traffic and were forced to cross the ocean in level flight at between 29,000 to 31,000 ft. This necessitated more enroute fuel stops, usually at Shannon in Ireland. The Comet would arrive over Marville around 1045 local time usually around 37,000 ft. Paris Radar control would hand the aircraft over to Marville Approach and the friendly voices of the Canadian controllers. Sometimes a section of two of RCAF F86 Sabres would come up meet us and say "Hello" The Marville Ground Controlled Approach Radar would guide the aircraft to the landing runway, often in very low visibility conditions as Marville experienced a lot of morning fog at the base. After landing the aircraft would be taxied to the ramp in front of the Air Movements hangar for an on time arrival of 1100 hours local to be met by the outbound crew preparing for departure at 1300 hours local. The incoming crew would then take crew rest in Marville for 2 or 3 days before taking the return leg home.

The flights back to Ottawa would typically take a slightly different route to try and get north of the strong westerly winds that blew across the Atlantic between Gander and Shannon. The Comet would depart Marville and fly to to the USAF base in Keflavik, Iceland in order to refuel for a northerly flight from Keflavik to Ottawa. The flight time was usually about 4 hours but the planning was rather unique. Because there was no alternate airports reasonably close to Keflavik, the crews would have to use Prestwick Scotland as an "enroute" alternate. They would fly about halfway between Prestwick and Keflavik to a point where they still had enough fuel to return to Prestwick in the event of bad weather or an emergency. Upon reaching this midpoint, the crews would do final checks on fuel, landing conditions and weather at Keflavik and if all was
okay they would proceed on to destination. At this point the crew would be totally committed to landing at Keflavik. The landing was followed by a quick fuel stop taking on a full fuel load for the 6 hour flight to Ottawa. Usually the route would take the aircraft well north of Goose Bay Labrador resulting in a direct approach into Ottawa. But careful monitoring of fuel and destination weather would dictate whether the crews could carry on to Ottawa or be required to go into either Goose Bay or Bagotville, Quebec for further refueling. The aircraft’s arrival over the Ottawa Uplands Airport "UP" Beacon at anywhere from 39,000 to 42,000 feet would signal the commencement of a "Jet Penetration" approach to the landing runway. This type of approach was carried out because it took the least time and fuel to get down to the runway. The aircraft’s "speed brakes" were used to get the aircraft from the high altitude down to the runway level in a little over three minutes. The passengers never really noticed the rapid descent because the cabin descent was strictly controlled at a safe comfortable rate by the Flight Engineer. The aircraft would arrive at the 412 Squadron ramp at about 0030 hrs Marville time or 1830 local time.

412 Squadron did so many crossings per month and with such frequency that the Shannon Oceanic traffic controllers were amazed that the RCAF had only two aircraft---they had thought we had several more!

In-Service Issues

Because the original Comet fleet had several accidents where the airplanes broke up in flight due to pressure cabin structural failure, even with the modified version of the aircraft there still remained some unsubstantiated concern over pressurization within the RCAF. Consequently, as an additional safety factor when flying at high altitude, the service pilots wore oxygen masks at all times when at the controls. In the event of an emergency decompression the pilots would be unaffected and could carry out the required emergency descent to a safe altitude. The pilots also trained for this procedure both in the aircraft and in a decompression chamber at the Institute of Aviation Medicine in Toronto.

There was, however, at least one further incident of depressurization on an RCAF Comet on 26 Feb 1958. The particular circumstances were described in a newspaper article:

*The cabin fuselage of an RCAF Comet transport was punctured during flight when a dinghy contained in the port wing blew out causing the panel to strike the fuselage, it was announced by AFHQ.*

*The aircraft, which belongs to 412 Squadron, Uplands, was in flight about 15 miles, southwest of Ottawa at the time of the incident. The puncture was caused by the dinghy stowage panel striking the fuselage, resulting in a pressure leak. The Comet descended from its altitude of 41,000 ft and landed without further incident.*

*Air Force officials confirmed that there is no similarity whatsoever between this incident and the previous Comet accidents which resulted in the grounding of the aircraft. The fact there was no serious results from the puncturing of the fuselage is evidence of the strength which has been built into the fuselage by the recent modifications. The RCAF Comets returned to operational service in November 1957 following modifications to the fuselage.*
RCAF Comet cockpit crews wore oxygen masks at all times while at altitude as evidenced by this image - (Canadian Forces Image)
In terms of other incidents, although normally very reliable as a jet-engined aircraft, the Comet still had a few engine failures and flameouts. For example, on an Uplands-Marville flight 14 November 1961, a Comet had just leveled out at cruise altitude after the climb out of Gander, Newfoundland. The aircraft was approaching mid-Atlantic, all flight checks were complete and everything was in order. The Captain then went back to the crew rest compartment to enjoy an early breakfast. Before he could have the first bite, the very quiet flying Comet suddenly became even quieter. Upon returning to the flight deck, he found that all four engines had flamed out. The First Officer was putting the aircraft into a descent and the Flight Engineer was furiously attempting to relight the engines. As the Captain took control of the aircraft, the engineer was successful in relighting the engines and the aircraft climbed back up to cruise altitude. The crew subsequently discovered what had happened and what had caused it. Apparently, the failure of two warning devices in the fuel system had occurred simultaneously. A fuel gauge on the centre tank had stuck at 453 kg (1,000 lbs) and a "red coloured" low fuel warning light had a burned out bulb and couldn’t be seen – consequently the engines had simply run out of fuel and switching tanks solved the problem. Appropriate measures were taken to ensure that this same problem could not occur on future flights.

One other recurring problem went on for a couple of years before a simple fix was put in place that solved the issue. A critical area of the Ghost 50 engine in the Comet was the "bearing" that held the rotating shaft at the rear end of the engine. The crew were trained to always be aware of the possible overheating of this bearing, and the possible disintegration and ensuing problems. The operating manual strongly outlined the procedure to be followed if an overheat occurred: Shutdown the affected engine, dump fuel if required and land soon as possible. There was no alternative. Over a period of time, the crews experienced several of these overheat warnings and the mandatory procedures were carried out. However, each time when the engine was examined on the ground it was found to be a false warning due to a malfunctioning wire and / or temperature gauge. Despite the false indications, nothing was done for a long time then finally a "crossover" system was installed in the system. This allowed the reading on one temperature gauge to be crossed over and read on another gauge (i.e. Number four engine reading could be read on the Number three engine gauge with the press of a button). The problem was finally solved at very little cost but, in the meantime, quite a few flights had been disturbed and a lot of fuel had been dumped.

Overall, however, the RCAF Comets were generally appreciated as being very reliable airplanes.

Final Missions

The last scheduled Comet flight flew into Marville on 1 March 1962, after which the CC-106 Yukon took over the schedule completely. The Comets still however flew into Marville after that time on a few unscheduled missions. The very last flight that was flown into Marville was on 8 August 1963.

A Pilot’s Opinion

Comet pilot, Jim Rittenger summed up his experience on the RCAF Comet as follows: ¹³

During my career I flew eleven different transport aircraft. Some I liked, some I disliked, but the Comet was truly my first choice. When it came on the world scene it was ten years ahead of any other production or proposed aircraft. (The one exception was a smaller passenger jet built by AVRO in Toronto, a plane that unfortunately ever got into production.)
The Comet was very streamlined, could fly to extreme altitudes, was relatively fast for its time and handled as quickly and smoothly as a fighter airplane. It was a shame that it suffered the airframe accidents that it did because I feel that really set the British Aircraft Industry back a long way. In fact, I believe their industry never did recover from this setback and thus Boeing with the 707 and McDonnell with the DC8 were able to come to the forefront in passenger jet production and take over completely. A comparison to the [CC-106] Yukon is impossible. They were two completely different aircraft and really suited for different purposes: The Comet for passengers and the Yukon for freight... Each was good for its role but Comet was a “Cadillac” and the Yukon was a “bus”. Time has proven the 707 and the DC8 to be very reliable operational aircraft, the 707 perhaps the better. A lot of people have put the 707 into the same category as the old reliable Douglas C-47 / DC3. I think this is appropriate, I have a lot of flying time on both. I operated the 707 in the military from 1970 to 1979 and on airline operation from 1979 to November 1985, it was the second best aircraft I flew. “First loves” are unique and I still feel, all things considered, and the time it was built, that the Comet was the better machine. (I could be biased I suppose!)

Disposal

RCAF Comets # 5301 and # 5302 were retired from 412 Squadron service on 10 October 1964. Military policy at the time required all RCAF aircraft to be ferried to the Aircraft Maintenance and Disposal Unit (AMDU) at RCAF Station Mountain View when they were officially “struck off strength” for disposal. Mountain View was an old World War II airfield, which was located close to RCAF Station Trenton. In accordance with this policy, the two RCAF Comet aircraft were ferried to Mountain View by 412 Squadron personnel on 30 October 1964. The final disposal and “sale” of the two RCAF Comets then became quite complicated and messy. Both aircraft were for sale as flyable airframes at Mountain View as they had been flown in in a serviceable state from 412 Squadron. The buyer from Crown Assets had made previous purchases (including the remaining VIP B-25 (#5248) from 412 Squadron) and was negotiating both with various interested parties to resell both aircraft at a profit.
Prior to its demise, RCAF Comet #5301 sitting in open storage at RCAF Station Mountain View. Note the taped up jet pipes and cabin hatch. - (Mike Ody Collection Image courtesy Mr George Trussell)

Sister ship Comet #5302 again sitting in open storage at RCAF Station Mountain View. - (Mike Ody Collection Image courtesy Mr George Trussell)
A number of potential buyers were flown, on at least thirteen different occasions, to Mountain View to see both aircraft. Various negotiations continued but the principal interested party decided that if he waited long enough the aircraft would be sold to him at scrap prices rather than true value.

RCAF personnel arrived at Mountain View one evening in the process to find # 5301 sitting on the ramp on its main gear and tail but with the nose cut off and gone with the remainder “looking like a beheaded fish.” Comet # 5302 had all RCAF avionics and equipment literally chopped out of it. The connectors had not been undone; the cables had all simply been cut. Similarly, the equipment had not been unbolted but instead have been “chopped out”. Who gave the orders for this type of destruction and precisely why it was given remains a mystery.15

The end result was however was Comet # 5301 was effectively destroyed and it was harder to sell Comet # 5302 alone rather than both together. It took some time and a lot of effort to repair the damage done to # 5302. Some parts from # 5301 were apparently used in this process. On the 30 July 1965, the aircraft was finally sold to Mr. Eldon Armstrong who planned to use the aircraft as an executive transport. Eventually, it was flown over to No. 6 Repair Depot at Trenton where it was repainted blue and white with the civilian registration “CF-SVR”. Later it was then ferried to Mount Hope airport (in Hamilton) where an ex-412 Squadron pilot and flight engineers would start it up periodically and taxi it around. The aircraft remained at Mount Hope until 1968.
The ownership of this aircraft then changed hands several times and ended up with a dispute in litigation. Arrangements were being made with Transport Canada for a ferry flight to a buyer in British Columbia when the aircraft was spirited away by another ex-412 Squadron crew and flown to Miami (via Malton to correct an undercarriage snag). The aircraft was apparently destined for Peru, but it never turned a wheel again after parking in Miami. The aircraft was re-registered there as “N373S” becoming the only US-registered Comet 1 in the process. There was some indication of a planned use in a charter service but the aircraft passed through several more owners. But, ultimately there were too many insurmountable operational problems, with the end-result that Comet 5302 was eventually scrapped and broken up in-situ in 1975.
THE MUSEUM’S AIRCRAFT - **COMET # 5301 (NOSE SECTION ONLY)**

A brief chronological history of RCAF Comet # 5301 is as follows:  

**21 February 1953** - First flight

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**18 March 1953** - Formally handed over to the RCAF at Hatfield, England for two months of intensive training flights to international destinations such as South Africa, India and Singapore.

**9 May 1953** - 5301 establishes an "unofficial" record flying from London to Beirut, Lebanon of 3,621 kilometers (2,250 miles) in just five hours and 10 minutes.

**29 May 1953** - 5301, captained by 34 year old Wing Commander Howard Morrison, becomes the first pure jet passenger aircraft to cross the Atlantic, landing at Uplands Airport in Ottawa at 18:51 GMT. The journey of 5,705 kilometers (3,545 miles) started at London Airport and proceeded via Reykjavik, Iceland in just 10 hours and 20 minutes, breaking the Atlantic speed record. The aircraft was greeted at RCAF Station Uplands by a large crowd of Canadian officials and military personnel.

**June 1953** - 5301 conducts a trans-Canada demonstration tour from the east to west coast.
April 1954 - The aircraft is withdrawn from use following the accident of BOAC Comet G-ALYY. At this point 5301 has flown 670 hours. The aircraft is stored at the de Havilland Canada plant in Downsview, Ontario.

26 July 1956 - 5301 is flown back unpressurized from Uplands to a de Havilland plant in Chester, England to be re-built as a Comet IXB with a strengthened fuselage, oval windows, new engines and other changes.

2 August 1957 - 5301 makes its first flight from Chester, England as a Mark IXB. The aircraft is returned to the RCAF the following day and departs on five weeks of “tropical trials”.

26 September 1957 - 5301 is returned to RCAF Station Uplands via the Azores and then is used in a training role until the end of October.

1 November 1957 - 5301 is returned to active service in 412 Squadron and resumes the roles of high-speed transport, VIP transport and Air Defence target duties. The aircraft also resumes regular trans-Atlantic flights to RCAF Station Marville in support of RCAF fighter bases in Europe.
Comet #5301 is shown here refueling in the Azores during a training flight on 11 Dec 1957. - (Canadian Forces Image PL-86786)

Comet #5301 on the ramp at RCAF Station Torbay, Newfoundland on 10 February 1958 transporting then Minister of National Defence, Mr. George Pearkes. - (Canadian Forces Image PL-116756)

Comet #5301 on the ramp at RCAF Station Whitehorse in the Yukon on 30 March 1958. - (Canadian Forces Image PL-116756)
An aerial portrait of Comet #5301 on 22 July 1958. - (Canadian Forces Image PCN-518)

Three views of Comet #5301 from a photo shoot on 15 June 1961. - (Canadian Forces Images (top to bottom) PCN 3078, PCN-3086 and PCN-3090)
Another in the same series from the photo shoot on 15 June 1961. - (Canadian Forces Image PCN-3083)

Comet #5301 at RCAF Station Uplands on 16 August 1961. - (Canadian Forces Image PL-138503)

A Comet departing Uplands on 24 September 1963. - (Canadian Forces Image RNC-1425-2)
**30 October 1964** - 5301 makes its last official flight with the RCAF being ferried from RCAF Station Uplands to RCAF Station Mountain View airfield for disposal.

**1965** - The 5301 airframe is decapitated at RCAF Station Mountain View with the nose section being cut off the aircraft. The rest of the airframe is scrapped but the nose section is then presented to the National Aviation Museum. The aircraft is officially "struck off strength" on 30 July 1965. The nose of # 5301 is put into storage at the museum and it has remained in this state to the present day.
Other Remaining Pieces

There are at least two other remaining pieces of Comet # 5301 which were preserved at the RCAF Memorial Museum (now the National Air Force Museum of Canada) in Trenton, Ontario: an escape hatch, and a pitot tube, which measured airspeed.

Two views of the over-wing escape hatch from RCAF Comet #5301 in the then RCAF Memorial Museum (now the National Air Force Museum of Canada). - (Image courtesy of the RCAF Memorial Museum via Roger Cyr)

The location of the escape hatch can be seen on RCAF Comet #5301 sitting in open storage at RCAF Station Mountain View. The hatch is closed off with black tape just underneath the lettering “AIR” in Royal Canadian Air Force. The pitot boom is also visible on the wing tip. - (enlarged view from Mike Ody Collection Image courtesy Mr George Trussell)
## SPECIFICATIONS

<table>
<thead>
<tr>
<th></th>
<th>Comet 1A</th>
<th>Comet 1XB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Passengers</strong></td>
<td>37-39</td>
<td>37-39</td>
</tr>
<tr>
<td><strong>Engines</strong></td>
<td>(4) x De Havilland</td>
<td>Ghost 50 Mk 2</td>
</tr>
<tr>
<td><strong>Static Thrust</strong></td>
<td>2,268 kgf (5,000 lb)</td>
<td>2,495 kgf (5,500 lb)</td>
</tr>
<tr>
<td><strong>Length</strong></td>
<td>28.37 m (93 ft 1 in)</td>
<td>28.37 m (93 ft 1 in)</td>
</tr>
<tr>
<td><strong>Height</strong></td>
<td>8.95 m (29 ft 4.25 in)</td>
<td>8.95 m (29 ft 4.25 in)</td>
</tr>
<tr>
<td><strong>Wing Span</strong></td>
<td>34.99 m (114 ft 9.75 in)</td>
<td>34.99 m (114 ft 9.75 in)</td>
</tr>
<tr>
<td><strong>Wing Area</strong></td>
<td>195.6 sq m (2,105 sq ft)</td>
<td>195.6 sq m (2,105 sq ft)</td>
</tr>
<tr>
<td><strong>Total Fuel Tankage</strong></td>
<td>31,395 l (6,906 Imp gal)</td>
<td>31,395 l (6,906 Imp gal)</td>
</tr>
<tr>
<td><strong>Maximum All-Up Weight</strong></td>
<td>52,163 kg (115,000 lb)</td>
<td>53,071 kg (117,000 lb)</td>
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<tr>
<td><strong>Payload Capacity</strong></td>
<td>5,352 kg (11,800 lb)</td>
<td>5,443 kg (12,000 lb)</td>
</tr>
<tr>
<td><strong>Cruising Altitude</strong></td>
<td>8,534-12,802 m (28,000-42,000 ft)</td>
<td>8,534-12,802 m (28,000-42,000 ft)</td>
</tr>
<tr>
<td><strong>Cruising Speed</strong></td>
<td>740 km/h (460 mph)</td>
<td>740 km/h (460 mph)</td>
</tr>
<tr>
<td><strong>Range with Maximum Payload</strong></td>
<td>2,849 km (1,770 mi)</td>
<td>2,849 km (1,770 mi)</td>
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</tbody>
</table>

*A general arrangement drawing of the Comet 1A from the de Havilland operating manual. - (Courtesy of Bill Upton)*
The Comet #5301 cockpit in January 2013. - (Image courtesy of Bill Upton)

An unidentified RCAF Comet cockpit on 23 May 1953. - (Library and Archives Canada Images PA-0677922 and PA-067924)
An unidentified RCAF Comet cockpit on 23 May 1953. - (Library and Archives Canada Image PA-067790)
The Radio Operator Station on 23 May 1953 in an unidentified RCAF Comet. Note the Flight Engineer panel in the upper left - (Library and Archives Canada Image PA-0677923)
The same Flight Engineer panel from 5301 in January 2013. - (Image courtesy of Bill Upton)
The Navigator Station in an unidentified RCAF Comet on 23 May 1953. - (Library and Archives Canada Image PA-0677925)
Operating Manual Diagrams

The following diagrams illustrate the breakdown of the various stations / components on the Comet flight deck / cabin and are drawn from the de Havilland Comet 1A operating manual. All of the following images are courtesy of Mr Bill Upton:
FIG. 1 PILOTS' FLYING CONTROLS AND INSTRUMENTS
KEY TO FIG. 1

1. Electrically operated stick shaker unit for stall warning.
2. Central column (two).
3. Nose wheel steering control. White arrow on upper spoke in vertical when nose wheels are central. Centralization actuator when nose wheels are locked down.
4. Elevator gear change indicator, marked FINE, AUTO TRIM, and COARSE. Refer to Item 38.
5. Machmeter switches (two). If aircraft reaches “zero” marked Mach No. with elevator gear change switch (item 38) at FINE, warning horn at navigator’s station sounds, and automatic elevator trimming begins. Gear change switch (elevator gear changes to AUTO TRIM).
6. Vertical speed indicator.
7. Turn and bank indicator (two).
8. Altimeter (two).
9. Stabilizer warning red lamp (two); both lamps light to give warning of stall when either stall damper unit operates.
10. Airspeed indicator (two).
11. Artificial horizon (two).
12. Hydraulic system warning lamp (two) for flying control circuits. Also portion of panel PRIMARY BOOSTER SYSTEM LOW PRESSURE WARNING (red lamp), yellow section SECONDARY (yellow lamp).
14. Warning U/C NOT LOWERED. Red lamp lights if either levers are less then 90° each with slighthing gear up.
15. Compass, Type P-13.
16. Alighting gear electrical position indicator. Top lamp (red) illuminates when landing gear is UNLOCKED; bottom lamp (green) P and N. Illuminates with gear is LOCKED DOWN. No light when locked up. Spare green lamp can be used by turning CRANKAGE selector to left or right.
17. Airspeed warning lamp for item 18. Labelled LIGHT ON, PUMP ON.
18. Yellow system pump switch on yellow panel, labelled BOOSTER EMERGENCY HYDRAULIC PUMP.
19. Change over levers for flying controls servosystems (quadrate marked BOOSTER, CHARGE-OVER, NORMAL, EMERGENCY). With arrows to indicate lever movement. Levers marked ALTIMETER, RUGGER, ALTERNATOR (I & S). Red master lever makes all three servos to be moved simultaneously to EMERGENCY.
20. Alighting gear door under warning lamps (three U/C, S & N, and U/C DOOR WARNING, LIGHT ON, DOOR NOT CLOSED). When gear is locked down, only NOSE lamp lights.
21. Alighting gear mechanical position indicator. Three red indicators moving in vertical line from LOCKED DOWN to LOST. Indicators identified with bins by U/C of PORT U/C, PORT STAB. NOSE, or NOSE WHEEL LOCK markings.
22. Accelerometer.
23. Wheel brake pressure gauges. GREEN system (two). Green label marked BRAKE PRESSURE MAIN SYSTEM, PORT or STD, against relevant gauges.
24. Wheel brake pressure gauges. RED system (two). RED label marked STANDY AND PARKING with PORT or STD, against relevant gauges.
25. Rudder pedal adjustment (para. 7).
26. Rudder pedals. Pedal lens used for normal brake application.
27. AIR BRAKE control lever, marked OFF (forward), ON. Raises black knob on lever to select.
28. Flap mechanical position indicator. Graded 0, 15, 30, 60, 90, 120 degrees of flap movement. Indicator also used as emergency selector and marked FLAP EMERGENCY SELECT. LEVER - TWIST TO RELEASE. When no used, flap movement directly related to lever movement (refer to item 33). Quadrant gated at 19 deg. and 60 deg. to accommodate indicator when used as emergency control.
29. Elevator trim control handles (two). Rates in neutral areas. (Refer to item 34).
30. ALTERNATOR trim control. Rotates horizontal wheel in neutral areas to select. Integral indicator quadrant labelled PORT and STD. Neutral areas slotted.
31. RUGGER trim control. Details as item 30.
32. Alighting gear selector lever, labelled U/C, UP, DOWN. Pull lever back and move lever to left to select. Refer to para. 8 for details of selector lock.
33. Wheel brake control lever for parking and emergency use. Labelled RED SYSTEM TO BRAKE. Lever sets marked OFF (forward), DIFF-COMAT, ON and PARKING ON. To introduce emergency brake supply (manual brake pedal) pull away rearward to DIFF-COMAT. ON. For parking, depress both and pull lever rearward to OFF in PARKING range of view. To release, release both and move lever fully forward.
34. Elevator trim indicators (two). Marked NOSE DOWN, N (neutral) and NOSE UP position.
35. Flap selector lever. Slot marked UP, 1, 2, (TAKING OFF), 3, 4, 5, 6, 7, 8, 9, 10, DOWN. Press button on lever with brake selector. Movement of lever followed by relative movement of flap. To raise flap from 9 deg. in fully UP, press the horn half way only.
36. Auto-pilot central controller (fig. 1).
37. Red lamp. WARNING, FINE-GEAR, U/C DOWN. Lamp illuminates if slighthing gear is down and elevator gear change is selected to FINE.
38. FINE and COARSE positions. PNEU setting (used at speeds other than those for take-off and landing) reduces ratio of elevator movement to stick movement to approximate 5% of its normal (COARSE setting). Use for AUTO TRIM function of gear change and refer to item 5.
39. RED hydraulic system pump switch, with OFF and ON positions.
40. GREEN hydraulic system flow indicator (two). Use green lamp labelled PORT, one used for other data, refer to item 44.
41. GREEN hydraulic pressure gauge, label MAIN SYSTEM.
42. RED hydraulic pressure gauge, label STANDY AND BRAKE PARKING. (Refer to Chapter 2 of this section concerning gauge reading when RED lamp OFF).
43. BLUE hydraulic system pressure gauge, label BOOSTER SYSTEM (for firing controls).
44. BLUE hydraulic system flow indicator (two). LIGHT ON, PUMP FAIL. One blue lamp labelled PORT, the other SYM. Lamp on indicates engine not running or unwanted flow from pumps.
KEY TO FIG. 2

1. Low-pressure (L.P.) FUEL COCK control (two). Lever slots identified with appropriate PORT or STAB. engines, with OFF and ON, FUEL ON lever and of (slit) selective positions. Pull lever back to select. Each L.P. cock lever acts as an on/off switch in the suction line of a hydraulic pump driven by the corresponding engine. L.P. cock set in ON gives hydraulic pump cock "on". 


3. High pressure FUEL COCKS control (four). Lever slots identified with appropriate PORT or STAB. engines, with OFF and ON (lower end of slit) selective positions. Pull lever back to select. 

4. Rear bearing temperature gauges - port engines (two). 

5. ENGINE STARTER MASTER switch. 

6. Oil pressure and temperature gauges - port engines (two). 


8. R.p.m. indicators - port engines (two). 

9. Fire bell (two). 

10. Fuel L.P. FILTER PRESSURE DROP WARNING lamps (four) located for each engine PO, PI, II, BO. Each lamp can be depressed to reset alarm. (Contrasts for fuel filter and chamber door-sting are located on a panel between the radio rack and the gallery: for details refer to Chapter 2 of this section). 

11. Fire control panel. 

12. R.p.m. indicators - starboard engine (two). 


14. Oil pressure and temperature gauges - starboard engine (two). 

15. Synchronoscope. 

16. Rear bearing temperature gauges - starboard engines (two). 

17. ENGINE FUEL PUMP ISOLATION SWITCHES (four) PORT, STAB, with NORMAL and ISOLATE positions. Switches control leaking valve provided as safety measure in event of failure of h.p. or seven line to pumps so that one pump capable of maximum delivery remains available for each engine if the other pumps fail. 

18. Throttle levers (four). OPEN, SHUT. 


20. Engine STARTER PUSHER switch. With master switch (item 1) ON and engine selected (item 21) starting cycle is initiated by pushing and holding this switch in for 3 sec. It will then be held in automatically until released towards the end of the starting cycle. 

21. Engine start selector switch. Selector can be set to OUTER, INNER, INNER, OUTER engine. This switch is mechanically connected to the starter push switch (item 20) to prevent movement of the start selector switch until the push switch has been automatically released. 

22. Engine RELIGHT PUSHER switch. 

23. ENGINE FIRE primary WARNING lamps (four). Refer to fig. 7 for reset switches.
KEY TO FIG. 3

1. Red push buttons (one on each column inner handgrip) for auto-pilot cut-out.
2. Zero reader indicator (two).
3. CL 1 compass gpy unit (two). Refer to item 10. Master indicator at navigator's station (fig. 5).
4. I, L, S. indicator (two).
5. I, L, S. MARKERS become identification lamps (three) OFF, MIDDLE, INNER with PRESS TO TEST dimmer switch.
6. Relative bearing indicator.
7. Zero reader course selector.
8. Zero reader control.
9. Compass deviation card.
10. CL 1 compass control panel. COMPASS selector switch can be set as follows: 7 o'clock - OFF, 8 o'clock - COMPASS, 9 o'clock - D.G. ONLY, 10 o'clock - COMPASS OFF, 11 o'clock - D.G. ONLY.
11. A.D.F. receiver control (two). Push unit labeled A.D.F. I (red label adjacent), unit labeled A.D.F. II (green label). Receivers master controller at navigator's station (fig. 5).
12. Loop controller (two).

15. Auto-pilot channel selector switches controlled by hinged door. Switches marked B (radar) A (anemometer) K (alarm). Engage channel (lower switch on unit) position. Door opens enables any or all switches to be pulled out to disengage corresponding channel.

16. Auto-pilot POWER supply switch. Pull out to switch on magnetic hold-on. Switch will remain in 'off' (in) position if S.H. supply is interrupted.

17. Auto-pilot control controller, containing items 14 to 16 and 18 to 21.

18. Auto-pilot pitch control switch. Mover in fore-and-aft direction, natural sense selection, spring-loaded to central. Two rates of pitch control available. Initial switch movement against a soft spring brings low rate into operation: further movement against increased spring pressure introduces higher rate.

19. THM indicator with luminous pointer. Mover in fore-and-aft direction to show state of elevator trim when aircraft is under auto control.

20. Turn control knob. Incorporates spring detent in centre position. If auto-pilot is engaged when this knob is in any position other than detent, the knobs will be inoperative, until it has been reoriented to detent position.

21. Anchor and green lamps. Indicate when auto-pilot is ready to engage (anchor on) or is engaged (green on, anchor off).

22. Depth control for item 21.

*Note. For full details of auto-pilot controls (items 14-22) refer to Chapter 2 of this section.
FIG. 5 ENGINE AND FUEL SYSTEM CONTROLS AND EQUIPMENT: ENGINEER'S STATION

1. Fuel pressure gauges (num. one for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
   - 1. High pressure fuel pumps
   - 2. Low pressure fuel pumps

2. Engine fuel selector switches (valve 1 for each tank). Markings as follows:
   - 3. High pressure fuel pumps
   - 4. Low pressure fuel pumps

3. Fuel pressure gauges (num. two for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
   - 5. High pressure fuel pumps
   - 6. Low pressure fuel pumps

4. Fuel pressure gauges (num. three for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
   - 7. High pressure fuel pumps
   - 8. Low pressure fuel pumps

5. Fuel pressure gauges (num. four for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
   - 9. High pressure fuel pumps
   - 10. Low pressure fuel pumps

6. Fuel pressure gauges (num. five for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
   - 11. High pressure fuel pumps
   - 12. Low pressure fuel pumps

7. Fuel temperature gauges (num. six for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
   - 13. High pressure fuel pumps
   - 14. Low pressure fuel pumps

8. Fuel temperature gauges (num. seven for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
   - 15. High pressure fuel pumps
   - 16. Low pressure fuel pumps

9. Fuel temperature gauges (num. eight for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
   - 17. High pressure fuel pumps
   - 18. Low pressure fuel pumps

10. Fuel temperature gauges (num. nine for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 19. High pressure fuel pumps
    - 20. Low pressure fuel pumps

11. Fuel temperature gauges (num. ten for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 21. High pressure fuel pumps
    - 22. Low pressure fuel pumps

12. Fuel temperature gauges (num. eleven for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 23. High pressure fuel pumps
    - 24. Low pressure fuel pumps

13. Fuel temperature gauges (num. twelve for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 25. High pressure fuel pumps
    - 26. Low pressure fuel pumps

14. Fuel temperature gauges (num. thirteen for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 27. High pressure fuel pumps
    - 28. Low pressure fuel pumps

15. Fuel temperature gauges (num. fourteen for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 29. High pressure fuel pumps
    - 30. Low pressure fuel pumps

16. Fuel temperature gauges (num. fifteen for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 31. High pressure fuel pumps
    - 32. Low pressure fuel pumps

17. Fuel temperature gauges (num. sixteen for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 33. High pressure fuel pumps
    - 34. Low pressure fuel pumps

18. Fuel temperature gauges (num. seventeen for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 35. High pressure fuel pumps
    - 36. Low pressure fuel pumps

19. Fuel temperature gauges (num. eighteen for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 37. High pressure fuel pumps
    - 38. Low pressure fuel pumps

20. Fuel temperature gauges (num. nineteen for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 39. High pressure fuel pumps
    - 40. Low pressure fuel pumps

21. Fuel temperature gauges (num. twenty for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 41. High pressure fuel pumps
    - 42. Low pressure fuel pumps

22. Fuel temperature gauges (num. twenty-one for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 43. High pressure fuel pumps
    - 44. Low pressure fuel pumps

23. Fuel temperature gauges (num. twenty-two for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 45. High pressure fuel pumps
    - 46. Low pressure fuel pumps

24. Fuel temperature gauges (num. twenty-three for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 47. High pressure fuel pumps
    - 48. Low pressure fuel pumps

25. Fuel temperature gauges (num. twenty-four for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 49. High pressure fuel pumps
    - 50. Low pressure fuel pumps

26. Fuel temperature gauges (num. twenty-five for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 51. High pressure fuel pumps
    - 52. Low pressure fuel pumps

27. Fuel temperature gauges (num. twenty-six for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 53. High pressure fuel pumps
    - 54. Low pressure fuel pumps

28. Fuel temperature gauges (num. twenty-seven for each tank). Labelled L.H., R.H., L.R., R.R. "HANG." Markings of fuel pumps are as follows:
    - 55. High pressure fuel pumps
    - 56. Low pressure fuel pumps
KEY TO FIG. 6 (Continued)

7. Thermal de-icing system magnetic indicator (two), labeled FUEL ENGINE INTAKE and TECH ENGINE INTAKE. Each indicator shows position of shutter in the corresponding main plane distribution duct as follows:

- OPEN on green background ... Deicing on, cold air intake blanked off.
- SHUT on red background ... Deicing off, cold air intake open.
- Amber ... Electrical power off, or while shutter is in intermediate position.

8. Mass flow indicator (two) on rear fuselage for reheat supply. Used in conjunction with item 17.

9. Cabin differential pressure indicator, calibrated 0-21 in. H2O.

10. Cabin rate-of-climb indicator; 0 to 2,000 ft. per min.


13. Flaps/landing gear temperature gauge: 0 to 100°F. Normal reading is 10 to 100°F. Maximum reading of 100°F. (See note, section 6.11)

14. Cam position dial (four) each with associated clutch button. Each pair of levers is labeled GROUND TEST, PRESS BUTTON AND ROTATE INDICATOR. Refer to Chapter 2 of this section for full details.

15. Discharge valve fire caches (refer to fig. 13)

16. Refrigerator (two) air intake VALVE control switch (two) OPEN, OFF, SHUT, PORT and STAB.

17. Mass flow switch (two) PORT and STARBOARD. Valve of air conditioning system. Each switch has AUTO, INCREASE, OFF and DECREASE selective positions. Indicates control position for corresponding mass flow valves. When in AUTO, constant flow is maintained automatically in conjunction with mass flow controller and metering unit.

18. Air conditioning system PRESSURE SUPPLY VALVES, one lever per engine. Select airflow by depressing lever head and sliding from SPILL to PRESS TO CASSET.

19. Thermal de-icing system control lever (two). Each lever (L.H. or R.H.) has three settings: OFF, ON FROM INNER ENGINE, ON FROM OUTER ENGINE. Depress white knob and move lever to desired setting of corresponding engine and air supply to the tail unit and to the corresponding main plane leading edge and engine air intakes (refer to Chapter 3 of this section for operation of associated intakes switches).

20. Fire/apex lighting gear emergency selector lever, U/C EMERGENCY ON, FLAPS EMERGENCY ON and OFF positions (refer to fig. 13).

21. REFRIGERATOR AIR SCOOP switch: OPEN, SHUT, For directing cooling air through the secondary heat exchanger.

22. Air conditioning system SAFETY VALVE control, with OPEN, NORMAL, MINIMUM and SHUT positions. Rotate knob to select position. Normal setting is NORMAL; refer to Section 3, Chapter 4 for emergency use. Valve will open automatically in event excessive pressure occurs, irrespective of setting of manual control.

23. Cabin ALTITUDE SELECTOR, graduated in THOUSANDS OF FT. Knob selector knob in regular position with required cabin altitude on graduated dial.

24. Cabin pressure RATE OF CHANGE - FEET PER MINUTE dial: control marked PUSH AND TURN, INCREASE, DECREASE.

25. Time-of-flight clock.
FIG. 7  ELECTRICAL CONTROLS AND EQUIPMENT: ENGINEER'S STATION

1. MAIN INVERTERS, A, B and C, START ( Marks) AND STOP ( red) switches. Depression of START switches initiates a supply to the inverter motor through the inverter starter unit. Depression of STOP switches breaks the inverter d.c. supply.

2. Main inverter red warning lamps. Lamps light if corresponding inverters are not in operation.

3. Instruments ON, OFF switches ( gated). Permit supply to POST, AST, HORUS, CLOS COMPASS, TURN & BANK indicator, STAR, ART, MORRIS.

4. Main inverters (A and B) change-over switches and phase-detect warning light switch ( gated). A and B selective positions. Contact output from A or B inverter to 115 VDC three-phase a.c. distribution lines. Also switches applicable phase-detect warning light circuit (light on 2nd pilot's instrument panel) into service.

5. 24 V A.C. instrument inverter switches (gated). For A or B instrument inverter selection.

6. ZERO LOADS, ON-OFF switches (gated). Supplies power for operating zero load equipment.

7. CO₂ FIRE EXTINGUISHER TEST switch and red lamp. LAMP LIGHTS WHEN EXTINGUISHER IS SERVICEABLE. When switch is pressed, lamp lights to indicate electrical discharging circuit is serviceable.

8. FIRE WARNING push switches [ four]; PUSH TO RIGHT PROXIMAL LIGHTS. Operates related switch to extinguish remote primary warning lamp on pilot's central control panel; subsequent to operation of engine key fire detection switch [two].
KEY TO FIG. 7 (Continued)

9. FIRE WARNING TEST push switch, LEADING EDGE BAY, ENGINE AND FORWARD CENTRE-SECTION. Operation of the push switch should energize all nine warning lamps on the fire control panel, and the warning bells.

10. BELL ISOLATION switches (bezel) BELL ON, BELL OFF, experiment limited for the following underside control panel switches: JUSTICE BAY, ALTERNATE BOOSTER BAY, and FREIGHT BAY. Switches allow alarm bells to be switched OFF after warning has been given by smoke detectors. Refer to item 21.

11. SMOKE DETECTORS MASTER SWITCH: ON, OFF. ON selection switches all detectors into service.

12. SMOKE DETECTORS TEST and RESET switches (ganged) labelled for zone EQUIPMENT, ALTERNATE BOOSTER AND FREIGHT BAY. To simulate presence of smoke in detector, move switches to TEST position. Panel cause bell to sound, smoke detector with bell and warning bell to ring. Afterwards, RESET switches by holding down.


14. Alternator ON/OFF switch (in pairs for each set of engines). Used for switching individual generators off/or on. Refer also to item 19.

15. POWER FAILURE red warning lamp (four) one for each switch (item 14). Labelled POWER FAILURE LT. - PORT (or STBD.) GENERATORS (alternatively). A lamp will light if failure of electrical output from the relevant alternator occurs.

16. Voltmeter. Calibrated 0 to 60 amps d.c., Indicate voltage of whichever source is selected on voltmeter switch (item 18).

17. Ammeter (four). Calibrated 0 to 1000 amps d.c. Indicates current load in related alternator.

18. Voltmeter switch. The individual line voltages may be read on the voltmeter by rotating the switch selector to the appropriate position on the display. Labelled: BUMPER, B.O.S.P., B.P., B.P./B.P., B.P./B.P.

19. Pull-push reset (bezel) switch (four) TO RESET FULL & PUSH TO FULL EXTENT. Used for remanasting alternator to power bus bar when engines are running. Reset switches ON/Off switch (item 18) must be ON.

20. BATTERY ISOLATOR RELAY FAILURE red warning lamp. Lamp lights if the battery becomes isolated from the main bus-bar.

21. ESSENTIAL SERVICES emergency change-over switches (coupled). In the event of failure of one or more power supply emergency batteries will supply services necessary for flight for a limited period when the switches are moved from NORMAL to EMERGENCY.

22. Radio switch and station box.

23. Radio jack box.

24. ENGINEER'S PANEL light control switch (two) for一期 engine lamp. Upper switch RED LT., lower switch WHITE LT. Rotate switch clockwise for red and counterclockwise for white.

25. ELEVATOR BOOSTER BAY SMOKE DETECTOR switch (two) one labelled BELL CUT OUT with BELL ON and BELL OFF positions. Other switch labelled SMOKE DETECTOR with TEST and NORMAL positions. Operate in similar way to items 15 and 18 respectively.

26. STALL WARNING TEST switch (two PORT or STBD). When moved to "OFF" stall warning detectors are bypassed to operate "stick-shaker", and light STALL WARNING lamp at pilot's station. Switch spring-loaded to "on" position.

27. ALTERNATOR EMERGENCY EXCITATION switches, one for each engine. If the normal power supply fails, SWITCH TO EMERGENCY PROCEDURE NORMALLY in tandem emergency batteries to alternator excitation circuit.
KEY TO FIG. 8 (Continued)

10. Swivel mounting for item 11. Friction adjuster at base.
11. Cloud and collision warning indicator. To slow, withdraw plunger from item 10, raise indicator, and release plunger to lock.
12. Radio services station box.
13. Cloud and collision warning control unit.
14. CL.2 compass amplifier.
15. CL.2 compass master indicator.
16. A.D.F. master receiver controller.
17. External air temperature gauge. On aircraft Construction No. 0001? the item is fitted to second pilot’s instrument panel.
18. Manometer. Not fitted on aircraft Construction No. 0007?
19. A.D.F. heading indicator and loop controller.
20. Sextant storage case.
22. Altimeter filter storage.
23. Zenith reader flight computer.
25. BLUE hydraulic system low pressure warning horn. Can be shut off by Booster Horn switch (fig. 4, item 26).
26. Repeata transmitter receiver.
27. Loran indicator unit.
29. Repeata indicator unit.
30. Radio altimeter indicator.
32. Lighting switch panel. Three on/off dimmer switches - SIDE LIGHT FOR lamp above item 28; TABLE LIGHT for charge lamps below main instrument panel; TOP LIGHT for lamp above station.
33. Repeata control unit.
34. Impact switch - I.F.F.
35. Altimeter.
36. Air speed indicator.
37. Air pressure indicator.
38. Air velocity unit control panel.
40. Sextant mounting.
KEY TO FIG. 9  (Continued)

13. A.D.F. receiver No. 2.
14. Space provision for Master oscillator.
15. Radio switch panel. Carries 19-volt and 28-volt supply switches and associated fuses; crystal leads, A.D.F. and Rebecca fuses; radio emergency ganged switches; for H.F. aerial switch and lamp (omitted).
16. 19-volt regulator No. 1.
17. 19-volt regulator No. 2.
18. I.L.S. 3-lamp power unit.
19. Intercom. power unit.
20. Space crystal storage.
22. I.L.S. heading and marker.
23. Power supply No. 1.
24. Power supply No. 2.
26. Distribution panel No. 2 - 19-volt supply.
27. H.F. amplifier No. 1.
28. Distribution panel No. 2 - 28-volt supply.
29. H.F. drive No. 2.
31. H.F. amplifier No. 2.
32. Distribution panel No. 1 - 28-volt supply.
33. A.D.F. receiver master controller.
34. A.D.F. bearing indicator and loop controller.
35. Ground-equipment storage.
36. Morse key.
37. Antenna.
FIG. II STEWARD'S CONTROL PANEL

1. Bar shelf lamp switch.
2. Freight compartment (opposite galley) lamps switch.
4. Cabin air temperature gauge.
6. Pilots' call lamp (white).
7. Forward compartment passengers' call lamp (two), port (red), starboard (green).
8. Cabin air temperature selector (refer to fig. 4, item 5).
9. Air conditioning system HUMIDIFIER SWITCH. AUTO, OFF, ON selective positions. When set to AUTO, humidifier operated automatically by humidistat to maintain cabin relative humidity between 20 and 28%.
10. Main-compartment passengers' call lamp (two), port (red), starboard (green).
11. Toilet compartment call lamp (amber) - (two).
12. Passenger forward compartment roof lamp switch.
13. Passenger main compartment roof lamps switch (two).
FIG. 12. STEWARDESS' STATION
LIST OF ABBREVIATIONS

BAe  British Aerospace
BEA  British European Airways
BOAC  British Overseas Airways Corporation
DH  de Havilland
F/L  Flight Lieutenant
F/O  Flying Officer
G/C  Group Captain
GMT  Greenwich Mean Time
RAF  Royal Air Force
RCAF  Royal Canadian Air Force
SIGINT  Signal Intelligence gathering
S/L  Squadron Leader
UAT  Union Aéromaritime de Transport
VIP  Very Important Person
W/C  Wing Commander

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Endnotes

1 The Argonaut was known as the Canadair North Star in Canadian service.

2 Cockpit Voice Recorders and Flight Data Recorders, more commonly known as “Back Boxes”, had not yet been invented and therefore required on commercial airliners.

3 “RCAF Clips Record of First Jet” Ottawa Citizen Newspaper article 06 June 1953

4 “Plan Tour In Canada For Jet Transport” Ottawa Citizen Newspaper article 06 June 1953

5 Drawn from: http://67.69.104.76:84/marville/other/maother-222.html

6 Drawn from: http://67.69.104.76:84/marville/other/maother-15.html

7 Drawn from: http://67.69.104.76:84/marville/other/maother-9.html

8 Drawn from: http://67.69.104.76:84/marville/other/maother-223.html

9 More likely a Convair F-102 Delta Dart


11 Ibid.

12 Upland Times newspaper - 13 March 1958


14 Primarily drawn from: http://67.69.104.76:84/marville/photos/planes/comet-63a.html
15 Ibid.

16 Drawn from: Painter, Martin, *The DH.106 Comet - An Illustrated History*, Pages 125 - 127