This is almost certainly the sole DH Comet 3 built, seen at Farnborough, in BOAC colours. This version never went into production □ M.J. Hooks

COMET
The First Jetliner

The turbojet was young technology in 1949 and unproven in civil use, but it did the de Havilland Comet jetliner proud from the start. Unfortunately the Comet had early fatigue problems from which it never fully recovered commercially

by Nick Corrie

Great Britain was unquestionably world-leader in gas turbine technology when WW2 ended, but America still held its long-established lead in civil airliners, albeit piston-engined. A technological leapfrog using turbine engines was the only way for us to overtake the Americans, and the de Havilland firm set about the task of building the world's first jetliner.

DH's design team, headed by R. E. Bishop, looked at various layouts before settling for a reasonably conventional all-metal aircraft, the DH 106 – eventually called the Comet. BOAC had accepted the finalised layout by October 1946, and, in January 1947, orders were placed off the drawing board by the Ministry of Supply for BOAC and BSAA; the latter, incidentally, was taken over by BOAC later on. Simply being a jetliner was enough to make the Comet revolutionary, and it was designed for four DH Ghost turbojets in the 4,500 to 5,000 lb thrust category. The jet engine was a simple device before evolution made it complex, much simpler, indeed, than contemporary piston engines. And the uncomplicated Ghost was no exception, with its single-stage centrifugal compressor driven by a single-stage axial turbine.

Work on the Comet went on in considerable secrecy, and the first prototype (G-5-1/G-ALVG) flew from Hatfield on 27 July 1949. The jetliner's wing was moderately swept at 20 degrees, and the pressure cabin gave an internal 8,000 ft at an altitude of 40,000 ft, ie a pressure differential of 8.2 lb/sq in. An innovation was Redux metal-to-metal structural bonding, and the Comet had hydraulically-powered controls without manual reversion, as well as a nosewheel undercarriage (an ultramodern airliner could hardly have anything else in 1949). Each wing was an integral fuel tank, with pressure refuelling, giving a total of 6,050 gallons – large for an aircraft of this size, but then the price of such high performance was fuel. Pressurisation and de-icing came from engine compressor air bleed.

Of course, the Comet's most radical feature was jet propulsion, not just because of its elegant working principles, but also because of the extreme performance it gave the Comet. Although turbojets were viable technology by the mid-forties, they were associated with

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COMET
The First Jetliner

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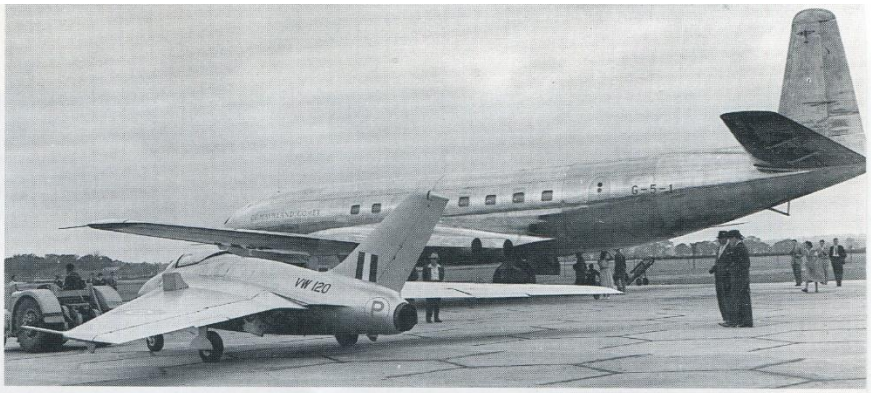
military aircraft, and the idea of a jetliner was an extraordinary leap forward when the Comet was being designed. The most modern contemporary airliners were piston-engined, such as the American Constellation, Douglas DC-6 and Boeing Stratocruiser. These impressive machines, quite without British parallel, seemed set to retain US supremacy, unchallenged by feeble British counter attacks from the Handley Page Hermes



Revolutionary when this photograph was taken, the Comet prototype G-5-1 poses beside another revolutionary machine, the DH 108 tailless research aircraft. Even today, the Comet looks sleek □ M. Brett

The first Comet was used as a testbed for DH Sprite rockets, shown on RATO trials. Climb angle is fairly shallow □ B. Robertson

and Avro Tudor. But the Comet was ready to eliminate British inferiority, handsomely, with its near-500 mph cruise. America's piston-engined best could only manage about 300 mph.

The jetliner was demonstrated in public at Farnborough in September 1949, and the second machine was flown a year after the first one (G-5-2/G-ALZK). Route proving and training flights were made with BOAC using G-ALZK, and a production line was set up at Hatfield, with the first production Comet 1 flying on 9 January 1951. Ten Comet 1s with 5,000 lb Ghost 50s were delivered to BOAC as G-ALYP to 'YZ from April into September 1952 (there was no 'YQ).

Then came the great day when G-ALYP inaugurated the world's first jet passenger service, leaving Heathrow on 2 May 1952 for Johannesburg via Rome, Beirut, Khartoum, Entebbe and Livingstone, flying the near-7,000 mile trip in just under 24 hours. London-Tokyo was started on 3 April 1953. There was no way contemporary (one can hardly say competing) piston-engined airliners could keep up with the Comet's 490 mph cruise – an incredible speed for an airliner, and the new jetliner slashed journey times.

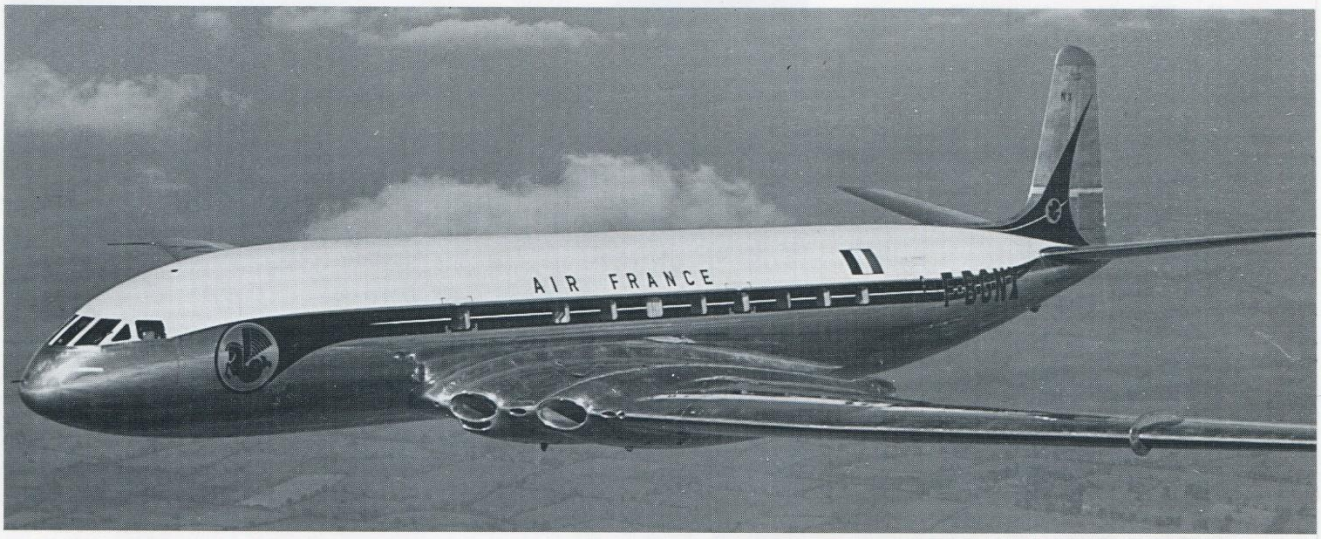
BOAC's Comet 1 flight deck housed two pilots, a flight engineer and a radio operator/navigator. Comet 1 operators could have alternative seating for 36 (first class) or 44 (tourist) passengers, and in BOAC's 36-seater the forward cabin had eight seats, while the main cabin took 28 passengers, its rear being about level with the engine exhausts. Freight and baggage were stowed under the floor, and in an additional compartment between flight deck and forward cabin. WCs were at the rear, as was another baggage compartment, and there was an all-electric galley in front of the forward cabin. The Ghost was a noisy crackling straight jet in those pre-turbofan days. But despite sounding "like all the banshees from Hell" outside, as an American observer put it, jet travel

Production of Comets and other de Havilland machines. In the foreground is one of three Comet 1As for the French airline UAT. Note the three escape hatches, at windows 2, 7 and 9 □ M.J. Hooks

Comet 1 G-ALZK was loaned by the Ministry of Supply to BOAC for route proving and training flights. The Comet was an extremely graceful machine, better looking, even, than the Constellation □ M.J. Hooks

civil aviation was rising into a new Elizabethan age, a turbine age in which Great Britain had a civil monopoly. This was not just because of the Comet, but also thanks to the superb new turboprop Vickers Viscount and the up-and-coming turboprop Bristol Britannia.

The improved Comet 1A was introduced with weight increased to 115,000 lb, more fuel capacity and water-methanol injection for hot-and-high take-offs. Canadian Pacific took two 1As, as did the RCAF whose 5301 was flown in stages to its new owners on 29 May 1953. This was the first flight across the pond by a jet transport, although the Comet 1/1A was



Air France was an early Comet user, taking three Comet 1As, starting Paris-Rome-Beirut services on 26 August 1953 □ B. Robertson

was very much quieter for passengers and crew than piston travel, with less vibration.

The Comet was as revolutionary in the early 'fifties as Concorde was about 25 years later – a quantum leap in performance over the well-established norm.

The prestigious Comet quickly became famous. Moreover, it was British at a time when the Americans ruled the civil roost, and, with the Comet, the British were beating the Americans at their own game. Suddenly, America's piston airliners seemed slow and old-fashioned. British neither designed nor used for fare-paying Atlantic service. Three Comet 1As went to UAT as F-BGSA to 'SC, and Air France took three (F-BGNX to 'NZ), starting Paris-Rome-Beirut flights on 26 August 1953. Further development led to the Comet 2, three feet longer with Rolls-Royce Avon 502 axial-flow engines of 6,500 lb thrust each. And BOAC ordered 11 machines as G-AMXA to 'XK, with G-AMXA first flying on 24 August 1953. DH planned the yet bigger Comet 3, causing considerable foreign interest, notably from Pan Am, and the Comet's future seemed assured.

But things suddenly started going sour for the Comet before any Mk 2s were delivered. On 26 October 1952, BOAC's G-ALYZ failed to unstick at Rome and in the ensuing mayhem the jetliner charged along on its belly, eventually coming to a halt with fuel pouring from ruptured tanks. But despite the proximity of hot Ghosts, there was no fire and everyone walked out of the wreck without injury except for a cut finger! The same thing happened to CPA's CF-CUN *Empress of*

Another early Comet operator was Canadian Pacific, whose Comet 1A CF-CUM is seen here □ M. J. Hooks

Comet 2s never went into airline service, but the few produced were modified after the Comet 1 crashes □ M. J. Hooks

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COMET
The First Jetliner

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Hawaii at Karachi on 3 March 1953, but this time fuel from broken tanks caught fire and, tragically, nobody survived. The accidents resulted from raising the nose too early, preventing the Comet from reaching unstick speed; the problem was addressed with revised take-off procedures and wing mods.

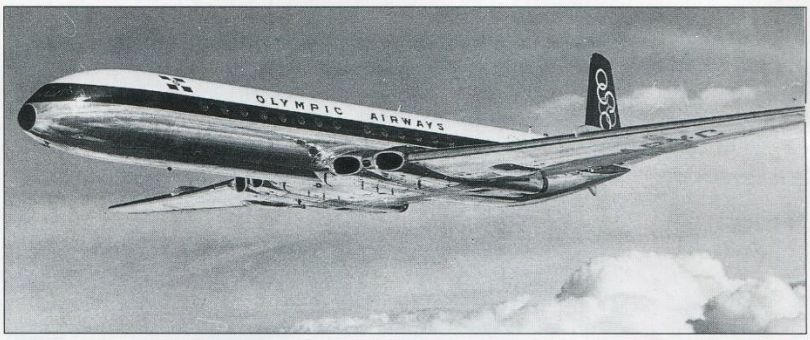
But this was just the start of the Comet's dark age. On the anniversary of the jetliner's entry into service with BOAC, G-ALYV broke up in the air on 2 May 1953 with total loss of life, six and a half minutes after leaving Calcutta. It had been known before take-off that there was bad weather ahead, but it was felt unnecessary to delay take-of. The Indian court of enquiry frankly admitted that it could not positively identify the cause of the crash, ruling out sabotage and suggesting structural failure either due directly to stormy weather, or loss of control or over-control by the pilot. So the Comets kept flying.

Then came another disaster when G-ALYP fell out of the sky from 26,000 ft into the sea off Elba, climbing out of Rome on 10 January 1954. There were no survivors. BOAC's Comets were temporarily taken out of service for detailed checking at Heathrow and, although nothing wrong was found, precautionary mods were made and the Comets started returning to work in March. But this was not the end of it, because on 8 April G-ALYY disappeared, again after take-off from Rome, crashing into the Mediterranean off Stromboli without survivors.

There was clearly something very wrong with the Comet. All machines were grounded, and then started the most intensive and detailed air crash investigation ever mounted in Great Britain. The Royal Navy brought parts of G-ALYP's wreckage up from the seabed in 400 to 500 ft of water – an enormous undertaking in 1954, when subsea technology was much less

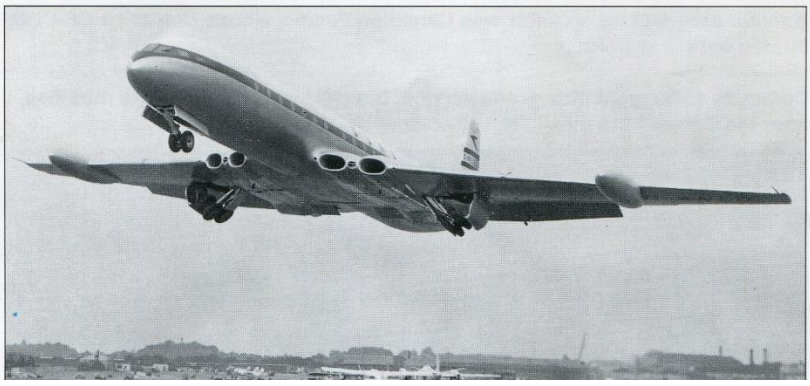
The flight deck could be 'cozy' especially on long-haul transatlantic trips

British European Airways was a Comet operator, and the writer had several pleasant flights in the firm's Comet 4Bs (Heathrow-Geneva) □ M.J. Hooks



Comet 4B G-APYC became SX-DAK for service with Olympic Airways, Greece's national carrier. The 4Bs had no external wing tanks □ M.J. Hooks

The only Comet 3, G-ANLO, was used as a development aircraft for the Comet 4. G-ANLO takes off during a Farnborough Air Show □ M.J. Hooks



Middle East Airlines helped to provide much-needed export trade for Great Britain plc by taking Comet 4Cs □ M.J. Hooks

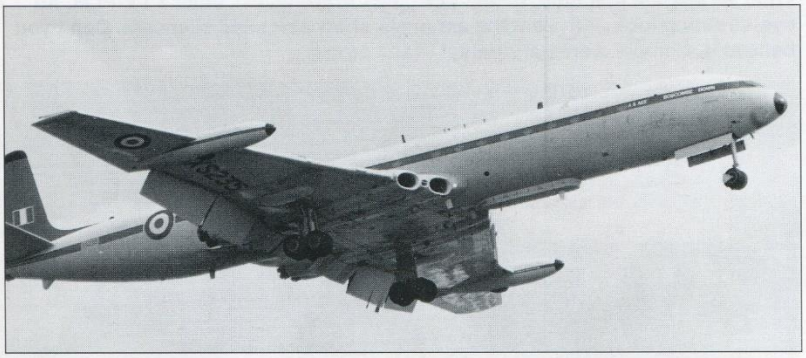
developed than now. But there was no hope of raising any of G-ALYY's wreckage; it lay far too deep, in over 3,000 ft of water. G-ALYP's recovered parts were brought home to RAE Farnborough and wired to a wooden, Comet-shaped frame at Berkshire Copse for reconstruction and analysis.

As well as wreckage analysis, there were flight tests and ground tests, and a massive mobilisation of scientific and engineering effort at Farnborough pursuing various theories to find the cause of the Comet crashes. Perhaps the most famous work of all was the water tank testing, in which a complete Comet fuselage (G-ALYU), with wings protruding either side, was enclosed in a massive water tank and taken through accelerated flight cycles, simulating cabin pressurisation and de-pressurisation (with water instead of air), as well as gust loading with hydraulic jacks flexing the wings. In this way, flights of several hours were compressed into a much shorter time in the tank, because it was only necessary to reproduce the number of loadings met in flight, not the flight duration.

It has been known since before WW1 that stresses in a load-bearing structure increase adjacent to a cut out, with heightened effect if the cut out has sharp corners. In pressure cabin terms, this means,

A BOAC Comet 4 coming in to land. Even with everthing down, in thoroughly 'dirty' configuration, the Comet looks sleek □ M.J. Hooks

Comet 4C XS235 *Canopus* first flew on 26 September 1963 as one of the final Comets produced, entering MoA service in December □ M.J. Hooks



for instance, that round or oval windows are better than rectangular ones. But whatever the window shape, if the stress-raising effects are not properly allowed for by adequate local reinforcement etc, then failure will start at the point of greatest stress.

And herein lay the clue to the Comet's failure. The fact that it had rectangular windows and cut outs for ADF aerials was not, in itself, dangerous. But this made a fatal cocktail when combined with manufacturing faults and use of a material having improperly-understood fatigue

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COMET
The First Jetliner

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characteristics, not to mention a less developed understanding of fatigue in those days. The RAE discovered from G-ALYP's wreckage that a fatigue crack, starting at a corner of the rearmost ADF cut out, had led to a sudden and rapid failure, and explosive de-compression.

The local stress increase at the cut out, while safe enough under static loading, was too high for a decent fatigue life under the cyclic loading of cabin pressurisation and de-pressurisation. Catastrophic fatigue failure was the tragic result. Earlier, supporting evidence had come from G-ALYU's fuselage which, on 24 June 1954, ruptured during tank testing, due to a failure starting at an escape hatch. The reason was the same as that which felled G-ALYP off Elba, and by September, Director of the RAE Sir Arnold Hall and his team were confident they had identified the Comet's problem as metal fatigue.

Now that the Comet's fatal weakness had been identified, it was possible to do something about it. Comet 2s were modified on the production line with thicker skins, rounded cut outs and jet pipes slightly angled outwards to reduce fuselage buffeting; more powerful 7,350 lb RR Avon Mk 117s were also fitted. These machines never entered airline service, and, of those started, only 15 flew. But Comet 2s gave reliable service as C Mk 2 transports with 216 Sqn, RAF, along with two T Mk 2 trainer versions.

In the meantime, the enlarged Comet 3 flew on 19 July 1954 as G-ANLO, just over

At the controls of an RAF Comet 2. This type gave good service with the RAF as C Mk 2 transports (and two Mk 2 trainers), but was not used by airlines, which went for Comet 4s instead □ B. Robertson

BEA's Comet 4B G-APMA *Sir Edward Halley* was quite a large airliner in its day, but it would now look small beside wide-bodied jets □ M.J. Hooks

What an elegant machine, is this Aerolines Argentinas Comet 4 LV-PLM. An eye-straining look at the engine exhausts show so-called silencers. Don't you believe it. Comets were very noisy! □ M.J. Hooks

The best laid plans of mice and men ...don't always go as hoped, and certainly not for Dan Air's Comet 4 G-APDL being raised by air bags □ M.J. Hooks

As well as Comet 2s, the RAF used Comet 4s, an examle of which is shown here as C Mk 4 XR387. Note the tail bumper, and the underwing bulges for the mainwheels □ B. Robertson

three months after 'YY had disappeared off Stromboli.. This machine had 10,000 lb thrust Avon 26s and looked very different to its predecessors, being 15 ft 6 in longer than the Comet 2 and much more elegant. The sole Comet 3 was used as a development aircraft for the definitive Comet 4 which had Avon RA 29 Mk 524s of 10,250 lb thrust, as well as transatlantic range, and incorporated lessons learned from the Comet 1 crash investigation. BOAC ordered 19 machines in 1957 as G-APDA to 'DT (skipping 'DQ), and the type first flew on 27 April 1958, starting work with BOAC on the transatlantic run on 4 October to begin airline farepaying

Mexicana was impressed with the Comet 4 G-APDA's excellent demonstration at Mexico City, and ordered Comet 4Cs for its *Golden Aztec services* ■ M.J. Hooks

SU-ALC was one of Misrair's Comet 4Cs shown climbing. In common with Comet 4s, they had wing-mounted tanks □ M.J. Hooks

Atlantic jet travel.

In due course course BOAC put its Comet 4s on other routes. Variants of the Comet 4 included the short-haul 4B with reduced span and stretched fuselage taking up to 101 passengers. The 4C retained the 4B's longer fuselage coupled with the 4's greater span. There was no Comet 4A; it was never built, being intended for Capital Airlines against an order which was cancelled. Comet 4s in their various versions went to Aerolineas Argentina, East African Airways, BOAC, BEA, Olympic, Mexicana, United Arab Airlines, Middle East Airlines, Kuwait Airways, Sudan Airways, the RAF (C Mk 4) and King Ibn Saud of Saudi Arabia as personal transport (Comet 4C).

About 65–70 Comet 4s of all variants were built, and they built up a first-class reputation. But this was a paltry number compared to Boeing 707 and Douglas DC-8 production. Unlike the Comet 1, which had no competition at all, the Comet 4 series had to compete with American jetliners, which were larger and much more in keeping with what airlines wanted. The Comet started off in a blaze of success in the early 'fifties, was rescued from severe technical problems at great cost and effort, and, rising from the ashes of near oblivion, it re-entered the ring to find intense US competition – indeed near invincible competition. But the Comet flies on, in the Rolls-Royce Spey-engined Nimrod. ■

TECHNICAL DATA
DE HAVILLAND DH 106 COMET 4

Type: Four-engined jetliner

Construction: All-metal with extensive Redux metal-to-metal bonding

Accommodation: 60 (first class) or 81 (tourist class) passengers. Flight deck crew comprises two pilots, flight engineer and radio operator/navigator. Pressurisation from engine compressor air bleed giving 8,000 ft (2,438 m) cabin altitude @ 40,000 ft (12,192 m)

Engines: Four Rolls-Royce Avon RA 29 Mk 524 axial-flow turbojets each giving 10,250 lb (4,649 kg) static thrust

Landing gear: Hydraulically-retractable nosewheel type. Twin nosewheels; each main unit comprises four-wheel bogie

Dimensions: Span 114 ft 10 in (35.00 m), length 111 ft 6 in (33.99 m), wing area 2,121 sq ft (197.05 sq m)

Weight: Empty (60 seats) 72,934 lb (33,083 kg), loaded (60/81 seats) 162,000 lb (73,484 kg), maximum landing (60/81 seats) 116,000 lb (52,618 kg)

Performance: Cruise 503 mph (809 kph) @ 42,000 kph ft (12,802 m), still-air range 3,225 miles (5,189 km) with 16,800 lb (7,620 kg) payload