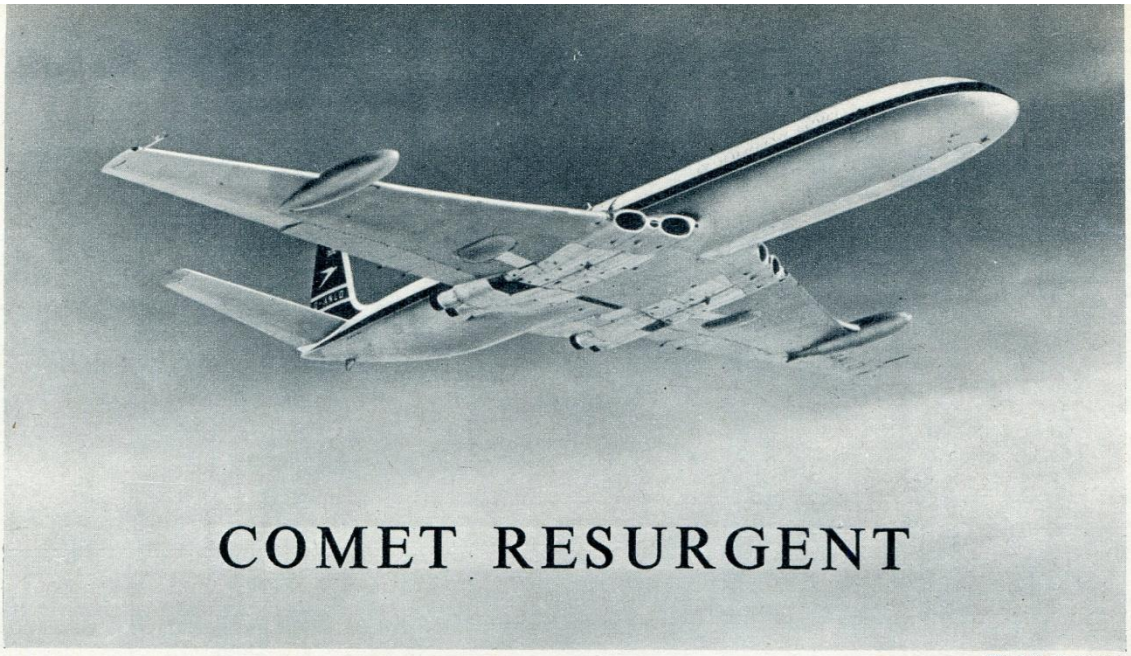


COMET RESURGENT

"Flight" photograph

A DECADE OF D.H. JET TRANSPORT DESIGN

THAT the Comet is "the most structurally tested aeroplane built to date" is a claim unlikely to be challenged. The de Havilland Comet 1, when it went into service in 1952, possessed a structure which could itself fairly claim to have undergone static tests at least as comprehensive as any to that date. Subsequent events, which exposed so publicly the wide gaps in man's knowledge of metal-fatigue, have now passed into the perspective of history. But the completely redesigned Comet structure which has since emerged probably represents—as it should—the contemporary art of structural design at its best.

The rig-testing programme behind the Comet 4 has been in progress without interruption since the start of the Comet 1 investigation in the early summer of 1954. The programme has been in two parts: (1) basic research into materials and design-methods to establish a new anti-fatigue design formula, (2) applied research to test actual detail Comet 4 components designed according to these new principles.

All this work, with one important exception, is now complete—at least so far as the Comet 4 is concerned, though obviously general basic research into fatigue goes on. The exception is the final proof-of-the-pudding test of a complete Comet 4 wing and fuselage. This assembly is now being immersed in the D.H. water tank at Hatfield where, during the next six months, it will be subjected to the now familiar programme of tank tests (*Flight*, December 30, 1955). A photograph appears on page 424.

It may be asked why, after such a comprehensive programme of demonstrating the safe life of the detail ingredients of the Comet 4 structure, an expensive verification test such as this is necessary. Scientifically, the results of satisfactory component-testing—which embraced seams, joints, materials, windows, canopies, centre sections, spars, undercarriage, etc.—might be proof enough. The fact that the complete test is nevertheless being made is a testimony to the thoroughness of the whole approach to Comet testing, as exhibited by D.H., the Air Registration Board and—not least important, since they have borne the greater burden of the cost—the Ministry of Supply.

The aim throughout the structural design and test-programme has been a minimum safe life for the Comet 4 higher than its useful operational life. If one assumes for "useful operational life" a figure of not less than 30,000 hr the magnitude of the test-programme can be appreciated. To provide for the scatter characteristics of fatigue, each specimen component has been tested to a figure five to six times in excess of this life (factors of 6 for the pressure cabin and 5 for the wing have in fact been applied).

An unexpected consideration in the early days of the Comet 4 design was the more severe fatigue-case presented by the (at that stage unforeseen) Comet 4B. This shorter-range member of the family—developed only during 1957 for B.E.A.—will obviously spend much more of its "useful operational life" riding gusts, pressurizing its cabin, landing, and so on. But D.H. are confident that the basic test-programme has been comprehensive enough to ensure that the 4B will be as good for 30,000 hr as the Comet 4.

A point worth noting particularly is that the fatigue-proofing process has been applied not just to the structure—i.e., to the parts of the aeroplane subject to flight loads. It has, in the words of a senior D.H. designer, been extended to "everything in the aeroplane that gets a towsing"; in order words, to a hundred-and-one components in the power systems and ancillary equipment.

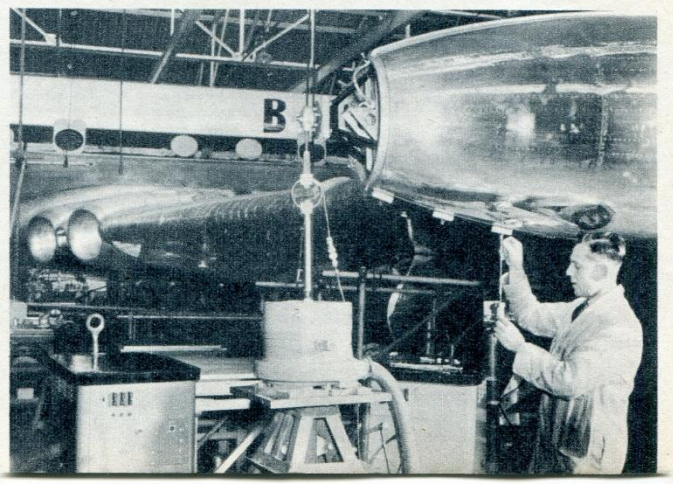
On the controversial structural question of "safe life" *versus* "fail-safe," the D.H. principle seems to be that there is no clear-cut distinction between either philosophy. If it is possible to design components to fail-safe, then this should obviously be done; but whether a component is fail-safe or not, it must certainly be designed for, and demonstrated to possess, a safe life.

General Comet 4 structural details worth highlighting are extensive modification of the rear fuselage to withstand jet-blast (the inner pipes of the 4, like those of the 2, are of course canted outwards to minimize the effect of blast experienced on the Comet 1s); redesign of the tailplane and elevators with thicker skins and doubled-up ribs to deal with the fatigue effects of jet noise; the use of 24ST (naturally aged aluminium alloy to American specification) on the lower tension surface of the wings; exclusion of zinc-alloy skins from the fuselage; and the use of steel for the important lug-forgings as employed for the attachment of wings, tailplane, and so on.

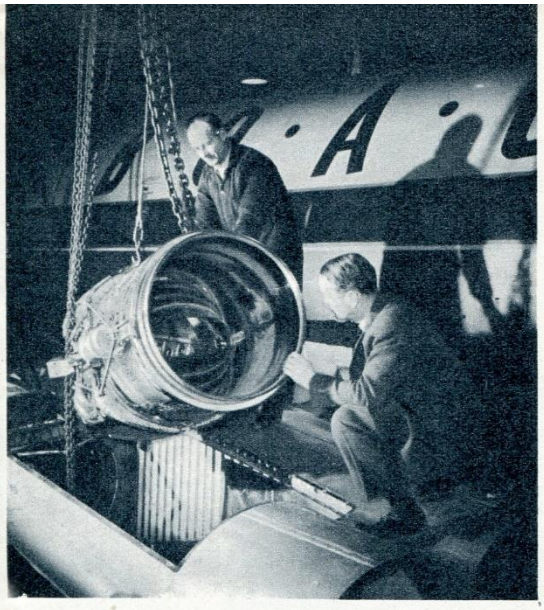
Structurally, therefore, the Comet 4 is a completely new design, to the extent that those familiar with the Comet 1 can examine almost any detail of the new Comet and find that it is different. All that remains the same, allowing for the different proportions, is the external shape.

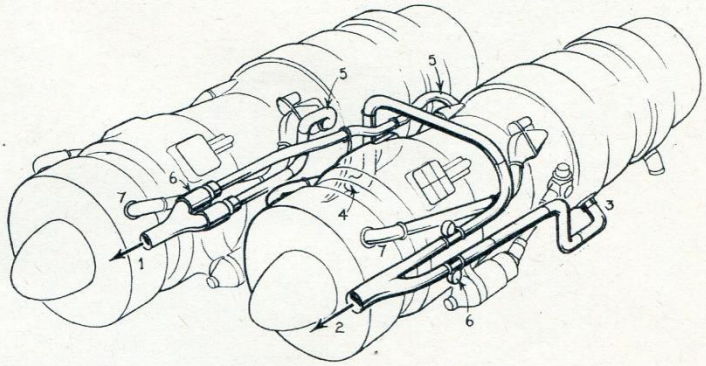
Re-engineering of the Systems. As was the case with the structure, each system in the Comet 4 was completely reassessed and in certain instances (e.g., electrics, cabin-air-system control, and flying controls) modified to embody features suggested by operational experience and modern ideas. A good new idea, for example, is the complete separation of all components associated with, respectively, the electrical and hydraulic systems.

In accordance with modern practice, the electrical power



The first production Comet 4, structurally quite different from previous Comets, undergoes a resonance test at Hatfield. Flight tests will begin next month, and deliveries to B.O.A.C. will start in September.





Four Rolls-Royce Avon RA.29s, rated at 10,500 lb thrust each, power the Comet 4. (Left) Test installation of the thrust-reverser in the Comet 3, for later incorporation in production 4s. (Above) How the RA.29 supplies not only the Comet's propulsion needs: 1, cabin air delivery; 2, anti-icing air delivery; 3, anti-icing air tapping (outer engines); 4, anti-icing air tapping (inner engines); 5, cabin air tapping; 6, control valves; 7, engine anti-icing air.

COMET RESURGENT . . .

distribution was duplicated by means of a split busbar, which, with a separate emergency busbar, provides for every contingency of electrical power failure. Capacity of the alternators is now 350 amps compared with 250 on the Comet 1, and all the electrical equipment has been thoroughly explosion-tested. American inverters are fitted (by Jack and Heintz) and American-type terminals are used; multi-pin plugs have been eliminated wherever possible.

The biggest change in the flying-control system is the introduction of artificial feel proportional to q, the parameter which determines air-loads according to the V^2 law. Q-feel is fully applied to the elevators, and the same system is used to restrict rudder-movement above 180 kt. No q-feel is applied to the ailerons, which cannot break the aeroplane. (Rudder movement by itself cannot in fact do so, but abuse of the rudder above 180 kt could conceivably cause excessive yaw and overcontrol; it thus requires restriction.)

The q-feel system is of D.H. design, and the external q-sensitive device (see cut-away drawing, pages 422-423) is remarkably neat and small. The compact dimensions have been achieved by using the effect of suction as well as of pitot-pressure to move—*à la* pneumatic jack—the operating piston. Though the flying-control system is still fully power-operated, Comet 4 pilots will have feel proportional to airspeed, as in natural-feel manual control systems.

Besides the inclusion of q-feel, numerous other changes have been introduced in the flying-control system. The Comet 1 was criticized for its high break-out force—the force required to displace the control column; in the Comet 4 this has been reduced from 18 lb-20 lb to 10 lb, mainly by the elimination of friction from the control system, and by the addition of automatic cable-tension compensators.

Another important addition is automatic trim with the autopilot (Smiths S.E.P.2) in use. Comet 1 pilots found it a nuisance to have to keep an eye on the trim indicator and to have to wind-on trim manually to compensate for the trim displacement of the autopilot. If they did not wind-on trim the autopilot's limit-switch could cut out, perhaps leaving the aeroplane considerably out of trim. The new system ensures that the autopilot trim position has been automatically compensated for. This compensation is achieved by an electric motor, in the pilot's trim circuit, which is sensitive to changes of load in the autopilot.

Stall-warning is provided artificially by means of a stick-shaker. The old Comet 1 gave warning of the stall by airframe shake—as indeed will the Comet 4. But because the stall can be fairly well advanced by the time the airframe starts to shake it was judged prudent to incorporate a stick-shaker. This installation was perfected on the Comet 2, and on the Comet 4 is arranged to operate at a speed 12 per cent above the stall whatever the aerodynamic configuration of the aircraft. Of course, a stalling situation is never likely to arise in service, and Comet 4 pilots can expect to experience stick-shake only during training and checks.

Again as in the Comet 2, gearing has been introduced into the elevator system so that the ratio of elevator displacement to stick movement is higher (2 : 1) during take-off and landing than during flight. Take-off is made with the elevator coarse; this is changed to fine during the climb to make the elevator less sensitive to stick movement. There is, in addition, a Mach-sensitive device in the elevator circuit (as developed for the French and Canadian Comet 1As) which automatically applies up-elevator at Mach 0.77. The Comet 3 has, incidentally, been tested up to a true Mach of 0.835.

Numerous refinements have been introduced into the flying controls. Requirements called for ability to trim the aircraft should the main controls fail: as the Comet achieves its trim by means of the main surfaces, special measures had to be taken. The solution is that the elevator has a duplicated power input and output—i.e., it has separate power boosters each with its separate control cable from the stick. Likewise the aileron power boosters have duplicated input and independent output, and the rudder is duplicated inasmuch as it has an independent trim circuit. The flying-control hydraulics, as before, are served by three systems, but these are now completely separate. The "yellow" emergency system, again as before, is supplied by an electrically driven pump, but one that is now cleared for continuous running if necessary.

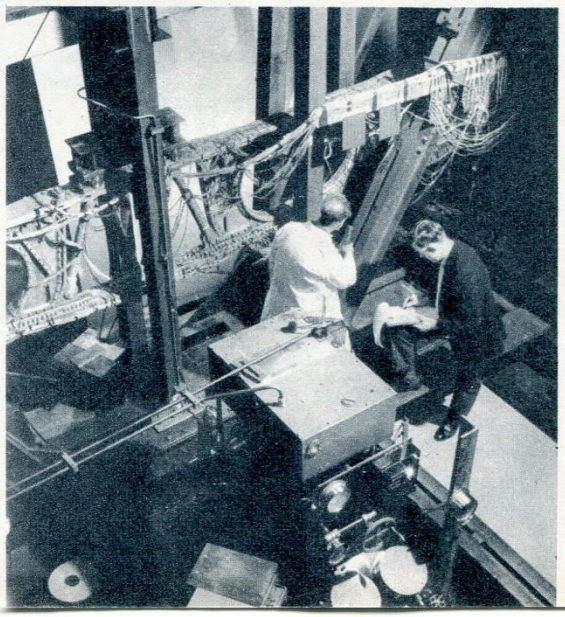
Other control improvements are more powerful ailerons (increased chord), and more drag for landing. The flaps are of the same general design, but movements have been changed so that "over the hedge" the inner split flaps move down from 60 deg to 80 deg. The outer plain-flap settings remain at 40 deg. A yaw-damper (autostabilizer) is fitted in the rudder circuit, and an automatic approach (I.L.S.) coupler is included in the autopilot system.

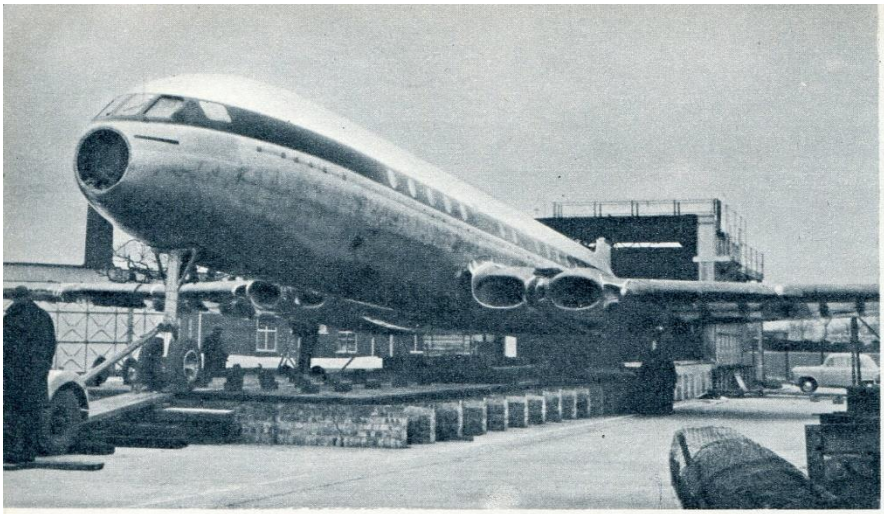
The Comet 4 (together with the Caravelle, whose control system conforms closely to that of the Comet) will be unique among transports in having power-operated flying controls, a legacy of the early days of Comet design when insufficient was known about the manual control problems of large, high-speed aircraft. But it is fair to add that no other transport will have flying controls which have been more thoroughly tested, or provided with more safeguards.

Another Comet 4 system which has been quite radically changed is that concerned with air-conditioning and pressurization. The

(*Continued on page 424, after double-page drawing of Comet 4*)

The structural-test programme behind the Comet 4 has probably been on a scale unprecedented in aircraft design history. Here is seen one of hundreds of tests: a strain-gauged spar undergoes fatigue reversals.

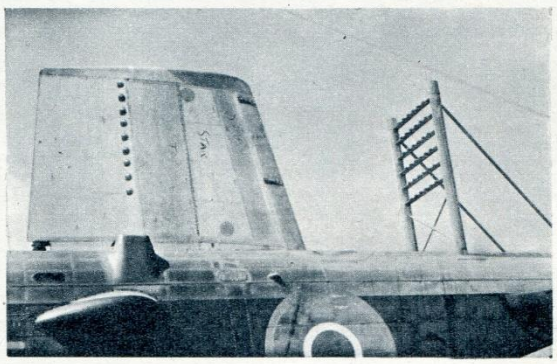


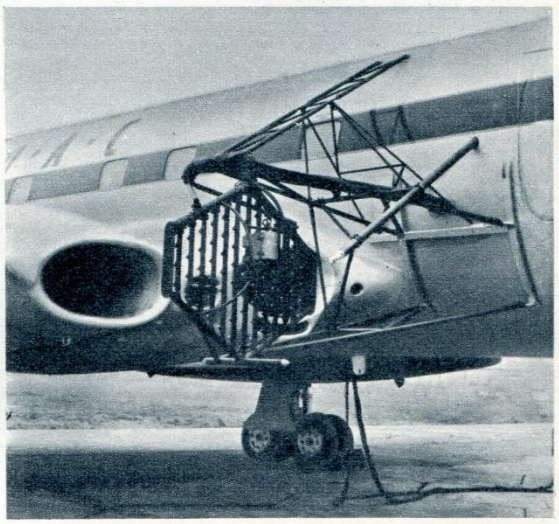


Last week, as seen here, the second production Comet 4 was moved into the D.H. water tank at Hatfield for final verification of all the detail fatigue-testing which the structure has already undergone. The aim is to clear the Comet 4 family of jet transports for a 30,000 hr life.

Below is seen a section of the Comet 4 tailplane mounted on the back of a Lincoln for subjection to heavy icing conditions. This work has been undertaken by Napier, designers of the Spraymat de-icing system. The lower picture shows the ice-making apparatus fitted to the old Comet 2X (Comet 1 with Avon engines) to test the engine's characteristics in heavy icing.

COMET RESURGENT . . .





cockpit control of this complex system is simple in the extreme, and almost fully automatic. The duplicated pressure controller, by Normalair, owes much to AiResearch experience. It is necessary only to preset the altitude at which it is required to start pressurizing, and the rest—temperatures, mass-flows, recirculation (no longer by a separate fan but by injectors all along the cabin), cabin rate of climb—is automatically taken care of. Two cold-air units made by D.H. Propellers under Hamilton Standard licence are fitted. De-misting and de-icing of the pilot's windscreens is now accomplished by glass with transparent electrically heated elements on the flat panels. Similar elements provide de-misting on the other panes.

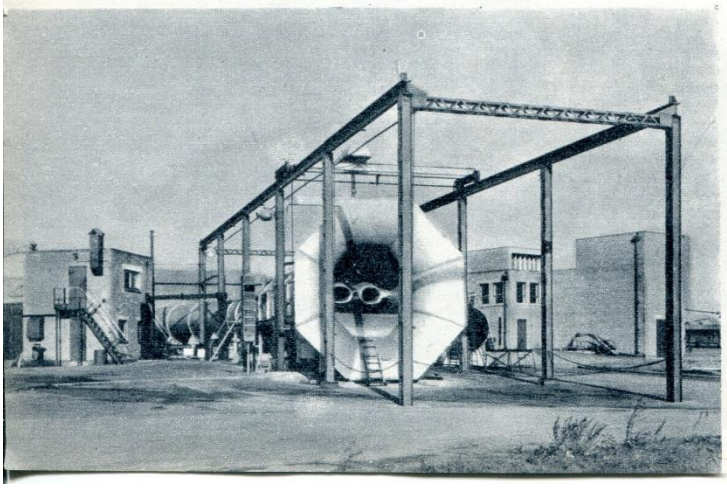
The de-icing arrangements have also been thoroughly overhauled, with the objective of clearance for the heaviest icing conditions envisaged by the British Civil Airworthiness Requirements, for both the airframe and Rolls-Royce Avon RA.29 engines. These axial compressor engines do not consume ice so imperturbably as did the old Comet 1s centrifugal-compressor D.H. Ghosts, and special tests are being carried out at Hatfield with a spray-rig (see accompanying photograph) on the original Avon-engined Comet 2X. The Napier company are contributing considerably to the development of the airframe de-icing system: a Lincoln is being flown with a portion of the Comet's tailplane—which incorporates the Napier Spraymat—mounted on its back for de-icing tests, as shown in the upper picture on the right.

The control cabin of the Comet 4 is without doubt the neatest and simplest of any large transport to date. The old Comet 1 was considered by flight crews to be exceptionally good: the cockpit of the new Comet 4—which owes a good deal to the advice of B.O.A.C.'s Comet fleet—could scarcely be bettered. The most noticeable change is the use of grey instead of black panels, American-style. All the instruments and controls stand out much more clearly, especially on the flight engineer's panel—one whose arrangement is worth singling out for special mention. Presentation of systems—e.g., electrics and fuel—conform as closely as possible to the "sense" of the systems themselves.

Although not applied to the Comet 4, the pilots' windscreen panels on the 4B (and no doubt the 4C if it materializes) are deepened by 4in to improve visibility.

The fuel system has been re-engineered quite extensively, the main improvements being to "foolproof" the blow-off valves of the pressure-refuelling system, and also to provide an independent fuel feed to each engine. No one fuel pipe is common to two engines, as it was in the Comet 1.

Rolls-Royce have built this "fire tunnel" at their Hucknall test establishment to prove the Comet 4 RA.29 installation's resistance to, and ability to deal with, fire. See text in col. 2.



The Comet 4 came under the close scrutiny of America's Civil Aeronautics Administration after Capital Airlines placed their now cancelled order. One of the points to which they gave special attention was the safety aspect of buried engines. They expressed no objection in principle to this kind of installation, but required practical demonstration of the fire-characteristics of the Comet's engine installation. As a result Rolls-Royce constructed a special "fire tunnel" at their Hucknall establishment (see left) containing a Comet 4 stub-wing complete with engines. All possible causes of fire have been applied during the tests, which are still in progress but have so far been perfectly satisfactory. The combustion-zone of the Comet 4's RA.29 installation is now, incidentally,

completely encased in titanium, and all fire detectors are of the Graviner Firewire type.

Rolls-Royce have made other important contributions to the Comet 4, in particular to the suppression of its noise (by an amount sufficient to have already satisfied the Port of New York Authority), and to the reversal of thrust for landing. The latter installation is not yet sufficiently developed for inclusion, as was at one time hoped, in the first of B.O.A.C.'s 19 Comet 4s, but it will be fitted retrospectively to those aircraft. The prototype Comet 2X has undergone ground tests with a prototvpe reverser, and the prototype Comet 3 is at present being equipped with reversers (on the two outer engines) for actual landing tests which will be made during the coming summer.

Finally—and most important from the point of view of selling the Comet to the passenger—the interior has been completely restyled for B.O.A.C. In accord with modern interior-styling practice the Comet 4's cabin represents a complete breakaway from the Corporation's traditional, and rather dull, dark blues and greys. Much use is made of colour, with a result which—judging by the impression which the mock-up gives—will more than match the "jet-age décor" which B.O.A.C.'s American airline rivals are introducing. The actual seating layout is of course flexible, the structural bulkhead in line with the wing spars forming a natural division for the different classes. B.O.A.C. have numerous schemes in mind: they will probably begin their Comet services to Sydney with 16 passengers forward in 56in pitch *de luxe*, four-abreast seats, and 43 passengers aft in 40in tourist, five-abreast seats. Any number of permutations of seating layout for the various classes of passenger can be played by B.O.A.C. (maximum "economy," or T-34, seating, if installed throughout both cabins, would be 81). D.H. have achieved the utmost possible flexibility of cabin layouts by providing lavatories and pantries both forward and aft in the cabin. An accommodation diagram appears on p. 423.

Five years will have passed between last deliveries of the old Comet I and first deliveries of the new Comet 4. Those years may have seemed long to the many who have wished impatiently to see the Comet re-established in service and ordered by overseas airlines. But the time has been well spent, to a degree which tempts one to say that if any of the new airliners is likely to give trouble-free service from the word go, that airliner will be the Comet 4.

FLIGHT TESTING THE COMET 4

IN a week or two's time the fruition of three years' design and development work, and of 50,000 hours' flying, will emerge from the de Havilland factory at Hatfield in the shape of the first production Comet 4 for B.O.A.C., G-APDA.

Normally, production aeroplanes issuing from the de Havilland assembly lines are not the concern of experimental flight-test, whose responsibility for developing the prototype is usually discharged by the time the first production aeroplanes appear.

The first production Comet 4, however, is sufficiently different from its progenitors as to require an "experimental" flight-test programme rather more elaborate than a normal production test. This programme will not be as lengthy as it might have been without the existence of the Comet 3 prototype, now 3½ years old and with 830 hours (in 581 flights) to its credit. Had the Comet 3 never been built, D.H. would have been confronted with perhaps a two-year programme of Comet 4 flying. As it is, they hope to have it ready for delivery to B.O.A.C. within 18 weeks of its first flight, in September of this year.

About 250 hours of Comet 4 test-flying should qualify the aeroplane for its full certificate of airworthiness. The distribution of these hours into various kinds of flight test work will be outlined in a moment: first must be recorded the indispensable contribution made by the Comet 3.

The prototype Comet 3 made its first flight at Hatfield in July, 1954, during the dark days of the Comet 1 investigation. Its future as a production aeroplane was uncertain for a year and a half, until in February 1955 B.O.A.C. placed their revitalizing order for an improved Comet, to be designated Comet 4. This New Comet, of which B.O.A.C. ordered 19, was to be the embodiment of all the experience and knowledge acquired, at such cost, to that date. D.H. reckoned that it would take three years to complete the transformation of their jet airliner, a measure of the amount of design and production work that lay ahead (see previous article). This estimate, though de Havilland have worked hard to reduce it, has in the event proved just about right.

Throughout this period, the responsibility of the experimental flight-test organization has been the testing and evaluation of the Comet 3 prototype in terms of the new Comet 4. Undoubtedly the greatest single advantage of the Comet 3 has been its aerodynamic identity with the 4. This has permitted D.H. to satisfy themselves in advance about the performance, stability and handling characteristics of the new Comet 4.

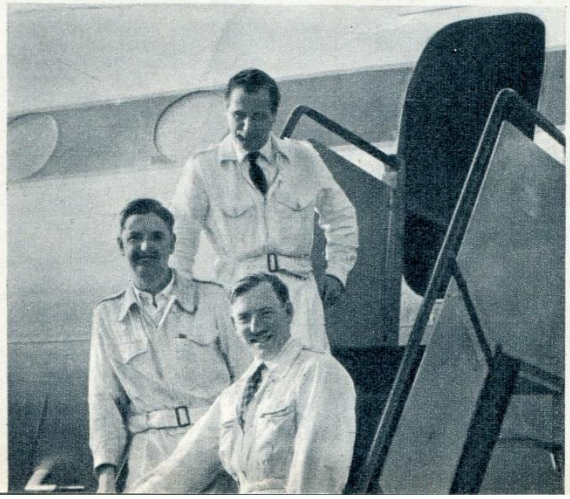
Though aerodynamically identical, the Comet 3 was unrepresentative in some fundamental respects—in particular, in its power, structure and weight—and it was untypical in many lesser respects also, e.g., in its systems and equipment. About a year ago, when Comet 4 redesign-work was well advanced, it was decided temporarily to withdraw the Comet 3 from flight tests and to make it as fully representative of the 4 as it could reasonably be made. This work, which began in July 1956, took seven-and-a-half months to complete. This reworked Comet 3 was dubbed the "3½." Actually, except for its structure (which could not have been much changed without building a new aeroplane) it was almost a Comet 3¾. The biggest change was to the engines: the Rolls-Royce Avon RA.26s of the original Comet 3 were replaced by the RA.29s of the 4, a modification which involved radical alterations to the engine-bays. Numerous other modifications were incorporated, mainly to the systems, in order to evaluate in advance new detail-design features of the Comet 4. (The flying controls system had already been amended to incorporate q-feel.)

This work made it possible to reduce the tests required of the first Comet 4 to the absolute minimum, and modifications to the Comet 3 will have saved D.H. possibly as much as a year on the whole Comet 4 programme.

Because the structure could not be much altered, there were certain operating limitations on the modified Comet 3. For example, it was designed for a maximum weight of 145,000 lb, whereas the

The three de Havilland pilots primarily concerned with the Comet flight test programme are (left to right) Peter Wilson, John Cunningham (D.H. chief test pilot), and Peter Bugge.

Of the 50,000 hr of Comet flying to date, some 5,000 hr have been in the course of makers' test flights. Members of the test team seen here (reading down) are E. Brackstone Brown, engineer; A. J. Fairbrother, aerodynamics; J. A. Marshall, instruments.



"Had the Comet 3 never been built, D.H. would have been confronted with perhaps a two-year programme of Comet 4 flying . . ." The Comet 3 is seen on test from its Hatfield base.

"Flight" photograph

COMET RESURGENT . . .

4 will be certificated for 156,000 lb. But the measurements and assessment of the Comet 3 inspire confidence in the behaviour of the Comet 4 beyond those limitations. It will, D.H. hope, be a straightforward matter of checking—a rather elaborate production flight test.

The actual Comet 4 programme will, according to present plans, be as follows. First—probably as these words are being read—the aircraft will undergo an extensive series of ground-functioning tests. All the systems, notwithstanding the hundreds of hours of rig-tests which have gone into their making, will be thoroughly checked according to a pre-arranged programme, especially those which could not be made fully representative in the Comet 3. For example, the flying control system, undercarriage, flaps and so on will undergo a large number of reversals, the electrical system will be subjected to a series of full-load checks, and the cabin air system will be run under simulated flight conditions. Next will follow fuel-flow calibrations and engine-runs, after which the first flight will be made.

The Air Registration Board require a minimum of 250 hours before full Comet 4 normal-category certification, of which at least 100 shall be under operational route-proving conditions. D.H. may be able to clear the aircraft in less flying time than 150 hours; but—as the next article relates—the balance up to 250 hours will be accomplished by B.O.A.C. No doubt the first few flights will be concerned with an assessment of the new systems—particularly the flying controls, which are mechanically quite different (mainly in respect of the emergency arrangements and the trimming) from any previous Comet, including the modified Comet 3.

There will follow an assessment of performance and handling, which will take the form of checks on Comet 3 results, plus items which could not be covered with that aeroplane because of its lower gross weight. For instance, high Mach number buffet-boundary will be explored, rough-air speeds will be checked, and handling at all c.g.s will be assessed throughout the speed range from the stall (including the ground stall at the higher weights) up to the limiting Mach number and i.a.s. In general, all the more critical handling characteristics found on the Comet 3—which the A.R.B. will have flown for 14 hours in its modified form—will be checked on the 4.

The performance evaluation will comprise spot-checks of Comet 3 results (e.g., a few cruise-consumption checks on the 40-odd done on G-ANLO) and of course there will be new performance measurements beyond the weight limit of that aeroplane up to the new maximum take-off weight of 156,000 lb. This will require further tropical trials in Africa, where the Comet 4 will probably also make a search for dry ice in the inter-tropical front. There is no anxiety that the RA.29 will be susceptible to these conditions, as was the reverse-flow Proteus; but its dry-ice behaviour will be checked nevertheless.

It should be recorded here that the Comet 4's take-off performance, which because of the aeroplane's plentiful power has always been good, looks like being well up on estimates, judging from Comet 3 results. And, as recently recorded in *Flight*, the basic weight of the first production aircraft has turned out to be considerably less than the brochure. In other words, range (or payload) is likely to be better than estimated.

In general, performance tests on the Comet 4 will amount to about 20 per cent of those done on the Comet 3. That aircraft will still be fully employed, not only for reverse-thrust landing tests, but also for such things as autopilot approach-coupler checks, of which at least 50 now have to be made before certification can be granted. And quite soon, no doubt, the Comet 3 will have its wing span clipped for an assessment to be made of Comet 4B performance.

It is difficult to estimate the amount of time which the A.R.B. will require for their flight evaluation of the Comet 4 before full certification is granted. But the D.H. flight-test department feel confident that it could be less than 10 hours—an encouraging indication of the amount of development which has gone into the new Comet, and the extent to which it will be taken as read.

B.O.A.C. AND THE COMET 4

Capt. T. B. Stoney, manager of B.O.A.C.'s Comet Flight.

MANY times during 1954, after the Comet 1 had been withdrawn from service, did one hear the question—particularly from B.O.A.C. crews: "When do you think the Comet will come back?" There never seemed to be any doubts that it would come back, so indestructible a symbol had the Comet become.

Though stunned by the way the Comet had suddenly fallen out of their lives, B.O.A.C.—literally everyone in the Corporation—did not lose faith in the aircraft. The Comet had inspired B.O.A.C.'s *esprit* and emotions as no other aeroplane had previously done. It was popular with crews, it swept in the traffic, it put B.O.A.C.'s name in front.

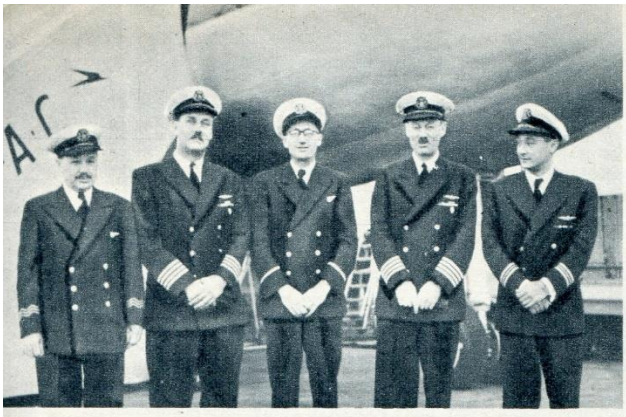
The air-transport industry has grown up a little since those days, and airlines are (to quote Mr. Donald Douglas) more interested in making money than headlines. The Corporation's new fleet of 19 Comet 4s should make both.

B.O.A.C.'s Comets will come back, in their new form, next September—nearly seven years after delivery of the first Comet 1, and more than four years after its withdrawal from service. As related in the preceding pages, the Corporation's new Comets will be virtually new aeroplanes, having twice the power, twice the range, a completely new structure and much improved systems.

According to present plans, B.O.A.C. will introduce the Comet 4 into service five months after taking delivery of the first aircraft in September. February 1, 1959, is the target-date scheduled for the inauguration of services to Australia. Comets are being put onto the Kangaroo service first in view of the partnership with Qantas; the Australian airline is due to take delivery of its Boeing 707-120s (bought largely with B.O.A.C.'s Comet 4 competition in mind) in May 1959. How quickly Qantas will establish their 707-120s in service after delivery remains to be seen; but Comets should dominate the Kangaroo route for at least four months. Comet 4s will be introduced at a four-times-weekly frequency, following the traditional Britannia 102 (formerly L.749A) route of London, Zurich, Beirut, Karachi, Calcutta, Singapore, Djakarta, Darwin, and Sydney. One of the four services per week will be routed *via* Colombo (Katanayaka), a service which is due to be inaugurated by Britannia 102s next month.

Britannia 102s will be completely and immediately displaced from the Australian route by Comet 4s, which will subsequently—starting in June 1959—displace B.O.A.C.'s medium-range turboprop from the Corporation's London-Tokyo route. By September 1959 Comet 4s should be handling most of the Far East services. Next, in January 1960, the Comet will take over the South African Springbok route, and by then the Britannia 102s will be relegated to the Corporation's services to East and West Africa, and those terminating in Pakistan and the Persian Gulf. There is a possibility—though B.O.A.C. do not confirm this yet—that Comets will reopen the Corporation's services to South America *via* the South Atlantic (suspended when Comet 1 capacity was withdrawn in 1954) in April 1960.

There have already been suggestions, as a result of PanAm's avowed aim to open transatlantic Boeing 707 jet services in October of this year, that B.O.A.C. should simultaneously introduce Comet 4s into transatlantic service. B.O.A.C. decline to be pressed on



Among the officers seen here, standing by one of B.O.A.C.'s two Comet 2Es, are (second from left), Capt. R. E. Millichap, deputy manager of B.O.A.C.'s Comet Flight, and (second from right) Capt. A. P. W. Cane. Formerly manager of the Comet Flight, Capt. Cane is now on the staff of B.O.A.C.'s general flight operations administration.

COMET RESURGENT . . .

this point. It has not been their intention to use Comet 4s on the North Atlantic, though they have looked at the aircraft's potential one-stop capabilities on this route. No doubt it would be a proposition, as a prestige-operation, but the Corporation is not likely to be easily persuaded—however great the political pressures—from its cautiously laid plans for introducing Comets on the Commonwealth routes.

Five months may seem an over-cautious length of time between delivery and service; but B.O.A.C.'s Comet Flight has set itself a training and route-proving programme of a thoroughness which even the most ardent prestige-protagonists would, in the light of B.O.A.C.'s past experiences, admit to be necessary. It is the Corporation's estimate that no less than 1,500 Comet 4 hours will have been flown between the time they receive the first aircraft from de Havilland in September to the time the first passengers are carried on February 1 next.

"Token" services would cause a severe disruption of commercial plans. It is B.O.A.C.'s intention that Comet services shall begin as a fully commercial operation right from the start. Four frequencies a week to Australia represents the most economical use of crews down this route, and makes it possible for the whole Comet operational machinery to be geared up to a realistic commercial speed right from the word go. But in order to mount such an operation at least half-a-dozen Comet 4s will be needed. B.O.A.C. expect to receive four before the end of this year from the Hatfield production line, with one or two more during January.

Thus B.O.A.C.'s choice of February 1 as the inaugural date for Comet services appears to be realistic, especially when additional time-allowance is made for the crew-training and route-proving programme. There will be eight route-proving flights to Sydney, accounting for about 600 hours, including local flying time down the routes. In addition, there will be a further 150 hours of "evaluation" flying under route conditions, 100 of which will no doubt meet the Air Registration Board's certification requirement referred to in a previous page.

All this accounts for 750 hours; in addition type-conversion flying will also account for 750 hours—making 1,500 hours in all before the first service.

The Comet fleet will eventually need 117 fully-trained crews to man its 19 aircraft. Each flight crew will comprise four men—two captains, a navigating officer, and an engineer. The actual requirements will be 261 pilots, 132 engineers, and 130 navigating officers. All 117 crews will, it is hoped, be trained within 18 months from the time type-conversions begin. The last aircraft of the fleet of 19 will be in service by December 1959 (the month in which B.O.A.C.'s first Boeing 707-320 is due to be delivered), by which time Comet crew-training should be nearly completed.

The requirement for the inauguration of services in February will be 24 crews. Comet-experienced pilots will have about 18 hours of route-proving, and those with more limited experience will get about 25 hours.

Initial conversion-training will obviously be for officers from the existing Comet 2E fleet (whose activities will be referred to in a moment). There are 21 Comet 2E captains, most of them ex-Comet 1 pilots, and including the manager of the B.O.A.C. Comet Fleet, Capt. T. B. Stoney, his deputy Capt. R. E. Millichap, the training officer Capt. B. G. Wallace, and other well-known former Comet 1 captains like Capt. E. E. Rodley.

All Comet 4 training flights will be based on London Airport, though circuits and bumps will have to be done elsewhere for obvious reasons. B.O.A.C. much appreciate the good relations existing with the airport staff, and many of the M.T.C.A. personnel have been given rides in 2Es to obtain first-hand experience of the A.T.C. problems—particularly jet problems—from the flight-crew's point of view. B.O.A.C.'s Comet 2Es have never been refused special facilities (e.g., an I.L.S. approach and overshoot) when sought; but obviously intensive training-sequences involving numerous take-offs and landings cannot be done around busy London. One likely alternative, with its excellent 10,000ft runway, is Stansted. Hurn—where Britannia crews are trained—may be too far away: an hour's dead flying (in between refuelling) at Comet consumption rates, even with jet fuel at 1s 5d a gallon, could be an unnecessary expense. An important advantage of London-based conversion-flying is, of course, the convenience with which simulator-training can be co-ordinated with actual flight-training.

Depending upon their previous Comet experience, type-conversion to the Comet 4 will require pilots to spend about ten hours on the flight trainer (not to be confused with the more elaborate Redifon flight simulator) and up to 12 hours in the air. Time in the air will, of course, be substantially reduced when the Redifon simulator is delivered before the end of the year.

About 18 of B.O.A.C.'s 261 Comet 4 pilots will be raw recruits. Because the Comet will be their first transport type, their training will be more elaborate, extending over a period of about eight months.

The Comet 2E has played an essential rôle in the B.O.A.C. Comet story. Two of these aircraft were delivered to the Corporation in August 1957, as the first stage in the long-term Comet 4 plan (see "Callsign Jet Speedbird," *Flight*, October 4, 1957). These two aircraft were fully modified production Comet 2s, similar to the ten previously delivered to R.A.F. Transport Command, with one important exception. The two outboard Rolls-Royce Avon RA.9 engines were replaced with Avon RA.29s, the object being to amass engine development hours while at the same time permitting B.O.A.C. to rebuild their Comet operations well in advance of Comet 4 deliveries.

By the time these words are read the two Comet 2Es will have completed about 2,700 flying hours since they were delivered to B.O.A.C. in the latter part of August last year. The aim was to clear the Rolls-Royce Avon RA.29 for a 500-hour overhaul life before the start of Comet 4 operations: in fact, these engines have already—two months before the end of the 2E programme—been cleared for 750 hr. Moreover, the A.R.B. have given their approval for one engine in each aircraft to be run to 1,000 hr. Whether or not, as a result of the strip, the RA.29 will be formally cleared for 1,000 hr between overhauls remains to be seen. But the fact that a transport turbojet of 10,500 lb thrust is, at this moment, in the running for a 1,000 hr life is worthy tribute to its makers and operators.

When B.O.A.C. took delivery of their 2Es they set a target of 3,500 flying hours to be completed by May 31, 1958. Owing to delayed deliveries, the programme had started 150 hours behind-hand. This was made up by increasing the weekly programme of round-trips to Beirut and back (or equivalent London-based single flights) from eight to eleven. In the event—thanks to the excellent serviceability of both the aircraft and its engines—the 3,500 hr programme will be completed by the end of May, according to the original schedule.

The aim has been to amass 125 hr per wek with the two 2Es, i.e., 9 hr utilization per day per aircraft. Often it has been more than this (in one recent week, for example, 13 round-trips between London and Beirut were made instead of the usual 11). Rarely has utilization been less than 9 hr per day, except when weather or training requirements have intervened.

The operation of jet transports at this rate for six months has obviously resulted in more than the proving of the RA.29 engines. Though dormant for three long years, B.O.A.C.'s Comet 1 experience (30,000 airline hours) has been thoroughly refreshed and reassessed in the light of today's operating conditions. The Comet 2E programme has also helped the Ministry of Transport and Civil Aviation, with whom there has been close liaison in such matters as high-level jet holding patterns, climb and descent procedures, *en route* cruising techniques, evaluation of Decca, and so forth. Soon, when their work on behalf of the Comet 4 is completed, the 2Es will co-operate with the M.T.C.A. in a new programme aimed at tackling the whole problem of integrating jet and conventional transports into the country's air traffic pattern.

Thanks to the Comet 2E, B.O.A.C.'s Comet Flight—to borrow a phrase from the U.S. Strategic Air Command—is at a high state of readiness, and the transition to Comet 4s should be smooth.