THE WORLD'S AIRLINERS

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FOREWORD

by Marshal of the R.A.F. Lord Douglas of Kirtleside, G.C.B., M.C., D.F.C., M.Inst.T.

(CHAIRMAN OF BRITISH EUROPEAN AIRWAYS)

Transport aircraft are daily becoming more important in the modern world. As the airlines expand their business from year to year (air traffic doubles in volume about every five years), so their growing fleets of aircraft become of interest to larger numbers of people—be they operators, aircraft manufacturers or simply air travellers or shippers of air freight.

So far as I am aware, no book in any way comparable with *The World's Airliners* has been produced before. There have, of course, been plenty of previous reference books setting out the technical characteristics of aircraft, including a number specifically devoted to transport aeroplanes, but I do not think anybody has previously attempted such a complete and carefully documented comparative analysis of every type of airliner currently in scheduled service.

No doubt there will inevitably be some who will contest some of the author's figures and conclusions. However, I do not think anybody, who studies the mass of information contained in this book, will doubt for a moment that a great deal of trouble has been taken to establish the accuracy of all the facts and figures given or will question the impartiality of the comparisons and criticisms which are made. The result is a unique study of the equipment used by the world's airlines. It provides for the first time a comparative statement of all the more significant characteristics, in a uniform standardised form, of every old and new airliner in scheduled service in the Western World, as well as of the Russian types used by countries of the Soviet Bloc. In addition, there are details of the helicopters employed in the first phase of scheduled operations with these aircraft.

Peter Brooks has had unusual opportunities during the years since the war to study transport aircraft developments. First with the British Government department responsible for civil aviation and then—from 1950 to 1961—with British European Airways, he has been closely involved in planning the operational and engineering development of airline equipment and in refining the techniques required for the efficient and economic use of this equipment to meet the rapidly expanding demands of this dynamic and fiercely competitive industry. During this period, B.E.A. has, in fact, been one of the relatively few airlines in the world which have been directly responsible for the initiation, development and introduction into service of a whole series of new types of successful major airliners. At the same time, the airline has been engaged in a sustained effort in the pioneering of scheduled helicopter services. Much of that which has been learned in this period about the technical, operational and economic requirements of aircraft for scheduled airline use is synthesized in the material contained in this book.

AUTHOR'S NOTE

A series of data sheets about transport aircraft, kept by the author for many years for convenient reference, form the basis of this book. The data has been corrected to September 1961 but this does not mean that it is now out of date.

There is a common misconception that the more dates in a book, the more quickly it becomes dated. This is why so many reference books contain undated information. In fact, this practice has the opposite effect to that intended: uncertainty about the date of information limits its period of usefulness because no allowance can be made for the effect of changes which can otherwise often be estimated if the time scale is known. For this reason, the opposite policy has been adopted in this book. The aim has been to ensure that all figures were correct as at mid-1961 and, where specific information (such as aircraft prices and engine overhaul lives) is liable to frequent change, it has—as far as possible—been precisely dated. In addition, in many cases successive figures have been quoted, and dated, so as to show historical trends which can be projected forward to give an indication of probable values at later dates. By this means, intelligent use of the material in this book should retain its value as a work of reference for a considerable time. This should be particularly true if it is used in conjunction with the most up-to-date information on transport aircraft which is given from time to time in special issues of the aeronautical journals.

ACKNOWLEDGEMENT

Some of the material in the Introduction to this book first appeared in a paper, "Profitable air transport: present requirements and future possibilities", read before the Third Symposium of the Cranfield Society held at the College of Aeronautics, Cranfield, on September 16/17, 1961.

INTRODUCTION

There has long been a need for a reference work about the world's airliners. Not only those in the airlines and in the aircraft manufacturing companies but also government authorities, airport operators, students of air transport, military staffs and even interested air travellers and airport visitors often want a convenient source of reference giving details of these new vehicles which have spread their network of services to the far corners of the earth. This book sets out to meet the requirement. Most standard references giving aircraft data present it in a form to which the manufacturers and aviation journals have adhered for many years, but which is more suited to military than to transport aeroplanes. The transport is different from other types of aircraft in that it is usually built in relatively small numbers and often remains in use in unchanged form for a long time. Its obsolescence rate is, in fact, normally so much slower than that of other aircraft that successful types often remain the most important in service long after more recent designs have appeared and been publicised as the latest vehicles in use. The great bulk of the world's scheduled air transport in 1961 was performed by some 5,000 aeroplanes of about thirty different major basic types. The majority of these aircraft are in highly intensive use and many of them have already been, and will remain, in service for many years. About half the aircraft in service in 1960 were more than ten years old, while the most numerous type—the Douglas DC-3—first flew more than a quarter of a century ago.

1961 is an appropriate point at which to produce such a survey because the so-called "jet era" in air transport is just beginning, making it a time of unusual change in the airline industry. The older piston-engined equipment is being replaced by turbine aircraft which are becoming the new standard main-line types of vehicle—much as the piston-engined metal monoplanes had been for the previous twenty-five years. This is not to say, however, that much of the older equipment will not continue to be used for a long time in a secondary role. Indeed, it will probably be some years before the older types entirely abdicate all their trunk route responsibilities. For these reasons, both old and new types are studied in this book.

Current and Future Airliner Developments

As has been said, an important proportion of the aircraft in airline service today continue to be of the older piston and turboprop types which have served the Airline Industry so well for many years but, as from the start of the 1960s, the new jets have established themselves as the competitively-significant first-line equipment on the majority of trunk routes. While these first generation jets have been making rapid—and on the whole astonishingly incident-free—progress bedding themselves down operationally, they have also given convincing evidence of their ability to "show-off" the propeller types in the airlines' fierce competition for revenue. On routes all over the world—although so far still predominantly on the longer hauls—jet aircraft have increasingly shown themselves to be competitively essential, while traffic on services flown with propeller aircraft has suffered correspondingly. The passenger appeal of the jet, which was first demonstrated by BOAC with the Comet I on the routes to Africa and the Far East in 1952–3, has now been confirmed beyond question.

At the same time, the economics of most of these radically new aircraft have not proved as unsatisfactory as some prophets of gloom had foretold. Indeed, the indications are that the operating costs of particularly the larger versions of the Boeing 707, of the Caravelle and of the various models of Comet 4 are working out close to estimates and should, in due course, at their differing economic levels, earn good profits for their operators. The DC-8 and the Boeings had to have major retrospective modifications to make good deficiencies in performance and handling, and the initial economic characteristics of the former may have suffered to some extent in consequence, but there is reason to believe that the DC-8 and, when they have accumulated enough hours, the Convair CV-880/990 series also—will in time win through to full commercial success (at least so far as their operators are concerned). The omens for the more recently designed British Trident, V.C.10 and B.A.C.111 should be equally good.

The fact is that even the first generation jets, the majority of which have single-flow engines of relatively high specific fuel consumption, are already proving to have reasonable operating costs. The only problem has been to fill these often much larger vehicles to economic load factors. Once they are properly worked into high-intensity service, the new types should be able to offer—at something in the region of threepence per seat-mile—a significant reduction in unit operating costs over their propeller-driven predecessors.

Those airlines which, by their example, launched the Industry into the "jet buying spree" in 1955–6 cannot have hoped for more than this. With the further developments of the jet engine now in prospect, additional worthwhile advances in operating economy and consequential further reductions in fares and expansion of the business should, in due course, become possible. It is already evident that the airlines' swing to jets was not the irresponsible act which some critics claimed.

While these important developments have occurred on the routes—where the final test must always be—a gradual change has occurred in the planning of those more progressive operators who play the key role in shaping future aircraft policy. A revolution in thought is taking place largely as a result of progress with more advanced designs of turbine engine since jet buying started in October 1955. At that time although Rolls-Royce, in particular, had even then been advocating dual-flow engines for a considerable time and was engaged in the development of the Conway by-pass engine, the possibilities of development in this direction had yet to be fully demonstrated. At that time also the turbine had still to establish the much higher standards of reliability which it has to offer, and the considerably longer overhaul lives, with all that these can imply in lower engineering costs.

The first dual-flow engine, the Conway, entered airline service on March 17, 1960 and, although its by-pass ratio (at 0·3 : 1) is too low to realise the full possibilities in improved economy which are now promised with more advanced engines of this type, it has already clearly demonstrated the correct direction for further progress which all the major jet engine manufacturers are now hastening to follow. Meanwhile, also, the pioneering Dart turboprop, with an overhaul life of 3,000 hours after seven years' service, had already achieved double the life between overhauls of the best piston engines and promised to do even better after further service. Turbine possibilities in this direction are becoming clear for all to see, as are the much higher than piston engine levels of reliability of all of the dozen or so types of turbine now in use with the airlines.

As a result of these developments, the dual-flow engine in one or other of its various forms is increasingly seen as the answer to the airlines' needs over the whole spectrum of their requirements. It has been clear for some time that many of the large first-generation jet airliners—particularly those with their engines in pods—would in time be re-engined with dual-flow engines, and that all the later larger jet transports would adopt this type of power unit from the start. However, it now seems that the jet engine may, sooner than was at one time thought possible, prove to be the best answer down to even the smallest and shortest-range feeder types of transport aeroplane. Thus, although the turboprop will undoubtedly have a longer and more useful innings on the shorter hauls than it has had on the longer routes, the indications are that even on the shortest hauls it may quite soon be proved inferior to the remarkably small, light and efficient dual-flow jets which are now in prospect. The signs are, in fact, that the jet may take over in all transport aircraft built after about the mid-1960's.

The advances in gas turbine technology which are creating these possibilities seem likely to provide dual-flow jet engines—with pressure ratios as high as 15 to 20 and by-pass ratios of 2·0 or more (i.e. 3·0 or more in American notation)—in all the required sizes for transport applications, with cruising fuel consumptions down to as little as 0·7 lb./lb./hr. The first generation single-flow jet engines have fuel consumptions of about 0·9 lb./lb./hr., while the piston engine and turboprop types average about 0·5 lb./hr. This means that the latest dual-flow jets have, in fact, reduced by half the disadvantage in fuel consumption under which the first jets have laboured in comparison with propeller-driven types. At the same time, these new engines may weigh as little as a fifth of a pound per pound of thrust, with remarkably small over-all dimensions. The resulting savings in weight and drag promise to more than offset the jet's higher fuel consumption now that this has been so substantially reduced.

Use of these engines in all transport aircraft will raise operating speeds to at least M 0·7 and those of the larger types to between 0·8 and 0·9. Somewhat lower speeds than the immediately subsonic regime of the larger trunk-route airliners will probably be selected for the smaller and shorter-haul types, because high cruising speeds give small benefits in savings in journey time on short sectors while the greater wing sweep required for the higher subsonic speeds makes it difficult to offer the good low speed characteristics and short field performance which are so important for shorter-haul applications.

Considerable progress is, however, being made in improving maximum lift coefficients of swept wings. The unswept wings of propeller-driven transports have, in practice, been giving C_{Lmax} of between 2·5 and 3·0 by the use of double-slotted or Fowler flaps. (This compares with a C_{Lmax} of 1·5 for unflapped wings.) However, the first swept-wing transports have suffered from a decline in maximum lift coefficient to 2·0 or even less. This loss is now being won back by a combination of improved detail design of trailing edge flaps and the use of leading edge slats or nose flaps. More complicated designs of flap (such as the treble-slotted type on the Boeing 727) are also in prospect. Flap blowing will probably, in due course, give further benefits. A possible future development is the jet flap, in which a sheet of high velocity gas replaces the mechanical flap. The greater circulation such a device can generate around a wing offers the possibility of increasing its lift to as much as four times that of a conventionally-flapped wing. Such a development can then be used either to improve cruising speed and economy or to reduce runway requirements. If applied to the improvement of economy, a reduction of about 15 per cent in operating costs may be possible.

Another development which might be applied to transport aircraft is boundary layer suction to reduce drag. If laminar flow can be achieved by this means over 75 per cent of a subsonic aircraft, the lift/drag ratio might be nearly doubled and the total operating cost of a long-range aeroplane reduced by something like ten per cent. Laminarisation over a greater proportion of the aeroplane would give even larger benefits. The main uncertainty about this development is whether effective boundary-layer suction can be achieved in practice in airline service. There is also the question of the cost of research and development of innovations such as jet flaps or boundary layer control. If such developments are of interest to the military, civil aircraft may be able to turn them to good economic account. However, if all the cost of their development has to be charged to any new civil transport aircraft which uses them, the resulting extra standing charges may go some way towards counter-balancing the potential reduction in intrinsic operating cost.

At present it is difficult to say whether either of the developments mentioned above will interest the airlines. New methods of direct lift may overtake the jet flap, while laminarisation may take so long to develop in practical form that it may be of value only if it can be applied to supersonic aircraft—and this has yet to be established.

Supersonic Transport Possibilities

In spite of the widespread study of supersonic transport projects now going on in several countries, it seems unlikely that the airlines will be ready to make use of such developments before the mid-1970s. The airlines have become so heavily committed to subsonic jets that they are unlikely to be able to face such a major step in re-equipment until they have had ten years or more to write off current types.

In addition, it seems unlikely—as has sometimes been suggested—