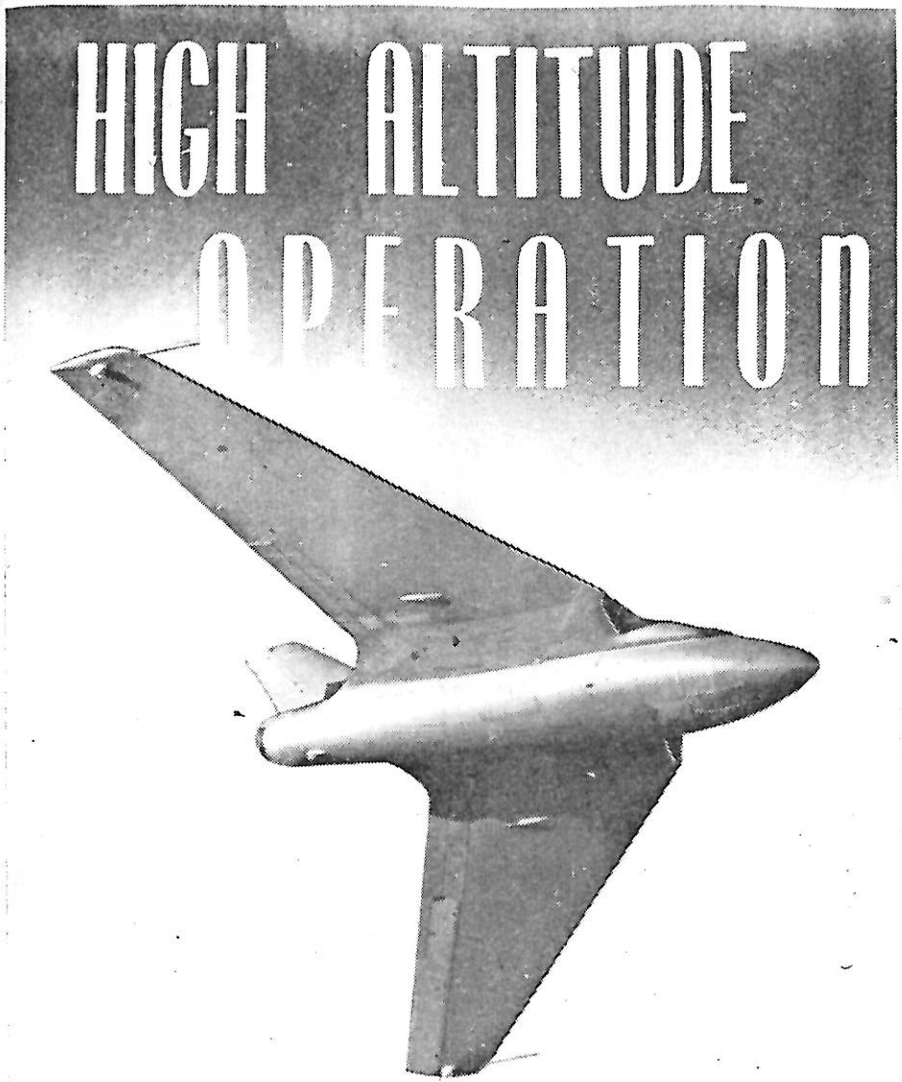
HIGH ALTITUDE OPERATION



We May Dream of Airliners Flashing Through the Stratosphere But Let's Study Some of the Down-to-earth Problems of High-Altitude Operation as Posed by an Expert

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THE picture of commercial air services operating at high speeds at high altitudes is one which has recently received considerable publicity, and the subject has attracted to itself a certain amount of glamour. This idea of "stratosphere flying," as it is often loosely called, has a considerable appeal to the imagination, at least to many members of the general public, even though they may have no very clear idea of the advantages to be gained by flying at these high altitudes.

This publicity, coupled with the fact that aircraft intended for high speed/high altitude operation are actually under design, and in some cases under construction, has encouraged an impression—and not only among the general public—that the introduction of such aircraft into commercial airline operation is not very far off.

Prophecy in aviation matters is always dangerous and I do not attempt to forecast when we may see these aircraft in operation, but it seems desirable that a note of warning should be sounded. For, while design work for the first stage of the necessary development program is well advanced, it must be appreciated that a large number of design and operating problems remain to be solved, and the research required to produce the necessary data—in many cases the amount of this research will be very extensive—is, for the most part, still at an elementary stage. Furthermore, if experience in these matters is any guide, it must be anticipated that, as research proceeds, fresh problems will arise.

Airline operators are keenly interested in the development of high altitude operation because, apart from the fact that more stable weather conditions exist at altitudes of 30,000 to 50,000 ft., high altitude is required to attain higher speeds for a given power in order to reap the advantages of turbine and jet propulsion.

Advantages of Speed

Higher speeds confer a number of valuable advantages from the operator's point of view. They may be summarized as follows:

1. Increased aircraft utilization, i.e. number of commercial operations, both per year and per major overhaul and inspection: hence, reduced maintenance charges per commercial flight, smaller number of aircraft for a given schedule, and consequent reduced fleet charges.
2. The elimination, to a large extent, of night stops and the associated expensive overheads in equipment, night stop facilities, and staff. On many routes the elimination or reduction of meals in the air and the weight of catering equipment, etc., with consequent increase in payload.
3. The reduction of passport and transit visa formalities, etc., if, due to elimination of night stops, passengers do not have to leave aircraft or airport at intermediate halts.
4. Increased regularity against adverse winds and hence reduced schedule tolerances, thus backing up 1 above.
5. Reduced number of crews, and hence increased payloads and lower overheads, since high speeds will eliminate need for relief crews on long operations.

Better Weather Upstairs

The better weather conditions should give:

a. Increased regularity due to avoidance of a large measure of the poor weather at lower altitudes; associated with this a corresponding reduction in flight hazards.

b. Increased passenger comfort.

c. Reduced crew fatigue, supporting 4 above.

Therefore directly or, in the last analysis, high altitude operations should lead to lower air fares, greater regularity of operation, and promotion of greater demand for air transport.

Associated with these considera-

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tions is the fact that the only engines which will, at acceptable weights, maintain the power for high speeds at high altitudes are the jet turbines and propeller turbines. These relatively light-weight engines would also give powers and speeds at lower altitudes which are appreciably greater than those for current aircraft; but such an application would be uneconomic, partly because of the engine characteristics and partly because of the unavoidable cost of speed in dense air at low altitudes.

The turbine engines also offer, potentially, reduced maintenance charges due to their smoother rotary motion and increased passenger comfort. These advantages and characteristics would, in any case, ultimately compel the operators to seek high altitude aircraft.

It is thus inevitable that operators will attempt to realize the advantages of high altitude operations set forth above. But in regard to large aircraft, both in their present form and in the future, it is well to bear in mind that they will always be expensive in design and research work, material, and cost of production.

Present Planes Not Obsolete

For these reasons alone they cannot be replaced at short intervals, and when too high initial costs are added problems of route facilities, crew training, equipment handling, passenger physiology, etc., it is evident that there must be an extended overlap period, possibly as long as the 10 years, from 1955 to 1965, when the aircraft as we know it today will still be holding its own against the high altitude types with which this article is mainly concerned.

In this connection it is well to remember that the performance even of the present-day medium-altitude aircraft is sufficient to offer the public a very fast and reliable form of transport, and any failings in these respects are due less to deficiencies in aircraft performance than to absence of proper ground facilities, signalling, and meteorological aids, absences which could equally well reduce the value of the high altitude aircraft.

By far the greater part of the necessary research programs in connection with high altitude/high speed aircraft is related to basic aerodynamic and control problems, strength of materials, and so on, the early stages of which are not directly influenced by the operators. These problems have to be solved by aircraft designers and aeronautical research establishments

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High Altitude Problem

A Problem	B Effect on aircraft design
I.—Economic methods of engine production.	
II.—(a) High turbine fuel consumption at low altitudes and powers.	Provision for airdrome-controlled stand-off periods, diversions to alternate, etc., increases aircraft tankage and gross weight for given operation.
(b) Prevention of turbine icing.	Major installation design problem.
III.—Wind strengths and frequencies at high altitudes.	Determines fuel tankage and gross weight of aircraft for regular operation.
IV.—Humidity and temperature at high altitude.	Determines turbine powers and consumptions; aircraft speeds, etc., scope and weight of cabin, air conditioning systems, etc., engine fuel flows; viscosity and specification of fuels and oils; characteristics of fuel system lines and pumps, etc., nature of anti-icing precautions to be taken on airframe and engines.
V.—Gust formation.	Aircraft structural strength; need for gust alleviators. Installation of radar gust and cloud detectors.
VI.—Local speed-of-sound barrier.	Aircraft strength; aircraft control and stability characteristics; unnecessarily low limits on aircraft operating speeds; need for anti-vice-speed flaps; special instrument development.
VII.—Low-speed control and stability characteristics with particular reference to (a) high sweep-back, (b) tail-less designs, (c) flap design.	Ultimate developments in range, speed, and payload, of subsonic speed aircraft are dependent on these problems, which have already limited scope of some existing projects.
VIII.—Radio aerials; suppression in aircraft structure.	Potential speeds, loads, and reliability of high altitude, jet-turbine aircraft will be considerably reduced if fixed communications aerials must remain external to the airframe.
IX.—Noise.	All work on noise suppression has been related to relatively low-frequency propeller, exhaust, and engine noises. It already appears that turbine-jets introduce new soundproofing problems.
X.—Effect of pressure loss due to cabin or cockpit window failure.	Might determine sizes of doors, windows; need for oxygen equipment; elimination of speed or strength limits on rate of descent.

Common to Aircraft Designers and Operators

C Effect on operators' program	D Current Development or Research Program	E Research Program Satisfactory or Unsatisfactory
Price of production turbines still unknown since they are still manufactured by toolroom methods. Operators cannot therefore estimate capital expenditure or operating costs with any accuracy. Prices still too high for economy.	Engine manufacturers will automatically clear this problem as designs become stabilized and normal production methods become possible.	Will be satisfactory in due course.
Increases final cost of aircraft; limits payload; reduces operational flexibility, and increases operational hazards.	Now taking low priority since materials, design for increased power and reduced fuel consumptions at high altitudes given greater priority.	Unsatisfactory.
Determines safety and regularity on flight up and down from high altitude.	Research and development programs in hand in industry but no results yet.	Only moderately satisfactory.
Determines first cost of aircraft; regularity of operation; schedule times; direct operating costs.	Radiosonde program by Meteorological Office. Not yet world-wide.	Unsatisfactory; lagging well behind operational program for aircraft. Operators may have to commence program with inadequate data. Basic design of present generation of high altitude aircraft may not be adequate for air purposes intended. ... ...
Regularity of operation and crew and passenger comfort.	As III. above.	As III. above.
Damage to aircraft and/or passengers in flight. Need to reduce speed below optimum for economy in order to avoid structural failure. Need for flight diversions. Hazards of undetectable gusts.	(a) Theoretical studies of gusts and preparation of statements of assumptions on gust formation, strengths, extent, and limiting altitudes. (b) Development of radar cloud detectors. (c) Carriage of gust recorders on civil aircraft.	(a) Probably as extensive as now practicable but still unsatisfactory. (b) Development and production too slow. (c) Of some value but not directly applicable to high altitude flight.
Limitations on potential speed of aircraft on extended descent from altitude. Limitations on normal cruising speed due to need to provide good margin of safety. Special training of pilots. Hazards due to lag in pilots' response if "vice-speed" inadvertently approached.	(a) Applied aerodynamic and structural research work by aircraft manufacturers and research establishments. (b) Instrument development. (c) Applied physiological research on pilot reactions.	(a) Assumed satisfactory. (b) Assumed satisfactory. (c) No information on work in hand.
Ultimate speed development of jet-turbine aircraft has been delayed by one generation, and even with successful development of existing projects operators cannot yet reckon on stability of max. operating speeds.	Manufacturers' programs of design and research have been limited through pressure to introduce earliest versions of commercial jet-turbine aircraft with current type layout so as to avoid new problems of control and stability.	Moderately satisfactory.
As for column "B."	Problem of suppressing aerials must be related to specific aircraft designs and is the joint responsibility of radio and aircraft experts. This liaison is producing satisfactory results only on aerials for radar equipment, and not communications gear.	Unsatisfactory.
Passenger comfort, crew health, and hence overheads will all be affected if new problems arise.	Applied research is not yet receiving attention, but cannot be dealt with until experimental turbine-jet aircraft are flown.	Satisfactory.
Passenger mental comfort. Hazard to aircraft, crew, and passengers. Payload as affected by weights of windows, oxygen equipment, etc.	Studies on effects of varying rates of decompression on invalids, elderly passengers, normal passengers, etc., required.	Moderately satisfactory.

High Altitude Operation

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long before the operator comes on the scene.

There are, however, a number of problems associated with high altitude/high speed aircraft which are of direct concern to the operator, and which also determine aircraft design characteristics. Some of them merely amount to the accumulation and statistical analysis of meteorological data, but it is possible that because of the inadequate collection of these data some of the high-speed/high altitude projects will be limited or delayed in their intended application.

The accompanying tables set out such problems, indicating the degree of advancement of existing programs of research. Not included in the table but of great importance are miscellaneous **physiological problems** associated with very high-speed transports. These problems include:

(a) The rapid change of climatic conditions on the ground. This will require provision of cabin air-conditioning equipment for use on the of cabin air-ground. Certain practical development work by manufacturers is under way but results so far are "unsatisfactory."

(b) The need for inoculations and injections when entering tropical regions. This introduces delay between decision to travel and actual departure date.

(c) Adjustment of meal times to suit local times. This might affect the weight and scope of catering equipment and hence payload.

(d) Claustrophobia due to confinement in closed spaces of small pressure cabins. This might affect the size of windows and doors, hence payload. Future experience probably will be the only source of information.

(e) Crew strain resulting from knowledge of effect of pressure failure.

(f) Passenger and crew reactions to rocket assistance take-off. This will determine aircraft payloads and airport dimensions in tropical regions. Progress in England on rocket assistance for civil aircraft is slow.

The existence of the above physiological problems is appreciated by the operators, but it is probable that their final solution can be achieved only on the basis of extensive operating experience.

Many of the items listed in the tables are relevant to low altitude conditions, but must be solved if high altitude flight is to be commercially practicable. It should be mentioned that where the word "unsatisfactory" is used in these tables it is intended simply to represent the state of research from the operator's point of view, and not to suggest that manufacturers or research agencies have made less profit than ought to have been achieved.

This summary of design and operating problems reveals how formidable is the amount of research that has still to be undertaken. It also raises the question whether design work already carried out on aircraft currently under design or construction may not have to be considerably modified at a later date when the results of research become available.

Clearly this possibility cannot be excluded, always bearing in mind that where commercial airline operation is concerned it is not sufficient that an aircraft may have flown successfully a few times under certain

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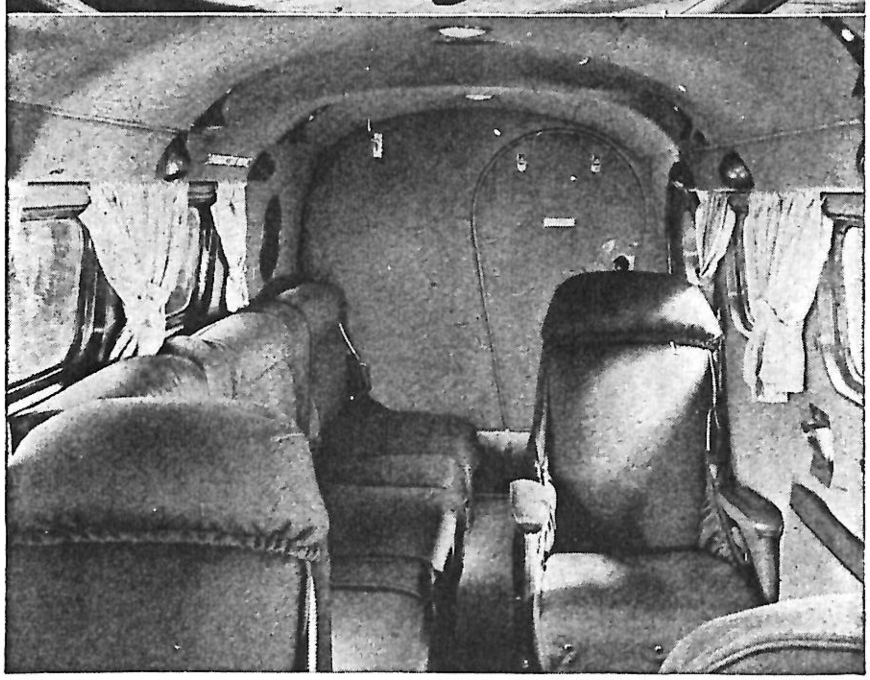

conditions, but that it can be relied upon to continue to do so under the most difficult conditions, and further to do so safely, regularly, economically and with at least a reasonable degree of comfort for its passengers.

The number of problems the solution of which can be left to be worked out in actual airline service is always strictly limited. It will be necessary to find the answers to the great majority of the problems listed in these tables before the aircraft are put into production for delivery to the operators.

Having said this, however, it should not be inferred that air transport development will in the meantime stand still. It must be borne in mind, as already pointed out in this article, that the conventional airplane operating at medium altitudes with piston engines, is by no means yet giving maximum results, and is capable of working faster and more regular schedules than those at present being operated, particularly as airdromes and route organization can be improved.

Furthermore, these aircraft are well tried and highly dependable. In this connection it cannot be too strongly emphasized that transport is repetition work, which means that until an airplane can be depended upon to operate, not merely with safety to its passengers and at economic costs, but regularly and punctually week in and week out at all times of the year, it is not ready for commercial airline operation.

The D H Sea Mosquito 37 is now in production. This has been recently unveiled and is a Mk 33 with provision for two large rockets.

It has been announced that there will after all be a Society of British Aircraft Constructors' display this year which will be held at the Royal Aircraft Establishment Farnborough in the autumn. This show is likely to be as spectacular as the show held the year before last with many new aircraft being shown for the first time. The emphasis will be on propeller-turbine engines as much as straight jets. Among the new prop-jets which may be available are the Naiad, Dart I and II, Mamba I and II, Python I, Theseus XI, Proteus, Clyde I and II, Phoebus.

There are a number of other propeller-turbine engines like the two Power Jets projects, Metrovick variants of the unducted fan and the de Havilland H-3. These engines deliver from 250 hp to 4,000 hp. There should be at least five different 600 mph aircraft, the Gloster E 1/44, Hawker N 7/46, a new variant of the Attacker, the Meteor IV and the D H 108.