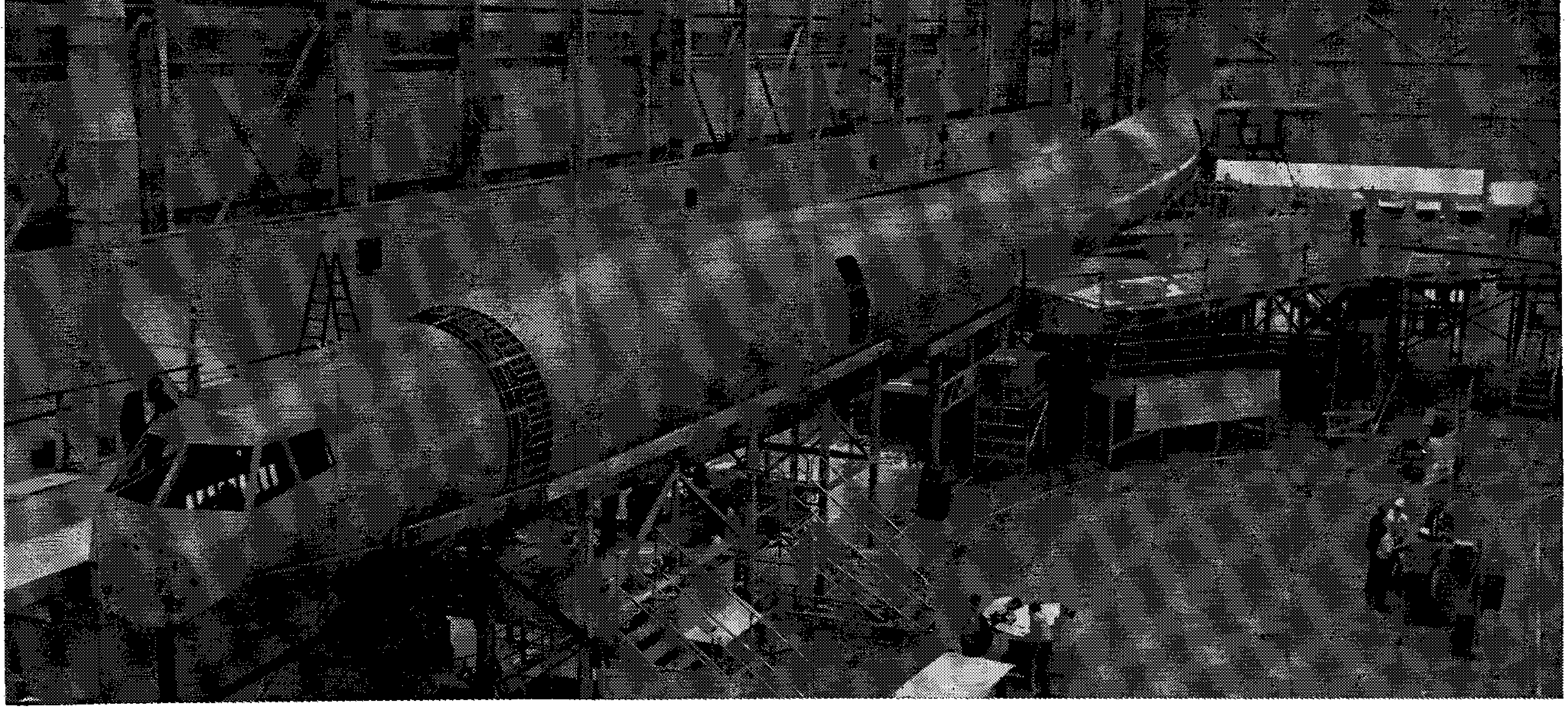
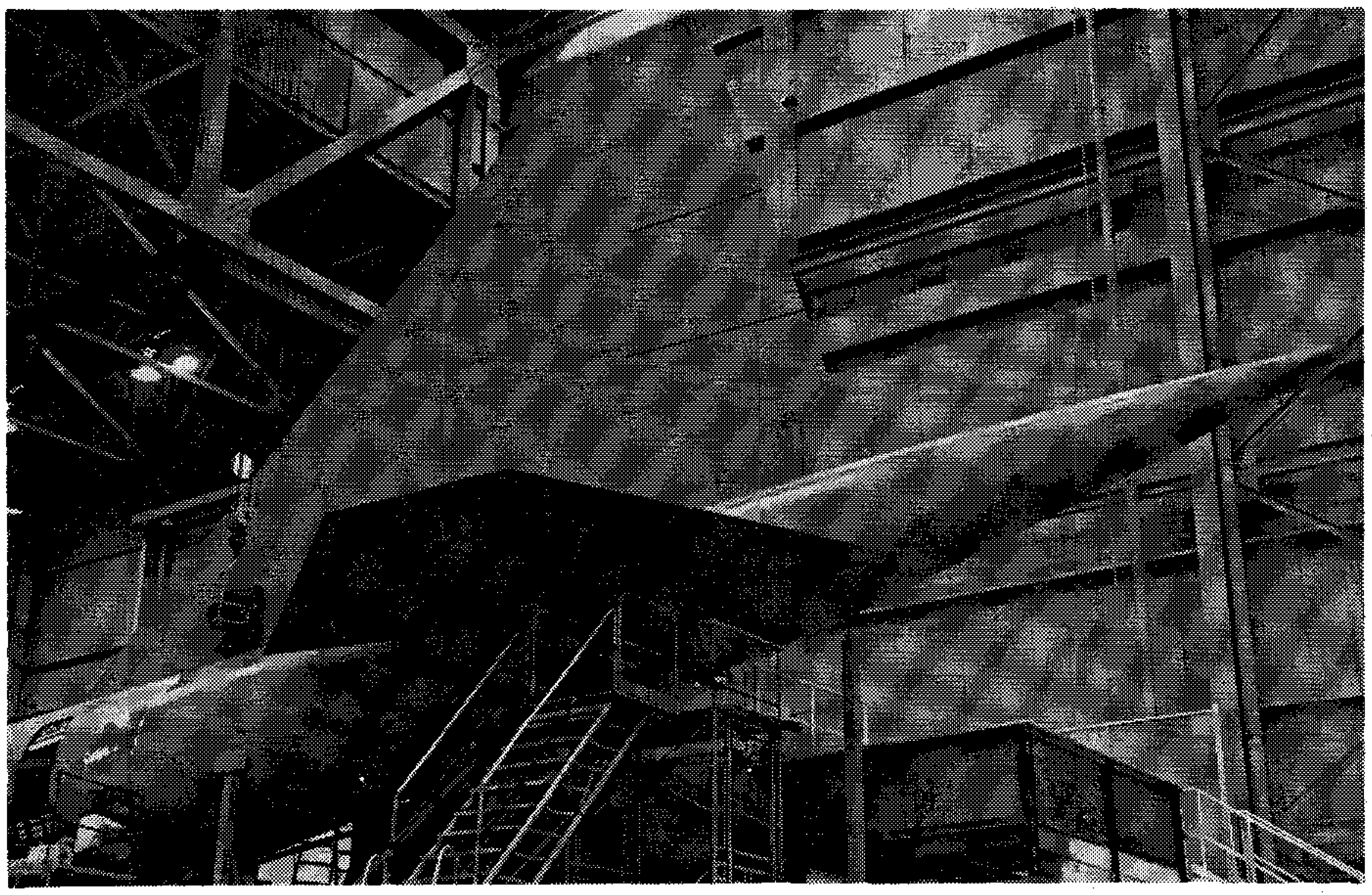
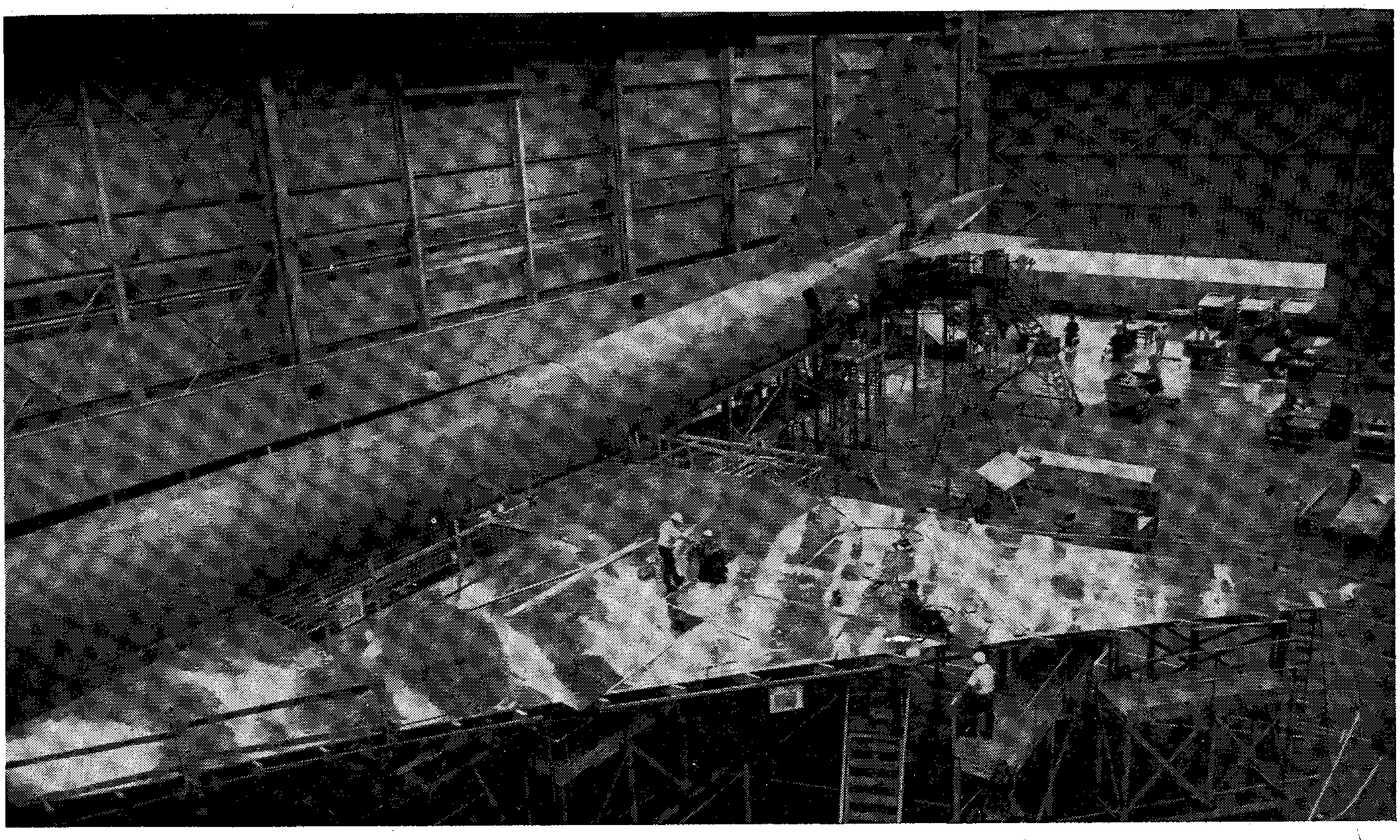
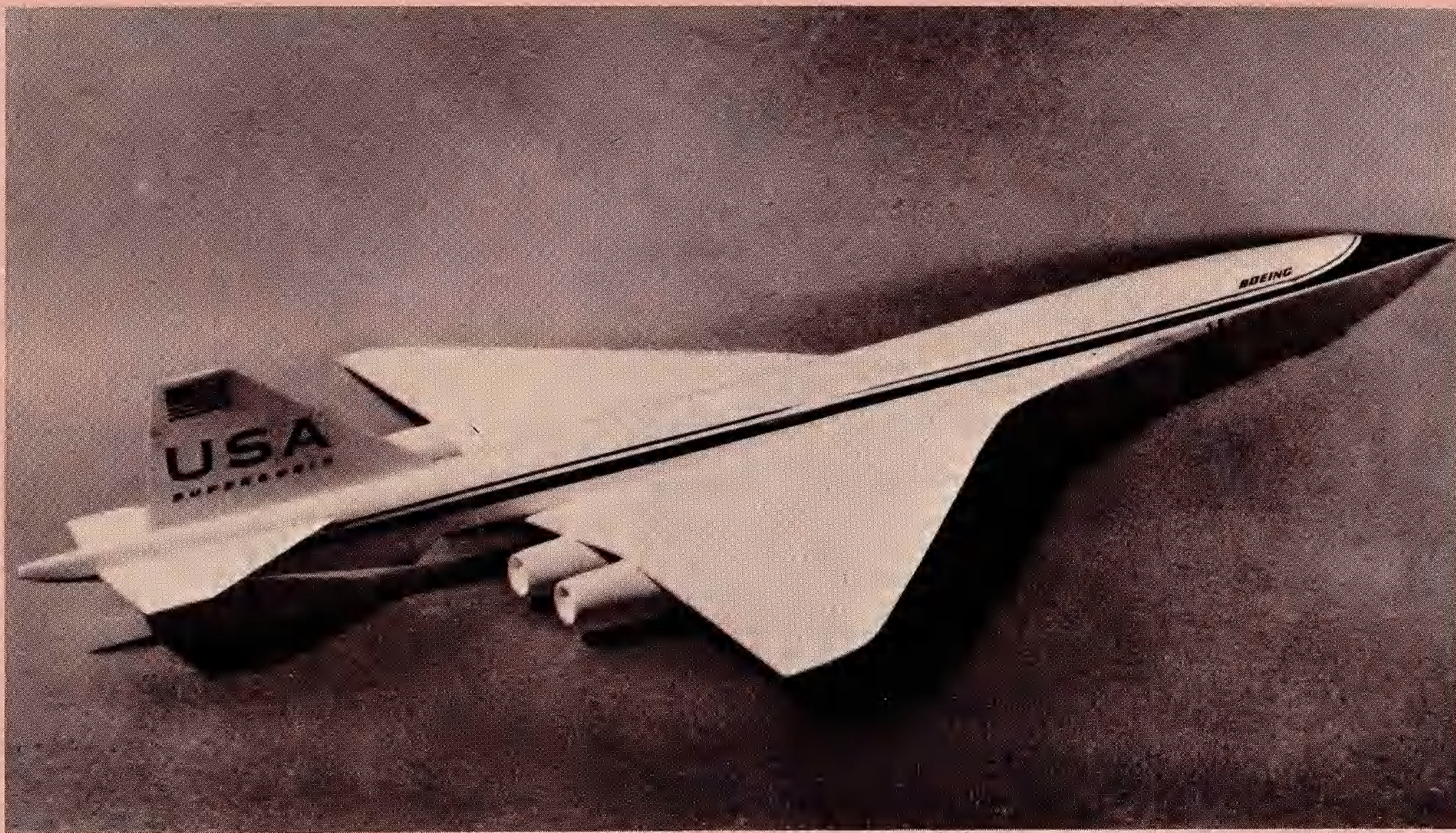




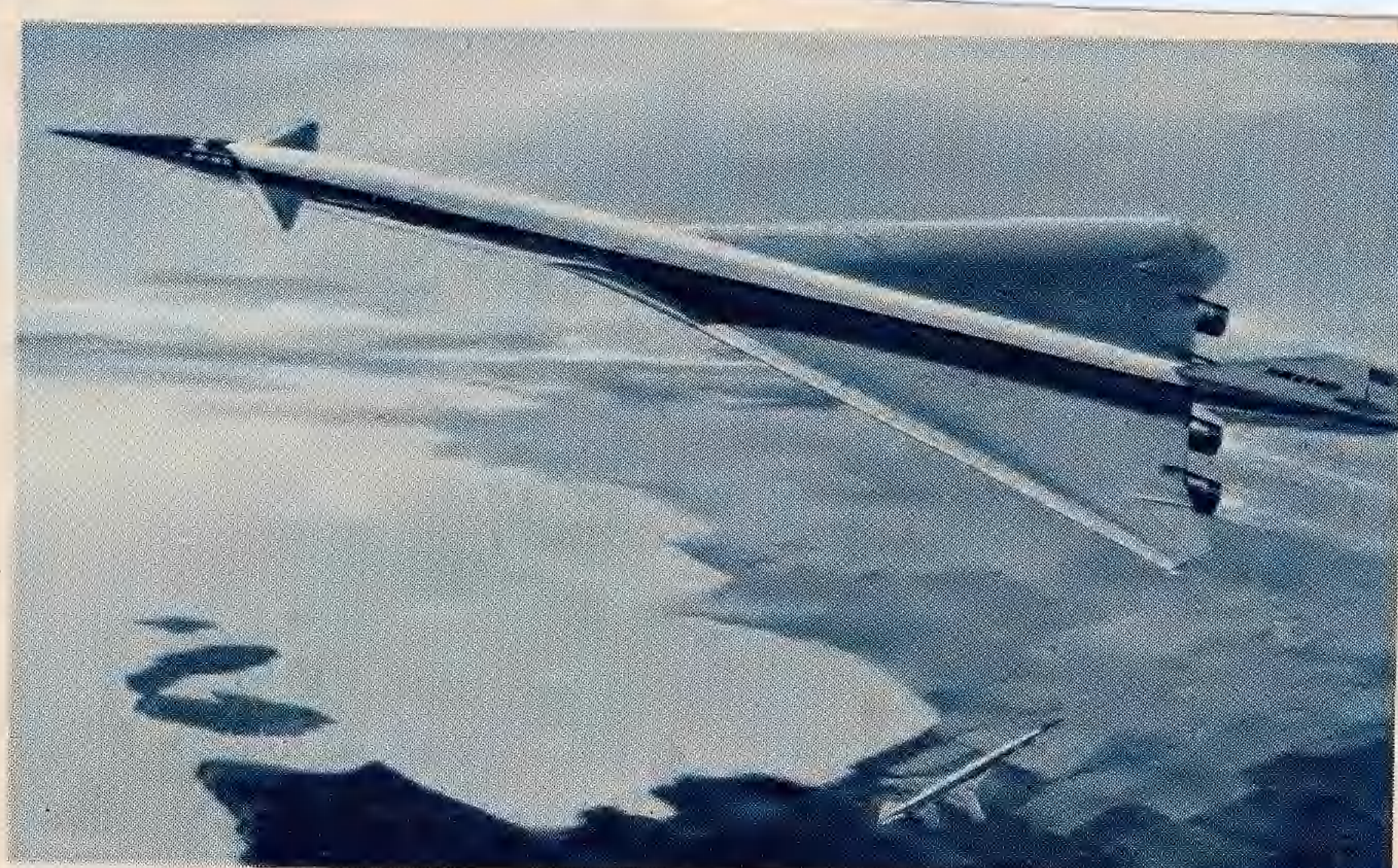
SST Mockup Takes Shape

Full-scale aluminum manufacturing mockup of U.S. supersonic transport is being assembled at Boeing's Developmental Center, Seattle. Cab section (photo, above) was most recent portion of fuselage to be added to the mockup. Still to be installed are forewing section, leading edge devices (note lines on floor in above photo) and hinged needle nose. Mockup, which will have a complete wing on only one side, is scheduled to be completed in July. Boeing has completed its Class 1 plywood systems mockup of the aircraft.





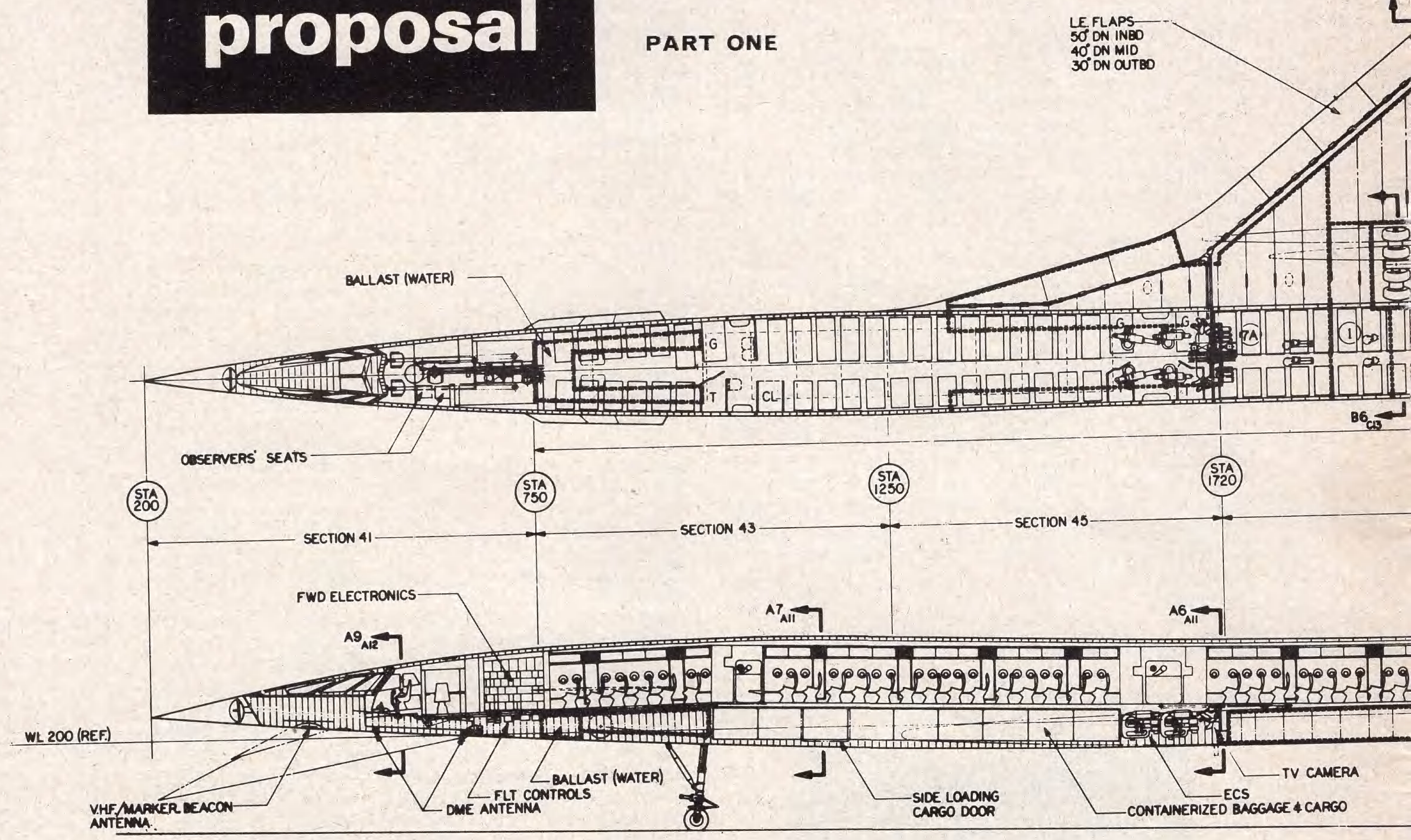
FIXED WING WITH LEADING EDGE sweep of 50 degrees is current planform for Boeing's supersonic transport. Certification date has slipped to late 1976-early 1977. Though swing-wing and its mechanism was dropped, weight of titanium'ed 1800-mph plane remains problem. Boeing suggested 3200-mi job for 299 passengers, 4000-mph'er carrying less.



SMALL CANARD WING has been added to SST transport by Boeing, double-hinged nose changed to single-hinge, fuselage extended to 318-ft, vertical tail moved aft.

Boeing's latest SST proposal

PART ONE



The configuration of the Boeing 2707-300 is the result of a re-evaluation of the SST programme objectives that was conducted during 1968. The 2707-300, it is claimed, provides the most balanced combination of performance, flying qualities and operational characteristics of all configurations considered during the re-evaluation. It represents a departure from previous SST designs because of the incorporation of a high-lift delta wing of moderate span in contrast to either a variable-sweep or a tailless-delta design of previous proposals. The use of a horizontal tail for longitudinal trim and control permits the use of high-lift devices and of increased span to assist in meeting the take-off and landing-performance objectives. The structure is primarily of titanium alloy to permit cruising flight at Mach 2.7 at altitudes of 60,000ft to 70,000ft. Power is by four General Elecrtic GE4/J5P afterburning turbojets, each delivering 63,000lb thrust at take-off.

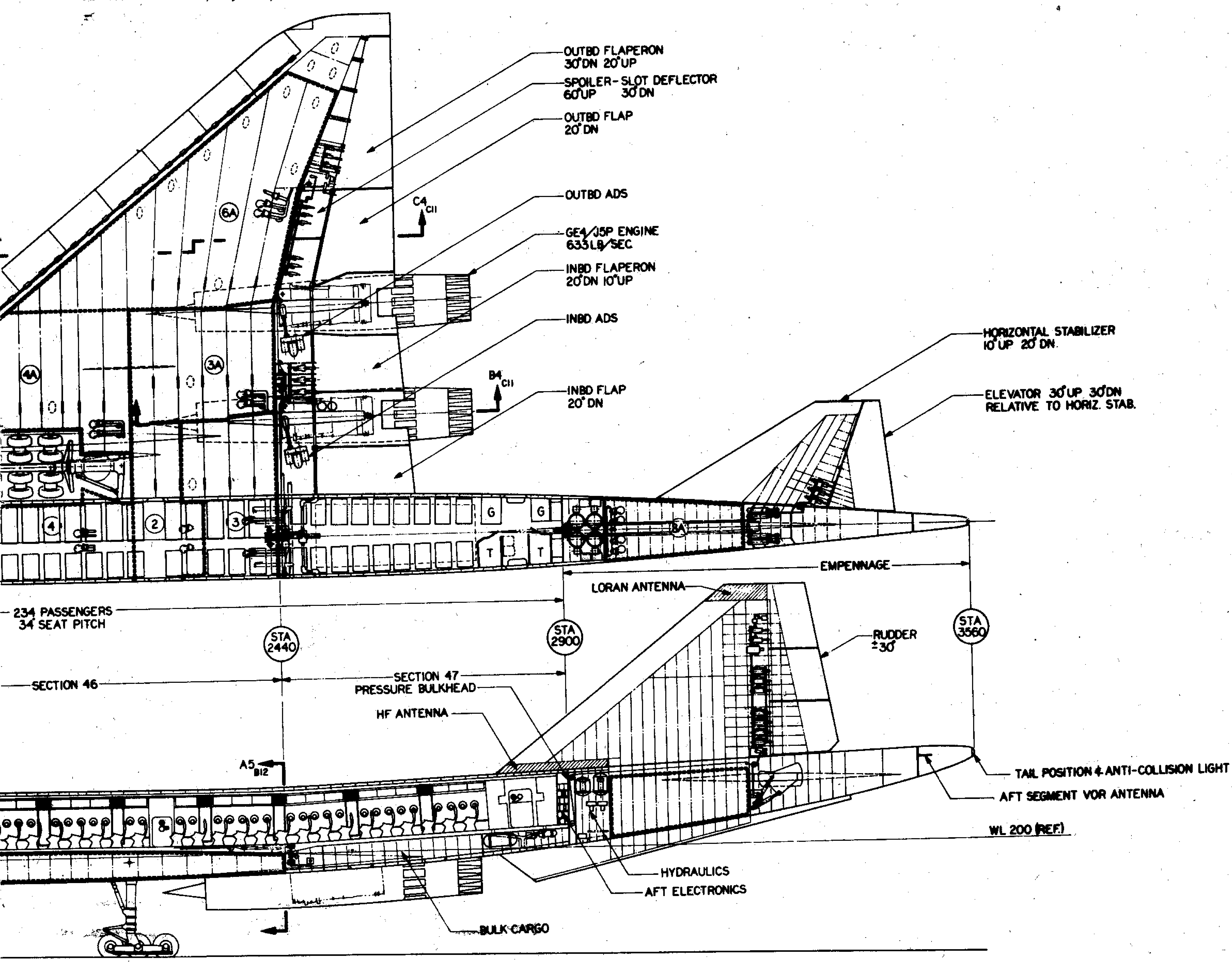
The 2707-300 design is the result of an integrated effort to provide a balanced combination of high- and low-speed performance, flying characteristics, passenger safety and comfort, and adaptability to expected airline and airport operational requirements.

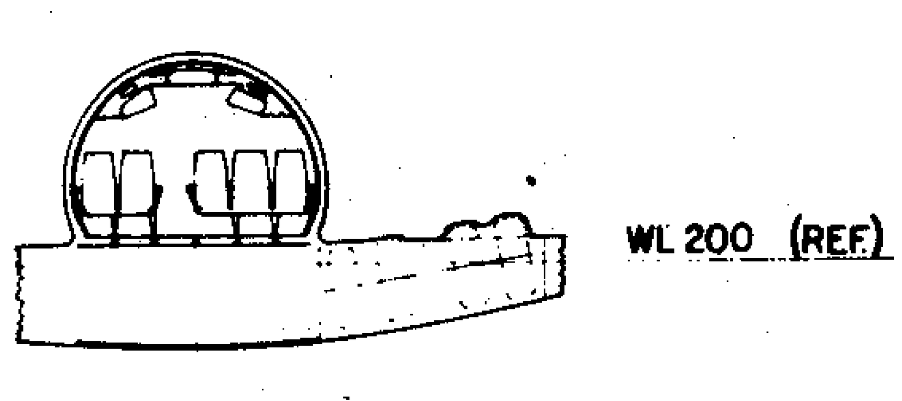
The passenger cabin is 176ft long of constant width for five-abreast over most of its length, permitting an all-tourist seating arrangement for 234 passengers and accommodating the installation of five lavatory and five galley compartments. A lower forward containerised cargo compartment provides 1,053 cu ft of volume and an aft lower compartment provides an additional 300 cu ft of bulk cargo capacity.

A conventional flight deck is arranged for operation by two pilots and a flight engineer, with seating provided behind the captain for two observers. A pivoting forebody with sliding visor is installed to meet requirements for forward vision at low speeds. Advanced instrumentation for all-weather landing is included.

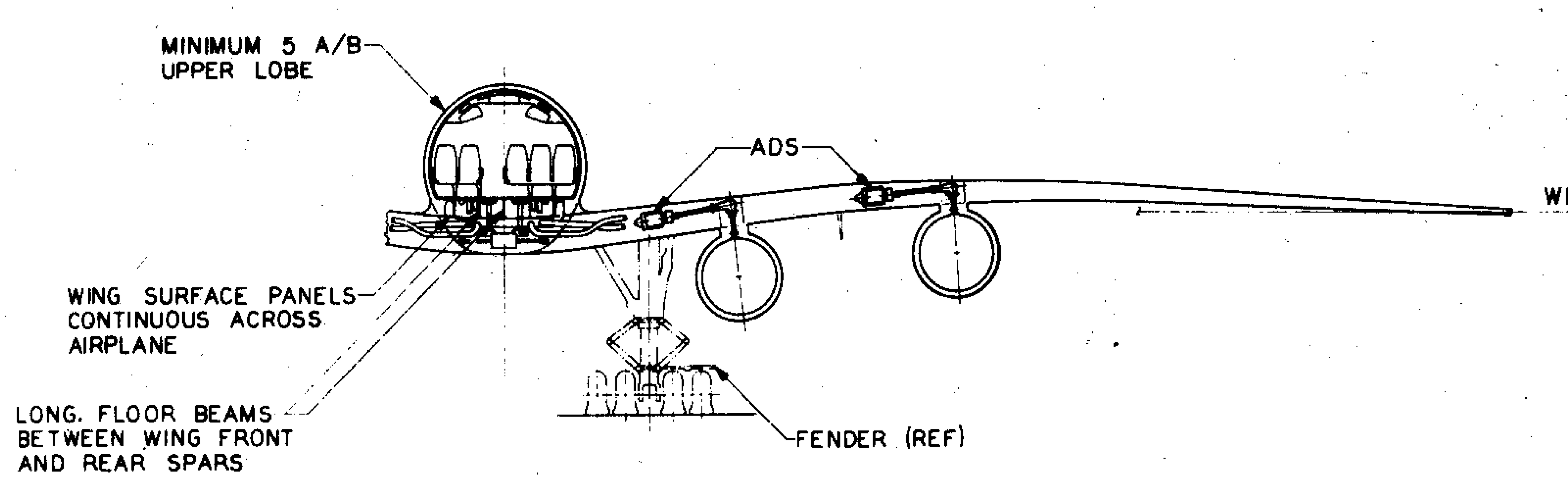
The engines are installed in separate pods incorporating associated inlet and nozzle components. The inlet is of the axisymmetric translating-spike type. An ADS (accessory drive system) consisting of a gearbox, shaft-powered from the engine power take-off, mounted in the wing trailing-edge adjacent to each engine. Each ADS serves two hydraulic pumps and an electrical generator. The engine starter and a boost compressor for the environmental control system are separately mounted directly to an engine-driven gearbox within each nacelle. The fuel system consists of integral tanks within the wing and tailcone.

The aircraft will be trimmed during transonic flight by a



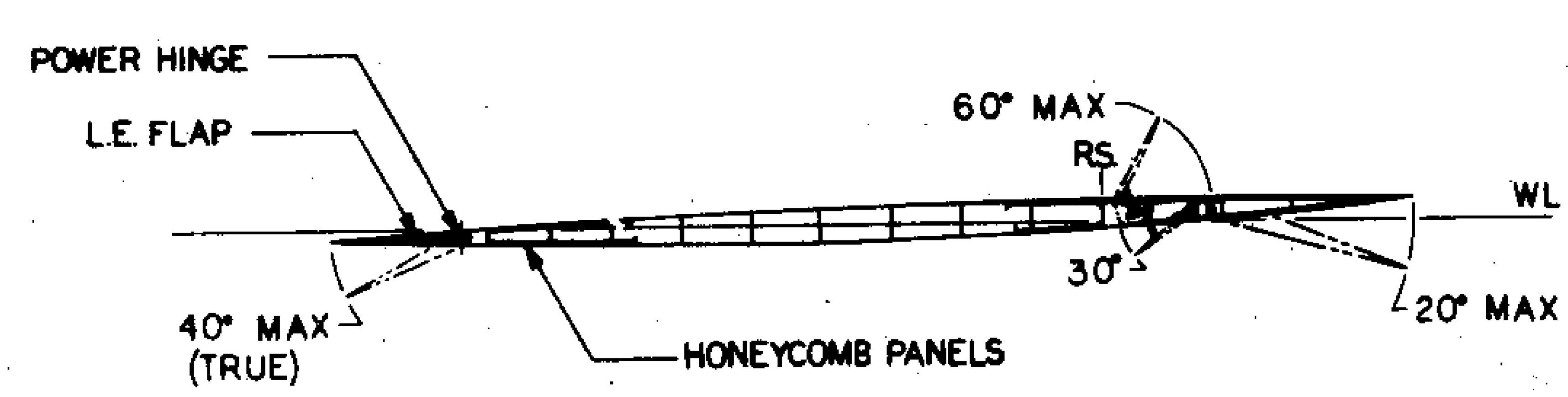


B6
SECTION AT WHEEL WELL



A5
SECTION AT REAR SPAR

The general arrangement of the Boeing 2707-300 supersonic transport is shown in the manufacturer's drawings reproduced on this page. Noticeable are the "broken back" appearance of the fuselage inside elevation and the gull-wing curves of the wing in the front elevation, both dictated by the aircraft's advanced aerodynamics. Basically of double delta planform, the new 2707 also has a horizontal stabiliser which makes it characteristically different in layout to the Concorde and Tu-144



C4
OUTB'D WING

Hercules exercise, so far from meriting any strictures, should be recognised as a great achievement, which could serve as a model for future occasions, when appropriate.

London W1 BRIAN CAPE,
Chairman, Hercules Standing Committee, Electronic Engineering Association

[Full details of British electronic equipment for the C-130K were given in *Flight* for November 18 and 25, 1965. Only one reference to the aircraft was made in the PAC debate. —Ed.]

BEA's Engineering History

SIR,—An article in *Flight* (page 888, November 28) and a similar one recently in *BEA News* stated that for the "first time in its history BEA is servicing and maintaining a fleet elsewhere than at Heathrow."

For the records, BEA engineering history started prior to Heathrow. Northolt, Speke and Renfrew bases maintained fleets, and Heron aircraft are still based at Glasgow, having been fully maintained there since being introduced new almost 14 years ago. Heralds were also based in Scotland and had every type of maintenance and development carried out there, from new, until they were sold in 1966.

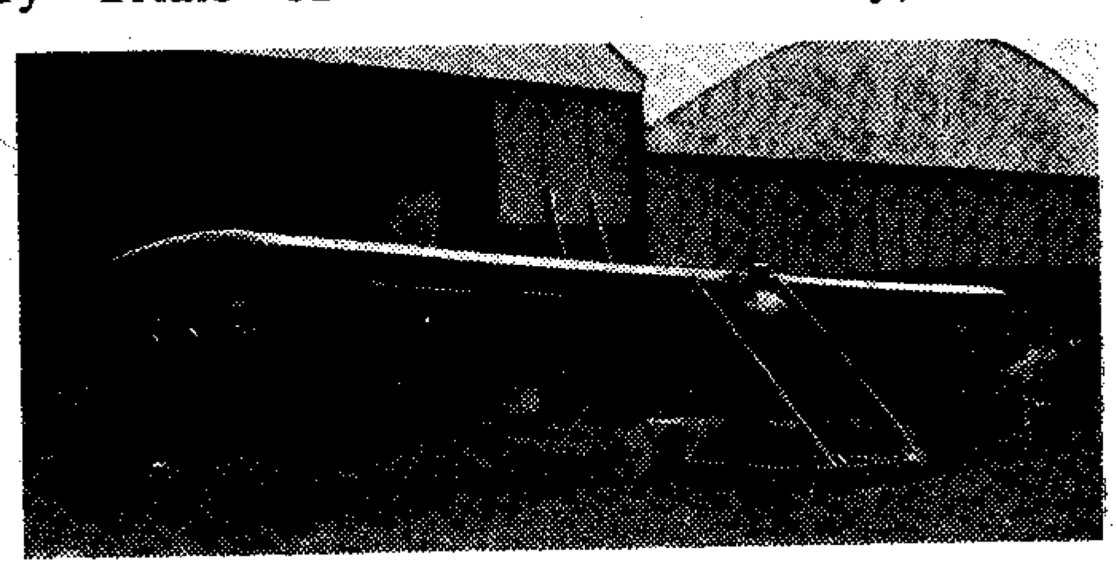
Regular Viscount, Vanguard and Trident Checks 1, and other types of maintenance, have been outstation commitments for a long time and the BAC One-Eleven programme is just the latest result of progressive maintenance decentralisation coupled with maintenance schedule developments practised at various BEA outstations for some years.

It will, however, be the first time in the history of Heathrow that they have not physically carried out the initial cycle of maintenance checks and "bedding in" period, etc, themselves, on a complex modern mainline aircraft type.

Inchinnan, Renfrewshire J. CORRIGAN

"Unknown" Identified

SIR,—Your "unknown monoplane" on page 1074 of *Flight* for December 26 was the Mersey, built for the Military Trials of 1912. Unfortunately, this aircraft



came to a sad end on August 13 of that year on Salisbury Plain, when it crashed, killing R. C. Fenwick, one of its designers, who was flying it at the time.

Ilford, Essex PHILIP JARRETT

Simulator or Flight Deck?

SIR,—The views expressed by "Mainliner" in his article entitled "Too Little Flying?" (page 890, November 28) are parochial, to say the least.

He can hardly expect to be taken seriously when he suggests that there is a move afoot among those responsible for budgetary control of airline expenditure to stop all flying training in favour of simulated flight.

Simulators are cheaper to run, of course, but their main advantage lies in the fact that they are more effective for certain types of training. "Mainliner" admits that the instrument flying standard of inexperienced new recruits weaned on simulators is quite satisfactory.

No responsible person in the industry would suggest that visual circuit flying can be carried out in a simulator at the present state of the art; neither, I am sure, would the Board of Trade condone the paring of flying training to a dangerous minimum.

When your contributor talks about very experienced co-pilots under training for promotion experiencing difficulty in handling a docile aeroplane he is wandering away from his basic argument.

This is not a training problem but the legacy of a system which relegates the co-pilot to the role of an undercarriage operator. If a man is hardly allowed to touch the "pole" during 12 to 15 years as a co-pilot, is it surprising that his standards deteriorate?

In the monitored approach system used by BEA the co-pilot is trained to a very high standard of instrument flying; and when the weather falls below a certain minimum he carries out the let-down, monitored by the captain. A side effect of his being considered a very important member of the crew is that he is given nearly 50 per cent of the take-offs and landings under visual flight conditions.

The end result of this, of course, is that when his turn comes for a command, he is very well qualified to move into the left-hand seat.

Heathrow Airport, London R. E. GILLMAN, *Captain*

Eagle Closure: Basic Reason?

SIR,—As one who until recently was employed in the commercial division of an IATA airline, I should just like to make one point about the demise of British Eagle which does not appear to have been covered in your correspendence columns.

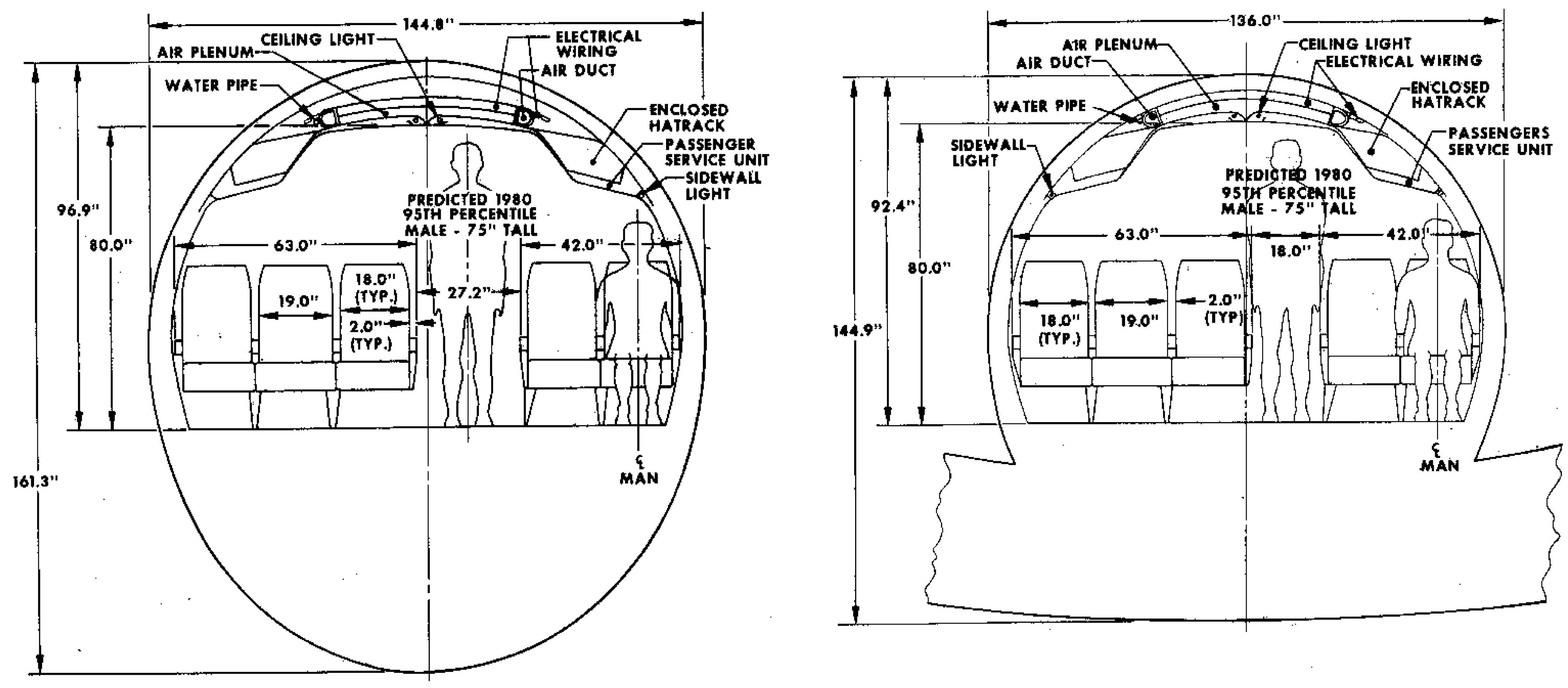
There can be few who did not respect the morale of all Eagle staff in contact with the public, and the uninformed would have found it difficult to believe that these competitive efforts were not providing any real profitable return. It is not my intention to lay the blame for Eagle's demise at any person's door, but two facts need to be stated. It certainly was not the corporations' fault, although some have said that Eagle was kept out of profitable markets by BEA and BOAC. This may or may not be the case; but, as Sir Anthony Milward has implicitly said: "Eagle knew the rules when they started." Quite apart from this, I cannot understand the psychology of anyone who considers that strong or monopoly producers should actually welcome competition. You fight to exclude competitors: that is what competition is. The villain of the piece is the Civil Aviation Licensing Act and the way it has been applied by the ATLB. The Act and its application is typical of much that is wrong with British industry, i.e., Government interference in an industry where State objectives are ambiguous and their implementation ineffectual.

Incidentally, your coverage of air transport marketing is, I think, first class; the only pity is that so few airline managers, particularly in the marketing area, seem to participate in your articles or correspondence columns. Professional reticence—surely not? It seems to me inconceivable that any airline manager of any responsibility or initiative would not wish to support your pressure for improved traffic statistics—everybody complains but nobody does anything. For that matter, why has no enterprising research company or collection of airlines ever organised a retail audit of travel agents' sales in the manner of the continuous research into grocery sales?

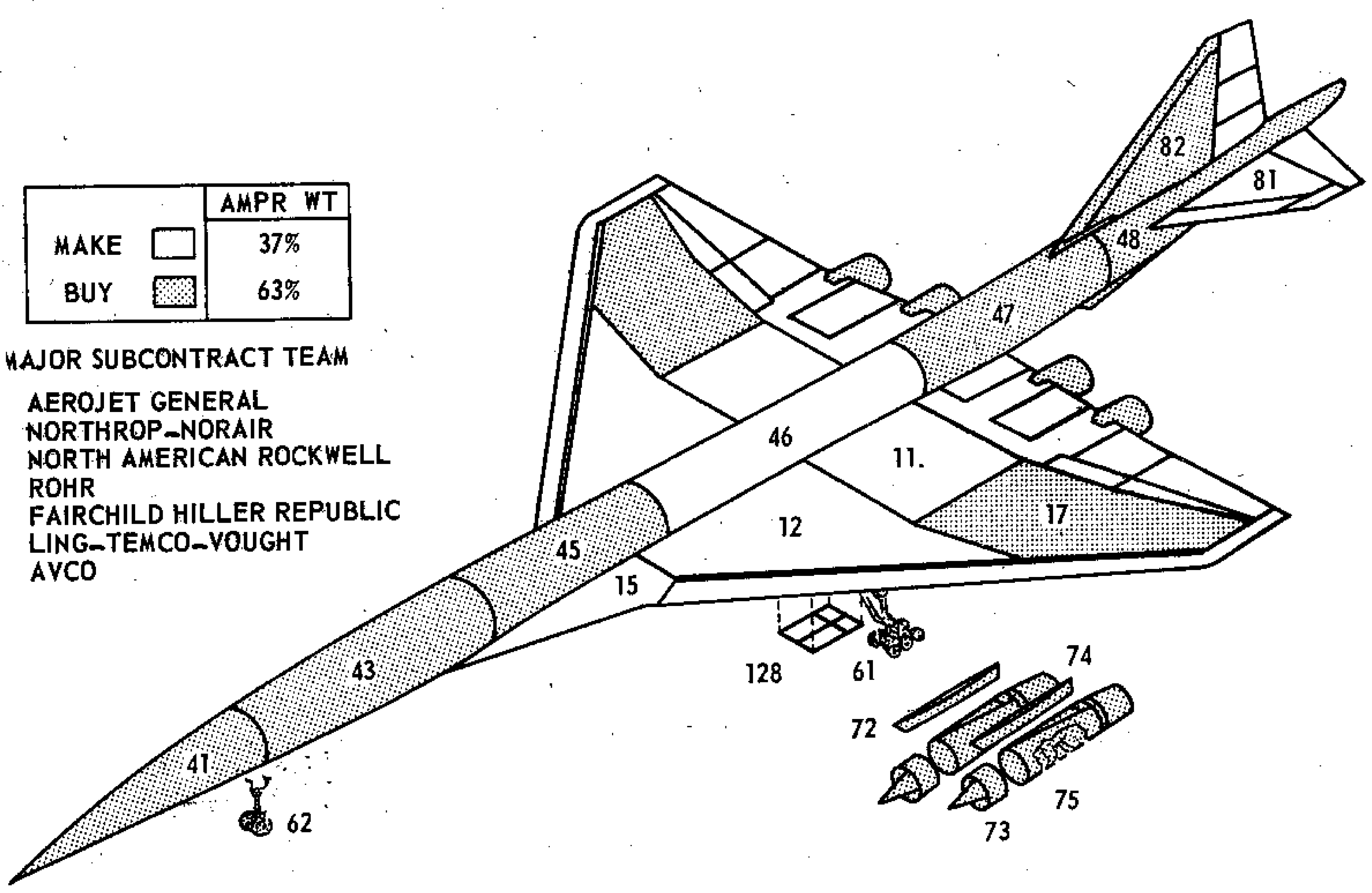
Finally, will none of your commercial aviation manager readership comment on the BOAC advertisement in the Atlantic edition of *Time* for December 20? The headlines read "International restrictions can't put a limit on love. . . . They can legislate right down to the number of vegetables you're allowed. . . . That pernickity agreement." This seems hardly in the spirit of IATA about which so much has been heard. Anyway, isn't it time IATA conducted a public relations campaign to make the consumer more aware of the advantages that he gets, not those that accrue to the carriers? And should we now expect BOAC to withdraw from IATA?

Kew, Surrey M. JONES
(Export sales manager)

Diary this week: page 88



Dimensioned sections through the fuselage of the 2707-300 show the five-abreast seating possible in the American SST at widest and narrowest stations. The 18in-wide aisle towards the rear of the cabin seems likely to be a little cramped



Shaded sections of the Boeing 2707-300 airframe are those which the prime contractor expects to sub-contract. The likely team of major manufacturers is specified. The numbers on this manufacturer's drawing refer to a production coding system

BOEING'S LATEST SST PROPOSAL . . .

combination of fuel management and transfer techniques. A water ballast tank is provided in the lower forward section of the fuselage, to be filled when only small payloads are being carried. The ECS (environmental control system) contains four independent sub-systems using engine bleed air, conditioned by air cycle machines. Dispatch capability is maintained with one pack inoperative. Passenger comfort and safety level, says Boeing, will be comparable to that of contemporary subsonic aircraft. Initial cooling of engine bleed air is accomplished within the nacelle to reduce the air temperatures in duct runs through the airframe structure.

Flight control is provided by conventional aerodynamic surfaces powered by multiple actuators driven by independent sources of hydraulic power and controlled by both mechanical and electric commands from the pilots or from the automatic flight control system. Multiple stability augmentation systems are employed to improve handling qualities, ride comfort and safety characteristics. A high-lift system of leading- and trailing-edge flaps is used for take-off and landing.

Electrical power is provided by four variable-speed constant-frequency generating systems of 75KVa each driven by their respective ADS gearboxes. Dispatch with one system inoperative is possible.

Hydraulic power is derived from eight ADS-driven pumps rated at 80 gal/min at 4,000lb/sq in. An auxiliary electrically driven pump which provides power for emergency landing gear release and brake operation during towing is also installed. An advanced concept of integrated communication and navigation equipment is installed, employing a central computer to process sensor inputs for conditioned outputs to the various instrumentation and control consoles. In addition to inertial navigation and conventional communication requirements, space and circuit provisions are being made so that this system may include air turbulence detection, collision avoidance, and independent landing monitors when such equipment becomes available. An AIDS (airborne integrated data system) with 500 test points is installed.

Structure The basic structural arrangement of the wing is a multi-spar sandwich panel using titanium 6Al-4V as the primary material. This is considered to be structurally more efficient for the relatively low end-load index of the fixed-wing design. Panel stability for flutter and compression necessitated some form of sheet stabilisation so that this material could be used. Aeroelastic requirements for maximum stiffness in torsion at minimum weight require that a proportionately greater percentage of the cover material be retained in the skins than is possible with a conventional stiff-stiffener rib construction.

Panel thickness and gauge combination were optimised to satisfy all the structural requirements while providing the proper resistance to heat conduction and lightning strike without the addition of single-function material such as insulation. The basic panel covers in the high end-loaded structure uses titanium 6Al-4V truss-core sandwich made by a combination of resistance seam welding, fusion welding, diffusion bonding and mechanical fastening. The panels in the lower end load regions outboard of the outboard engine and forward of the wheel well use titanium 6Al-4V titanium stressed-skin panels.

Panel widths were selected to satisfy fail-safe requirements, and the individual panels are mechanically attached to the in-spar structure. The front and rear spars are of conventional stiffened-sheet construction to provide easy attachment of leading- and trailing-edge structures, surface actuators and systems while all the in-spars will use a welded titanium 6Al-4V sine-wave construction.

For the fixed leading- and trailing-edge structure and control surface structures use is made of a combination of titanium 6Al-4V stressed-skin panels, truss ribs and wedges fabricated from Stresskin or adhesively bonded titanium honeycomb. Brazed steel heat-resistant panels are used in the trailing-edge areas over the engines.

The basic structural shell of the fuselage is a semi-monocoque design using frame stabilised skin-stiffener construction augmented with integrally stiffened skins in the high compression and shear areas. The basic structure material is titanium 6Al-4V continuous rolled sheet. The relatively high end-loads caused by the bending characteristics of the fuselage shell structure, combined with hoop tension pressure loading and insulation requirements, showed this type of construction to be competitive with a sandwich-type shell in structural efficiency; but, says Boeing, considerations of construction, bi-axial crack containment and the minimising of the technical risk dictated the selection of the more conventional structural concept.

The forebody skin and stiffeners are annealed titanium 6A1-4V. The aft upper crown structure makes use of annealed skins and heat-treated stiffeners to provide the optimum strength design compatible with the fail-safe requirements. The side shear panels over the wing and the lower panels of body fore and aft of the wing and through the wing centre section use titanium 6A1-4V integrally stiffened skins to optimise the compression and shear design allowables.

Basic arrangement of the fin and tailplane primary structure is of a multi-spar sandwich form. The basic material is titanium 6A1-4V. The internal spar is of welded sine wave construction. The cover panels are titanium 6A1-4V stressed skin, and their widths were selected to satisfy fail-safe requirements; they are mechanically attached as individual panels to the in-spar structure.

Leading-edge wedges and trailing-edge control surfaces are of titanium stressed-skin panels, truss ribs and titanium stressed-skin or brazed steel wedges. The aft body structure is a frame stabilised sandwich shell using titanium 6A1-4V stressed-skin panels in the primary load-carrying structure. The aft body fairing is a frame stabilised titanium honeycomb shell made by adhesive bonding using polyimide adhesive.

The main undercarriage is a conventional two-leg arrangement with each leg carrying a 12-wheel bogie sized to provide the equivalent flotation of the DC-8-63. Each leg is attached to the wing structure and retracts forward into a cavity in the wing. During retraction the bogie stays in a horizontal position to minimise the frontal area (even so, there is a blister fairing on the top surface). The basic structural material of the gear is 4340 modified steel heat-treated to 270,000lb/sq in-300,000lb/sq in—a material currently used on subsonic jets. Components such as the torque links, side struts and drag struts will use titanium 6A1-4V or titanium 6A1-6V-2SN.

Propulsion System The propulsion pod consists of an inlet, the engine, nozzle and thrust reverser. The inlet is axisymmetric and has a translating centrebody, movable cowl throat doors, and cowl by-pass doors. The thrust reverser is part of the ejector nozzle assembly.

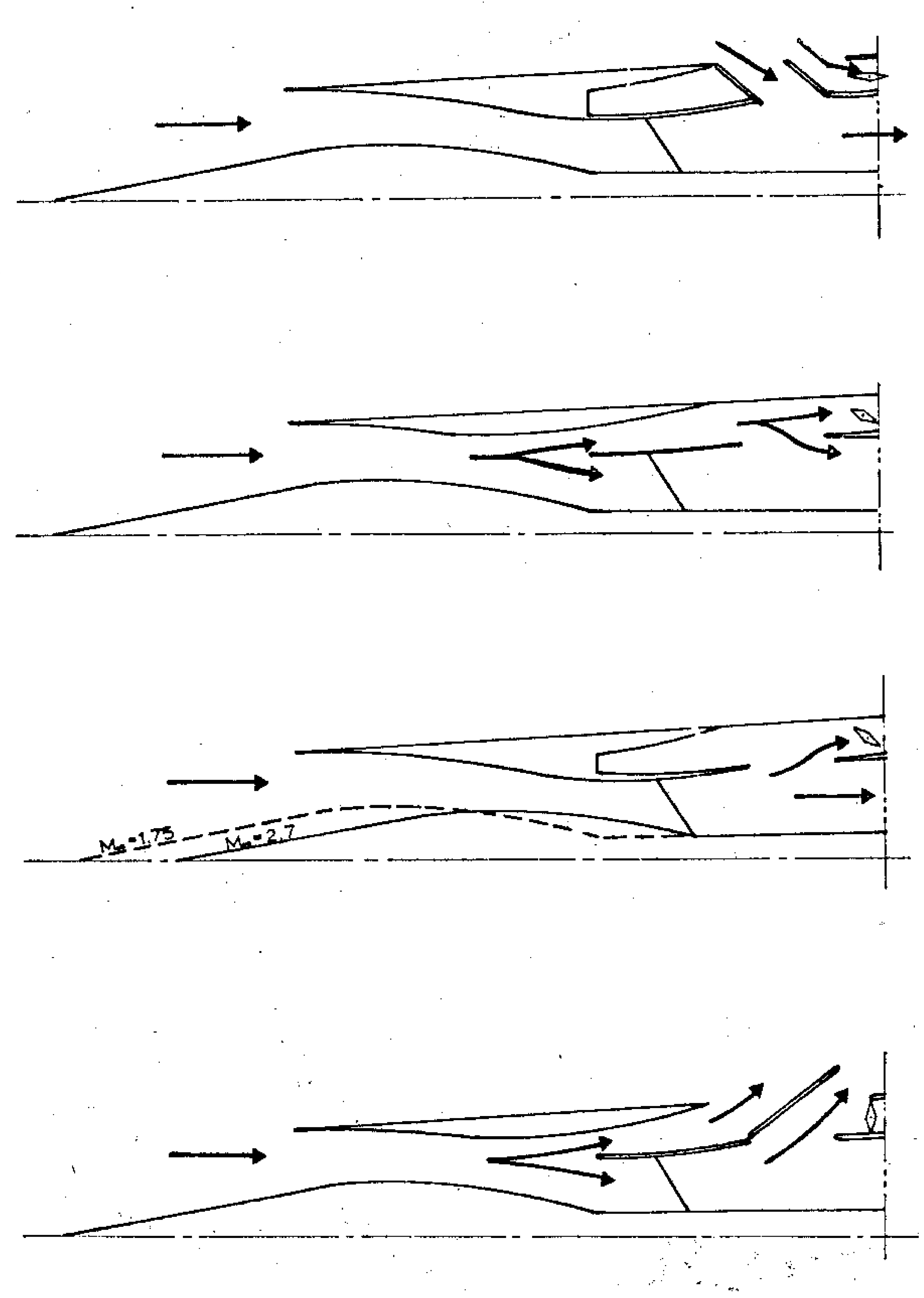
The axisymmetric translating centrebody inlet comprises a movable centrebody, cowl throat doors and by-pass doors to obtain proper inlet/engine airflow matching during all flight conditions. A boundary-layer bleed system is installed in the inlet to provide shock/boundary layer interaction control and to improve the overall diffusion efficiency. Shock stabilisation devices (vortex valves) are installed in the inlet throat to provide inlet stability to downstream disturbances. The boundary layer bleed scoops on the forebody provide boundary layer control and increased buzz suppression capability.

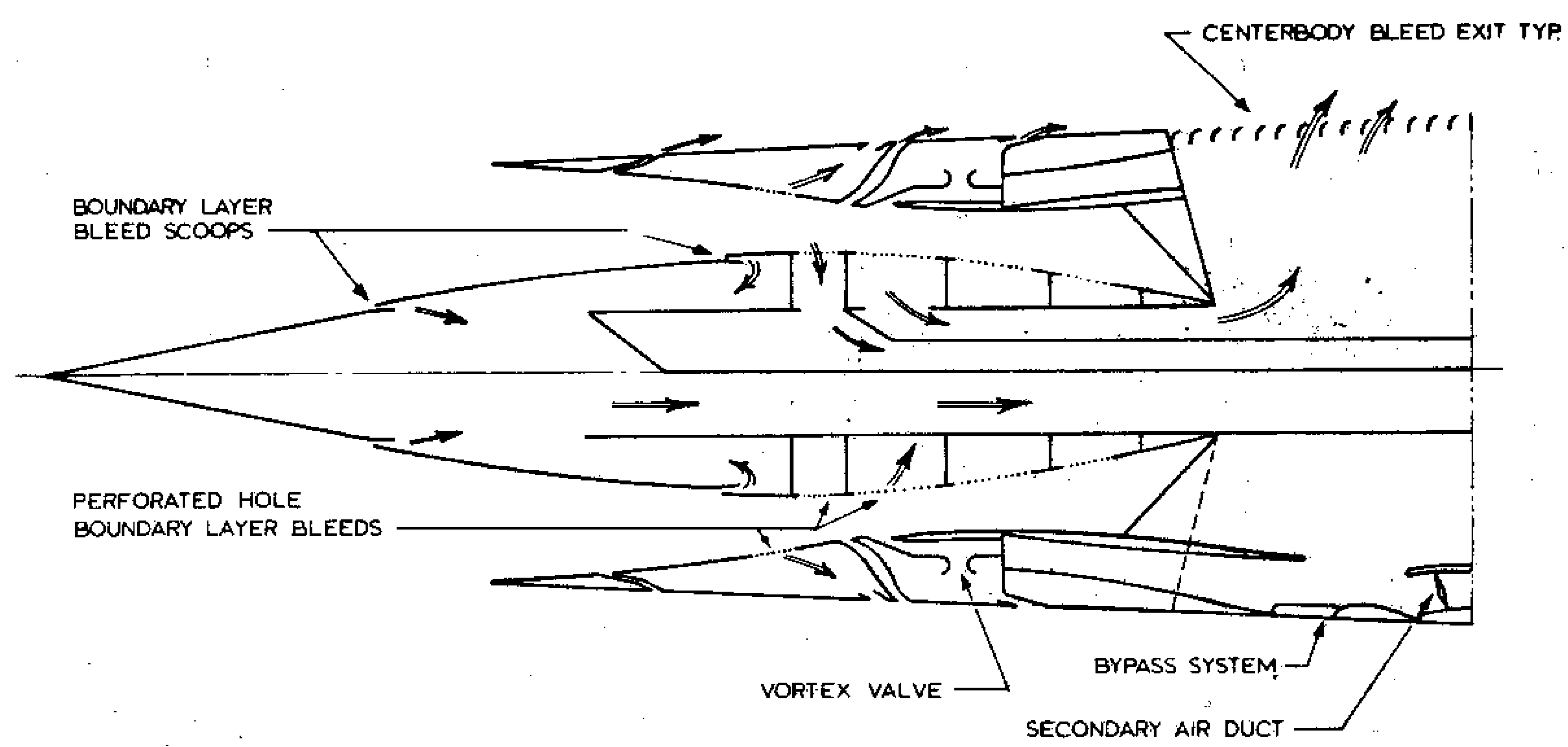
Basic operational modes of the translating centrebody inlet are shown in Fig 1. During take-off the centrebody is fully extended, the throat doors are closed and the take-off doors are open to reduce the cowl lip suction and to provide cooling air for the secondary air system. In the external compression mode of operation up to Mach 1.75, the centrebody is fully extended and the throat doors are open to

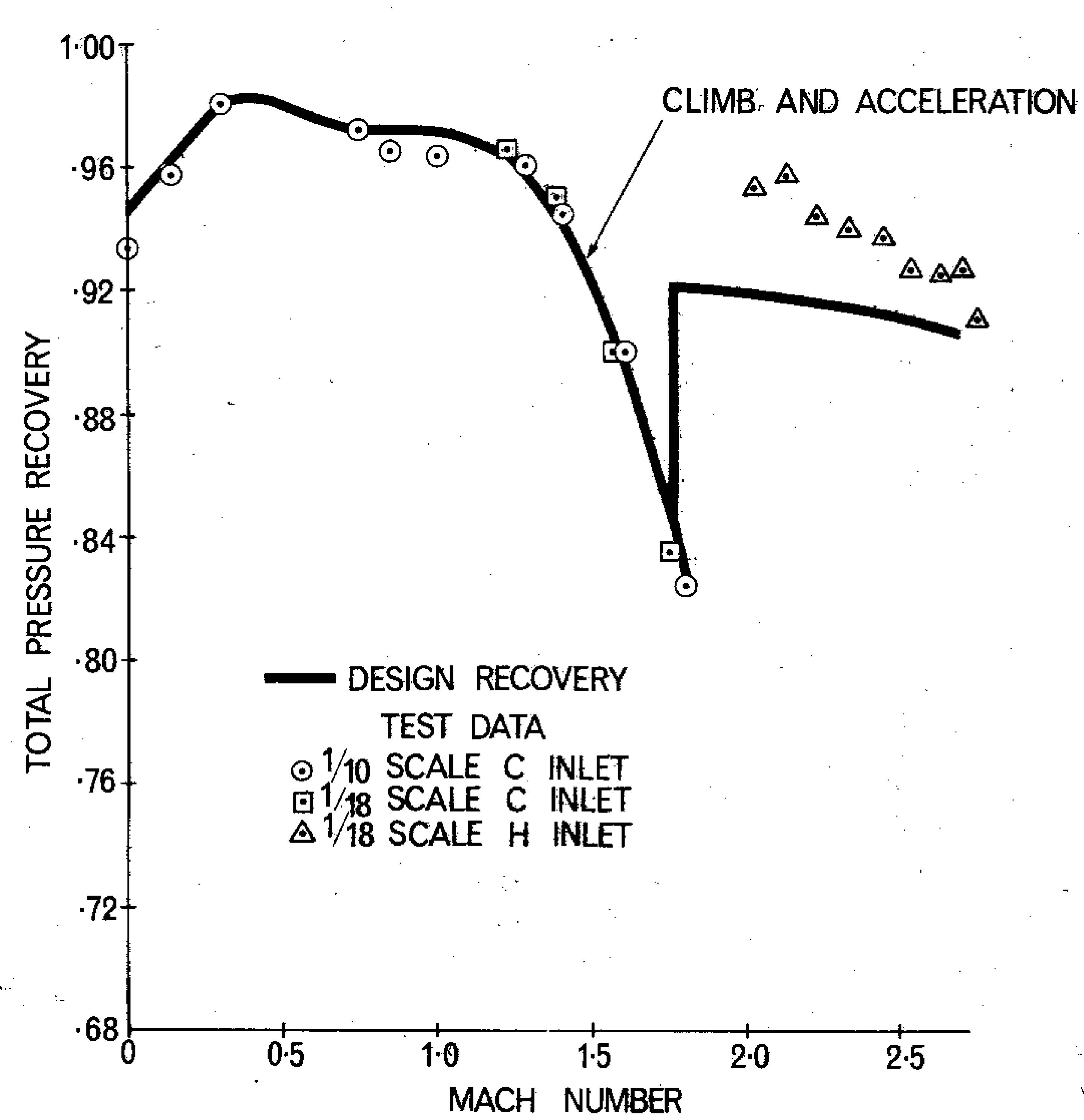
Fig 1 (below) Basic operational modes of the translating centrebody inlet. Reading downwards: Take-off, external compression (Mach 1.75), internal compression (Mach 1.75), windmill brake

Fig 2 (right) Centrebody inlet: bleed system

Fig 3 (below, right) Design total pressure recovery of the centrebody inlet during climb and acceleration







BOEING'S LATEST SST PROPOSAL . . .

The complete installation of one of the 63,000lb-thrust GE4/J5P afterburning turbojets, right, showing the arrangement of the axisymmetric translating spike intake and exhaust nozzle/thrust reverser assembly

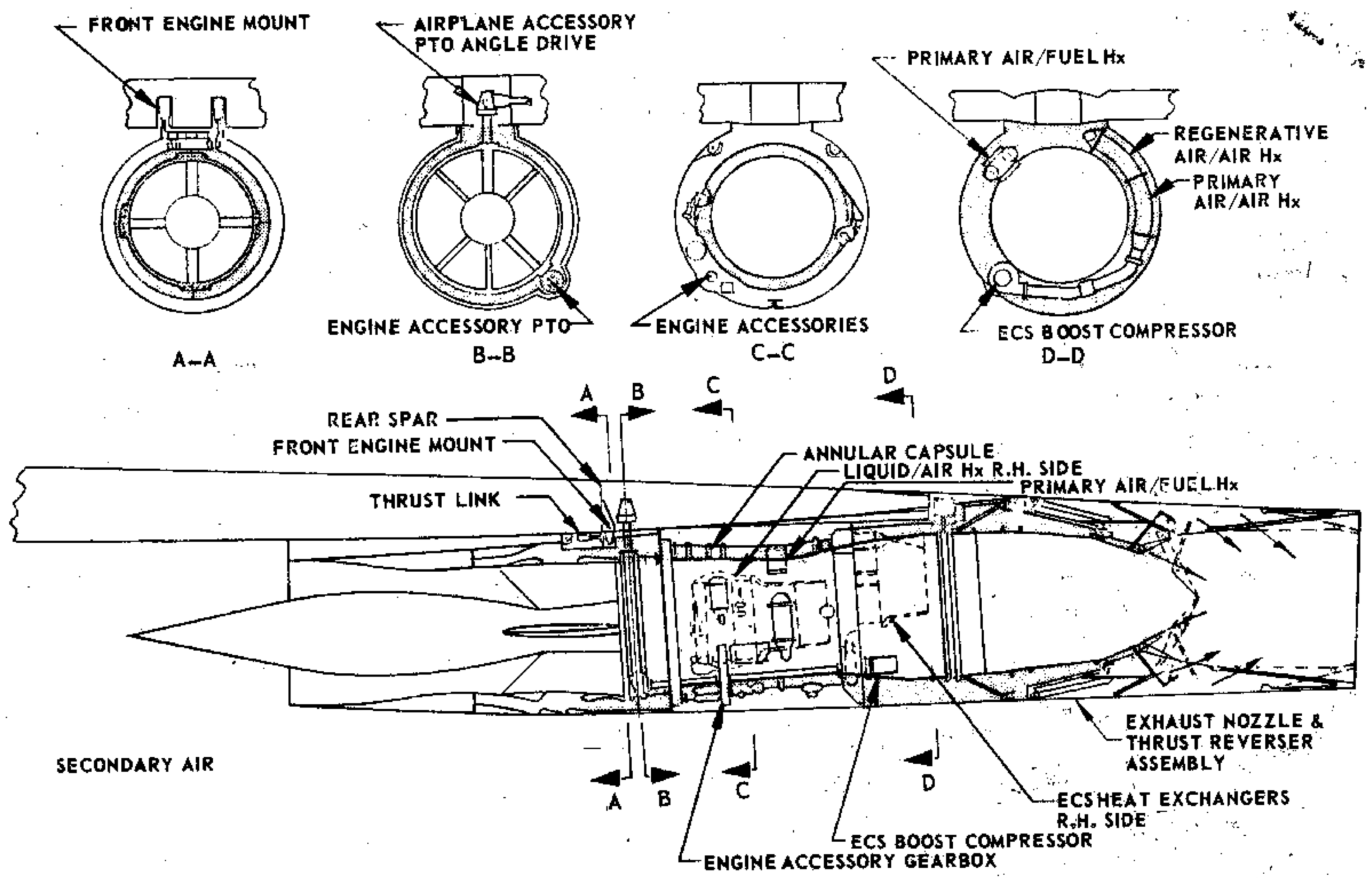
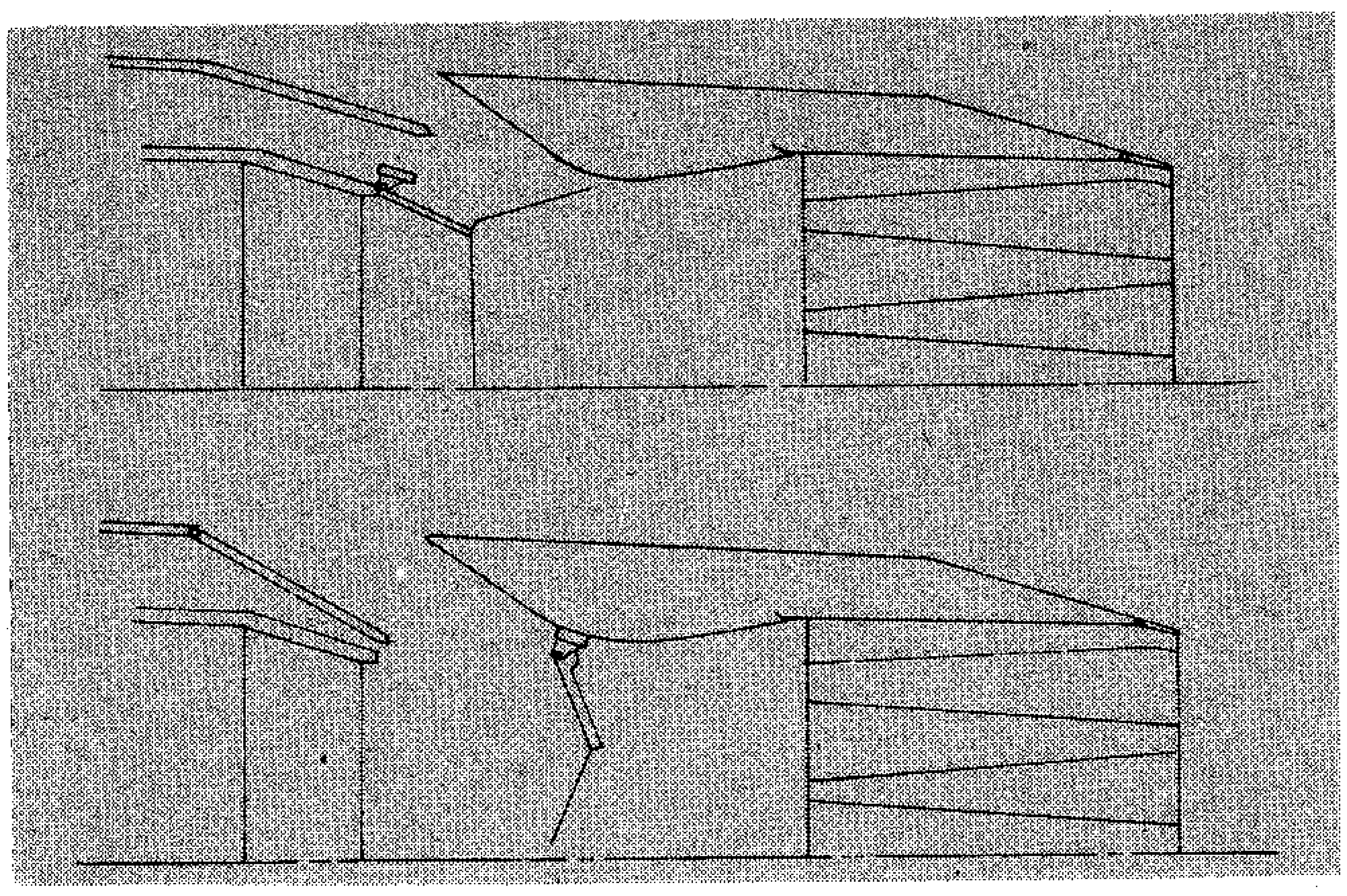


Fig 4 (below) Nozzle installation in the subsonic cruise (upper) and reverse-thrust modes



provide increased throat flow area to satisfy the engine demand. Above Mach 1.75 the inlet is in the started or internal compression mode. The throat doors are closed and the centrebody and by-pass doors are positioned to maintain a constant throat Mach number. If the windmill brake is applied to an engine at cruise, the throat doors and the by-pass doors are opened and the centrebody extended to maintain a started inlet and to satisfy the engine demand.

The bleed system for the translating centrebody inlet (Fig 2) consists of bleed scoops located on the centrebody and perforated hole bleeds located on the cowl and centrebody. The bleed system provides boundary-layer control, shock stability, and improved diffusion efficiency. The cowl bleed is discharged directly overboard, while the centrebody bleed is routed through the support struts and discharged overboard through openings in the cowl.

Design total pressure recovery of the translating centrebody inlet during climb and acceleration is shown in Fig 3, together with some of the data obtained from model testing. The test data is stated to agree well with the theoretical design recovery at all Mach numbers. The sharp rise in the curve at Mach 1.75 is due to the transition of the inlet from the external compression mode to the internal compression mode.

Performance characteristics are shown below. The GE4 engine is a high-performance medium-pressure-ratio turbojet designed for continuous cruise at Mach 2.7. It has a nine-stage compressor with variable stators and inlet guide vanes, an annular combustor, a two-stage turbine, and a modulating afterburner.

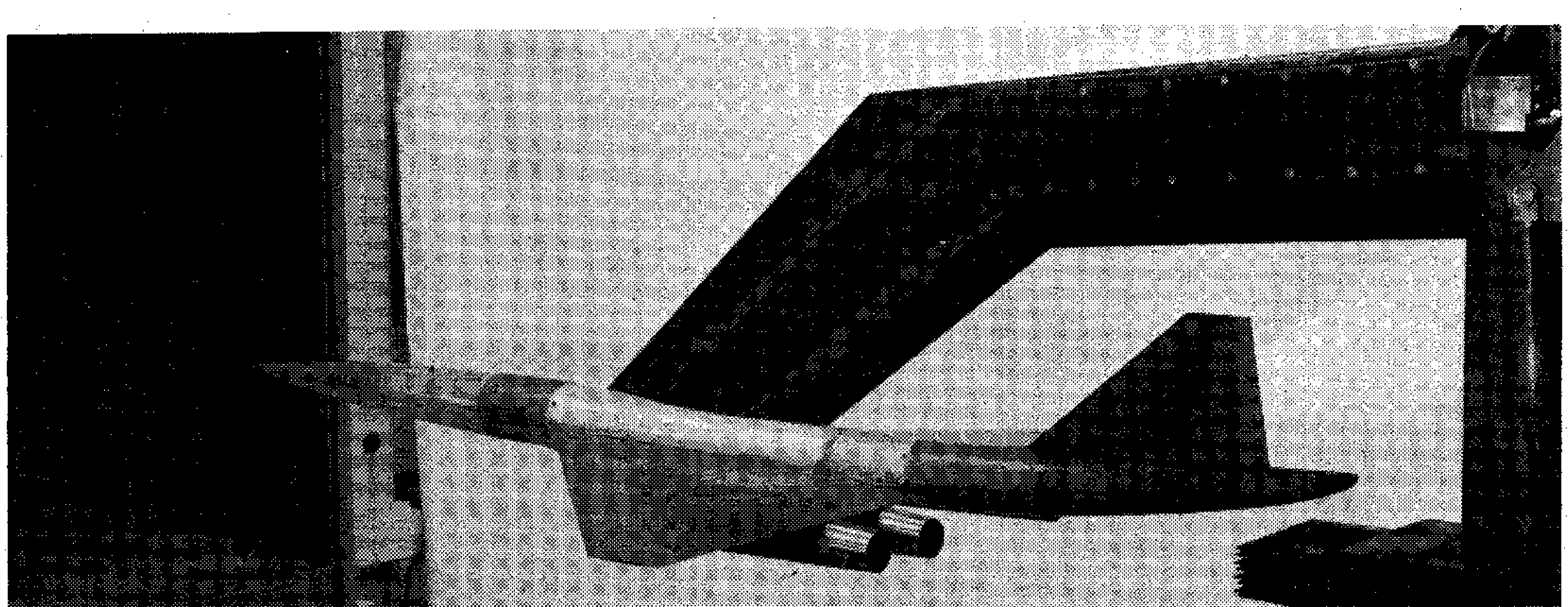
GE4 Engine Characteristics

Maximum augmented take-off thrust ..	633lb/sec
Sea level static airflow	11,300lb
Engine weight	67.000lb
Maximum non-augmented take-off thrust	50,500lb
Number of compressor stages	9
Number of turbine stages	2
Type of nozzle	Ejector with thrust reverser

The nozzle installation is shown (Fig 4) in the subsonic cruise mode and reverse thrust mode. In the present design the engine and nozzle can be separated and development of each can proceed independently. The primary nozzle is translated aft to block the exhaust flow for thrust reversing. The reversed gas is discharged forward through selectively opened tertiary doors.

A 1/50-scale model of the complete aircraft incorporating kerosene/oxygen turbojet simulators installed is shown (here) mounted in the Boeing supersonic 4ft×4ft wind tunnel. The cluster of probes installed on the sting behind the model is for measuring the jet exhaust temperature profiles during various manœuvres at supersonic speeds. These tests, it is stated, proved that the jet exhaust did not create temperature problems on the aft body or horizontal tail surfaces.

(To be continued, with details of the flying controls, flight systems, and performance and operational characteristics)



One-fiftieth-scale wind-tunnel model with kerosene/oxygen simulated turbojets

SST: FUNDS, FANS, AND FUSS

The house approved the full $290 million Fiscal 1971 appropriation for Boeing's supersonic transport prototypes. First flight is estimated for March, 1973. The SST's House victory came despite a flood of anti-SST warnings of sonic boom damage and environmental pollution. The FAA has established a regulation against boom causing flights over the U.S.

At Boeing's Seattle Development Center on June 5 the first full-size metal mockup of the 285-passenger SST was unveiled. It will be used for engineering studies on assembly of components and interior systems.

Congressman William E. Minshall (R.-Ohio), commented in *The New York Times* after the House approved the funds: "All they have to show for $1 billion we've obligated so far is a pile of drawings and engineering specifications." He is ranking Republican on the appropriations subcommittee, which approved SST funds over his objections.

remaining jack will correct the rudder position automatically without any action by the pilot.

LANDING GEAR: Retractable tricycle type, of Messier design, the main wheels retracting inward into the wings and the nose-wheel forward into the fuselage. Steerable nose-wheel. Main-wheel legs are interchangeable, right with left. Main-wheel doors are attached to the main oleo legs, and the landing gear is self-lowering and self-locking in the event of hydraulic failure. Dunlop low-pressure tyres (main wheel tyre pressure 56·9 lb/sq in = 4 kg/cm²) are fitted for rough-field operation. Messier hydraulically-operated brakes on main wheels.

POWER PLANT (Prototype): Two 870 ehp Turbomeca Astazou XIV turboprops, each driving a Hamilton Standard three-blade propeller of 8 ft 0 in (2·44 m) diameter. Fuel in four main tanks, two in each outer wing fore and aft of the main spar, with total capacity of 385 Imp gallons (1,750 litres). Refuelling point above each wing. Production aircraft will be fitted with more powerful turboprop engines (see introductory copy), and the design is such that podded turbojet or turbofan engines may be substituted without major airframe alteration.

ACCOMMODATION: Crew of one or two on flight deck, with additional jump-seat for a third crew member when carried. Airliner-type seating for eight, ten or twelve passengers (those in the ten-seat layout being at 32 in = 81·3 cm pitch), with galley and toilet at rear. Alternative six-seat executive, or fourteen-seat high-density layouts are available. Access to passenger cabin is via a door on the port side, aft, which on the prototype is incorporated within a larger cargo door. The latter door will be an optional feature on production aircraft. Emergency exit on starboard side, just forward of trailing-edge.

ELECTRONICS AND EQUIPMENT: Wide range of radio and navigation equipment available for production aircraft, according to role, including complete ARINC system. Prototype has Air-LB VHF radio and electrical recording systems, Bronzavia radio-navigation equipment, gyro compass and ILS.

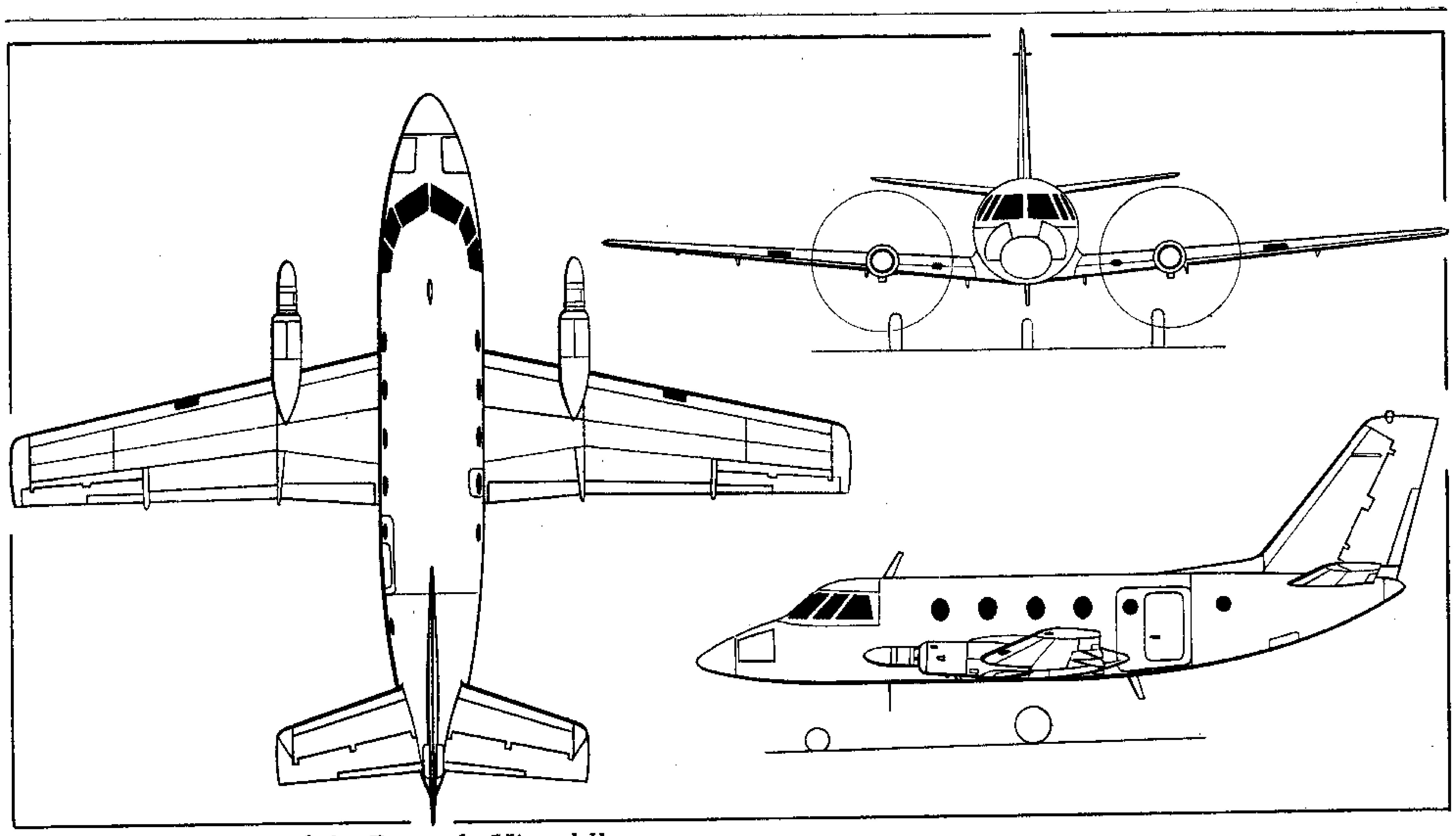
SYSTEMS: Cabin air conditioning, pressurisation, heating and ventilation standard. Messier hydraulic system.

DIMENSIONS, EXTERNAL:
- Wing span: 47 ft 8¾ in (14·55 m)
- Length of fuselage: 40 ft 2¼ in (12·25 m)
- Passenger door:
  - Height: 4 ft 5¼ in (1·35 m)
  - Width: 2 ft 7½ in (0·80 m)
- Cargo door (optional):
  - Height: 4 ft 7 in (1·40 m)
  - Width: 4 ft 3¼ in (1·30 m)

DIMENSIONS, INTERNAL:
- Cabin: Max height: 5 ft 5¾ in (1·67 m)
  - Max width: 4 ft 10½ in (1·49 m)
- Cargo hold (freighter):
  - Max length: 16 ft 9 in (5·11 m)
  - Volume: 415 cu ft (11·75 m³)

AREA:
- Wings, gross: 290·63 sq ft (27·00 m²)

WEIGHTS (production aircraft, estimated: A = 6-seat executive, B = 8 passengers, C = 10 passengers, D = 12 passengers, E = cargo version):
- Basic operating weight, empty:
  - A: 7,716 lb (3,500 kg)
  - B: 7,346 lb (3,330 kg)
  - C: 7,363 lb (3,340 kg)
  - D: 7,430 lb (3,370 kg)
  - E: 7,099 lb (3,220 kg)
- Max payload:
  - A: 1,146 lb (520 kg)
  - B: 1,521 lb (690 kg)
  - C: 1,896 lb (860 kg)
  - D: 2,271 lb (1,030 kg)
  - E: 3,086 lb (1,400 kg)
- Max T-O weight:
  - A, B, E: 12,236 lb (5,550 kg)
  - C: 11,751 lb (5,330 kg)
  - D: 12,192 lb (5,530 kg)



General arrangement of the Dassault Hirondelle

- Max cruising speed:
  - A, B: 280 mph (450 kmh)
  - C, D: 310 mph (500 kmh)
  - E: 261 mph (420 kmh)
- Time to 20,000 ft (6,100 m) (all versions): 13 min
- Service ceiling (all versions): 30,850 ft (9,400 m)
- Service ceiling, one engine out (all versions): 16,400 ft (5,000 m)
- T-O run:
  - A, B, D, E: 2,955 ft (900 m)
  - C: 2,625 ft (800 m)
- T-O to 50 ft (15 m) at 11,464 lb (5,200 kg) AUW (all versions): 2,460 ft (750 m)
- Landing run:
  - A, B: 2,135 ft (650 m)
  - C: 2,230 ft (680 m)
  - D: 2,300 ft (700 m)
  - E: 2,395 ft (730 m)
- Range at max cruising speed, 45 min reserve:
  - A, B: 1,926 miles (3,100 km)
  - C, D: 1,243 miles (2,000 km)
  - E: 1,118 miles (1,800 km)

BOEING

USA: THE BOEING COMPANY, Head Office: PO Box 3707, Seattle, Washington 98124

BOEING SST MODEL 2707-300

Following the decision to abandon the original Model 2707-200 variable-geometry supersonic transport design, Boeing are developing a new fixed gull-wing design known as Model 2707-300. The General Electric GE4 engines specified for the original design are retained and much of the systems design is being carried over to the new model.

A major structural change is that the Model 2707-300 wings will utilise sandwich skins instead of the machined panels specified for the earlier design.

It is expected that two flying prototypes of the Model 2707-300 SST will be built, with the first flight scheduled for 1972. The following description applies to the prototypes. Various cabin arrangements are being studied for the eventual production aircraft, including a five-abreast all-tourist layout for 234 passengers.

TYPE: Long-range supersonic transport prototype.

WINGS: Cantilever low-wing monoplane of delta planform. Special wing sections. Aspect ratio 2·55. Chord 101 ft 1 in (30·81 m) at root, 12 ft 6 in (3·81 m) at tip. Thickness/chord ratio 3·7% at root, 3% at tip. Gull-wing design, with 4° dihedral from root to outboard engine, 3° anhedral from outboard engine to tip. Sweepback at quarter-chord 50°. Titanium (Ti-6A1-4v) fail-safe structure of multiple built-up spars, beams and ribs. Majority of wing covered with titanium alloy sandwich. Stainless steel skin in engine bays. Stainless steel leading-edge and tip sections. Full-span in low-speed flight. Simple hinged leading-edge flaps. Slot deflector upper and lower spoilers at mid span. No trim-tabs. All control surfaces hydraulically powered by redundant systems. No anti-icing equipment.

FUSELAGE: Conventional semi-monocoque fail-safe structure, with skin panels, stringers and frames of titanium alloy.

TAIL UNIT: Conventional tail unit of similar construction to wings, except that trailing-edges are also of stainless steel. Variable-incidence tailplane, with elevators. Three-segment rudder, of which top segment is locked at supersonic speed. All control surfaces hydraulically powered by redundant systems. No trim-tabs or anti-icing equipment.

LANDING GEAR: Retractable tricycle type in cooled wheel wells. Hydraulic actuation, all units retracting forward. Conventional oleo shock-absorbers. Each main unit consists of a bogie with six dual wheels carrying 12 tyres size 40 × 12. Twin-wheel nose unit with tyres size 34 × 16. Main wheel tyre pressure 200 lb/sq in (14 kg/cm²). Graphite disc brakes. Individual wheel anti-skid control.

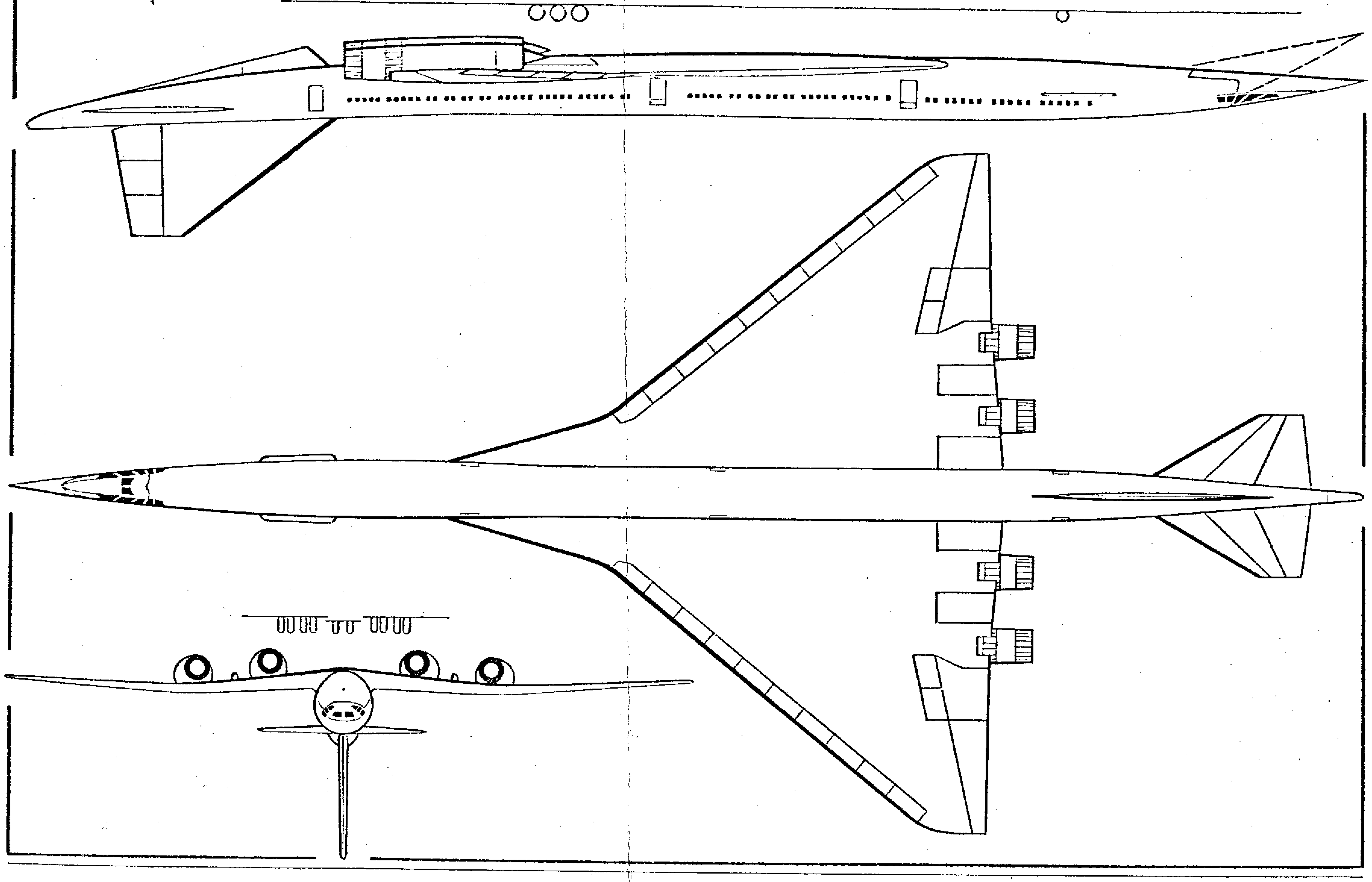
POWER PLANT: Four General Electric GE4/J5P turbojet engines in individual underwing pods. Fuel in four main tanks, with auxiliaries. Fuel trim system. Total potential fuel capacity 440,000 lb (199,580 kg). Refuelling points in leading-edge of inboard wing.

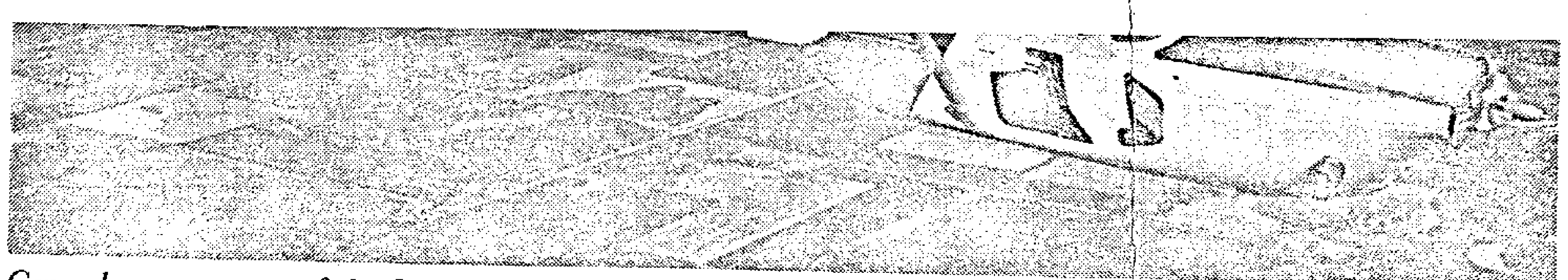
ACCOMMODATION: Prototype will carry flight crew of three. Plug-type (inward/outward) side-hinged doors. Forward and aft freight holds under passenger cabin floor.

SYSTEMS: Air-cycle air-conditioning and pressurisation system, differential 11 lb/sq in (0·77 kg/cm²). Four independent hydraulic systems for flying controls and landing gear, pressure 4,000 lb/sq in (281 kg/cm²). Pneumatic engine starting system. Variable-speed constant-frequency electrical system, supplied by four 75 kVA engine-driven generators.

ELECTRONICS AND EQUIPMENT: Advanced instrumentation, radio and radar to customer's specification.

DIMENSIONS, EXTERNAL:
- Wing span: 141 ft 8 in (43·18 m)
- Length overall: 280 ft 0 in (85·34 m)
- Height overall: 50 ft 1 in (15·27 m)
- Tailplane span: 33 ft 6 in (10·21 m)
- Wheel track: 20 ft 4 in (6·20 m)
- Wheelbase: 104 ft 9 in (31·93 m)
- Passenger doors (forward):
  - Height: 6 ft 0 in (1·83 m)
  - Width: 3 ft 6 in (1·07 m)
  - Height to sill: 15 ft 5 in (4·70 m)
- Passenger doors (centre):
  - Height: 6 ft 0 in (1·83 m)
  - Width: 3 ft 6 in (1·07 m)
  - Height to sill: 14 ft 2 in (4·32 m)
- Passenger doors (rear):
  - Height: 6 ft 0 in (1·83 m)
  - Width: 2 ft 8 in (0·81 m)
  - Height to sill: 17 ft 6 in (5·33 m)



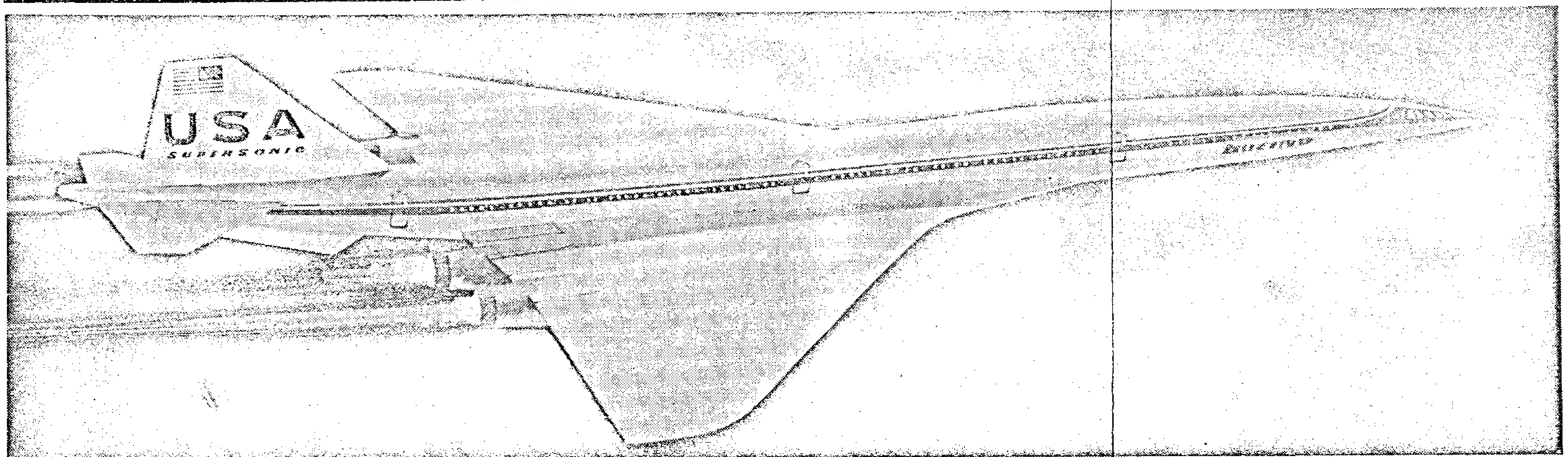


General arrangement of the Cessna O-2TT, and photograph of the O-2T

aircraft, while more than 40 Dukes have been completed.

TYPE: Four/six-seat cabin monoplane.

WINGS: Cantilever low-wing monoplane. Wing section NACA 23016·5M at root, NACA 23010·5 at tip. Aspect ratio 7·243. Chord 9 ft 2⅛ in (2·80 m) at centre-line of fuselage, 2 ft 11⅝ in (0·90 m) at tip. Thickness/chord



A three-view drawing and artist's impression of the Boeing 2707-300 SST

Width 5 ft 8 in (1·73 m)
Height to sill 11 ft 0 in (3·35 m)
Baggage and freight doors (rear, two):
Height 2 ft 7 in (0·79 m)
Width 2 ft 4 in (0·71 m)
Height to sill 13 ft 0 in (3·96 m)

DIMENSIONS, INTERNAL:
Cabin (passenger section, including galleys and toilets):
Length 178 ft 0 in (54·25 m)
Max width 11 ft 8 in (3·55 m)
Max height 6 ft 8 in (2·03 m)
Baggage holds:
Fwd belly, containerised 1,053 cu ft (29·82 m³)
Aft belly, bulk 300 cu ft (8·50 m³)

AREAS:
Wings, gross, incl ailerons and flaps 7,900 sq ft (734 m²)
Vertical tail surfaces, total incl ventral fin 783 sq ft (72·74 m²)
Horizontal tail surfaces, total 591 sq ft (54·90 m²)

WEIGHT:
Max ramp weight 635,000 lb (288,030 kg)

PERFORMANCE (estimated):
Max level speed at 73,000 ft (22,250 m) Mach 2·7
Max permissible diving speed Mach 2·9
Max cruising speed at 60,000-70,000 ft (18,300-21,350 m) Mach 2·7
Lift-off speed 207 mph (334 kmh)
Approach speed 164 mph (263 kmh)
FAR T-O field length 7,700 ft (2,350 m)
FAR landing distance 7,500 ft (2,290 m)

CESSNA

USA: CESSNA AIRCRAFT COMPANY. Head Office: Wichita, Kansas 67201

In December 1966, Cessna received an initial contract from the USAF for 145 Model 337 Super Skymasters, which were given the designation O-2A. Equipped for forward air control (FAC) missions, they differed from the civil version by having dual controls as standard, quickly-removable rear seats and four underwing pylons for external stores. An urgent requirement for additional FAC aircraft in 1966 dictated this "off-the-shelf" purchase, and a total of 223 O-2As and O-2Bs (a psychological warfare version) were delivered during the first year. Follow-up contracts called for 154 additional aircraft for delivery by November 1969.

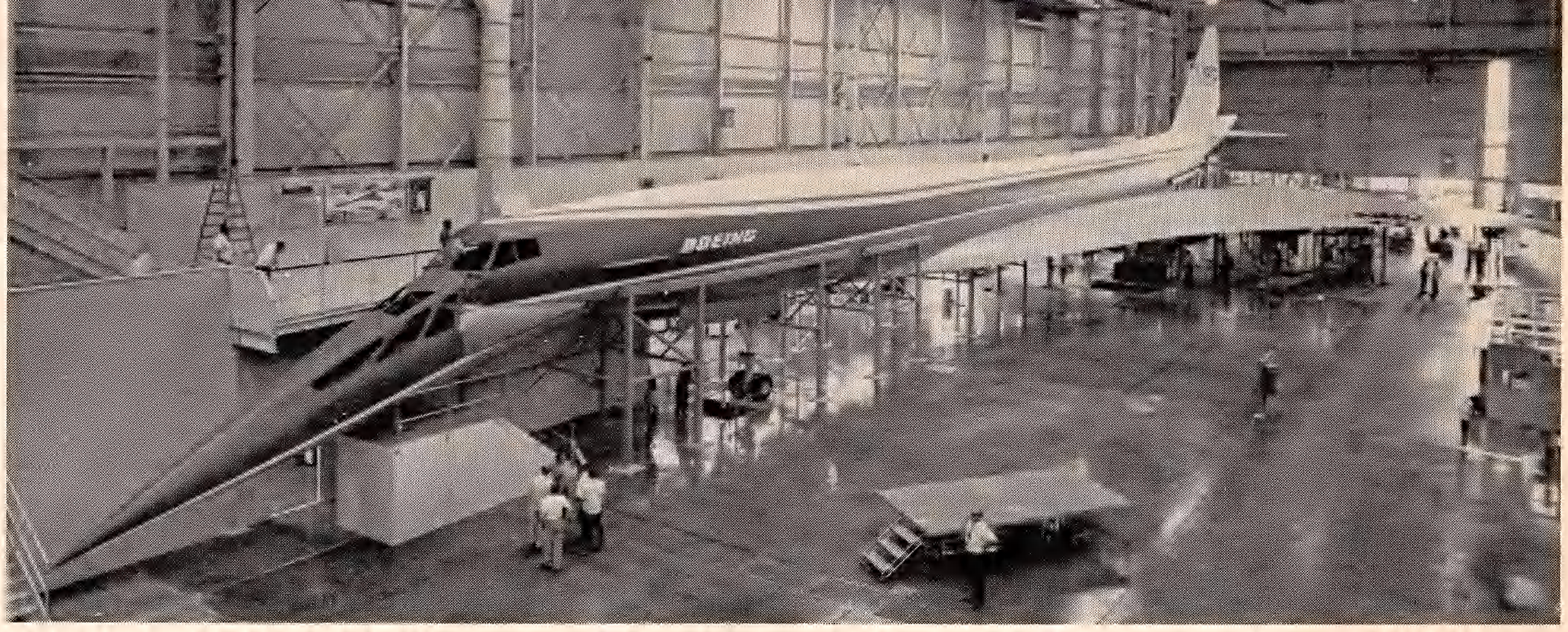
After analysis of the comments and mission requirements of pilots who had flown the O-2s under combat conditions, Cessna decided to develop the basic piston-engined O-2 series into a twin turboprop STOL aircraft for FAC missions, designated **O-2TT** (Tandem Turbine). To provide a prototype for flight demonstrations, Cessna have fitted standard O-2 airframe with the Allison 250-B15 turboprop engines, added wing area and high-lift devices specified for the O-2TT. Designation of this prototype, which retains the side-by-side crew seating of the O-2A, is **O-2T** (Turbine). The O-2TT has further changes as indicated below.

CESSNA O-2TT

The O-2TT retains the basic O-2 airframe, but has a new forward fuselage providing tandem seating for the crew under a bubble canopy. The new nose section gives improved visibility, as both crew members are seated forward of the wing, and leaves ample room in the rear fuselage for night acquisition and other special equipment or personnel. Two doors on the starboard side of the cabin section, forward of the wing, allow easy entry and exit.

STOL requirements have been met by the use of high-lift devices which include a constant-radius leading-edge, drooping ailerons interconnected with single-slotted flaps, and an increase of 21 sq ft (1·95 m²) in the wing area.

An extended landing gear, with wheel and tyre sizes increased to 6·50 × 8, and raised propeller hub locations, provide substantially increased ground clearance for both propellers, making the O-2TT suitable for operation from unimproved strips. Two 317 shp Allison 250-B15 turboprop engines provide 214 hp more than the power plant of the piston-engined version, and have Beta control to give propeller-reversing



Class 2 structures mockup of the Boeing supersonic transport is constructed primarily of aluminum to a tolerance of 0.0030 in.

Volpe Rebuts Critics of SST Program

By Richard G. O'Lone

Seattle–Lack of a U.S. supersonic transport could mean that overseas competitors will do to this nation's aircraft industry what imported autos have done to Detroit, according to Transportation Secretary John A. Volpe.

Volpe's warning came at the unveiling here June 5 of the Class 2 structures mockup of the Boeing 2707-300 supersonic transport.

The secretary called the program a "cooperative industry-government investment" in the nation's future, and an effort that would give future U.S. workers "an opportunity to earn a living in a trade in which they are best skilled."

Secretary Volpe cited the inroads that imported cars have made into the U.S. auto industry, pointing out that such a situation could not have been imagined 20 or 30 years ago, when Detroit was the auto capital of the world.

"This could happen to our aircraft industry," he said. "There are those who—with ostrich logic—reason that if we don't build a supersonic transport there won't be any supersonic transports. But I have already seen the British-French Concorde in flight, and I have on my desk . . . reports on the success . . . of Soviet supersonic flight."

Critics who insist private industry alone should handle the program overlook the nature of the competition, Volpe said. The Concorde effort, untroubled by stockholders or interest rates, can draw on the resources of two wealthy and highly industrialized nations, he said, while the Soviet Tu-144 is a "100% government effort."

The market for supersonic transports exists, and other nations are aiming at it, he said.

Boeing President T. A. Wilson said he was "dismayed by the severity of the attacks on the program," but pointed out that these assaults have brought about a thorough debate in Congress and the news media.

The SST is a cleaner method of transportation than the automobile by a factor of 25, Wilson said, and will provide a $22-billion positive effect on the U.S. balance of trade over the life of the program while providing jobs for thousands throughout the nation.

The 287-ft. long aluminum mockup, built to a 0.0030-in. tolerance, is used to verify the detailed design of the prototype configuration. It was ready for use a month ahead of schedule, although it still lacks actuators for the wing leading and trailing edge devices, and the mockups of the General Electric GE4 powerplant are not yet in place. The horizontal tail control surfaces can be moved, the landing gear can be retracted and the hinged nose can be actuated.

Boeing officials maintain that design of the mockup is so precise that 95% of it will be applicable directly to the prototype, compared with about 25% in the case of the Boeing B-52 jet bomber.

The manufacturer also is displaying a small interior mockup of a piece of the passenger cabin, showing five-abreast seating in one of the larger cross-section areas of the fuselage, which has a varying diameter due to area ruling. The interior is representative of the state-of-the-art, and is almost identical to the new wide-body appearance designed for present-generation jet transports (AW&ST Apr. 28, 1969, p. 32).

Boeing hopes to build a full-scale interior mockup in the future.

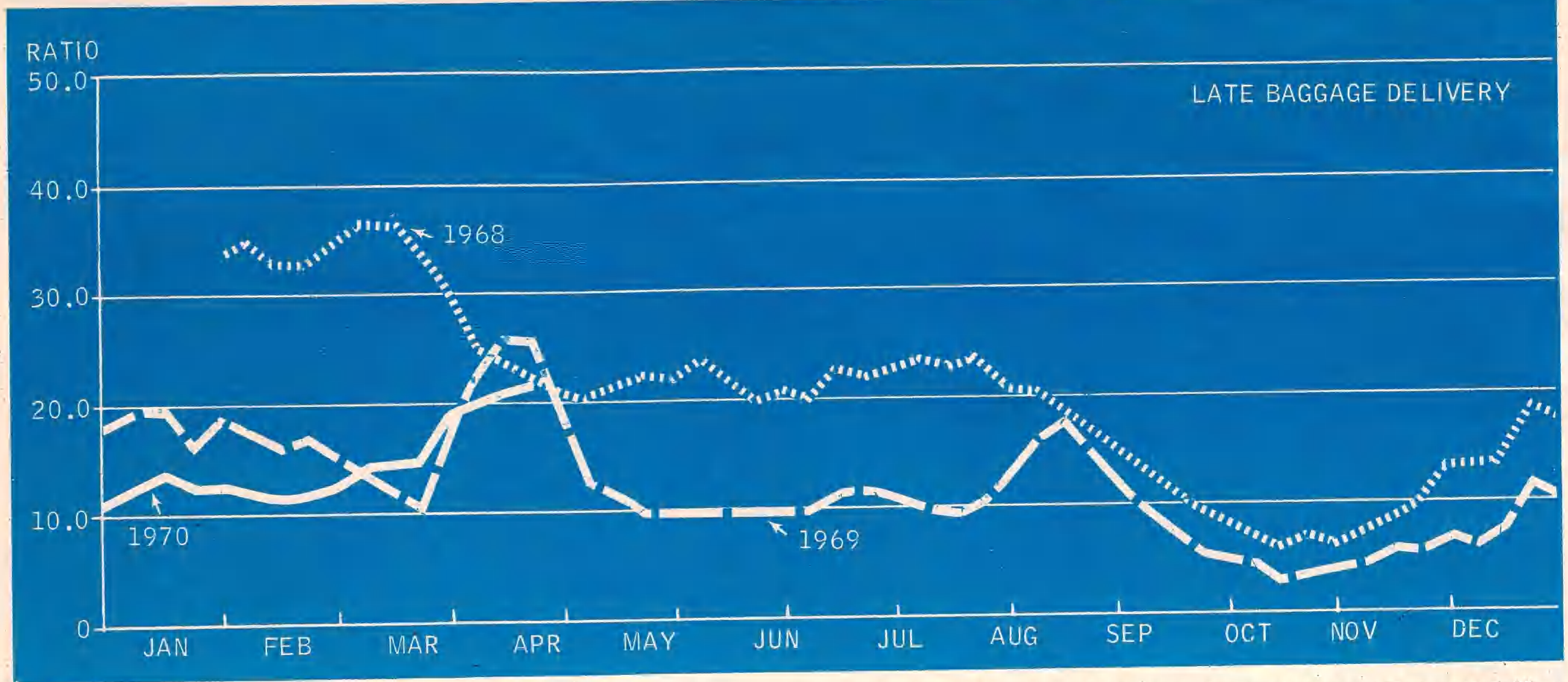
Other points that emerged during the ceremonies and news conference included:

- Boeing apparently is not ready to accept a four-month delay that would push the first flight from November, 1972, to March, 1973 (AW&ST June 1, p. 26). "There has been discussion of a possible slide," said Boeing's SST chief, H. W. Withington, "but as far as we are concerned, we are still on the schedule that was set last fall."
- Secretary Volpe blamed a $76-million cost rise on wage increases and delays due to a cut in funding last year, and pointed out that "if we can hold it to $76 million, I think we will have done exceptionally well."
- Boeing cannot be sure that more major SST subcontractors will not defect until they are all signed to contracts, a process that is due to be completed this month, Withington said.

Of the nine major subcontractors, three have signed contracts and three have withdrawn—the latest being LTV Aerospace Corp. (AW&ST June 8, p. 18).

Fairchild-Hiller last week agreed to take over fuselage section 47 that had been dropped by Avco (AW&ST May 11, p. 39), and was signed to a $34.5-million contract to produce that piece plus its original part of the airplane—aft fuselage section 48 and empennage—for the two prototypes.

Part of the work dropped by LTV—fuselage section 45, just forward of the wing—will be built by Boeing-Wichita, which also took over adjoining section 43 when it was dropped by Aerojet-General Corp. (AW&ST Feb. 2, p. 22). The other piece that LTV was to build—the wing strake—will be built by Boeing in Seattle.



Eastern Airlines charts also measure details of passenger service quality. Late baggage delivery, where many carriers are falling below standards, is measured by number per 1,000 non-Air Shuttle passengers receiving bags more than 20 min. after arrival.

hensive document than most carriers use. A recent one had 25 charts on a four-week moving average basis, including:

- Compliments, complaints, and ratio of compliments to complaints, all on a per-1,000-passenger basis.
- Departures and arrivals within 15 min., block to block schedule performance, and average number of flights delayed as a total and broken down into those caused by ground services, maintenance and flight operations. The latter includes cockpit, legality and turnaround delays. Flights canceled for maintenance also are shown.
- Passengers inconvenienced per 1,000 as a total and broken down by reason of late baggage delivery, bags mishandled, meal shortages, cancellations of connections, diversions, oversales and downgrades in seating.
- Reservations telephone answering time, as a percentage of those answered within 20 sec.

Eastern uses an 85% standard in the telephone answering area. It has standards for some other areas that involve work performance—as a 4.2-passenger-per-1,000 meal shortage ratio—and for broader measures like the compliment to complaint ratio of 1.45:1.

In its daily operations performance summary, the carrier also grades by letter—A through D—in four major categories: operations and the marketing areas of revenue, reservations and international regions. The grades are based on success in meeting various standards on that day and are accumulated over a month against the monthly target of grade A days.

System operating performance has targets in 10 areas. These are expressed in percentages, such as a 1% maximum for flight cancellations or a goal of 80% flight originations within 3 min. It is a commentary on the degree of congestion today that the block-to-block on-time standard is 50%.

On one recent day, 9 of the 10 standards were met or exceeded. The below-standard area—departure delays, where the actual figure was 11.58% against a 10.64% maximum—was flagged on the report since the target had not been met for three consecutive days.

However, the day was during the air controllers slowdown. And the overall performance for system operations was rated A. Revenue performance was the only area to get lower than an A. Revenue was 96.2% of forecast, against a target of 101%. Again, this was during the traffic slowdown, and system revenue passenger miles were three percentage points below forecast and Air Shuttle 13 points below.

The monthly report, besides aggregating the customer handling figures, analyzes the types of complaints received and the passenger inconvenience record and comments on the results. The February report, for example, noted that 4,000 fewer passengers were inconvenienced because of flight cancellations than in 1969, but pointed out the Feb. 9, 1969, blizzard had snarled operations in the northeastern states. Oversales were 46% higher in February, 1970, the report added, largely because of the National Airlines strike which reduced normal attrition rates.

TWA, one of the originators of today's statistical performance measures that date from the late 1930s, is putting these as well as cost, revenue and profit data on microfilm display consoles for a six-month test of the equipment. One console will be placed near the desk of TWA President F. C. Wiser, Jr., so that he can call out in seconds current operating data, whether baggage delivery performance or system profit and loss.

Quality-of-service indices can be used two ways. They can be examined in terms of whether standards are too high and costly. Or they can be used as checks, as Eastern does, on whether fleet and operating changes are resulting in undesirable lowering of service and adverse customer reaction.

The whole question of cost control can also be looked at in two ways. Is the problem one of too high an expense level? Or is it a question of too small a growth in revenues?

Pan American is scrutinizing its costs and has established budget and expense controls. A new vice president of budgets sits in on weekly budget reviews. Nevertheless, the airline is emphasizing the other side of the coin as much or more. As Najeeb E. Halaby, Pan American president, said in a recorded telephone pep talk to employes: ". . . It's selling our way out of our problem that is going to help us. Let's get off our bottoms and to the top again."

Halaby said the carrier has developed a profitability plan that is based on improved quality of service, better employe performance, greater operating efficiency and new marketing programs. Not only is Pan American seeking to increase airline business volume, particularly by stimulating budget travel and containerized air freight, but it also is looking outside the airline field.

The latter move includes food and beverage sales and real estate and land development. Another area is utilization of the pool of technical personnel at the Aerospace Services Div. supporting the Air Force Eastern Test Range.

(This is the second of a two-part series.)

January 5, 197

Aviation Week & Space Technology

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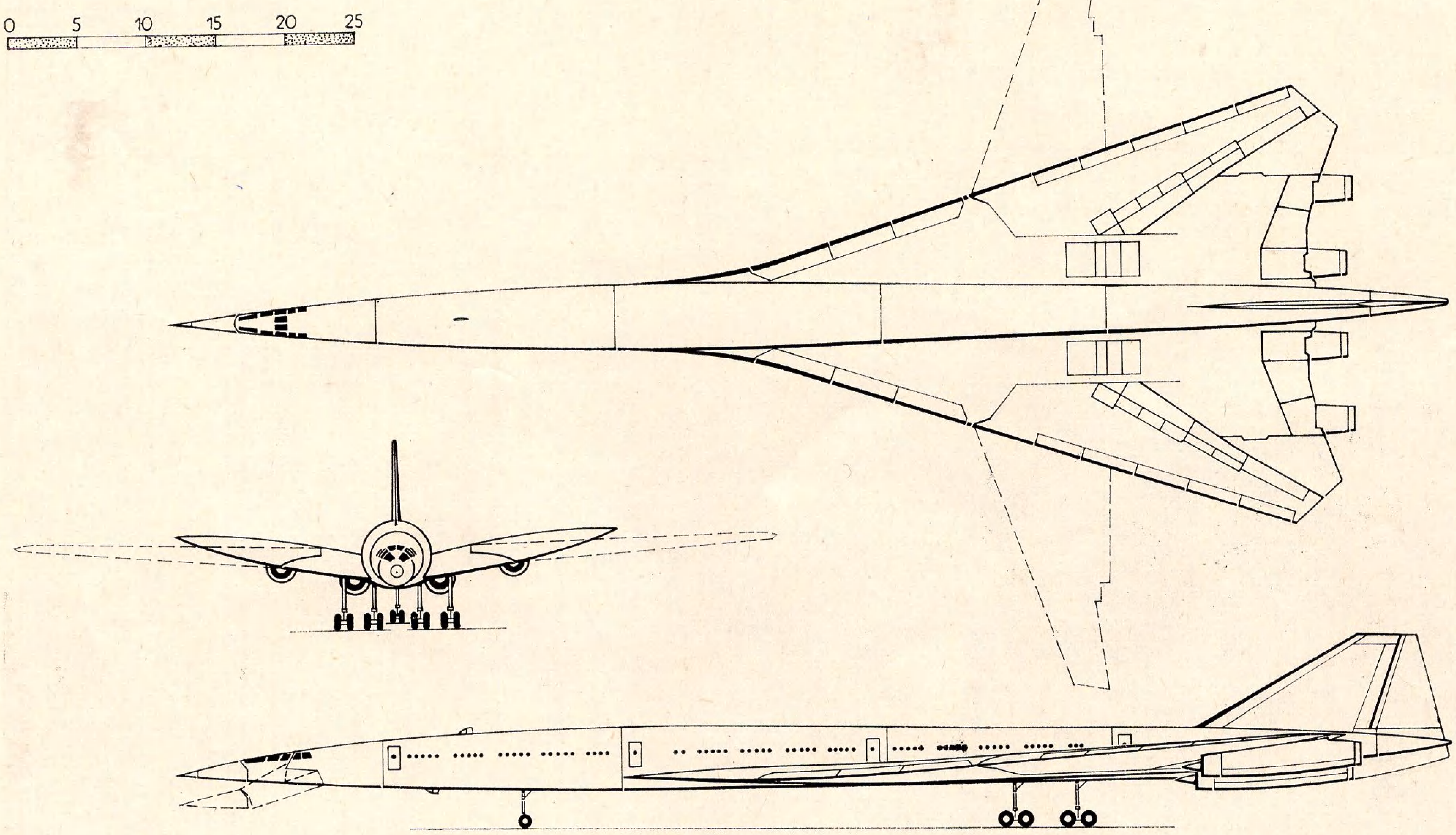
A McGraw-Hill Publication $1.00

Boeing 2707-300 model

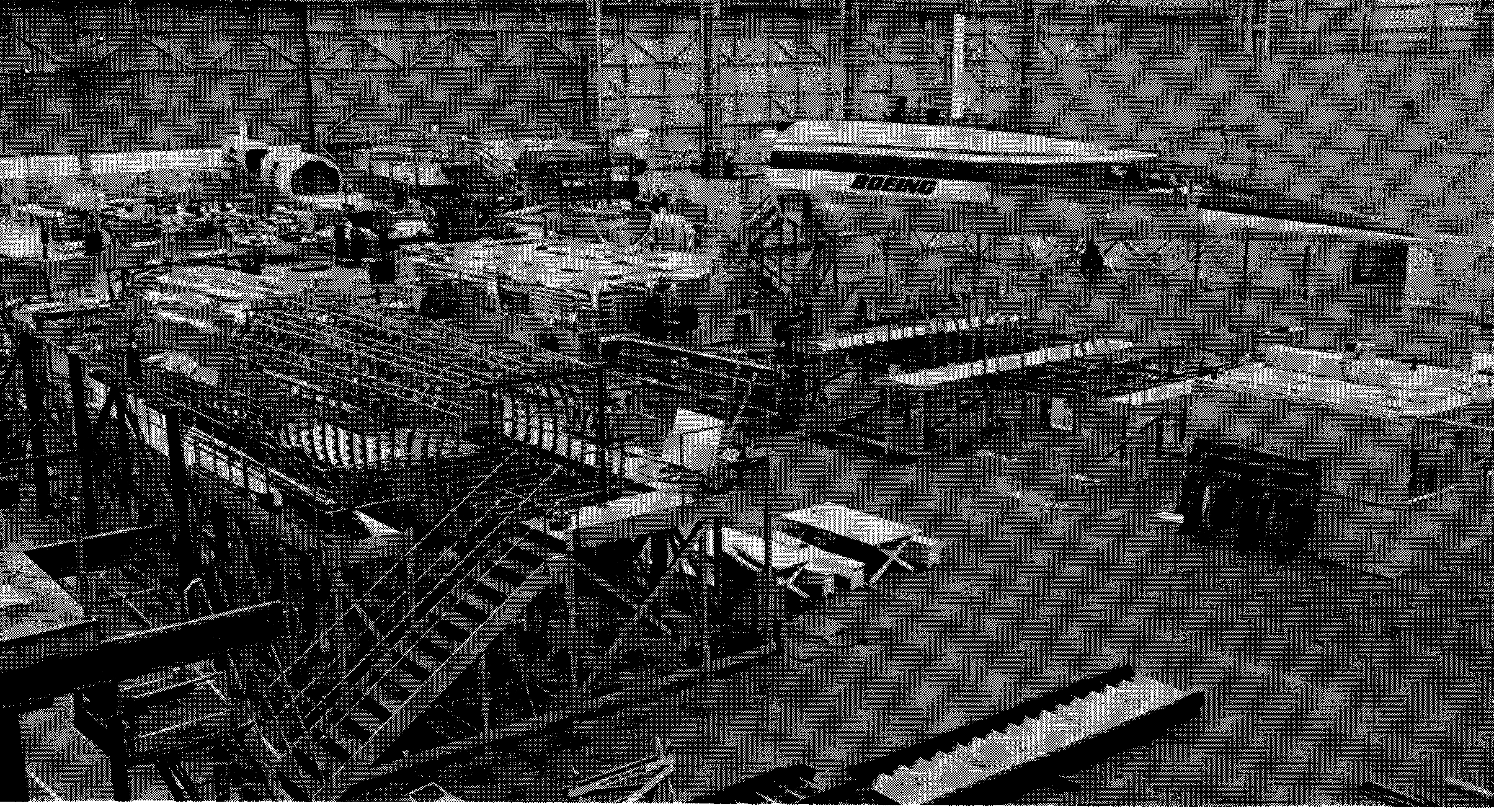
Special Report: **U.S. Supersonic Transport Program**

BOEING



BOEING 2707
(USA)

Erstflug des Prototyps:		1969
Verwendung:		Überschall-Verkehrsflugzeug
Passagierzahl:		277–300
Triebwerk:		4 × General Electric GE4/J5P
Startleistung	kp	4 × 28 670
Abmessungen:		
Spannweite		
ausgespreizt	m	54,97
angeklappt	m	32,23
größte Länge	m	93,27
größte Höhe	m	14,10
Flügelfläche	m²	836,13
Massen:		
Leermasse	kg	130 308
max. Nutzlast	kg	34 020
max. Kraftstoffmasse	kg	166 513
max. Abflugmasse	kg	306 175
max. Landemasse	kg	195 045
Flugleistungen:		
Reisegeschwindigkeit in 21 000 m Höhe	km/h	2900
entspr. Machzahl		2,7
Reiseflughöhe	m	21 000
max. Reichweite	km	6840
Einsatz im Luftverkehr		ab 1974



Class 2 aluminum mockup of the Boeing 2707-300 is under construction (left) at the Boeing Developmental Center, where the prototypes will be built. Wooden mockup for interiors and systems are under construction in background.

Air Transport

Special Report: U.S. SST Program

Reprograming Bolsters 2707 Effort

Tool design, fabrication started and parts construction set to begin this fall as growth performance of engine continues

By Laurence Doty

Washington—Reprograming, embracing all technical, financial and operational aspects of a supersonic transport, has strengthened the U.S. project with a renewed momentum that is overcoming problems created by early design difficulties.

Delays which have caused severe slippages in production schedules are not likely to be made up as the program now moves into hardware procurement. Planned first flight of a prototype supersonic transport slipped from 1970 to 1972. This year alone, the flight target date has receded from an early 1972 to late that year.

In the initial program, issued in June, 1967, production was scheduled to begin in mid-1970 with deliveries set for early 1974. This later was revised to provide for first production in 1972 and deliveries in 1975.

Now, production is planned for 1975 with deliveries commencing in the spring of 1978.

But the delta-wing design with horizontal tail now has been firmly validated by the Office of Supersonic Transport Development of the Federal Aviation Administration, participating airlines and the airframe and engine manufacturers: Boeing and General Electric. Technicians and engineers generally agree that the project can be considered well under way.

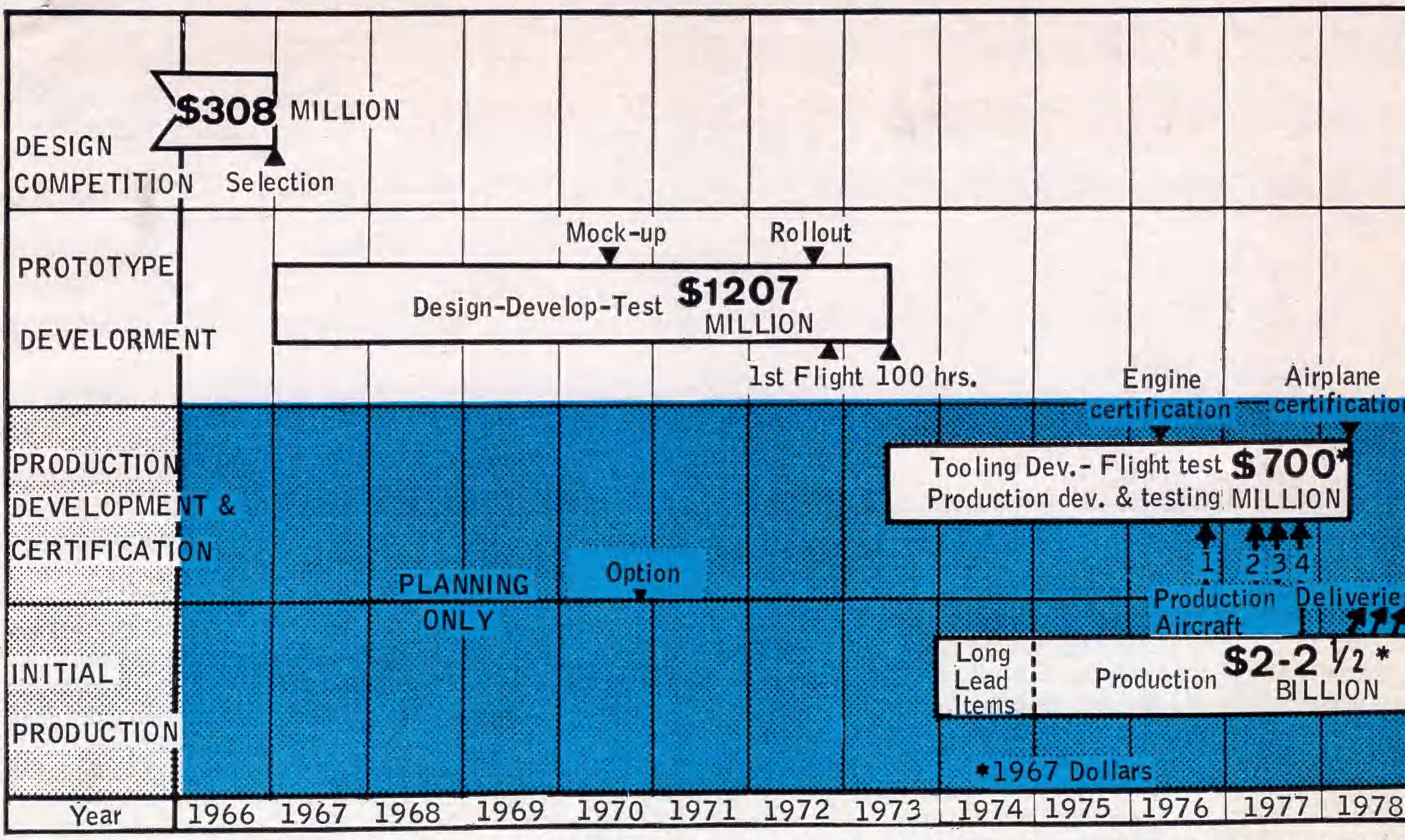
Transition from preliminary design to actual released structural drawings is in process. Tool design and fabrication have been started and parts construction is scheduled to begin this fall. Growth performance of the GE4/J5P engine continues at a steady pace.

The delay in the U.S. program has provided the British/French Concorde and the Russian Tupolev Tu-144 supersonic transports with a firm lead time. The deferral has also produced the possibility of building second-generation aircraft based on these two designs which would match the U.S. supersonic transport economically and operationally.

Had it not been for a well-defined program backed by a confident industry and three determined Administrations, a healthy share of the supersonic transport market for the U.S. would have been seriously threatened by overseas competition. Nevertheless, the potential competitive impact of new models which could be built abroad is ever-present and could force new changes in the basic U.S. program.

To date, a majority in Congress has demonstrated a willingness to support the program. Opposition stems not so much from the large investment Congress is being called upon to generate but from a widespread misunderstanding of the nature of these funds.

The U.S. foresees a total world aircraft market of $125 billion by 1990. Of this, supersonic transport sales would account for $25 billion, with the U.S. taking $20 billion of that amount through the sale of a forecasted 500 aircraft.



Latest master schedule for Boeing 2707 calls for first flight of the prototype in 1972 and production deliveries beginning in 1978. Total costs of program phases through production peak financing are shown.

in Overcoming Early Difficulties

The government will be asked to invest $995 million in the prototype phase. Once production starts, the project is expected to become self-sustaining, through sales and private investment.

By the time 300 aircraft have been delivered, the government will have received, through royalties on each supersonic transport, its total investment of close to $1 billion. There is some possibility that additional requests for federal funds to support initial phases of production may be required. But this probability is not contained in current projections.

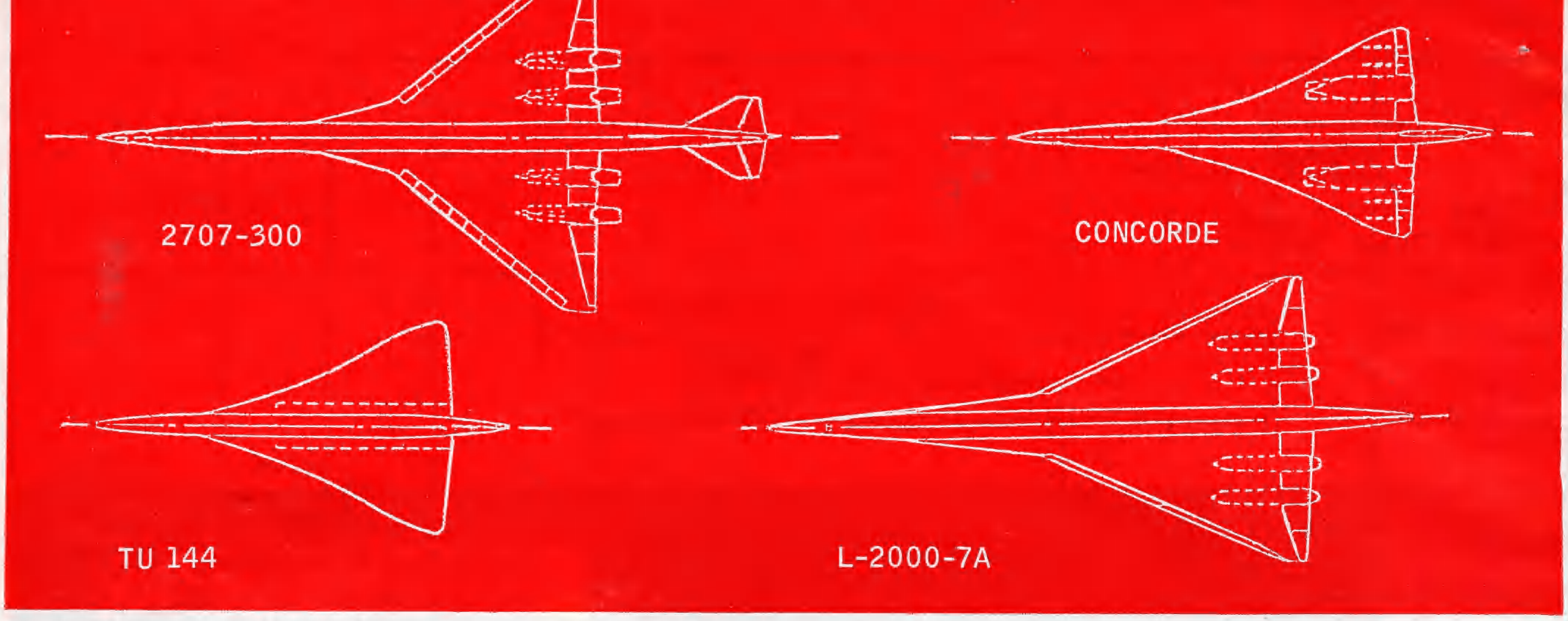
The time element remains all-important. By mid-summer of this year, 42 months or about 55% of the 76-month prototype program, will have elapsed. This factor alone has added impetus to competition from abroad.

The deferred program offers some advantage in developing prototypes which will be more advanced in design than might otherwise have been possible. These include:

- Airlines now believe they have sufficient time to consolidate their resources in preparing for an entirely new type of operation. The supersonic transport will drastically revise conventional concepts of route structures, marketing and flight procedures. This will be particularly true if the aircraft is required to operate subsonically over populated land areas, as is expected, because of the sonic boom problem. An Airlines Supersonic Committee has been formed to permit close cooperation between the manufacturers and the carriers to ensure standardization and efficient operational development. The committee is headed by N. R. Parmet, Trans World Airlines vice president-equipment development, and is represented by 26 U.S. and non-U.S. airlines.
- Switch from a variable-sweep configuration to the delta-wing design, principal reason behind the need to protract the program, served to broaden the spectrum of design research and development. This provided engineers and designers with an extended working platform.
- New design will enable manufacturers to offer a family of supersonic transports, with each model suited to the particular requirements of individual airlines. This is feasible because of the continuity of the wing structure from tip to tip and the placement of the fuselage on the top of the wing. Thus, smaller body sizes can be adapted for very long-range routes and larger sizes for short-range routes.
- New lightweight structural design concepts, such as titanium fabrication and welded honeycomb sandwich-skin panels now undergoing process development, can be installed in the prototypes because of the program time lag.
- General Electric will be able to increase takeoff thrust of the GE4/J5 engine well above guaranteed 50,600 lb.

A convergent design, in which all factors meet at an optimum point, has been achieved by overcoming engineering problems while, at the same time, meeting essential commercial requirements. These include a satisfactory payload/range relationship, stability, high and low-speed performance and acceptable maintenance and operational economies. A full-scale mock-up of the aircraft will be completed by early summer.

Most of this work has been accom-



Planform drawings compare configurations of U.S., Anglo-French and Soviet supersonic transports.

plished through government financing. This is a proper term because the money is not an outright appropriation but an investment which will be recouped by the government with a reasonable rate of return after 300 aircraft have been sold.

Thus far, since the beginning of the program, $623 million has been funded by the government. This was not attained without floor battles in both the House and Senate directed by critics protesting the noise problem, challenging the need for a supersonic transport as well as deploring the switch in design.

For Fiscal 1970, $96 million in new obligational authority was sought. With a $99-million carryover, this would have put government participation this year at $195 million.

Boeing will contribute $14.3 million and General Electric $6.5 million to bring total investment in Fiscal 1970 to $215.8 million.

The House approved the $96 million, but the Senate balked and, late last year, voted to slice that amount by $10.9 million (AW&ST Dec. 22, 1969, p. 12). This is serving as a warning as to the obstacles FAA must surmount when it requests $314 million in Fiscal 1971 to cover production costs of two prototype aircraft.

Government financing will continue through the prototype phase, which will include 100 hr. of flight tests. Total estimated costs are now put at $1.2 billion.

The governments share will be $994 million. If 500 aircraft are sold, the government stands to collect $1 billion in royalties in addition to original investment.

Balance of the total cost is represented by $60 million in risk money contributed by the airlines for delivery position. Allowable costs of $153 million will be provided by the manufacturers, plus $132 million for facilities and sales expenses which are not allowable.

The program is now in Phase 3—prototype design, construction and initial flight testing. Phase 2 covered the design competition, which was won by Boeing with its swing-wing design and by GE with the GE4 engine. The variable-geometry wing design was dropped because of structural weight problems. First phase involved basic research.

Phase 4 will include production development and certification, followed by the final phase which will cover actual production.

By the time of certification, the two prototypes will have accumulated about 8,000 hr. of flight time.

Originally, there was an overlap between the prototype and production phases, with production starting during the prototype testing. Now the overlap has been dropped. Production development will begin in mid-1973, when the 100-hr. prototype flight testing is scheduled for completion.

This would call for first deliveries of production aircraft in early 1978. But if competitive pressures from the Russians or the British/French consortium prove to be a threat to U.S. sales prospects, the option to overlap can still be put into action.

The decision to return to the original plan would require substantial reprograming and would have to be made by September, 1970. This would move aircraft deliveries up to late 1975.

Here is how the program has progressed thus far under three Administrations.

- Formal announcement was made in June, 1963, by President Kennedy in an address at the Air Force Academy in Colorado Springs. The statement was inserted in the speech shortly before it was delivered because of a Pan American World Airways decision at that time to purchase six Concordes. This was the first recognition of the seriousness of competition from abroad.
- Initial research on the supersonic transport was promptly launched and continued through Fiscal 1963.
- Phase 2 was conducted during Fiscal 1964 and 1965. This period of preliminary design work was followed by an 18-month design competition which was completed in December, 1966.
- President Johnson approved Phase 3 in 1967 and contracts with Boeing and General Electric were signed on May 1, 1967. This was followed by the first significant delay in the program because of a discovery of a number of defects found in the Boeing design during the evaluation process. Boeing agreed to make the necessary corrections before awarding major subcontracts. It was not until January, 1968, that Boeing submitted a new package. But this was rejected by the FAA because of an unacceptable gap between payload and range performance.
- FAA then instructed Boeing to submit by Jan. 15, 1969, a design on which manufacture of a prototype could be based. During this period Boeing discovered that the structural weight of the variable-sweep configuration imposed too large a penalty on range/payload requirements. In September, 1968, Boeing chose the fixed delta wing with the horizontal tail as the best of alternative designs. This was submitted to FAA on schedule.
- President Nixon requested Transportation Secretary John A. Volpe to investigate all aspects of the program on Jan. 29, 1969. Recommendations were obtained from a government review team, an independent consultant group, nine U.S. airlines and an ad hoc committee of the federal goverment.
- On the basis of the four reports, FAA advised Volpe the program was ready to enter construction. President Nixon ordered commencement of prototype construction on Sept. 23, 1969.

Supersonic Family Evolving at Boeing

Greatest interest focuses on long-range configuration with five-abreast seating and 321-passenger seven-abreast design

By William H. Gregory

Seattle—Design and operational analysis of the Boeing 2707-300 transport is evolving a family of five or more aircraft. Greatest interest here at the moment is centering around two of these.

One is a long-range version of the five-abreast prototype fuselage configuration in which design refinements have increased projected seating from 234 passengers to 250. The other is a maximum-seating version of 321 passengers, seven abreast, with New York-London or Los Angeles-Hawaii range.

Boeing Co. is beginning to stress the long-range version. This is not the same aircraft as the validation prototype, which drew a lukewarm reaction from airlines as an operational aircraft because of the impact of the lower seating on unit operating costs. But it may be close enough to raise questions by carriers.

Boeing also includes as a possibility in the family a Mach 1.1 transport, using the same airframe, for domestic operations. This aircraft would require a turbofan engine, but would use as many components as feasible of the General Electric GE4 turbojet engine for the Mach 2.7 version. Such a turbofan engine might go almost to the Concorde Mach 2.2 cruise level without becoming grossly inefficient, according to Boeing studies.

Why Boeing is emphasizing the long-range configuration now is based on its computer simulation of the supersonic transport on actual airline routes. With a maximum New York-Paris range, the simulation distribution put 300 arrivals and 300 departures daily into John F. Kennedy International Airport at New York.

That amount of daily supersonic transport traffic is unrealistic or impossible even at major gateways, Boeing concluded.

The alternative is to disburse this traffic to other airports in the U.S. and in Europe, which means a longer range aircraft.

Supersonic transports cannot trade off range for payload, or payload for range, with the same flexibility that subsonic transports can. At the range-payload knee, the supersonic transport curve slope is steeper than the subsonic transport's. This means supersonic transport design hinges on hitting the right range points for a variety of airline route systems.

There is another possible consideration. Aircraft with aluminum structure can be prototyped with so-called soft tooling. Many parts can be made at a bench by a man with a hammer and a wood block. This is not the case for the titanium-structure U.S. supersonic transport.

Titanium structure must be hot formed, for example. Dies and equipment for hot forming are hard tooling. If the production aircraft causes changes in detail tooling, it will have impact on cost.

Unlike Boeing's subsonic transport family, different versions of the 2707-300 will mean a change in fuselage cross-section size. The concept for differing versions calls for cutting the wing chordwise at the center and moving the two halves apart to allow for the wider fuselage.

The change would mean a new set of body frames, which is not considered economically unfeasible since the fuselage is conventional skin, stringer and frame construction. The relative cost impact might be no greater than it was for new versions of the 707 family that used the same fuselage cross-section but needed a new wing. Nevertheless, it is clear Boeing is trying to design the prototype as close to the production version as possible for cost—and for schedule reasons as well.

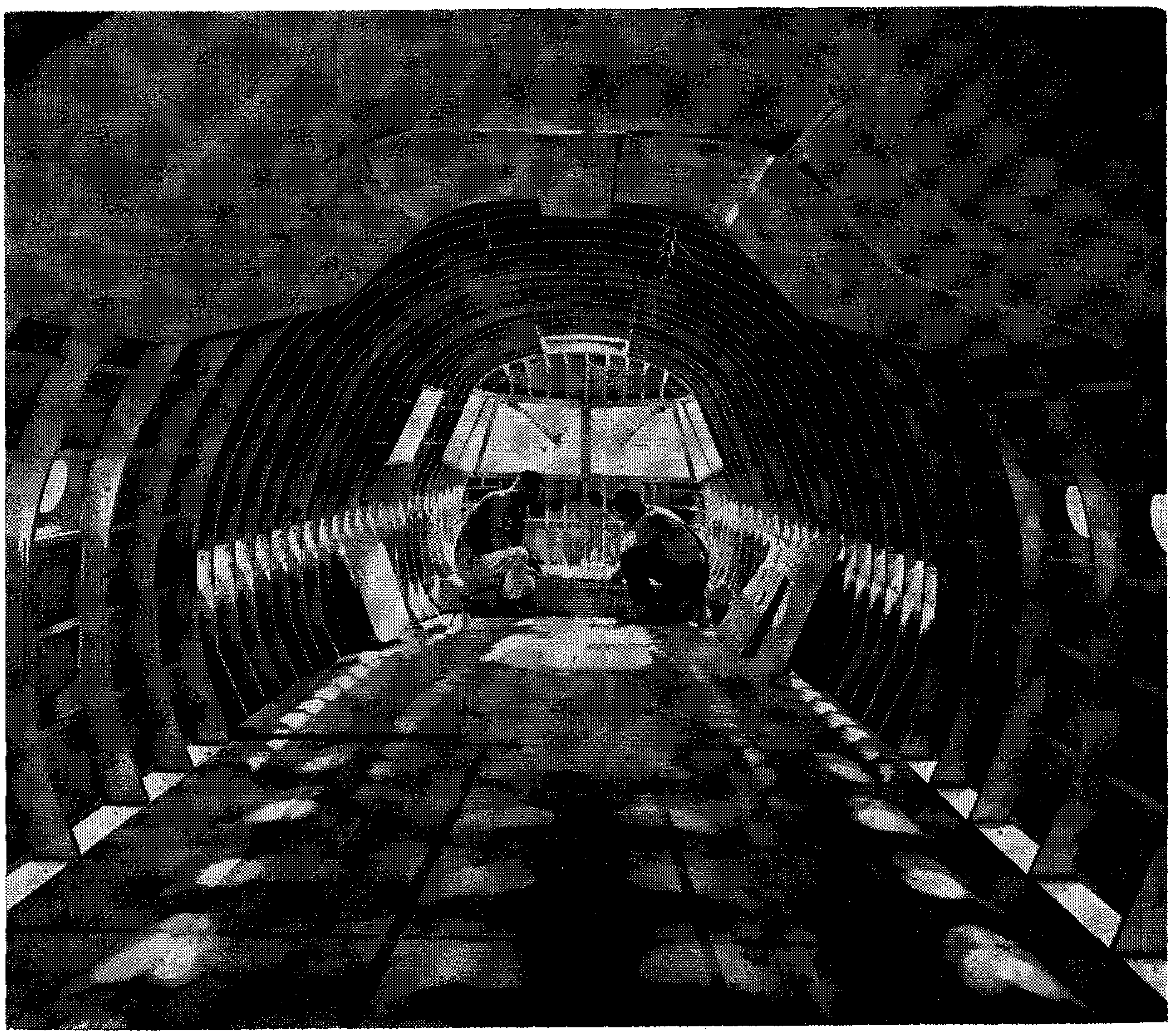
For definition, Boeing and the Federal Aviation Administration program managers have been using a configuration that falls midway between the long-range version and the maximum-seating version. This aircraft seats 281 in mixed first-class and economy seating, or 298 all-economy using six-abreast rows.

Fuselage length of the prototype version has grown from 280 to 286 ft. since the 2707-300 design was unveiled. The 281/298-seat version has a 298-ft. fuselage length. The 321-passenger layout, because of the seven-abreast seating, is 2 ft. shorter, or 296 ft. Gross weight of all three production versions is the same: 750,000 lb.

The foreward fuselage nose and cab sections and the tail section would be retained in all these configurations. Fuselage cross-sections are not constant in any of the versions because of area ruling, but the general increase in size is 18-20 in. for each added seat width.

More seat room was added in the prototype fuselage as part of a design refinement process. This entailed:

- Refairing the forebody for better drag characteristics.
- Refairing the aft fuselage and carry-



Forward fuselage mockup of Boeing 2707-300 prototype gives indication of its interior size with cabin overhead structure in place.

ing the tail cone back 6 ft., again for better drag characteristics.

■ Relocating the aft pressure bulkhead and moving hydraulic reservoirs and other components located there.

The latter two steps provided the 16 seats. In addition, relocating the hydraulic components to the wing outboard of the wheel well will provide better access for maintenance in airline service.

For the most part, there has been little external change over the last year in the design that John M. Swihart, chief engineer for the production airplane, calls extremely stable. Other significant refinements have been made, however, including:

■ Recambering and retwisting the wing.

■ Revising the horizontal stabilizer pivot point and elevator actuation system.

■ Programing of up to 3 deg. of leading and trailing edge flap setting varying with Mach number in the subsonic and transonic speed ranges for most efficient lift/drag ratios.

Such refinements have increased subsonic lift/drag ratio from 13 to 14.2 and supersonic ratios from 7.19 to 7.34. The supersonic L/D improvement is equivalent to 4-4.5 drag counts, which is worth about 100 mi. in range.

Entailed in the wing reshaping is a 1-4-in. thickening of the root and smoother fairing out to the wheel well which eliminated the bump on the top surface at the outside edge of the landing gear stowage area.

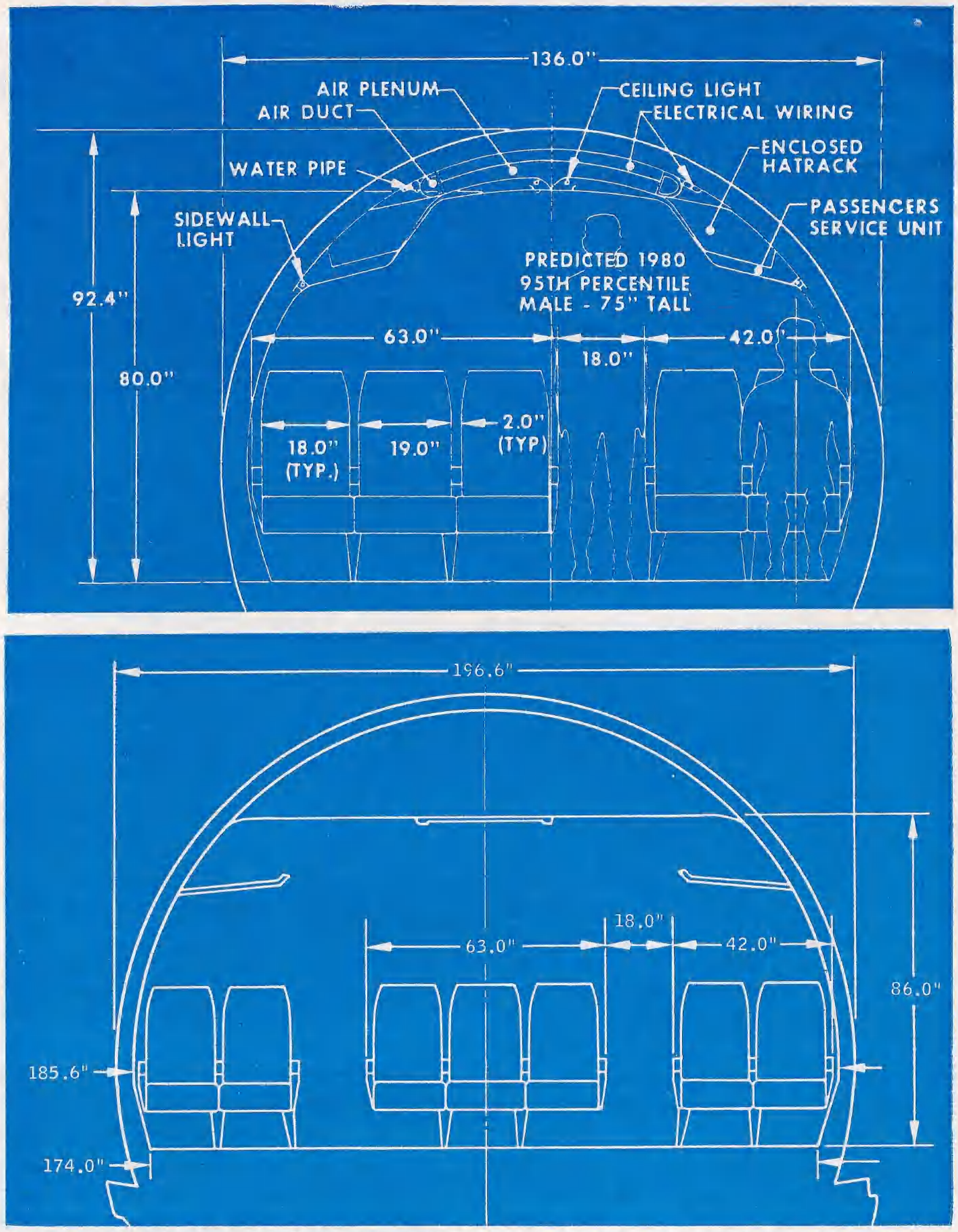
This meant an increase of 0.2 of a drag count. This was more than offset by changing the wing twist, a 2.5-drag count reduction; smoothing the leading edge transition in sweep angle, worth 0.6 of a drag count, and reshaping the lower wing surface, worth 0.1. The net was 3 drag counts.

The January validation wing twist was linear from zero at the root to −3 deg. at the tip. Now the wing twist is more abrupt, from zero at the root to −1.2 deg. at 20% semispan. Then the increase is very gradual to −1.65 deg. at the tip.

Reshaping the lower wing surface, essentially creating a flat spot in the nacelle inlet area, had a more important objective than the small drag reduction it provided.

Flow tends to be outboard on the underside of the wing, and the supersonic cruise Mach number at the inboard inlet was higher than the outboard. The vertical gradient also was averaging a marginally acceptable difference of 0.08 Mach. The flat spot put the inboard nacelle at Mach 2.65 average and the outboard at 2.61 and reduced the vertical gradient variation to 0.04-0.05.

This change means that a single inlet configuration can be produced for all four inlets.



Cross section layouts for 5-abreast and 7-abreast seating differ 5 ft. in width. Seven-abreast seating has two aisles, adding further to the cross-section expansion.

Continued testing is showing improvement in the validation performance data for inlet pressure recovery supersonically, and is matching subsonic predictions. A one-third scale inlet in front of a General Electric J85 turbojet engine at the Arnold Air Development Center at Tullahoma, Tenn., has been run with throttle bursts to demonstrate that no inlet unstarts or other undesirable effects occurred.

Inlet configurations have run through designation letters A to P and modifications of these with numerical suffixes. The validation inlet was more sensitive than the FAA liked, but the government managers say the version now chosen, designated N-5, combines high performance with high stability.

Both Boeing and the FAA agree that the pudding has reached the stage where it has to be proved. Technical uncertainties that can be resolved on the ground with test specimens or wind tunnel hours have been resolved. Those that remain need answers from full-scale flying prototypes. Some examples:

■ Hinge moments.

■ Flutter.

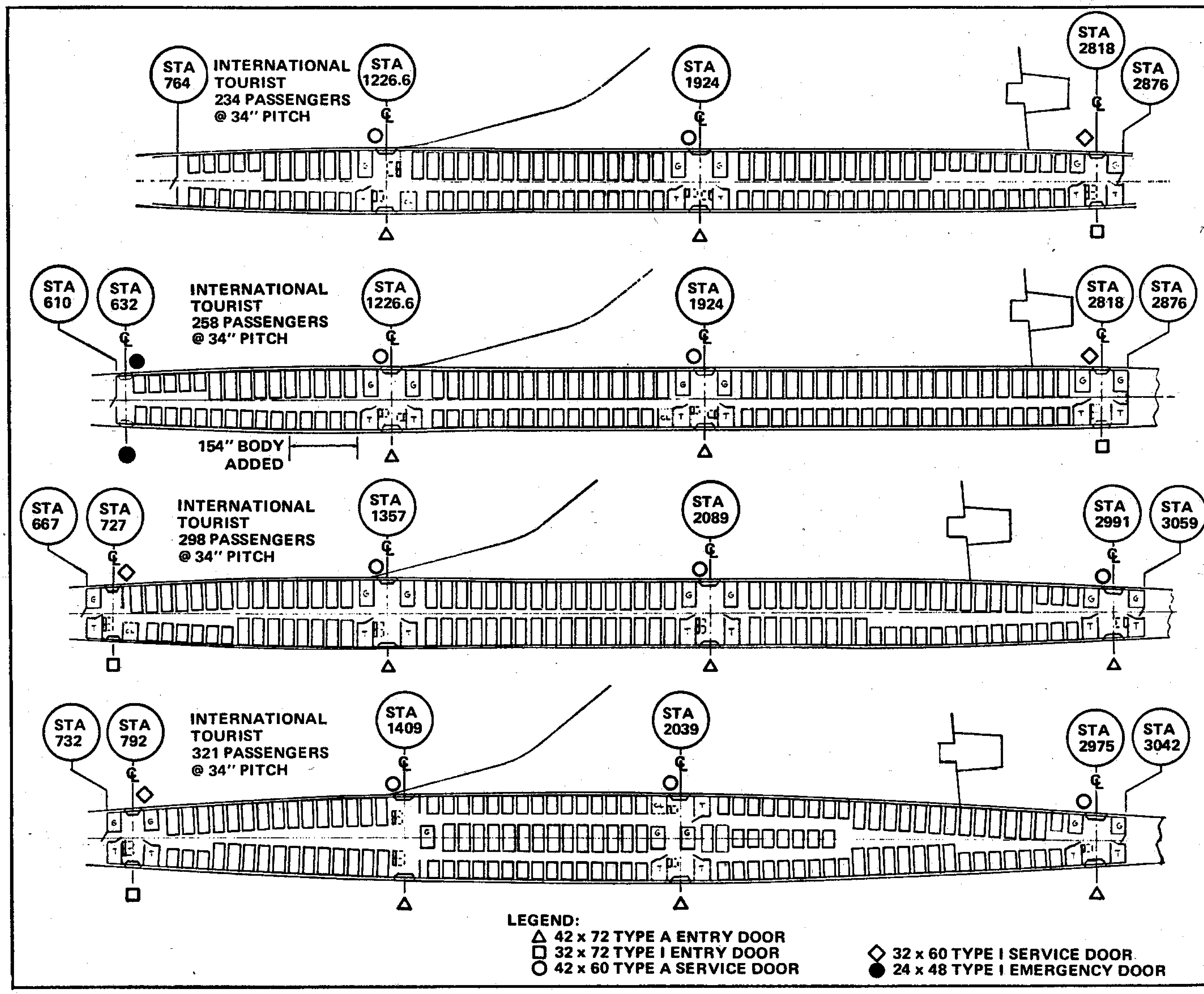
■ Ride quality stability augmentation system.

■ Fuel sealant.

Scale models can only approximate control hinge forces, and these will only be determined precisely on a full-scale airplane in flight.

It was this area that led to problems in the 2707-200 variable sweep wing version. With wings swept, the planform was an arrow, and aeroelasticity of this wing caused the need for more control system hydraulic horsepower and thus a much heavier and larger hydraulic system.

Now the tide seems to be running in the other direction, as indicated by the change in stabilizer design. In the validation aircraft, designers expected the elevator would have to be programed to vary in travel and rate with Mach num-



Seating profile for Boeing 2707-300 versions show differences in fuselage cross-section for the validation configuration, 5-abreast, and for 6-abreast and 7-abreast seating. Design refinements have raised prototype fuselage seating to 250 passengers from 234.

ber up to Mach 0.9. Three hydraulic actuators were provided on each side for the elevators, in addition to four actuators in the fuselage that power the stabilizer.

Further analysis has convinced Boeing that the programed elevator is unnecessary. The hinge point has been moved back from 30% to 37% of the reference chord, the six elevator actuators replaced with a simple mechanical linkage to operate like a conventional control tab, and simpler single barrel actuators substituted for the four heavier dual-tandem actuators in the fuselage. The change saves about 1,000 lb.

Flutter is another question that a full-scale aircraft, shaken on the ground and flown, is needed for answers. The FAA put an extra 8,000 lb. in the validation airplane to allow for heavier structure, if needed. Not all of it will be, estimates now indicate.

Aircraft weight has stayed within 1% during the refinement period, and today it is slightly above the target of 305,000 lb. operator's empty weight (OEW). Prototype gross weight is 635,000 lb., 115,000 lb. less than the production aircraft.

Boeing and the FAA have pretty much agreed on the technical uncertainties, but there is less optimism on the part of the FAA than Boeing over need for a ride stability system.

It is not a safety of flight item, but could be important to passenger comfort. Because of the long fuselage, there can be considerable springboard effect depending on structural stiffness. The question is whether to put such an expensive system on the prototype in the first place, and in the second, whether the hydraulic system can accept inputs from accelerometers for damping out the motion.

Getting a fuel sealant with the target life of 50,000 hr.—equivalent to 15 years in service—is still a problem. But Boeing has qualified a prototype version with 5,000 hr. life in operating cycles with a maximum 450F temperature.

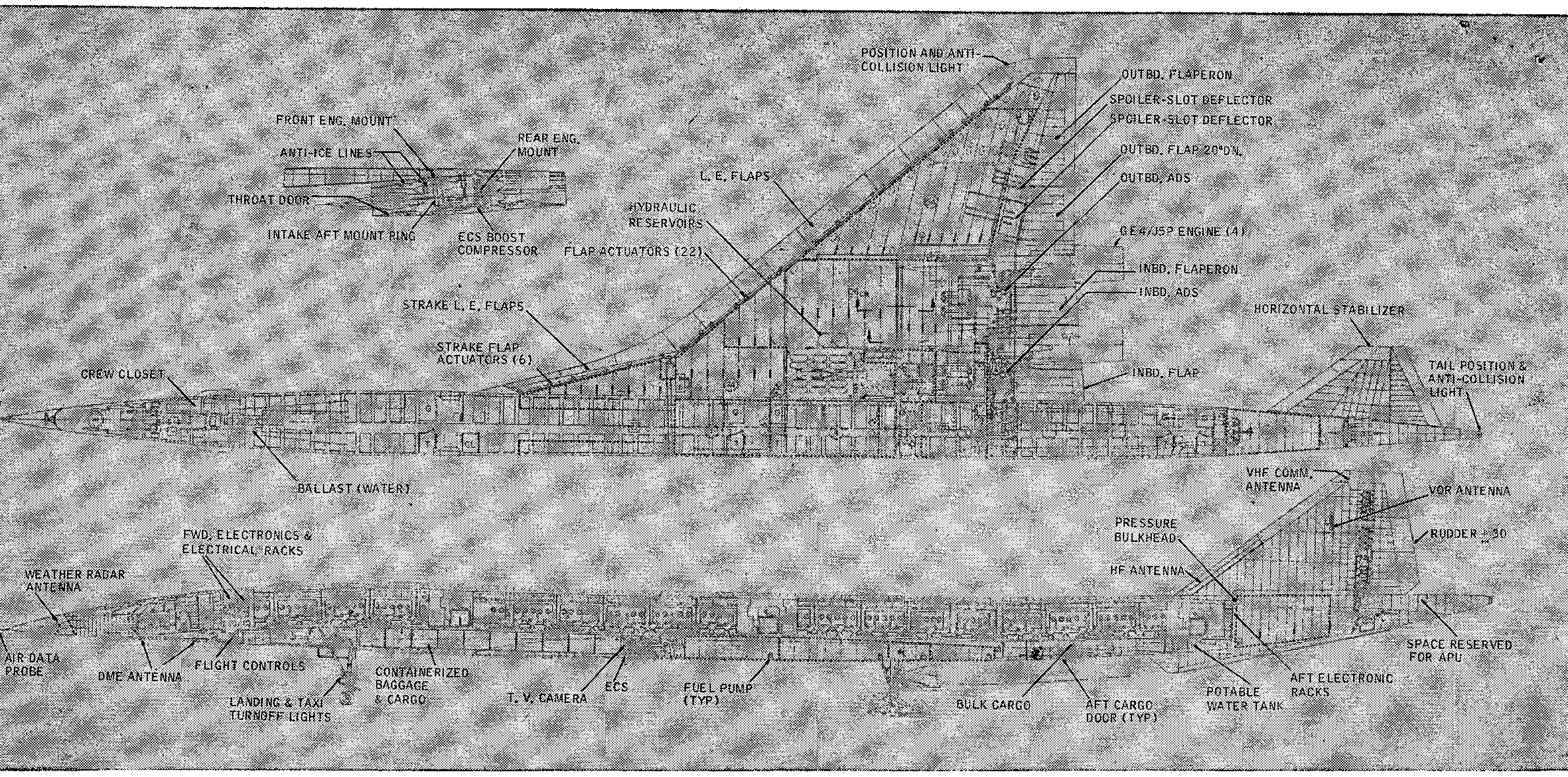
Boeing engineers believed they had demonstrated the prototype sealant with environmental testing using fewer cycles but a longer heat soak. But the White House Office of Science and Technology insisted that the test be rerun duplicating flight profile exactly.

This is being done now, and no deterioration has been observed in 360 hr. of testing.

The sealant is Dow Corning experimental 77-028, a two-component fluorosilicone rubber, which is designed for filleting and faying, that is application to a flat surface or between two flat surfaces, instead of as a channel sealant used for military aircraft.

Subsystems and components generally have remained unchanged. Fuel will not be transferred for trim control as in the Anglo-French Concorde, but it will be transferred in a pre-planned invariable sequence from the wing tanks to the four main fuselage tanks for supply to the engines.

Center of gravity travel in cruise is

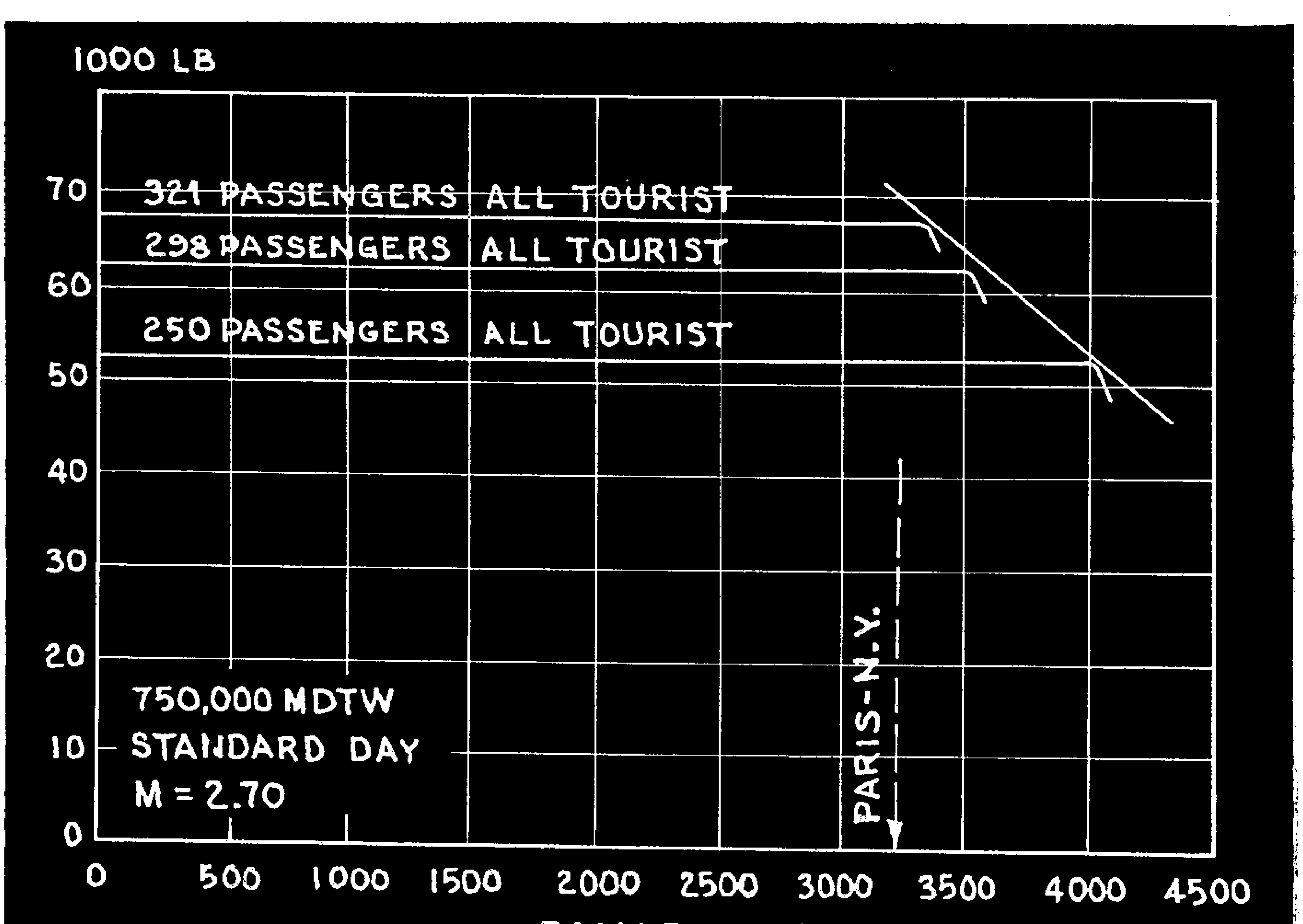


Side profile of Boeing 2707-300 PPD configuration includes addition of 16 seats in fuselage aft section gained by design refinement. Two four-abreast rows are added at rear, as well as an extra seat to each of eight four-abreast aft rows of the earlier layout. Major components are designated, and profile of inboard engine nacelle is included (top, left). PPD stands for prototype point design, which is the prototype as if it were certificated and fitted out as a transport aircraft.

Description/Performance Comparison Summary

	Boeing 2707-300	Concorde	Tu-144
Max. takeoff weight (lb.)	750,000	385,000	330,000.
Maximum landing weight (lb.)	460,000	240,000	
Material	Titanium	Aluminum	Aluminum
Wing configuration	Delta + tail	Delta	Delta.
Length	298 ft.	193 ft.	188.5 ft.
Height	51 ft. 7 in.	38 ft.	34.5 ft.
Span	143 ft. 4 in.	83 ft. 10 in.	72 ft.
Wing area (sq. ft.)	7,700	3,856	
Engine	4 GE 4/J 5	4 BS Olympus 593	4 Kuznetsov NK144
Thrust (augmented) (lb. per engine)	63,200	38,300	38,500.
Passengers	298	128	120.
Takeoff speed, (kt.)	197	201	190.
Takeoff distance, standard day plus 15° (ft.)	10,300	10,900	
Cruise speed: Mach number	M 2.7	M 2.05	M 2.35.
Miles per hour	1,786	1,350	1,550.
Mean cruise altitude (ft.)	63,000	56,000	59,000.

Range-payload chart compares refined prototype 250-passenger version with 298 and 321-passenger configurations. Steep slope at knee of each is partially indicated.

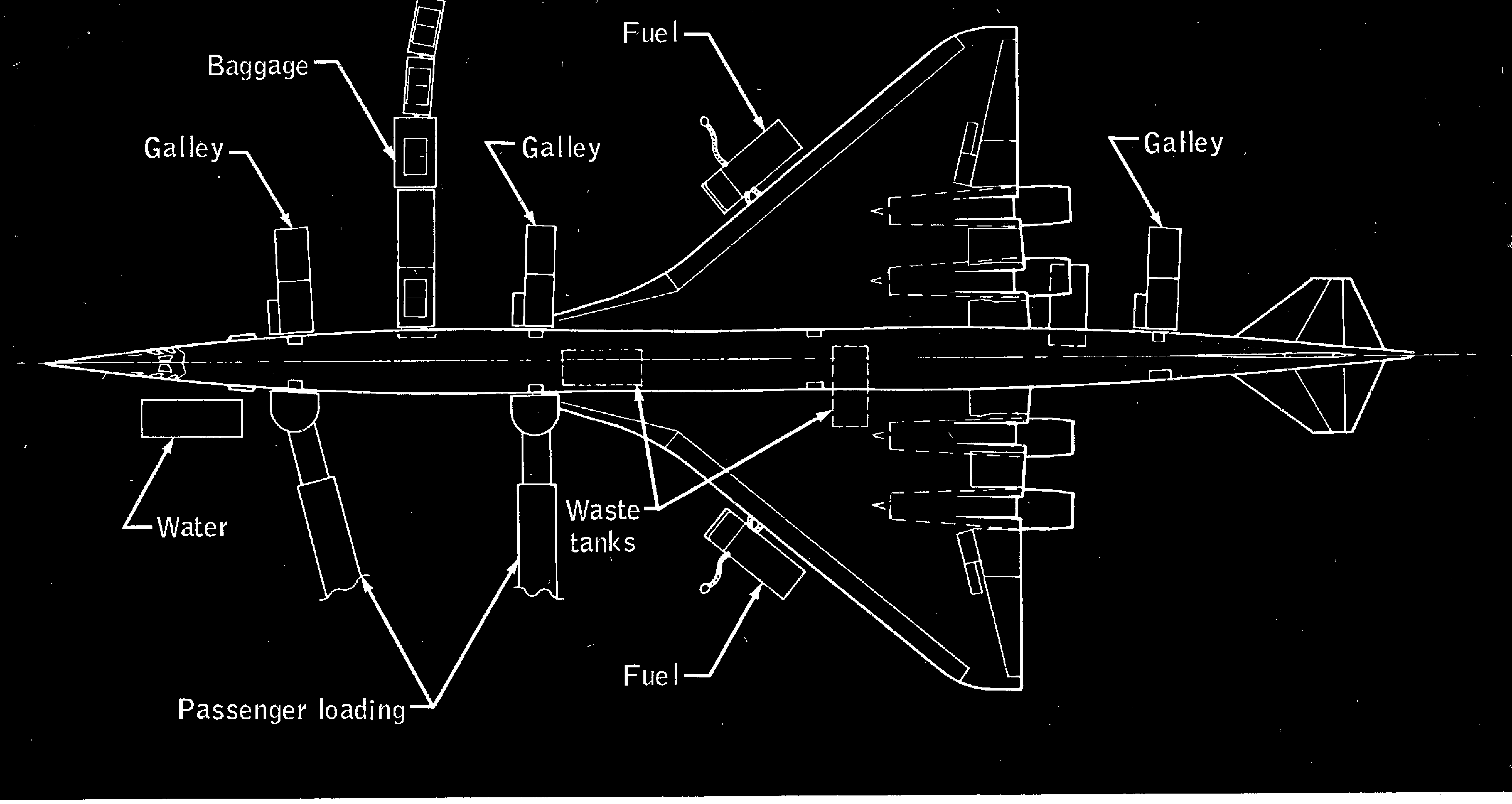


critical and must remain with 0.5% of its takeoff location. This is accomplished partly by the fuel load distribution and transfer sequence, but a 12,000-gal. water ballast tank in the forward fuselage is also needed for payloads under 60% and unrestricted loading. Adding cargo, or restricting passenger loading to zones can reduce the ballast needed, which, in any event, does not compromise payload.

Brake and tire wear has been classed as a problem area. But Boeing believes this has been overstated.

Two innovations that hold promise in this area are:

- Pyrolytic graphite brakes, now undergoing tests on operational subsonic aircraft. Their cost now is about the same as beryllium, previously favored for the supersonic transport, but with the potential for twice as many landings before overhaul. Heat sink capacity is greatly improved and maximum temperature capability is 4,000F.
- Radial ply tires. Though common in automotive use, these have not been heretofore supplied for aircraft. Their lower pressure provides a better landing gear footprint, and their wear qualities and high-speed characteristics are better. Most important, their cornering capability, demonstrated in auto racing, can add significantly to service life, since most rubber is lost not in landing touchdown but in high-speed turns off runways with associated hard braking beforehand.



Service equipment arrangement for Boeing 2707 is shown positioned after engine shutdown on arrival.

SST Keyed to Current Airline Operations

By James P. Woolsey

Design of the U.S. supersonic transport has been keyed so extensively to compatibility with current airline operations that major carriers will have little difficulty integrating the airplane with their systems.

Aside from the difference in speed, the aircraft's other major characteristics are very close to those of even today's subsonic jet transports.

By the time the Boeing 2707 supersonic transport enters service in 1978, the Anglo-French Concorde and Russian Tupolev Tu-144 supersonic aircraft will have been operating for up to six years. Also, the Boeing 747 giant jet transport will have been flying in and out of major cities for nearly eight years, and other wide-bodied subsonic aircraft will also have been in service for some time.

Similar Procedure

Aside from the 2707's other obvious difference—noise—the airplane could easily enter service today and would not require extensive special procedures by airlines and airports.

Supersonic transport operations will be very similar to ground service and support operations of today's jets as well as flight environment from 35,000 ft. down. The major exceptions to this result chiefly from engine noise problems.

When the 2707 operates in its supersonic envelope, it will be at altitudes no existing commercial aircraft fly. Design limitations dictate that the airplane be at least at 30,000 ft. before it can even reach Mach 1 speeds under most atmospheric conditions. At its expected Mach 2.7 cruise speed, the aircraft will be at 60,000 ft. or more.

Flight plan preparation for a typical transatlantic excursion will not be any more difficult than today, Federal Aviation Administration officials maintain. But more attention will be devoted to engine noise at low altitude and the boom problem resulting from speeds above Mach 1 at high altitude. Transonic acceleration will occur at a relatively low altitude, 27,000-35,000 ft., and will create a severe boom, but one whose impact point is precisely predictable so that it can be kept away from populated land areas.

Flight plan must also ensure that the less severe boom produced during cruise will not pass over a land area. In the New York-Paris profile, a 50 naut. mi. deviation from a straight Great Circle route will be made to avoid the coast of Newfoundland.

The same consideration must be given for arrival at the destination point, although there is no super boom problem. No extensive overpressure rise results in decelerating from supersonic speed down through Mach 1 to subsonic speed.

Several new systems in the 2707 cockpit are expected to simplify the task of adhering to the flight plan. Crew complement planned will be two pilots and a flight engineer, but they will have several advanced systems to work with.

Arrival Promptness

FAA officials predict that the additional speed of the supersonic transport, coupled with its flight management system, will enable crews to meet estimated arrival times within seconds rather than minutes. Another expected benefit resulting from the advanced systems is less cockpit workload.

Three of the flight management systems are represented on the pilot and copilot main panels with pictorial displays. These displays are:

- Cathode ray-tube for the electronic attitude director indicator. The display, at top center will have four modes: taxi, takeoff/approach, cruise and attitude. The tube will present, either by television or digital or symbolic displays, such items as speed error, radar altitude, flight path angle, flight path acceleration and attitude. The tube will also serve as visual display for the aircraft's instrument landing system. When in taxi mode, a television picture will present that operation.

- Large moving map for the inertial navigation system. The display will be directly underneath the electronic attitude director indicator for both the captain and first officer. Like the 747, the 2707 will have three inertial systems, but the pictorial display will be new. The moving map will show desired course and actual position. It will also have the capability of providing short-term prediction of probable ground track of up to 1 min.
- Multi-function screen for alphanumeric, symbolic or graphic data presentation such as rate of climb profile and vertical navigation. The location of this pictorial display is under evaluation in Boeing's simulator.

The crew would sketch desired climb profile on a scaled grid on the display. The system would provide real-time pictures of actual vertical position in relation to desired position. Similarly, other vertical navigation problems could be monitored on the display along with such items as fuel management.

Still other systems will assist in keeping actual and estimated times of arrival within seconds. These are an advanced autopilot or auto flight control system, air data computers and automatic throttle, flare-out and roll-out system. Together with the integrated pictorial displays, these systems will give the 2707 Category 3B landing capability.

Another cockpit change that crews will find is the lack of a control column—yoke or wheel—for roll and pitch. In its place will be a pair of control handles (AW&ST Nov. 18, 1968, p. 84) permitting an unblocked view of main panel for the electronic attitude director indicator and area navigation displays.

Subsonic aircraft in airline service do not have the total capability afforded the supersonic transport by these advanced systems, but they will have much of it by 1978. Several of the main components are already in advanced stages of development. Electronic attitude director indicators have been used extensively in military aviation and a cathode ray-tube area navigation pictorial display was tested in a Boeing 727 last year. An electronic attitude indicator system has been tested in the Boeing prototype 707, and has been considered for the Lockheed L-1011 (AW&ST Mar. 31, p. 72).

Compatibility with current airline equipment has also been a major factor in plans for servicing and preparing the 2707 for flight operations.

FAA officials predict that about 70% of all major ground support items can be used for both the 747, the wide-bodied trijets and the supersonic transport. With few exceptions, servicing and flight preparation operations will be performed as they are today. Turnaround time is expected to be about 90 min., while servicing during transient stops is expected to take only 30 min. But most servicing will be turnaround since the airplane is not likely to be used in multi-stop operations.

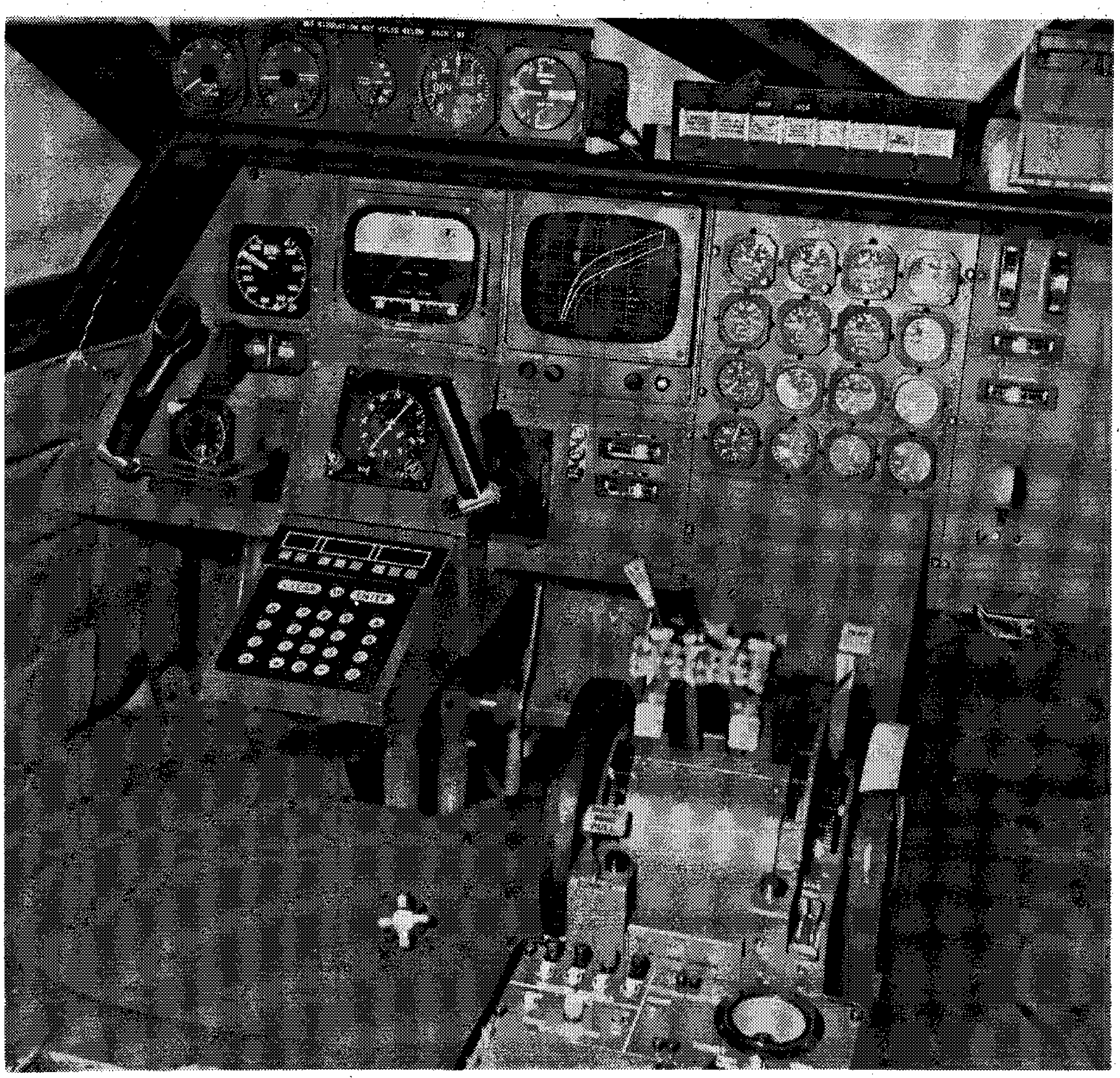
Fueling the 2707 is not expected to present any severe problems other than the time it might take to fill the tanks to the 71,000-gal. capacity of the aircraft. Total weight of the fuel will be 475,000 lb. The aircraft will use standard jet kerosene. Its tank system comprises four main tanks and eight auxiliary tanks. All will be fed through two pairs of ports, one under each wing near the leading edge about midway between the fuselage and wing tip. Each will be about 12 ft. above the ground.

Acceptance rate will be 2,200 gal./min., or 550 gal. per port. The 747's rate is 500 gal./min. at each port. Boeing estimates the supersonic transport can be filled in less than 30 min., assuming the airport can provide the fuel fast enough. Hydrant fueling at Dulles International Airport is currently 300 gal./min. for each hose. This is expected to increase to 500 gal./min. in the next year. Fueling from trucks may not be practical because one operation would require many trucks. Also, many current trucks are limited to flow total of 1,200 gal./min., using four hoses.

The supersonic transport's hydraulic system will require special fluid because of its high operation temperatures. The overall hydraulic system will be similar in requirements to those of supersonic military aircraft and the Concorde.

Passenger, baggage and cargo loading will be very close to that planned for the 747 and other wide-bodied jets. It is expected that nose docking will be used, with passengers entering and departing through jetways and similar devices. Those capable of serving the 747 will also be employed for the 2707. The airplane will have two loading doors on each side of the fuselage forward of the wing. Two more will be located over the wing and two others near the tail. Door heights will be about 14 ft. 6 in. above ground level except for the rearmost doors. They may present loading problems. At 19 ft. 5 in. above the ground they are nearly 2 ft. higher than the 747's doors.

Baggage will be containerized like that planned for the 747. The containers



Development cab cockpit in supersonic transport simulator facility is used in evaluation of panel mounted control handle configuration developed by Boeing project pilot James R. Gannett and engineer John D. Warner. Handles provide unobstructed view of electronic attitude display indicator, also under development evaluation, and navigation display and input console. Multi-function display is at right. Electronic attitude indicator gives pilot highly sensitive readout of changes in flight path, and also shows pitch attitude and vertical flight path separately for such situations as a nose-up descent. Display here is on loan from Sperry Flight Systems Div., but Boeing has purchased two systems from Norden Div. of United Aircraft for evaluation.

will be smaller than the 747's, but officials believe the same carts and loaders might be used for the 2707. Cargo will also be containerized and is not expected to present any problems. Generally, the loading and unloading operations will be simpler than the 747's because of the smaller capacity of the supersonic transport. Boeing predicts that complete passenger boarding and departing can be done in 15 min.

The 2707 will present one pre-flight problem not commonly encountered in today's airline operations. A water ballast system will be needed to offset center of gravity problems resulting from light loads. If, for example, the 2707 had to fly with only 20 passengers, it would require 13,000 lb. of water in a special ballast tank located near the nose wheel. Less amounts of ballast are needed if more passengers are carried. If the aircraft carries 237 or more passengers, no ballast will be required.

FAA officials say there is a possibility the production aircraft will not have light-load ballast requirements. They expect this can be eliminated through design refinements. But the prototype will have the ballast problem.

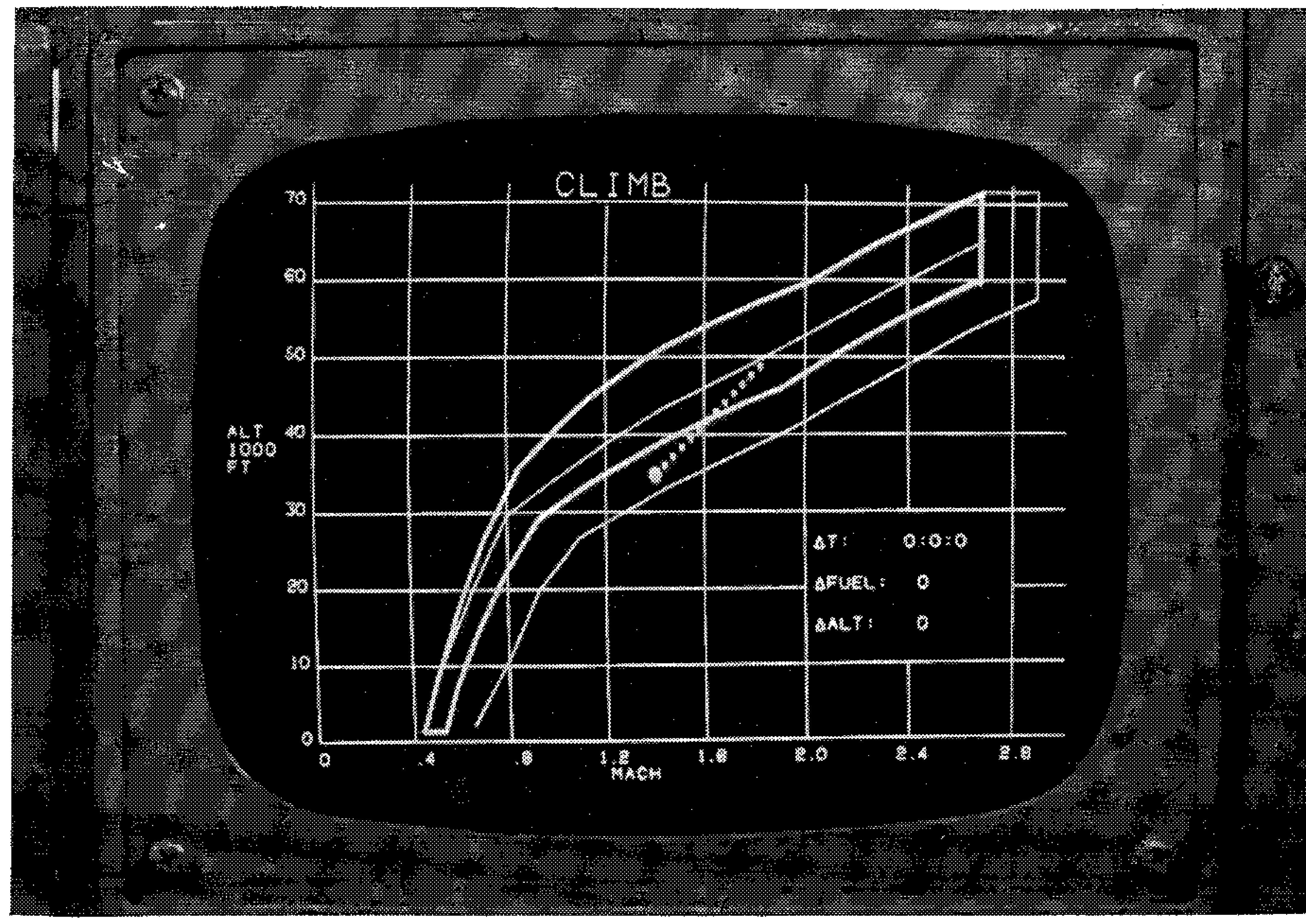
Taxi operations with the supersonic transport will be an unusual experience for most airline pilots because of the airplane's fuselage length. The general configuration will be similar to the Concorde, but distances will be greater between the components important to taxiing operations.

Fuselage Length

Fuselage length of the 2707 will be 298 ft., which is twice that of a Boeing 707 and 105-ft. longer than the Concorde. Distance from the main landing gear to the tail will be 121 ft., while on the Concorde this will be only 72 ft. Distance between the main and nose landing gear on the 2707 will be 112 ft. 10 in., nearly twice that of the Concorde. Distance from the nose gear to the nose tip will be 63 ft. 9 in., almost the same as the Concorde.

Turning radius for nose clearance will be 182 ft. with the nose wheel at its maximum 71.5-deg. steering angle. The airplane will require a 183-ft. wide runway to make a 180-deg. turn.

Another characteristic of the 2707 is the distance the crew will be in front of the nose gear. In some turns, the crew will be out over the grass while the nose gear is still on the runway or taxi way. To assist in the taxi operations, the aircraft will have a television system to provide the crew a picture of where the nose gear is in relation to the edges of the runway. Periscope lens will be mounted in front of the main landing gear and will point forward to the nose gear. The television picture will be presented on the electronic attitude director indicator.



Multi-function display undergoing evaluation in the Boeing 2707 development cab simulator shows present position (large dot) and trend (small dots) in relation to programed climb profile (solid lines). Pilots can call out climb, descent, noise profile or other displays, rapidly update information through the associated computer, or call out status information such as engine operation or air traffic control clearances. This hardware was supplied by Sanders Associates but specifications for operational equipment are due to go to vendors.

Another feature of the 2707 that will greatly ease taxi operations is a droop nose. It will give crews better cockpit visibility than in current jets. During taxi operations, the nose will be in the down position to give the pilot vertical straight-ahead field of vision 16 deg. up and 22 deg. down. The horizontal field will be about the same as in current jets.

Pilots will also receive a benefit from the airplane's configuration since they will have no increased concern with wing clearances. The 2707's span will be 3 ft. less than a 707's.

Takeoff and climb operations with the supersonic transport also will show substantial compatibility with existing airline and air traffic control systems. Generally, in most phases of its flight envelope below 35,000 ft. the airplane is designed to perform as conventional subsonic jets. In fact, FAA claims the 2707 will be able to cruise subsonically without a decrease in range capability. But officials concede it would not be the most economical way to perform subsonic service.

Major variations from normal takeoff and climb procedures will be caused mostly by the 2707's noise and boom problems. The first evidence of this will occur during climb out when maximum effort will be made to diminish noise over communities near the airport. With noise abatement procedures, the 2707 will actually produce less community noise than current subsonic jets. But the cost will be increased noise within the confines of the airport.

Takeoff runway requirements at maximum gross takeoff weight of 750,000 lb., would be 10,500 ft. on 86-deg. day.

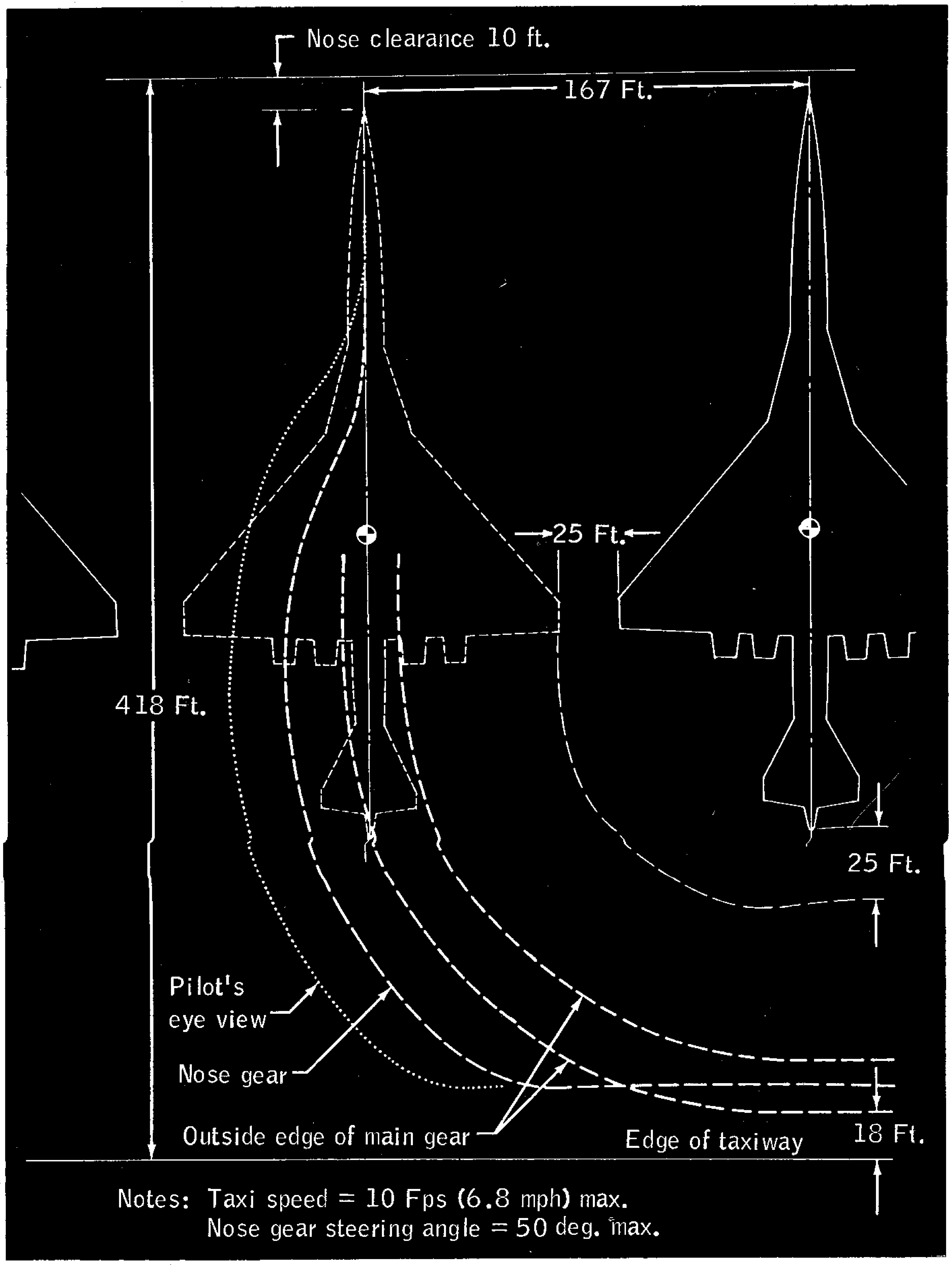
Throttles will be set at maximum augmented power for takeoff, with each engine producing about 67,000-lb. thrust. The airplane will rotate at 171 kt. and lift off at 197 kt. Liftoff angle will be 10 deg., and it will be reached almost simultaneously with liftoff speed. FAA officials say the rotation and liftoff will be similar to that of today's 707s.

Required angle of attack will not be as great as with straight delta-wing aircraft. Length of ground roll between rotation and liftoff will be reduced because of wing trailing edge lift-augmenting devices. Feasibility of these devices was made possible by the addition of horizontal tail surfaces to provide sufficient trim power. Body angle during climb out will not exceed the 20 deg. associated with current subsonic jets.

Climb Rate

Following liftoff, the airplane will maintain maximum climb rate while keeping under a 250-kt. speed restriction with maximum augmented power. Standard noise abatement procedure over land will occur when the airplane is 3.5 naut. mi. from brake release. During a typical transatlantic flight, the airplane will be at between 1,500 and 1,800 ft. at this point. A 707, at this point in the same flight, would reach about 700 ft.

The noise abatement procedure will be started by reducing power to about 40% of maximum available. Even at this power, the 2707 will maintain a 3.5% climb gradient, or a rate of 850



Turning radius using 50-deg. nose wheel steering is shown for parking, along with wing tip and nose clearances at terminal.

fpm. FAA officials maintain that even more severe procedures could be effected for special noise-sensitive areas. For example, power could be reduced to 30% and a 500-fpm. climb rate could be maintained. FAA says the prime consideration in the power reduction for noise abatement is leaving enough power, without throttle change, for level flight with one engine out.

Duration of flight at this airspeed and climb rate would depend upon the area being flown over. For a departure from Kennedy International out over the Atlantic, it would continue until the airplane reached 9,700 ft. Power would then be increased without afterburning and the aircraft would be leveled off until 350-kt. airspeed is reached. During this, the nose section also would be raised to level position for cruise.

When 350 kt. calibrated airspeed is reached, the airplane begins to enter its own operational environment. The aircraft then begins to climb again until it reaches 27,000-35,000 ft.

At this point, the airplane starts its move through Mach 1 to its cruise altitude. Rate of climb is decreased, the afterburner is relit for the first time since the beginning of the noise abatement procedure at 3.5 naut. mi. from brake release and maximum augmented power is applied. During this phase of the flight, the supersonic transport needs all its available power. Maximum augmented power is retained until reaching cruise altitude of 60,000 ft. or more, depending on temperature, gross weight and other variables.

The airplane is designed to cruise at Mach 2.7, but this may vary with conditions. Because of the light traffic anticipated at these altitudes, supersonic transports are expected to have considerable freedom in cruise altitude selection. As a result, altitude will probably be selected according to where the airplane can perform most economically at Mach 2.7. A limiting factor for cruise speed is stagnation temperature, which will be held to 500F. If the airplane is limited to under 60,000 ft., stagnation temperature may be reached before Mach 2.7 speeds are attained. But such altitude limitations are not expected.

Another benefit from the low traffic density at these altitudes will be availability of a climb/cruise profile. The airplane will be permitted to climb several thousand feet during a transatlantic flight with no control change, just on reduced weight from fuel consumption.

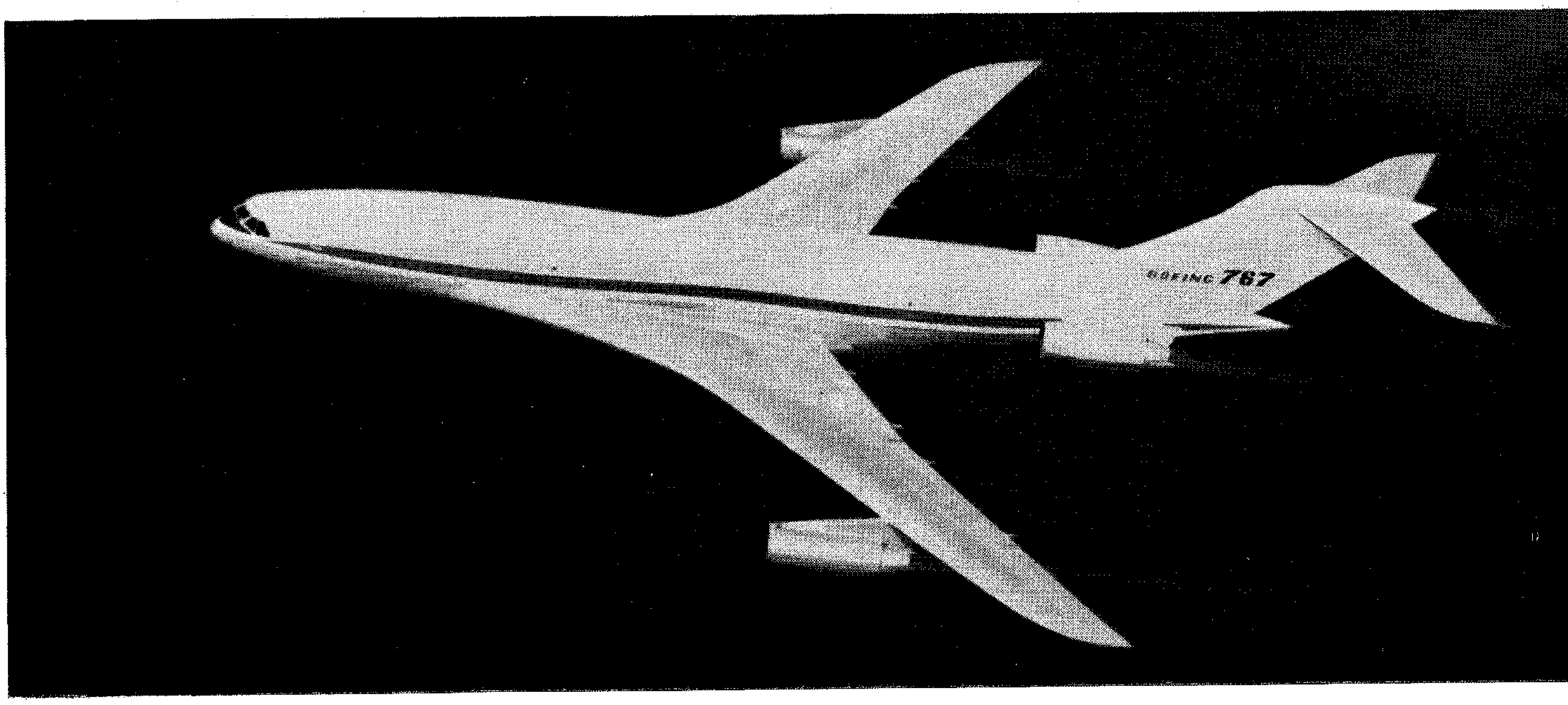
Stagnation temperature, as a major factor in determining cruise speed and altitude, will be new in airline operations. These high temperatures are caused by the highly compressed air associated with supersonic speed. Highest temperatures will be found at wing and tail leading edges and the airplane's nose section.

After supersonic flight, the high-skin temperatures will not cause any ground handling problems. FAA officials note the compression problem ends when the aircraft decelerates through Mach 1 to subsonic speed. This will occur at 40,000-30,000-ft. altitude where air temperatures are sufficiently low to cool the hot areas before the airplane lands. FAA officials estimate fuel receptacles, for example, will be 100F after supersonic flight. Large metal items with more heat retention might only be as hot as 150F.

Descent, approach and landing with the supersonic transport are not expected to present many operational problems. Descent to subsonic speed will be dictated, in many instances, by boom considerations. But there will be no super boom as the airplane reduces speed down through Mach 1 as there is when it is accelerating.

The 2707 will be equipped with a Category 3B automatic landing system, permitting landings in zero ceiling, 200-ft. runway visibility conditions. A typical approach speed for the end of a transatlantic flight would be about 150 kt. The supersonic transport would lower its nose just after it decelerates to subsonic speed.

Block time planned for the New York-Paris flight is 2 hr. and 45 min., assuming there are no delays and severe noise abatement requirements. The airplane would require just 15 min. from takeoff to beginning of transonic acceleration at 27,000 ft. Attainment of Mach 2.7 cruise and 60,000 ft. or higher would take only 10 additional minutes. Descent from cruise altitude to subsonic speed at approximately 40,000 ft. would also require only 10 min. From there to touchdown and unloading, the airplane would need about the same time as today's subsonic jets, in this case about 30 min. with no delays.



Boeing Studies Advanced Subsonic Transport

Boeing Co. has unveiled this design for a 200-passenger transport that uses a supercritical wing to cruise at Mach 0.98 (AW&ST July 12, p. 26). Boeing, General Dynamics and Lockheed-Georgia Co. have $1-million contracts from the National Aeronautics and Space Administration to study advanced transport technology (AW&ST June 21, p. 28).

cargo carriers, and to expand the area in which it can operate unlimited off-route charters. This is generally the all-cargo carrier's designated geographical area of operation. Airlift asked the Board to add unlimited cargo charter authority to Alaska, Hawaii, Central and South America and the Caribbean.

The Board decided to propose to add only the Caribbean islands to Airlift's existing "areas of operation" of the contiguous 48 states and between the states and Puerto Rico and the Virgin Islands.

"What, in essence, Airlift asks is that the Board invoke extraordinary procedures to strengthen Airlift's depressed financial posture. While the Board is concerned about the continued economic viability of Airlift . . . the resuscitative measures requested by it cannot be adopted," the Board said in its proposed rule-making procedure.

The Board said the islands of the Caribbean would be consistent with its policy that unlimited off-route charters should be restricted to areas that are in proximity to a carrier's certificated routes. The Board added that an expansion in the permissible percentage of off-route charters would create serious diversionary results.

Airlift reached its 2% limit this year at the end of June. It has been receiving exemption authority from the Board for some off-route charters since then. Airlift plans to renew its efforts for more off-route charter authority in response to the Board's proposed change in rules.

Airlift claims its violation of the 2% limitation in 1970 was only a technical one, due to uncertainty over what mileage qualified as base revenue miles. It also believes that it will be able to demonstrate that it is innocent of the tariff violations it also is charged with in the enforcement proceeding.

Hawaii Fares Opposed

Washington—American Airlines' proposed discount standby summer excursion fares to Hawaii from five eastern and midwestern cities provoked complaints to the Civil Aeronautics Board from five other carriers and prompted similar filings by three.

United, which asked the Board to suspend the filing set for effectiveness Aug. 2 through Sept. 16, Mondays through Thursdays, also filed a defensive tariff from four of the five mainland cities included by American—Boston, Chicago, Detroit and New York. United called the proposed fares, for which all ages are eligible, unreasonably low and charged they would dilute revenues. Trans World and Continental also filed for the fare from selected cities.

The rate would be the same as for group inclusive tours for 154 or more persons. Roundtrip charge would be $275 from New York, compared with regular coach fare of $426.

Hawaiian and Aloha airlines were among the complainants, protesting that the American tariff does not include the common fare provision typical of Hawaiian fares, permitting travel to an outer island destination without extra charge to the passenger.

United R-Nav Flights Use Inertial Navaid

Chicago—United Air Lines plans to initiate area navigation operations this week using Delco Electronics Carousel 4 inertial navigation systems aboard its Boeing 747 and McDonnell Douglas DC-8-62 jet transports.

The airline received operational certification from the Federal Aviation Administration June 16, following a demonstration program that included flights between Chicago and San Francisco, Los Angeles-New York and San Francisco-New York, concluding with a nonstop flight from New York to Honolulu June 14.

United will put the area navigation (R-Nav) routes into its computerized flight plan program, where they will be monitored and compared with other routings for time and fuel savings, according to Thomas G. Angelos, the airline's manager-navigational aids.

Carousel 4s used in the program are standard Arinc 561 systems, which will be manually updated by the flight crew from VOR/DME readings whenever cross-track error exceeds 2 mi. and positional error exceeds 2 naut. mi., maintaining flight in compliance with FAA Advisory Circular 90-45.

Working with Jeppesen & Co., United has modified several navigational charts for use aboard the R-Nav flights.

The special charts include FAA-designated waypoints and cross-track VOR/DME fix indications.

Boeing Designs Aircraft to Challenge

By C. M. Plattner

Los Angeles–Boeing Co. has begun discussions with airlines on a 767 family of transport aircraft smaller than the Lockheed L-1011 and McDonnell Douglas DC-10 airbuses but retaining a wide body fuselage with a double-aisle seating arrangement for use in the 1970s.

The 767 family includes two-, three- and four-engine configurations and is the distillation of engineering and marketing efforts carried on under a variety of titles in the past several years. These include New Airplane Program and 757 studies.

Boeing has been discussing its 767 shopping list with potential airline customers largely in parametric terms to establish a sales toehold for one or several of the design variations. Talks have been under way for over a month.

Boeing's fundamental 767 argument is that a transport with wide-body appeal and advanced technology engines will be economically attractive on many medium-range and lower density routes in the 1970s than larger airbus aircraft.

The Seattle firm at this point is trying to cover all bets insofar as range is concerned and is studying short-, medium- and long-range versions.

Tentative development timetable for the 767 hinges on airline interest, which so far has ranged across the spectrum from quite interested to little enthusiasm, one Boeing official said.

Boeing has established a tentative two-stage program timetable. If sufficient firm commitments are received prior to Mar. 15, the first aircraft would be delivered in mid-1973.

If the Mar. 15 deadline is not met, which is likely, the development schedule would be shifted ahead four months with Sept. 15 as the go-ahead goal. This would result in a mid-1972 first flight and initial deliveries in the fall of 1973.

Payload of the 767 has been established in the 200 mixed-class passenger category. This compares with equivalent passenger loads of 250-275 passengers for the L-1011 and DC-10 and 375 for the 747.

The 767 design matches more closely American Airlines' original U.S. airbus guidelines than the L-1011 and DC-10, which grew from those requirements.

Indications are that American may well become a key customer in 767 definition if the program moves from the present configuration determination stage into a development program.

In its present form the Boeing 767 consists of three different payload-range models:

- **The 767-100.** This baseline aircraft has a payload of approximately 200 passengers and range of 2,000 naut. mi.
- **The 767-200.** This model is identical to the 767-100 except that the fuselage is stretched 12 ft. to accommodate 230 passengers. Gross weight remains the same but range is cut to 1,250 naut. mi.
- **The 767-300.** This version is identical in exterior dimensions to the 767-100 but carries more fuel to provide range of approximately 3,700 naut. mi. Payload is decreased somewhat to 180-200 passengers.

For each of these basic payload/range models, Boeing defined two-, three- and four-engine configurations with the single exception that no twin-engine aircraft was detailed for the long-range route. This resulted in a total of eight different designs.

Boeing declined to analyze a long-range (767-300) twin because it would have to be used over water where operational regulations limit this application in comparison with three- and four-engine designs.

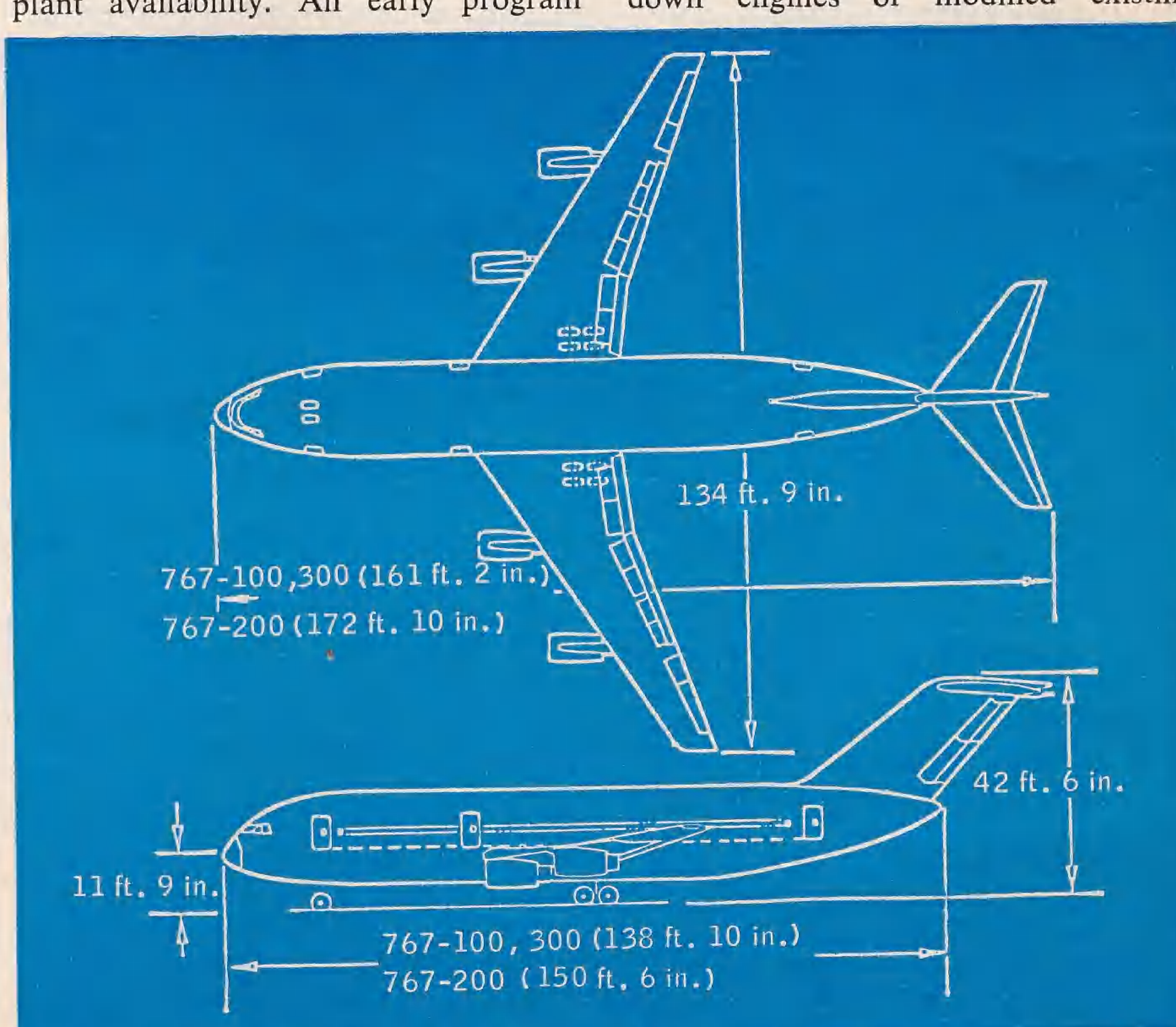
A key aspect of the 767 is powerplant availability. An early program start-up probably would dictate that the configuration be a twin-engine aircraft. Only the twin-engine versions would be powered engines now committed to development.

Boeing elected to use the RB.211 as a baseline engine because of a very slight improvement in direct operating cost but lists the Pratt & Whitney JT9D and General Electric CF6 as alternates with no preference among the three.

Boeing envisions a 42,000-lb.-thrust class engine for its 767 twin which is in the general class of all three candidates.

The engines used in the study were a 42,500-lb.-thrust RB.211, a 42,900-lb.-thrust CF6 and a 42,300-lb.-thrust derated JT9D-7. For comparison a 45,500-lb.-thrust JT9D-7 also was studied. With the higher-thrust JT9Ds, payload capacity increased from 200 to 230 passengers, but aircraft mile costs increased proportionally.

For the two other thrust category engines, Boeing acknowledges that either a new engine will have to be developed or an existing model modified to provide the desired bypass ratio and resulting economics. However, studies by Boeing and other firms in the past generally have indicated that scaled-down engines or modified existing



The 300 version of the 767 design would have four engines and high T-tail.

If a potential market for 150 of the civil version is found, the company probably will build the prototype within a year.

Major civil market is expected in the so-called emerging nations of Africa and Asia, where Kaman foresees a 12-15 passenger version with cargo capability of about 6,900 lb., including sling loads.

In the domestic and European markets, the company will be pushing a 6-8 place corporate model, also with cargo capability.

The K-700's fuselage width, with clam-shell doors in the rear, will facilitate loading outsize or bulky cargo. The arrangement also will make possible rapid, straight-in litter loading. Kaman believes the aerial ambulance market in the U.S. may prove to be much larger than generally anticipated.

Price Undecided

The company is not ready to price the K-700 as yet, but informally doubts that it will be as low-cost as some of its competitors, notably the Bell 212 (AW&ST Oct. 14, 1968, p. 25).

Price of the civil K-700 will be dictated to a large extent by the customer demand. But Kaman officials at present believe that sufficient demand will be found to hold the cost to a reasonably competitive level, considering the helicopter's expected performance.

Performance calculations call for a service ceiling of 18,200 ft. and a hovering ceiling out of ground effect of 17,500 ft. Normal range will be 419 mi. and ferry range about 850 mi.

First production versions of the K-700 could be available 20 months after program approval.

Kaman is studying the possibility of licensing production of the airframe and final assembly overseas. The company notes that the transmission, powerplant and rotor systems of the K-700, based on HH-43B experience, are relatively simple to transport and do not tend to sustain damage in shipment.

UH-2 Technology

K-800, although designed largely around UH-2 technology and components, draws heavily on the results of Kaman's efforts in Army's high-speed helicopter research program (AW&ST Feb. 8, 1965, p. 74).

Kaman added a General Electric YJ85 turbojet engine for thrust augmentation and wings from a Beech Queen Air to a modified UH-2C and as a result achieved speeds of up to 215 mph.

Proposed K-800 would use a pusher propeller in the rear of the fuselage to achieve thrust augmentation, but would retain the Queen Air wing, with the outer panels removed.

Transmission and rotor system are basically the same as on the UH-2C, but the hump which contains the transmission has been lowered into the fuselage of the K-800 to reduce drag. This also permits a straight line shift to drive the thrust augmentation propeller and the anti-torque rotors in the tail. Crew compartment has moved forward 4 ft. to allow the lowering of the engine and transmission.

Powerplants will be General Electric T58-GE-16s instead of the T58-GE-8 engines in the UH-2C and they will be somewhat more recessed into the fuselage. Total power output for the two engines will be 3,740 shp. Power train to the main rotor will be flat-rated at 2,400 shp. to 95F; to the pusher propeller, it will deliver 3,200 shp.

Rotor life of the UH-2C rotor system has been increased to 2,500 hr. through the use of new bonding techniques and Kaman anticipates a 3,000 hr. life with the Seacat/Firecat rotor system. Gear box life will be about 1,200 hr.

This power will give the Seacat a 250 kt. maximum speed at a gross weight of 15,300 lb. and a cruise speed of 210 kt.

The Seacat could be built by retrofitting present UH-2C airframes or from new production. Kaman obviously is aiming for the latter, but has recently received a $2.1-million contract from the Navy to retrofit 12 UH-2Cs to HH-2C armed and armored helicopters.

This retrofit consists of adding a chin-turret mounting a 7.62-mm. General Electric Minigun, two 7.62-mm. machine guns in the rear cabin to fire sideways, armor plate protection for the crew and engines, additional avionics to aid in locating downed pilots and stretched acrylic shatter-proof windows.

These aircraft will be based on destroyers and destroyer escorts off the Vietnamese coast and used primarily for search and rescue missions.

Kaman is convinced the Navy will have to buy a multi-mission helicopter. The company believes the Seacat, in addition to its armed role and search-and-rescue capability, will be able to perform anti-submarine missions, vertical resupply of other ships, electronics countermeasures and decoy work, and possibly cruise missile defense roles (AW&ST Feb. 10, p. 13).

Three UH-2A/B helicopters have been converted to ASW testbeds for the Navy and evaluated. These featured a quick-change capability which permitted the ASW gear to be installed in 20 min. and removed in 30 min.

Similar flexibility is planned for the Seacat.

News Digest

Navy is studying a combination air-to-surface missile system, named Harpoon, for combating hostile surface ships, including high-speed Russian-built patrol boats of the Komar and Osa class. The latter are armed with Styx cruise missiles.

Civil Aeronautics Board has permitted domestic passenger fare increases by trunklines and local service carriers to go into effect. The fares will produce an average increase of slightly less than 4% in revenues for the trunklines and about 10% for the locals (AW&ST Jan. 27, p. 25). Various changes were made effective between Feb. 20 and Mar. 6.

Ling-Temco-Vought, Inc. moved last week to sell 2 million shares of its Braniff International holdings and reduce its interest in National Car Rental Inc., and Computer Technology, Inc. The equity sale appears to mark a reversal of LTV's past practice of building a conglomerate through use of debt capital to buy equity.

Fokker F-28 Fellowship orders climbed to 22 last week. Newest customers are Australia's Ansett group, which purchased two for MacRobertson Airlines, and Martinair, a KLM charter affiliate, which ordered one.

United Air Lines has placed a $2.5-million order with Radio Corp. of America for AVQ-30C long-range C-band weather radar sets (AW&ST Aug. 14, 1968, p. 106) for its Boeing 747 and McDonnell Douglas DC-10 transports. Installations will include dual receiver-transmitter units and dual indicators.

Braniff International has ordered two Douglas DC-8-62 jet transports and arranged to lease three Boeing 727s from Air West. Cost of the DC-8-62 order is $18.5 million, including spares.

Pan American has awarded Brooks & Perkins, Detroit, a $928,000 contract for cargo containers contoured for the lower compartments of its Boeing 747s. Each 169-cu. ft. container will hold a payload of 2,600 lb. and is sized to fit in van-type trucks for overland transport.

British government has offered Maylasia a squadron of Hawker Hunter Mk. 9 jet fighters for service in 1970 and a squadron of Hawker Siddeley P.1127 Harrier VTOL fighters for service in 1971. Proposal is to offset the withdrawal of British forces in early 1970s.

Congolese air force has ordered 17 Aeronautica Macchi MB.326G light attack aircraft. The aircraft, powered by the Rolls-Royce Bristol Viper Mk. 540 engine, was developed from the MB.326 trainer (AW&ST Aug. 19, 1968, p. 56).

Airbuses

engines generally are an unsatisfactory solution.

The three-engine 767s are powered by hypothetical engines in the 28,000-lb.-thrust category. The four-engine 767s are powered by hypothetical 19,000-20,000-lb.-thrust-engines. Boeing feels that an engine of the latter size may have other applications making its development attractive to an engine manufacturer.

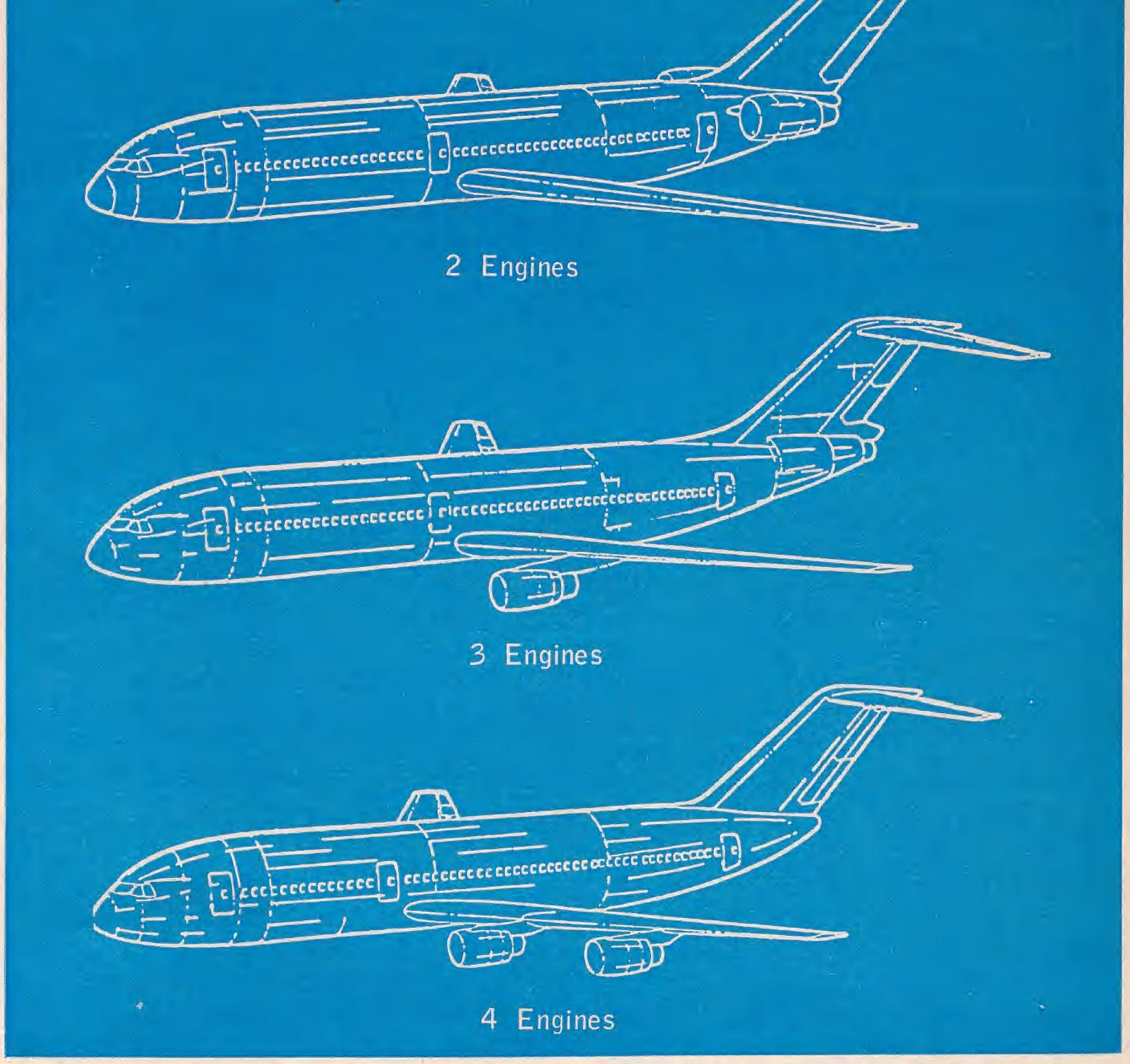
The widespread variation of range and payload in the 767 models is indicative of the apparent limited grasp Boeing has on a potential market. Seemingly on more solid ground is the general payload capacity selected to fill the gap between aircraft such as the 727-200 and airbus aircraft. Capacity of the 767 is similar to that of McDonnell Douglas series 60 DC-8s, although the stretched DC-8s have a longer range.

Boeing found in its 767 analyses that each of the three different configurations—two-, three- and four-engine—had pluses and minuses.

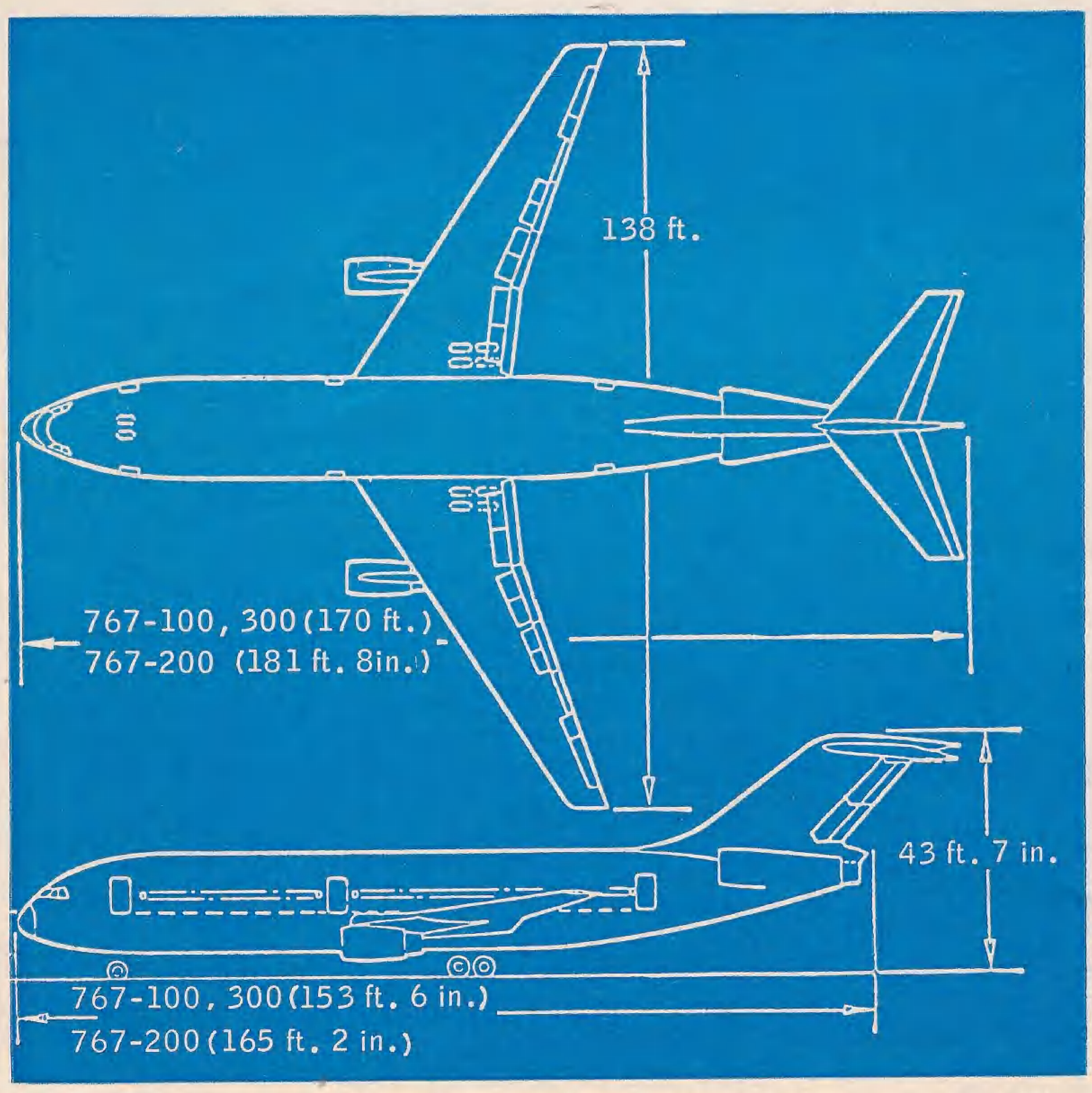
The four-engine versions are lightest in both operating weight empty and gross weight. Direct operating cost in terms of cents per mile, however, is remarkably close for the three configurations and probably will not be influential in determining the number of engines.

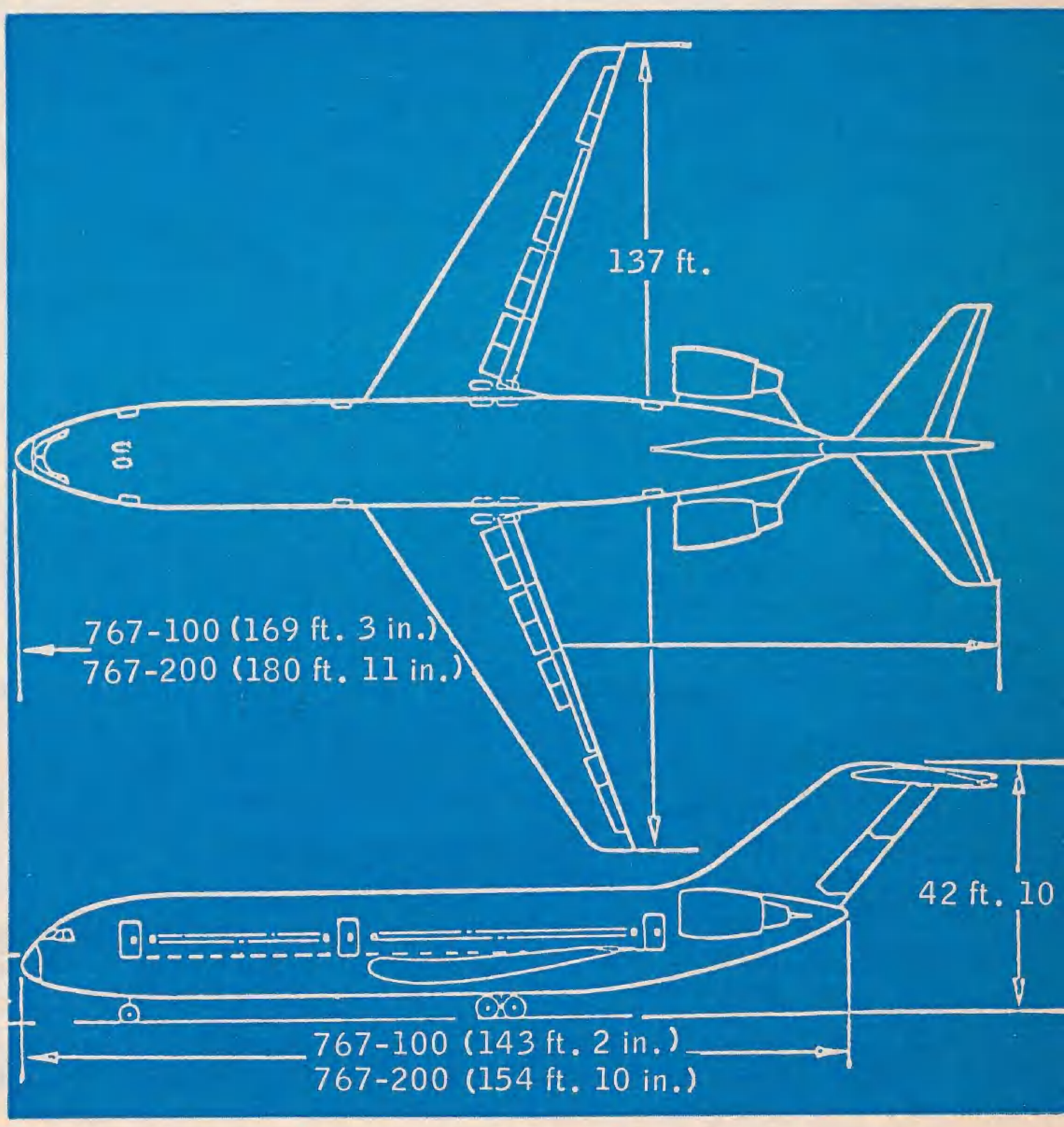
The three-engine configuration is the most expensive at an estimated $12.7 million. This compares with estimates of $11.9 million for the twin and $12.2 million for the four-engine 767. These prices are for the baseline 767-100, although the same relation holds for the more expensive 767-200 and -300.

As would be expected, stretching the fuselage to increase seating within each basic payload/range model resulted in a greater noise signature, longer takeoff field lengths and higher approach speeds. The heavyweight-300 versions have the longest takeoff field lengths

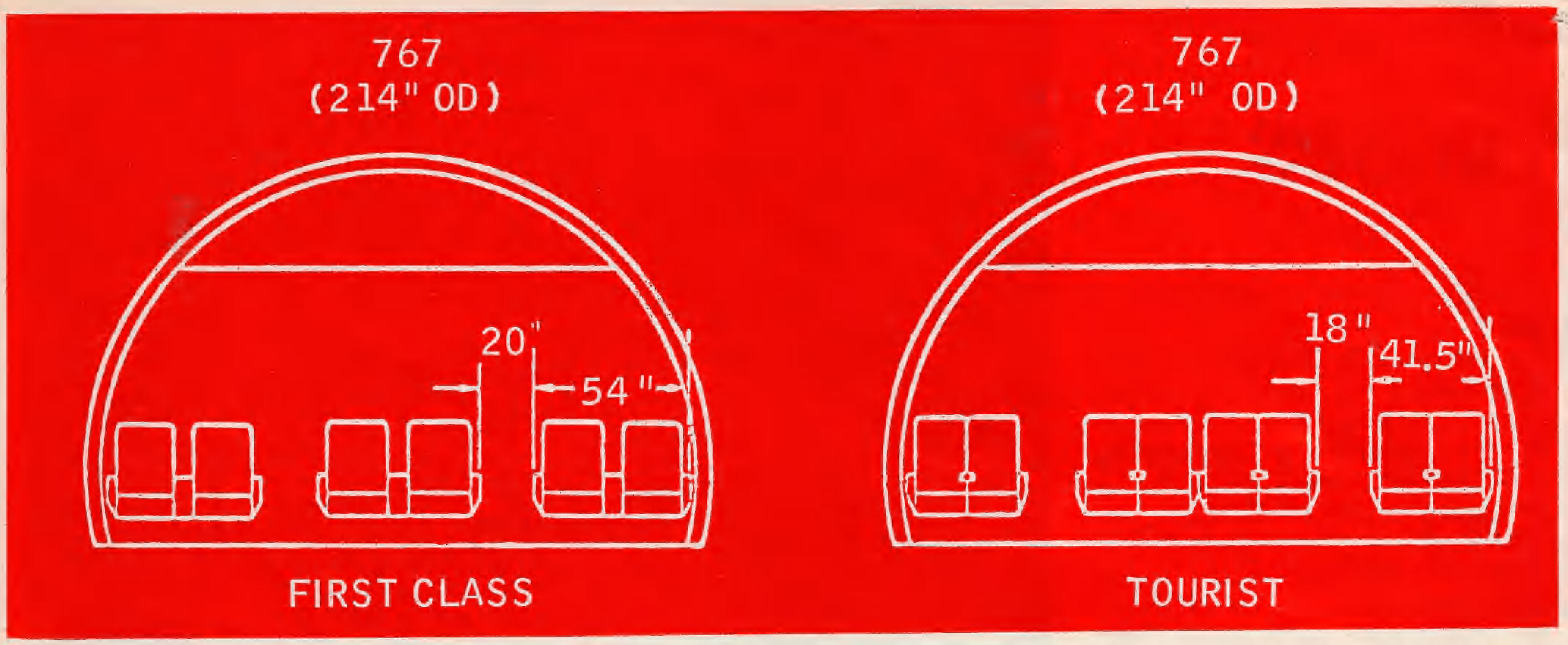


Drawings of the three 767 models show some departures from past Boeing designs, such as use of T-tail and side inlet scoops (center) for No. 2 engine.





The 200 design has three engines (left) and the smallest of the three, the 100 version (right), has twin-engines.



Circular fuselage cross section of the 767 has an outside diameter of 214 in., providing six-abreast, first class (left) and eight-abreast, tourist seating (right), with seat and aisle widths similar to that of the 707.

and the lowest initial cruise altitude, beginning at 31,000 ft. rather than 33,000 as with the other models. All 767 models are designed for a minimum cost cruise Mach number of 0.85.

Generally the twin-engine 767s are most noise critical on approach noise with a 106 epndb. signature. This is the upper limit of proposed Federal Aviation Administration criteria. Takeoff distance, because of second-segment climb restrictions, is more critical with the twin- than with the basic three- and four-engine versions.

The twin-engine version, for example, on a 90F day would be unable to carry a full payload from Chicago's Midway Field to Denver, whereas both the three- and four-engine aircraft could.

Midway Field, with a 5,700-ft. runway length and Denver's airport at a 5,331-ft. elevation, were selected by Boeing as the two key terminals from the 767 design standpoint. This is similar to the role played by New York's LaGuardia Field in the airbus design definition.

All three 767 models studied have T-tails, probably for simplifying comparison. The 767 twin has engines mounted on the rear fuselage, 727-style, rather than slung from wing pylons.

Boeing believes the advantages to rear engine mounts are that the fuselage can sit lower on the ground. This will provide 11- to 12-ft. floor heights, which are closer to present 707/727 floor heights than the 15-ft. clearances typical of 747 and DC-10 aircraft.

The basic twin-engine 767-100 would have these features: gross weight, 259,800 lb.; wing area, 2,350 sq. ft.; length, 169 ft. 3 in.; wingspan, 137 ft., and tail height, 42 ft. 10 in.

Wing, engines and gross weight would remain the same in the stretched 767-200, but length would be increased to 180 ft. 11 in.

The three-engine model 767 has an airbus-type engine placement, one under each wing and the third buried in the tail. The distinguishing feature of this design is a boundary layer inlet for the No. 2 engine.

Boeing engineers believe the new arrangement with each half of the divided inlet located at the base of the vertical tail will have significant performance benefits over existing third engine installations.

The three-engine 767, although basically a one-stop transcontinental aircraft, has the flexibility of growing to an over-water international aircraft, Boeing believes.

General characteristics of the 767 three-engine aircraft are:

■ Baseline—100 version gross weight, 262,700 lb.; range, 1,970 naut. mi.; wing area, 2,380 sq. ft.; length, 170 ft.; wingspan, 138 ft., and tail height, 43 ft. 7 in.

■ Stretched—200 version range, 1,280 naut. mi.; length, 181 ft. 8 in., but otherwise identical characteristics.

■ Long-range—300 version gross weight, 310,000 lb.; range, 3,660 naut. mi., and other configuration features identical to the 767-100. Three 29,000-lb.-thrust engines are used compared with 27,700-lb.-thrust engines in the two above versions.

The four-engine 767 model similarly is sized in three payload range configurations. The 100 is designed for a Chicago-West Coast leg of 1,970 naut. mi.; the 200 for a 1,280-naut. mi. one-stop continental capability and the 300 for a 3,600-naut. mi. intercontinental range.

The four engines all are slung on pylons beneath the wings, which raises floor height somewhat but the general configuration otherwise is retained.

The four-engine 767s have these characteristics:

■ **Baseline**—100 version gross weight, 250,200 lb.; wing area, 2,270 sq. ft.; length, 161 ft. 2 in.; wingspan, 134 ft. 9 in., and tail height, 42 ft. 6 in.

■ **Stretched**—200 version fuselage length, 172 ft. 10 in., but otherwise identical characteristics.

■ **Long-range**—300 version gross weight, 293,800 lb.; powerplants rated at 20,000-lb. thrust, compared with 18,800-lb.-thrust engines for the other two versions.

The circular fuselage cross section of the 767 has been set at 214 in. outside diameter in an attempt to provide a double-aisle, high ceiling, vertical wall environment at the least cost in drag and structural weight. This diameter compares with 256 in. for the 747, 235 in. for the L-1011, 237 in. for the DC-10 and 148 in. for the 707/727/737 family. Apparently, no attempt is being made at this stage to compromise the design for carrying cargo.

Most of the proposed 767 floor plans are based on eight-abreast seating in the main cabin, which would provide roughly the same aisle and seat widths as are found in current 707s. Seat pairs would be 41.5 in wide, with an 18-in. aisle and no divider between the two middle-seat pairs. A typical eight-abreast L-1011/DC-10 floor plan, for comparison, has 44.5-in.-wide seat pairs, 20-in. aisles and an 8-in. gap between the middle two-seat pairs.

Six-abreast first-class seating in the 767 would compare roughly to four-abreast arrangements now found in 707s, but would be considerably tighter than the 747, which has aisle widths approaching 3 ft.

Boeing has studied an alternate seven-abreast tourist seating arrangement, which would have a center triplet flanked by two doublet seat sections. The company has not yet solved the problem of equitably spacing the 73-in. wide-center triplet seats without providing more luxurious seating in the center section than is found along the walls.

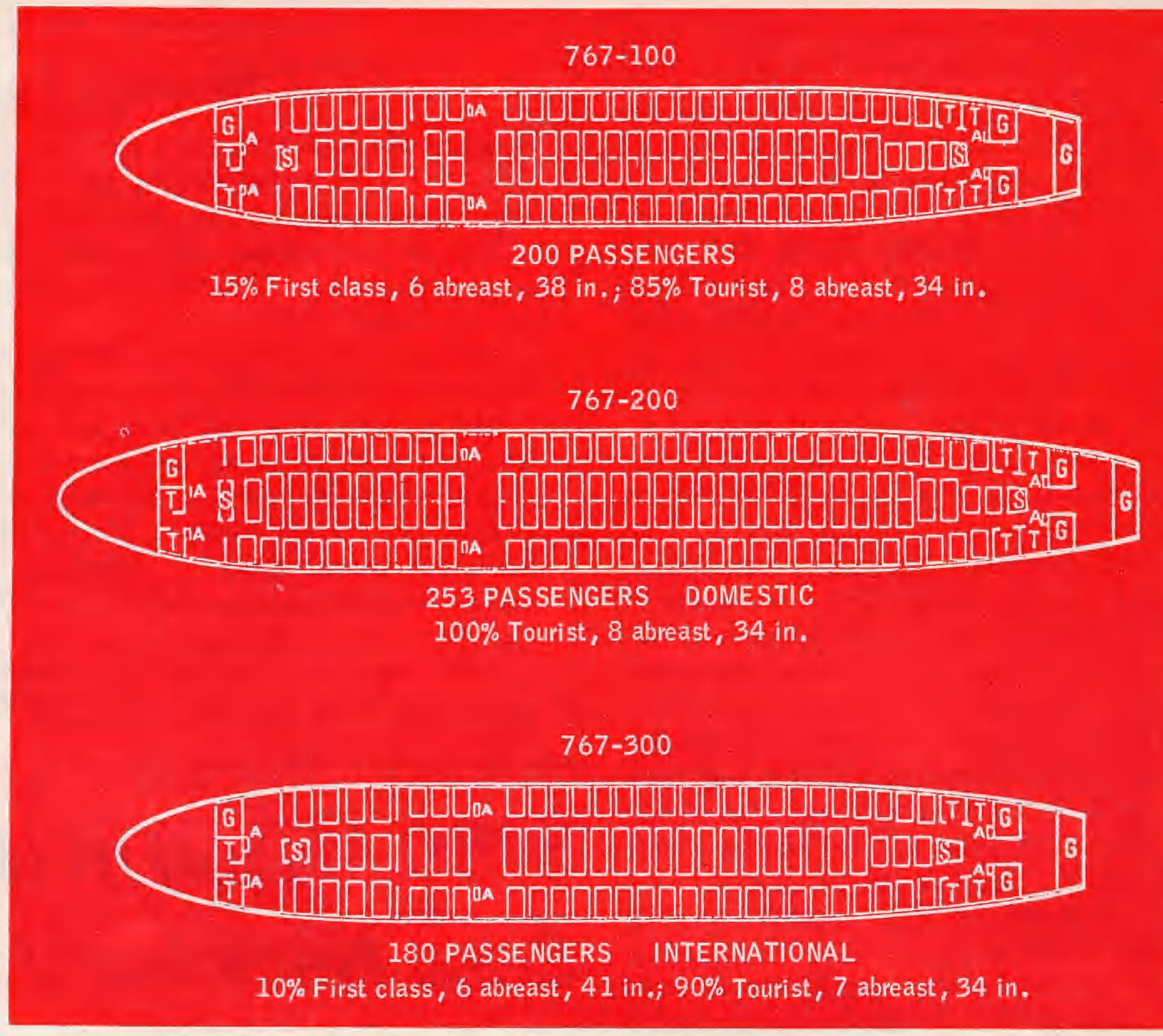
A typical interior arrangement for the 767-100 would seat 200 passengers in a 15/85% first-class/tourist mix. Six-abreast rows in first class are spaced at 38 in. and eight-abreast tourist seats are pitched at 34 in. In an all-tourist arrangement, 221 seats, eight-abreast at 34-in. pitch could be installed.

The stretched 767-200 using the same ground rules would accommodate 231 and 253 passengers, respectively. A maximum-density plan with only galley provisions for snacks and beverages could seat 259 people.

Payload of the long-range 300 model like the basic 100 is 200 mixed-class passengers. An alternate 180-passenger version, seating tourist customers seven-abreast, also has been studied.

From the standpoint of economics—the most significant factor in airline management thinking—Boeing feels the 767 will more profitably serve the medium-density market area than any other aircraft. Calculations show the highest profit per passenger for peak payloads between 131 and 230 passengers on a 500-mi. route. On one-stop transcontinental 2,000 stat. mi. ranges, the 767 profit per passenger for peak payloads between 140 and 200 people is predicted to be higher than the DC-10/L-1011 and 707s which bracket it on either side.

Typical direct operating cost for the 767-100 is approximately $2.25 per airline statute mile with a 200-passenger payload. Direct operating cost in cents per seat statute mile typically would be 1.1 cent.



Proposed mixed seating arrangements include 200-passenger layout for the 767-100, split 15% first class, 85% tourist (top). Plan (center) for the 200 model would seat 253 passengers in a 100% tourist arrangement. Floor-plan for the long-range 300 (bottom) would seat 180 passengers in a 10/90% mix.

El Al Returning to Schedule After Arab Attack at Zurich

By Donald E. Fink

Geneva–El Al Israel Airlines has moved quickly to re-establish its normal international schedule following the Feb. 18 machinegun and grenade attack on an El Al Boeing 720B at Zurich's Kloten airport. The aircraft—Flight 432 en route to Tel Aviv from Amsterdam—was departing from Zurich following a scheduled stop.

The attack was launched by four members of the Arab Palestine Liberation Front—three men and a woman—who sprayed the aircraft with 50 to 60 rounds of 7.26 mm. machinegun fire as it taxied out for takeoff. There were 17 passengers—including Gideon Raphael, director general of Israel's Foreign Ministry—and 11 crew members aboard.

An El Al trainee-pilot was seriously wounded, and one of the attackers was killed when a passenger aboard the aircraft opened an emergency escape door and returned fire.

A Boeing 720B leased from Aer Lingus to replace an El Al aircraft damaged in a similar raid Dec. 26 at Athens (AW&ST Jan. 6, p. 32) will be used to replace the aircraft damaged at Zurich, according to an airline spokesman. The fuselage was pierced by 40 shells and the nose wheel tires were punctured. At least one grenade exploded near the aircraft, but caused no damage.

An El Al maintenance team was flown to Zurich to make emergency repairs. El Al officials said the aircraft is expected to be returned to regular service shortly.

The passengers and crew—except for the trainee-pilot—and the passenger who fired on the attackers flew to Tel Aviv the following day on a New York-Tel Aviv flight which diverted to Zurich. Normal service on the Amsterdam-Tel Aviv route was expected to be restored by late last week.

The Zurich attack came during the airline's normal slack period and, therefore, had no immediate impact on scheduled operations, according to El Al officials. Load factors have been generally depressed in all Middle Eastern airline operations, and seasonal increases are not expected to begin before late April.

Meanwhile, Swiss authorities are

Western Control

Los Angeles–Kirk Kerkorian, Las Vegas financier, has increased his holdings of Western Air Lines common stock to about 30% from the 25% he had acquired through a tender offer last December (AW&ST Dec. 16, 1968, p. 30). He would not say, however, whether he intends to seek control of the Los Angeles-based carrier.

Pacific Southwest Airlines, of San Diego, is seeking control of Western through an exchange of stock (AW&ST Dec. 23, 1968, p. 31).

J. Floyd Andrews, Pacific Southwest president, said last week proposals to increase PSA's authorized capital stock and to approve a contemplated tender offer for Western stock will be submitted to Pacific shareholders at the annual meeting here April 21.

Kerkorian had acquired 1,265,000 common shares previously and has increased this to 1,357,000, plus $6,184,000 of Western convertible debentures.

questioning the remaining three Arab attackers and the El Al passenger who returned their fire. All four were arrested when Kloten Airport police and fire units converged on the aircraft.

The El Al passenger was thought to be an airline security guard. However, airline officials refused to confirm that armed guards have been assigned to all El Al flights as a protection against attacks. Palestine Liberation Front members also hijacked an El Al aircraft en route to Tel Aviv from Rome last July and forced the captain to fly to Algiers (AW&ST July 29, 1968, p. 28).

The Zurich attack has prompted another wave of protests by international civil aviation organizations and a further tightening of security at civil airports. Officials at Kloten said strict security measures had been taken following the Athens attack, but had been relaxed about 10 days ago.

The Arab team drove into the center of Kloten Airport on an access road which leads to the general aviation area. They went on foot to the taxi strip leading to the end of the runway and hid behind a snowbank, according to Kloten officials. The attack was launched as the El Al aircraft taxied past.

The crew stopped the aircraft short of the runway, cut the engines and ordered the passengers out of the aircraft. Emergency escape chutes on the left side of the aircraft were used. The runway remained clear and normal traffic operations continued following the attack.

At Geneva's Cointrin Airport, additional security measures were put into effect, and El Al aircraft have been ordered to park at the far end of the ramp.

A spokesman for the International Air Transport Assn. here said the organization deplores the Zurich attack and all similar incidents involving the air transport industry. He said this important segment of the world's public transportation system should not be exploited to carry out combat operations between countries.

IATA earlier had condemned the Athens attack and the Dec. 28 Israeli retaliatory commando attack on Beirut International Airport, during which 13 commercial transports were destroyed.

The latest incident has added new urgency to IATA's attempt to organize a three-level campaign to counter air piracy and attacks on commercial transports.

This includes an increased effort to prompt the International Civil Aviation Organization to revise the Tokyo convention and include stricter regulations on air piracy.

IATA also is asking its member airlines to pressure their governments for strong national legislation against hijacking, bomb scares and other actions.

747 Receives Full-Load Taxi Tests

San Francisco—Boeing Co.'s No. 1 747 giant jet was loaded to 713,000 lb. last week for high gross weight taxi tests after accumulating 7 hr. 3 min. of flight time in the test program that began Feb. 9 (AW&ST Feb. 17, p. 26).

The aircraft's tanks were loaded with 324,825 lb. of fuel on Feb. 19 and water ballast was added to bring the 747 to its maximum taxi weight for the runway tests.

The aircraft was flown for the second time Feb. 15 after a minor flap misalignment problem experienced on its maiden flight was solved.

The landing gear was retracted and extended in flight for the first time in this 2-hr. 18-min. flight, which otherwise was marked only by a high fuel tank pressure reading that was ascribed to a faulty indicator.

During a 23-min. flight on Feb. 17, the pressure setting on the No. 2 engine oil regulator was adjusted after it was found to be set too high. On Feb. 18, the aircraft flew twice—once for 2 hr. 42 min. and again for 24 min.—without incident.

After the taxi tests, the aircraft was scheduled to be de-fueled and then remain on the ground for a few days for instrumentation checks.

$160 Million in U.K. Funding Seen Necessary for BAC 311

London—British Aircraft Corp. last week said it could build the BAC 311 wide-bodied jet transport with government funding of $160 million. The 311 is competing for government aid with the Anglo-French-German A-300B airbus project.

The sum is about half the amount needed for full development to certification, considering that the Rolls-Royce RB.211 advanced technology engines envisioned for the BAC 311 is already funded as part of the Lockheed L-1011 airbus agreement. BAC said the $160 million asked from the government is a fixed sum, recoverable by a levy on sales.

BAC also is researching subcontractors in an effort to form a funding consortium to raise the other $160 million for the project. The company has said the project could be viable, particularly in the export field, with initial orders for 50 airplanes.

So far, Laker Airways has ordered four BAC 311s. If the A-300B project falls through, British European Airways may order as many as 20, although the airline also is evaluating prospects of the Lockheed L-1011 at the same time.

The figure of $160 million is about the same amount as the government would be asked to put into the tri-country consortium for the A-300B. At present, all work on the new design, which replaces the large A-300, is being funded by the companies involved, Hawker Siddeley Aviation in Britain, Sud Aviation in France and Deutsche Airbus GmbH in Germany, since governmental letter of agreement expired last Aug. 31.

With ministerial meetings delayed pending French finance talks (AW&ST Feb. 17, p. 34), Prime Minister Harold Wilson last week told the House of Commons that the government is taking a cautious line on A-300B funding.

In a recent visit to Germany, he proposed mutual consideration of the BAC 311 as a joint project, and told the House:

"The airbus they (Germany and France) tried to get us to agree to last year has now been dropped as being the wrong project. That is why we advocate more caution in evaluating economic as well as technical aspects of what is now proposed."

Wilson stressed that the British government will not "waste money on projects whose economic value has not been proved." He also cited the proposed Multi-Role Combat Aircraft, a European project in which "governments are anxious that it should make progress, although there are still problems of program definition, because not only Britain and West Germany, but other countries, have slightly different concepts of the roles which should be included for this all-purpose airplane."

In the House of Lords, the government chief whip, Lord Beswick, said that, at the moment, there is no definite figure on initial orders required for the A-300B. Originally, the plan was for a minimum of 75 for the A-300, shared by Air France, BEA and Lufthansa.

Beswick said that if the BAC 311 attracts orders, it will have a good case for government support, adding: "On the basis of experience, there is no reason why the United Kingdom government should not support a UK project if it appears to be getting world airline support."