Army Program Tests Bell UH-1B at High Speeds
727 Designed for Low Approach Speeds

By David A. Anderson

Renton, Wash.—Prime engineering design goal of the Boeing 727 medium-range jet transport program was to obtain lower approach speeds for bad-weather conditions.

Ability to operate the airplane in and out of small fields and to fly short to medium stage lengths economically were two other requirements that influenced the design.

This trio of operational requirements, plus an extensive market survey that defined the traffic potential and therefore both the capacity and the interior layout of the 727, built a rigid frame of reference for the Boeing designers.

Working within these restrictions, the engineers developed refinements of layouts, designs and systems that had characterized their earlier efforts in multi-jet aircraft. The result is that the 727 looks like a Boeing airplane, and in spite of its high-mounted T-tail and three rear engines, it looks like a conventional airplane. Only when the observer’s attention is shifted to detail does the full breadth of the engineering approach dominate the design.

The airplane, which was rolled out of the hangar Nov. 27 (AW Nov. 26, p. 42), is powered by three Pratt & Whitney Aircraft JT8D-1 engines each rated at 14,000 lb. thrust for takeoff. Wing span is 108 ft. 7 in., and over-all length is 134 ft. 1 in. Interior can be arranged to carry 70 first-class passengers in four abreast seating, or 114 tourist-class passengers in six abreast seating. Maximum takeoff weight is 142,000 lb. in the specification, but an alternate at 152,000 lb. is being offered to the airlines and Boeing believes that all of them will use it.

Boeing’s philosophy in the design of the 727 sprang from operating conditions associated with the short to medium-range hauls envisioned for the airplane. On such runs, the 727 would be expected to fly in and out of fields with about 3,000-ft. runways, in all kinds of weather and without relying on extensive approach aids. It would cruise normally at lower altitudes, which would mean exposing the passengers and the airplane to more turbulence over longer periods of time than those associated with long-distance jet transportation.

The only way to approach this problem was to design a wing with high wind loadings for cruise in order to minimize the drag, and with high maximum lift coefficients in order to minimize the stall and approach speeds. Boeing’s first major decision on the 727 program was to develop a high-lift system for the airplane which would best by substantial margins the lift coefficients obtained on the company’s earlier transports.
Basically, the 727 wing looks like its counterpart on the Boeing 720 series. But the sweep angle, dihedral angle, airfoil section, high-lift devices and control surfaces differ from those of the 720. Wing loading at maximum flight weight of 142,000 lb. is 86 psf, and for the alternate weight of 152,000 lb., the wing loading is about 92 psf. These figures lie between similar values for the Boeing 720 and 720B series. Maximum landing wing loading, for a weight of 131,000 lb., is 79.5 psf, considerably higher than the 720 series.

Engineers designed and tested a large number of flap systems, including some using boundary-layer control. All of these were tested in wind-tunnels either at Boeing or in the Seattle area. Some of them were promising enough so that full-scale hardware was built and flown on the Boeing 707 prototype, the "Dash 80."

**Flap Mechanisms**

Chief 727 Project Engineer J. E. Steuer said that at one time during the development of the airplane there were 41 engineers designing competitive flap mechanisms, aimed at practical mechanics and easily maintained structures.

The final result was that the wing was designed with trailing-edge triple-dotted flaps running spanwise from the fuselage to the inboard nacelle and from the inboard aileron to the outboard aileron. The leading edge of the wing carries Knudsen flaps in three segments from the fuselage to the inboard pylon, and four-segment leading-edge slats from that point out to the wingtip. Boeing has not released actual maximum lift coefficients of this wing, but the company has said that it shows more than 40% improvement over the 720 and 707 wings. Actual ratio of lift coefficient flaps down to flaps up is 1.7 for the 707 and 720, and 2.4 for the 727.

Wing sweep is 32 deg, measured at the quarter-chord point. Both the sweep and the dihedral angle are less than those on the 720.

Because the cruise profiles are different, and because the wing-mounted engines of the 720 affected the wing aerodynamics, the airfoil sections of the 727 wing have been changed. The inboard leading-edge extension is similar to that on the 720. Gross wing area is 1,650 sq ft.

Wing structure is basically a two-spar box beam with conventional rib construction. Surfaces are built from riveted skin-stringer combinations.

From the body out to the wingtip, the volume between the spars is an integral fuel tank, with 7,000 gal, normal capacity.

It was not enough to provide the 727 with large lift increments for the approach and landing. They had to be stable lift increments, which meant that the airplane had to be stable and controllable down to its minimum flying speed and that the autopilot system had to be developed along different lines to take full advantage of the airplane's flight characteristics. Complete description of the autopilot system appeared in *Aviation Week* (Nov. 19, p. 93).

Surface controls for the 727 were also an evolutionary development from the airplane systems that went before. Combination of ailerons and flight spoilers is used for lateral control; dual rudder handles the directional control and the elevator is conventional. Irreversible hydraulic control systems are utilized on all three axes.

The wing trailing edge, in addition to carrying the large flaps, also carries --starting at the body and working out along the span--three spoilers on the upper surface, an inboard aileron, four more spoilers, and an outboard aileron.

For lateral control, two spoilers are available, five per side. Four of these are the outboard spoilers and the fifth is the nose-outboard of the inboard spoilers.

The remaining two spoilers on each side are for ground blanking only. The inboard ailerons are used during high-speed cruise flight only; the outboard ailerons operate only when the flaps are down. The spoilers pick up anytime there is more than five degrees deflection of the control wheel. They
are programmed so that they deflect only 15 deg. when the flaps are down, and 30 deg. when the flaps are up. Both these deflections should produce a roll rate of one radian per second. Brake spoilers deflect to 45 deg.

Split rudders carry anti-balance tabs. If one rudder system should fail and produce a hard-over signal, the other rudder would deflect automatically to compensate. There are dual yaw dampers, one for each rudder, with authority confined to five degrees on top of any rudder pedal input.

Hydraulic Systems

There are three hydraulic systems, two of these are dual parallel systems for longitudinal and lateral control, and the third is a back-up system for the rudder. First of the systems is powered by dual pumps driven by the left and center engines. It operates the airplane control and flap systems and the landing gear. Second of the systems, which operates simultaneously with the first, is powered by dual electrically driven pumps. If one hydraulic system fails, the second supplies control power automatically and immediately. The third system drives the lower rudder segment and the leading-edge flaps, and is powered by a single electric motor-driven pump.

If the two main hydraulic systems fail, the airplane control goes into manual automatically and the third system drives the lower rudder. Under these conditions, the airplane is not only flyable but can be landed with manual control. The manual system provides enough power to produce a roll rate of six degrees per second, and a full flare with the elevators; but the 727 cannot demonstrate a complete stall under this condition.

Stick Forces

Both lateral and directional control systems produce artificial stick forces or "feel" with inputs. For the ailerons, a 10-lb. couple gives the feel at full deflection; for the rudder, the feel is 80 lb. on full rudder.

The elevator has a hydraulic feel system, based on integrated inputs from the stabilizer position and dynamic pressure, read from dual pitot inlets, electrically decided, one on each side of the fin. Integration of these two bits of information gives a close approximation of the center of gravity, primarily by defining the trim of the aircraft and its static stability margin for any condition of flight. If one hydraulic system fails, there is no change in feel detectable by the pilot; if two systems fail, the elevator feel is produced by a spring which gives stick forces corresponding to those usually felt at 140 kt.

The forward cockpit shell and wind-