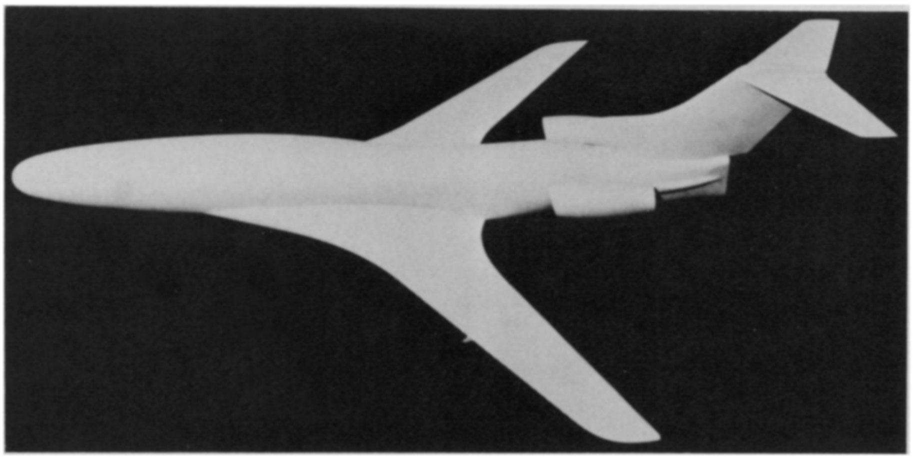
Dr. Whitcomb's superwing



Smoother, faster, cheaper flying is the promise of the flying flattop: the supercritical wing—by Jonathan Eberhart

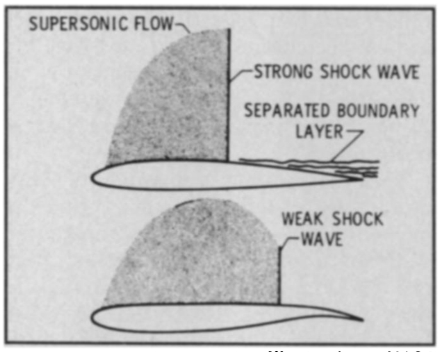
It's a subtle difference, almost invisible to the untutored glance, but it can make a big difference to an airplane. Better fuel economy, longer range, higher speeds, better maneuverability and smoother flight are its potential, and all apparently without any disadvantages. "Something for nothing" is a supposedly unattainable goal, but the supercritical wing is close enough that it helped win its designer a 1973 National Medal of Science.

The supercritical phenomenon has long been a limitation on the performance of aircraft flying at "transonic" speeds—from slightly below to slightly above the speed of sound. Because the upper surface of a conventional wing is curved, air moving across it in flight has to travel more than a straight-line distance to get from the front of the wing to the back. Since this part of the air stream around the plane has to travel a greater distance than the rest in the same length of time, it is forced to move faster. The result is that, as an aircraft approaches the speed of sound, the air over the wing "goes supersonic" before the rest of the air stream does.

The problem is that this supersonic flow of air creates a shock wave along the top of the wing. The part of the flow that is closest to the wing surface (called the boundary layer) loses some of its energy from friction with the wing, so it becomes too weak to push through the shock wave without slowing down. The slowdown causes the downward pressure on the wing to increase, which creates drag on the plane.

Overcoming the drag takes extra power—and extra fuel. World War II fighters approaching the speed of sound in dives often ran out of speed because of it. Today's jet transports, passenger liners and executive aircraft do most of their flying in that range, and suffer the consequences.

In 1965, Richard T. Whitcomb, an aeronautical engineer at NASA's Langley Research Center in Virginia, had the idea of simply flattening out the top of the wing. The air doesn't have to move so fast to reach the trailing edge of the wing, and the resulting shock wave is both weaker and farther back on the wing (80 to 90 percent of the way, according to some figures, compared with 15 to 20 percent on a conventional wing). This reduces the drag, which improves the plane's efficiency—



Illustrations: NASA

New wing profile alters shock wave.

less power is needed to hold a given speed.

The wing's curvature, however, is also what gives it lift, since the faster-moving air reduces the downward pressure. Whitcomb therefore flattened out just enough of the wing to shrink and relocate the shock wave; the rear edge of the new wing is even more steeply curved than that of a conventional one. (In fact, minimizing the air slowdown behind the shock wave is such a key subtlety in the program that, because of its military implications, it has been classified until this month.) In addition, a "cusp"—an up-and-down curve—is built into the rear of the wing's underside; the cusp shows additional promise of improving the efficiency of non-supercritical wings, and will be flight-tested in 1974.

After moving from Whitcomb's drawing board to the wind tunnel, the new wing was flight-tested by installing a simplified version on an F-8 jet fighter. In 80 flights, beginning on March 9, 1971, the wing was found to improve the plane's performance by 15 percent. Even the earliest flights revealed that the plane could fly significantly faster without an appreciable increase in aerodynamic drag.

Another advantage to the supercritical wing is that it can be made thicker, offering more fuel capacity without decreasing either its efficiency or its weight. Flight tests with a T-2C jet trainer showed that the new wing's efficiency stayed the same even when its thickness ratio (thickness to front-to-back length) was increased from 12 percent to 17 percent, and suggested the use of ratios up to 42 percent.

The first complete supercritical wing —with flaps, fuel tanks and so on— flew Nov. 1 of this year on a movable-wing F-111, which allows choosing the wing angle that gets the most increase in efficiency. Boeing, General Dynamics and Lockheed have all studied the wing for use in future large jets, and Boeing and Douglas are now building prototypes of military transports that include supercritical wings. Gates-Learjet is designing one into its executive jet, and supercritical shaping is being studied for such diverse applications as propeller blades, helicopter rotors and even turbine vanes. □