Engineering Notes

ENGINEERING NOTES are short manuscripts describing new developments or important results of a preliminary nature. These Notes cannot exceed 6 manuscript pages and 3 figures; a page of text may be substituted for a figure and vice versa. After informal review by the editors, they may be published within a few months of the date of receipt. Style requirements are the same as for regular contributions (see inside back cover).

AIAA 81-4162

HISTORICAL NOTE

Aircraft Technology Development in Sweden 1930-1980

Olof Holme*
Saab-Scania AB, Linkoping, Sweden

DURING the 1930s a relatively slow buildup of resources for aeronautical development took place in Sweden. A professor of aeronautics was installed at the Royal Institute of Technology in Stockholm and he was provided with a low-speed wind tunnel with a 1 m diam test section. The industrial activities were concentrated at two new companies, Svenska Flygmotor AB (now Volvo Flygmotor AB) and Svenska Aeroplan AB (now Saab-Scania AB), for design, development, and production of engines and airplanes, respectively. Finally, the national Aeronautical Research Institute of Sweden (FFA) started its activities in 1940, with departments for structures and aerodynamics. For the latter a low-speed wind tunnel with a 3.6 m diam test section was built.

The outbreak of World War II severely limited Sweden's ability to import aircraft and to obtain information about aeronautical research and development abroad. These circumstances accelerated development within the country, such that during the war years a number of propeller airplanes were designed and produced for the Swedish Air Force.

The first of these, the dive bomber B17, was provided with a bomb sight BT9, developed from entirely new principles. In a straight dive toward the target, the position of the airplane with respect to the target (height and dive angle) was determined. During pullout, position, attitude, and speed of the airplane were followed by an electromechanical computer which automatically released the bomb when the ballistic conditions for a hit were satisfied. This bomb sight has since been successfully developed and exported to several countries. The latest version has an electronic computer and the height measurement has been replaced by laser ranging.

The most remarkable airplane of the period was, however, the fighter J21 (Fig. 1) which had a single engine with a pusher propeller, working between twin booms carrying fins and a stabilizer. In order to save the pilot from being hit by the propeller when trying to escape from the airplane, an ejection seat was invented. The J21 is one of the earliest airplanes in service with a device of this kind. The escape systems of all jet airplanes built in Sweden have evolved from this ejection seat. The latest version makes escape possible down to zero height and up to 1200 km/h indicated airspeed.

When jet engines became available after the war, it was found to be possible to convert the J21 to a jet fighter by replacing its piston engine and propeller with a jet engine (DH Goblin) and raising the stabilizer to clear the jet. Thus the aircraft industry as well as the Air Force got a flying start into the jet age.

However, a new airplane was needed to exploit the full potential of the new engine. A top speed of 1000 km/h was set as a design goal and, guided by results of German research made available after the war, it was decided to give the wing a moderate sweep back. The result of the design work was the J29 "Flying Barrel" (Fig. 2), which made its first flight in 1948. The engine was a DH Ghost, which in later versions of the airplane was provided with an afterburner of Swedish design.

The J29, one of the world's first swept-wing fighters in service, turned out to be a very successful design, which has been produced in greater numbers than any other Swedish airplane. The design goal for top speed was exceeded by good margin and the airplane held for some time world records for speed in closed circuits of 500 and 1000 km. The climb speed of the version with an afterburner was for its time outstanding.

Immediately after the J29 a strike airplane, the A32 Lansen was designed with more sweep back, thinner wing sections, and a more slender fuselage made possible by an engine with axial flow compressor (RR Avon).

Simultaneously, project studies for a supersonic fighter were started. The studies were soon concentrated on delta wings, mainly because such wings could be built with the technique used for earlier airplanes. A search for the best compromise between conflicting demands on wing thickness, span, area, and leading-edge sweep from considerations of aerodynamics, structures, and weight led to the double-delta wing with a moderately swept outer wing joined to a sharply swept inner wing. For the given wing area, span, and relative section thickness, the double-delta gives a greater depth of structure at the wing root than a pure triangular wing. In addition, wind-tunnel tests showed the double-delta to have better lift and pitching moment characteristics at high in-

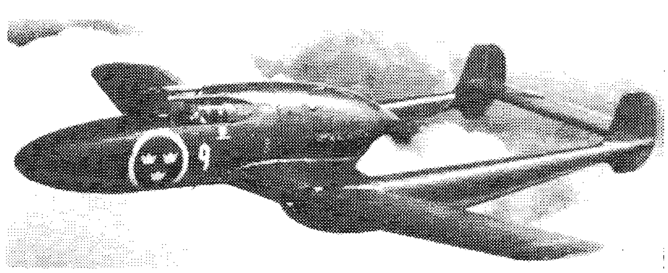

Fig. 1 The J21 fighter.

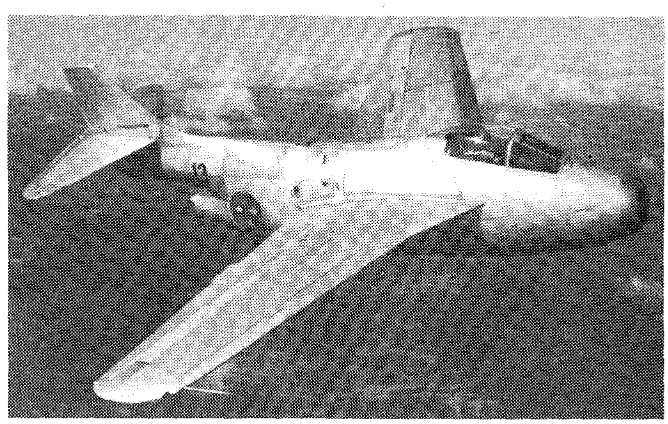

Fig. 2 The J29 "Flying Barrel."

Received March 23, 1981.

*Senior Aerodynamicist, Aircraft Technology, Design and Development Sector, Military Aircraft.

cidence than a comparable pure delta, due to the beneficial influence on the flow over the outer wing vortex which separates from the leading edge of the inner wing. The same effect is created by the strakes on some recently designed airplanes.

From the results of these studies the supersonic fighter J35 Draken (Fig. 3) was designed. It made its first flight in 1955 and has since been produced for the Swedish Air Force in four fighter versions with successively more powerful engines and improved weapons systems. There are also two-seat trainer and reconnaissance versions. For export a strike version has been developed with a takeoff weight twice as high as that of the first fighter version. With a top speed in excess of $M=2$ the J35 has good maneuverability and modest demands for runway length.

In the late 1950s the Swedish Air Force adopted a basic philosophy demanding that future aircraft should be able to operate from very short runways. As supersonic performance was still required, it was felt highly desirable to utilize the experience with the J35 and continue to use delta wings. For that reason a broad investigation into ways of improving their high lift capabilities was started.

A tailless delta, designed to be statically stable in pitch, cannot use trailing-edge flaps as a high lift device because an upward deflection of the flaps is needed to trim the airplane. As an unstable airplane was deemed unacceptable, wind-tunnel tests were made of combinations of the wing and a separate horizontal stabilizer. With the stabilizer behind the wing, it was found almost impossible to obtain satisfactory longitudinal stability due to the strong downwash from a delta wing at high incidence. A stabilizer in front of the wing has the advantage that the trim force on the stabilizer is added to the wing lift. In wind-tunnel tests it was found that, with a triangular stabilizer immediately in front of and slightly above the delta wing, a beneficial interference took place between the leading-edge vortices from the stabilizer and the wing. The interference increased both the lift at a given incidence and the range of incidence for acceptable longitudinal stability.

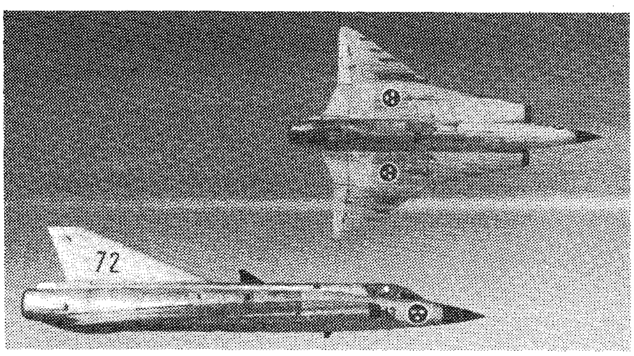

Fig. 3 The J35 single-seat supersonic interceptor fighter.

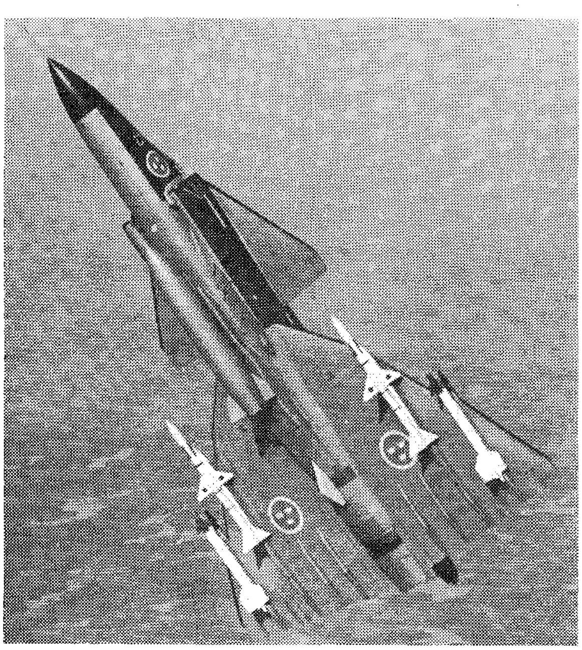

Fig. 4 The JA37 Viggen.

This discovery formed the basis of the aerodynamic layout of the JA37 Viggen (Fig. 4) which combines a top speed in excess of $M=2$ and low gust sensibility at high speed and low altitude with a low touchdown speed at a moderate angle of attack. To fulfill the runway requirements, the engine has a thrust reverser and the undercarriage is designed for no flare (carrier-type) landings.

The airplane, which made its first flight in 1967 has been delivered to the Swedish Air Force in a strike and a reconnaissance version. A fighter version with a more powerful engine and modernized equipment is being delivered.

Viggen Thrust Reverser

AIAA 81-4163

Bengt Ahrén*
Saab-Scania AB, Linkoping, Sweden

ONE basic requirement for the A/C 37 Viggen was the capability to take off and land on 500 m runway strips. To achieve such a landing, the aircraft had to possess several specific features, the most important of which were: low approach speed, means to reduce touchdown scatter, and high rate of deceleration on the ground. The most efficient method of reducing speed quickly, even on icy runways, is thrust reversal. In 1962, when the Viggen program began, thrust reversers for afterburning engines were not available. In spite of this, it was decided to make the aircraft capable of thrust reversal and to start development of a reverser for the RM8 engine, the military version of the Pratt & Whitney (PWA) JT8D.

From the beginning, the reverser layout was based on a PWA concept consisting of a "blow-in-door" ejector, similar to the TF30 nozzle in the F-111, with a number of blocker doors for thrust reversal integrated into the ejector. In the Viggen, a single-engine aircraft, it was found advantageous to integrate the ejector nozzle into the rear fuselage instead of connecting it to the afterburner primary nozzle. Thus, because the ejector/reverser unit was an airframe component, Saab became responsible for its development and production.

After preliminary design and model testing, the original concept of the ejector/reverser layout was modified considerably and had the following main features. A fixed geometry ejector with a cylindrical inner shroud is connected

Received March 23, 1981.

*Head, Aircraft Technology, Design and Development Sector, Military Aircraft.