EO 05-1-3/2

ROYAL CANADIAN AIR FORCE

DESCRIPTION OF MAIN ELEMENTS OF AIRCRAFT STRUCTURE

(This EO replaces Part 2 of EO 05-1-3)

ISSUED ON AUTHORITY OF THE CHIEF OF THE AIR STAFF

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DESCRIPTION OF MAIN ELEMENTS OF AIRCRAFT STRUCTURE

GENERAL

1 The main structural parts of an aircraft are fuselage, wings, empennage and undercarriage.

FUSELAGE STRUCTURE

2 Fuselages of most military aircraft are of all-metal construction, assembled in a modification of the monocoque design which relies largely on the strength of the skin or shell (covering) to carry the various loads. This design may be divided into three classes: monocoque, semi-monocoque, and reinforced shell. Different portions of the same fuselage may belong to any of these classes.

3 The monocoque has, as its only reinforcement, vertical rings, station frames and bulkheads. The semi-monocoque, in addition to these, has the skin reinforced by longitudinal members, that is, stringers and longerons, but has no diagonal web members. The reinforced shell has the skin reinforced by a complete framework of structural members. The cross-sectional shape is derived from bulkhead and station frames and longitudinal contour is developed with longerons and stringers.

4 The skin, which is fastened to all these members, carries, primarily, the shear load, and, together with the longitudinal members, the loads of tension and bending stresses. Station frames are built-up assemblies located at intervals to carry concentrated loads, and at points where fittings are used to attach external parts such as wings, landing gear and engine mounts. Longerons and stringers may be single pieces or built-up sections.

5 The metal in general use for aircraft construction is aluminum alloy, principally one or the other of the two alloys commercially known as 24S and 75S. These are about three times lighter than steel and, after being heat-treated, have a strength approximately equal to that of mild steel. For some uses, generally surface covering, this alloy is made in sheets with a thin covering of pure aluminum on both sides. In this form it is commonly known by the trade name Alclad. The pure aluminum serves as a protective coating to the base metal. Extrusions, widely used for stringers, are usually of the same alloy as the skin.

WING STRUCTURE

6 Wings are usually all-metal stressed-skin construction, of cantilever design. The most frequent arrangement has two main spars with ribs placed at frequent intervals to form the wing contour and space the spars.

7 On aircraft of low wing loading, the wing covering merely transfers the applied air loads to the ribs and thence to the spars. The spars resist the main bending load resulting from the lift of the wings and the weight of the fuselage. The spars and ribs form a torque box to resist the various complex loads on a wing in flight and landing.

8 On aircraft with higher wing loading, the skin itself must resist much of the primary load. In order to do this without local deflection, it is stiffened most frequently with spanwise stringers of extruded or formed section. Corrugated sheet fastened to the outer skin may also be used. This concept is further developed in wings of double skin with corrugated sheet or continuous hat-section stringers between the skins.

9 Some recent aircraft wing skins are integral; that is, the wing skin is first extruded as a

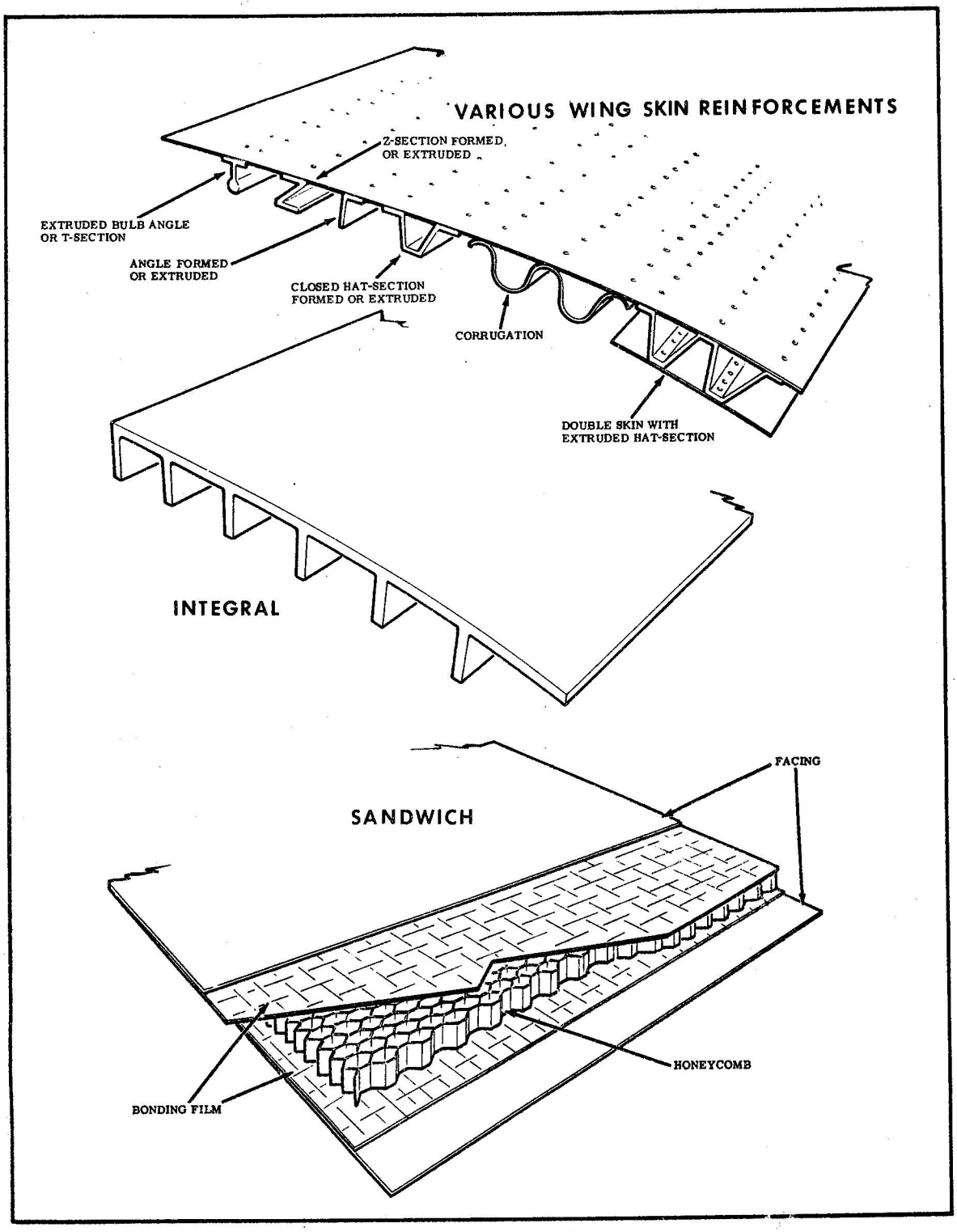

Figure 1 Typical Wing Skin Reinforcements

heavy slab and the space between the stringers is then milled out. These skins are well suited to resisting compression loads without wrinkling.

10 Another development, used in various parts of the aircraft, is the sandwich construction. The original sandwich arrangement used in the deHavilland Mosquito consisted of a balsa core and a birch plywood facing. Arrangements on some recent aircraft consist of aluminum alloy facings bonded to a balsa core, aluminum alloy facings bonded to aluminum honeycomb core, and various other combinations of aluminum alloy and glass fibre, both facings and cores. The purpose is to achieve a skin of high strength to weight ratio, capable of resisting loads without local deflection. For examples of various types of skin stiffeners, see Figure 1.

ENGINE MOUNTING

11 A piston engine is mounted on an engine mount of steel tubing, which in turn is attached at a firewall. On multi-engine aircraft, the firewall is usually fastened directly or indirectly to the front spar and the wing is reinforced with additional bracing between the front and rear spars. This is accomplished by employing heavy ribs, a tubular structure, a stressed skin nacelle or a combination of these. On single engine aircraft, the firewall similarly attaches to the longeron terminals, at which point the fuselage is reinforced by a heavy frame.

12 Jet engines are mounted in trunnions that project from castings, forgings or built-up sections. These trunnion supports are usually suspended between two heavy frames in the fuselage or nacelle. Single jet engine aircraft have split fuselages, the split usually being located just aft of the trunnion support. The longerons at this point terminate in pick-up fittings and are braced by heavy frames. The aft end of the fuselage is usually of steel, to withstand the elevated temperatures.

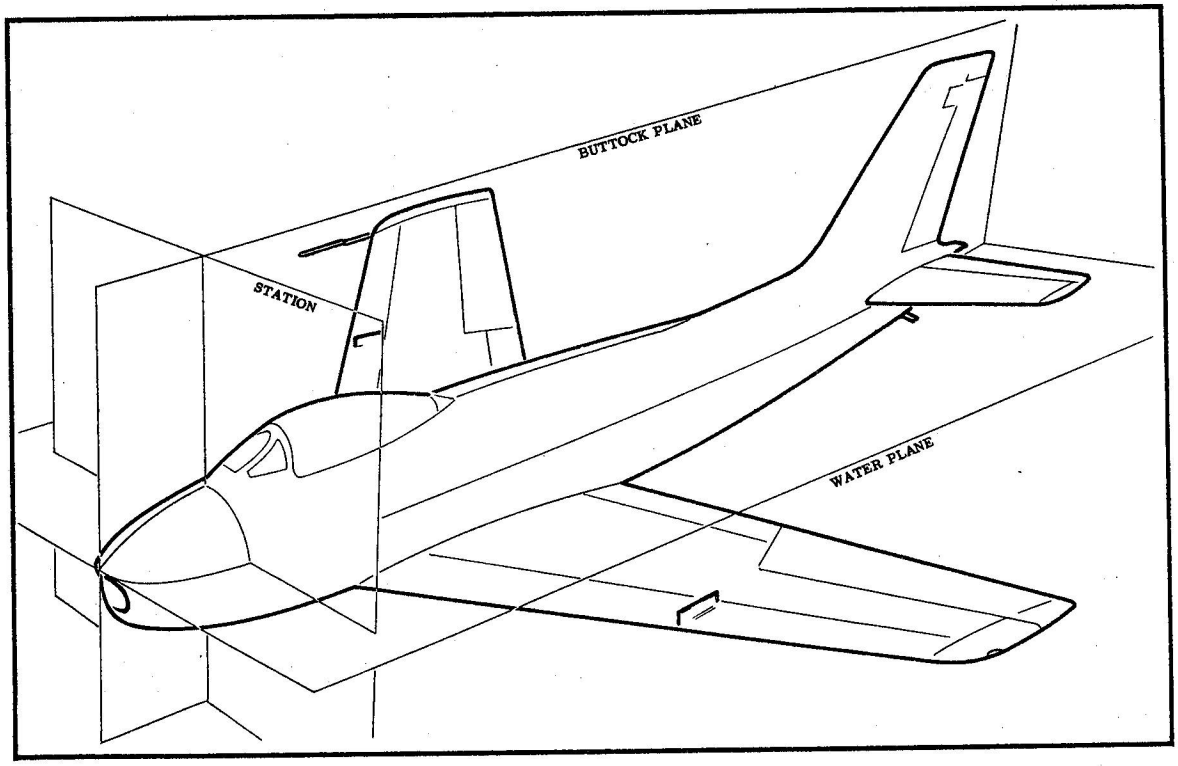

Figure 2 Aircraft Reference Planes

EMPENNAGE

13 The structure of the vertical stabilizer or fin, and of the horizontal stabilizer or tailplane, is usually similar to that of the wing. The control surfaces are frequently of monospar construction with ribs and stringers or intercostals. Covering on control surfaces is fabric or light gauge alloy. Trailing edges on later aircraft are frequently extrusions of arrowhead section.

UNDERCARRIAGE

14 The undercarriage consists mainly of shock struts, axles and wheels. The shock struts (oleo legs) and axles are usually steel or aluminum forgings; the wheel castings of magnesium or aluminum alloys.

AIRCRAFT REFERENCE PLANES

GENERAL

15 The aircraft notation system of stations, buttock planes and water planes is derived from naval architecture, see Figure 2.

16 Stations are vertical planes normal (at right angles) to the fuselage fore and aft reference line. Thus, a firewall would lie in a station plane. Buttock planes are vertical planes parallel to the fuselage reference line. A cockpit wall would lie in a buttock plane. Water planes are horizontal planes parallel to the fuselage reference line. The cockpit floor would lie in a water plane. Buttock lines and water lines may be regarded as edge views of their respective planes.

17 Zero station is frequently at the nose of an aircraft, or at the firewall in a single engine aircraft. The location varies with different designs, sometimes being placed about midway along the fuselage reference line. Buttock plane 0 and water plane 0 usually occur at the fuselage reference line, so that the line of intersection of these two planes coincides with the fuselage reference line. Specific locations are named by their distances in inches and decimals of an inch from the 0 plane. Buttock planes and lines are marked left and right, and water planes and lines located below the 0 plane are usually indicated by the minus sign.