NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, DC 20594

January 30, 1997

STRUCTURES GROUP - ENGINE STRUT SUMMARY

ACCIDENT	:	DCA96MA070
Location	:	East Moriches, New York
Date	:	July 17, 1996
Time	:	2031 Eastern Daylight Time
Airplane	:	Boeing 747-131, N93119 Operated as Trans World Airlines (TWA) Flight 800

GROUP	Name/Organization
Chairman	Deepak Joshi NTSB Washington, DC
Member	Kevin Dean FOR Boeing Commercial Airplane Group Seattle, WA
Member	Steve Green 01-29-97 Air Line Pilots Association (ALPA) Herndon, VA
Member	~~Dennis Santiago~~ CHARLES HALE 02-03-97 International Association of Machinists (IAM) JFK Intl Airport, NY
Member	Terry McKinney Trans World Airlines (TWA) Kansas City, MO
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1.0 Engine Strut

1.1 General Description

All strut, strut to wing, and strut to engine primary structure was recovered from the Green debris area. See Figure A7.20 for identification and tag numbers. The condition of each strut was first examined by the Powerplant Group and is documented in Powerplant Group Factual Report. The necessary hardware of each strut was disassembled from the engines by the Powerplant Group for engine examination. Following is the factual documentation of the strut by the Powerplant Group prior to disassembly of the strut hardware.

Strut No. 1 :- The recovered piece of the strut was the structure between the forward and aft engine mounts, with both the forward and aft engine mounts still attached. The forward engine mount had a piece of the left side of the fan case and strut. The access panels were missing from the left side.

Strut No. 2 :- The strut was separated from the engine, although it was recovered and returned with the engine. The right side of the pylon had crushing damage with the skin pushed inward between the internal structure. The skin on the lower left side of the strut was bent outward and the access panels on the left side were missing.

Strut No. 3 :- The strut remained attached to the engine, extending just aft of the fan struts to in line with the turbine exhaust case engine mount rails on the left side and two rib bays further aft on the right side and bottom. The nose section of the strut was missing with the upper skin on the strut bent upwards and to the rear. The lower stringers of the strut were bent towards the right. The bottom of the strut over the engine mount was buckled upwards and the adjacent skin on the right side was buckled inwards. The access panels on the left side of the strut were missing.

Strut No. 4 :- The strut was crushed on the right side and buckled inward on the center of the left side. The engine mount remained attached to the strut. The front of the strut was crushed axially aft about 5 inches. The access panels were missing.

The Structure Group documented all the strut, strut to wing and strut to engine primary structure after the disassembly of strut hardware by Powerplant Group.

1.2 Strut No. 1

The No. 1 strut suffered severe impact damage with separation of the aft section from the wing. Damage occurred to the strut aft box structure from the rear engine bulkhead, nacelle station (NS) 222, to the aft torque bulkhead NS 269, (Fig.A7.2). The upper link, strut upper spar fitting fractured at the forward fuse pin connection and exhibited tensile rupture

(Fig. A7.3). Separation of the midspar to wing attachment occurred through both the inboard and outboard midspar primary chord sections common to each midspar fitting. Fracture of each chord initiated at the forward most row of fasteners of the midspar fitting horizontal duckbill flange. The fracture surface exhibited tension failure with slight bending. Both fracture exhibited ductile failure mode. The midspar structure assembly was sooted but free of fire damage except for a remnant of the aft torque bulkhead web, that remained attached (Fig. A7.3 and A7.18).

The diagonal brace strut lower spar fitting fractured at the aft lug attachment and exhibited twisting and bending in an outboard direction (Fig. A7.3). The diagonal brace sustained impact damage to the center of the brace with localized crushing of the tube wall (Fig. A7.3). There was evidence of sooting along the aft length of the brace. Fuse pins were intact at each end of the diagonal brace including the underwing diagonal brace fitting which remained attached (Fig. A7.5).

The engine separated from the strut at the front and rear engine mount as a result of rupture of the fan case frame and the turbine exhaust case ring, respectively (Fig. A7.4), (Refer to Power Plant Group Chairman's Factual Report). Both strut bulkheads and their respective mount attachment suffered no impact damage. The remaining strut structure suffered no impact damaged except for the aft torque box section (Fig. A7.2).

Wing to strut fitting attachment

Both midspar underwing fittings (Fig. A7.3, A7.18) remained attached to the lower skin and suffered no impact damage. Some minor sooting was found. Both the midspar fittings remained engaged with their respective fuse pins (Fig. A7.5). The wing diagonal brace fitting and wing box internal support fitting separated as one unit from the wing (Fig. A7.3). Both support fittings sustained impact damage. The outboard underwing vertical support fittings had separated in the forward direction with the front spar web, although both units still remained fully attached to the underwing fitting with the fuse pin assembly intact (Fig. A7.5). Both the primary bolts remained intact (Fig. A7.18). The upper link remained attached to a section of front spar by the upper link fitting. Both the link and the fitting sustained slight damage and deformation including lateral inboard bending of the link. Fuse pins remained engaged at each end of the link assembly and suffered no impact damaged (Fig. A7.3). The side brace attachment fitting was fractured and bent at the wing lower skin (Fig. A7.2).

1.3 Strut No. 2

All wing to strut, strut to engine, and strut structure was recovered. There was evidence of impact damage to the upper link and upper spar fitting. The impact forces were predominantly in an up and outboard direction which exhibited rupture of the upper link and strut upper spar fitting through lateral bending and compression fractures (Fig. A7.7). The

corresponding structural disconnect ruptured the upper spar, rear engine mount bulkhead, and midspar web (Fig. A7.8). Primary separation of the midspar chords initiated at the 12th and 1st row of fasteners ahead of the inboard and outboard midspar fitting duckbill flanges, respectively (Fig. A7.7, Fig. A7.18). The midspar chords exhibited bending in an outboard direction. The lower spar, from nacelle Station 227 rear engine bulkhead, to the aft torque bulkhead exhibited severe impact damage, with separation of the strut lower spar fitting (Fig. A7.6). The lower spar fitting remained attached to the diagonal brace which ruptured at the clevis end common to the wing fitting (Fig. A7.7). Fracture of the diagonal brace also occurred approximately 35" forward of the aft fuse pin exhibiting bending and twisting (Fig. A7.7).

The forward section of the strut box ruptured at approximately NS 142 forward to the forward bulkhead which separated and remained attached to the fan case frame (Fig. A7.7, A7.6). The side brace lug fractured in bending and tension at the wing side attachment (Fig. A7.6). A section of the rear engine mount bulkhead structure remained attached to the turbine exhaust case (Fig. A7.8). Forward and rear engine mount assemblies remained fully intact with no impact damage.

Wing to strut attachment fittings

The inboard midspar underwing support fitting remained attached to the wing box lower skin (Fig. A7.7). There was evidence of some damage at the forward section of the fitting with slight lateral deformation along the longitudinal free flange. The fitting remained intact with the midspar duckbill fitting and the fuse pin assembly (Fig. A7.9). The midspar fitting exhibited no evidence of damage. A large section of the outboard midspar underwing fitting separated (Fig. A7.18) from the wing lower skin. The outboard half of the fitting included a section of the inboard leg. The remaining inboard section remained attached to the wing box skin. The bulk of the fitting disconnected from the wing box skin with the front spar fitting and the fuse bolt that still remained engaged. The fitting separated along the attaching fasteners of the lower skin with fracture separation outboard, some sooting was also present along the forward face of the fitting. The wing diagonal brace fitting was found attached to the lower wing skin with the forward 12 inches fractured and separated with the wing skin due to impact (Fig. A7. 7). A 4-inch outboard section of the diagonal brace clevis lug remained attached with the aft fuse pin still engaged (Fig. A7.7). The recovered upper link fitting had separated from the front spar web (Fig. A7.7). Both fitting and upper link remained secured by the fuse pin and were extensively damaged. The fuse pin exhibited no impact damage.

1.4 Strut No. 3

All wing to strut, strut to engine, and strut structure was recovered. Both the strut midspar fittings remained attached to the wing box underwing fitting with both fuse pins

engaged (fig A7.11). The inboard midspar fitting was undamaged and remained attached to the midspar chord section that had fractured approximately 20 inches forward of the midspar duckbill fitting flanges exhibiting tension and bending in an up and outboard direction (Fig. A7.19). The strut upper spar fitting (upper link) separated at the net section of the lug in tension (A7.11). Both fuse pins remained engaged at each end of the upper link (Fig. A7.13). The aft end remained intact to the upper link fitting with both fittings being deformed/damaged in an outboard direction (Fig. A7.11).

The outboard midspar fitting engaged the midspar primary chord with all attachment fasteners fully in place. The aft vertical flange common to the aft torque bulkhead vertical chord had separated completely from the midspar fitting at the stem radius and was bent aft. At approximately 50 inches forward, of the midspar duckbill flanges, the midspar chord separated in bending and tension with noticeable indications of outboard direction (Fig. A7.19). The strut aft torque box section (NS222 to NS301) exhibited evidence of severe impact damage with full separation of the inboard side skin from the aft torque bulkhead to the rear engine bulkhead. The outboard side skin from NS 236 to the aft torque bulkhead had also separated from the structure. The impact damage in this area exhibited, tearing, and general crushing of the structure (Fig. A7.10). The midspar web was also severely damaged (Fig. A7.12). The diagonal brace was recovered with both the strut lower spar fitting and the wing diagonal brace fitting attached with their respective fuse pins. All three units were damaged (Fig. A7.11). The strut lower spar fitting was extensively damaged with the aft attachment flange warped and cracked (Fig. A7.11). The diagonal brace suffered impact damage and exhibited extensive cracking along the longitudinal direction initiating from each clevis throat radius. The diagonal brace exhibited twisting and bending laterally in the area of damage (Fig. A7.11).

A 20-inch section of the forward strut box, from NS 148 forward to the forward engine bulkhead (NS128) suffered impact damage with full separation of the front engine mount bulkhead (Fig. A7.10). The mount attachment was recovered and remained attached to the fan case frame. Except for the bulkhead skin attachment structure, the bulkhead face and engine mount assembly, including the cone bolt attaching members, remained intact (Fig. A7.12). The strut was recovered and remained attached to the engine turbine exhaust case. The rear engine bulkhead and lower engine attachment were relatively undamaged.

Wing to strut attachment fittings

The strut No. 3 inboard midspar underwing fitting were recovered and remained attached to the wing box lower skin. This fitting exhibited minor damage with some localized nicks and gouges to the longitudinal flanges just aft of the fuse pin housing boss. The damage is indicative of the strut midspar fitting clevis contact during spring back when the midspar chord fractured (Fig. A7.19). The outboard midspar underwing fitting partially separated along the longitudinal parting plane in an outboard direction (Fig. A7.11), with the forward section of the joint separating from the front spar with the vertical support fittings.

A 2-foot section of the inboard leg of the fitting remained in place on the wing skin. The separated forward joint still engaged the damaged strut midspar fitting and fuse pin assembly. The diagonal brace underwing fitting separated with the diagonal brace as a combined unit (Fig. A7.11). The diagonal brace underwing fitting suffered damage. The outboard flange fracture and separation with nicks and gouges to the vertical flange and is consistent with diagonal brace clevis necking (Fig. A7.11). The upper link fitting separated from the front spar in an outboard direction with a 2-foot section of wing front spar web remained attached. Both lower skin shear were ties fractured and the fitting upper flange to skin fasteners separated in tension. Each leg of the fitting sustained minor deformation. Both fitting halves were secured with the fuse pin assembly which remained undamaged. The forward fuse pin remained engaged at the forward end of the upper link (Fig. A7.13). The side strut brace member fractured in bending in the aft direction at the wing attachment fitting (Fig. A7.10).

1.5 Strut No. 4

All wing to strut, strut to engine, and strut structure was recovered The inboard midspar fitting was intact and remained attached to the wing box underwing fitting, with the midspar fuse pin engaged. The inboard support at the inboard midspar fitting position separated just ahead of the midspar duckbill flanges at the strut midspar chord, (approximately 15 inches forward of the inboard fuse pin). The fracture exhibited tension failure and the chord was bent (Fig. A7.19). The upper spar fitting lug fractured and separated from the upper link connection at the forward joint (Fig. A7.15). The fracture surface exhibited tension/ductile failure. The link with both fuse pin assemblies remained attached to the upper link pitch fitting at the front spar (Fig. A7.17).

The outboard midspar fitting remained attached to the wing box underwing fitting with the fuse pin engaged. The midspar fitting duckbill flanges had fractured along the 4th row of the fasteners of the upper flange from the fuse pin, and the lower flange had separated completely at the most aft juncture (Fig. A7.19). Both flanges had indications of downward and inboard bending and twisting.

Fracture of the torque bulkhead chord, common to the vertical stem of the duckbill fitting, occurred at a section 16 inches below the fitting stem (Fig. A7.19). The aft torque bulkhead structure was not recovered except some remnants of chord attached to the lower spar fitting and midspar fittings. The diagonal brace separated at the wing diagonal brace fitting at approximately 12 inches forward of the fuse pin attachment. The 12" diagonal brace fragment remained attached to the wing fitting with the pin assembly. Fracture of the basic tube section is indicative of bending and twisting action (brace being forced in the aft direction against the flanges of the wing fitting) (Fig. A7.15). The majority of the diagonal brace remained with the strut and engine case.

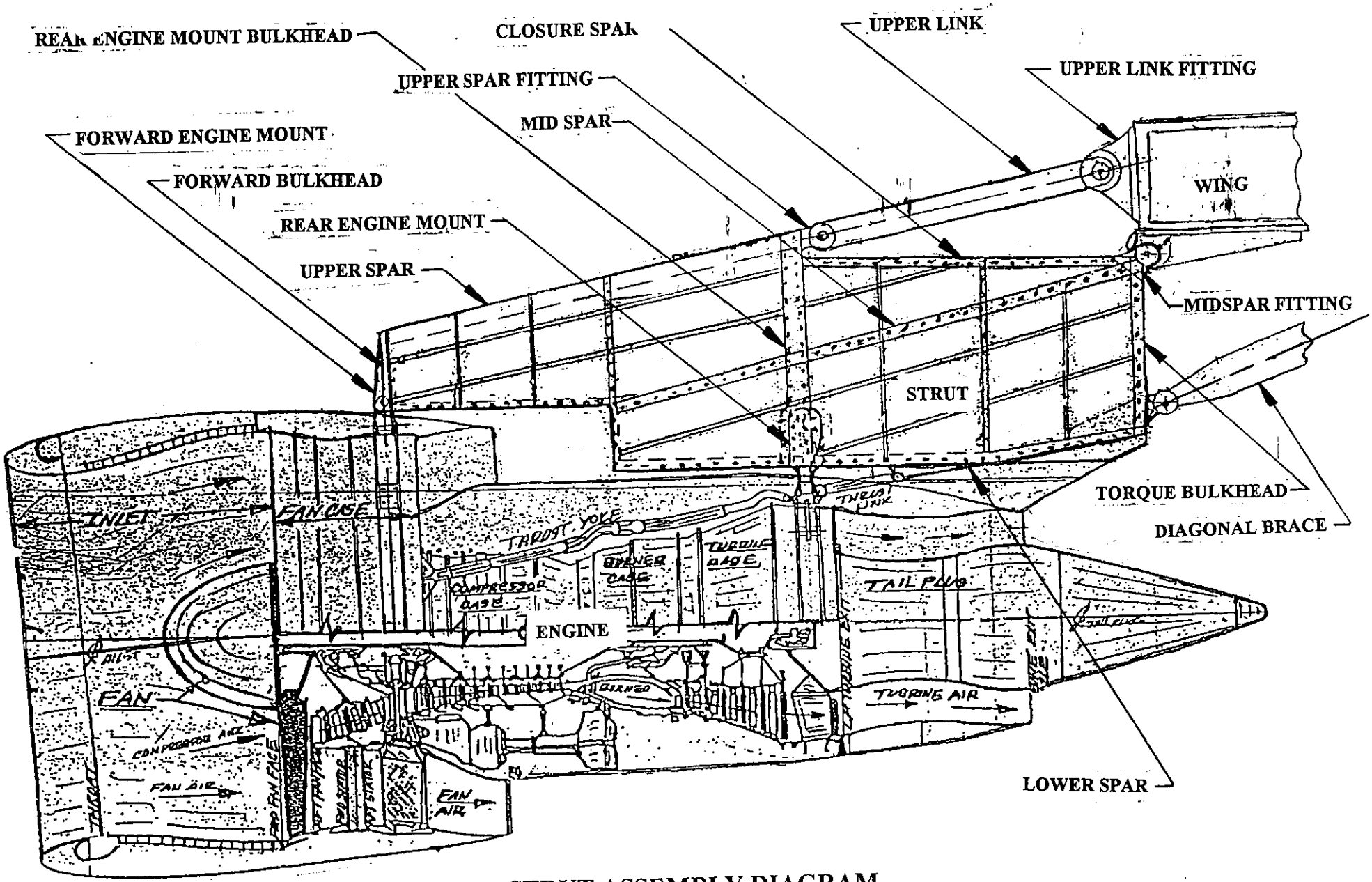
The diagonal brace, lower spar fitting, thrust link, and rear engine block fitting suffered severe impact damage. All these four units remained in place attached to the turbine case assembly (fig. A7.16). Both sides of the strut side skin suffered extensive damage with the outboard section missing from the aft torque bulkhead forward to NS 193. The rear engine bulkhead (NS 222) was extensively damaged including the upper spar and upper forward nose skin (upper spar) with the outboard skin peeled back in an outboard direction (fig. A7.14). The inboard side skin separated from NS 236 to NS 269, and this section was not recovered. The remainder of the side skin was heavily crushed with the forward bulkhead pushed aft, approximately 5 inches along the forward firewall web (Fig. A7.14).

The forward engine mount was intact and remained attached to the damaged forward bulkhead. Both tangential links were in place at the rear engine mount and turbine exhaust case. The right tangential link was deformed aft (Fig. A7.16).

Wing to strut attachment fittings

The strut underwing fitting at each location, including the upper link fitting, was found in place with the wing box and suffered minor damage. The outboard strut underwing fitting exhibited extensive inboard bending deformation of the fuse pin attachment lugs. All fittings sustained witness marks and gouge marks to the flange on the aft side of the fuse pin boss from contact during the aft rotation of the midspar fitting clevis. Fuse pins remained engaged at each joint and exhibited no damage (Fig. A7.15, A7.19). The upper link was intact and remained attached to the wing box front spar fitting (upper link fitting). The upper link sustained localized flange bending damage on each side of the inboard and outboard free flange. Both the fuse pins remained engaged (Fig. A7.17). The side brace support tube separated at the wing lower skin attachment fitting and was bent in aft direction.

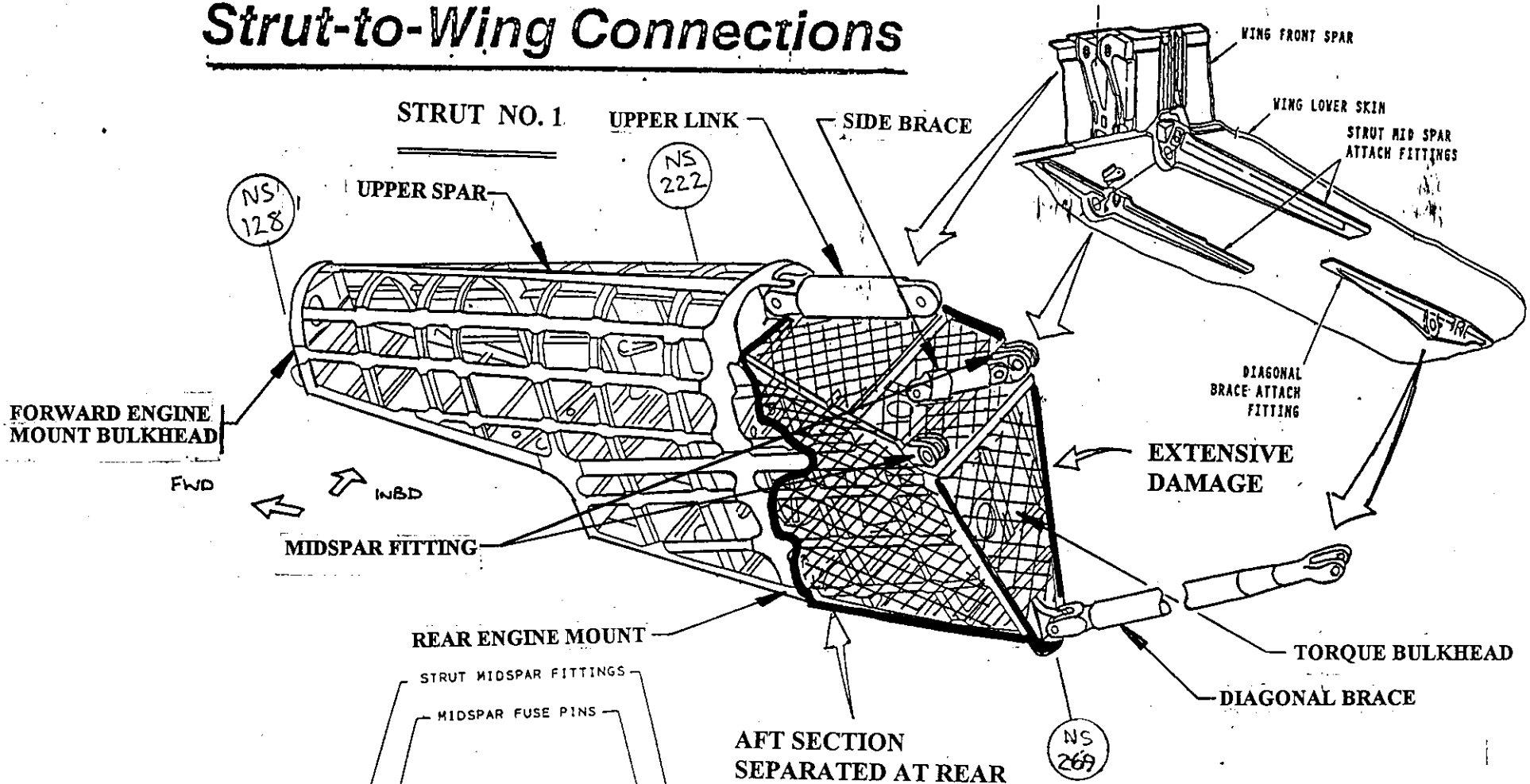
All strut related fracture surfaces (available for examination) were visually examined in detail and exhibited ductile failures.

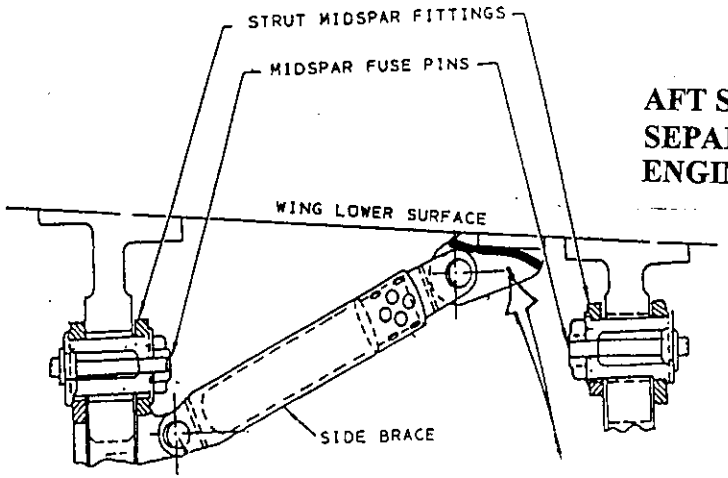


STRUT ASSEMBLY DIAGRAM

A7.1

Strut-to-Wing Connections

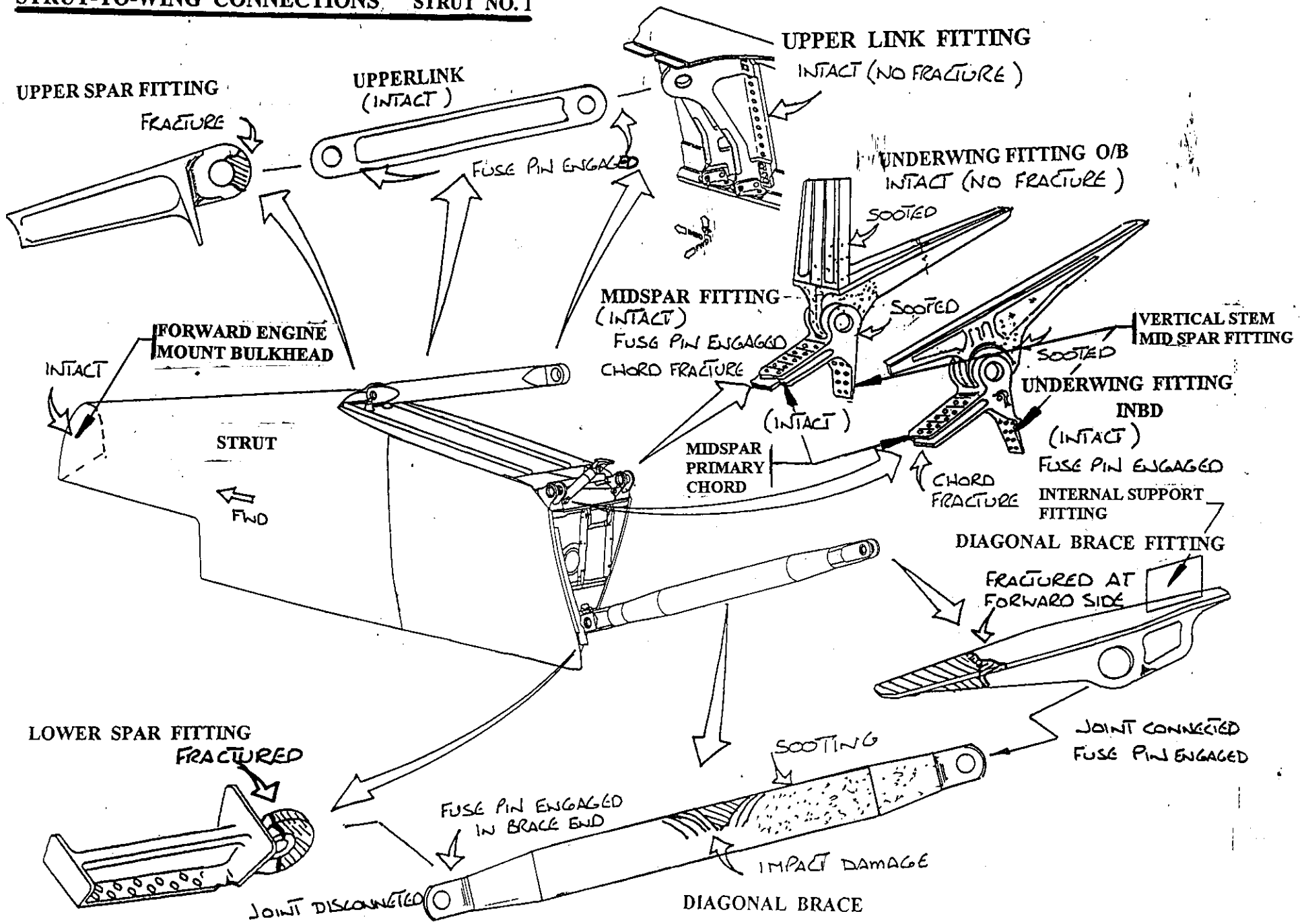




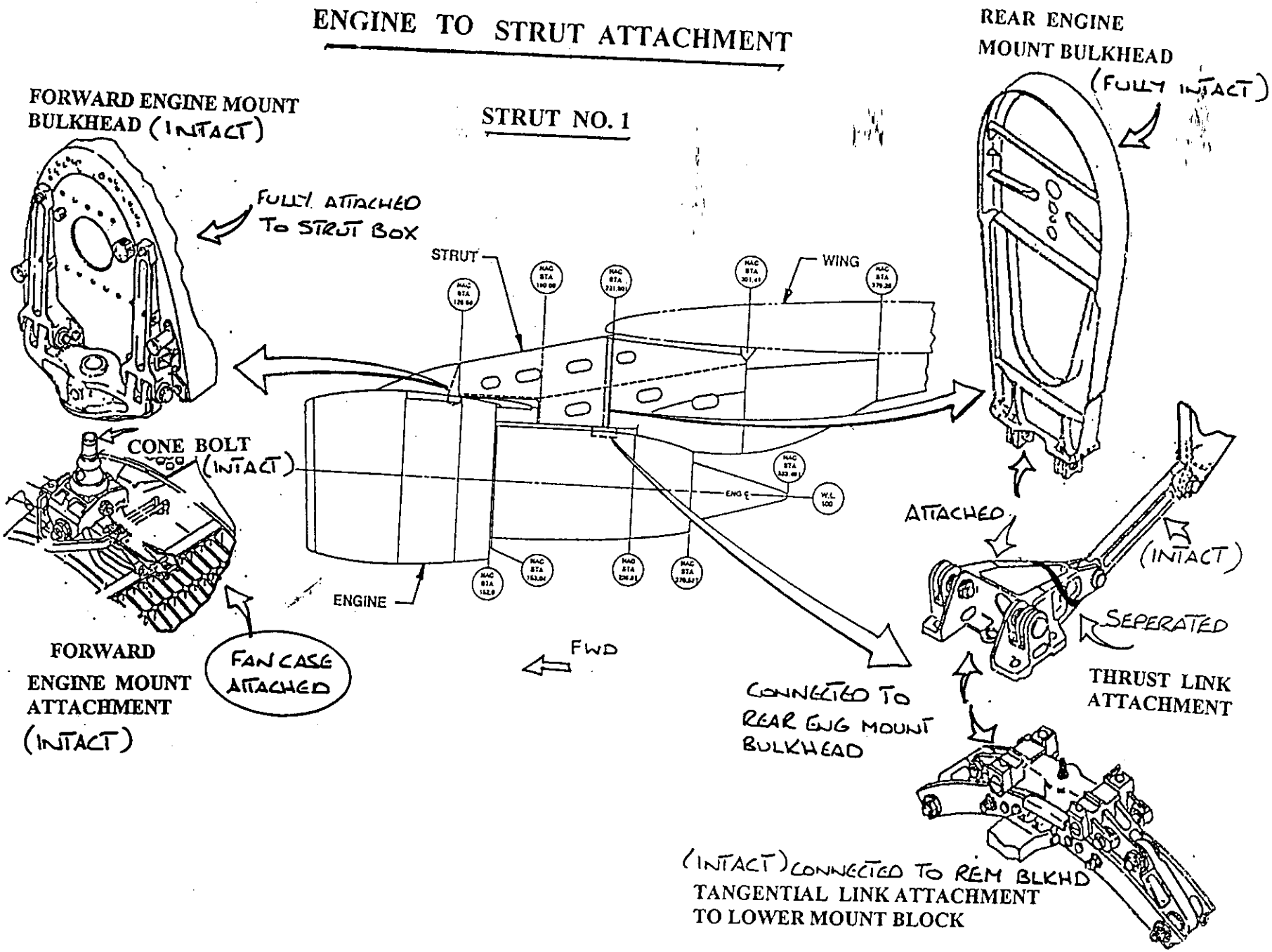
3rd Generation" Fuse Pins

SIDE BRACE ATTACHMENT SEPARATED AT WING CONNECT (DUCTILE FRACTURE)

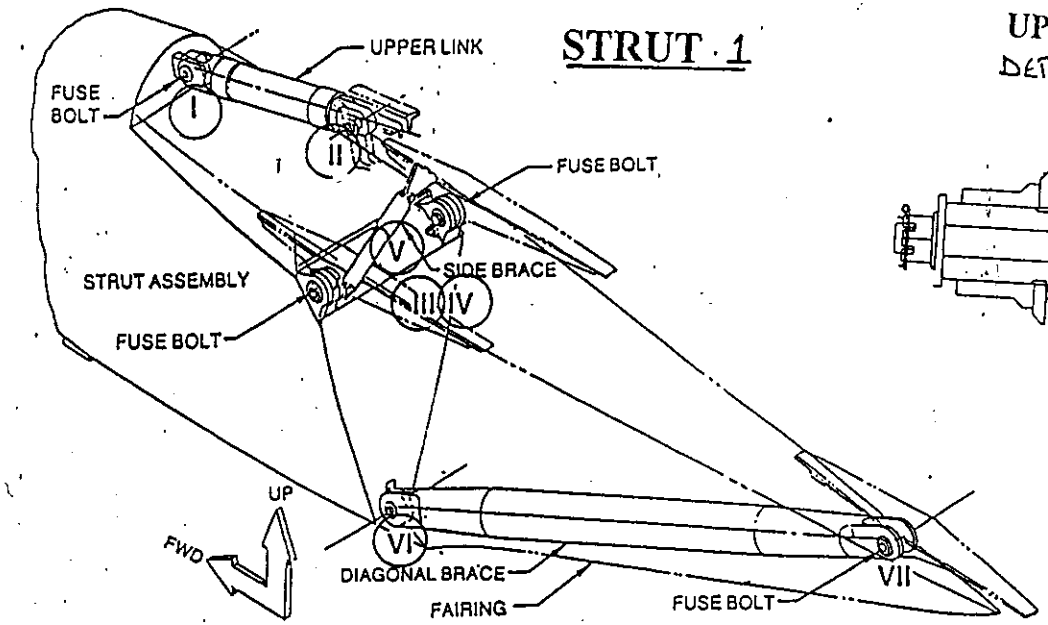
STRUT-TO-WING CONNECTIONS STRUT NO. 1

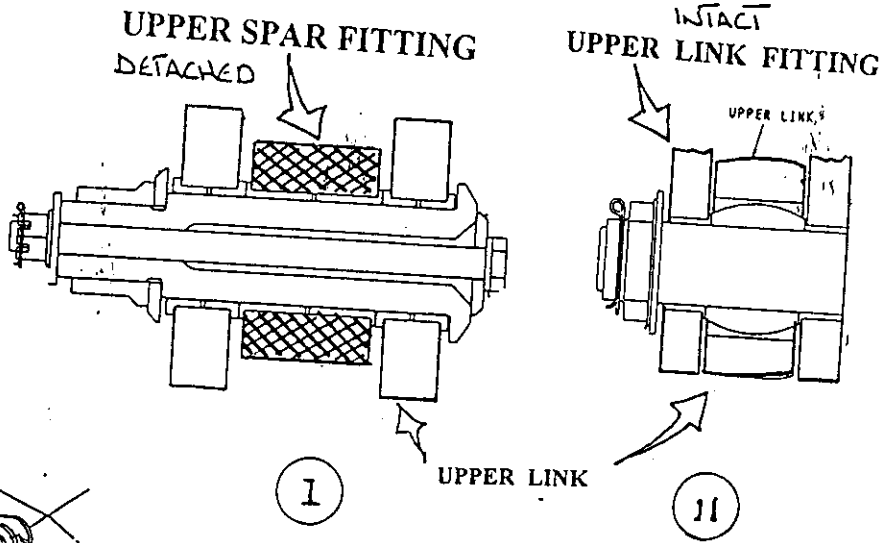


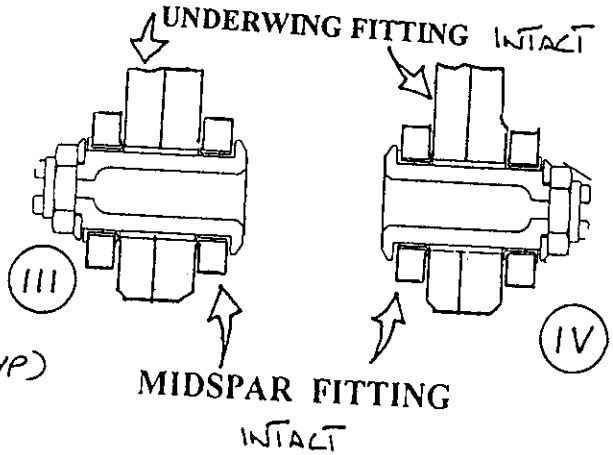
ENGINE TO STRUT ATTACHMENT

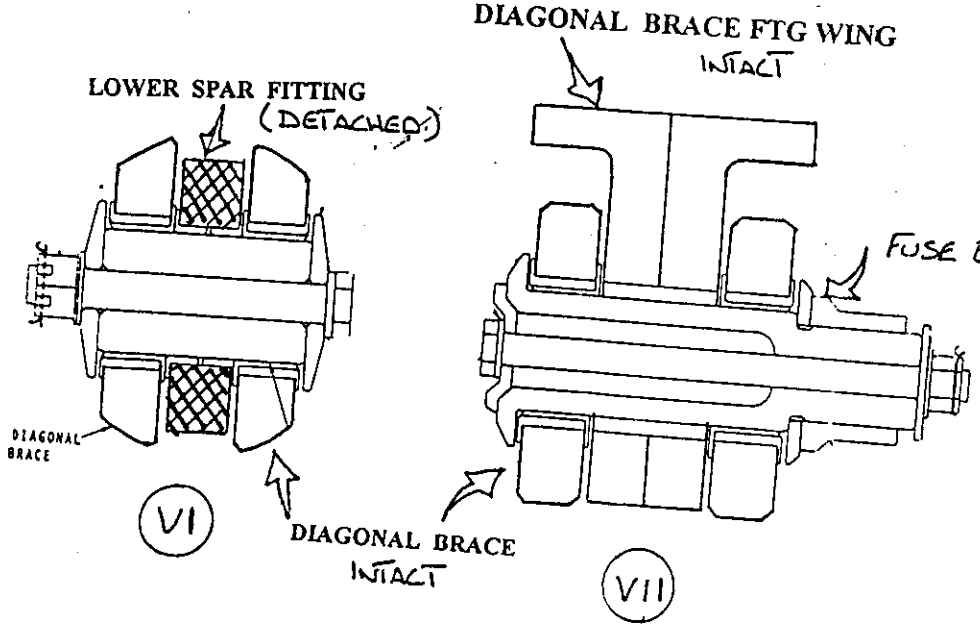


Strut-to-Wing Connections FUSE BOLT









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STRUT - TO - WING CONNECTIONS

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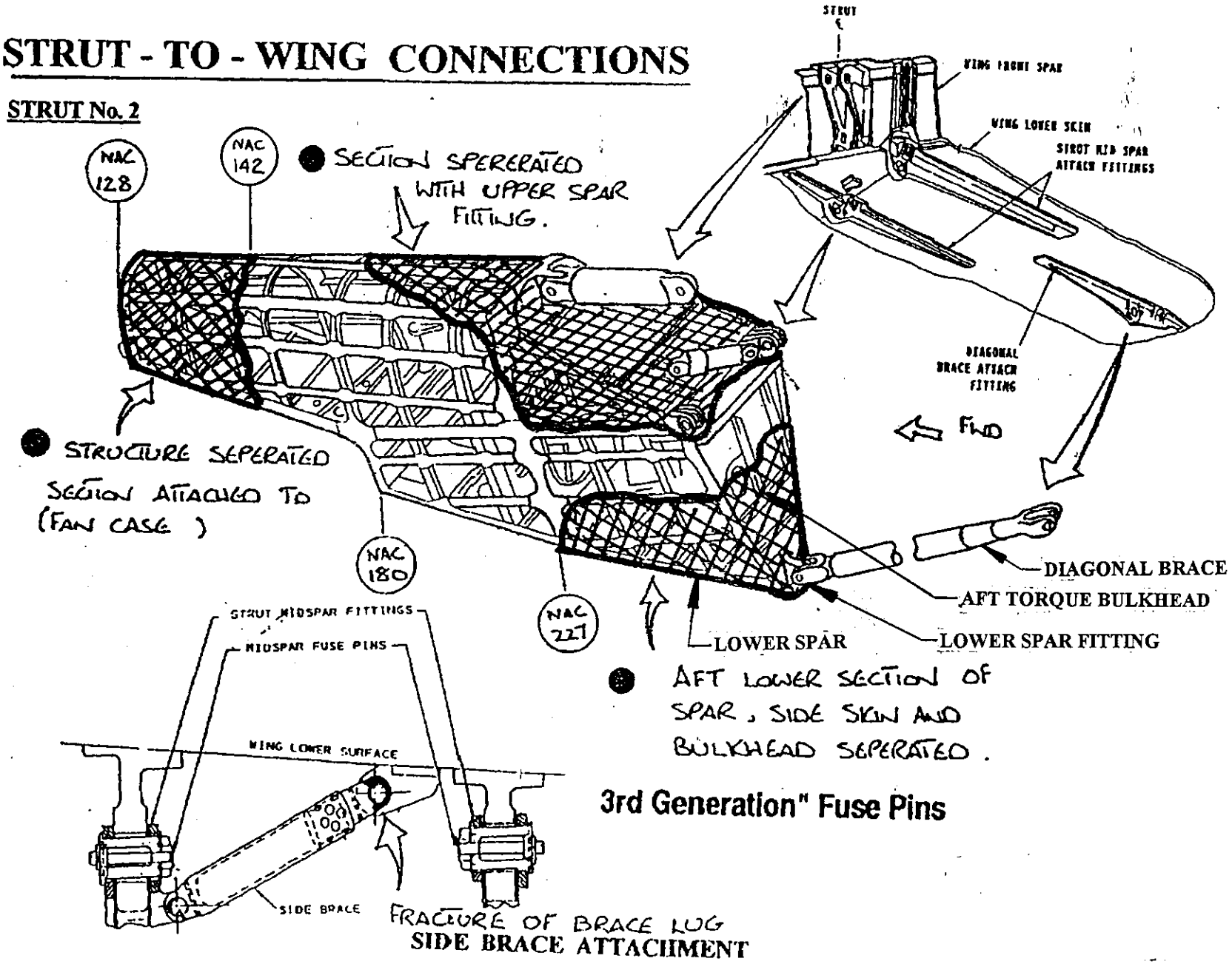

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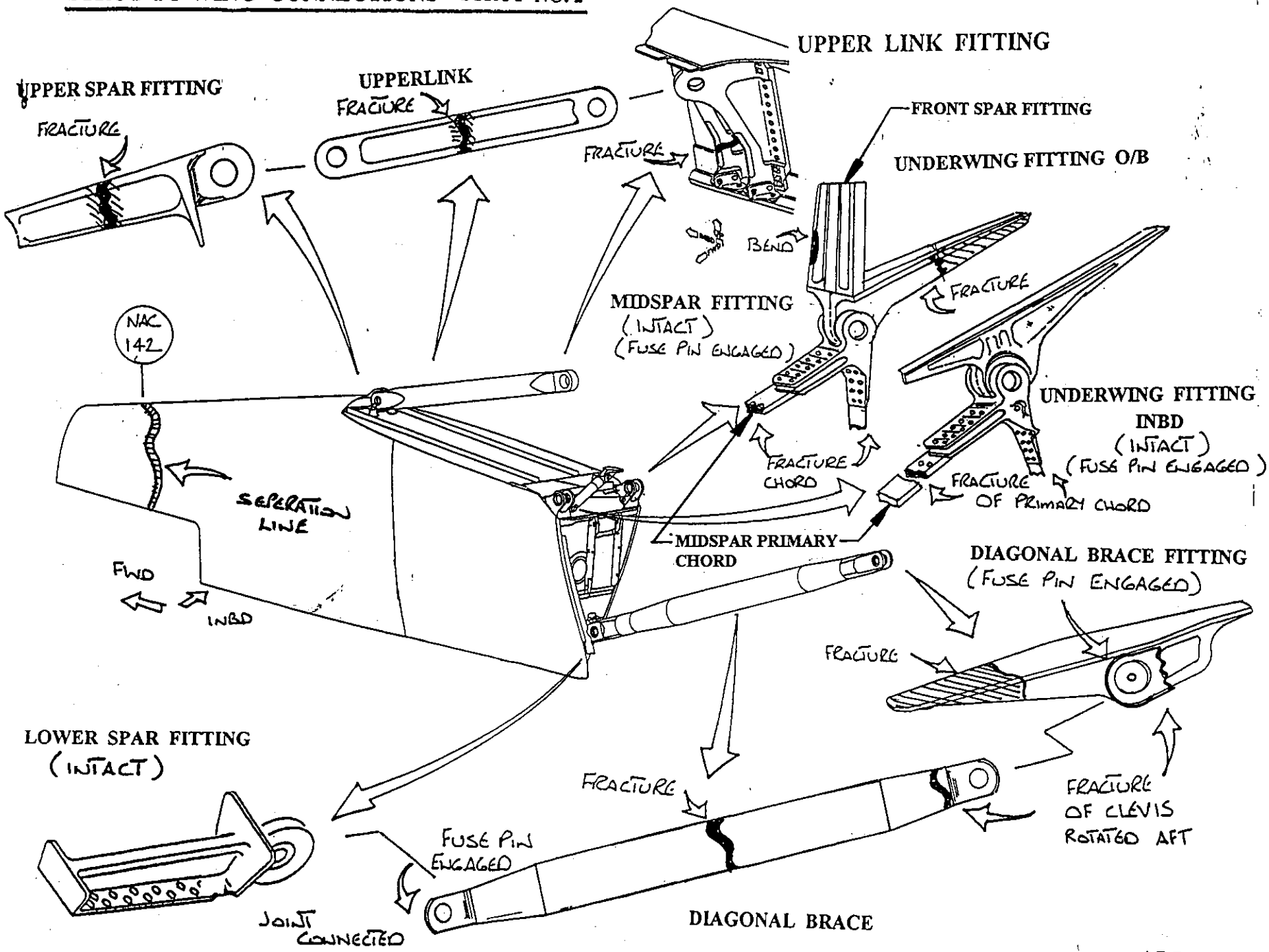
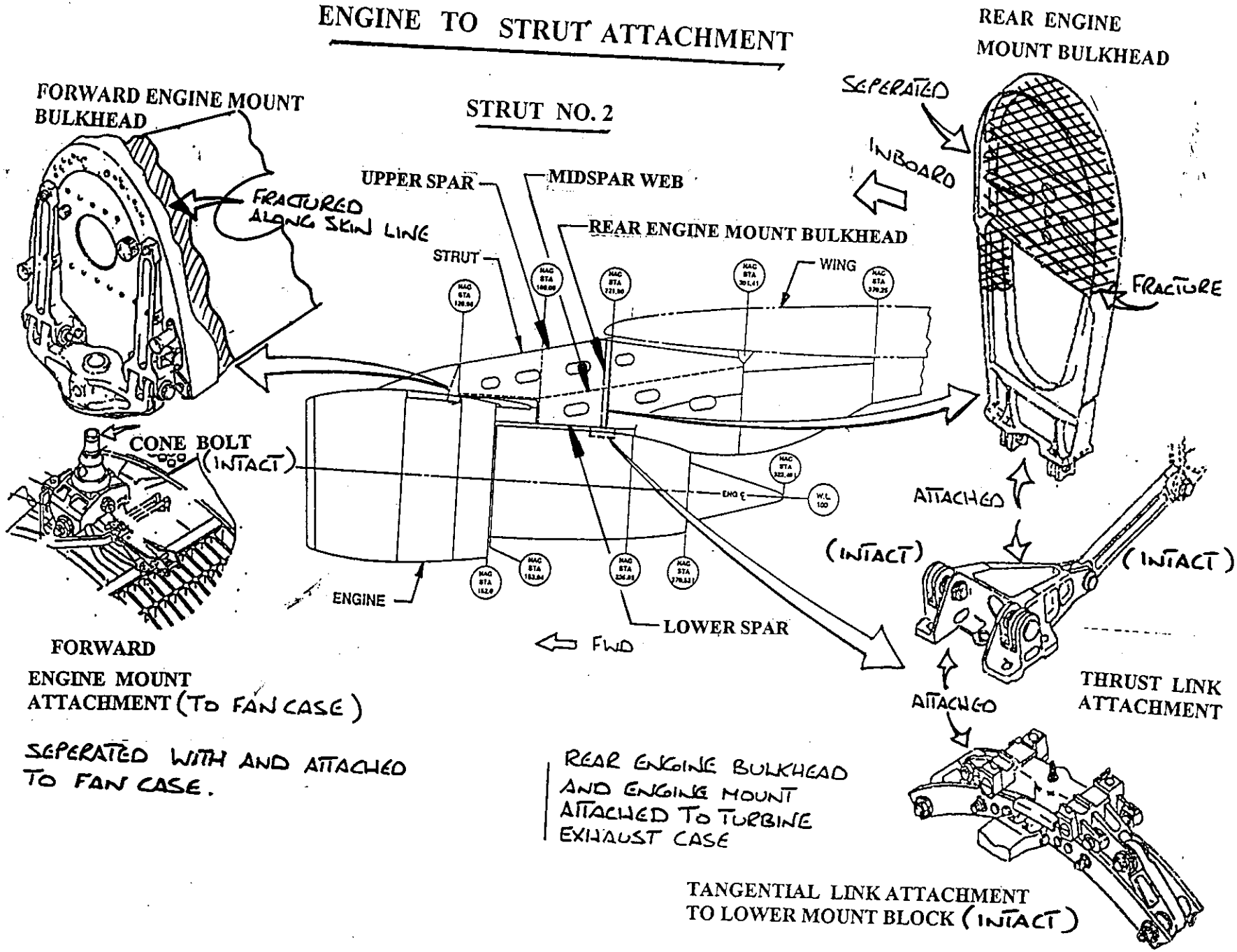
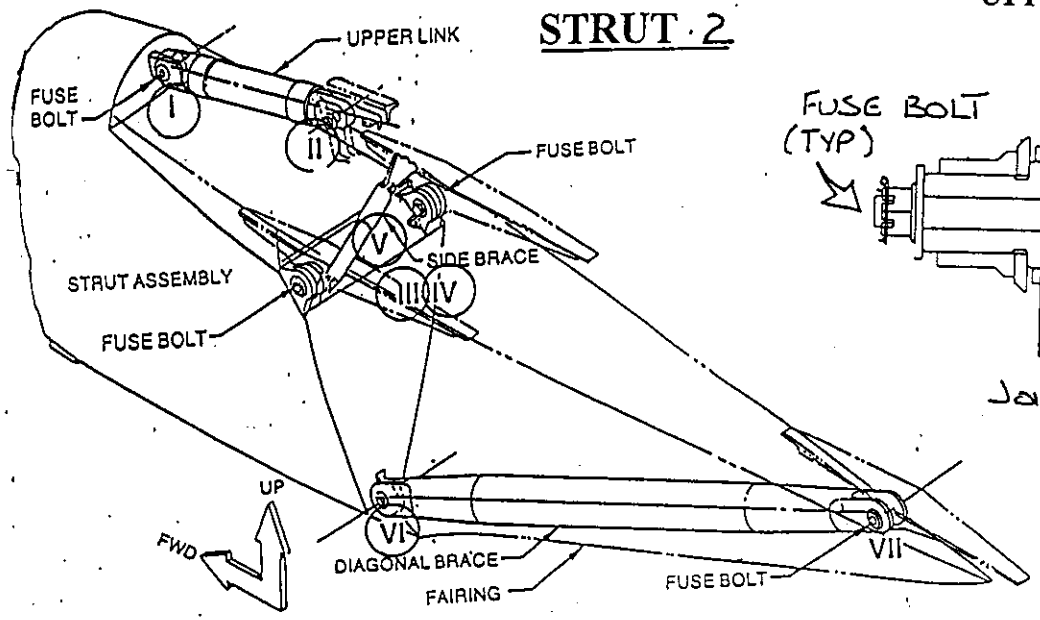
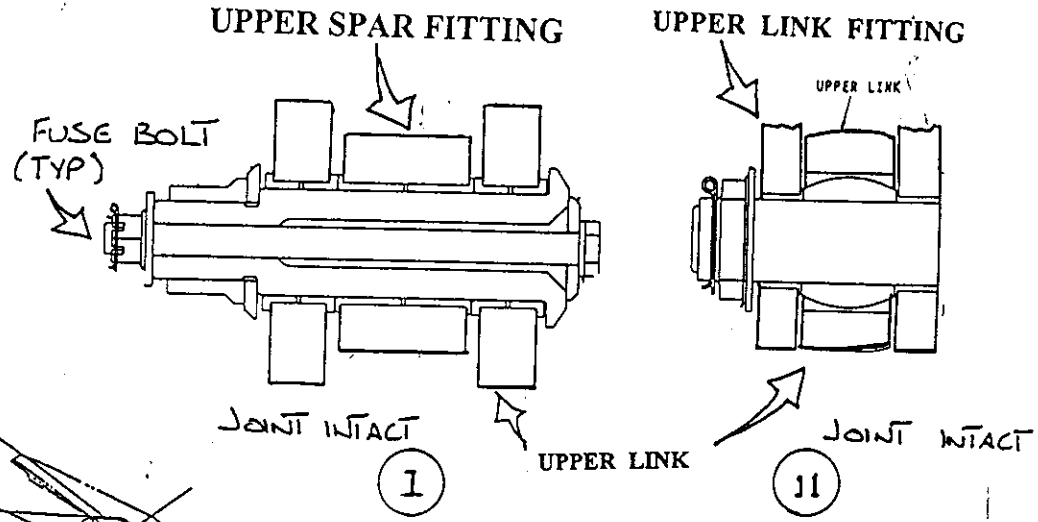


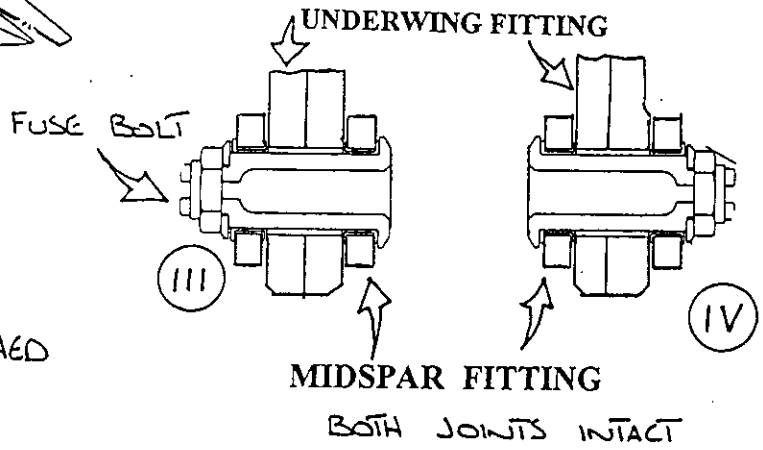
ENGINE TO STRUT ATTACHMENT

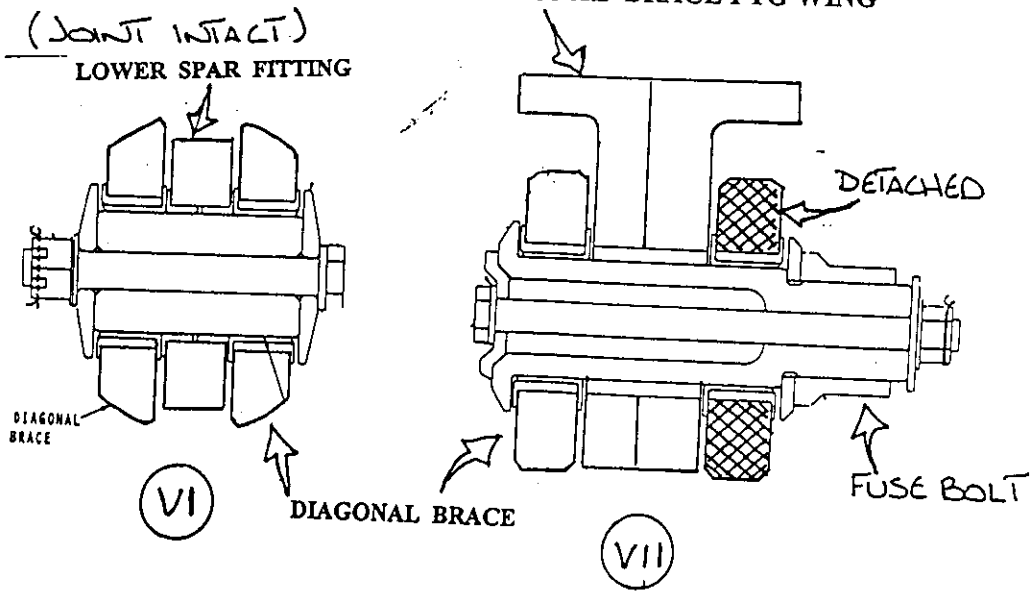


Strut-to-Wing Connections FUSE BOLTS







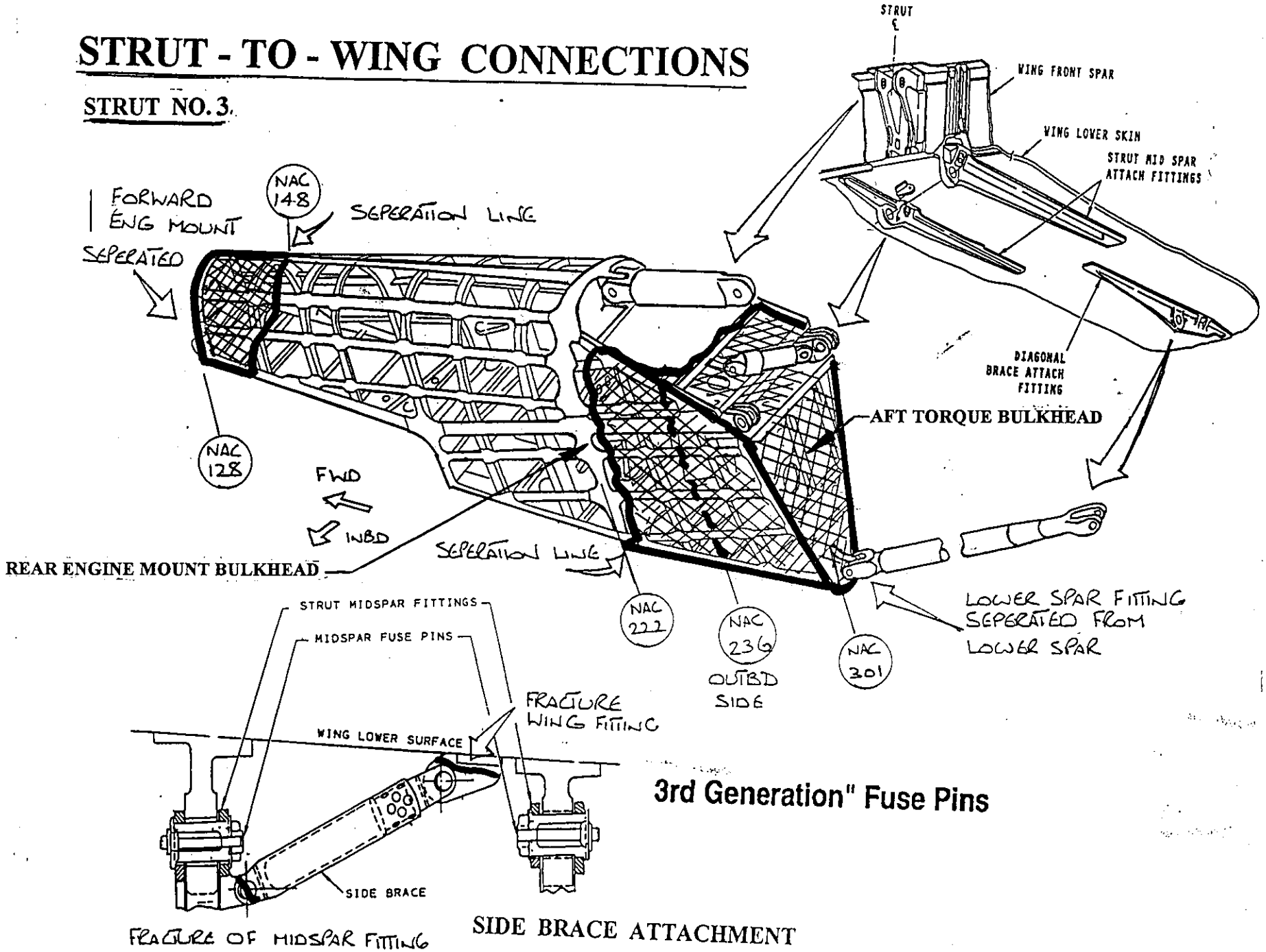


ATTACHED TO FUSE BOLT

DETACHED FROM FUSE BOLT

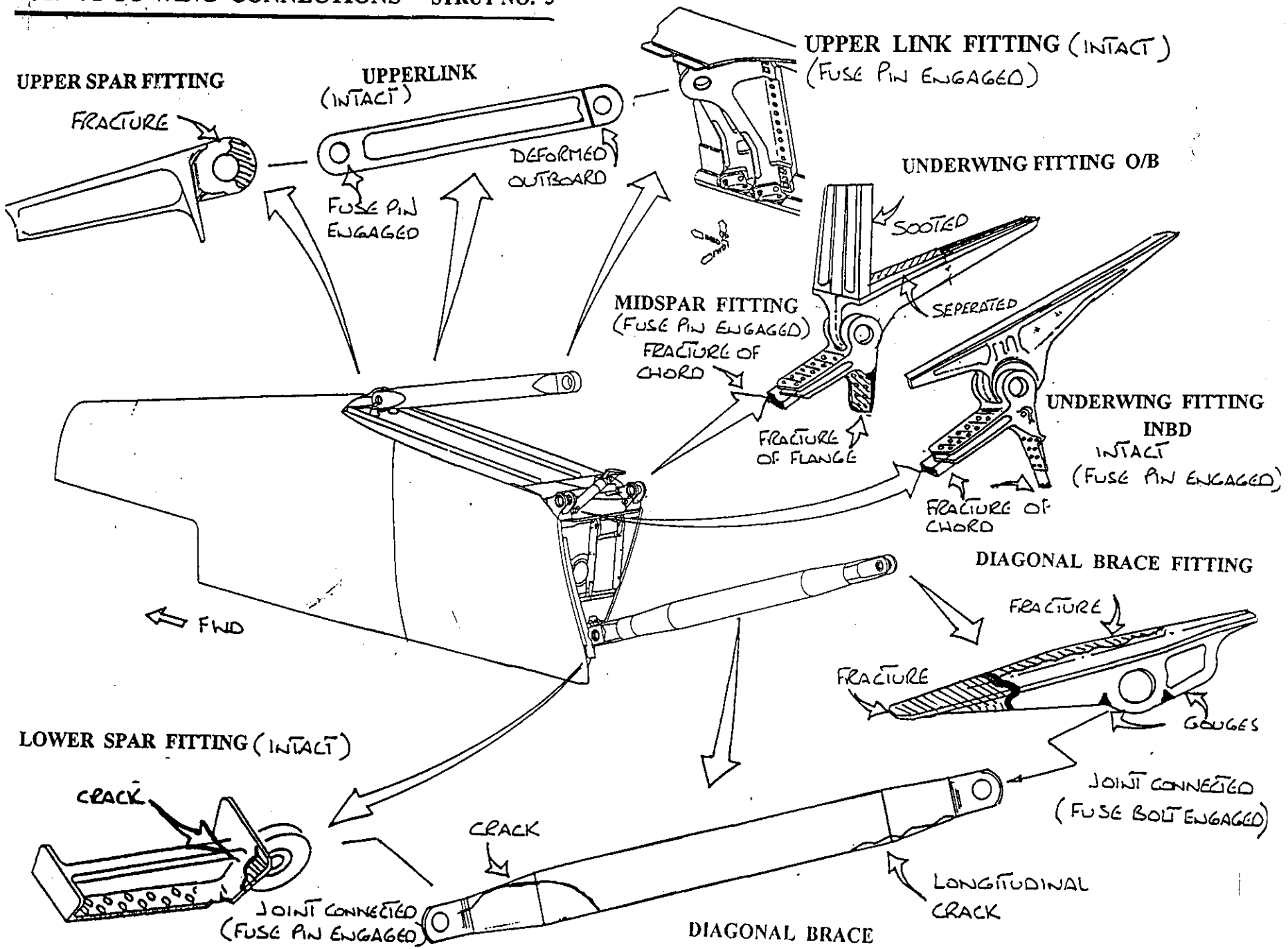
STRUT - TO - WING CONNECTIONS

STRUT NO. 3.

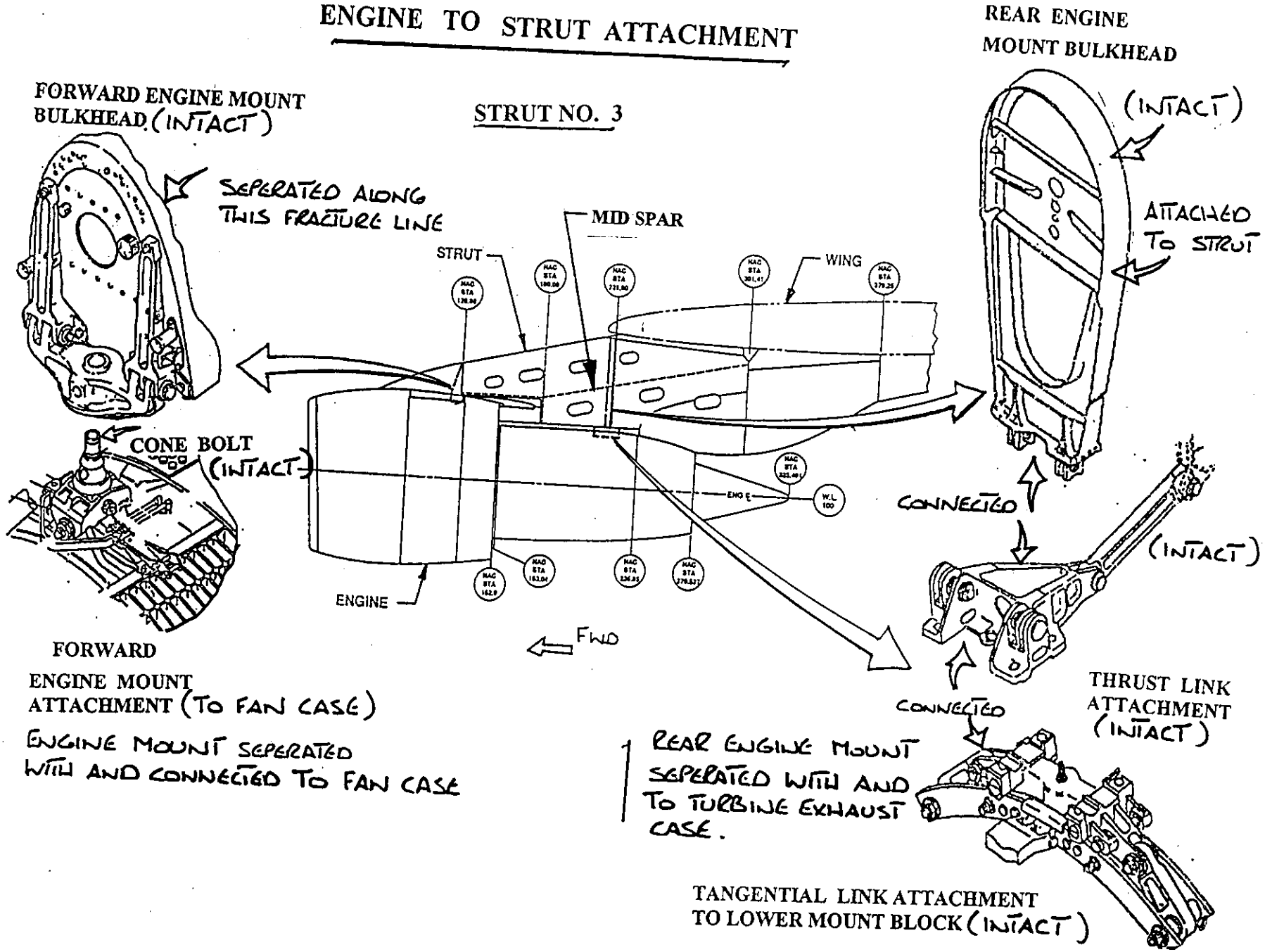


3rd Generation" Fuse Pins

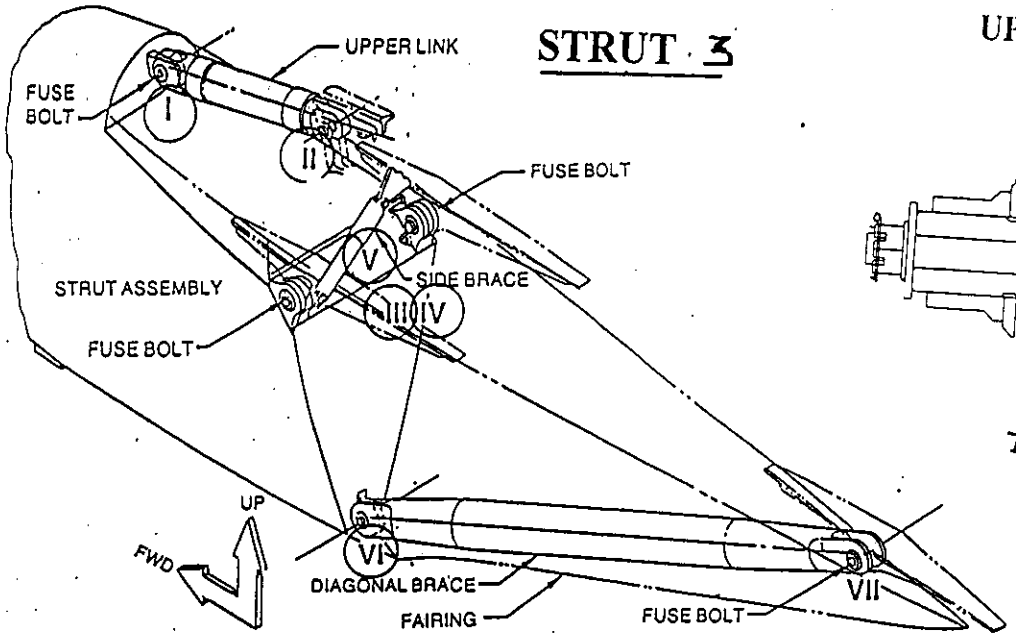
S1 T-TO-WING CONNECTIONS STRUT NO. 3

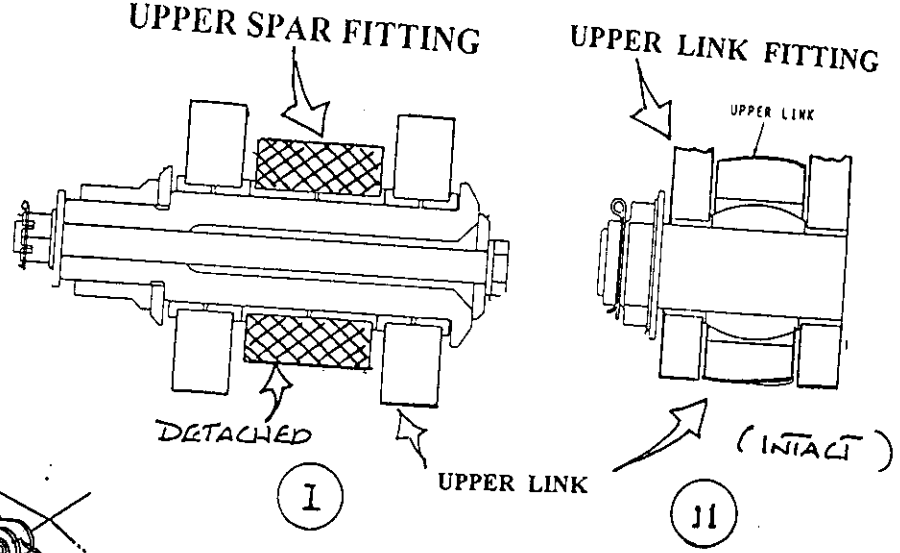


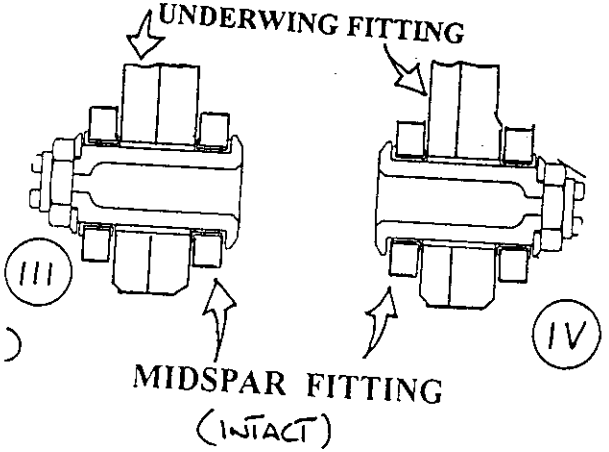
ENGINE TO STRUT ATTACHMENT

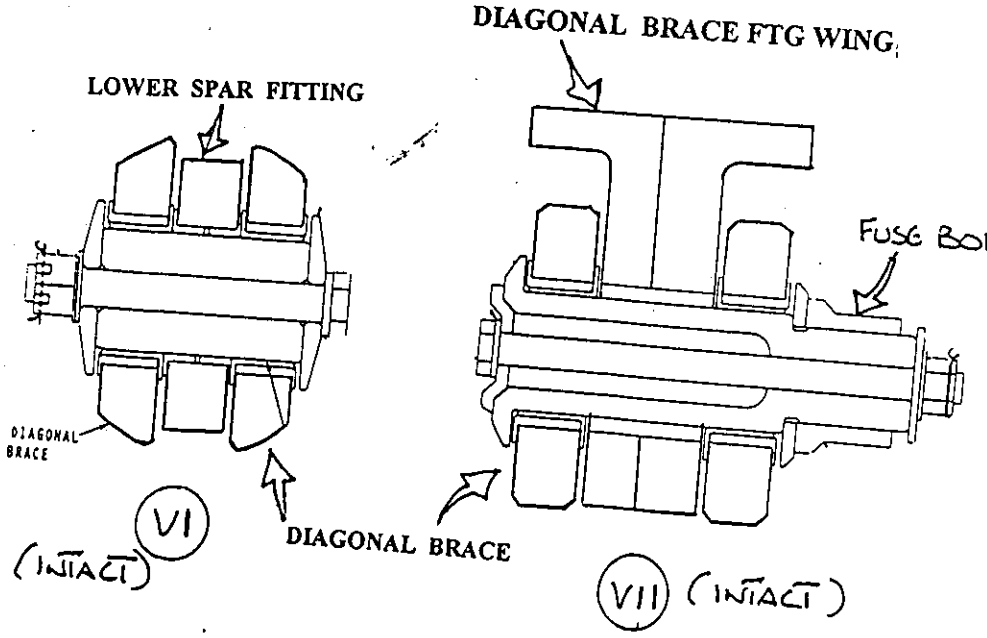


Strut-to-Wing Connections FU_ _ BOLTS







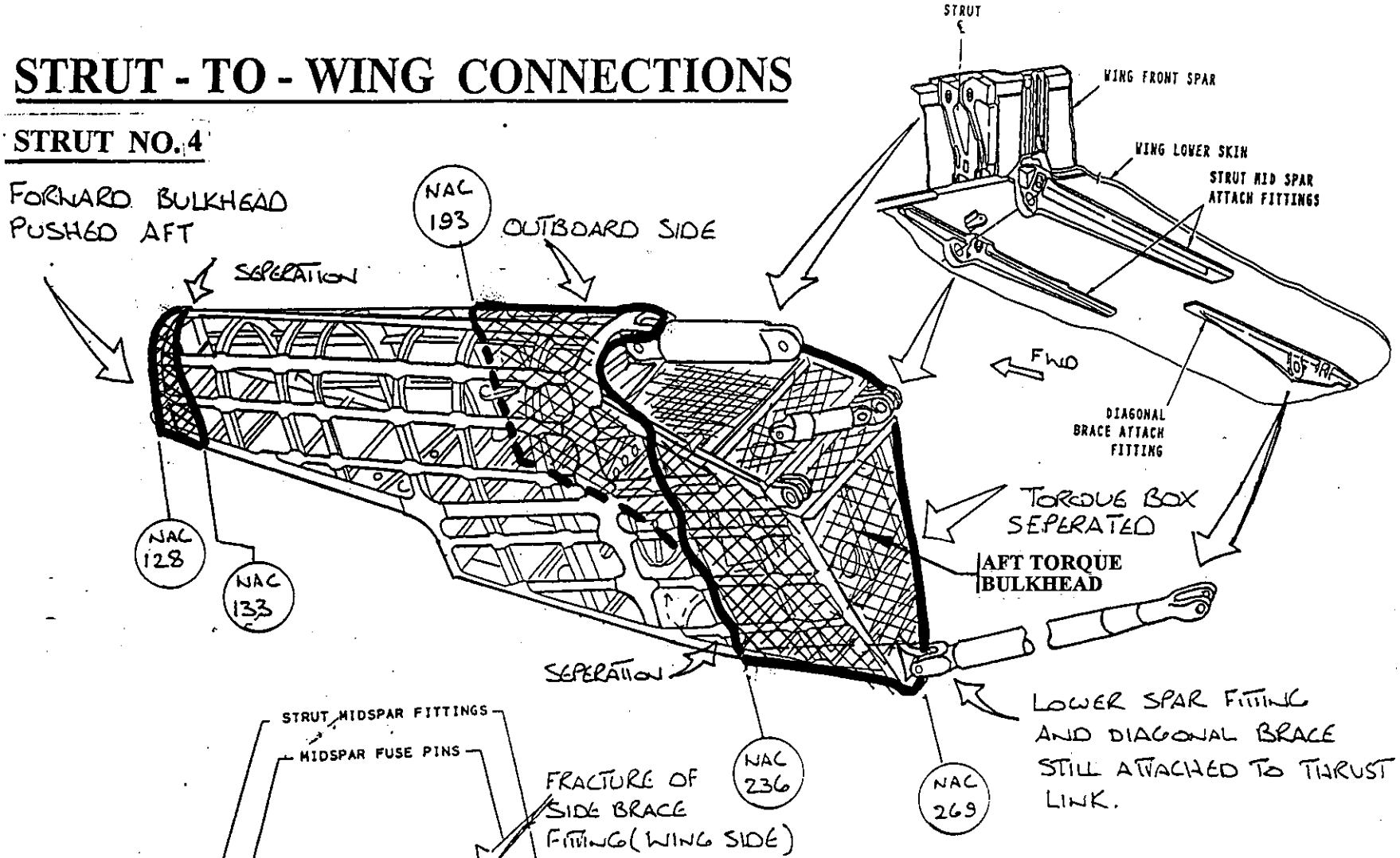


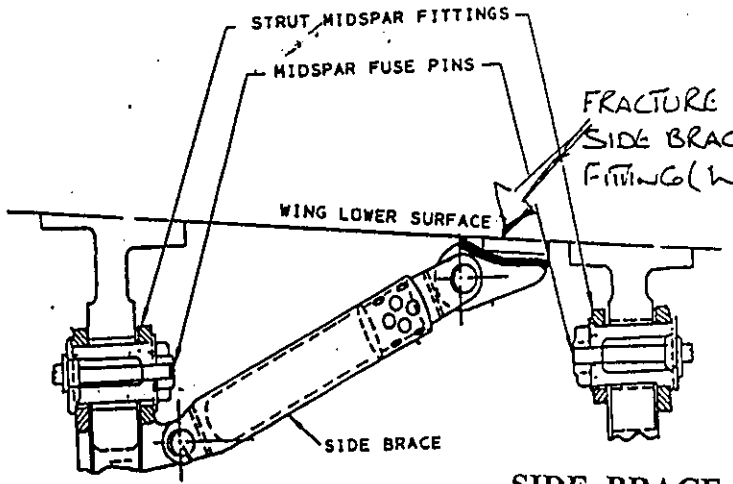
ATTACHED TO FUSE BOLT

DETACHED FROM FUSE BOLT

STRUT - TO - WING CONNECTIONS

STRUT NO. 4

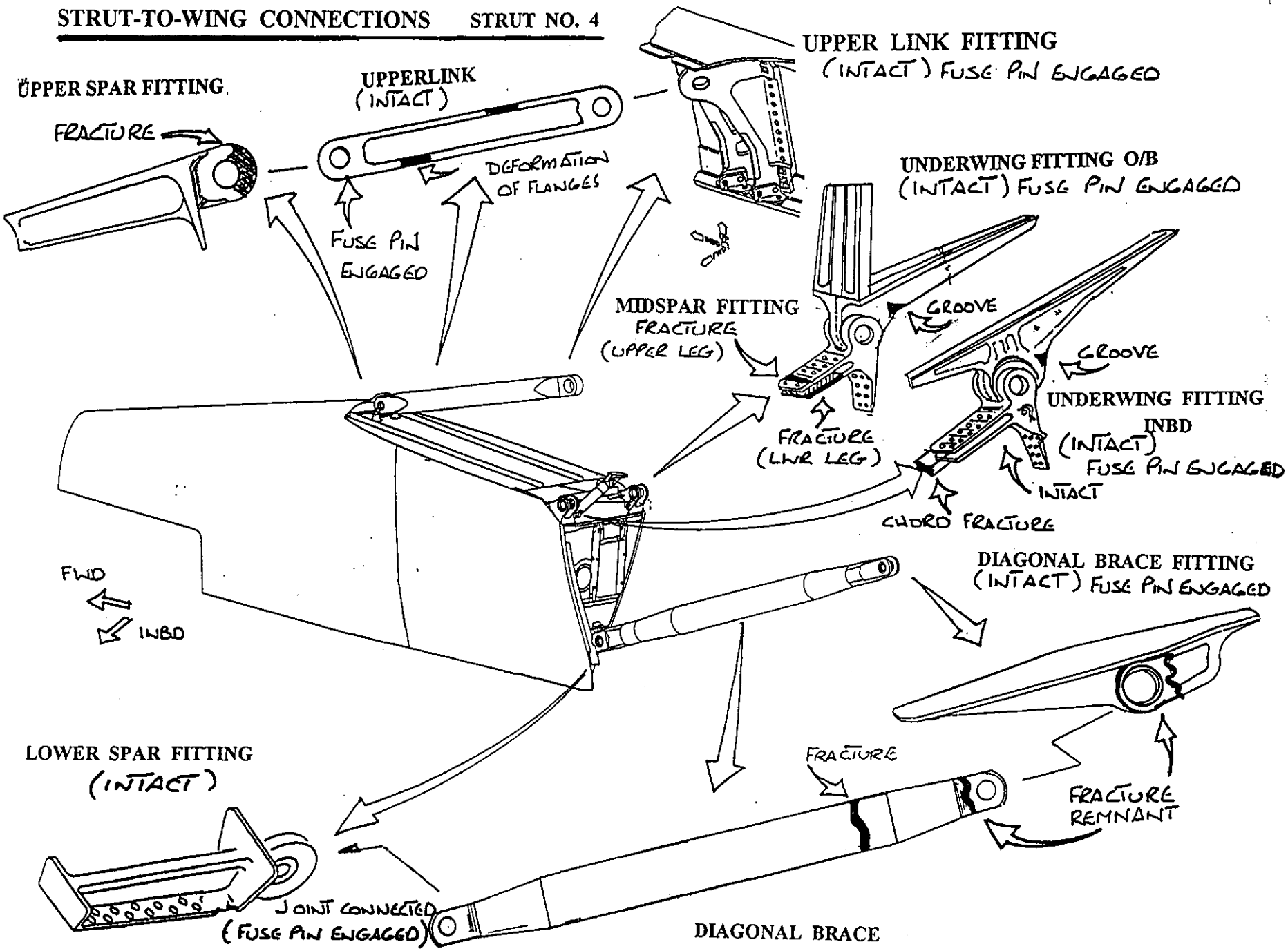




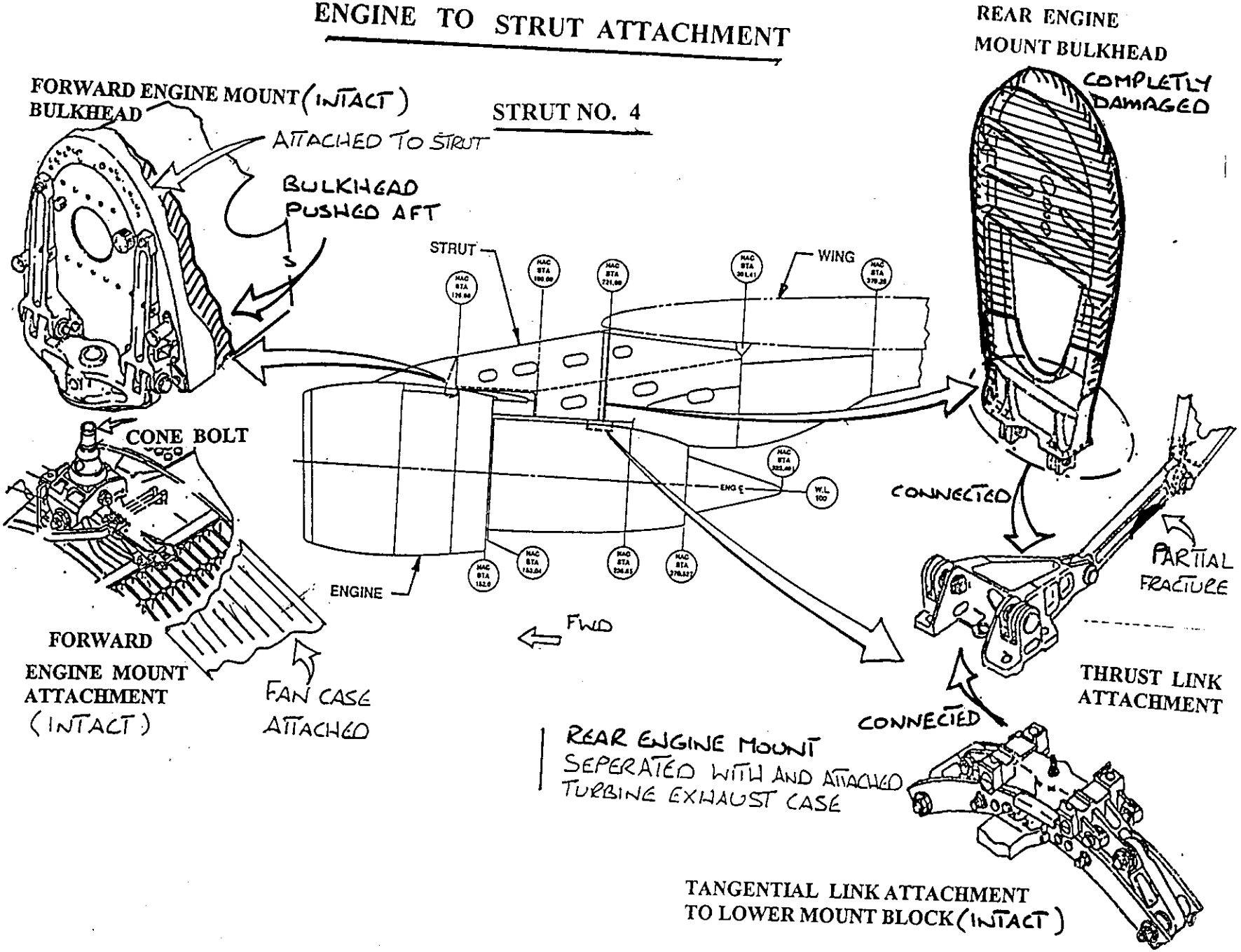
3rd Generation" Fuse Pins

SIDE BRACE ATTACHMENT

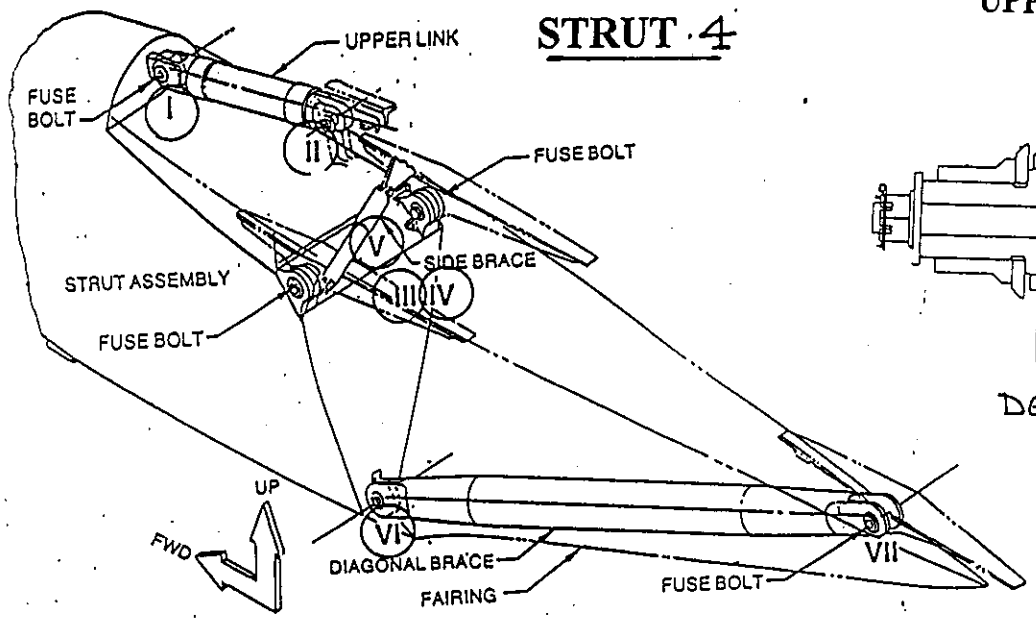
STRUT-TO-WING CONNECTIONS STRUT NO. 4

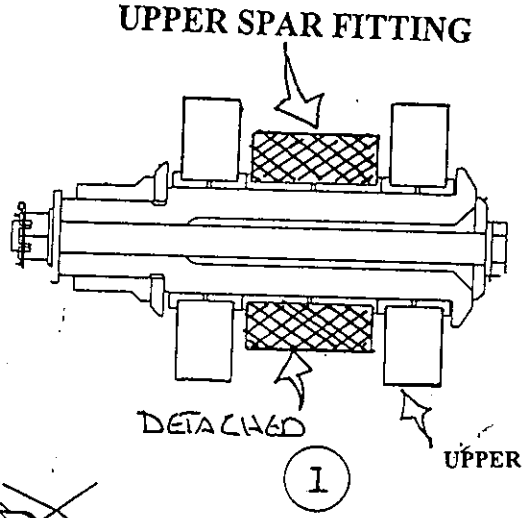


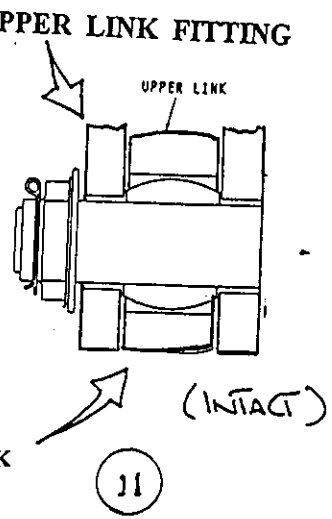
ENGINE TO STRUT ATTACHMENT

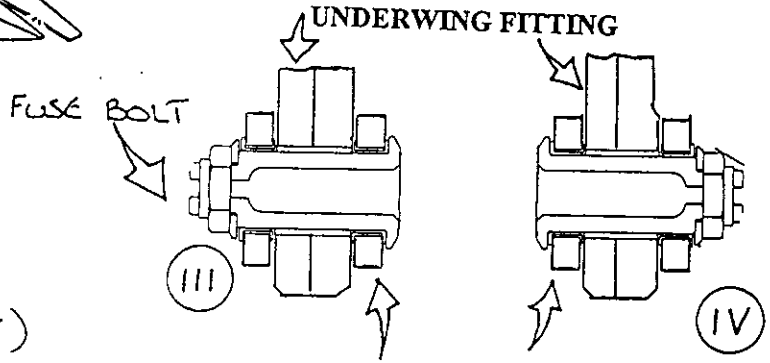


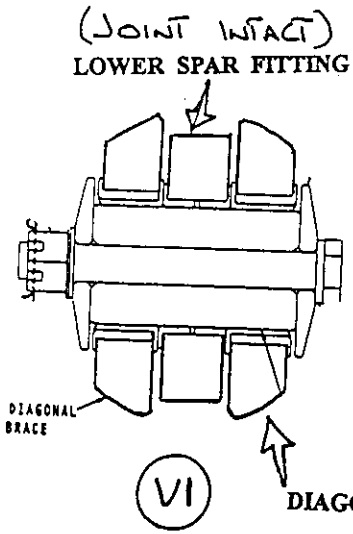
Strut-to-Wing Connections FUSE BOLTS

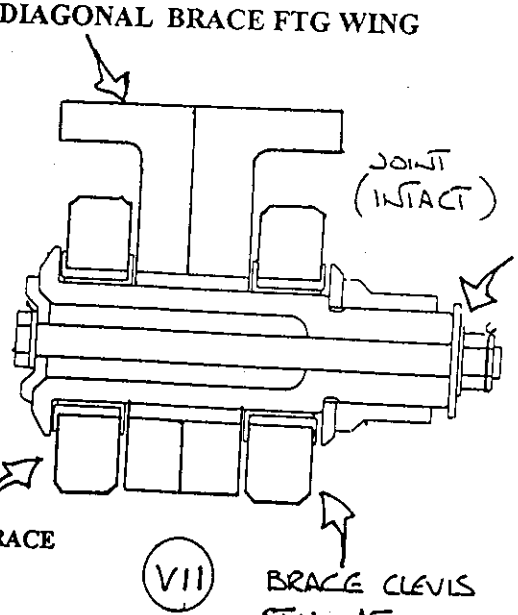








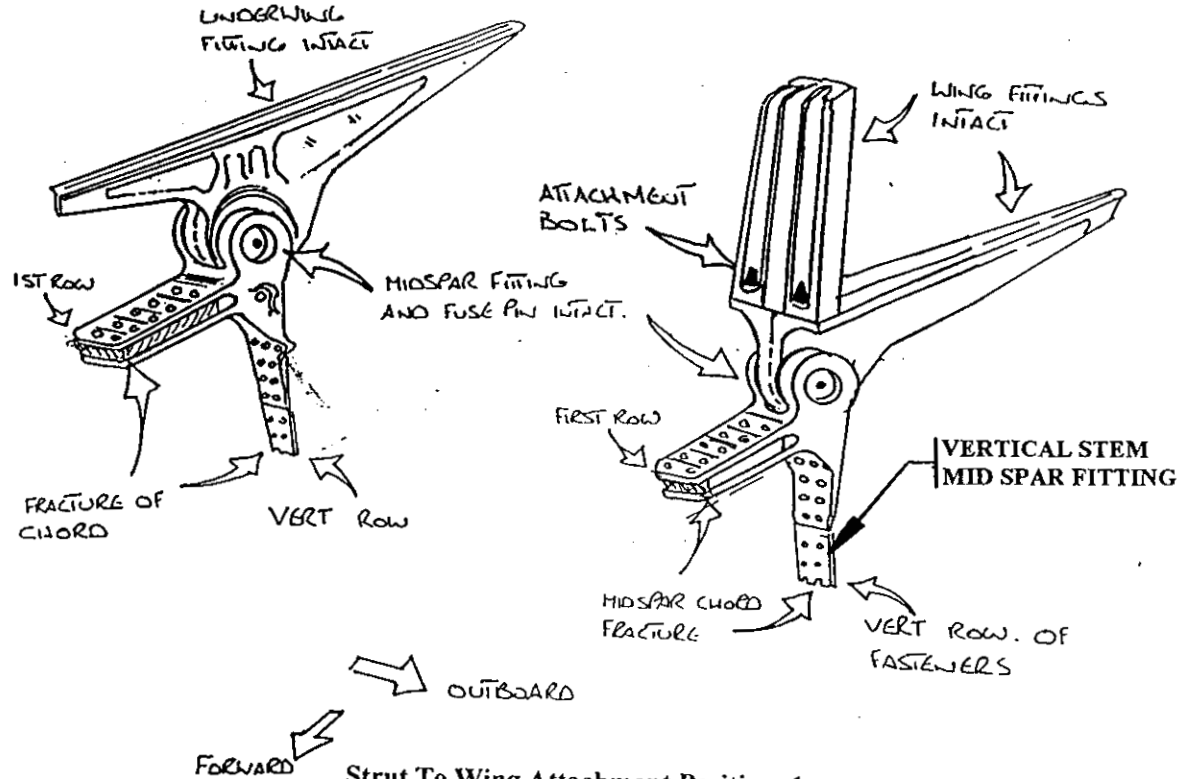




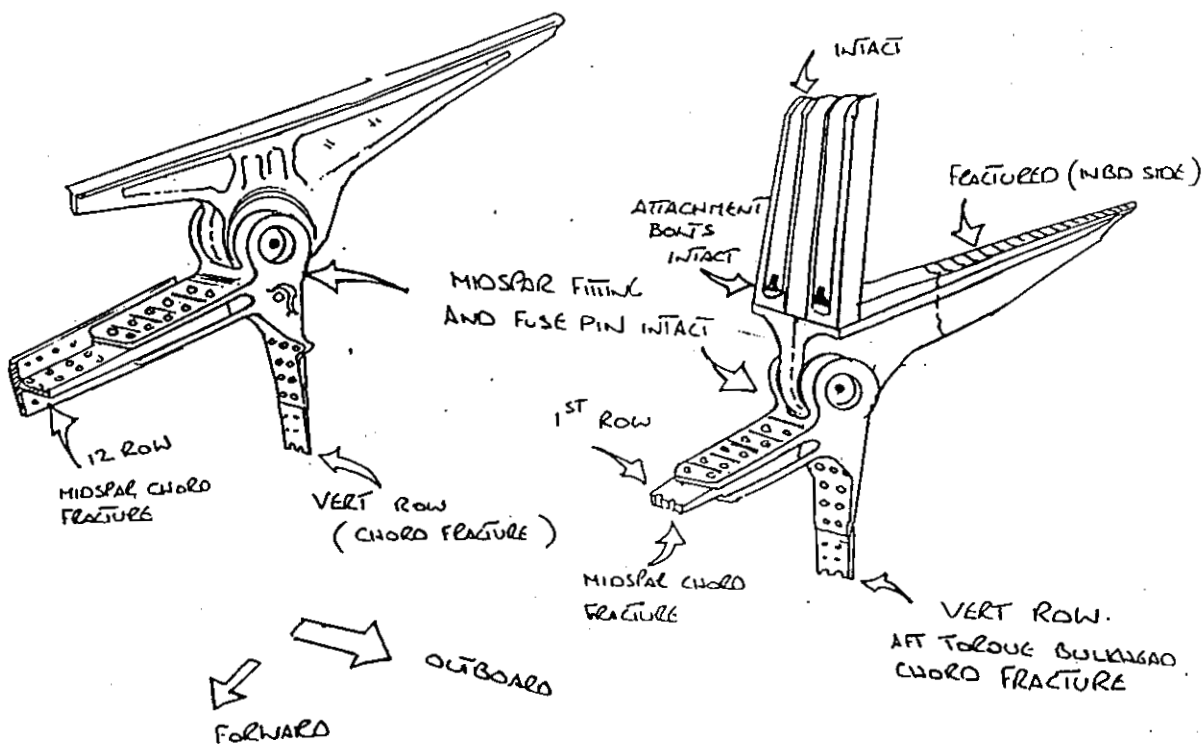
ATTACHED TO FUSE BOLT

DETACHED FROM FUSE BOLT

MIDSPAR FITTING

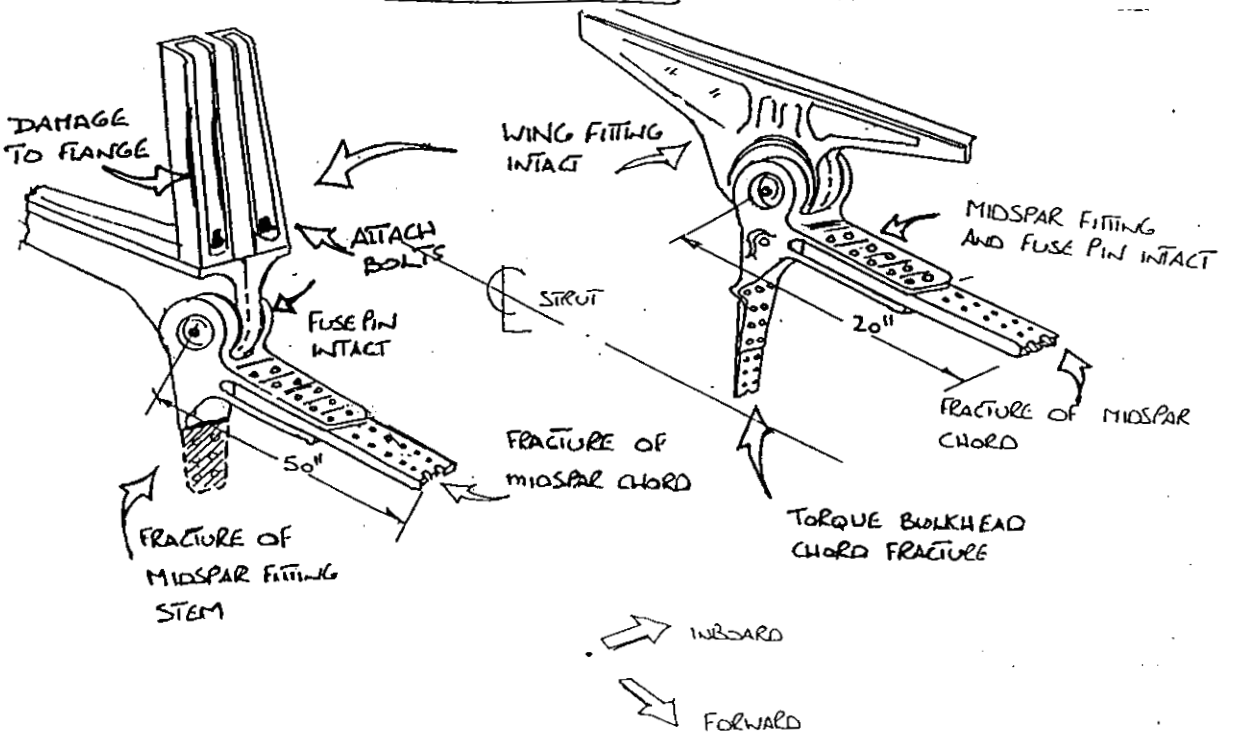


Strut To Wing Attachment Position 1

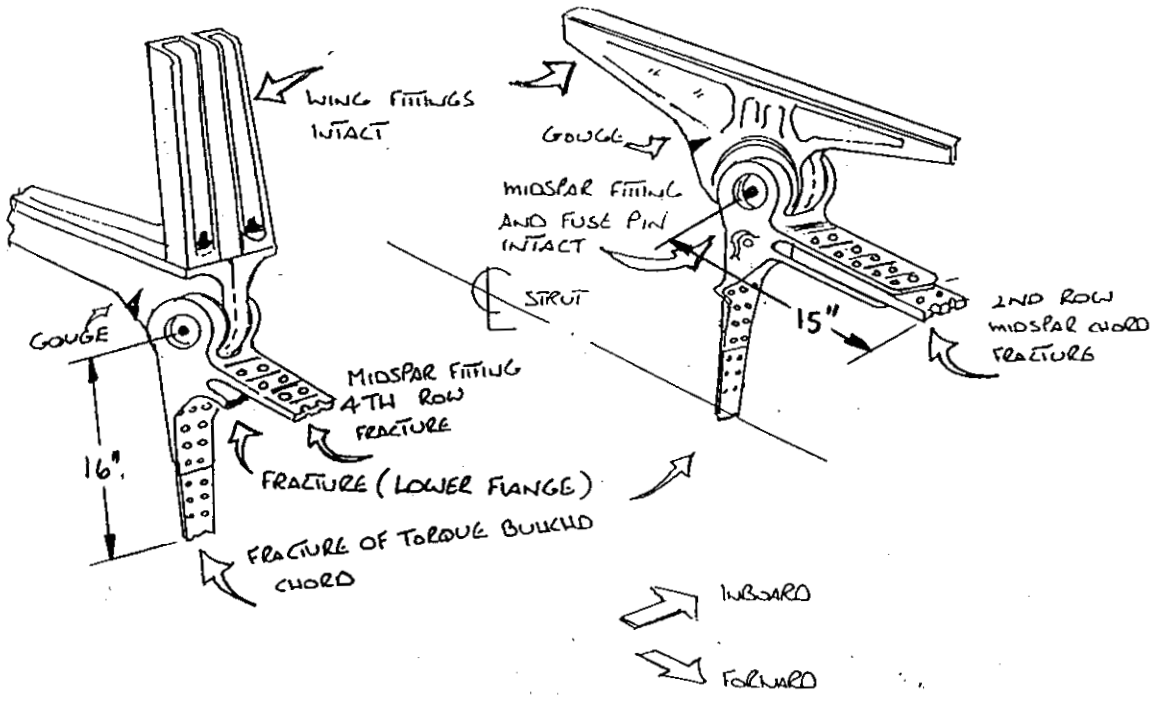


Strut To Wing Attachment Position 2

MIDSPAR FITTING



Strut To Wing Attachment Position 3



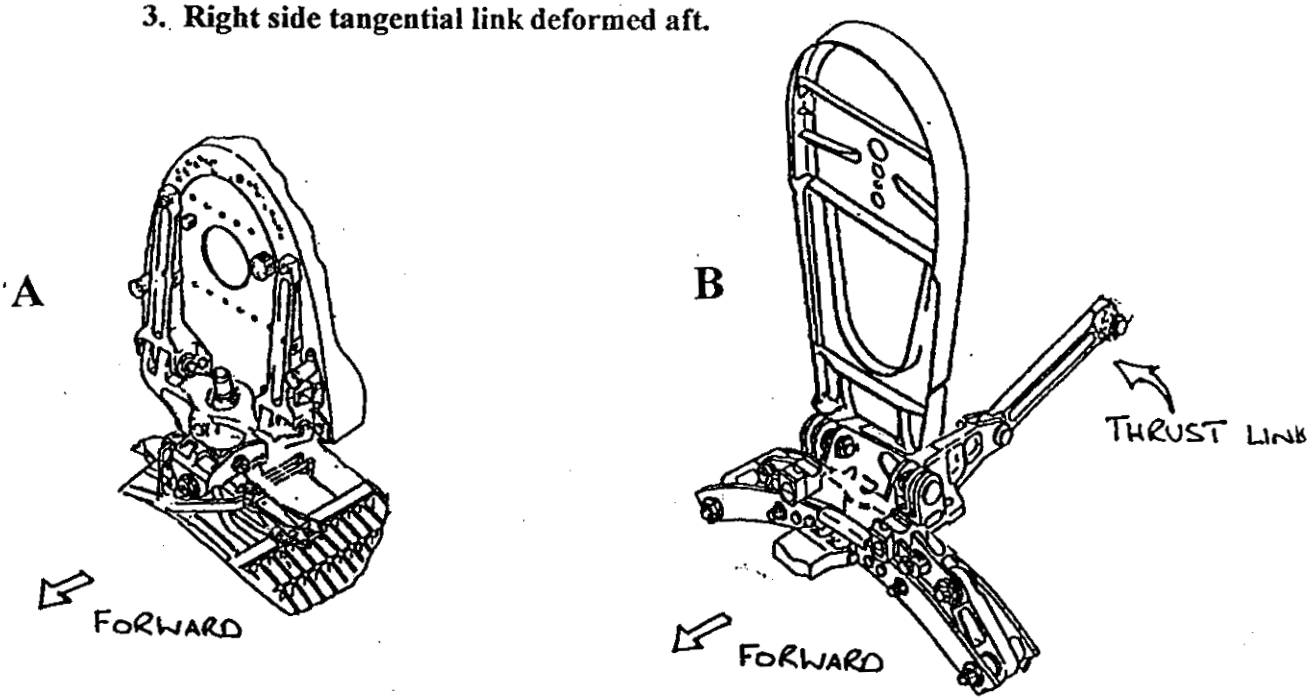
Strut To Wing Attachment Position 4

ENGINE TO STRUT ATTACHMENT FORWARD AND REAR ENGINE MOUNT

x - Engine Mount Bulkhead and Fittings Attached to Strut

		ENGINE POSITION			
STRUCTURE	FIGURE	①	②	③	④
FORWARD ENGINE MOUNT	A	X	1	1	X
REAR ENGINE MOUNT	B	X	2	X	2/3

1. Assembly seperated from strut and attached to fan case.
2. Attached to turbine exhaust case.
3. Right side tangential link deformed aft.



SUMMARY
WING / STRUT ATTACHMENT AND STRUT FITTINGS RECOVERED

COMPONENT	STRUT 1	STRUT 2	STRUT 3	STRUT 4
MIDSPAR FITTING INBOARD	C876	C884	C186	C186
MIDSPAR FITTING OUTBOARD	C876	Z2830	C186	C186
UNDERWING FITTING INBOARD	C876	C884	C186	C186
UNDERWING FITTING OUTBOARD	C876	Z2830	C186	C186
DIAGONAL BRACE UNDERWING FITTING	Z3082	C006	C209	C186
UPPER LINK FITTING WING	C876	Z3019	C186	C186
FUSE BOLT MIDSPAR INBOARD	C876	C884	C186	C186
FUSE BOLT MIDSPAR OUTBOARD	C876	Z2830	C186	C186
FUSE BOLT DIAGONAL BRACE WING	Z3082	C006	C209	C186
FUSE BOLT DIAGONAL BRACE STRUT	Z3082	X	C209	C186
FUSE BOLT UPPER LINK WING	C876	Z3019	C186	C186
FUSE BOLT UPPER LINK STRUT	C876	X	C186	C186
SIDE LINK	C876	C884	C186	C186
REAR ENGINE MOUNT BLOCK	X	X	C012	X
UPPER LINK	X	X	X	C186
DIAGONAL BRACE	Z3082	X	C209	X
FORWARD ENGINE MOUNT	X	X	X	X
CONE BOLT (FORWARD MOUNT)	X	X	X	X
UPPER SPAR FITTING STRUT	X	X	X	X
LOWER SPAR FITTING STRUT	X	X	X	X
TANGENTIAL LINKS	X	X	C012	X
THRUST LINK	X	X	C012	X
THRUST YOKE	X	X	X	X
STRUT	X	C290	X	C815

NOTE: TARGET NUMBER AS INDICATED X – NO TARGET NUMBER ISSUED