APPENDIX A

Note: The following extracts are from documents current at the time of the accident.

1. Definition of the symbol 'CHK' used in the Dan-Air 707 Maintenance Schedule (and other 707 Schedules of UK origin).

The following extract defines the meaning of 'CHK' as it applies to the structural and mechanical areas relevant to this investigation.

"1. Throughout the schedule the abbreviation 'CHK' has been used to signify the inspection requirements. This is to be interpreted to mean:-

1.1 That the item has been inspected 'in situ' (unless otherwise stated) to a degree at least sufficient to ensure it remains serviceable until the next higher period for inspection of the item becomes due.

1.2 That the item was free at the time of inspection from any defects likely to affect airworthiness.

1.3 The inspections made to ensure the above must comply with the minimum standards set out hereunder having regard to the material from which the item is made and applying these standards wherever physically possible.

1.4 **Metal parts** - eg all structural members, bodies or casing of units in systems and in instrument, electrical and radio installations, metal pipes, ducting, tubes, rods, levers etc.

Inspect for:-

(a) Cleanliness. External evidence of damage, leaks, overheating or discharge. Bulging. Obstruction of drainage or vent holes or of overflow pipe orifices. Correct lie of fairings and serviceability of fasteners.

(b) Security of attachments, fasteners, connections, locking and bonding.

(c) Freedom from - cracks (visual), distortion, dents, scores, chafing, evidence of wear, pulled or missing fasteners - eg rivets, bolts, screws, separation of bonds, failure of welds and spot welds. Deterioration of protective treatment and corrosion. Correct sealing of fairings. Fluid ingress.

(d) Discolouration and flecking of dial markings.

1.5 **Rubber, Fabric, Fibreglass and Plastic Parts** - eg ducting, flexible pipes, flexible mountings, seals, insulation of electrical cables, windows, etc.

Inspect for: (a) Cleanliness, cracks, cuts, chafing, kinking, twisting, crushing, contraction - sufficient free length. Deterioration. Crazing. Loss of flexibility, overheating. Fluid soakage.

(b) Security of attachment (supports, packing and electrical bonding correctly positioned, serviceable and secure) connections and locking.

1.6 **Control System Components**

Inspect for: Correct alignment - no fouling. Free movement. Distortion. Evidence of bowing. Scores. Chafing. Fraying. Kinking. Evidence of wear. Flattening. Cracks. Loose rivets. Deterioration of protective treatment. Electrical bonding correctly positioned, undamaged and secure. Attachments, end connections and locking secure."

2 Definition of the term CHECK used in the Boeing Maintenance and Planning Data document (BMPD).

The following is extracted from the relevant BMPD.

"**EXPLANATION OF TERMS**

(a) CHECK: A check is construed to mean a thorough examination of an item, component and/or system for general condition, as applicable, with special emphasis in the following areas:

Proper attachment, safety wiring, cotter pins, fasteners, clamps, latches, tubing, plumbing, electrical wiring and connections, linkages, cables, broken strands, bearings, alignment, clearances, lubrication, obvious damage, cracks, delamination, fraying, operating pressures, fluid leakage, excessive wear or play, corrosion, evidence of overheating, rubbing, aging, preservative coating or finish, cleanliness and general appearance."

3. The following extracts from the Dan-Air Boeing 707 Approved Maintenance Schedule were those regular inspection items which were intended to cover the rear spars and related structure of the horizontal stabilizers outboard of the root attachment fittings:

Text of the Dan-Air work card used by the inspectors carrying out the 'C' check items listed above:

	HORIZONTAL STABILIZERS, ELEVATORS AND TAB INSPECTION NOTE: 1) Includes ME112 items (27-13 and 27-14) 2) Move control surfaces to both extremes to facilitate inspection of area. Shake check surfaces for play and wear.
1	Inspect for condition, security and fluid leaks, all visible structure, balance panels and cables, actuating mechanism linkages, hinges, bonding straps, system components including snubbers. Include fuselage structure above stabilizer area. Inspect fairings, plates and Vortex generators. (a) AD 62-8-4. Required 321 A/C **ONLY** Inspect horizontal stabilizers balance panel covers per Fig 1. (b) Check the condition, security and number of static discharges installed. (A total of 12). **INCLUDE KEYPOINTS:-** (1) Cracks, elevator closure ribs. (2) Elevator hinge cracks. (3) Tap check honeycomb tabs and trailing edges for delamination and for unbonding at bonded seams. (4) Skin doubler cracks at fin attach fittings. (5) Balance panel cover cracks.
	FIGURE 1 **HORIZONTAL STABILIZER BALANCE PANEL COVERS INSPECTION** Perform a visual inspection of all balance covers and elevator tab control covers (located inboard of No 1 balance bay) on upper and lower surface of horizontal stabilizers. (a) Inspect all panel attachments and all small insp. door attachments for cracks. (b) All cracked panels must be repaired or replaced before further flight (Ref Repair Manual 51-9-1 & 2) (c) If track grips are defective, remove and check balance panels for cracks.

Item	QTY	Requirement		General	Location Access Panel
		NE Period	Requirement		
55. STABILIZERS 55.10 HORIZONTAL STABILIZER					
Horizontal stabilizer External skin		Pre-flight	Walk around inspection (lower surfaces)		91,92
		C	CHK - close visual inspection, check all exterior plates closed	PA Card 55-3280 52-3080	
Horizontal stabilizer Internal structure		2C	CHK		1630-1635 1667
		3C	CHK	PA Card 52-1280	1609-1612
		6C	CHK	PA Card 52-1282	1669 L/R
		2D	CHK		1614, 1615 1624-1628 1649-1653 1668
Elevator balance panel bays			CHK		93,94,1615 1624-1628 1649-1653 1668
Elevator hinge assy on elevator and tail-plane		C	CHK		93, 94

4. Extract of relevant 'C' check items listed in Manufacturers BMPD document, ie corresponding to the Dan-Air inspection items listed previously:

'C' CHECK TYPE ITEMS

MODEL 707–320B/C		TIME			
DESCRIPTION		CHECK	ACCESS DOOR NUMBER	HOURS & TENTHS	
				ELAPSED	MAN HRS
STABILIZERS					
04-55-01	Horizontal stabilizers	X		.4	.8
	A. Exterior surfaces	X			
	B. Brush and seal	X			
	C. Rear spar and hinge fittings	X			
	D. Drain holes	X			
04-55-03	Vertical and horizontal stabilizer trailing edge cavities. Check for accumulation of dirt, lint and debris.	2	1512 1513 1514 1515 1516 1517 1518 1615 L&R 1624 L&R 1625 L&R 1626 L&R 1627 L&R 1628 L&R	0.9	0.9
04-55-04	Vertical and horizontal stabilizers. Check for aerodynamic cleanliness including skin damage, rough paint, large gaps or dents, rough patches, surface mismatch at access panels and condition of aerodynamic sealant at skin butt joints.	2	NONE	1.3	2.6

5 The text of the Structural Inspection contained in the Dan-Air Schedule was identical to that in the Manufacturers BMPD document, and the relevant item is listed below:-

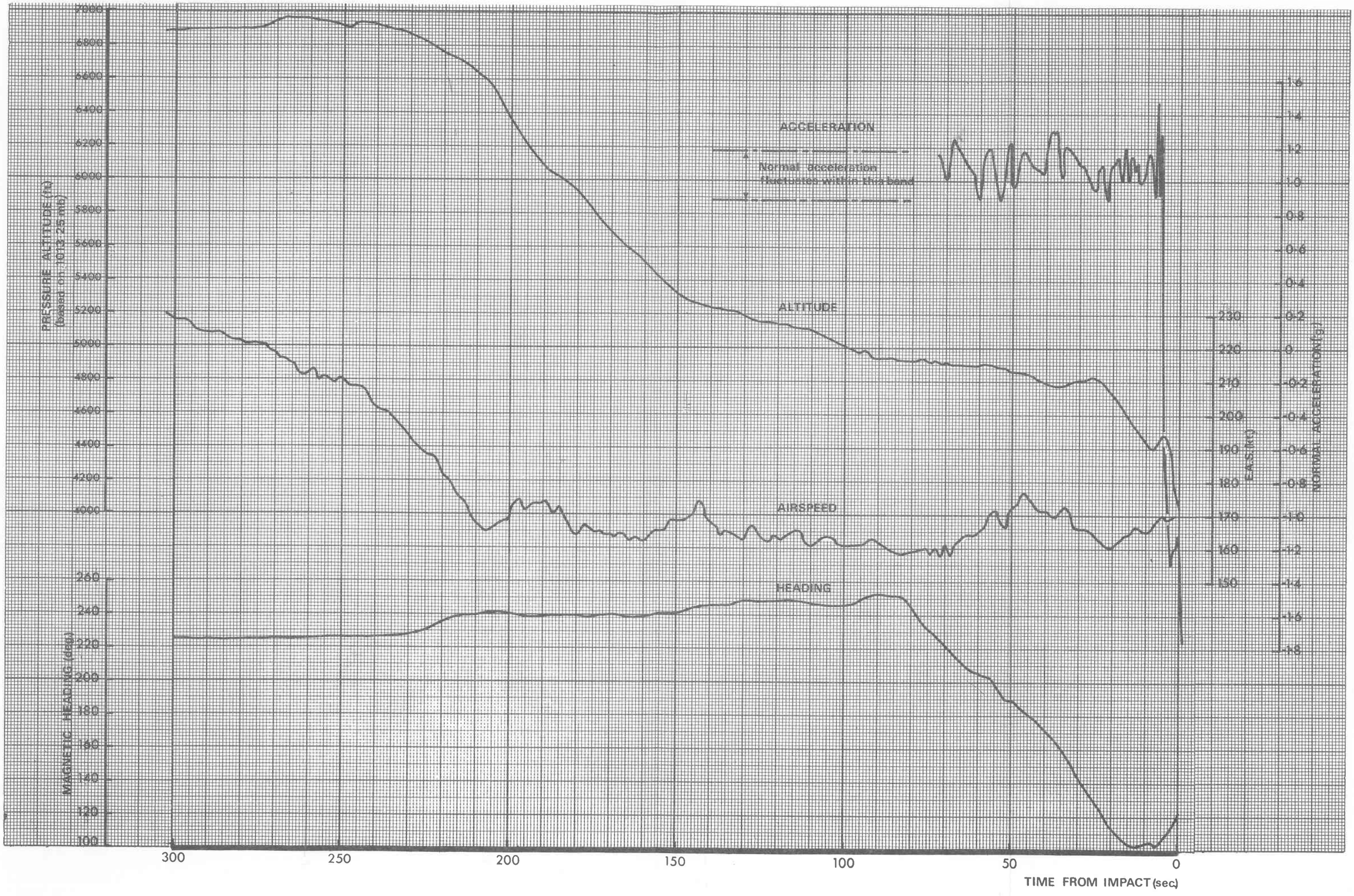
"Horizontal stabilizer internal structure.

A. Inspect spar and rib chords, webs and stiffeners for cracks or loose fasteners.

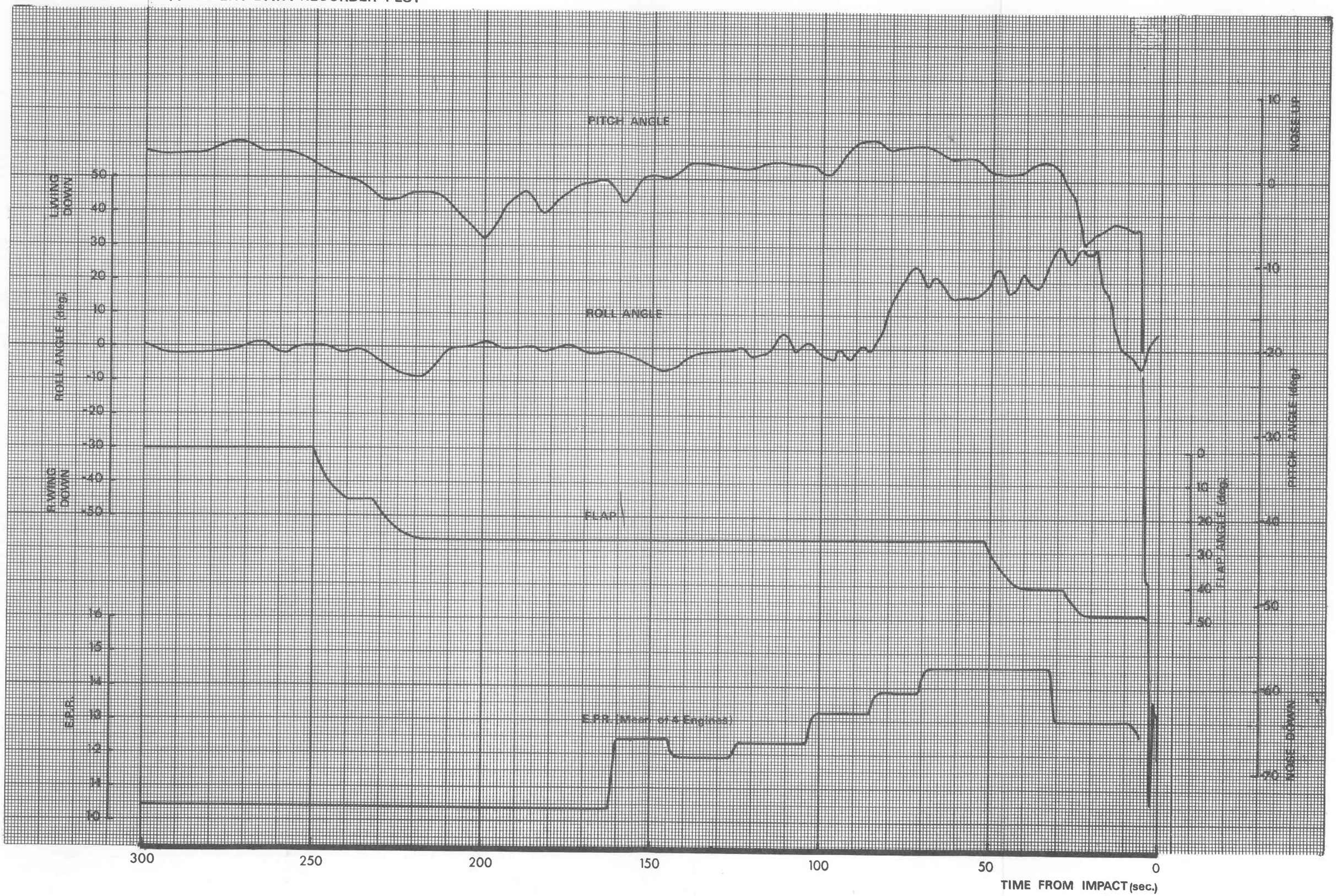
B. Inspect center section spar chords, fittings and lower skin.

C. Inspect adjacent structure."

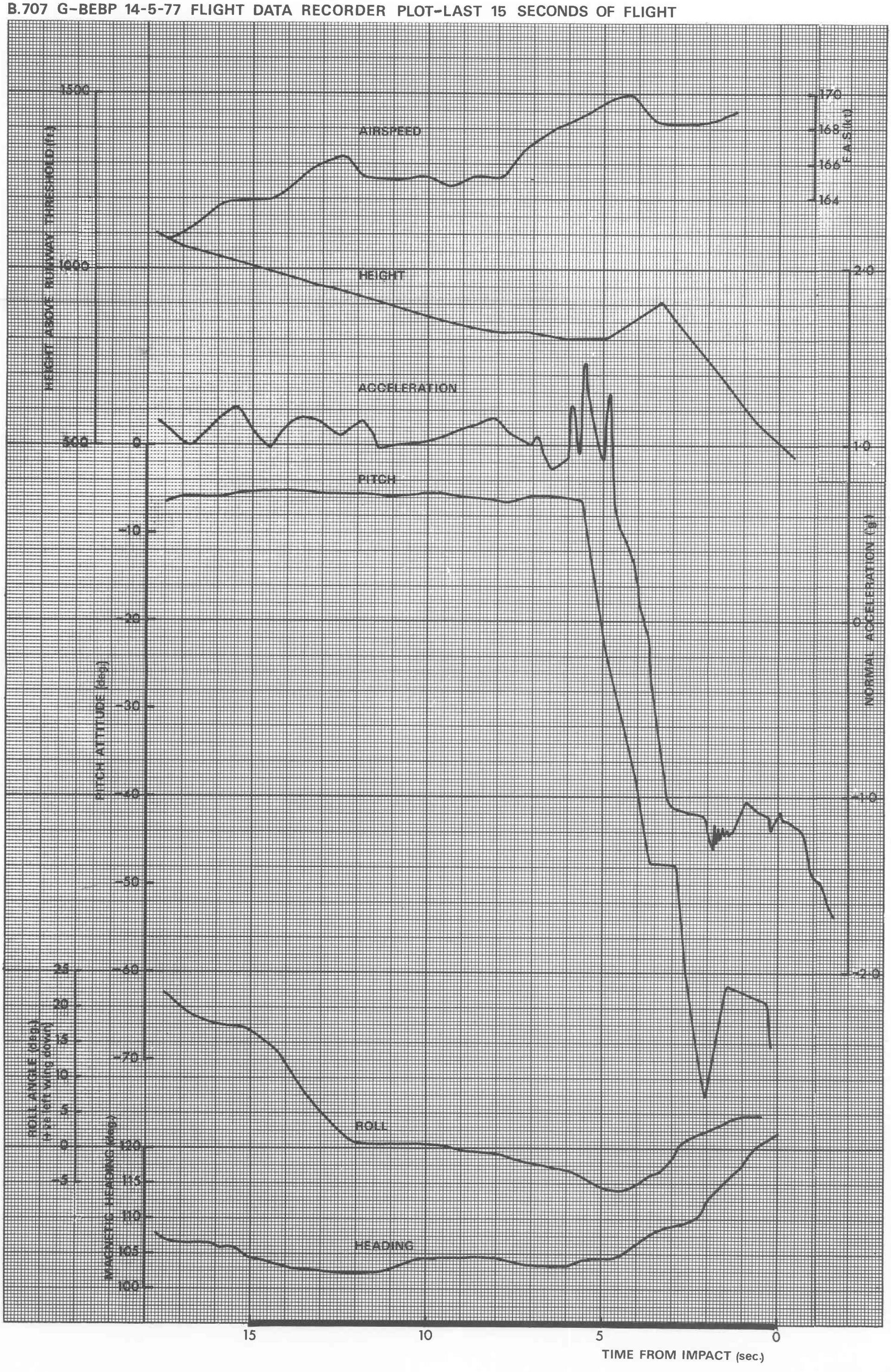
B 707 G-BEBP 14-5-77 FLIGHT DATA RECORDER PLOT

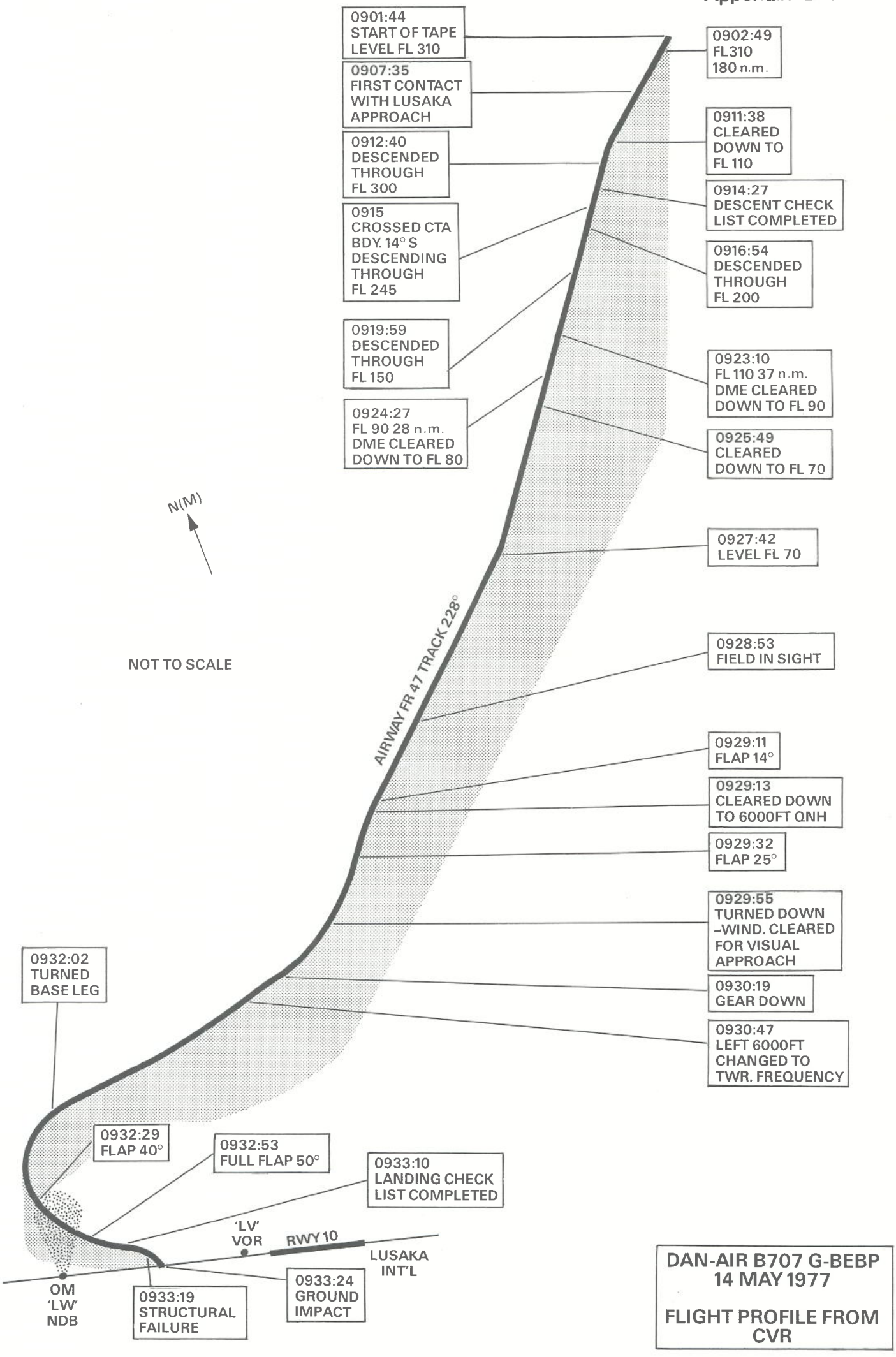


B.707 G-BEBP 14-5-77 FLIGHT DATA RECORDER PLOT



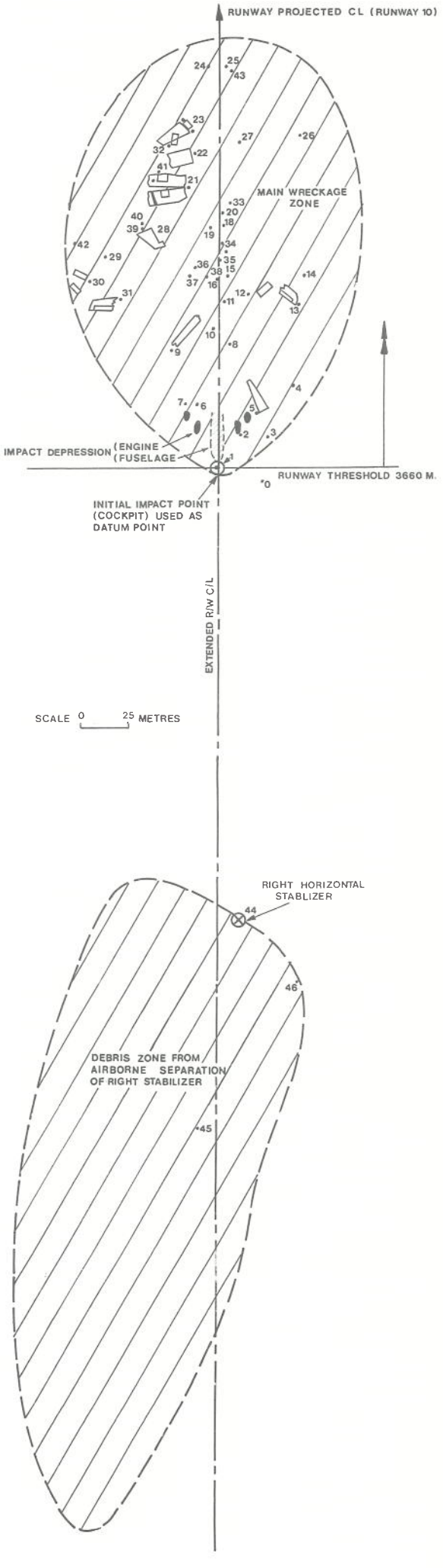
B.707 G-BEBP 14-5-77 FLIGHT DATA RECORDER PLOT-LAST 15 SECONDS OF FLIGHT





DAN-AIR B707 G-BEBP
14 MAY 1977

FLIGHT PROFILE FROM CVR



KEY

0 Nose undercarriage complete

1 Nose impact point

2 No. 3 engine

3 No. 4 engine- fan and LP compressor section

4 No. 4 engine-diffuser case

5 Section of right mainplane lower skin containing No. 3 and 4 engine pod drag strut attachments with struts

6 No. 2 engine – complete

7 No. 1 engine – complete

8 Main undercarriage complete (right)

9 Section of left mainplane lower skin containing No. 1 and 2 engine pod strut attachments with one strut attached

10 Main undercarriage (left) almost complete

11 No. 4 engine-turbine section

12 Flap section (left inner)

13 Outer right mainplane, aileron, spoiler (parts) and tip-stbd

14 No. 4 engine- thrust reverser (rear)

15 Section of fuselage left undercarriage

16 Flaps section (left outer)

17 Section of flap with screw jack (ext 50° approx.)

18 Section of fuselage and STN 990 exit door

19 Air cycle unit

20 Intercooler

21 Rear fuselage section split in half (from rear press.bulkhead fwd approx 8m)

22 Section of fuselage around stn990 area, fwd end rear freight compartment

23 Left horizontal stabilizer, elevator and centre section complete with stabilizer screw jack

24 Section of wing skin (upper) with stringer from outboard section

25 Section of wing skin (upper) with stringer from outboard section

26 Pair of wheels on axle with brake units

27 Section of wing (ws 360)

28 Fin complete (less rudder and HF aerial)

29 Thrust reverser

30 Left outer wing sections and flap with aileron

31 Section of left wing tip with aileron

32 Right fillet flap and structure complete with screw jack extended approx. 50°

34 Intercooler

35 Air cycle unit

36 Mid section of rudder with pfcu

37 Rudder – badly damaged top section

38 Flap screw jack (extended)

39 Rudder-bottom section (badly damaged)

40 Rudder – lower front spar section

41 Trim drum and cable – horizontal stabilizer

42 Thrust reverser (rear)

43 Honda generator – stored in rear of cargo hold during flight

44 Right horizontal stabilizer complete

45 Piece of closure rib from right horizontal stabilizer

46 Piece of rear fuselage skin and structure from left side adjacent to stabilizer rear spar (with stabilizer position witness marks)

Figure 1 WRECKAGE PLOT

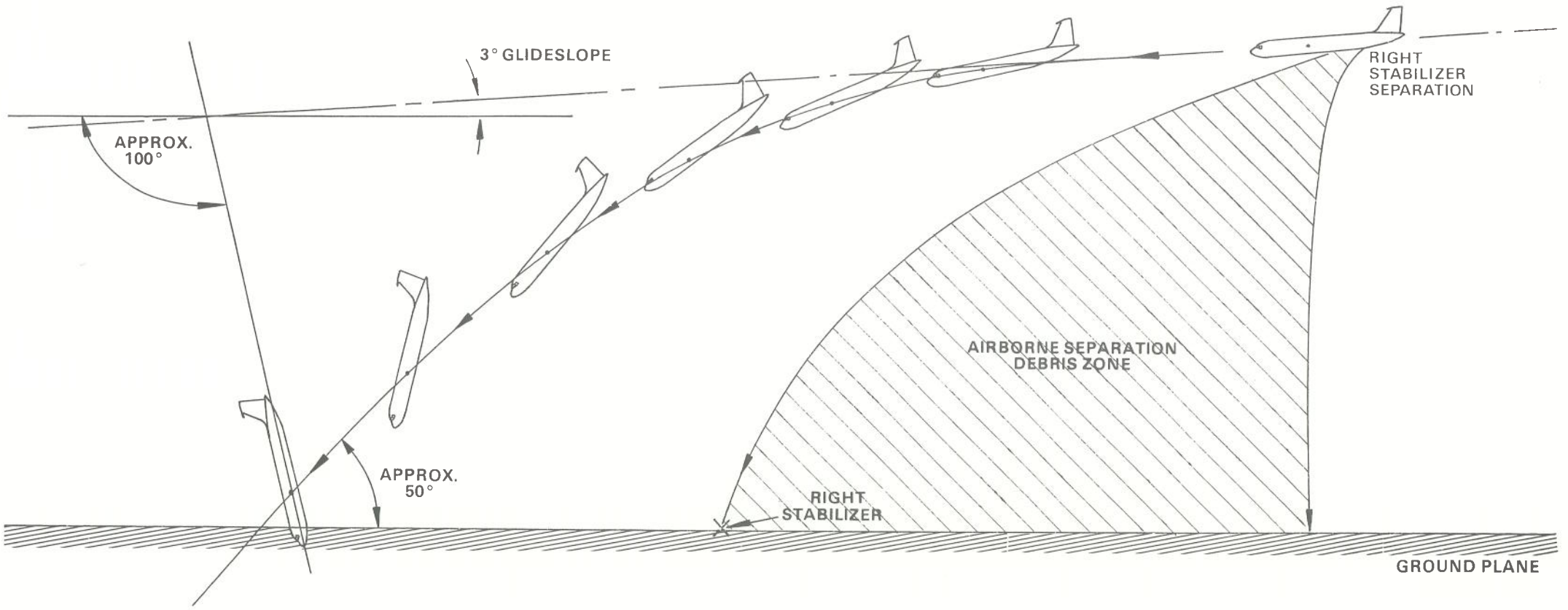


Figure 2 G-BEBP ESTIMATED TRAJECTORY FOLLOWING STABILIZER SEPARATION

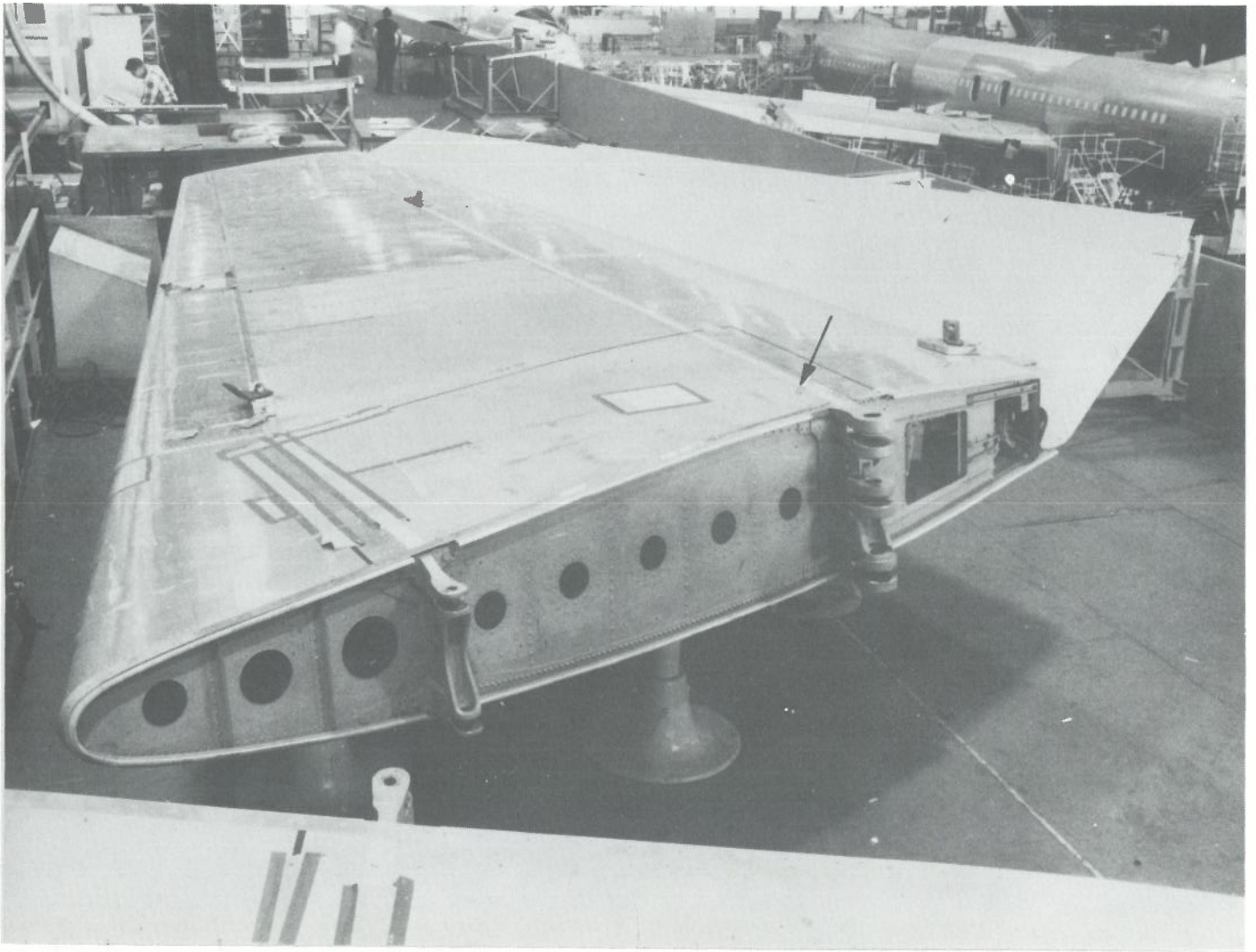


Figure 3 BOEING 707 300 SERIES/400 SERIES HORIZONTAL STABILIZER (G-BEBP crack location arrowed)

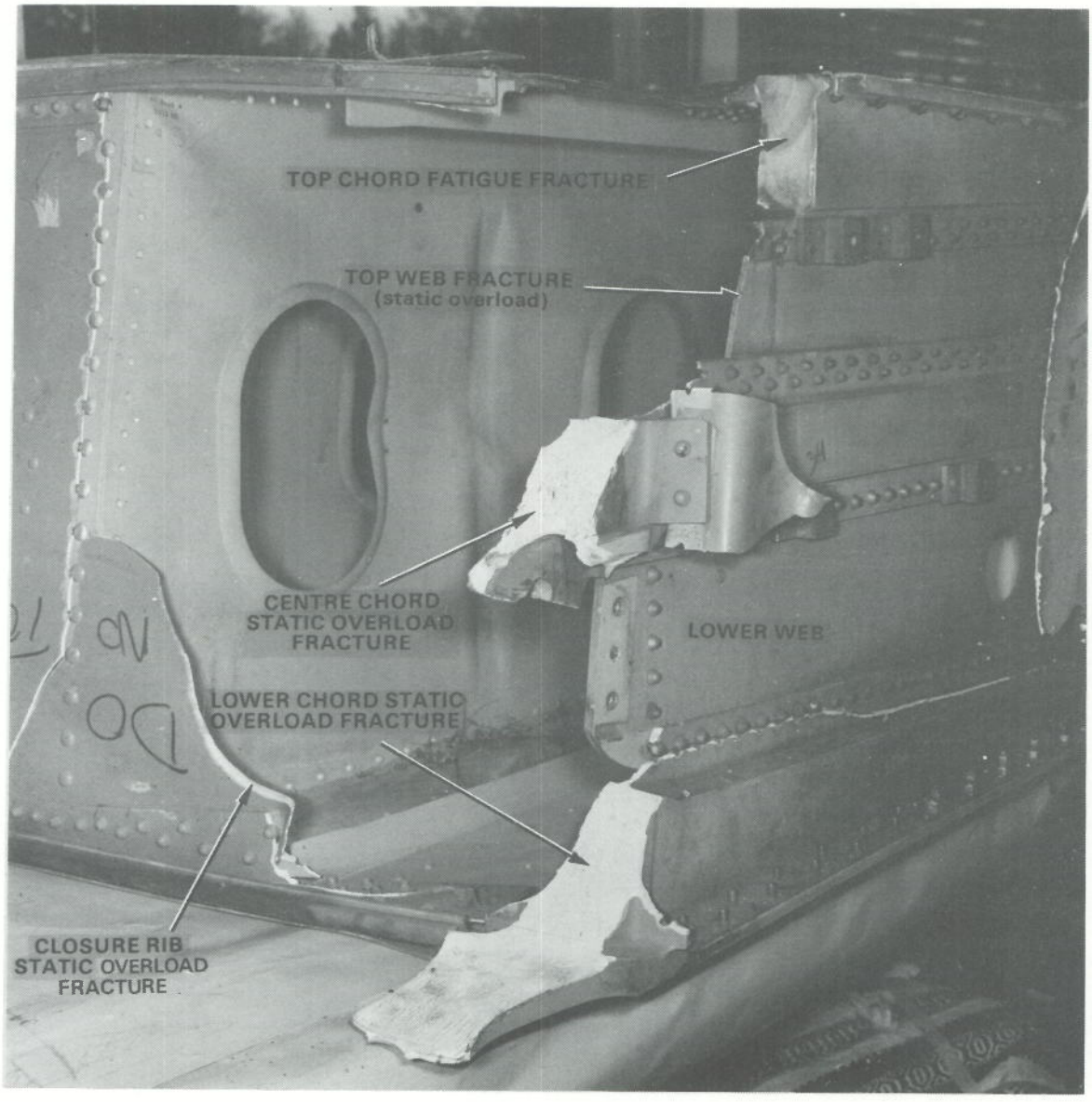


Figure 4 **G-BEBP HORIZONTAL STABILIZER STRUCTURAL FAILURE DETAILS – rear spar outboard fracture surfaces and closure rib fracture.**

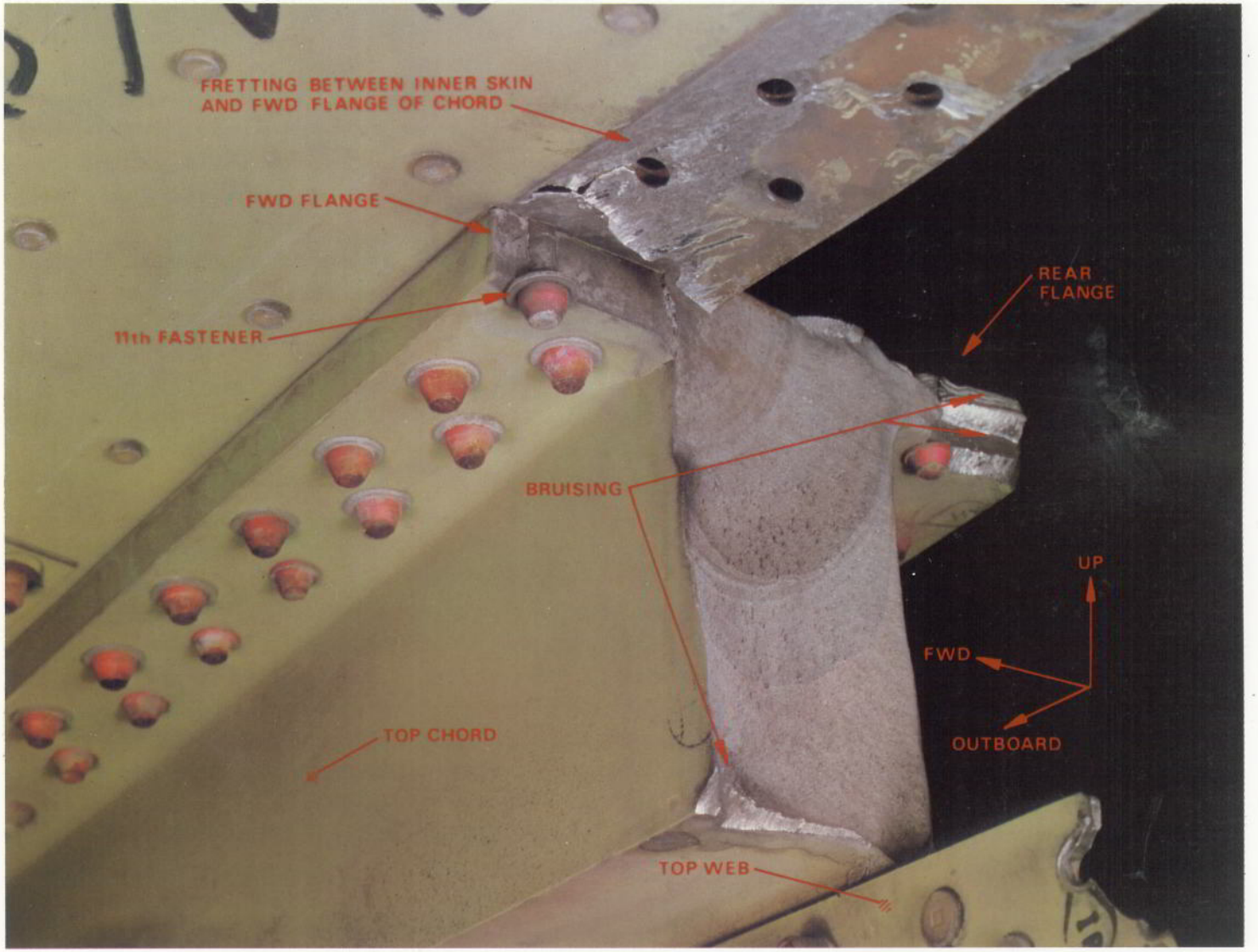
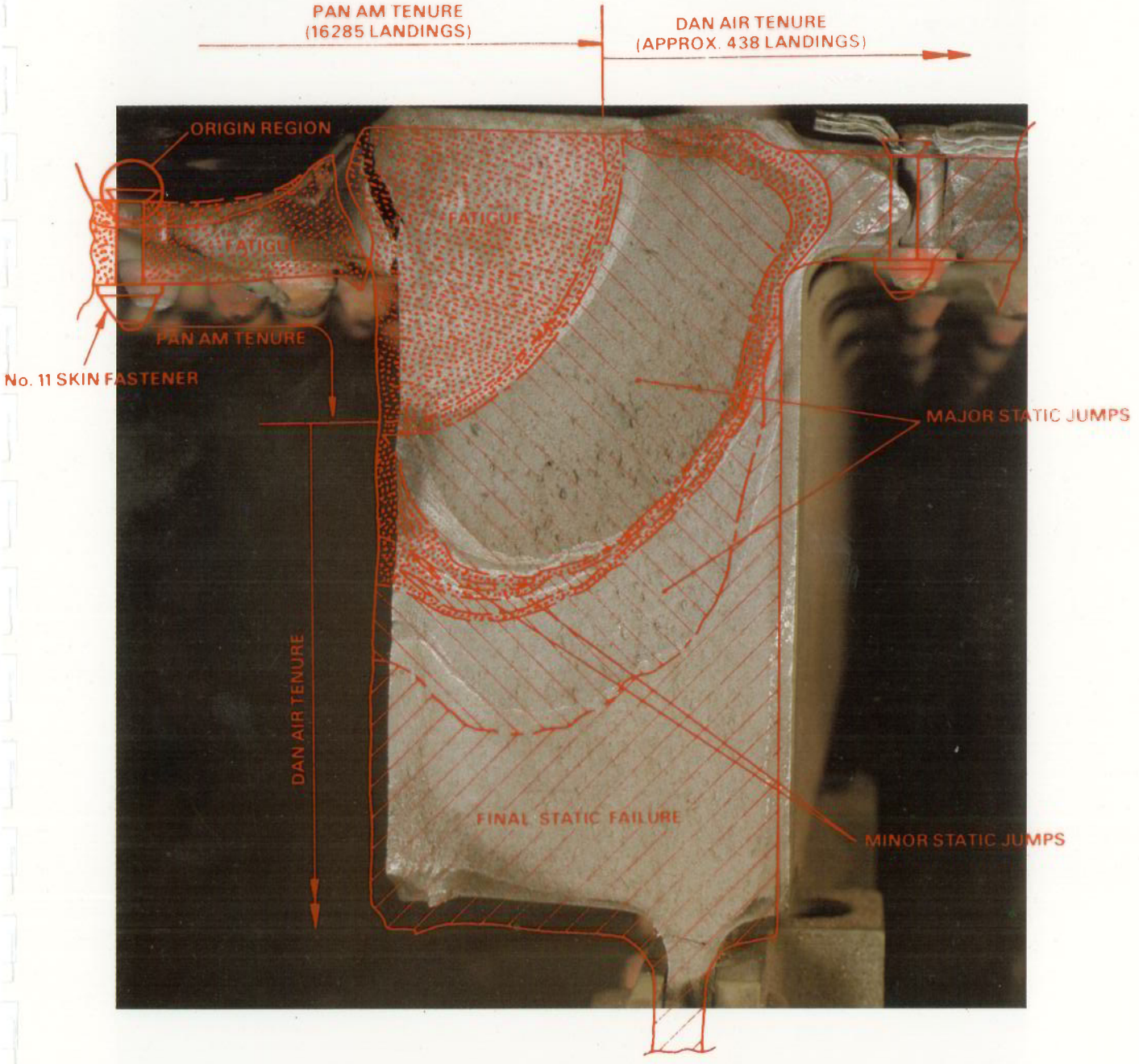


Figure 5 G-BEBP HORIZONTAL STABILIZER TOP CHORD FATIGUE FRACTURE – showing bruising on fracture surface and fretting on top skin.



Over-lay to Figure 6 – Fatigue Fracture details

KEY

CRACK PROGRESSION IN FATIGUE MODE

CRACK PROGRESSION AS "SINGLE" STATIC TENSILE JUMP

FINAL STATIC TENSILE FAILURE

Figure 6 **FATIGUE FRACTURE DETAILS – G-BEBP HORIZONTAL STABILIZER REAR SPAR TOP CHORD**

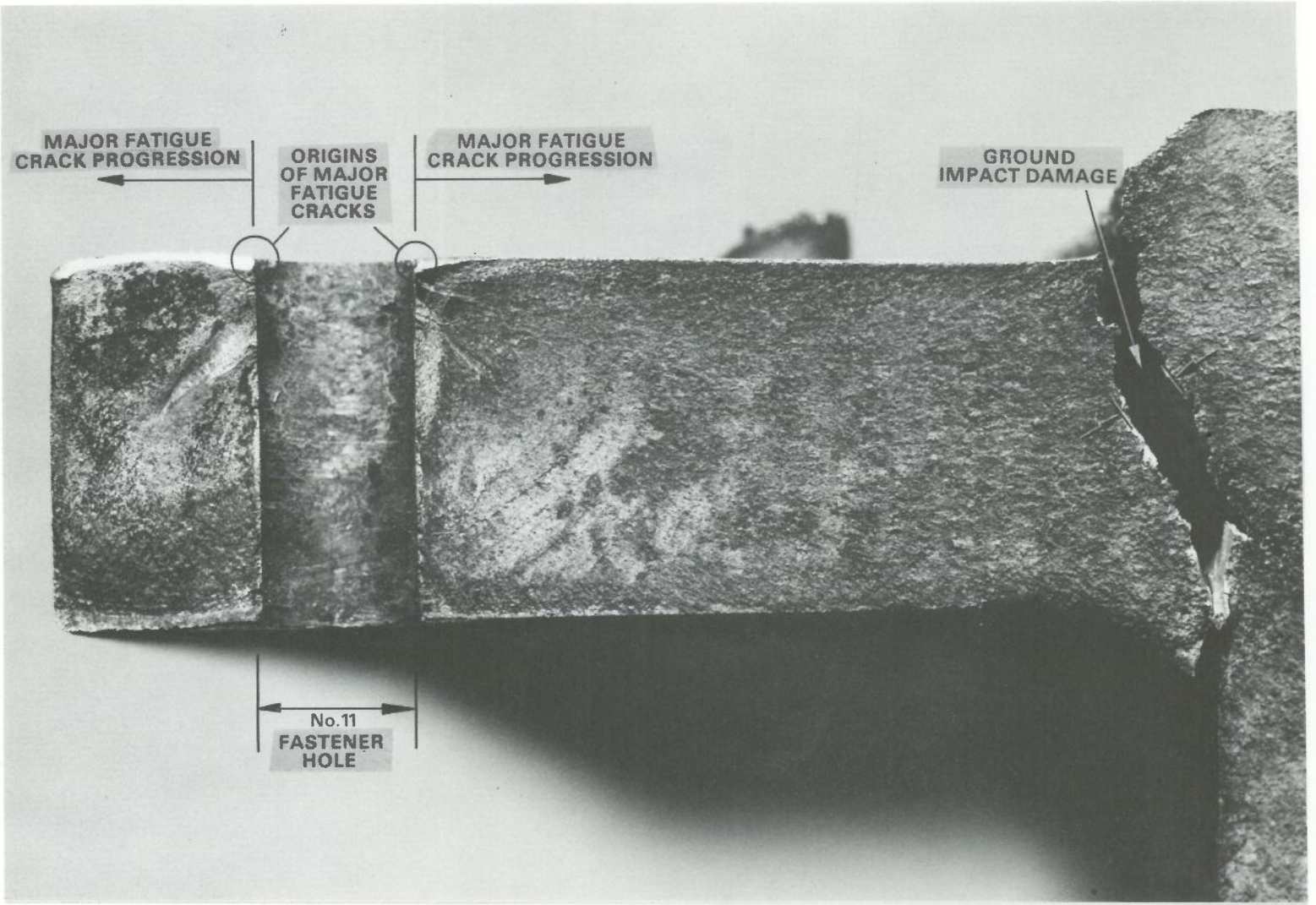


Figure 7 G-BEBP HORIZONTAL STABILIZER TOP CHORD FATIGUE FRACTURE DETAILS – origin regions in forward flange.

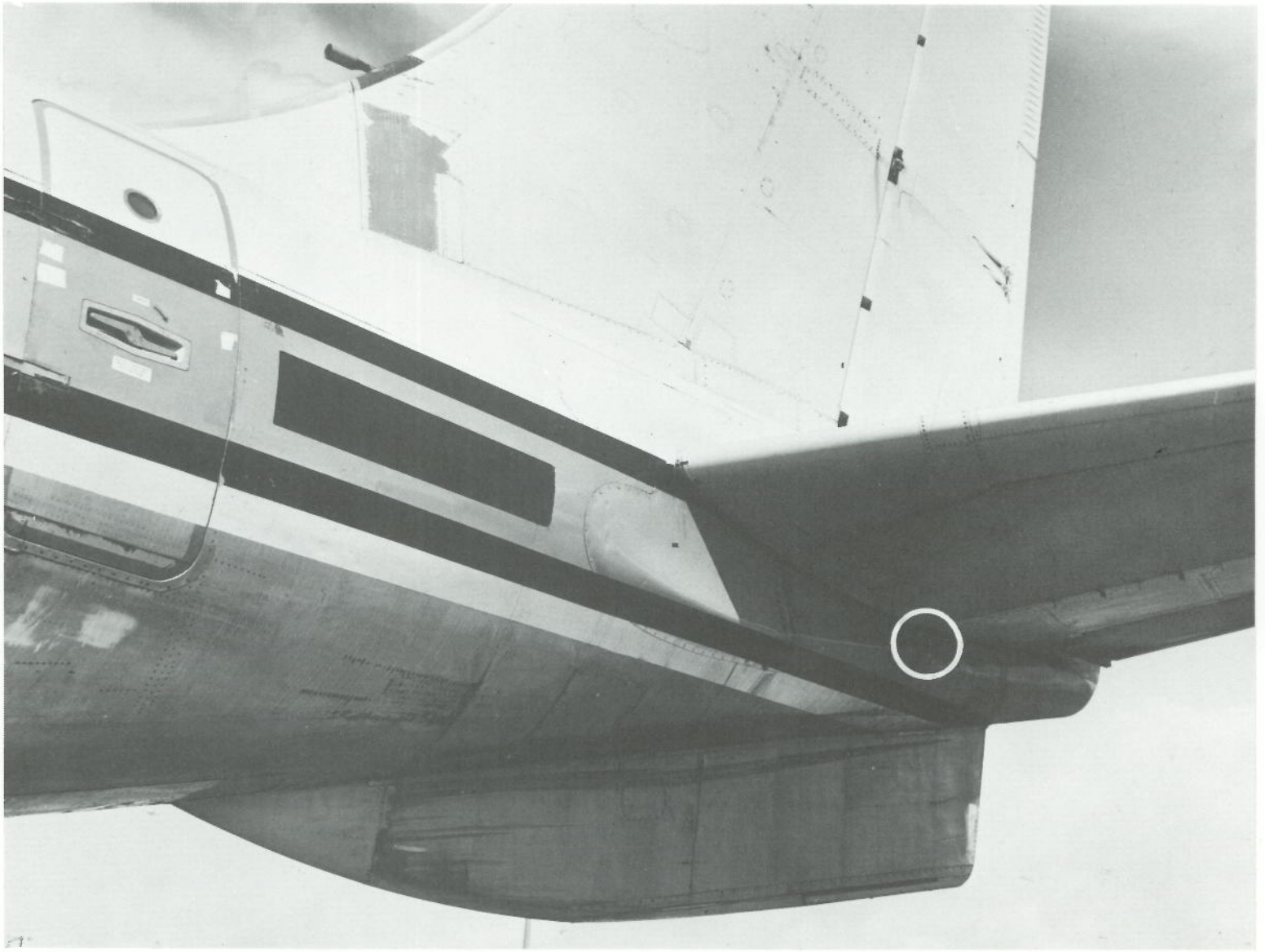


Figure 8 Boeing 707 300 SERIES. EMPENNAGE AND REAR FUSELAGE – showing area of fuselage structure which on G-BEBP was found to contain witness marks of stabilizer incidence (see figure 9)

NOTE: AIRCRAFT SHOWN DIFFERS FROM G-BEBP IN HAVING AN UNDERFIN

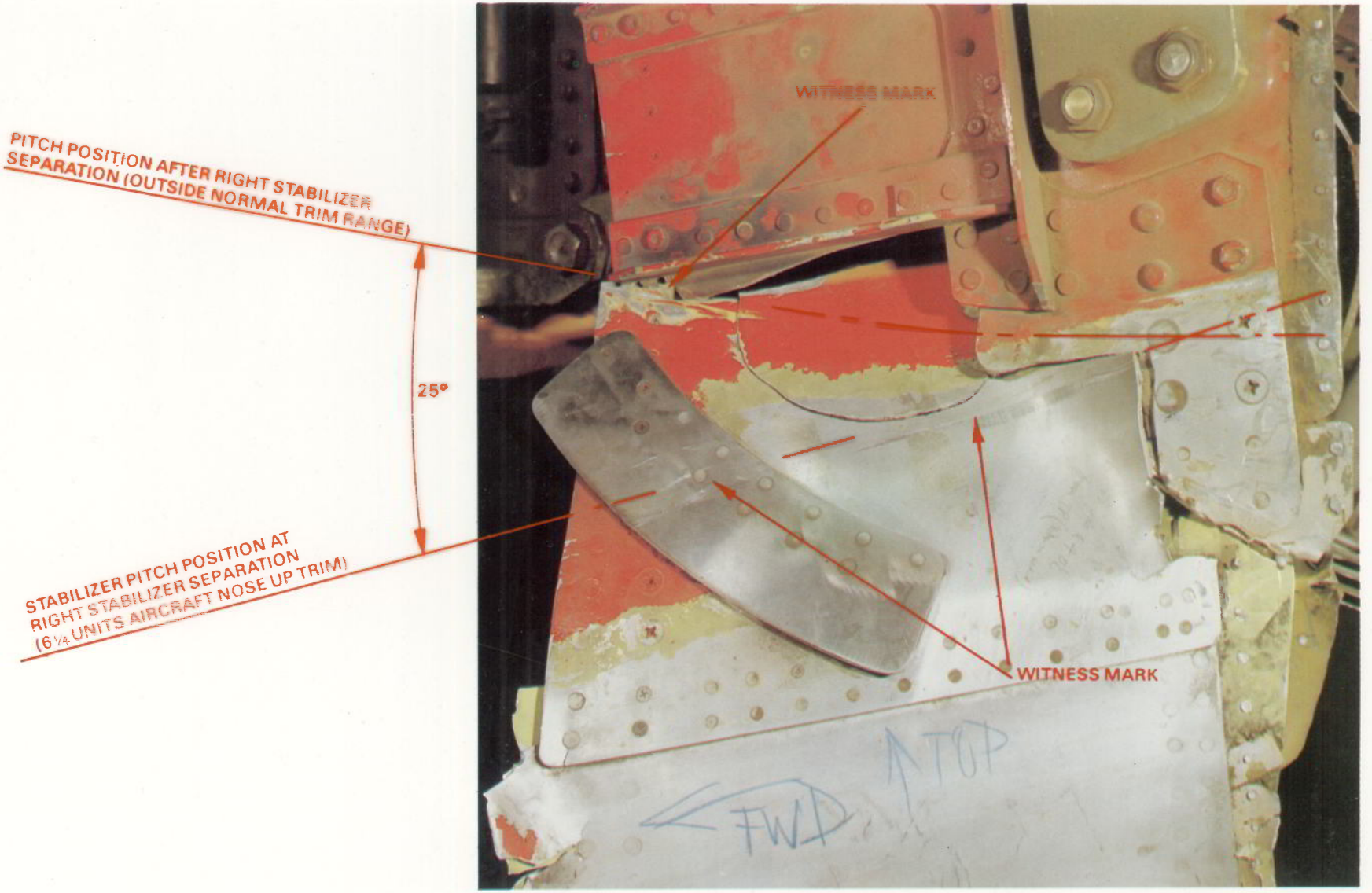


Figure 9 G-BEBP SECTION OF REAR FUSLAGE FROM REGION DETAILED IN FIGURE 8 – Containing witness marks of stabilizer incidence setting made by edge of left stabilizer bottom skin

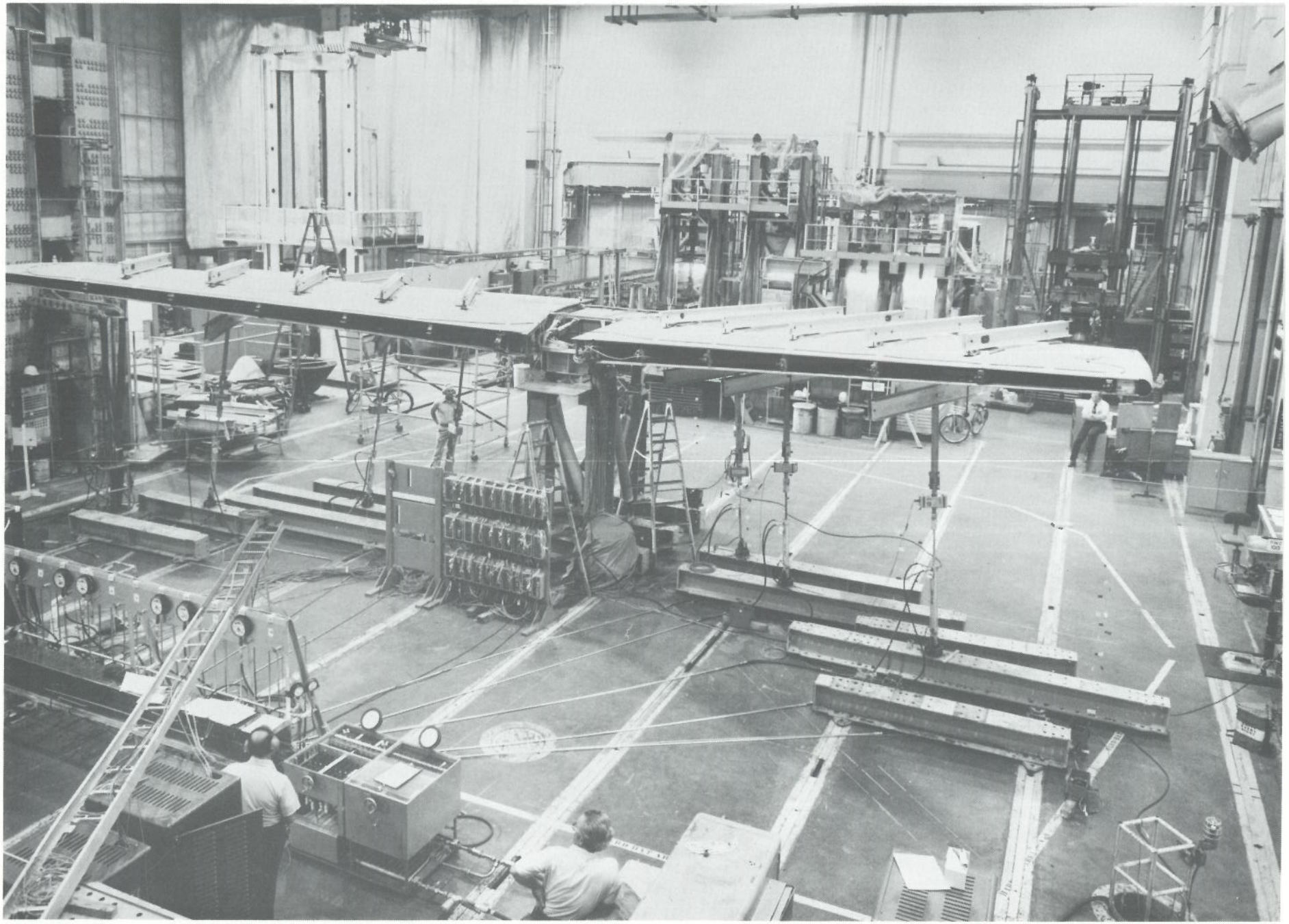


Figure 10 POST ACCIDENT STRUCTURAL TEST RIG

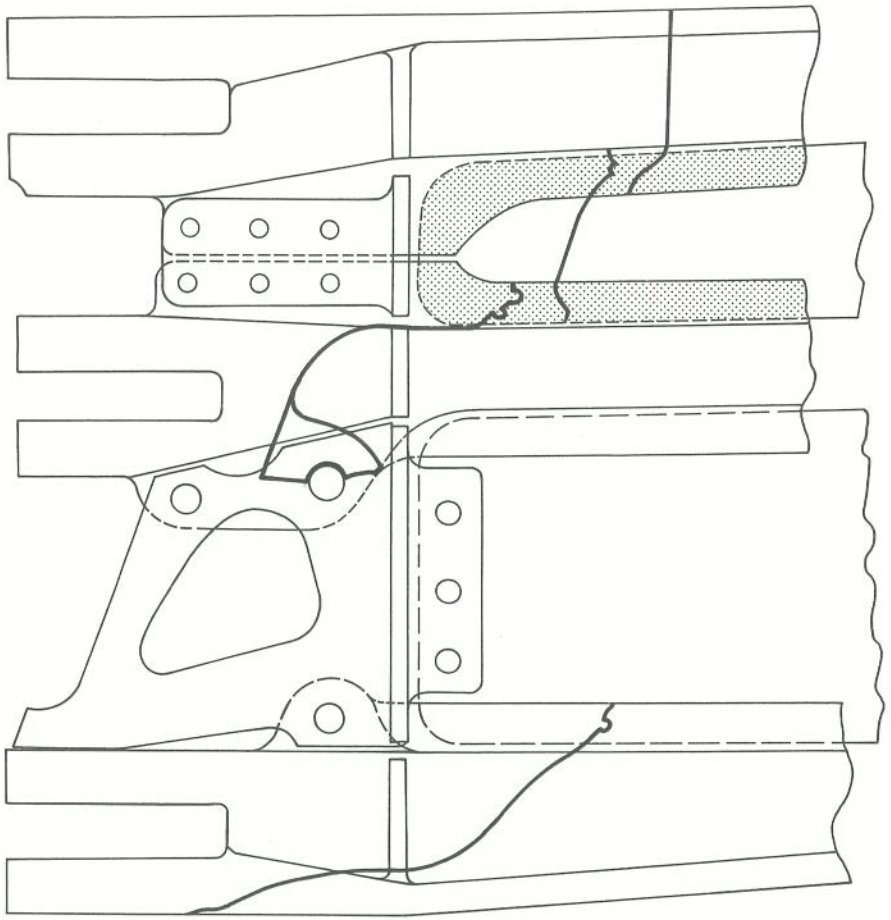


Figure 11a G-BEBP REAR SPAR FRACTURE

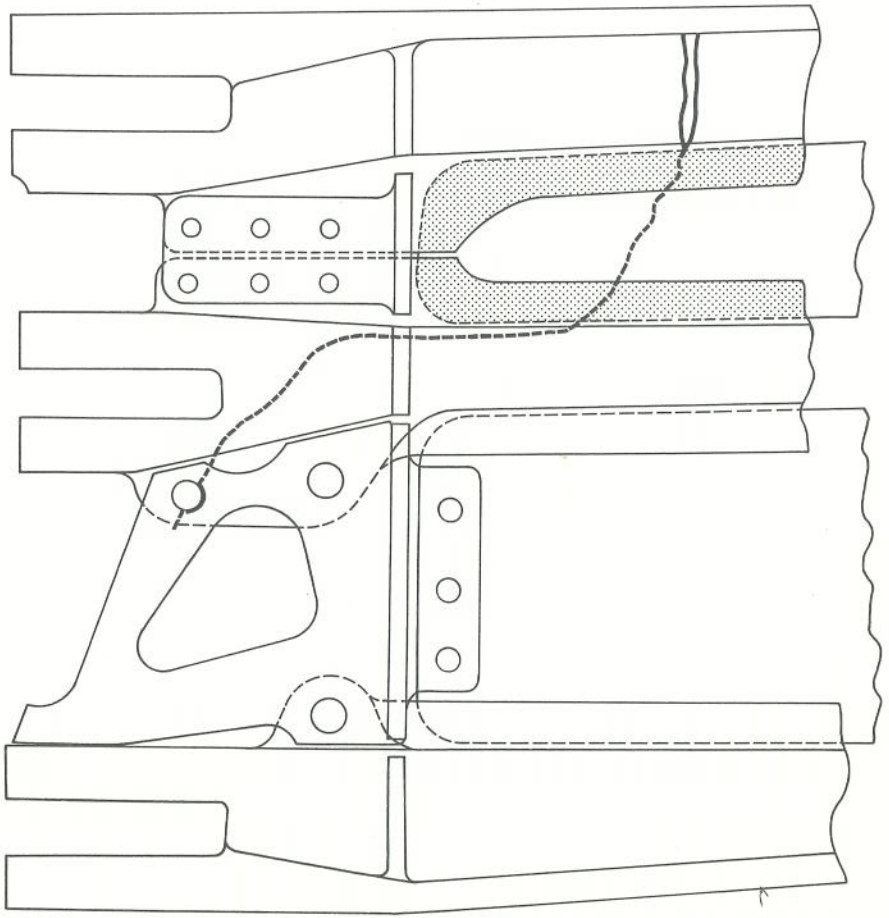


Figure 11b TEST SPECIMEN REAR SPAR FRACTURE

COMPARISON OF HORIZONTAL STABILIZER REAR SPAR FRACTURE LINES – G-BEBP AND POST ACCIDENT STRUCTURAL TEST SPECIMEN

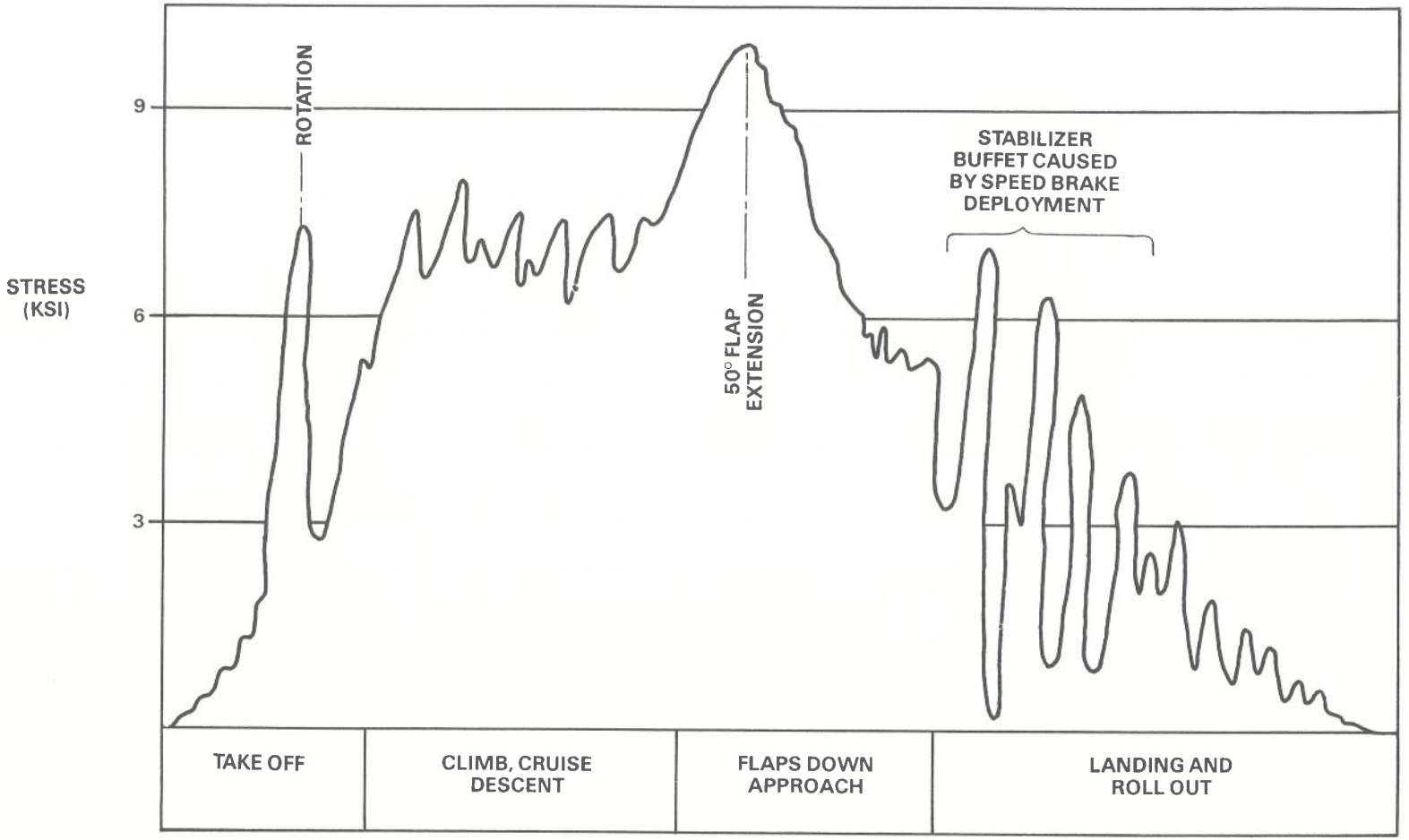


Figure 12 TYPICAL FLIGHT STRESS PROFILE – 707 300 SERIES HORIZONTAL STABILIZER STRESS IN REAR SPAR TOP CHORD

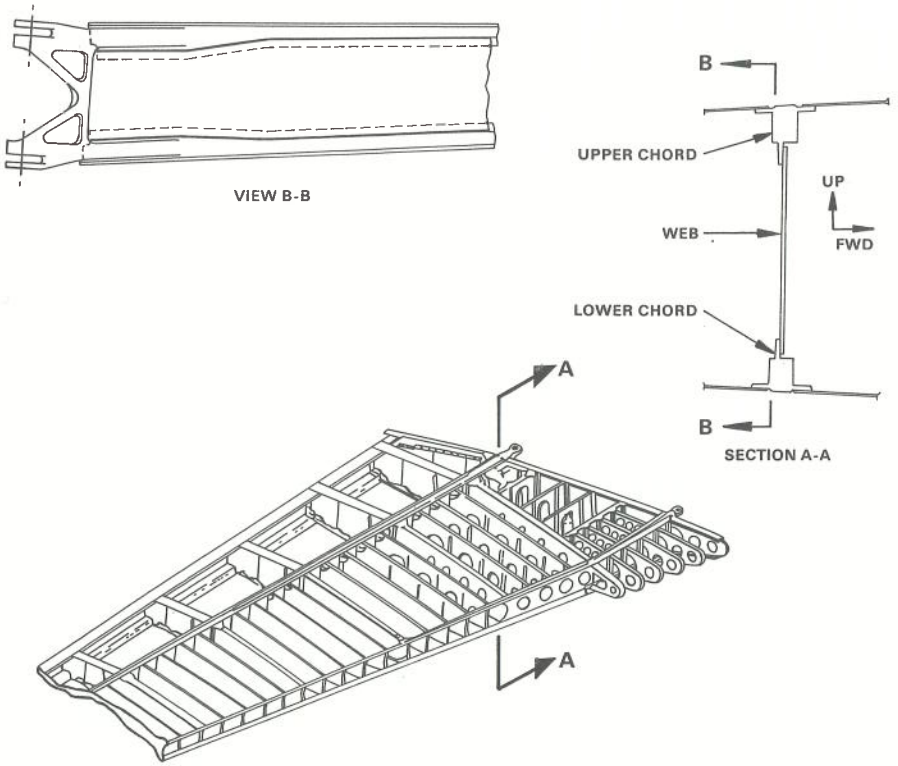


Figure 13a
BOEING 707-100 SERIES/720 SERIES.
HORIZONTAL STABILIZER STRUCTURE

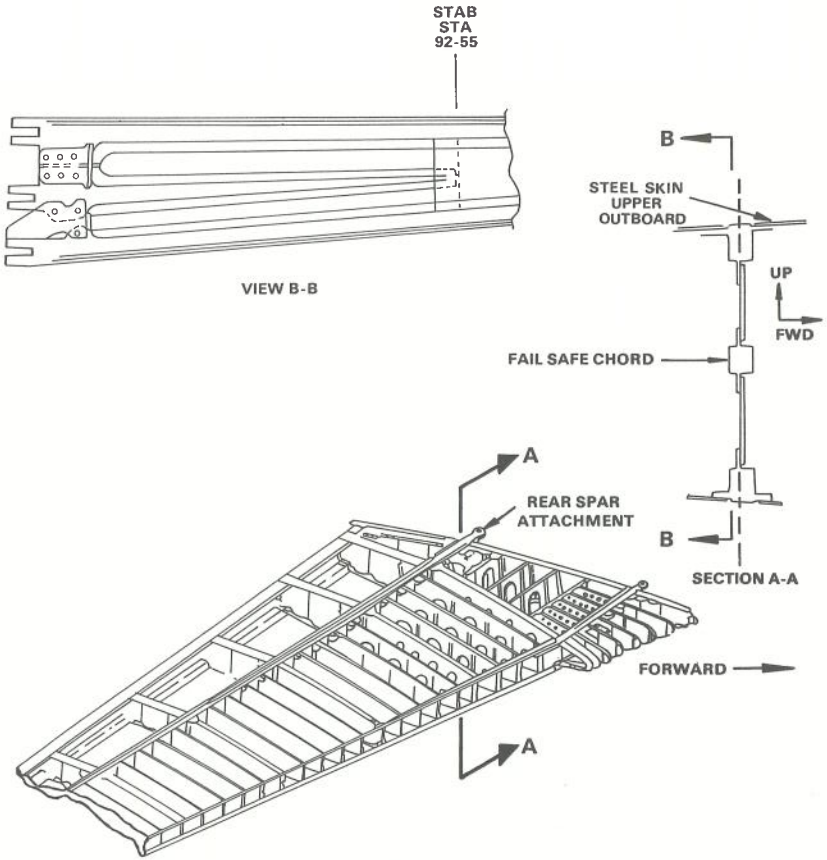


Figure 13b
BOEING 707 300 SERIES/400 SERIES.
HORIZONTAL STABILIZER STRUCTURE

COMPARISON OF THE TWO TYPES OF HORIZONTAL STABILIZER STRUCTURE ON THE BOEING 707.

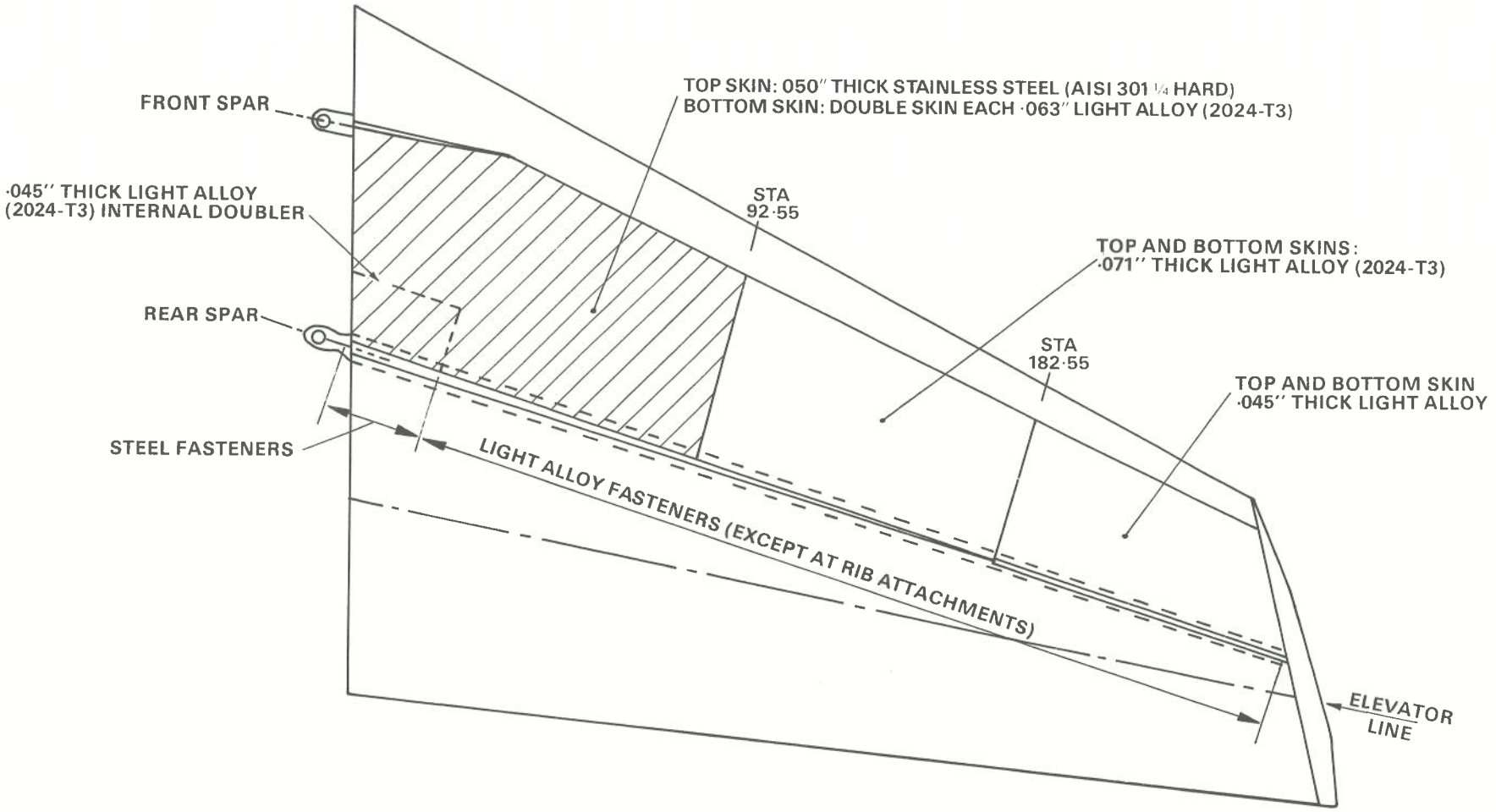


Figure 14 BOEING 707 300/400 SERIES. DETAILS OF TORSION BOX SKINS AND REAR SPAR FORWARD FLANGE FASTENERS

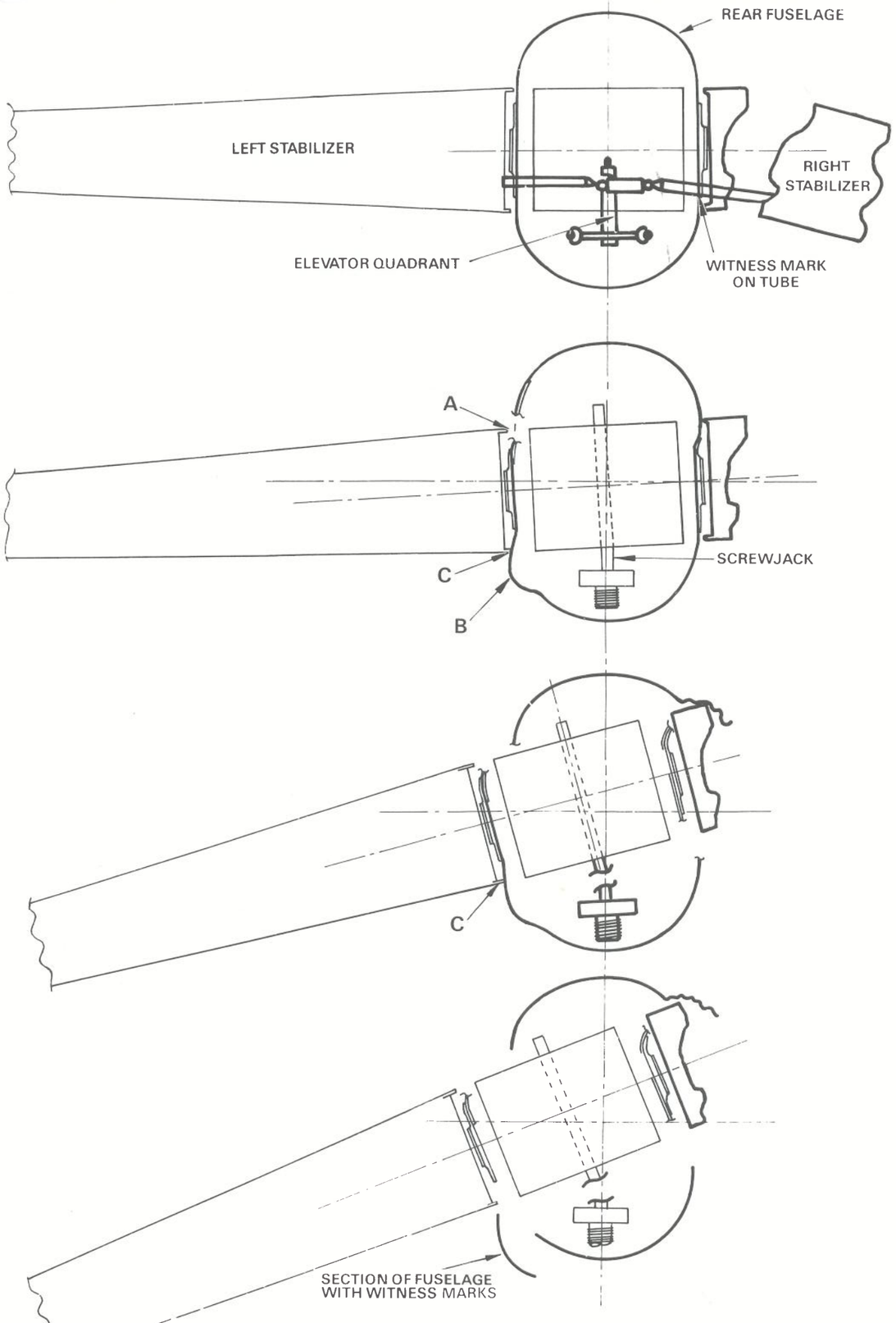


Figure 15 AIRBORNE BREAK UP SEQUENCE
(section through tail end of fuselage viewing forward)

(1) Failsafe spar chord fractures and right stabilizer separates from aircraft. Departing stabilizer pulls elevator push/pull tube from elevator quadrant (located in rear fuselage) forcing elevator control circuit to full-up elevator condition. Witness mark produced on push/pull tube by contact between tube and side of tube aperture in rear fuselage skin whilst at the full-up elevator position.

(2) Sudden loss of stabilizer download on right side combined with simultaneous increase in down load on left side (caused by full up elevator) produces excessive asymmetric load on stabilizer centre section to rear fuselage mountings. Left stabilizer wrenches tip downwards twisting centre section in rear fuselage and producing fuselage fracture at 'A', bulging at 'B' and 'S' shaped distortion of right hand pivot housing structure.

(3) Stabilizer pitch trim screwjack bends at base accommodate distortion.

(4) Witness mark (corresponding to stabilizer trim setting of 6¼ units aircraft nose up) produced at 'C' by contact between inner edge of stabilizer bottom skin and fuselage side skin.

(5) Left stabilizer tip downwards movement continues. Right hand pivot mountings torn from fuselage structure and whole left stabilizer moves outboard and downwards, pivoting about lower end of screw jack which bends further to accommodate movement. Left side lower fuselage skin remains attached.

(6) Screwjack fractures at base allowing whole stabilizer to rotate nose up about left pivot under influence of the full up elevator. Second witness mark produced at 'C' recording new stabilizer position.

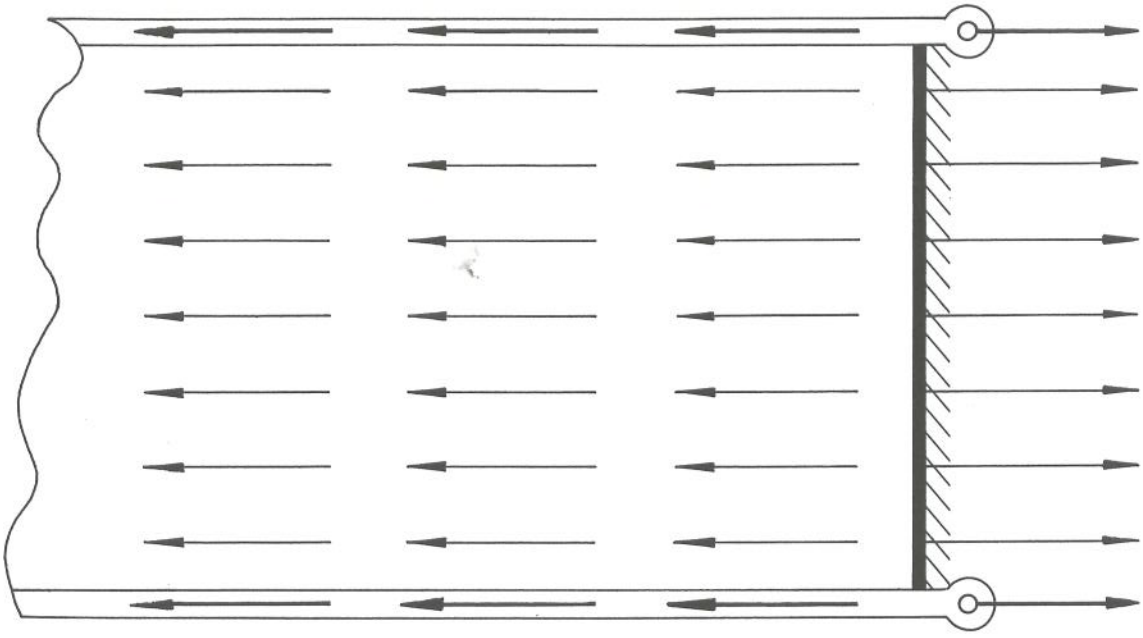
(7) Reduction in download caused by change in stabilizer incidence acts to reduce the downwards velocity of the stabilizer, but momentum prevents immediate arrest of movement.

(8) Stabilizer tip downwards motion continues to the point where the section of rear fuselage containing witness marks is broken out of aircraft by downwards movement of stabilizer rear spar.

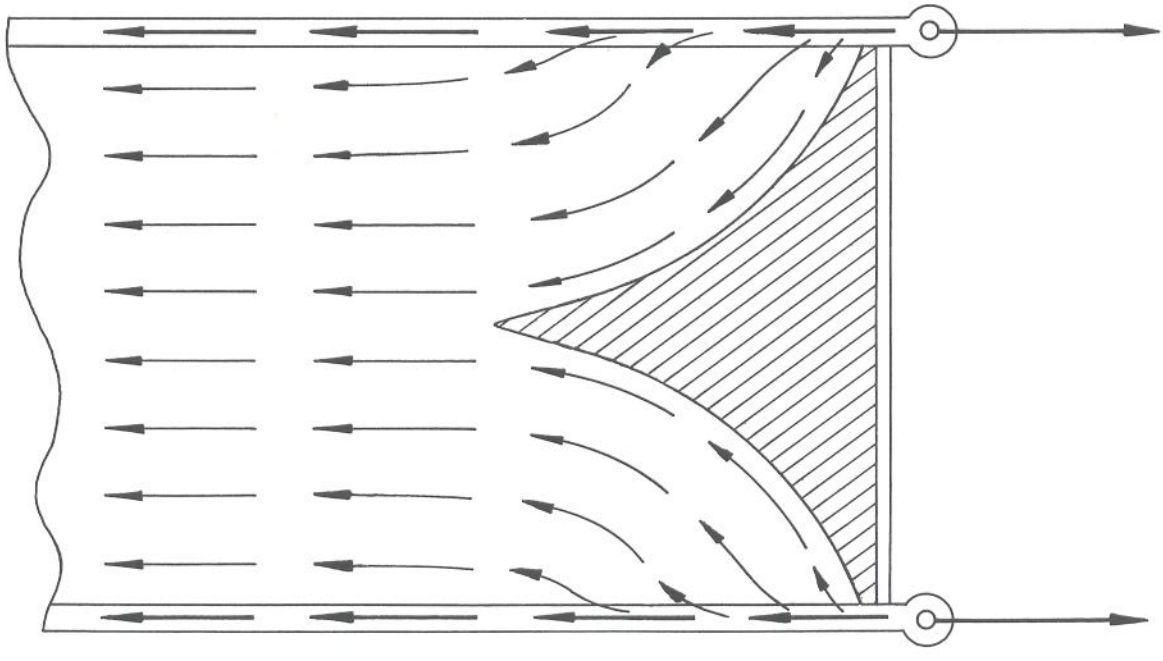
(9) Stabilizer tip downwards motion eventually ceases and stabilizer pitch attitude stabilizes in a high aircraft nose down condition.

Complete breakup sequence occurs in less than 0.5 second.

Produced in England by Her Majesty's Stationery Office, Reprographic Centre, Basildon



STIFF CLOSURE RIB



NON-STIFF CLOSURE RIB

Figure 16 EFFECT OF CLOSURE RIB STIFFNESS (IN BENDING) ON TOP AND BOTTOM SKIN STRESS DISTRIBUTION IN A TYPICAL WING BOX CONSTRUCTION

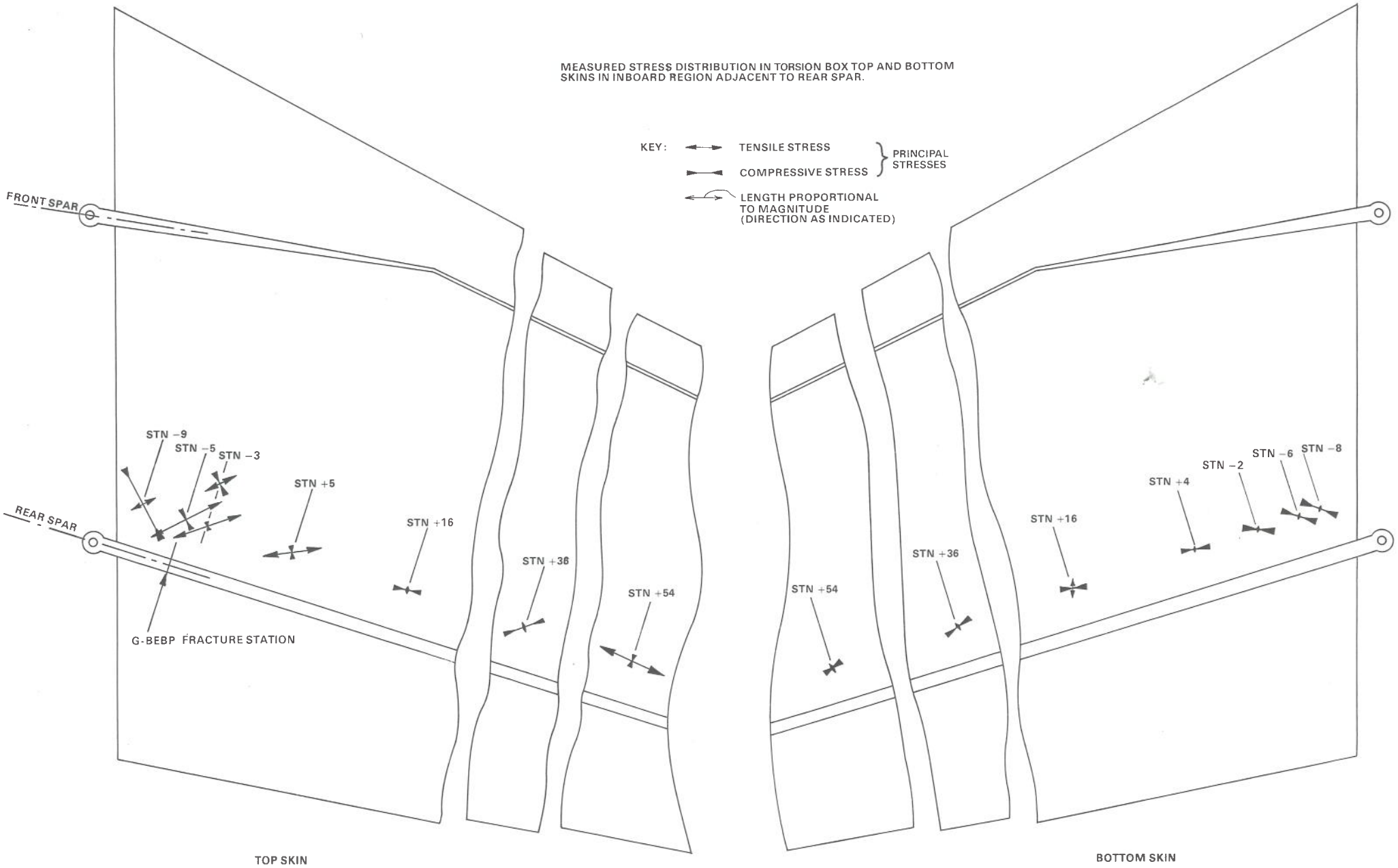


Figure 17 POST-ACCIDENT STRUCTURAL TEST DATA: SKIN STRESS DISTRIBUTION

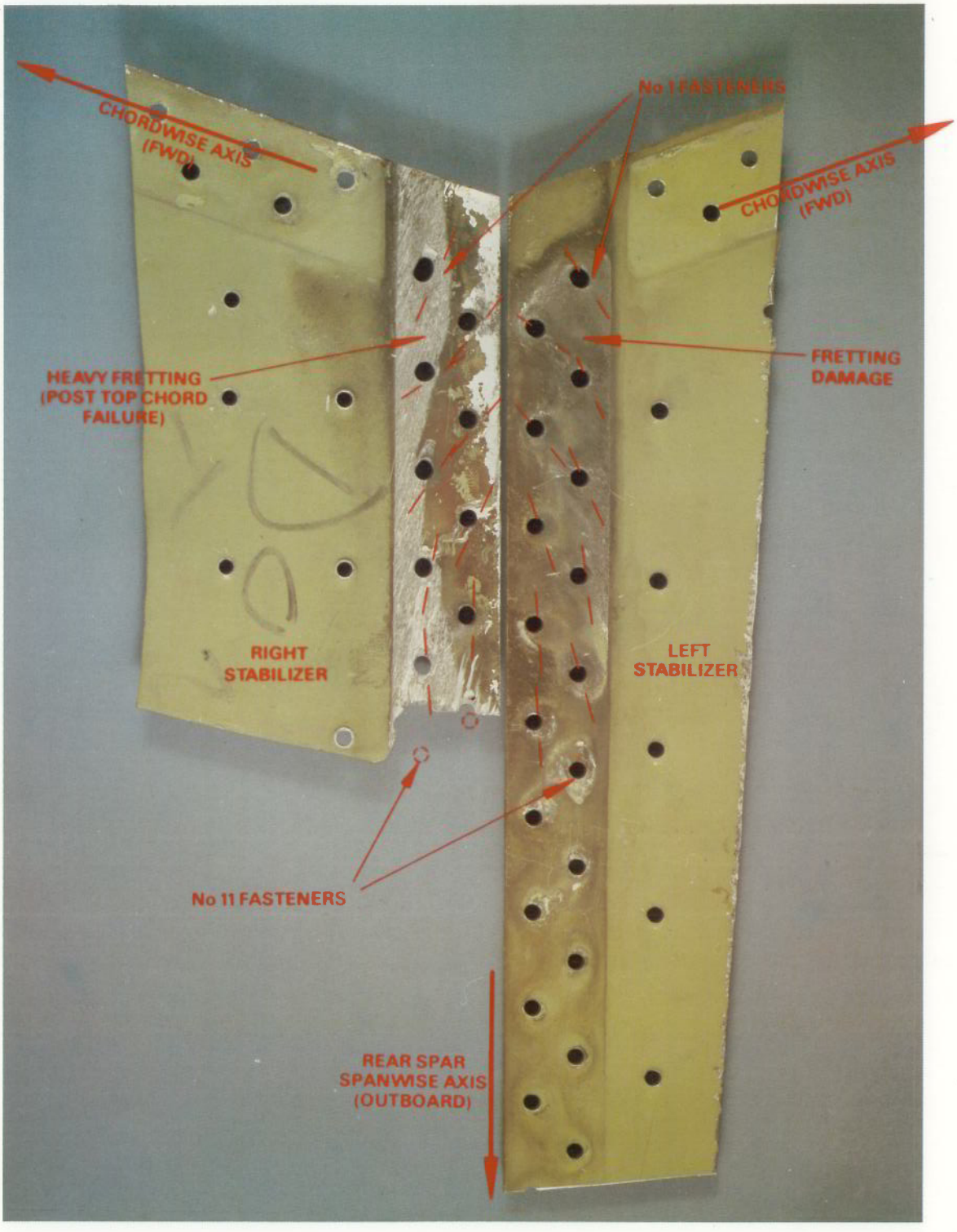


Figure 18 G-BEBP HORIZONTAL STABILIZER TORSION BOX TOP SKIN DOUBLERS FROM REGION ADJACENT TO INNER END OF REAR SPAR – Comparison fastener hole distortion patterns and fretting damage to inner face of skins from left (undamaged) and right (separated) stabilizers

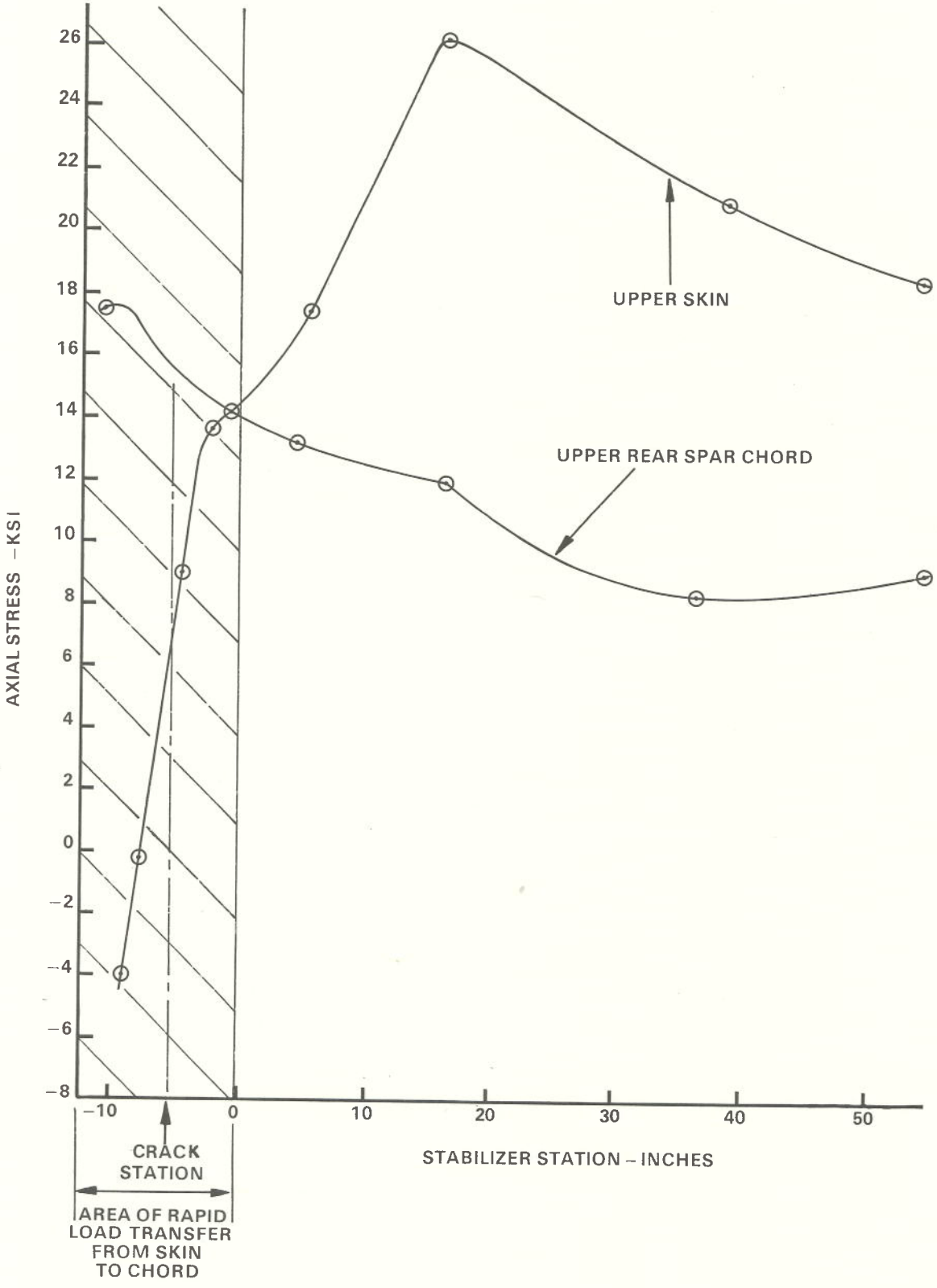
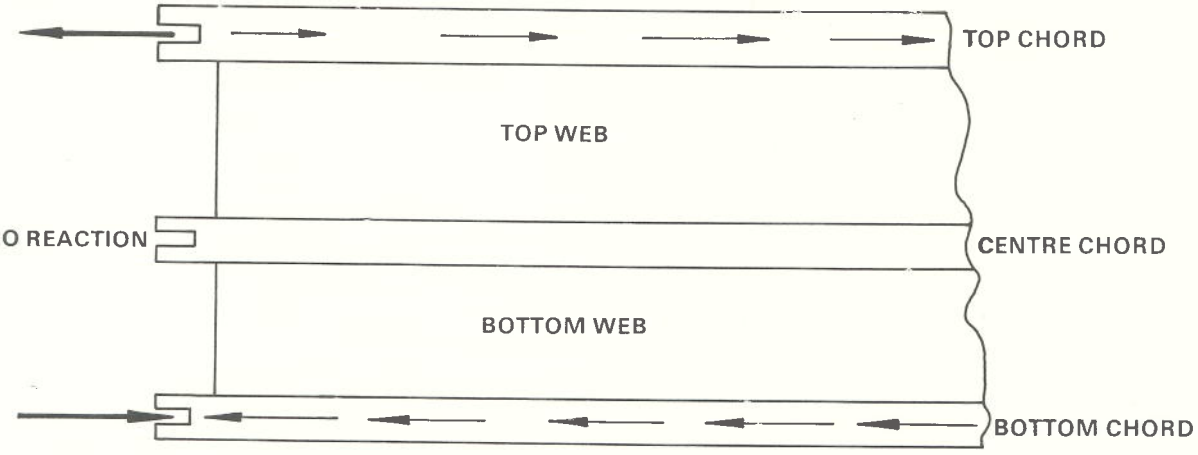
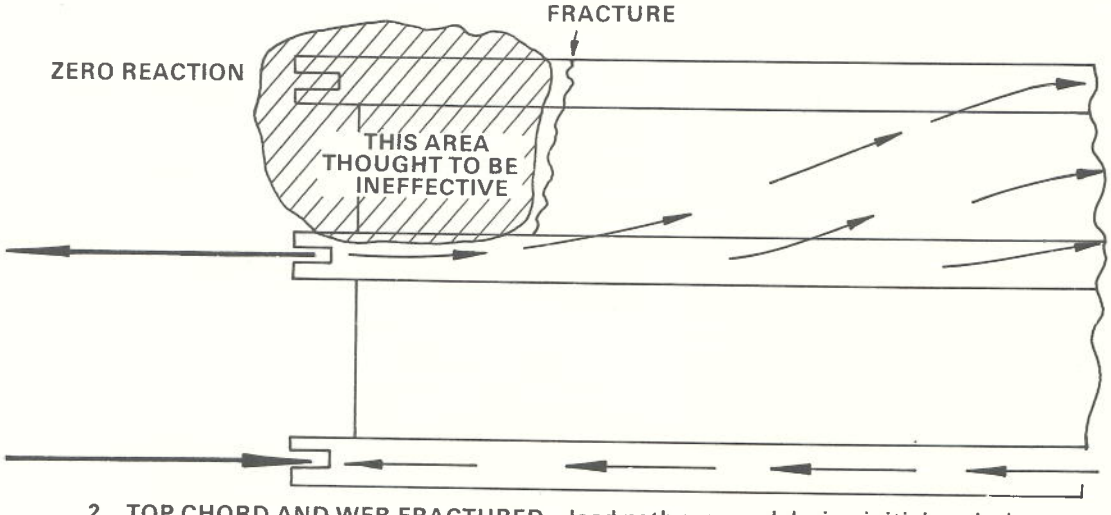


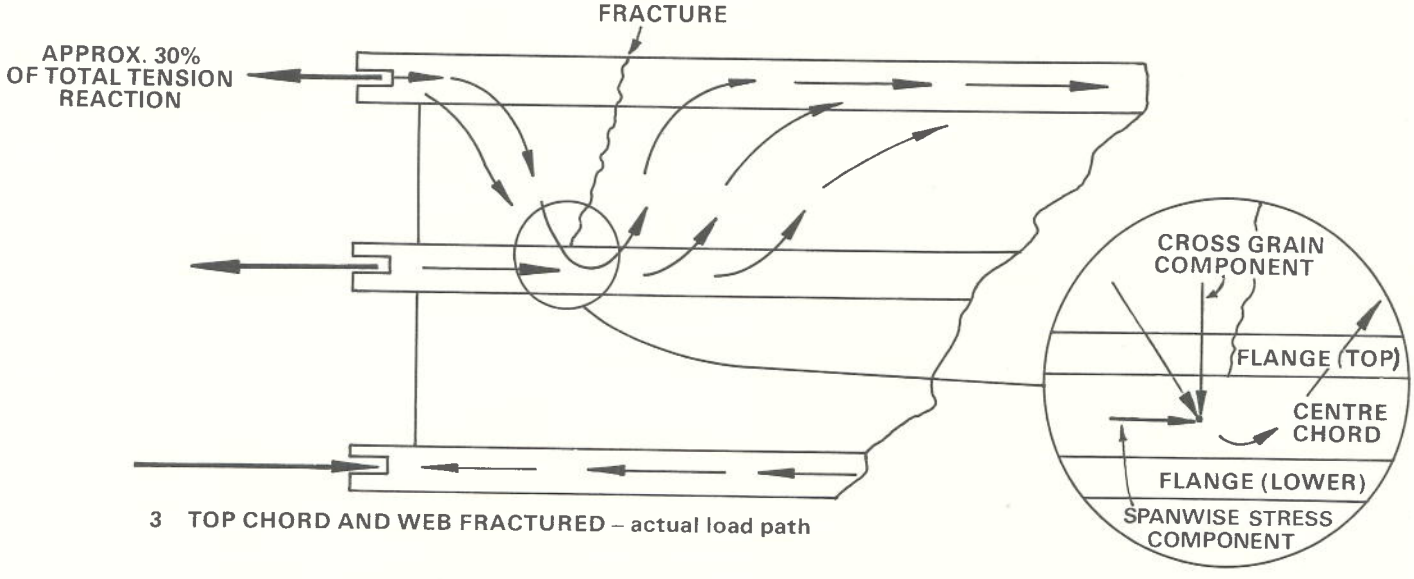
Figure 19 POST-ACCIDENT STRUCTURAL TEST DATA, SPANWISE STRESS COMPONENT IN TOP SKIN ADJACENT TO REAR SPAR



1 STRUCTURE INTACT – centre chord carries no load



2 TOP CHORD AND WEB FRACTURED – load path assumed during initial analysis



3 TOP CHORD AND WEB FRACTURED – actual load path

NOTE: CHORD FLANGE OMMITED FOR CLARITY

Figure 20 IDEALIZED LOAD PATHS IN REAR SPAR (shear loads omitted)

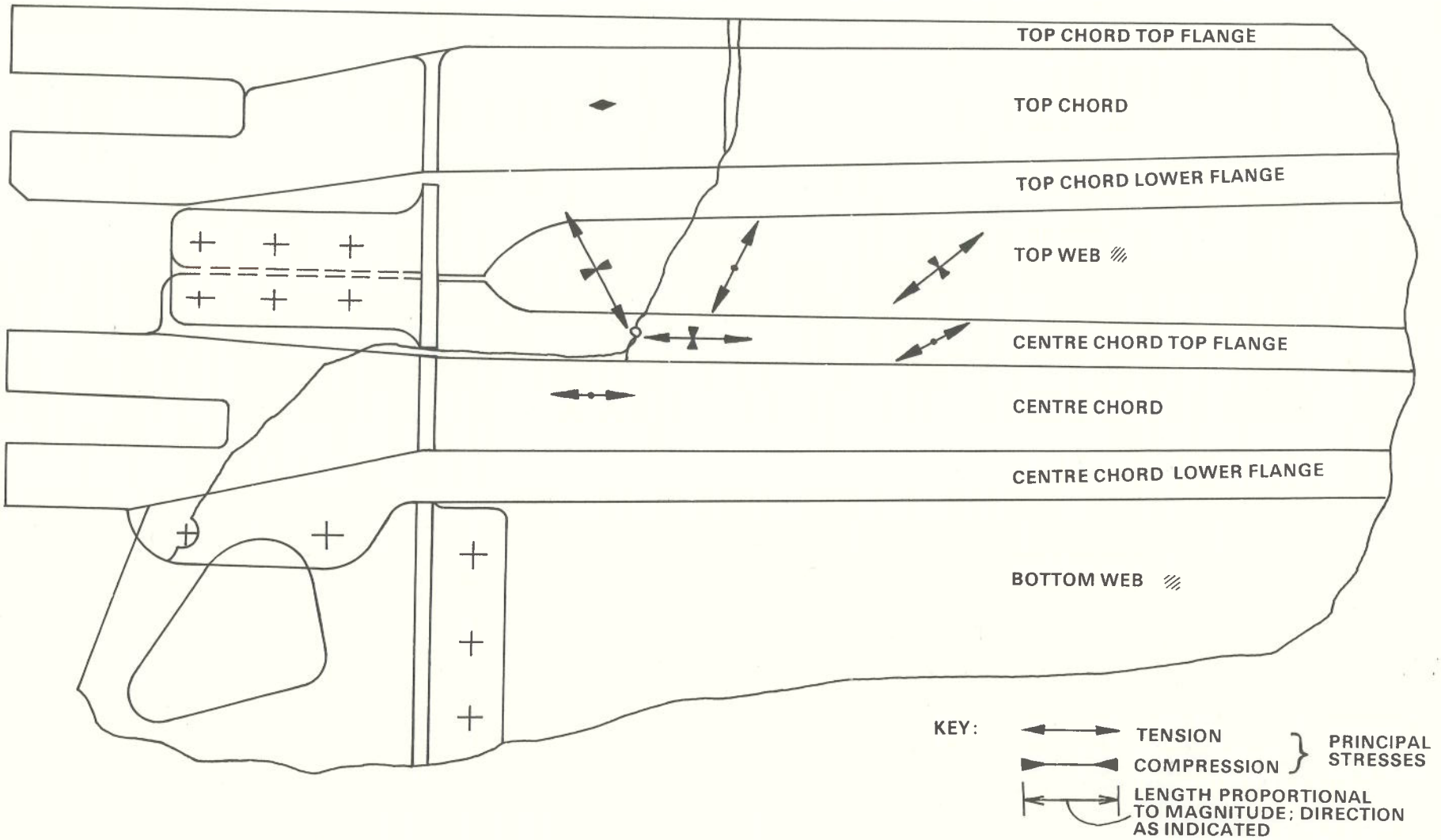
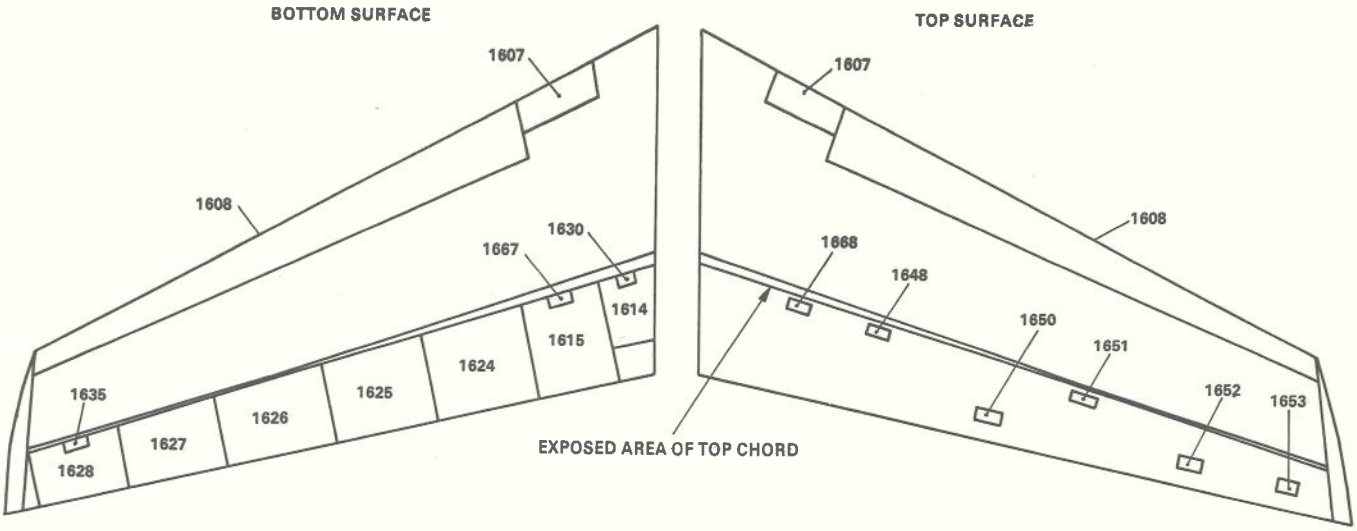
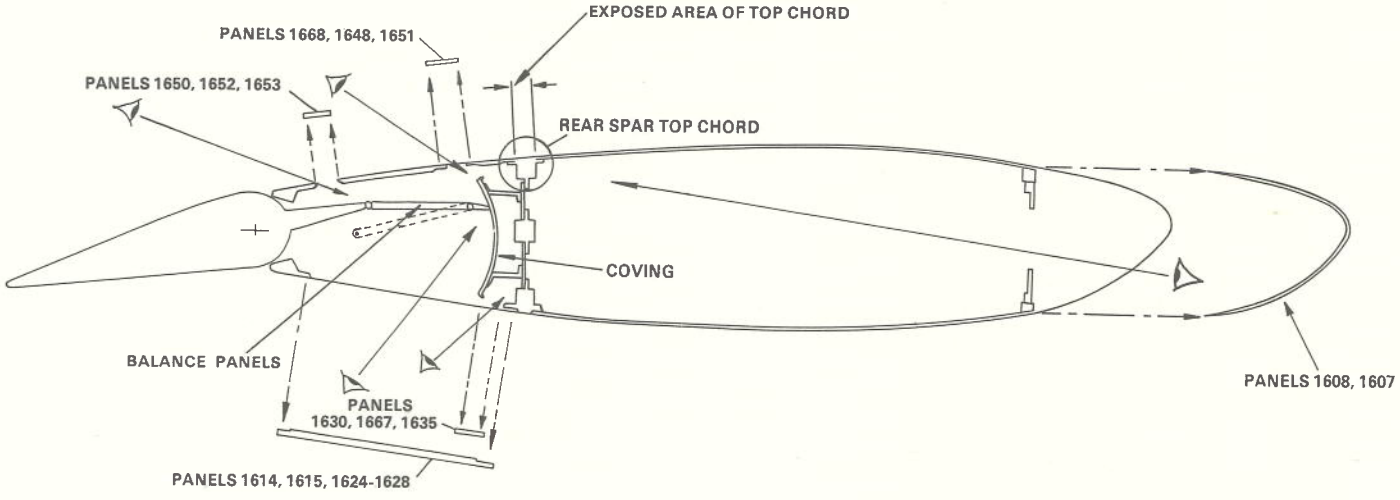


Figure 21 **POST ACCIDENT TEST DATA – stress distribution in rear spar adjacent to web fracture**





PANEL DESCRIPTION	PANEL REF. Nos.	BOEING RECOMMENDED PERIOD	DAN AIR SCHEDULE
TRAILING EDGE CAVITIES: BOTTOM SURFACE SMALL PANELS	1667, 1630, 1635	NONE	ALTERNATE 'C' CHECKS (2000 HRS.)
TRAILING EDGE CAVITIES: TOP SURFACE SMALL PANELS	1668, 1648, 1650, 1651, 1652, 1653,	NONE	ALTERNATE 'D' CHECKS (14,000 HRS.)
TRAILING EDGE CAVITIES: BALANCE PANEL COVERS (LARGE PANELS) EXCLUDING INNERMOST PANEL OVER BELL CRANK BAY	1615, 1624, 1625 1626, 1627, 1628	'C' CHECKS	ALTERNATE 'D' CHECKS (14,000 HRS.)
TRAILING EDGE CAVITIES: BOTTOM SURFACE BELL CRANK BAY COVER	1614	NONE	ALTERNATE 'D' CHECKS (14,000 HRS.)
LEADING EDGE SECTIONS	1608, 1607	SAMPLE INSPECTION ‡ FLEET EVERY 21,000 HRS. (84,000 HRS. MAX.)	SAMPLE INSPECTION ‡ FLEET EVERY 14,000 HRS. (56,000 HRS. MAX.)

Figure 22 BOEING 707-300/400 SERIES:ACCESS PANELS USED TO INSPECT INTERNAL STRUCTURE OF HORIZONTAL STABILIZERS