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

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STRUCTURES GROUP - WING CENTER SECTION 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	**Jim Powers** **Boeing Commercial Airplane Group** **Seattle, WA**
	Other Boeing Members **Arnie Reimer** **Warren Steyaert** **Bob Whittington**
Member	**Steve Green** **Air Line Pilots Association (ALPA)** **Herndon, VA**
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Member	**Dan Rephlo** **Trans World Airlines (TWA)** **Kansas City, MO**
Member	**Steve Klapack** **Federal Aviation Administration** **Garden City, NY**

1.0 CENTER WING SECTION

List of acronyms and abbreviations:

CWS	Center Wing Section
STA	Body Station
WL	Water Line
LBL/RBL	Left or Right Butt Line
BBL	Body Butt Line (also BL)
FS	Front Spar
MS	Mid Spar
RS	Rear Spar
LSOB/RSOB	Side-Of-Body (R or L), same as BBL 127.5
AFT	Aft direction
SWB	Spanwise Beam
RHS/LHS	Right/Left Hand Side

Notes:
1. See the attached figure for Center Wing Section configuration.
2. Detailed descriptions of all the damage to the CWS are presented in the various sections of the CWS documentation.
3. For fire and sooting damage, see Fire and Explosion Group documentation.
4. For metallurgical information, see Metallurgical Group documentation.

1.1 GENERAL DESCRIPTION

The center wing section (CWS) is a multi-cell box which connects the right and left wings through the fuselage. It is comprised of five cells formed by the Front Spar (FS), Spanwise Beam (SWB3), SWB2, the Mid Spar (MS), SWB1, and the Rear Spar (RS). The CWS extends chordwise from the front spar at approximately STA 1000 to the RS at approximately STA 1238 and spanwise between the left side-of-body (LSOB) rib at LBL 127.5 to the right side-of-body (RSOB) rib at RBL 127.5. The SOB ribs separate the CWS from the outboard wings. The MS from both of the wings connect through the CWS at fuselage STA 1140. There are three spanwise beams (SWB) in the CWS which extend from the left to right SOB ribs. SWB3 at STA 1042 is aft of the FS. SWB2 at STA 1096 is aft of SWB3 and forward of the MS. SWB1 at STA 1180 is aft of the MS and fwd of the RS. The CWS has upper and lower skin panels which are connected to all the spars and beams thus forming a closed box structure. The whole CWS box section is an airfoil shape and has the same contour as that of the outboard wings at the side of body. On N93119 (a 747-100) the center fuel tank is bounded by the RS on the back, a LSOB and RSOB on each side, and SWB3 on the front. The area between SWB3 and FS is a dry bay.

Typical design and construction of the FS, MS, and SWB's consist of "I" shaped vertical stiffeners which are connected to a web with rivets. The upper and lower ends of the vertical stiffeners attach to shear ties which are bolted to the upper and lower skin of the CWS. There are

tension fittings at locations where the spanwise beams intersect the longitudinal floor beams and where the spanwise beams intersect the keel beam. The upper and lower edges of the webs attach to "L" or "J" shaped chords. The horizontal flanges of these chords are fastened to the upper or lower skins of the CWS.

The RS and SOB ribs have "Z" shaped stiffeners which are connected to a web with rivets or bolts. The upper and lower skins have "Z" shaped stringers connected to the skins with rivets or bolts.

The MS, RS, SWB's, SOB ribs, and the upper skin panel utilize 7075 aluminum alloy. The FS web and the lower skin panel utilize 2024 aluminum alloy.

The CWS fractured into multiple pieces with the majority of the pieces recovered from the green debris area. Approximately 75% of the FS, 60% of the SWB3, and the manufacturing access door from the SWB2 were found in the Red debris area. Most major components of the CWS have been over 90% identified with the exception of the region of LSOB rib. The right side of the CWS both interior and exterior is generally much more heavily sooted than the left side. There are also localized area within the CWS which exhibit significant fire and heat damage. There is a wide range in size of the recovered pieces however some of the smaller fragments are associated with the LSOB region. The LSOB rib web was fracturd into numerous small pieces with an average size of approximately six to eight square inches. These pieces are curled and bowed and a general direction of deformation could not be determined. The web of the RSOB aft of MS exhibit evidence of outboard bowing. The entire upper skin from LSOB to RSOB exhibits a multiple wave deformation pattern. The lower skin panel exhibited no general deformation pattern.

Examination of the damage to the upper part of SWB3 and FS of the CWS revealed that the SWB3 fractured at the connection to the upper skin and rotated forward about the connection to the lower skin impacting the aft surface of the FS. The FS fractured at the connection to the upper skin panel and rotated forward into the forward cargo compartment.

1.2 FRONT SPAR (FS)

The front spar fractured into four large sections, covering most of the span, along with several smaller pieces. Outboard of LBL100 and RBL65, small FS segments were found in the green debris area. The middle of the FS consisting of 75% of the total spar was found in the Red debris area. The section comprising the center of the FS web (BL0) had two vertical ruptures, and the edges of the ruptures were curled forward at various locations. The FS web has punctures and small holes at various locations. The skin around the edge of the holes is either curled forward or aft.

Most of the FS stiffeners, which are attached to the aft side of the web, had impact damage on the aft flanges. The damage is approximately 11"-14" below the upper shear ties with the flanges generally crushed forward at these locations. This damage is consistent across the aft side of the FS web at various spanwise locations. Black impact marks were observed on the aft side of the spar

web just to the right of BBL 0 and on the aft flange of the adjacent stiffener at RBL 11.07. The impact marks are spaced approximately 1.5" apart and each mark is oriented approximately 45 degrees down (from the left horizontal). The impact marks on the web were located approximately 45 degrees forward and down to the left from the impact marks on the stiffener.

The left side bottom corner of the FS fractured into numerous small pieces. These pieces were curled 180 degrees forward and outboard. All of the pieces from this area were recovered from the Green debris area. The web segment from just inboard of the left SOB to LBL 76.00 (CW504) had no significant scrapes or gouge marks, and was relatively straight.

There was evidence of small fatigue cracks in the FS shear ties along the lower chord at several locations. Details of this documentation are included in the Metallurgical Group notes.

There was evidence of small (less than 1") "spike-tooth" fractures[1] at four locations on the web of the FS: RBL 5, RBL 6.8, RBL 30.99, and RBL 37.99. Details of this documentation are included in the Metallurgical Group notes.

1.3 SPANWISE BEAM #3 (SWB3)

The SWB3 fractured into five large sections, extending across most of the span, and several smaller sections. The right outboard segment from RSOB to RBL 78 was found in the Green debris area and exhibited fire damage. Three vertical stiffeners remained attached to the web, but were separated from the upper shear ties. The area of SWB3 near RBL 95 was laterally crushed and badly mangled, and the stiffeners were bent slightly forward. The web/stiffener structure is bowed forward from the bottom. Spike-toothed fractures were observed at seven locations on SWB3 between RSOB and RBL 83.24.

The structure from inboard of RBL 57 to LBL 75.9 separated into three large sections and was found in the Red debris area. There was light to medium soot on these sections. In general, the vertical stiffeners remained attached to the web but the lower shear ties had separated from the lower skin. The web of the beam in this area was relatively straight.

The section outboard of LBL 75.9 to LSOB fractured in numerous small pieces. All of these pieces were found in the Green debris area and exhibited evidence of sooting. The web was curled 90 degrees forward at LBL 100.

The forward face of this beam constitutes the aft face of the dry bay area of the CWS. All the heads of the rivets that are used to assemble the web to the stiffeners are coated with black sealant on the forward face. The spacing between the rivets is 1.5", in both vertical and horizontal directions. Most of the stiffeners exhibited impact damage and were fractured anywhere from 0" to 12" below the upper skin.

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[1] Fractures exhibiting a spike tooth characteristic are indicative of a very rapid strain rate produced by a high energy event.

1.4 SPANWISE BEAM #2 (SWB2)

The SWB2 fractured into four large and several smaller sections. All of the pieces were found in the Green debris area, except for one piece near the center (CW703) that was found in the Red area. The location of one piece (CW706) was unknown (white tag). The right outboard section from RBL 98.5 to the RSOB rib was heavily distorted and bent with multiple folds. The section from RBL 91.10 to RBL 25.2 (CW702) remained attached to the upper skin, and the web was fractured just under the upper chord from RBL 57 to the right outboard end. The lower edge of the web separated from the lower chord and the remaining fasteners in the web exhibited shear fractures. This piece exhibits spanwise compression damage (accordion shape) to the web and attached stiffeners. The outboard edge of this web section was generally curled aft. Spike-tooth fractures were evident in this section and the entire section was sooted with the exception of the lower edge of the web.

The manufacturing door with a small piece of web attached (CW703) was found in the Red debris area. The rivets that attached the door to SWB2 exhibited shear and/or tension failures. The door exhibited an S-shape deformation, with forward bending except at the lower left corner, which was bent aft and shows impact damage on lower edge. The deformed shape of the door did not match the shape of its surrounding structure. The door had three penetrations in the forward direction. Light soot, as opposed to heavy soot on the surround structure, was observed on the forward side of the door.

A section of lower chord and web from the right, inboard portion of SWB2 (CW704) was found in the Yellow debris area. The lower chord separated from the CWS lower skin and the fasteners attaching the chord to the skin failed in tension, except one fastener just outboard of RBL 9 which exhibited aft bending. The inboard edge of the web (inboard of the stiffener at RBL 9) had numerous horizontal fractures and was curled tightly forward at several locations. The web just outboard of the stiffener and directly below the door (CW703) was bent 180 degrees aft. The web inboard and outboard of RBL 25 has multiple penetrations with very jagged features around the edge of the hole. Spike-tooth fractures were observed on portions of the web section.

Section CW705, which consists of web and stiffeners just left of BL 0.0 including a honeycomb access door, was recovered in the Green debris area. The stiffeners, web, and door exhibited forward bending. The access door was bowed forward and the middle of the door was missing, with the surrounding honeycomb shredded forward. Most of SWB2 left of the door is missing.

1.5 MID SPAR

The mid spar fractured into one large section (RBL 85 to LBL 49) and several smaller pieces from the right and left outboard area (RSOB to RBL 68 and LBL 49 to LBL 110, respectively). One of the right outboard pieces was recovered from the Yellow debris area (CW805), but the rest were found in the Green debris area. Reconstruction of these pieces revealed no distinct deformation pattern of the web or stiffeners, but did contain evidence of sooting. The

lower end of the stiffener web flange on CW805 was bent inboard and aft.

The large section of the mid spar extended from RBL 85 to LBL 49 and from the lower chord to the upper chord (CW801), with 12 stiffeners remaining attached. This section of the mid spar exhibits evidence of fire damage and sooting. The lower chord is bent aft 45 degrees at LBL 17.27 and is fractured at RBL 34.00. The upper chord remains attached to the upper skin panel from RBL 17.00 to LBL 17.00. The left side of the mid spar was bent aft approximately 12" at LBL 44.65. The lower, left half of the mid spar bent diagonally aft from LBL 17.00 at the upper chord to RBL 34.00 at the lower chord. The extreme left lower corner at LBL 44.65 bent aft 90 degrees. The right access door was bowed slightly forward. A portion of the left access door aft skin was burned and bent aft. The forward skin of this door is missing.

The mid spar section from LBL 49 to LBL 110 fractured into numerous pieces. The bulkhead web attach flange of the stiffeners remained attached to the web for most of the pieces and the web is bowed aft both inboard and outboard about LBL 75. One section of the mid spar between LBL 60-90 exhibited an "S" shape deformation inboard to outboard and was sooted.

1.6 SPANWISE BEAM #1 (SWB1)

The SWB1 fractured into three large sections (on the left side) and numerous smaller sections. The smaller sections were located on the right side from RSOB to RBL 53.00 (CW903, CW909 to CW913) and were found in the Green debris area (except CW911, which has been tagged white).

CW909 included a 36-inch section of upper chord and the web between RBL 76 to RBL 40. Some of the fasteners common to the upper skin exhibited tension and/or shear failure. The free flange of the chord at the outboard end was bent up. The lower web edge at RBL 60 had a portion of the web bent forward, and exhibited spike-tooth fractures. Only the web flange of the LBL 49.6 stiffener remained and was bent forward. There was sooting on the skin flange and the web flange of the upper chord at the aft side and some sooting on the forward side of the web.

Two inboard lower web edges at RBL 67 (CW911) were curled aft. The upper portion exhibits a 4-inch long spike-tooth fracture along its lower edge.

The fasteners through the upper shear tie common to the upper skin on the SWB1 section from BL0 to RBL 53 remained attached and exhibited tensile failure.

The forward side of the access door remained intact and the aft face sheet was missing with very little damage to the honeycomb core.

The left side of SWB1 fractured into three large sections, (CW901, 902, 907) and each of the sections had evidence of heavy sooting with local areas of fire damage. A large section (CW901) extending from the stiffener at LBL 57.51 to approximately BL 0. This includes the upper chord, the web, one access door, stiffeners at LBL 11 through LBL 57.51, and stabilization

straps. The upper 34" of the stiffener at LBL 57.51 is not attached to the web and shows a shear failure of the rivets common to the web on CW902. The rest of the stiffeners remained attached to the web. The majority of the stiffener free flanges remain attached except at LBL 11.00. The stiffeners did not exhibit any notable bending in the fore/aft direction. The access door remained attached to the adjacent vertical stiffeners and web. There is a hole in the honeycomb core and the core ribbon around the hole is shredded in the aft direction.

1.7 REAR SPAR (RS)

The RS fractured into four large pieces (CW1001, CW1003, CW1004 and CW1006) and numerous smaller pieces. All were found in the Green debris area. Section CW1001 included the right hand rear spar terminal fitting (pickle fork fitting) and the rear spar web from upper to lower surface and from RSOB to RBL 85.00. CW1001 remained attached to a section of upper fuselage that was heavily burned. The pickle fork remained attached to the web but the free flange of the fork legs buckled/crippled, with the lower spar chord being displaced 12" to 16" aft of its original location. There was no soot on the forward side of the web and the aft side of the web was dirty, typical of its normal exposure to the dirt inside the wing landing gear wheel well.

The section inboard of the right pickle fork fractured into numerous smaller sections. Another section (CW1010) consisted of a lower portion of the web and lower spar chord from RBL 10 to RBL 85. The skin flange of the lower spar chord and the attached lower skin panel was bent upwards at RBL 52 at approximately a 20 degree angle. The fasteners common to the spar chord, web, and missing stiffeners (at the lower chord) showed tension failures.

A section containing a portion of the web from LBL 11 to RBL 33 at the upper spar chord and LBL 19 to BL 0 at 10" above the lower chord suffered damage on the entire periphery of the web, with the edges bent both forward and aft. The lower portion of the web was bent forward approximately 180 degrees. The CWS scavenge pump is not attached to the spacer plate or the spare web. The mounting spacer plate for the CWS fuel scavenge pump remained in place on the aft side of the rear spar, but it had been deformed away from the spar web except at the 9-11 clock position. The three bolts that mount the spacer to the spar web were in place and the safety wires were still attached. There was a partially sooted outline of the pump housing on the spacer plate and a difference in soot levels on the forward side of the spar web where the pump is mounted as compared with the remainder of the web. There is only a very light soot deposit on the spar web where the spacer plate has been deformed from the web. The forward side of the lower portion of the web that is bent up 180 degrees has a location that shows impact damage to the web and to the fillet seals on the fastener heads. This section shows heavy soot and fire damage on not only the forward and aft surfaces but also on the web and stiffener fracture edges. It also shows marked difference of soot levels as compared with the adjacent segments. The stiffener to web interface at LBL 11 shows both sooted and unsooted regions on the interface where the stiffener is missing. The protruding portion of the fasteners that have failed also show soot accumulation.(See Fire and Explosion group notes for details of the sooting and fire damage). Two segments of the rear spar (CW1009) remained attached to stiffeners that remained attached to the keel beam box.

The left outboard end of the CWS rear spar consisted of small (CW1008, CW1015 and CW1016) segments of the outboard leg of the left rear spar pickle fork fitting near the SOB, along with a portion of the left rear spar terminal fitting and the web adjacent to the fitting. The terminal fitting on CW-1008 was fractured on the inboard side at approximately the inboard edge of the pickle fork. The fasteners common to the pickle fork and terminal fitting on CW1008 remained intact. The outboard aft flange of the pickle fork (CW1015) was broken from CW1008, consistent with a counter-clockwise rotation of CW1015 (as viewed from above). The fracture was primarily in the fillet radius between the two portions of the fitting. The holes in the terminal fitting showed deformation downwards and inboard. Marks observed on the outboard side of the fail-safe strap on CW-1015 were coincident with the fastener locations on the adjacent outboard wing segment.

1.8 UPPER SKIN

The upper wing skin fractured into eight large sections and numerous smaller sections. All of these items were found in the Green debris area.

The right forward section (CW101), included part of the upper skin panel, stringers, and floor beams, extends from the RSOB to LBL 30, and from S-22 to the FS. The underside of the skin panel contains most of the stringers from S-22 to S-33 and includes the skin flange of the FS upper chord. The panel is bowed up approximately 12" at RBL 57.5 and the stringer at S-31, 32, and 33 are buckled and broken at RBL 57.5. The tension fittings at SWB3 remain intact on the lower side of the skin panel as well as the portion that remains attached to the floor beam on the upper side. (See sketch in CW602 for complete definition of remaining tension fittings on the lower surface). The left outboard end of the panel at LBL 30.00 has a very jagged fracture and has portions curled upwards as much as 45 degrees. The stringer splice fittings at RBL 127.5 (which attaches to the RSOB) at S-30 to S-33 remain attached to the stringers. The fastener holes common to the double plus chord are elongated inboard and outboard at the lower surface of the holes with a slight elongation on the upper surface of the holes. There are small metal fragments embedded in the sealant on the lower surface of this panel. (See Metallurgy Group Report for further description of these fragments.) There is no evidence of pre-existing cracks or corrosion on this panel. Some sooting is evident on the lower surface of the panel.

The left forward section of the upper skin fractured into smaller sections. The inboard fracture edge at LBL 30 is jagged and curls upwards at 45 degrees. The outboard edge bends down at a 45 degree angle on a 15" radius and has jagged edges. The forward portion of the upper skin is buckled in an "S" shape as viewed from the front (view looking aft).

The mid section of the skin fractured into three large sections on the right and several smaller sections on the left. The right portion of the upper skin (CW104) remains attached to RW-7 which was cut for reconstruction. The stringers at S-24 through S-26 have no skin panel above them and approximately 25" of each stringer is bent upwards at 90 degrees. There is evidence of heavy sooting in this area.

The fasteners remaining in the double plus chord free flange and the stringer end splice

fittings at S-31 through S-33,(CW104) exhibit shear failures in both inboard and upward directions. This section exhibits sooting and fire damage.

A large piece of mid upper skin extending from the rear spar to S-18 with its inboard edge at RBL 80 (CW105) is still attached to the upper section of the fuselage (RF17) that is heavily burned. The fracture line running approximately at RBL 80 is extremely jagged, and the end of the panel and the attached stringers are bent upwards at 45 degrees starting at RBL 100. The upper chords of the stub beams that attach to the RBL 98 floor beam are buckled and bent aft. The inboard end of the stringers S-10 through S-13 match the general deflection of the upper skin panel. The tension fittings at RBL 98 at both SWB1 and the MS remain attached on the upper and lower surfaces of the skin. A portion of both the MS and SWB1 remain attached to the upper skin near the RSOB. The portion of SWB1 is bent aft at its inboard end and the portion of MS is bent slightly forward at its inboard end. There is heavy sooting and fire damage on the upper surface and some soot on the lower surface.

A very large section of the upper skin mid section (CW102) includes of portion of skin panel, stringers, and floor beams that extend from RBL 78 to LBL 45, and from SWB1 to S-22. It also has a large section of MS (CW801) and SWB2 (CW702) still attached. The skin panel has multiple smaller fractures and bends of varying radii in several directions, but is generally bowed up at the inboard and outboard ends. The fracture edge at LBL 45 has a local curl down. The forward edge of the panel at SWB2 is bent upwards at 35 degrees and there is a fracture in the panel aft of SWB2. Just forward of SWB2, there is a 3 inch x 1 inch vertical puncture in the skin. At LBL 20 just aft of the MS, there is a semi-circular 6 inch x 8 inch delamination on the skin lower surface that is bent down approximately 4 inches from the inner surface of the panel. It remains attached on the inboard edge. Small metal particles were found imbedded in the sealant in the lower surface of this panel. There is evidence of heavy fire damage.

The aft side of the upper skin fractured into two large pieces and several smaller pieces at the aft left corner. The right aft side (CW103) extends from LBL 5 to RBL 100 and from RS to SWB1. The upper surface of this panel is burned. Only the skin flange of the upper rear spar chord remains attached. The forward edge of the fracture goes through the fastener line at SWB1.

The inboard edge of the panel is bent upwards 10 degrees starting approximately at RBL 8. The left side (CW135) extends forward from the rear spar to SWB1, and from LBL 98.6 inboard to about LBL 5. The panel is bowed up approximately 12 inches about a fore-aft axis located at its mid span.

A significant portion of the left side of the upper skin, inboard of the LSOB, fractured into numerous small sections.

1.9 LOWER SKIN

The lower skin fractured into six large sections and several smaller sections. All these sections were found in the Green debris area.

The entire right side of the lower skin (CW201) extends from S-1 to S-23 was cut from the lower right hand wing skin (RW-3) for reconstruction of the CWS. The inboard edge of the skin from rear spar to S-5 is curled down and the stringers are separated from the panel from S-1 to S-4. At S-5 the stringer matches the periphery of the panel and remains attached. Between S-6 and S-8 there is a portion of the panel that is fractured at RBL 110 and the outboard edge is bent downwards whereas the inboard edge between S-7 and S-8 is bent upwards. The skin between S-11 and S-13 extending inboard, has a very jagged fracture pattern and is bent both upwards and downwards at multiple locations. The skin portion between S-15 and S-23 exhibits general upward bending with multiple smaller curvatures both upwards and downwards. Just forward of S-21, the skin is fractured from RBL 127 to RBL 100 and the outboard edge of the skin forward of this fracture is bent down. The skin splice stringer flanges remain attached to the skin panel with some fasteners, and the majority of the remaining fractured fasteners indicate tension failures. The majority of the fastener holes on the skin do not exhibit elongation except at SWB1, S-17 and S-22, where there is some elongation of holes fore and aft. On the forward right outboard side of this section, there is evidence of pillowing of the skin between the stringers in an upward direction. There is evidence of fire damage and soot accumulation. (See the Fire and Explosion Group notes for further detail).

The forward side of the lower skin separated in two large and three smaller sections (RH corner). The forward left side (CW-221) is a large section of skin panel with stringers that extends from the LSOB to RBL 33 and from S-15 to the FS. Using the area at BL 0 as a reference, the panel bends down 15 degrees at LBL 43 going outboard and bends up at a 10 degree angle at LBL 72. The depth of the bend is 7 inches at the FS and about 12 inches at SWB 3. There are small fatigue cracks on the aft side of the FS shear ties at LBL 84 and LBL 92. There is also a small fatigue crack at the fillet radius of the FS chord near the longeron splice at LBL 80. (For documentation of the fatigue cracks, see Metallurgical Group report.) The upper tension fitting on the upper surface of the skin panel at the longeron splice is fractured through the tension bolt hole and is deformed at the forward end. The lower tension fitting attached to the lower surface of the panel is intact, but the hole for the horizontal tension bolt is elongated vertically. The underwing longeron fitting exhibits a tension failure at the aft bolt hole with some bending to the left. There is some soot on the inner and outer surfaces of the skin panel.

The mid section of the lower skin fractured into one large section (CW207) and numerous smaller sections located on the right and left sides. The panel (CW207) is bent down at the center (approximately LBL 50), and there is a fracture near the forward edge that extends from the inboard edge aft of SWB2 to LBL 16. This fracture produced a section of skin panel that is bent sharply up at the aft edge and down at the forward edge. There are only a few rivets remaining in the skin panel and they exhibit shear failures. Only a portion of the skin flange of the keel beam attach chord remains attached with some fasteners, and the remaining fractured fasteners exhibit tension failures. The fastener hole that is common to the keel beam tension fitting at SWB2 exhibits elongation in the forward direction on the lower surface. The upper and lower surfaces are sooted.

The aft section of the lower skin (aft of MS) fractured in two large sections and various smaller sections at the aft left corner. A large section (CW205) is bent in "S" shape and is comprised of skin panel and stringers that extend from S-4 to the midspar (S-10) and from the

LSOB to approximately RBL 92 (70). The S-7 and S-8 stringers remain attached to this section at the LSOB paddle fittings and are bent and twisted in several directions. There is a puncture in the skin panel 6 inches forward of SWB1 at LBL 37 with the surrounding skin bent down. The right end of this section has the general shape of an upward deflected dome that is as high as 14 inches in relation to the adjacent structure. The dome is centered about RBL 57.5 between S-8 and S-9. The sections around this area including CW232, CW231, and CW201 exhibit this same general domed shape. A spike-tooth fracture occurred at RBL 39 just forward of S-9. There is soot on the upper and lower surfaces of the panel.

Another large section (CW202) extends from RBL 98 to LBL 69 (60) and from approximately S-1 to S-5 and has only a small section of S-5 skin flange remaining attached. The panel is bent in an inboard/outboard direction with the RH and LH sides both bent downward from BL0. The right side is bent down approximately 10 degrees and the left side is bent down starting at 10 degrees and gradually increasing to about 45 degrees. The few rivets remaining in the skin panel exhibit shear in an inboard and outboard direction, but the fasteners at RBL 57.5 at S-2, 3, and 4 are bent aft ranging from 45 to 60 degrees. On the right outboard side of this section, there is evidence of pillowing of the skin between the stringers in an upward direction. The keel beam attachment stiffeners at RBL & LBL 9.0 have pulled away from the lower skin and the fasteners exhibit evidence of tension failures. There is evidence of sooting on the lower surface of the skin.

1.10 RIGHT SIDE-OF-BODY RIB (RSOB)

The RSOB fractured into six larger sections and numerous smaller sections. The majority of the pieces were recovered from the Green debris area. Recovery locations of some of the sections are unknown and are designated with white tags. These pieces were assembled on the floor to determine the mode of failure. In general, the RSOB exhibited evidence of outboard bulging in the forward and mid sections.

The RSOB forward section is comprised of CW308, CW309, CW310, CW317, and CW335 which exhibit evidence of outboard bowing when assembled. In addition, other forward smaller sections (CW313, CW314 and CW317) also exhibited evidence of bowing. One piece (CW314) is bowed inboard at the center with rivets remaining in the fastener holes that exhibit shear failures. CW313 and CW317 are heavily bowed outboard at their centers. CW313 has a few fasteners remaining in the holes that exhibit combinations of tension and shear failures. CW317 has rivets that exhibit tension failures and some that exhibit shear failures. The webs of all three sections are sooted on the inboard side and clean on the outboard side.

The mid section of the RSOB is made up of CW303, CW304, and CW323. The segment CW303 extends forward 36 inches from the MS location up to SWB2, and is 40 inches high. The upper edge of this segment remains attached to the double plus chord vertical flange located between CW301 and CW302. The web is generally flat except for the lower fracture edge which has a slight inboard curvature (an indication of outboard bowing). There are soot deposits on this part. The section CW304 previously had a Yellow tag and was changed to a White tag. The aft fracture edge of this part mates with CW323. A small section CW323 has forward and aft sides

bowed inboard 2 inches about SWB1 stiffener. When assembled with other pieces this section exhibited evidence of outboard bowing.

The aft section of the RSOB includes CW305, CW306, CW311, and CW312. The section CW305 contains the first two stiffeners aft of SWB1 and exhibits a significant outboard bulge of heavy web and stiffeners. The fracture lines are clean. The remaining sections of the aft RSOB are relatively flat.

1.11 LEFT SIDE-OF-BODY RIB (LSOB)

The web of the LSOB fractured into numerous small sections. The average size of the web pieces are approximately six to eight square inches. About 70 percent of the web remains either unrecovered or unidentified. Recovered pieces are curled and bowed, and a general direction of the bow could not be determined.

The lower chord of the LSOB rib fractured into numerous smaller lengths ranging from 2 inches to about 20 inches. These chord sections have "U" or "S" shapes. The lower chord pieces were assembled to determine the mode of failure. The assembly exhibited a general inboard outboard wave shape running forward and aft. The MS stiffener fractured into two sections (CW407A and CW407B). The lower section (CW407B) remained attached to the lower chord and is bowed outboard. The upper mid spar section (CW407A) is bent 90 degrees outboard at the lower end. There is no evidence of any fire damage or soot accumulation on the pieces of the LSOB rib.

1.12 BODY BUTT LINE 0.00 RIB (BBL 0)

The BBL 0 rib extends from the MS to SWB1 (forward bay), and from SWB1 to the RS (aft bay) along the centerline of the center wing tank. The aft bay section fractured into one large and several smaller pieces. The forward bay fractured into several pieces. All the pieces were found in the Green debris area.

A large section (CW1103) of the BBL 0 rib, extends from SWB1 aft to CW1102 (about 8 inches forward of RS) and from the upper skin panel down to a few inches above the lower skin panel. This section is bowed about 5 inches to the left at its center. The connection at the forward end where the rib attaches to the SWB1 is bent to the right. All the vertical stiffeners remain attached to the panel, except some have outer flanges missing. There is evidence of sooting on both sides of the part.

The BBL 0 rib between MS to SWB1 fractured in several smaller sections. A segment (CW1101) of the BBL 0 rib from the MS extending aft 20 inches has a general "S" shape along the forward vertical edge. The bow in the upper end is centered about 11 inches from the top and bows to the right. The bottom has jagged fractures which are bent up and to the left. A small section (CW1105) mates to CW-1101 and is fractured just above the lower rib chord on the lower side. The fractures around the periphery of the part do not follow fastener lines. There is a flap of web on the front of the part about 4 inches wide that is folded over to the right. CW-1106 extends from the

SWB1 forward about 10 inches and from the upper chord down 52 inches, and is generally flat. The top 6 inches of the forward edge is folded down to the left. All the sections between MS and SWB1 exhibit evidence of sooting.

CENTER WING TANK - GENERAL CONFIGURATION

CW Designation

Upper Skin	CW-100
Lower Skin	CW-200
RSOB Rib	CW-300
LSOB Rib	CW-400
Front Spar	CW-500
SWB #3	CW-600
SWB #2	CW-700
Mid Spar	CW-800
SWB #1	CW-900
Rear Spar	CW-1000
BL 0.0 Rib	CW-1100

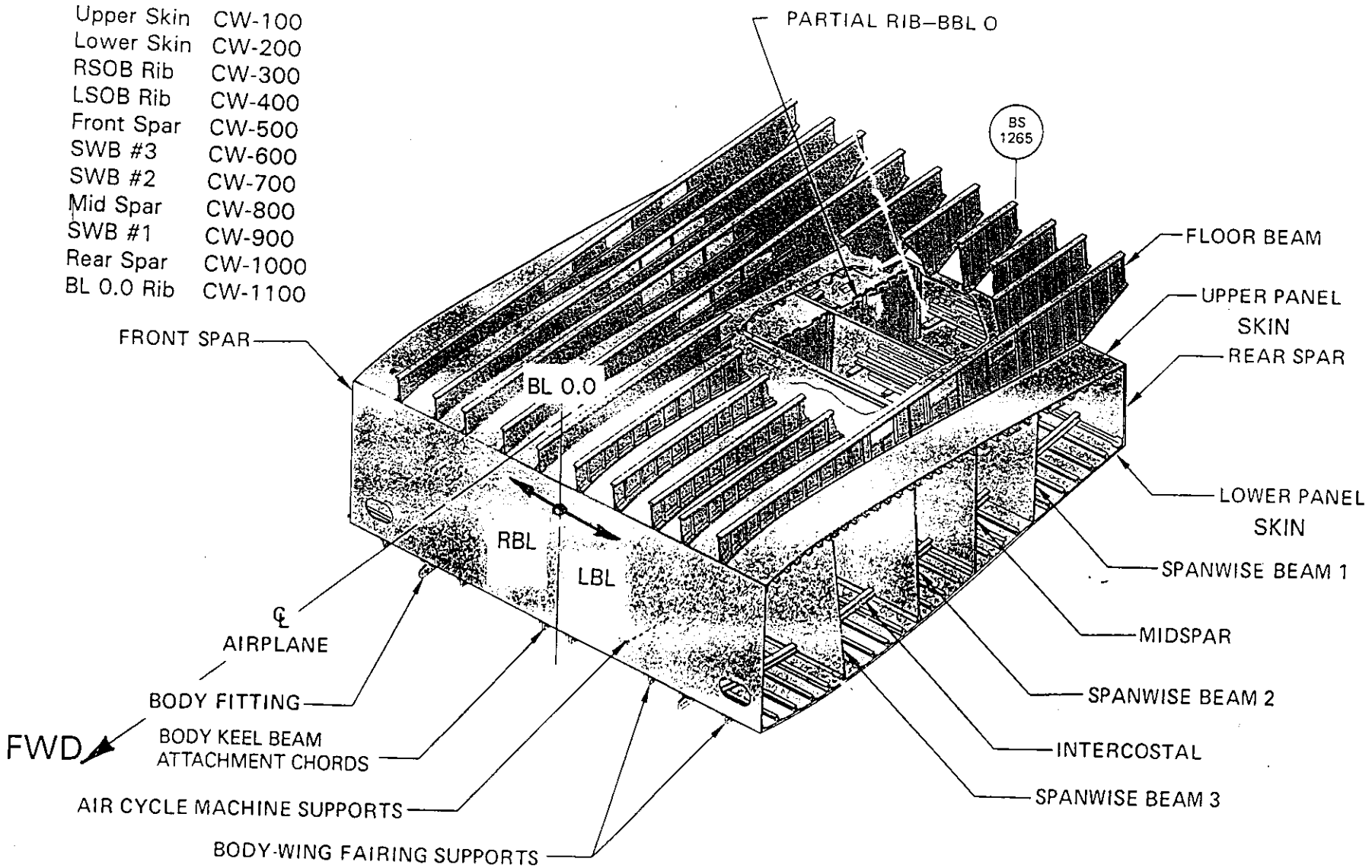
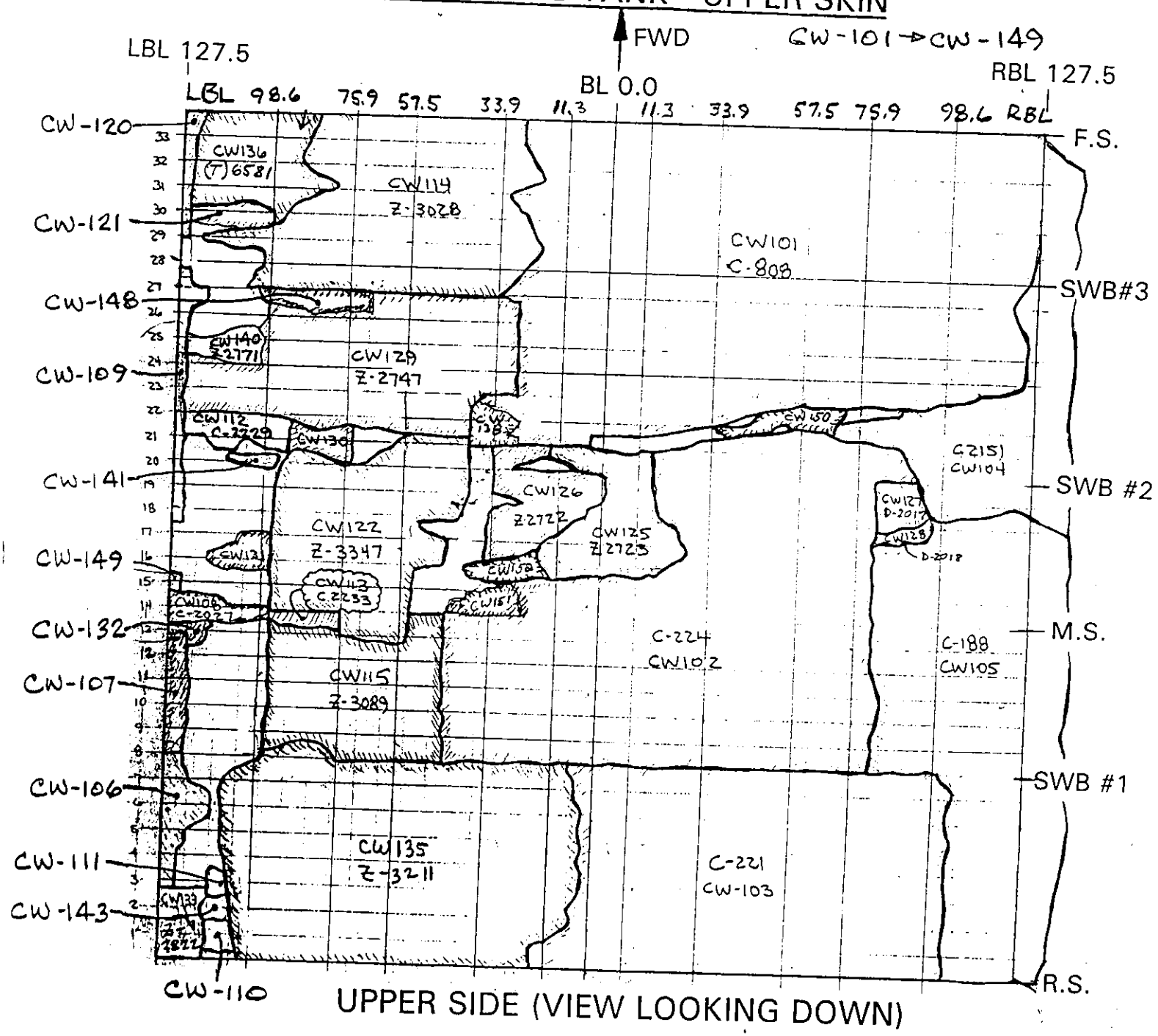
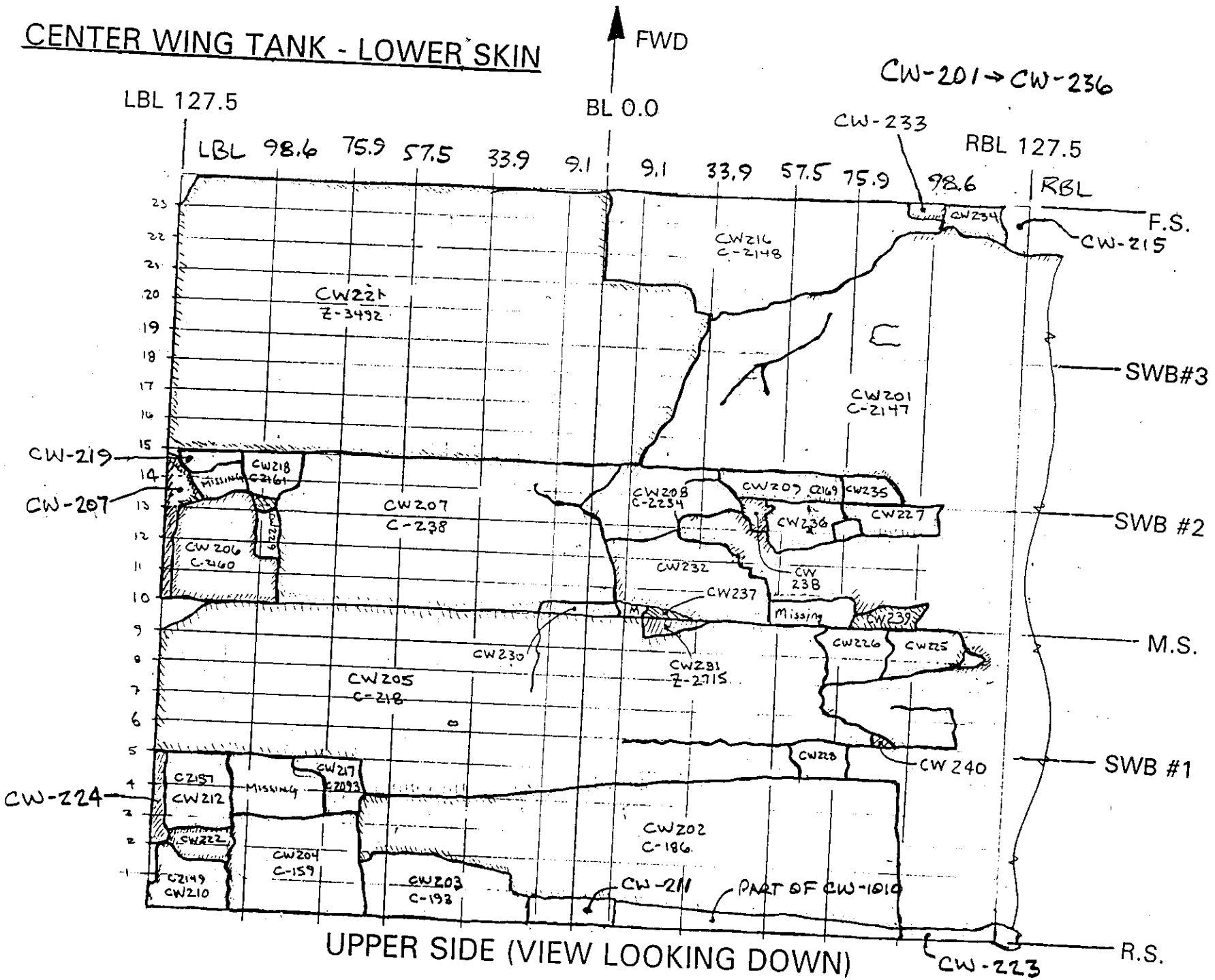


FIGURE 1

CENTER WING TANK - UPPER SKIN



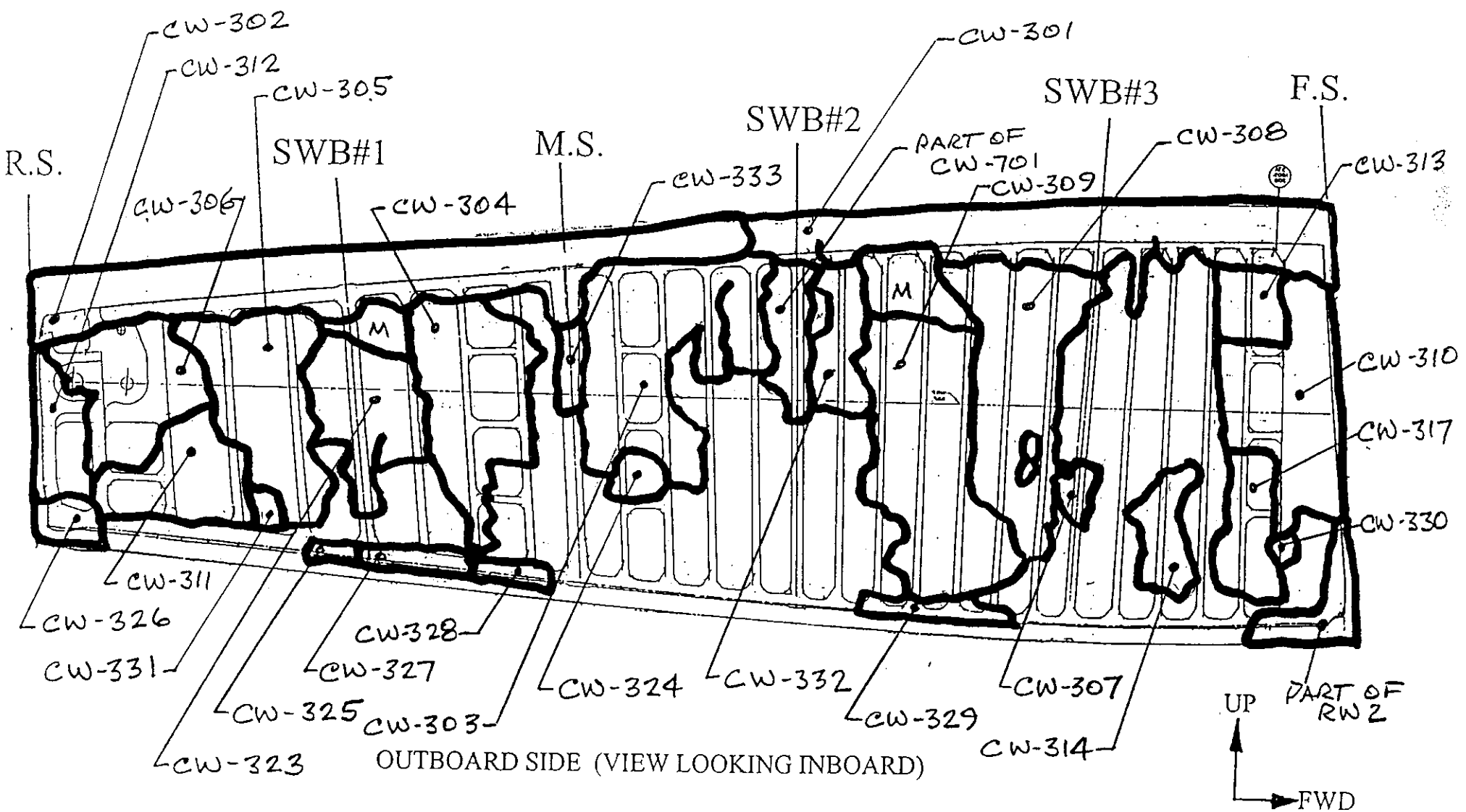
CENTER WING TANK - LOWER SKIN



CWT SIDE-OF-BODY RIB RBBL 127.5

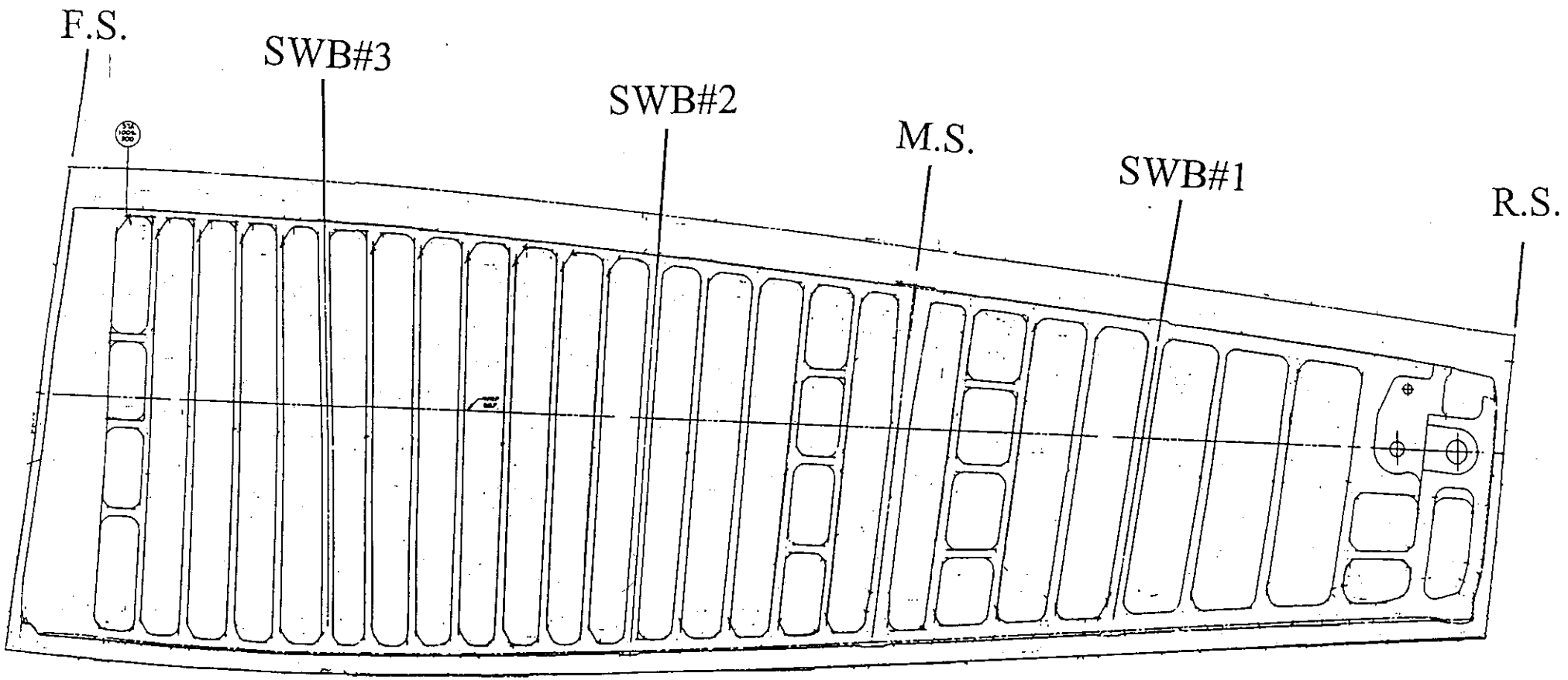
CW-301→CW-333

ITEMS NOT SHOWN
CW-315, 316, 318, 319
CW-320, 321, 322

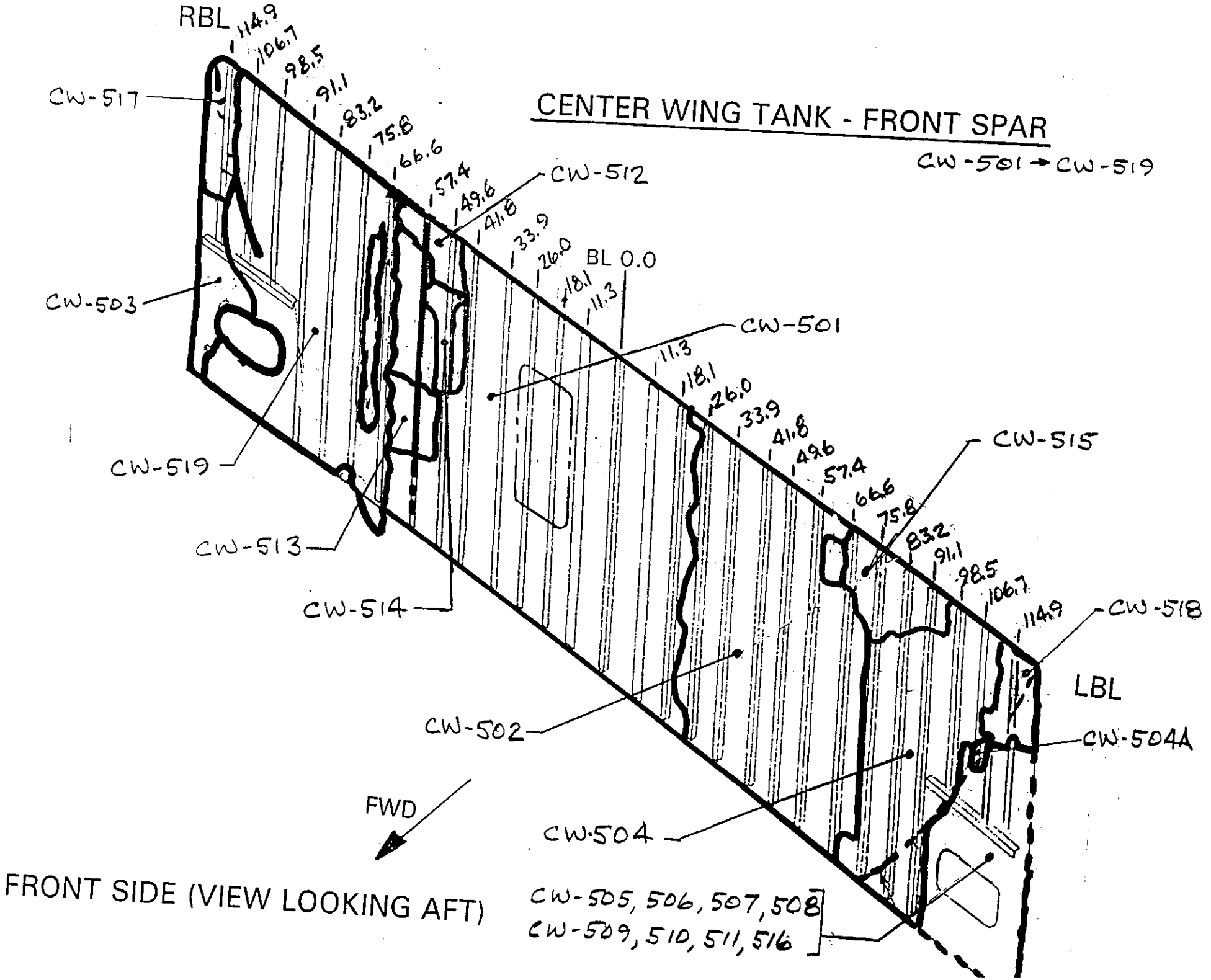


OUTBOARD SIDE (VIEW LOOKING INBOARD)

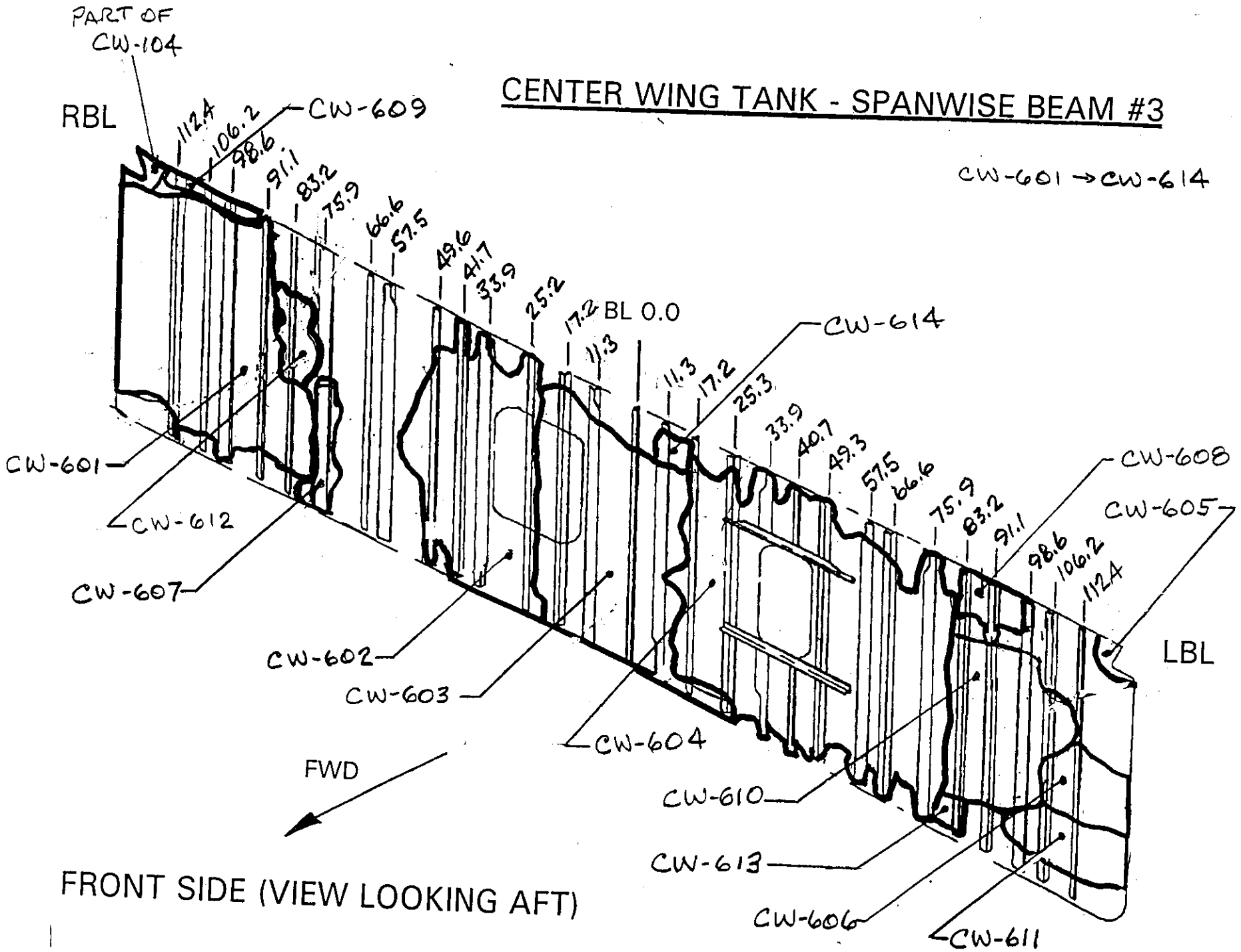
CWT SIDE-OF-BODY RIB LBBL 127.5



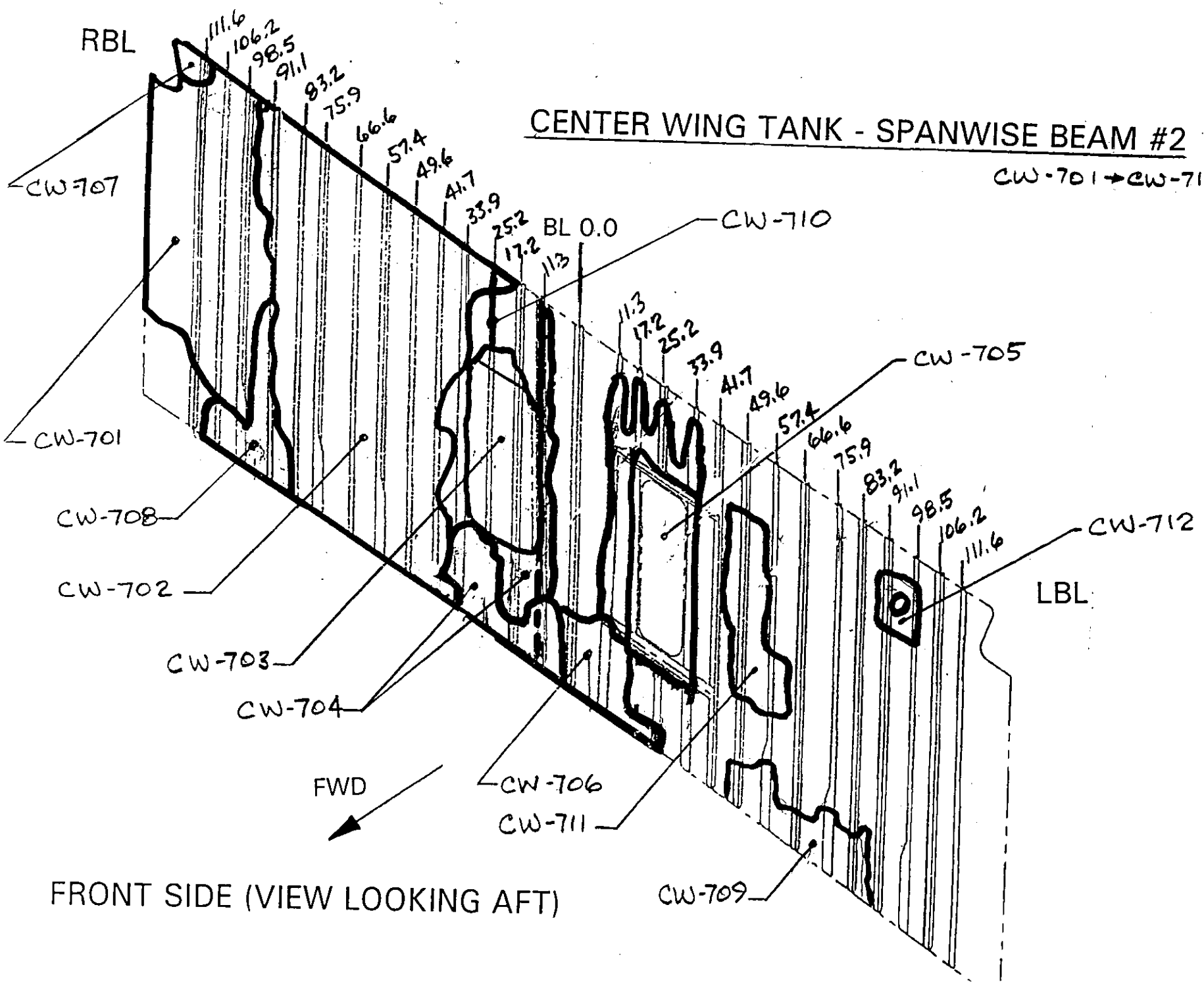
OUTBOARD SIDE (VIEW LOOKING INBOARD)

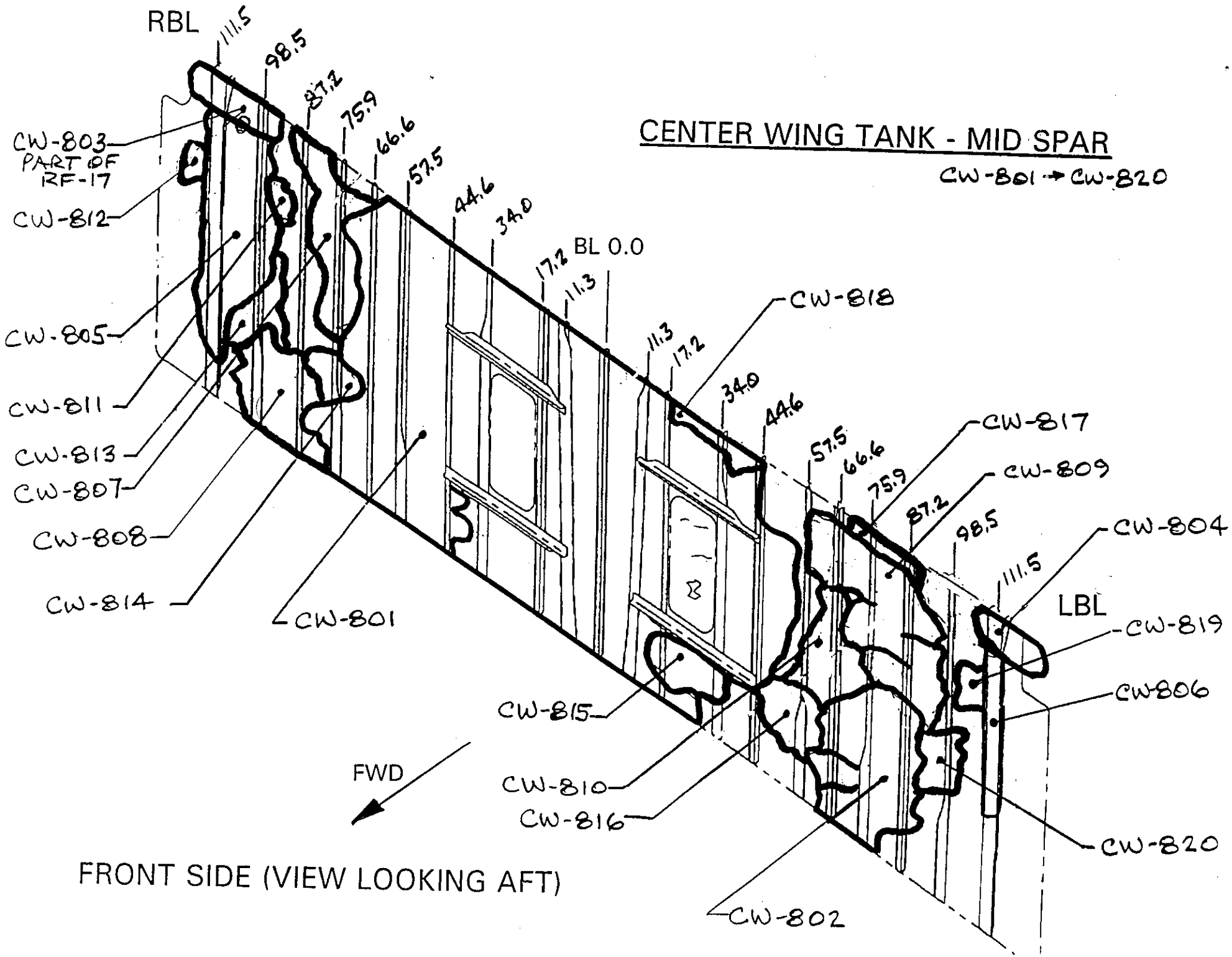

CENTER WING TANK - FRONT SPAR
CW-501 → CW-519
RBL
114.9
106.7
98.5
91.1
83.2
75.8
66.6
57.4
49.6
41.8
33.9
26.0
18.1
11.3
BL 0.0
CW-517
CW-512
CW-503
CW-501
CW-519
CW-515
CW-513
CW-514
CW-518
LBL
CW-502
CW-504A
CW-504
FWD
FRONT SIDE (VIEW LOOKING AFT)
CW-505, 506, 507, 508
CW-509, 510, 511, 516

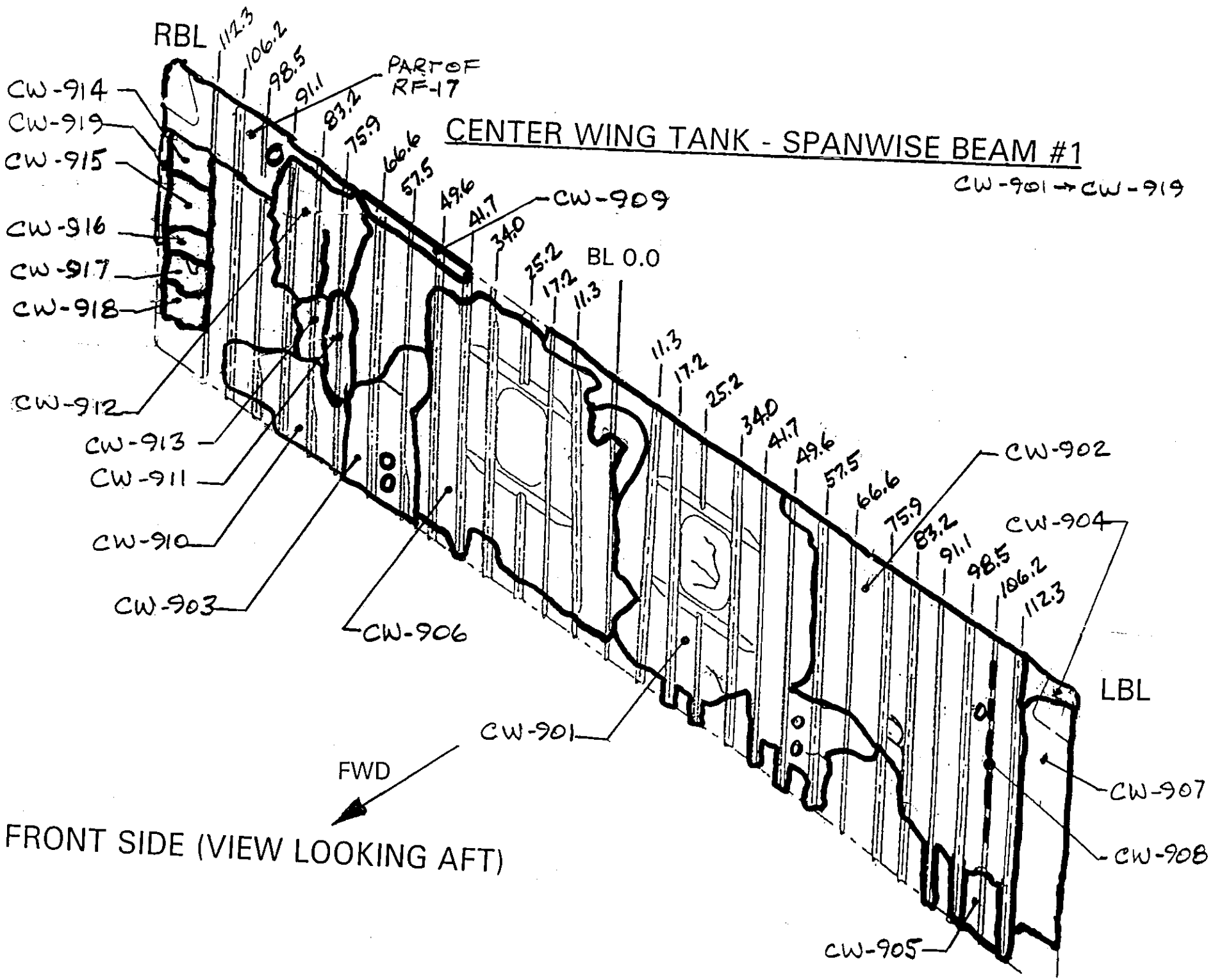
CENTER WING TANK - SPANWISE BEAM #3

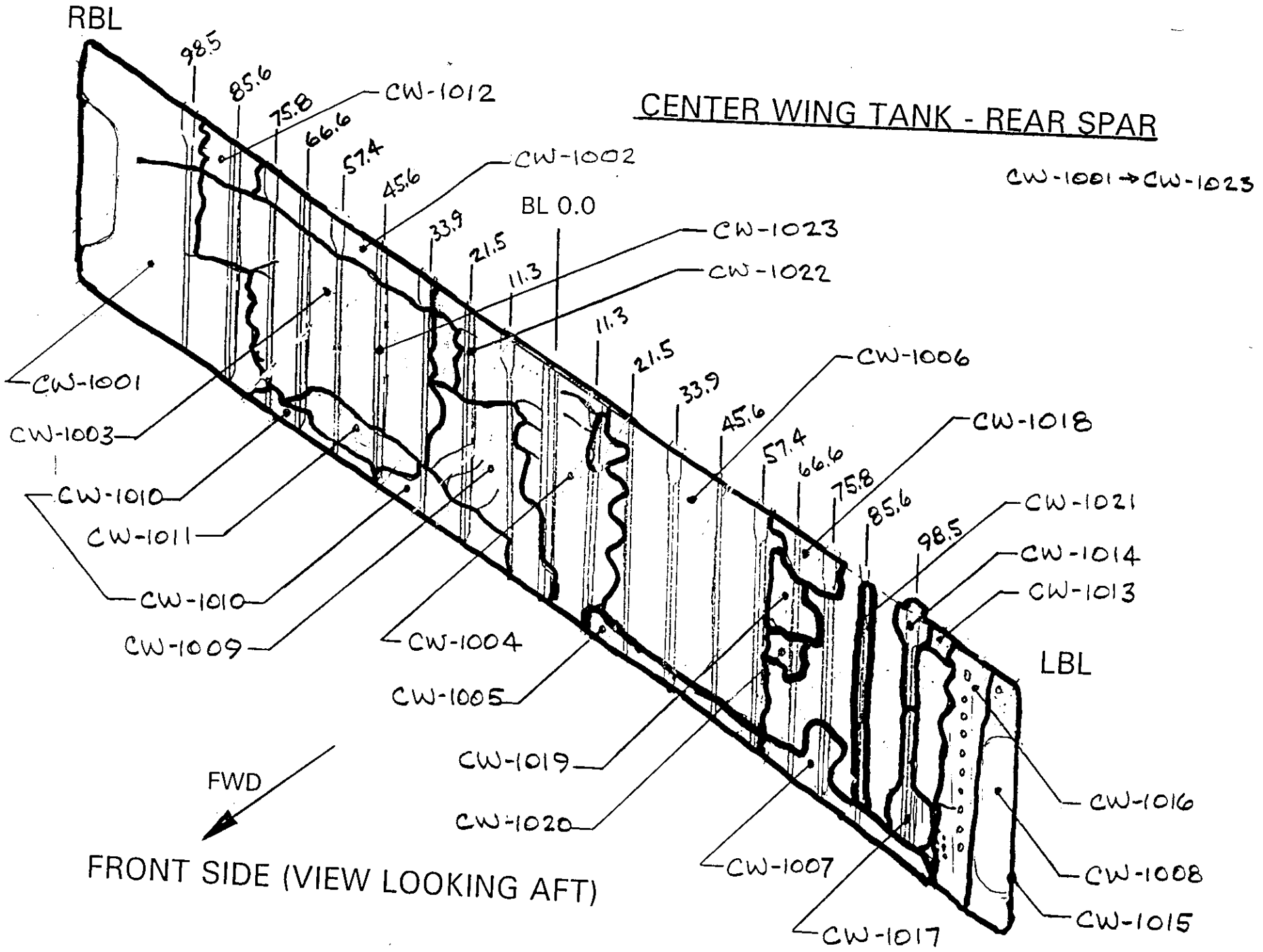


FRONT SIDE (VIEW LOOKING AFT)

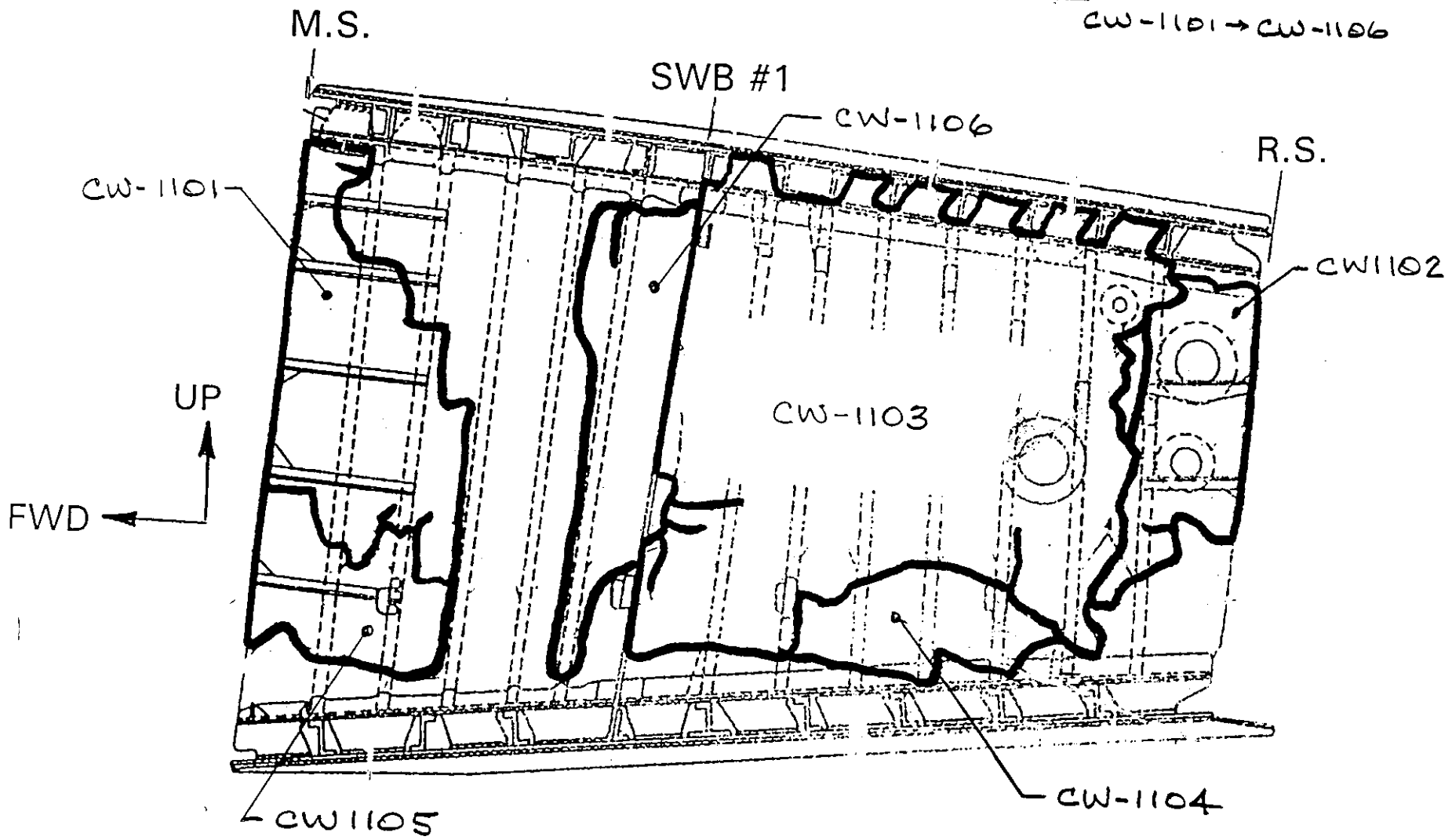

CENTER WING TANK - SPANWISE BEAM #2
CW-701 → CW-712
RBL
111.6
106.2
98.5
91.1
83.2
75.9
66.6
57.4
49.6
41.7
33.9
25.2
17.2
11.3
BL 0.0
11.3
17.2
25.2
33.9
41.7
49.6
57.4
66.6
75.9
83.2
91.1
98.5
106.2
111.6
LBL
CW-707
CW-701
CW-708
CW-702
CW-703
CW-704
CW-710
CW-705
CW-712
CW-706
CW-711
CW-709
FWD
FRONT SIDE (VIEW LOOKING AFT)


CENTER WING TANK - MID SPAR
CW-801 → CW-820
RBL
111.5
98.5
87.2
75.9
66.6
57.5
44.6
34.0
17.2
BL 0.0
11.3
CW-803
PART OF
RF-17
CW-812
CW-805
CW-811
CW-813
CW-807
CW-808
CW-814
CW-801
CW-818
CW-817
CW-809
CW-804
LBL
CW-819
CW806
CW-820
CW-815
CW-810
CW-816
CW-802
FWD
FRONT SIDE (VIEW LOOKING AFT)


CENTER WING TANK - SPANWISE BEAM #1
CW-901 → CW-919
RBL
LBL
BL 0.0
PART OF RF-17
CW-909
CW-902
CW-904
CW-914
CW-919
CW-915
CW-916
CW-917
CW-918
CW-912
CW-913
CW-911
CW-910
CW-903
CW-906
CW-901
CW-907
CW-908
CW-905
112.3
106.2
98.5
91.1
83.2
75.9
66.6
57.5
49.6
41.7
34.0
25.2
17.2
11.3
FWD
FRONT SIDE (VIEW LOOKING AFT)


CENTER WING TANK - REAR SPAR
CW-1001 → CW-1023
RBL
LBL
BL 0.0
98.5
85.6
75.8
66.6
57.4
45.6
33.9
21.5
11.3
11.3
21.5
33.9
45.6
57.4
66.6
75.8
85.6
98.5
CW-1012
CW-1002
CW-1023
CW-1022
CW-1006
CW-1018
CW-1021
CW-1014
CW-1013
CW-1016
CW-1008
CW-1015
CW-1017
CW-1007
CW-1020
CW-1019
CW-1005
CW-1004
CW-1009
CW-1010
CW-1011
CW-1010
CW-1003
CW-1001
FWD
FRONT SIDE (VIEW LOOKING AFT)

CENTER WING TANK - BL 0.00 RIB



LEFT SIDE (VIEW LOOKING RIGHT)