CENTER WING

Metallurgy Group Notes - Wing Center Section Study

October 8, 1996

The purpose of this study was to determine the motion of the front spar, midspar, and spanwise beams No. 3, 2, and 1, relative to the upper and lower skins. Where applicable, we examined the shear tie bolt holes for deformation or witness marks, deformation to bolts attaching shear ties to chords or skin, and deformation to chord fastener holes.

Figure 1 shows a sketch of the wing center section. Each of these structures contain numerous vertical members called stiffeners that are situated parallel to each other and provide support for the upper and lower skin and the spanwise web. The stiffeners and web are attached to a upper and lower spanwise chord to fabricate a beam. The chords attach directly to the skin. The vertical stiffeners attach to the chords by shear ties. The chord for the front, midspar and spanwise beam No. 3 are forward of the shear ties, whereas, the chord for spanwise beam No. 1 is AFTof the shear ties. (see figure 1).

Examination of the wing center section revealed that the front spar moved forward relative to the upper and lower skin. The chords for this spar separated spanwise along the radius (see figure 2) . A major portion of the shear ties for the lower skin and attachment bolts were found attached to the chord, whereas, less than half of the shear ties for the upper skin were found attached to the chord. The AFT side of the attached shear ties contained a gap on the AFT end between the shear tie and the chord (see figure 2). The shear tie for the front spar is attached to the chord by four bolts. In the remaining areas where the shear ties and attachment bolts separated from the chord, bolts were found protruding out of the chord and several holes were found with no bolts. Typically, the two forward bolt holes on the chord contained deformation or gouge marks on the forward side indicating that a bolt attached to a shear tie departed in the forward direction. Several holes which correspond to the AFT holes of the shear ties contained similar gouge marks on the forward side. Several bolt holes exhibited no deformation indicating that the shear tie bolts were pulled straight out of the hole. Where bolts were found attached to the lower chord, these bolts were vertically oriented or deformed slightly forward indicating that the departing shear tie was moving forward.

Spanwise beam No. 3 was found to have moved in the forward direction. In this beam, shear ties are attached to the chords by two bolts, with the exception that on the upper skin along the passenger floor beam locations one larger diameter bolt is used to attach the shear tie to the chord. Examination of the upper skin where the shear ties were attached to the upper spanwise chord

by one bolt, revealed the associated stiffeners separated approximately 6 inches below the inside surface of the upper skin. The upper portion of the stiffeners contained diagonal fractures in a direction which would suggest forward movement relative to the skin. In the remaining areas where the shear ties and two attachment bolts separated from the upper chord, the bolt holes on the inboard side of the chord contained gouge marks on the forward side. At the lower skin, the chord and portion of the web from LBL 114 to 26 and RBL 34 to 49 remained attached to the lower skin. The chord and web were deformed in the forward direction. In these areas, the majority of the shear ties were found separated from the chord. The inboard face of these chords contained a combination of bolt holes with gouge marks on the aft side and bolts protruding out of the chord that were deformed in the aft direction, as if the lower portion of the stiffener rotated AFT about the chord (see Figure 3). The bolt holes on the lower chord from LBL 18 to RBL 26 exhibited tensile pullout (no lateral deformation) and the chord for the upper skin in this area exhibited bolt holes with gouge marks on the forward side. Using the same observations, the upper portion of this spanwise beam in the range RBL 58 to 106 was found to have moved forward and the lower portion in the same area moved AFT.

The AFT faces of the stiffeners for the front spar exhibited impact damage between 4 and 39 inches from the shear ties for the upper skin. Between 4 and 30 inches of the upper portion of spanwise beam No. 3 were missing along its length as well. This corresponding damage to the AFT faces of the front spar stiffeners and top portion of spanwise beam No. 3 is consistent with the top of spanwise beam No. 3 striking the stiffeners of the front spar.

Spanwise beam no. 1 was found to have traveled in the AFT direction. The lower portion of this spanwise beam from LBL 114 to RBL 41 was found to have rotated FWD about the chord of the lower skin and the upper portion in the same area moved AFT. The upper portion of the stiffeners LBL 11, LBL 34 through 98, and RBL 11 through 41 were found with diagonal fractures in a direction further supporting the spanwise beam in these areas moved in the AFT direction.

Spanwise beam No. 2 and the mid spar did not exhibit consistent deformation patterns in any of the common fastener holes or bolt holes to indicate which direction these items traveled with respect to the skin. see additional comments SPG, 11-03-96

The wing center section was examined to determine which stiffeners had separated from the skin but had a shear tie attached to the stiffener. In this category, an effort was made to determine if one or more bolts were attached to the shear ties. This examination revealed that bolts protruding out of the shear ties were nearly straight indicative of tensile pull through. None of the bolts for the shear ties in the wing center section exhibited shear separation.

Initial examination of the spanwise beam stiffener shear ties revealed a unique damage pattern. In many cases, the shear tie fastener had withdrawn from the shear tie flange while the shear tie had simultaneously translated longitudinally. The result was a witness mark, typically a gouge, on the face of the shear tie flange which corresponded to the direction which the shear tie had moved relative to the center tank skin. In nearly all cases, the surviving fastener was only slightly bent. It appeared that useful information could be obtained by mapping these witness marks.

This effort resulted in the examination of every surviving shear tie and shear tie attachment site on the upper and lower skins, as well as the shear ties which remained attached to the stiffeners. A dimensionally correct map was generated which depicts the location of the shear ties and the shear tie fasteners in one of three categories: skin, stiffener or missing. A color convention was established to depict the location of the shear ties, fasteners, and the source of directional information. After examining the shear tie, shear tie fasteners, and shear tie fastener holes, information was correlated to produce a direction of translation for the shear tie relative to the center tank skin.

Specifically, the components of each shear tie were examined. The chord flange was located, either on the chord or still attached to the stiffener. The bolt holes were studied for hole elongation and/or witness marks left from the bolt stud translating after it withdrew from the hole. If the bolt stud survived in the corresponding surface, it was also studied to look for bending deformation. From these sources, a direction of translation was identified for the shear tie relative to the chord (skin).

In cases where the chord had been pulled away from the skin, the shear tie fastener holes in the skin were not studied. It was felt that deformation of the holes in the skin could not be specifically attributed to the shear tie movement, since deformation may also have occurred when the chord was separated from the skin. Thus, this information would be inconclusive.

In cases where the bolt hole elongation and the bending deformation of the surviving stud did not agree to within approximately thirty degrees, both directions were depicted on the map. However, in cases where one source showed a direction and the other indicated only tensile failure, with no direction, the direction was depicted without noting the tensile information. In cases where all of the available information indicated a tensile failure, then a tensile failure was depicted.

In cases where the shear tie remained attached to the chord, the chord flange was studied for indications of separation from the skin. Numerous shear ties showed a slight separation of the flange from the skin on one side only. This was depicted on the map with a discreet symbol.

The butt line 0 web shear ties were examined; however, little directional information could be obtained since these shear ties typically fractured at the tee radius.

The conventions used are as follows:

MAGENTA identifies features associated with and/or information derived from the center tank skin

BLUE identifies features associated with and/or information derived from the individual stiffener

A SQUARE indicates a shear tie chord flange. If the square is magenta, the shear tie chord flange is attached to the respective spar chord; if it is blue, the entire shear tie is attached to the stiffener; concentric blue and magenta squares indicate that the shear tie is attached to the respective spar chord as well as a complete stiffener. Portions of the square may be omitted to illustrate missing shear tie chord flange structure. No symbol has been designated to indicate missing shear tie stiffener flange structure; that information is not shown on the map.

A SMALL CIRCLE indicates a bolt hole. If it is colored, then the bolt is still present in the structure identified by the color. If it is not filled in, then the bolt is missing.

An ARROW originating at the bolt/bolt hole indicate the direction that the SHEAR TIE MOVED RELATIVE TO THE SKIN. The color of the arrow indicates the structure from which this direction was derived.

An ARROW pointing to a shear tie indicates the direction that the shear tie was observed to be lifted off of the spar chord.

A RED ARROW, not shaded in, indicates a failure direction derived from examination of the bolt shank fracture.

An X SYMBOL indicates a fractured fastener with portions still present in the structure. The color indicates which structure each portion is found in.

A LARGE CIRCLE indicates no directional information could be derived from the bolt/bolt hole.

A SOLID LINE parallel to the spar indicate surviving spar web structure.

A SMALL ARROW indicates the direction that the surviving spar web structure is bent.

SD GREEN 11/03/98
ACIA

The number of pieces recovered from the side of body (SOB) rib for the left and right sides of the wing center section were not sufficient as of October 8, 1996 to initiate examination. Examination will be required at a later date.

Frank Zakar 10/8/96

Frank Zakar, NTSB Metallurgist

James R Straus 10/8/96

James Straus, Boeing Metallurgist

Neil Scoville 10/8/96

Neil Scoville, TWA

[signature] 11/03/96

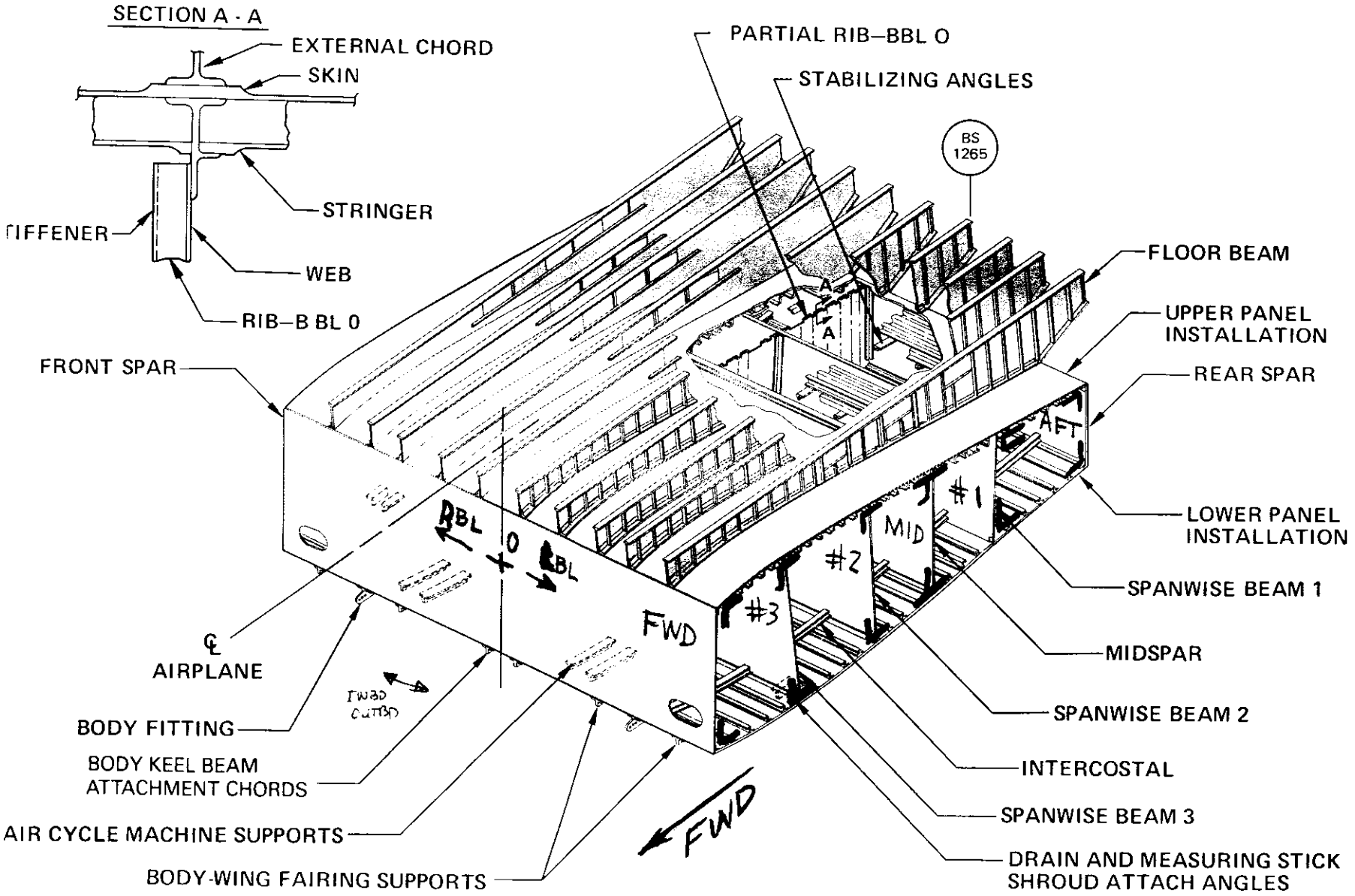
Steve Green, ALPA

LH 12/12/96

" PL. REFER TO WING CENTER SECTION SHEAR TIE FACTUAL SUMMARY "

FIGURE 1

Wing Center Section



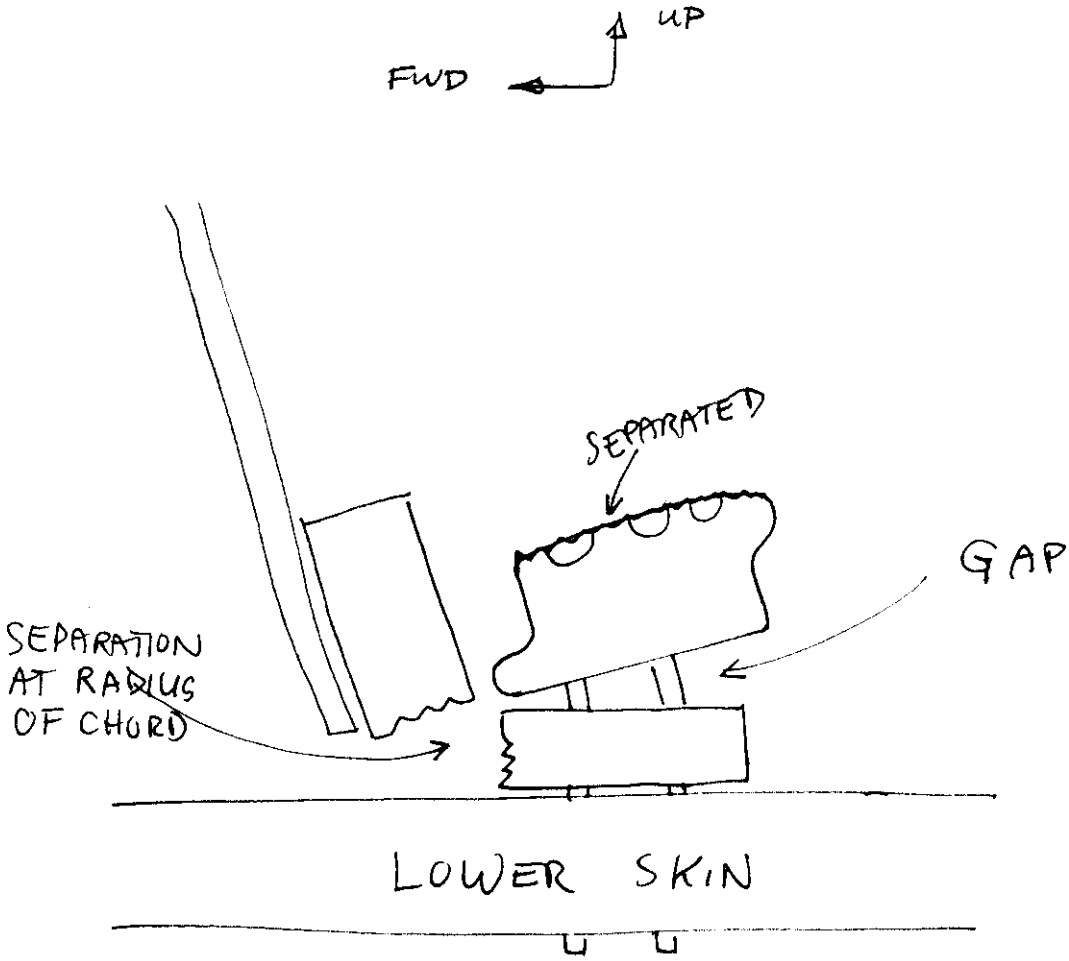
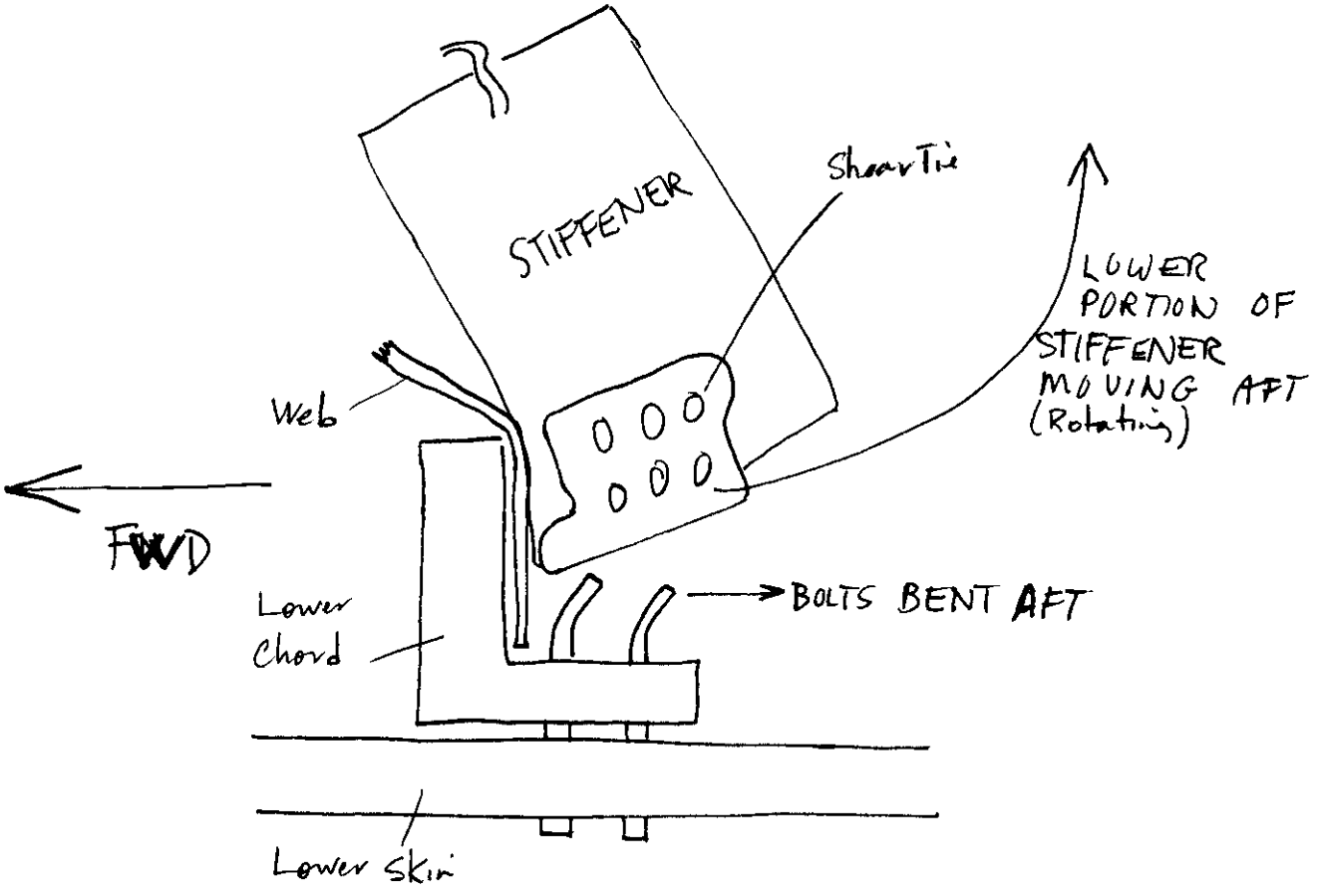
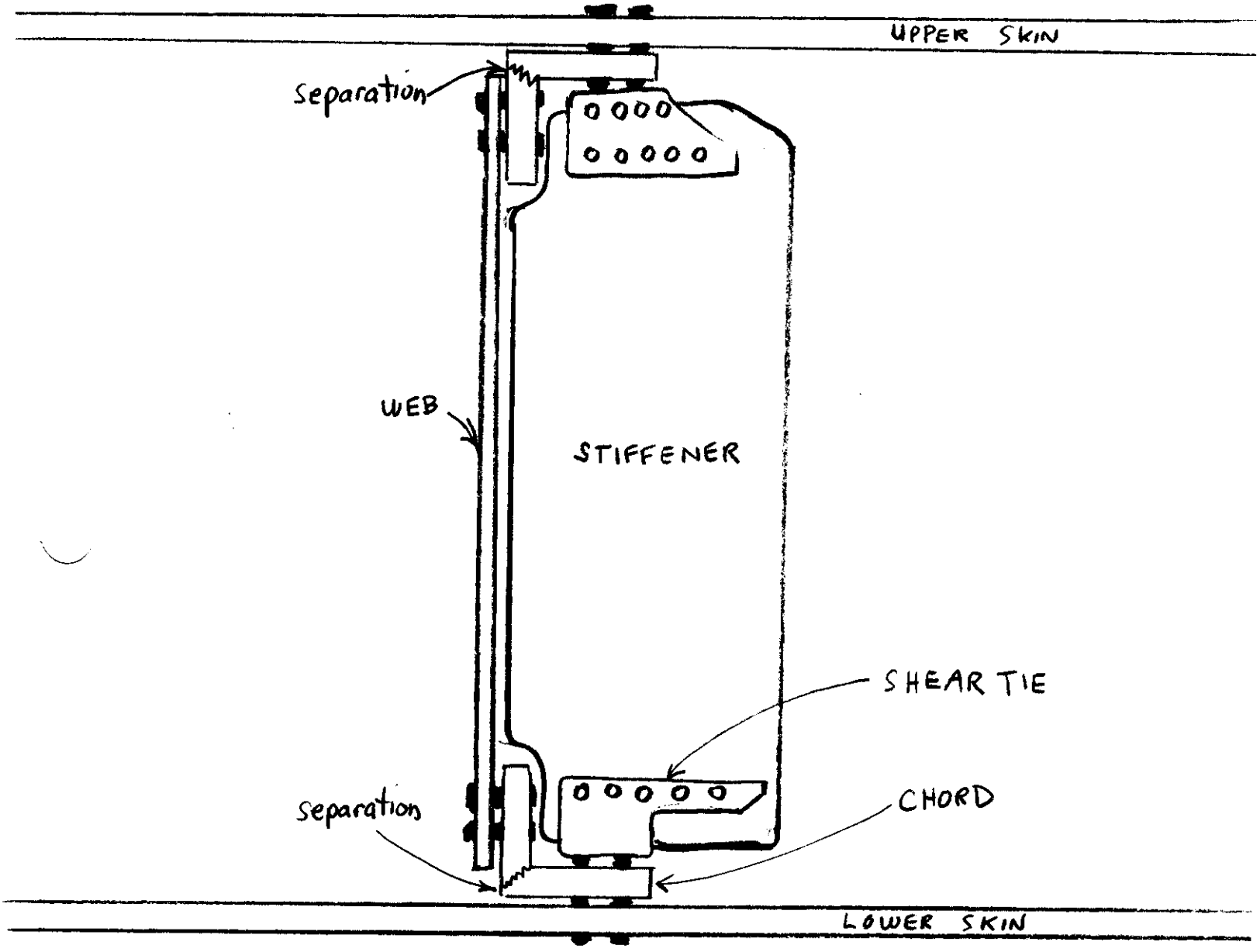

UP
FWD
SEPARATED
GAP
SEPARATION
AT RADIUS
OF CHORD
LOWER SKIN
FORWARD SPAR

FIGURE 2.



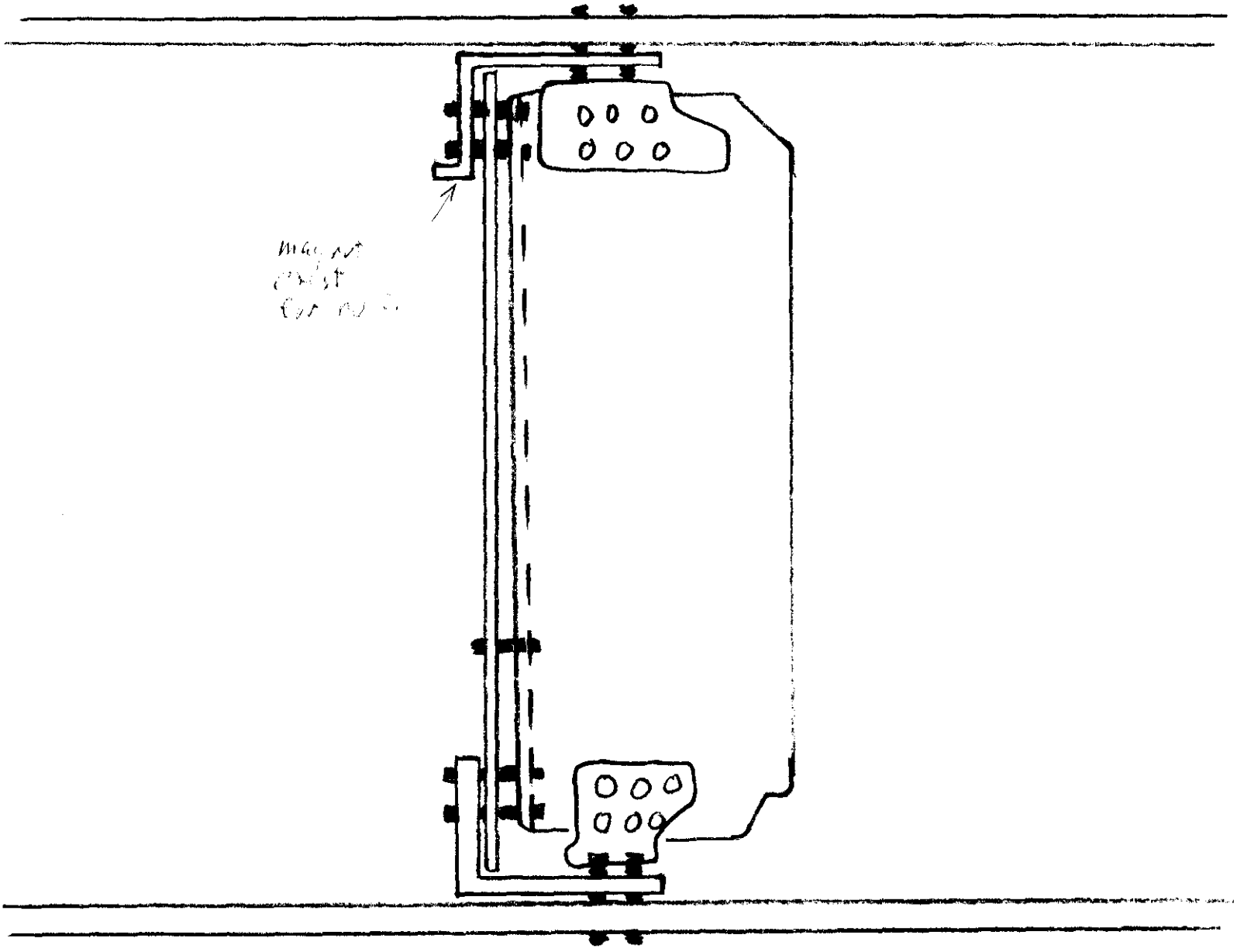
SPANWISE BEAM # 3
LOWER PORTION

FIGURE 3

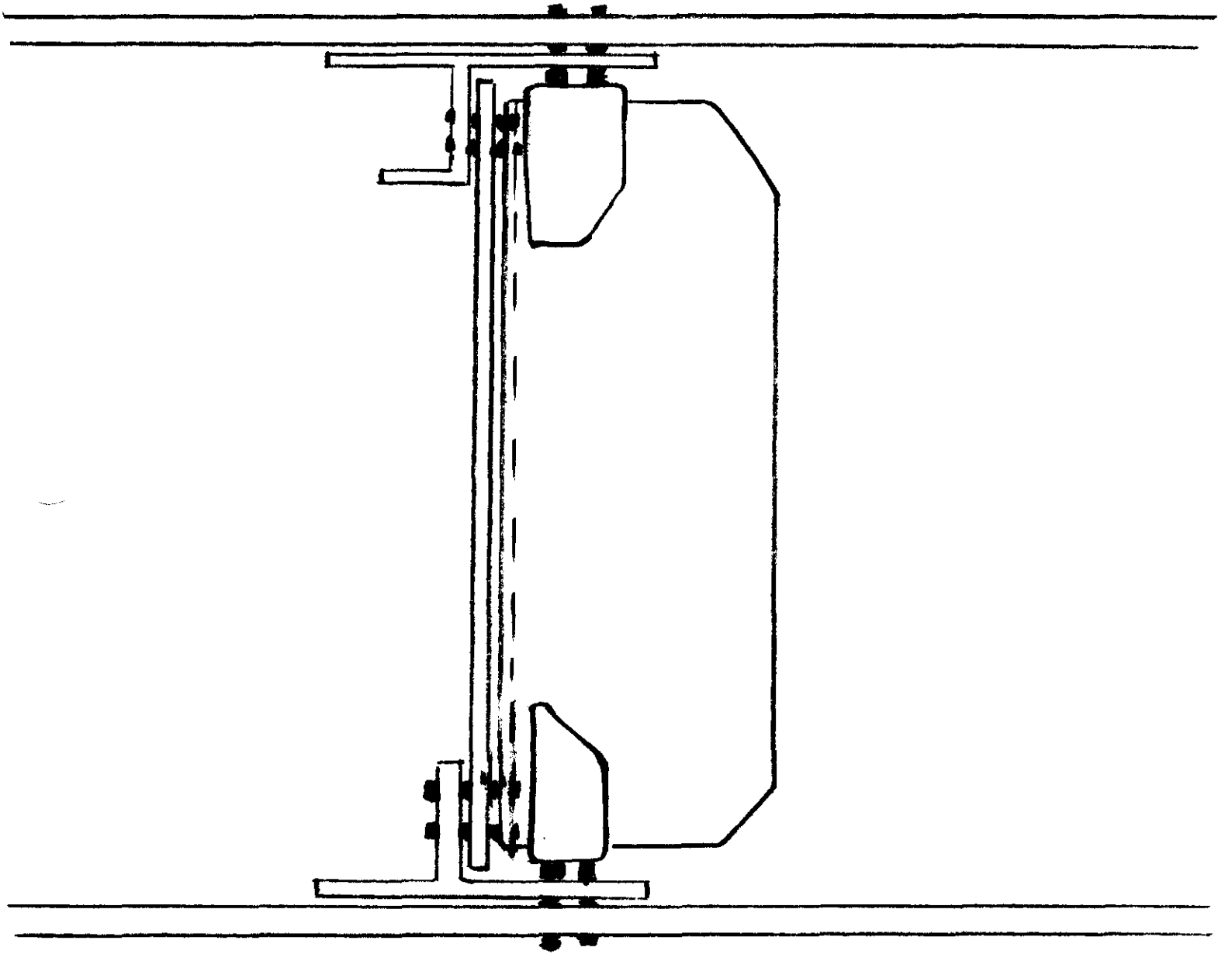


FORWARD SPAR

(SIDE VIEW)

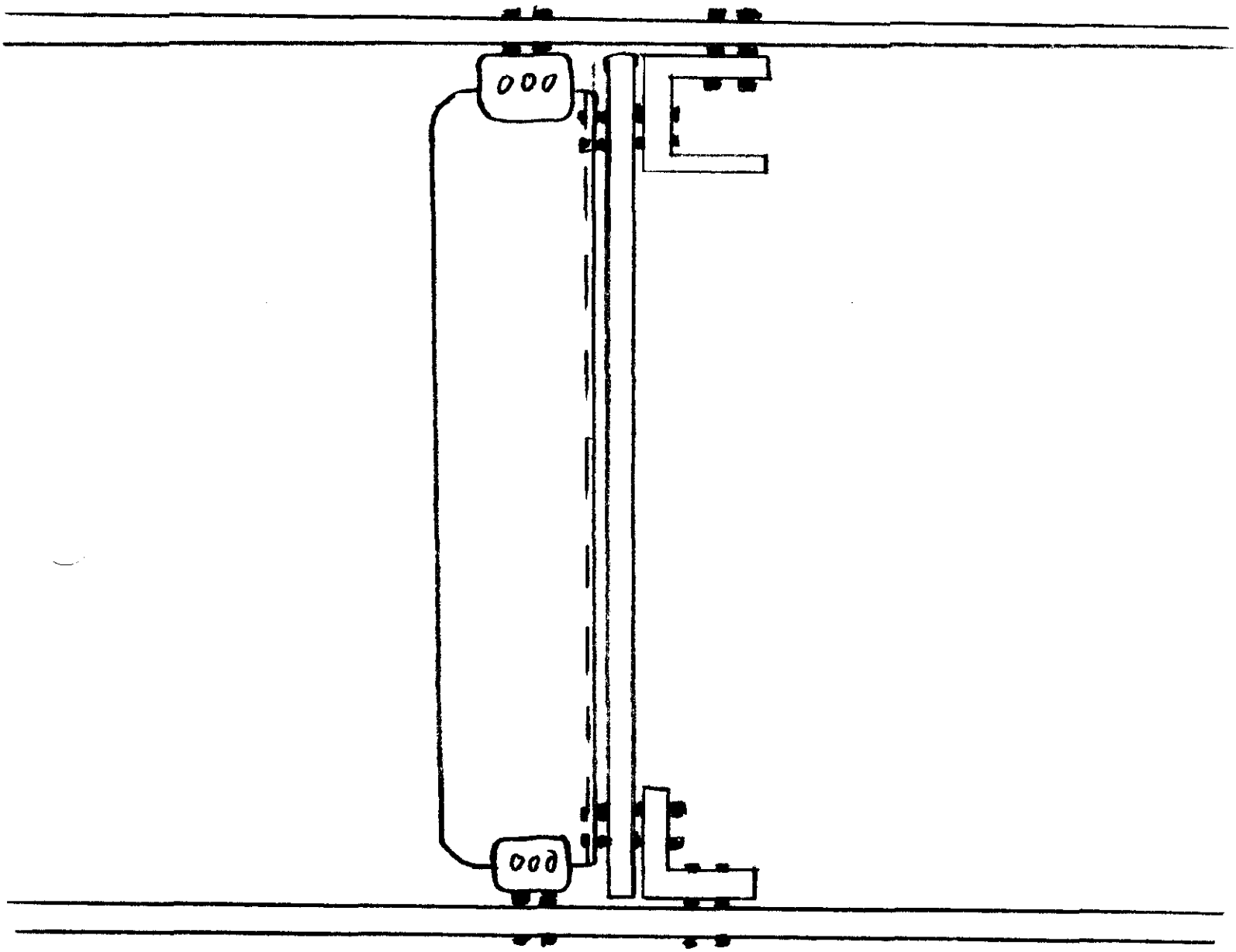


SPANWISE BEAM # 3 (S-19)



MID SPAR

(S-10)



SPANWISE BEAM #1 (S-6)