NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

July 24, 1998

MATERIALS LABORATORY FACTUAL REPORT Report No. 98-107

A. ACCIDENT

Place	: East Moriches, New York
Date	: July 17, 1996
Vehicle	: Boeing 747-131, N93119
NTSB No.	: DCA96-M-A070
Investigator	: Al Dickinson

B. COMPONENTS EXAMINED

Spacer, P/N 69B92451-1, for the scavenge pump from the center fuel tank and attachment hole located on the aft spar fragment CW-1004 .

C. DETAILS OF THE EXAMINATION

The spacer for the scavenge pump and aft spar fragment were delivered separated from each other to the Safety Board materials laboratory. A photograph of the as-received parts is shown in figure 1. According to the center fuel tank structures notes, titled " Rear Spar-Wing Center Tank, CW-1004, C-2139, Green", the aft spar fragment was recovered with the spacer still attached to the aft face of the spar, with three screws and safety wires intact. Two of the three screws were not available for examination.

The examination was conducted on June 30, 1998 with participation from the following individuals:

Frank Zakar, NTSB, Materials Engineer
Merritt Birky, NTSB, Chairman, Fire and Explosion Group
Spencer Phyllips, Physical Science Technician
Wes Kennedy, Boeing, Metallurgist
Fred Liddell, IAM, Air Safety Investigation
Bob Young, TWA, Director of Flight Operations
Mike, ALPA, Accident Investigations and Engineering
Paul Russ, Lear Romec, Director of Engineering
Joe Mano, FAA, Major Accident Investigations

Installation of the Scavenge Pump Assembly

The scavenge pump assembly contains a motor unit, spacer, and receiver unit. The motor unit is installed on the aft face of the aft spar (outside the center fuel tank), and the receiver unit is installed on the forward face of the aft spar (inside the center fuel tank). The spacer is installed between the motor unit and aft spar in the area indicated by arrow "R" in figure 1. The motor unit and receiver were not recovered in the salvage operation. The housing for the receiver unit is made from C355 aluminum alloy casting[1], heat treated to the T-6 condition, according to a representative from Crane Corporation - Lear Romec Division, the manufacturer of the scavenge pump. An impeller is located inside the receiver unit.

Spacer

Figure 2 shows close-up photographs of the spacer, arrowed "S" in figure 1, for the scavenge pump. This spacer is manufactured with 6 screw holes, labeled "1" through "6" in figure 2. Screw hole "1" is located approximately in the 1 o'clock position looking forward.[2] Each screw hole has a corresponding attachment hole for a safety wire.

Visual examination of the spacer revealed overall deformation (cupping and twisting) such that the forward and aft faces did not sit flush with the surface of a flat table or the mating aft surface of the aft spar, regardless of the orientation. A screw containing bending deformation in the thread portion was found partially inserted into hole "1" and, in turn, a safety wire was attached between the head of this screw and the spacer. Fragments of safety wire were found attached to the spacer adjacent to holes "4" and "5". The ends of all the safety wires showed evidence that they were cut.

The wall of screw holes "3" and "5" on the aft face of the spacer contained an impression mark from the threads of a screw in the areas indicated by arrows "8" in figure 2. The edge of screw holes "2", "4", and "6" contained deformation marks towards the outer diameter in the areas indicated by arrows "9" in figure 2. These deformation marks are consistent with the screws bending toward the outer diameter. A wall fragment of the spacer had separated in the area indicated by arrow "w" in figure 2. The fracture from this fragment intersected a hole for a safety wire. Also, the inside diameter face of the spacer contained mechanical damage in the two areas indicated by arrows "m" and "n" in figure 2.

The forward face of the spacer contained a crescent shaped discoloration between holes "1" and "2" in the area bound by a dashed line and the outside diameter in figure 2. Another crescent shaped discoloration was found between holes "4" and "5" that was bound by a dashed line and the inside diameter in figure 2.

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[1] C355 aluminum casting contains % by weight 4.4-5.5Si, 0.2Fe min, 1.0-1.5Cu, 0.1Mn min, 0.4-0.6Mg, 0.1Zn min, 0.2Ti min, aluminum remaining, according to Metals Handbook, Desk Edition.

[2] Description of spacer is based on a clock face, where the 12:00 o'clock position is the top end looking forward

Energy Dispersive X-ray Spectrographic (EDS) Analysis of the Spacer and Screw

The spacer is made from 2024 aluminum alloy, heat treated to the T3 condition. This alloy contains 4.4% Cu, 0.6% Mn, 1.5% Mg, remaining aluminum, by weight (nominal). A small area on the aft face between holes "3" and "4" was cleaned with grit paper to remove dirt so that an EDS spectrum could be obtained for a baseline. EDS analysis of the cleaned area produced a spectrum that contained aluminum, manganese, and copper, which is consistent with the composition of 2024 aluminum alloy. A spectrum of the surface of the two damaged areas on the inside diameter each produced a spectrum that contained oxygen, carbon, sodium, magnesium, silicon, chloride, sulfur, cadmium, and calcium, in addition to the elements found in the base metal (baseline). The aft face between the 9 and 1:30 o'clock position was covered with a dark deposit compared with the remaining portion of the spacer. The spectrum of the dark deposit contained peaks of carbon, oxygen, magnesium, silicon, phosphorus, sulfur, chloride, potassium, calcium, titanium, and iron, in addition to the peaks in the base metal. Scanning electron microscope examination of the dark deposit revealed oxide scale.

Stereo microscope examination of the screw revealed that the crown of the threads exhibited minor rubbing damage and that white residue was present in the threads. EDS analysis of the surface of the white deposit produced a spectrum that contained major peaks of cadmium, iron, chloride, oxygen and carbon, and minor peaks of aluminum, sodium, magnesium, silicon, phosphorus, sulfur, manganese, titanium and zinc.

Aft Spar

The bottom portion of the spar was bent forward and, in turn, this bend portion partially obstructed the scavenge pump attachment hole area. The aft face of this bent portion contained deep, narrow, flat-bottom gouge marks that were oriented parallel to each other in the areas indicated by unmarked arrows in figure 3. The bottom end of the spar in the area of the fold also contained similar gouge marks (indicated by arrows "K" in figure 3). The bent portion was cut out in the area indicated by a dashed line in figure 3 to facilitate examination of the forward face and attachment hole for the scavenge pump.

Figure 4 shows a photograph of the forward face of the bent portion of the spar after it was excised. The bottom end of this piece contained a portion of the lower spar cap that was coated with a layer of black sealant. A layer of sealant was found torn off the forward face of the cap in the area bound by unmarked arrows in figure 4, exposing bare metal surface. The bare metal surface contained random oriented gouge marks. The position of these gouge marks on the bent portion coincide with the installed location of the receiver housing. No fragment of the housing for the receiver was found attached to the aft spar and cap.

The aft face of the spar in the area of the attachment hole for the scavenge pump contained an outline pattern of the spacer between arrows "S" in figure 5. The area located outside this pattern contained a heavy deposit of dirt and soot. The region inside the outline pattern contained a crescent shaped discoloration between holes "1" and "2", in the areas bound by a dashed line and the outside diameter in the upper photograph of figure 5. Similar discoloration was found between holes "4" and "5", in the areas bound by

a dashed line and the inside diameter in the upper photograph of figure 5. These crescent shaped discoloration marks correspond to those found on the forward face of the spacer in figure 2. Further, the screw holes on this spar contained deformation and thread marks consistent with those found on the spacer. Two gouge marks in the shape of an arc were noted on the aft face of the spar in the areas indicated by unmarked arrows in the upper photograph of figure 5. One of these marks intersected screw hole "3" and the other nearly intersected screw hole "5".

The forward face of the spar in the area of the attachment hole for the scavenge pump contained an outline pattern of the receiver mounting flange between arrows "N" in the lower photograph of figure 5. The forward face of the aft spar in the area of the attachment hole contained a crescent soot mark between holes "1" and "2" (see area bound by a dashed line and the outer diameter of the receiver mounting flange in the lower photograph of figure 5). The surface of the aft spar underneath the receiver mounting flange showed no evidence of sooting, except for the crescent soot mark noted earlier. The attachment hole for the scavenger pump contained no mechanical damage that corresponded to the two mechanical damaged areas found in the inside diameter of the spacer (indicated by arrows "m" and "n" in figure 2).

Figure 6 shows a photograph of the mating faces of the spacer and aft spar. Figure 7 shows a photograph of the spacer as if installed on the aft surface of the spar. As indicated earlier, the aft face of the spacer between the 9 and 1:30 o'clock position was covered with a dark deposit. The spar in the area above the spacer was also covered with the same dark deposit.

The orientation of the spacer and spar in figure 7 is consistent with the recovered position of the spacer, according to a photograph found in the center fuel tank structures notes. Examination of the photograph in the structures notes revealed screws were installed in holes "1", "3",and "5" in figure 6.

The spacer and attachment hole area on the aft spar contained no evidence of arcing damage, or the presence of melted and resolidified deposits. No preexisting fractures were found in the submitted parts. All fractures contained features typical of overstress separations.

Conductivity and Hardness Testing

Conductivity measurements were made on the spacer and aft spar in the areas indicated in the sketch in Table 1. The conductivity measurements of the spacer and the aft spar were within BAC 5946 specified values (see Table 1). Rockwell hardness testing on the forward face of the spacer between holes "4" and "5" measured from 72 to 78 HRB, which was within the specified range (63 to 83.5 HRB).

Measured Dimensions

The outside and inside diameter, and thickness of this spacer measured approximately 4.3 inches, 2.9 inches, and 0.18 inch, respectively.

Frank P. Zakar
Materials Engineer

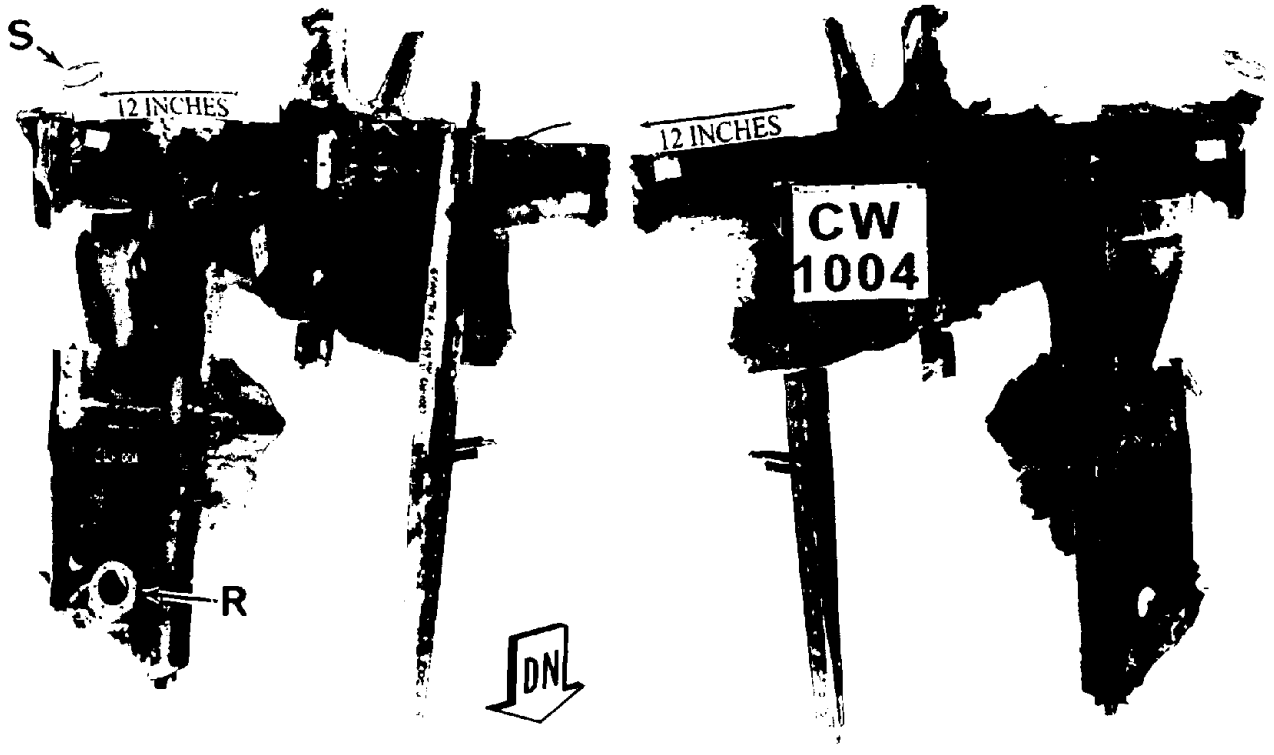


Figure 1. As-received fragment of the aft spar showing the aft face (left) and forward face (right). The spacer, arrowed "S", for the scavenge pump is shown hanging above the spar.

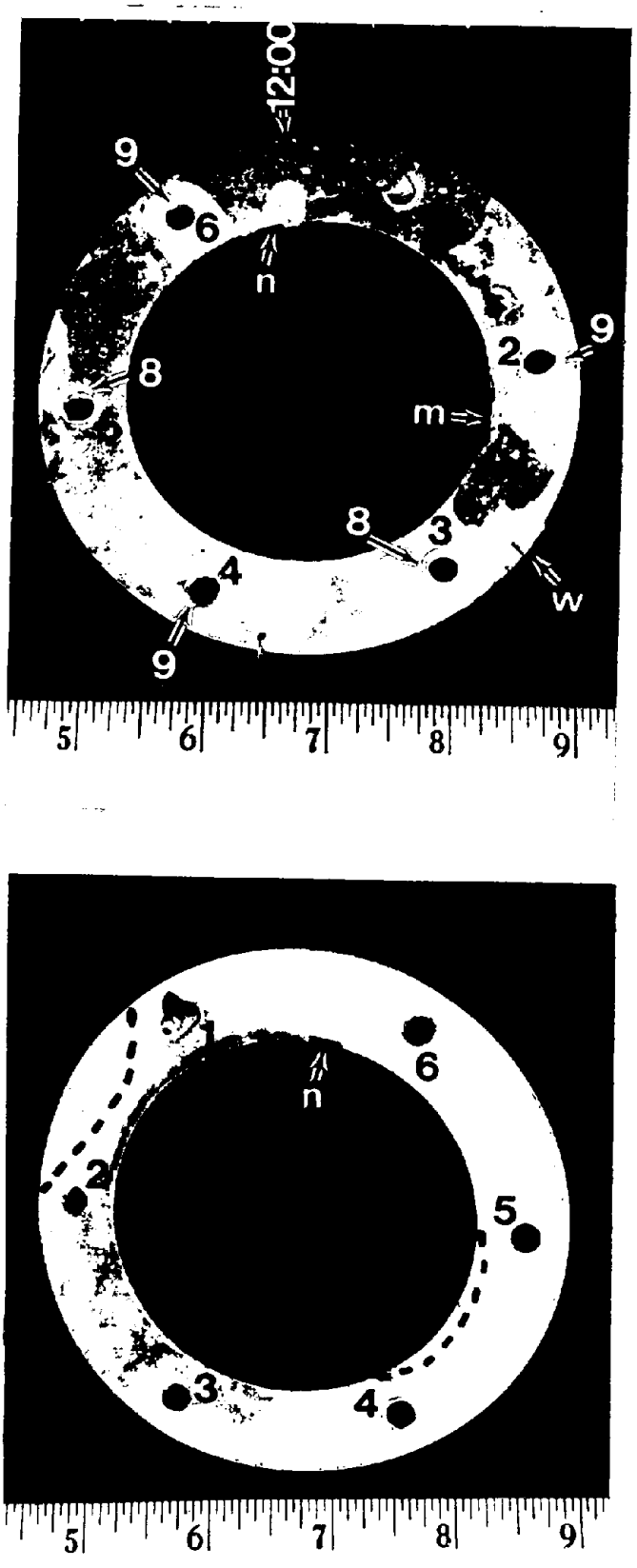


Figure 2. Overall view of the aft face (top) and forward face (bottom) of the spacer for the scavenge pump.

Figure 3. View looking aft at the bent portion of the aft spar that is obstructing the forward face of the attachment hole for the scavenge pump (above) and view looking up at the bottom side of the bent portion (bottom).

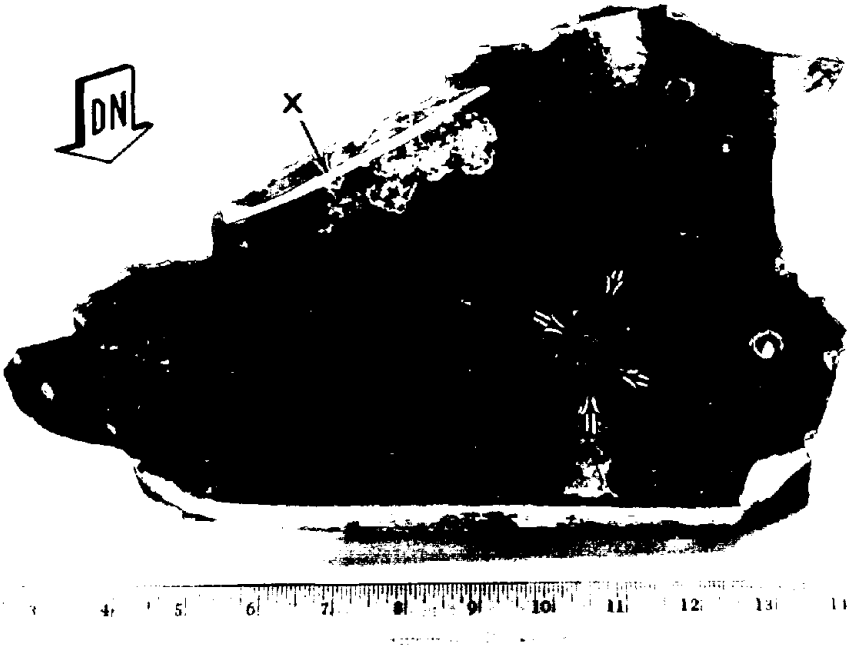


Figure 4. Close-up view of the excised bent portion of the aft spar showing the forward face which was not visible prior to excising. Cut end is indicated by arrow "X".

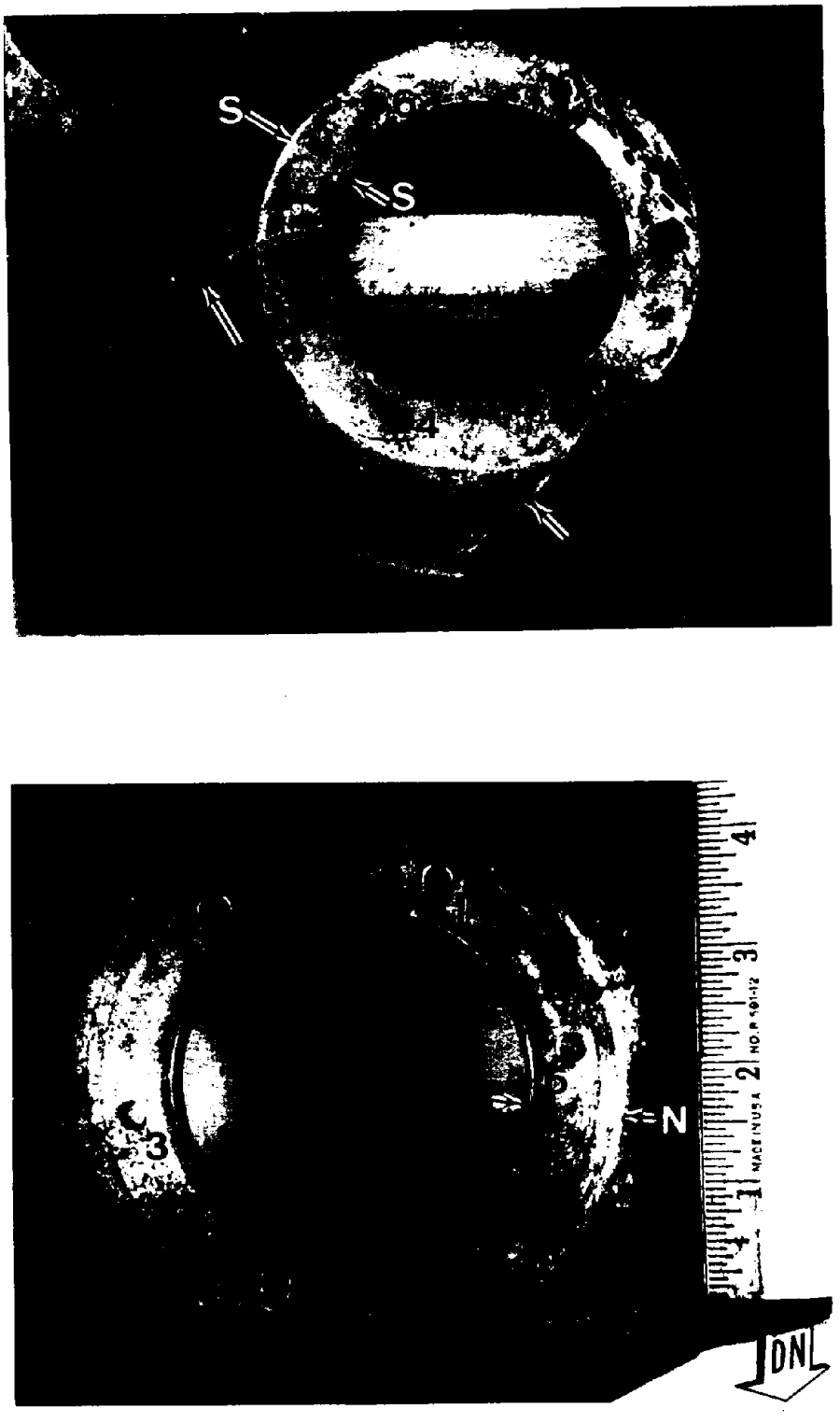


Figure 5. Overall view of the aft face (top) and forward face (bottom) of the aft spar in the area of the scavenge pump attachment hole. The number next to each screw hole corresponds to those on the spacer in figure 2.

Figure 6. Mating surfaces of the spacer and aft spar.

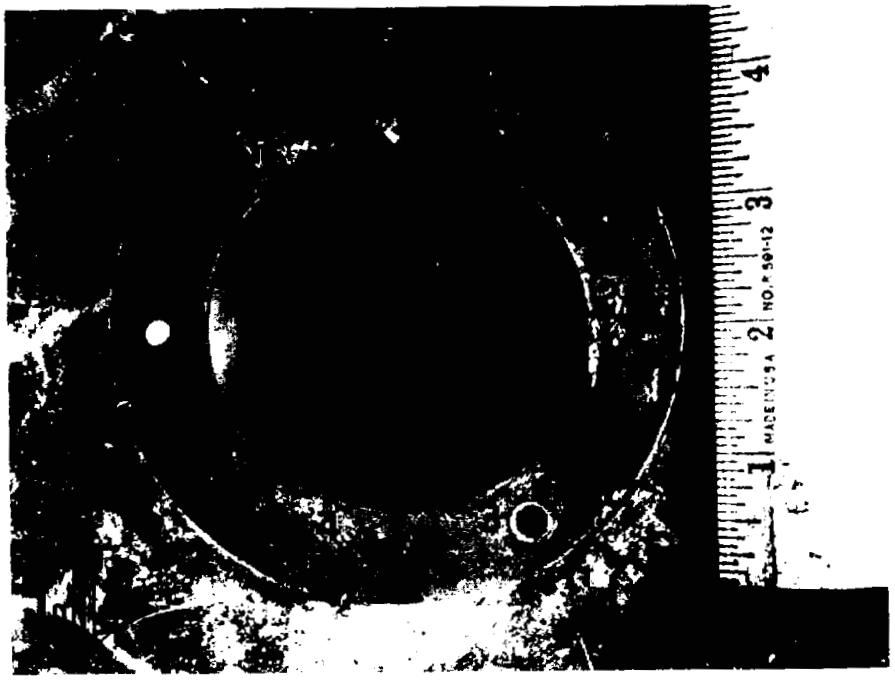
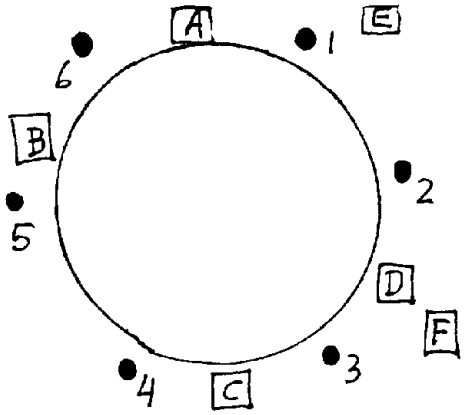
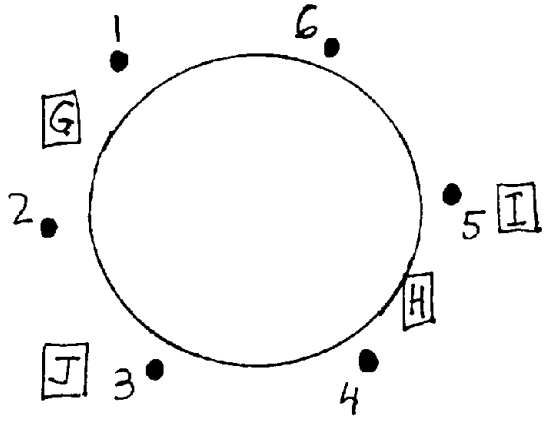
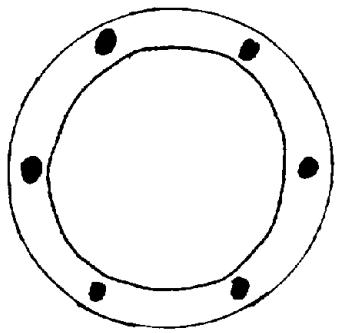


Figure 7. View looking forward showing the spacer attached to the aft spar, as if installed when recovered.

TABLE 1. EDDY CURRENT MEASUREMENTS

POSITION OF TEST PROBE	MATERIAL	SPECIFIED CONDUCTIVITY (% IACS)	MEASURED CONDUCTIVITY (% IACS)
 AFT SURFACE OF AFT SPAR	7075-T6 Aluminum alloy (1.6Cu, 2.5Mg, 0.23Cr, 5.6Zn, % by weight, nominal)	30 - 35	A = 30.5 B = 30.5 C = 30.6 D = 30.5 E = 30.5 F = 30.6
 FWD SURFACE OF AFT SPAR	7075-T6 Aluminum alloy	30 - 35	G = 31.0 H = 31.0 I = 31.0 J = 31.0
 SPACER (FWD & AFT SURFACE)	2024-T3 Aluminum Alloy (4.4Cu, 0.6Mn, 1.5Mg, % by weight, nominal)	28.5 - 32	All measurements were 29.0