

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



WPR24FA226

MATERIALS LABORATORY

Factual Report 24-065

September 12, 2024

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A. ACCIDENT INFORMATION

Location: Eatonville, Washington
Date: July 6, 2024
Vehicle: Champion 7GCBC, N3464D
Investigator: Stephen Stein, AS-WPR

B. COMPONENTS EXAMINED

Mixture control cable pieces with attached lever and mounting frame pieces.

C. EXAMINATION PARTICIPANTS

Specialist Matthew R. Fox, Ph.D.
NTSB
Washington, DC

D. DETAILS OF THE EXAMINATION

An overall view of the submitted mixture control cable pieces with attached lever arm and mounting frame pieces is shown in figure 1. The mounting frame was clamped to the engine end of the cable sheath, and the cable was fractured 1.121 inches away from the edge of the mounting frame clamp. The cable on the control side of the clamp was bent in several locations along its length, and the cable did not translate within the sheath when pushed by hand. The tail piece of the cable with the mating side of the fracture was loosely attached to the lever arm piece.

As installed, the cable was inserted through a hole in the attachment bolt shank and was then clamped to the sidewall of the hole with a washer and nut. The nut was secured with a cotter pin. The remaining tail piece held within the lever attachment assembly could be moved and rotated easily by hand to some extent in all directions, but resistance was met in pulling or pushing the piece before the piece separated from the assembly.

The cable attachment area on the lever arm assembly was mostly covered with an oily substance. A soft-bristle brush soaked in a solution of Alconox detergent and water was used to clean the oily deposits from the attachment area. While the initial cleaning removed oily deposits from the washers and bolt exterior, the through hole in the bolt and the tail piece within the hole remained covered with oil.

Next, the terminal end of the tail piece was pushed into the attachment bolt until resistance was met. With the terminal end pushed inward to the point of resistance, the oil-covered fractured end of the piece was visible on the control side of the attachment as shown in figure 2. In that position, the tip of the fracture surface

on the tail piece was approximately flush with the outer diameter of the bolt shank on the control side of the assembly.

Using two-dimensional measurement features on a Keyence 7000 microscope, a circle was fit to the opening between the nut-side washer and the far edge of the through-hole in the bolt, and the resulting circle had a diameter of 0.0556 inch. The spacing between the nut side and lever side washers was measured with calipers in multiple locations around the circumference. The measured gap ranged from 0.079 inch to 0.084 inch. The diameter of the mixture cable as measured using calipers on the tail piece was 0.052 inch.

Next, the hardware and tail side of the cable were disassembled from the lever arm piece, and a piece of the cable with the fracture surface on the control side was cut from the rest of the cable. The separated cable pieces, the attachment bolt, and the nut-side washer were then cleaned with acetone using a combination of ultrasonic cleaning and brushing with a soft bristle brush.

Views of the cable at the fracture location after cleaning are shown in figure 3. The cable pieces were bent in alternating directions near the fracture location as shown in the upper image in figure 3. Two relatively deep wear marks were observed on the tail piece, and multiple shallower wear marks were observed on the cable near the fracture on the control side as indicated in figure 3. The outside edges of the indicated wear marks on the tail piece were approximately 0.52 inches apart, which was equal to the outside diameter of the nut-side washer. The series of five discrete wear marks on the control side piece were spaced approximately evenly along a distance of 0.157 inch. The mark closest to the fracture was located up to 0.076 inch from the closest part of the fracture surface. For comparison, the width of the nut side washer flat (outside radius minus inside radius) was 0.1265 inch.

A closer view of the fractured ends of the control cable is shown in the lower image in figure 3, where the cable pieces are shown rotated approximately 180 degrees about the axis relative to the upper image. The tail piece was bent approximately 45 degrees adjacent to the fracture location. The fracture was mostly on slant planes roughly with a chisel shape on the tail side and a notch shape on the control side. The notch was offset relative to the cable axis, producing a longer leg and a shorter leg of the notch. A crack extended from the base of the notch on the control side roughly parallel to the plane of the longer notch leg, and the adjacent shorter leg of the notch was bent outward. A deformation crease was observed on the outside diameter at the base of the bent notch leg as indicated in the lower image in figure 3. Rub damage was observed on mating sides of the fracture surface on the longer notch leg as indicated in the lower image in figure 3, which corresponded to sliding contact associated with the bending deformation on the shorter notch leg.

The fracture surface on the cable piece from the control side was further examined using a scanning electron microscope (SEM). Aside from smooth areas corresponding to contact damage or local shearing, the fracture surfaces had dimple features consistent with ductile overstress fracture. An overall view of the fracture surface is shown at the right side in figure 4. The fracture surface on the longer leg of the notch showed textured features with step-like terraces. An area of rub damage near the base of the notch and the crease on the outside diameter associated with the bent shorter leg of the notch are indicated. The tip portion of the longer leg of the notch is shown at the left in figure 4. Some of the steps were smeared consistent with local shearing deformation. At the tip of the shorter notch leg, the fracture progressed in a transverse plane and exhibited round dimples, consistent with tension overstress. The cross-sectional area associated with the transverse fracture was approximately 2.3×10^{-4} square inch.

Views of the cleaned attachment bolt shank at the through hole are shown in figure 5. The shank surface on the control side of the hole is shown in the upper image in figure 5, and the corresponding terminal end-side of the through hole is shown in the lower image. On both sides of the shank, the hole's edge furthest from the nut-side washer was worn.

The washer from the nut side of the assembly is shown in figure 6, where the side of the washer that faced the control cable is displayed after cleaning had removed most of the oily deposits. The washer had multiple cylindrical wear grooves consistent with wear against the control cable. In figure 6, the grooves associated with the tail piece and the control side of the cable at the time of fracture are indicated near the 9 o'clock and 3 o'clock positions, respectively. Additional wear grooves from previous control cable positioning were noted as indicated near the 7:30 and 1:30 clock positions. At the 9 o'clock and 3 o'clock positions, the wear grooves were deepest and widest near the inside diameter of the washer. At the contact wear grooves associated with the previous installation position, the wear grooves were relatively deeper and wider at the outside diameter of the washer when compared to the grooves at the fracture positions.

Submitted by:

Matthew R. Fox, Ph.D.
Chief Technical Advisor - Materials

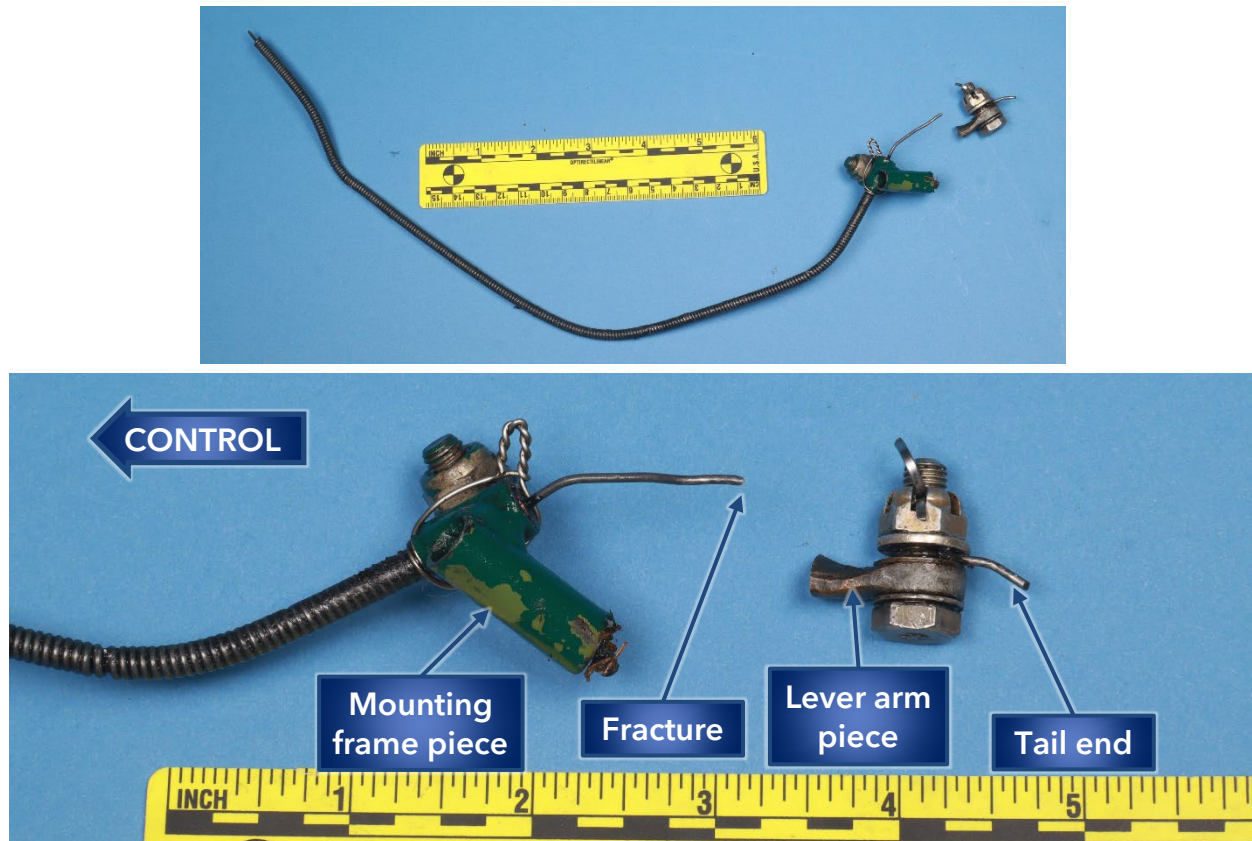


Figure 1. Overall view of the submitted pieces (upper image) with a closer view of the cable fracture location (lower image).

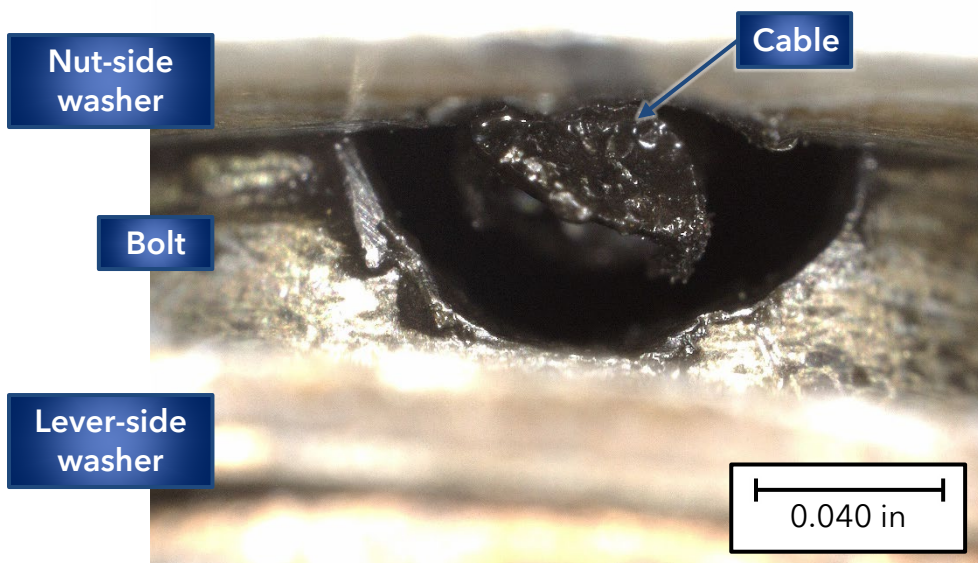


Figure 2. View of the grease-covered fracture surface on the tail piece held within the lever arm attachment hardware after initial cleaning.

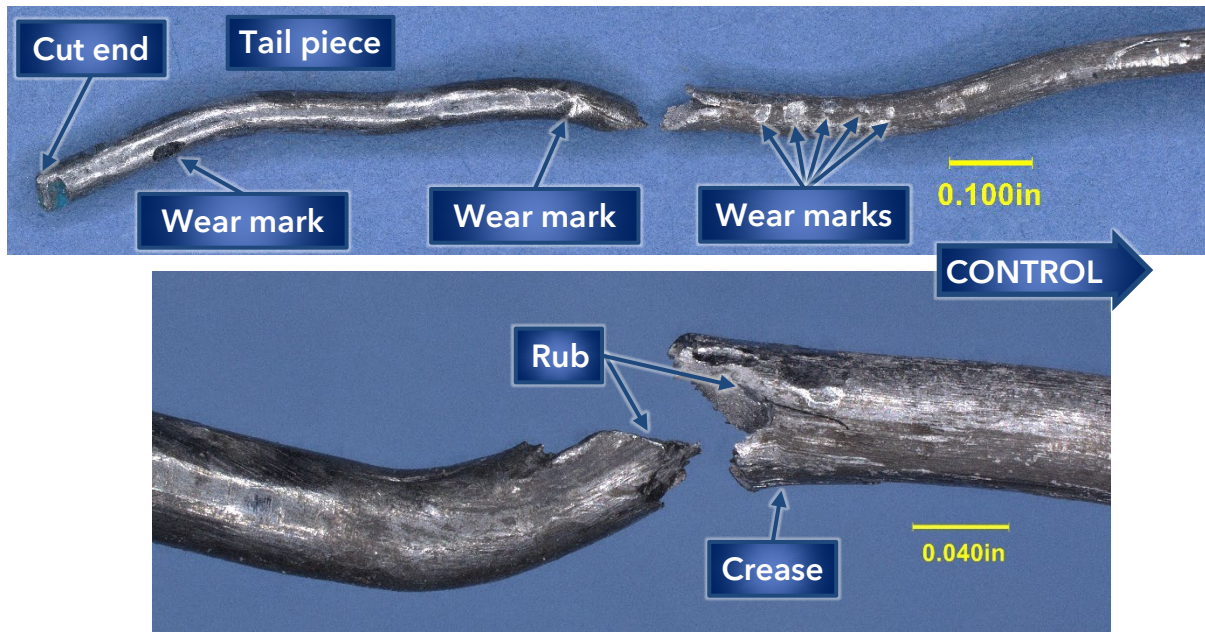


Figure 3. Close views of the fracture location after the tail piece had been removed from the attachment hardware, the control side had been cut from the rest of the cable, and both sides had been cleaned.

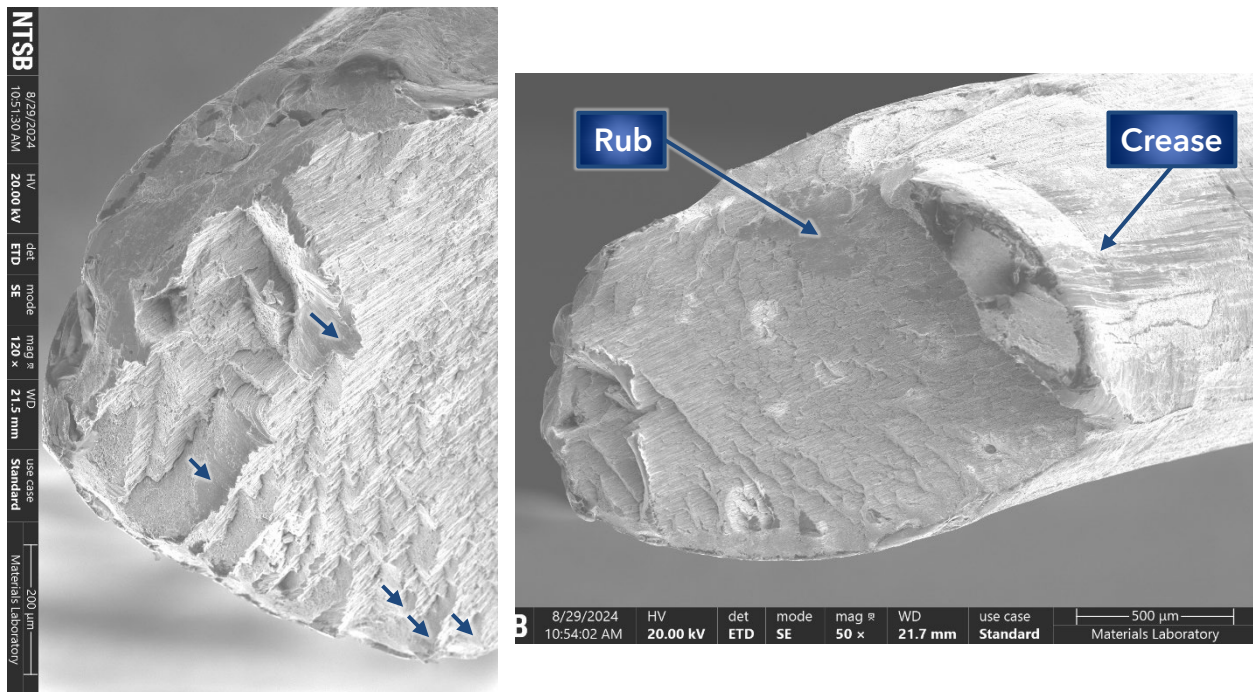


Figure 4. SEM images of the control side of the fracture. Unlabeled arrows in the left image show areas of sliding contact deformation on step features near the tip end of the fracture surface.

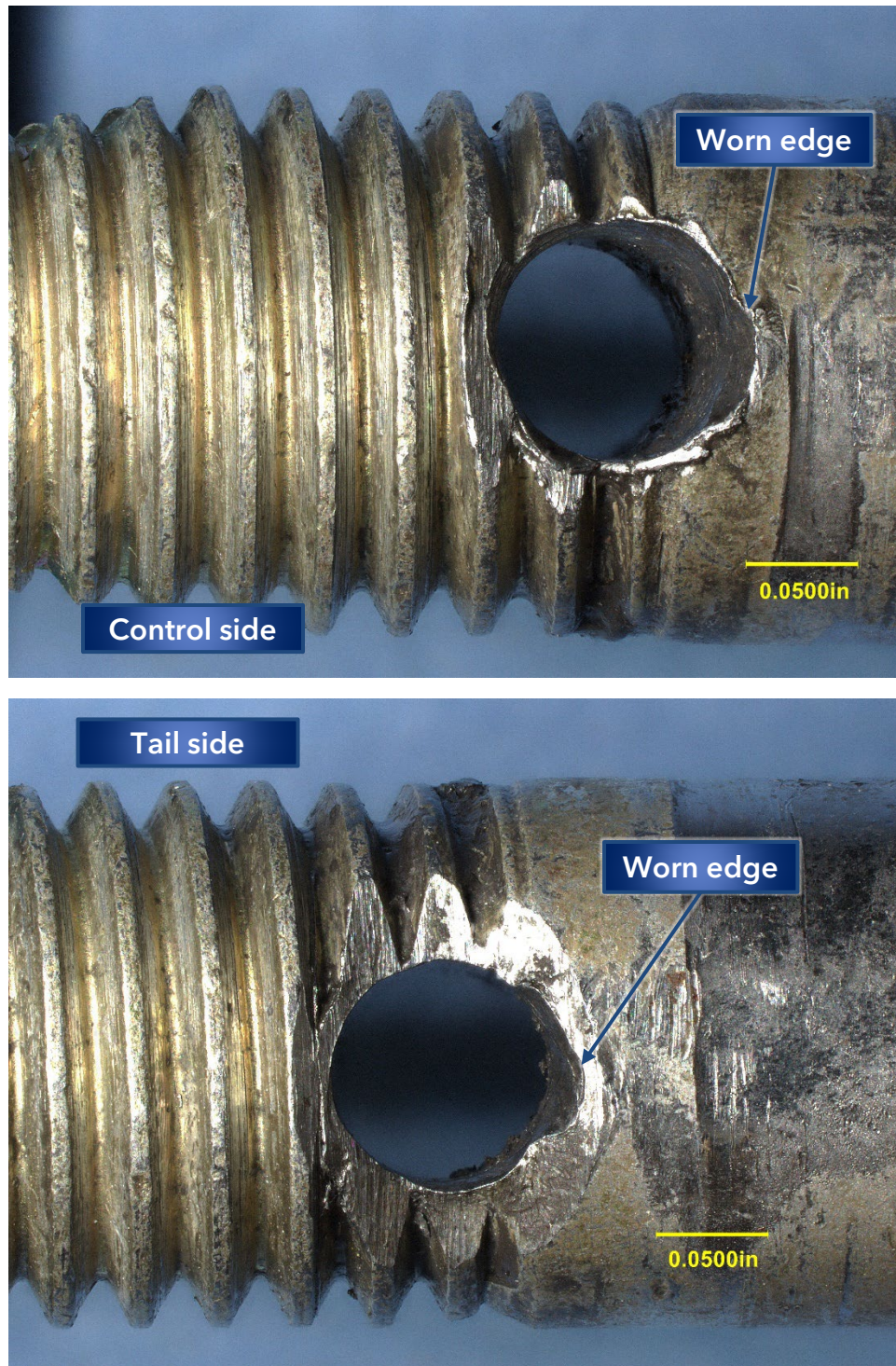


Figure 5. Views of the cable attachment bolt shank showing wear at the edge of the through hole for attaching the mixture control cable.

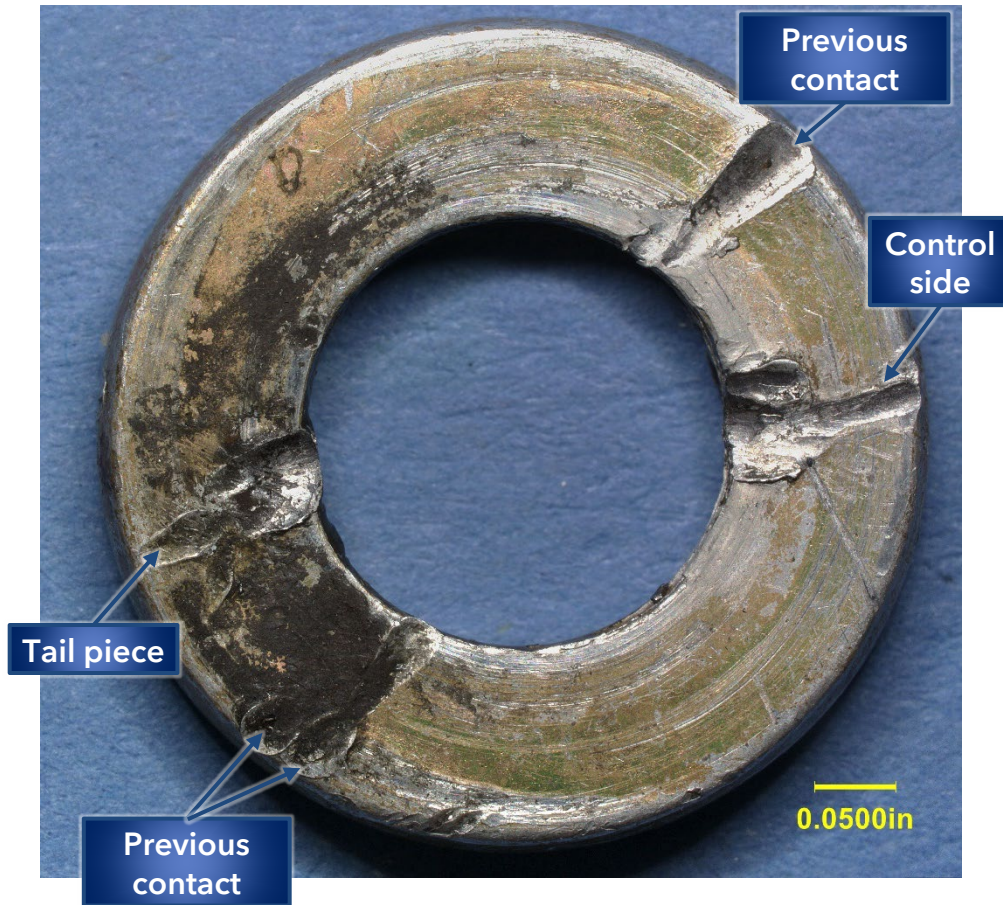


Figure 6. View of the nut-side washer showing the side that faced the control cable after some cleaning. Wear marks associated with contact with the tail piece and control side of the cable at the time of the accident are indicated. Wear marks associated with previous cable contact are also indicated.