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

March 25, 2011.

MATERIALS LABORATORY FACTUAL REPORT Report No. 11-023

A. ACCIDENT

Place	:	Aleknagik, Alaska.
Date	:	August 9, 2010.
Vehicle	:	DHC-3 Otter, N455A.
NTSB No.	:	ANC10MA068.
Investigator	:	Robert Swaim, AS-40.

B. COMPONENTS EXAMINED

1. Vertical Speed Indicator.
2. Airspeed Indicator.
3. Attitude Gyro.
4. Attitude Indicator
5. Terrain Awareness Annunciator.

C. DETAILS OF THE EXAMINATION

Vertical Speed Indicator (VSI).

The display of the vertical speed indicator submitted for examination is illustrated in Figure 1. Examination of the instrument revealed an adhesive identification plate on the rear of the case displaying “PART NO. 7130”, “SER NO. 8667”, “DATE 3/05”, “CODE C. 47”, “TYPE II 0-3,000 FT/MIN”, “United Instruments Inc, Wichita, KS”. On the side of the case “MAR 29 2005” was stamped in white. Air currents were applied to the static source port and the needle was observed to fluctuate. Ultra-violet (UV) examination of the dial revealed no fluorescence. Examination of the dial revealed no indications that the needle had impacted it and the needle was observed to be at least 1/8-inch from the dial surface.

Airspeed Indicator (ASI).

The airspeed indicator received for examination was missing a significant amount of its case and its bezel, exposing the inner mechanism. The needle and the portion of its pinion it was originally fitted on were also missing. The airspeed indicator is illustrated, as received, in the left image in Figure 2. Approximately 25% of an identification plate remained attached to the rear of the case and displayed “MANUFACTURED U”, “RE. 1709”, “2137193”, “2”, “TYPE C14”, “M’F’R’S PART NUMBER”, SERIAL”, “BEN”, and “PI”.

An overhaul sticker on the side of the case is indicated by the red arrow and displayed “Woodlawn Instruments Ltd.”, “Ottawa, Ontario, Canada”, “(613) 737-3305”, “W.O.: 16094”, “Date: 24 2/95” and “OH, T”.

Examination of the inner mechanism revealed that it was intact although the rim of aneroid wafer had been bent for approximately 1/2-inch circumferentially. Mechanical manipulation of the aneroid wafer to reproduce the expansion it would receive during operation revealed continuity to the needle pinion. The inner mechanism is illustrated in the right image in Figure 2 with the wafer indicated by the yellow arrow and the needle pinion indicated by the green arrow. Slowly increasing air pressure was then fed into the pressure port at the rear of the case. The wafer expanded and the needle pinion rotated almost 360-degrees before the wafer burst open adjacent to the bent portion of the rim.

The dial displayed graduations indicating between 40 and 260 miles per hour (mph). A white arc was observed between the 55-mph graduation and 93-mph, a green arc was observed between 63-mph and the 145-mph graduation, a yellow arc was observed between the 145-mph graduation and 193 mph and a radially oriented red line was observed at 193-mph. Examination of the dial revealed missing paint, scuff marks and scratches mostly between the 150-mph and 155 mph graduations. The area between the145 mph and the 155 mph graduations is contained within the red box in the left image in Figure 3 and is illustrated in the right image. The red arrow indicates the area of missing paint where the dial’s base metal was exposed and the black arrow indicates the area on the 150-mph graduation where the missing white paint exposed the underlying yellow paint. The purple arrows indicate scuff marks in both side of the 150-mph graduation, the blue arrows indicate a scratch that extended from the periphery to the 100-mph number as indicated by the blue arrow in the left image and the green arrow indicates a scratch extending from the periphery to the 150-mph graduation. UV examination of the dial revealed no fluorescence.

Attitude Gyro.

The face of the attitude gyro received for examination is illustrated in the left image in Figure 4 with the manufacturer indicated by the yellow arrow. UV examination of the face revealed that the orange components and the green material on the screw head indicated by the green arrow fluoresced. The airplane knob, the airplane, the ring, the football and the mask are identified. Rotation of the airplane knob was found to move the airplane up and down. When initially handled, and immediately after removing the bezel, the football was found to swing freely but the ring did not rotate. During subsequent handling of the instrument the ring became loose and rotated freely.

Examination of the case revealed the identification label indicated by the green arrow in the right image in Figure 4 that displayed “SIGMA-TEK”, “model number 5000B-39”, “serial number T36378P” and “part number 1U149-010-1”. The adhesive label indicated by the yellow arrow displayed “MID-CONTINENT INSTRUMENT CO. INC.” and the company’s address. The date “FEB 23 2005” was stamped with white paint at the

location indicated by the yellow arrow and “MAR 29 2005 was also found similarly stamped on the case. The red label on the case detailed installation precautions.

Screws in the rear of the case were removed and the internal mechanism was extracted with the rear cover. The partially disassembled attitude gyro is illustrated in the right image in Figure 4 with the bezel, the case and the extracted internal mechanism identified. On the internal mechanism the ring, the football and the mask are identified for comparison with the left image. Examination of the internal mechanism revealed that the roll yoke rotated freely and the pitch housing assembly containing the air driven gyro, also rotated freely, limited only by the allowable movement of the football arm. The pitch housing was disassembled and an examination of the extracted rotor and the inner surface of the housing revealed no indications of contact.

Attitude Indicator.

The case of the attitude indicator received for examination displayed indentations and deformation. The indicator was missing the bezel assembly, exposing the display. The face of the attitude indicator is illustrated in the left image in Figure 5 with the mask, the football and the ring identified. The caging rod assembly[1] protruded from the display and is also identified. UV examination of the face revealed that the orange flag fluoresced. The football was locked in place between the ring and the mask and the ring could only rotate approximately 10-degrees. The interior of the instrument was illuminated to find that roll yoke rotation was limited by the yoke contacting the buckled side of the case.

Examination of the case revealed the adhesive identification label indicated by the green arrow in the right image in Figure 5 which indicated that the instrument was a “LIFESAVER™ ATTITUDE INDICATOR” part number “4300-411”, serial number “B05-11643” manufactured by “MID-CONTINENT INSTRUMENT COMPANY”. A battery, attached to the rear of the case, displayed a label indicating its part number, “9015607” and its serial number, “B10-10964”. The battery was disconnected and removed to reveal a label indicating that it requires a “4 month max recharge” and was last charged “3/22/10”.

The internal mechanism was extracted from the case and during the extraction the caging rod assembly fell out. The partially disassembled attitude indicator is illustrated in the right image in Figure 5 with the roll yoke, the pitch housing the caging ring and the caging rod assembly identified. Examination of the caging rod revealed that the arm at the rear of had been bent rearwards. The arm on the caging rod assembly is illustrated in Figure 6 with the component parts identified and a yellow arrow indicating the location of the twist. The bearing that normally engages with the caging ring identified in the right image in Figure 5 was examined and found to rotate smoothly and easily. The football, the mask and the ring were obscured by the side plates which were then removed.

Examination of the internal mechanism revealed that the roll yoke rotated freely and removal of the ring allowed the football to oscillate freely, limited only by the allowable

[1] A mechanism that holds the yoke and housing assemblies in place during aerobatic maneuvers, to avoid damage to the instrument.

movement of the football arm. The pitch housing was disassembled and an examination of the rotor revealed no indications of contact with the housing. An examination of the housing's inner surface revealed circumferential bands of exposed base metal occupying approximately 100-degrees of arc and diametrically opposed. One of the bands is illustrated in the left image in Figure 7 and located between the two red arrows. On this side of the housing a second smaller band was observed and is located between the blue arrows. A closer view of the surface within the red box is illustrated in the right image in Figure 7 with the previously noted bands similarly indicated by the red and blue arrows. The black arrow indicates a distinct scratch on the band indicated by the red arrow and the white arrow indicates a distinctly circumferentially oriented portion of the band. The purple arrow indicates a group of circumferentially oriented scratches not evident in the left image.

Terrain Awareness Annunciator.

The case of the terrain awareness annunciator displayed an adhesive label identifying it as a model MD41-1028, s/n B05-10948 manufactured by "MID-CONTINENT INSTRUMENT Co, WICHITA, KS". Examination of the annunciator revealed that the white button identified as "TERR INHB" was protruding approximately 1/4-inch from the fascia. The examination also revealed that the multi-pin connector on the rear had been rotated slightly counterclockwise and was pointing slightly downwards, as viewed from the rear. The fascia of the terrain awareness annunciator displayed the name "GARMIN" and is illustrated in the left image in Figure 8 with the fascia indications identified in the colors they display when illuminated (red for "PULL UP", white for "TERR INHB" and amber for "TERR" and "TERR N/A").

Handling of the annunciator revealed a rattling noise indicating that there was a loose item inside it and when the fascia was removed a small piece of plastic material fell out. The annunciator is illustrated in the right image in Figure 8 with the fascia removed and the exposed bulbs identified as in the left image. The green arrow indicates a photocell used for automatic illumination dimming and a red arrow indicates the loose item that fell out.

The lower half of the case indicated by the blue arrow in both images in Figure 8 was removed to reveal the main circuit board illustrated in the left image in Figure 9 with the annunciator inverted. The examination of the main circuit board revealed a matching fracture on the rear end of a chip where it was screwed to the mounting bracket for the multi-pin connector at the location indicated by the yellow arrow. The examination also revealed no indications of soil on the main circuit board or on the bulb circuit board.

Prior to an examination of the bulbs illuminating the fascia indications the blue sheaves on the "TERR INHB" illustrated in the right image in Figure 8 were removed. Microscopic examination of all bulb filaments revealed that, with the exception of the four "TERR INHB" bulbs, all the others displayed similar typical features. A typical bulb filament is illustrated in the right image in Figure 9 with the filament posts and the filament supports identified. The black arrows indicate portions of the filament that were uniformly coiled and intact. The annunciator bulbs are illustrated in the left image in Figure 9 and are

collectively identified as in Figure 8 with the exception of the “TERR INHB” bulbs which are individually identified as “TI-1”, “TI-2”, “TI-3” and “TI-4”. A white arrow indicates an internal bulb that provides general instrument panel illumination and was included in the examination.

Examination of bulb “TI-1” revealed distinctive stretching at the locations indicated by the red arrows in the left image in Figure 10 and overall deformation of the filament.

Examination of bulb “TI-2” revealed distinctive stretching at the location indicated by the red arrow in the right image in Figure 10. The filament was broken and the fractured ends are indicated by the yellow arrows with deformation at the end adjacent to the filament support.

Examination of bulb “TI-3” revealed distinctive stretching at the locations indicated by the red arrows in the left image in Figure 11. The filament was broken, with a separated portion lying adjacent to the base of the filament supports, and the fractured ends are indicated by the yellow arrows.

Examination of bulb “TI-4” revealed distinctive stretching and deformation at the location indicated by the red arrow in the right image in Figure 11. Minor stretching was observed at the locations indicated by the green arrows.

The loose item indicated by the red arrow in the right image in Figure 8 was a piece of black plastic material and is illustrated in Figure 12 with red arrows indicating the fracture face that matched the fracture face on the chip indicated by the yellow arrow in the left image in Figure 9.

Examination of the “TERR INHB” button hole in the fascia revealed rub marks in the radiused corners and a thin band of a soil deposit on the inner surface of the fascia. A view of the hole is illustrated in the left image in Figure 13 with the lower edge of the fascia indicated with a blue arrow, as in Figure 8. The green and white arrows indicate the radiused corners that displayed a rubbed appearance when compared to the side indicated by the red arrow and the yellow arrow indicates the soil deposit. The side of the “TERR INHB” button normally adjacent to the fascia side indicated by the red arrow in the left image in Figure 13 is illustrated in the right image. The white arrow indicates the button corner that is normally adjacent to the fascia corner indicated by the white arrow in the left image and an examination of the corner revealed faint soil deposits with a longitudinal orientation. The green arrow indicates soil deposits on the side of the button that were located within 1/8-inch of the button face, the blue arrow indicates soil deposits that were located within 1/16-inch of the button face and the red arrow indicates soil deposits in the lower corner, normally located behind the fascia.

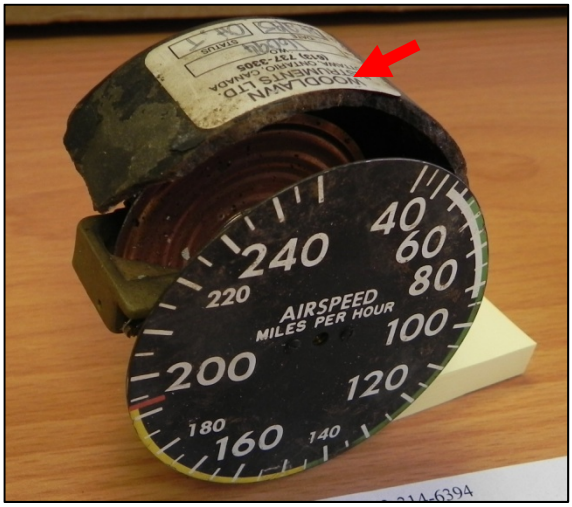
The opposite side of the hole illustrated in the left image in Figure 13 is illustrated in the left image in Figure 14 with the lower edge of the fascia also indicated with a blue arrow. As in the left image in Figure 13 the green and white arrows indicate the radiused corners that displayed a rubbed appearance when compared to the side indicated by the red arrow and the yellow arrow indicates the soil deposit. The side of the “TERR INHB” button normally adjacent to the fascia side indicated by the red arrow in the left image in Figure 14 is illustrated in the right image with a green arrow indicating soil deposits on the

corner and a white button indicating a portion of the deposits that displayed a longitudinal orientation. As in the right image in Figure 13, the red arrow indicates soil deposits in the lower corner, normally located behind the fascia.

Repeated operation of the “TERR INHB” button revealed that the switch it was attached to was a momentary switch and the button returned to the protruding position previously noted when it was released. The switch is indicated by the green arrow in the left image in Figure 9.

Derek Nash
Mechanical Engineer

Figure 1. The face of the vertical speed indicator received for examination.



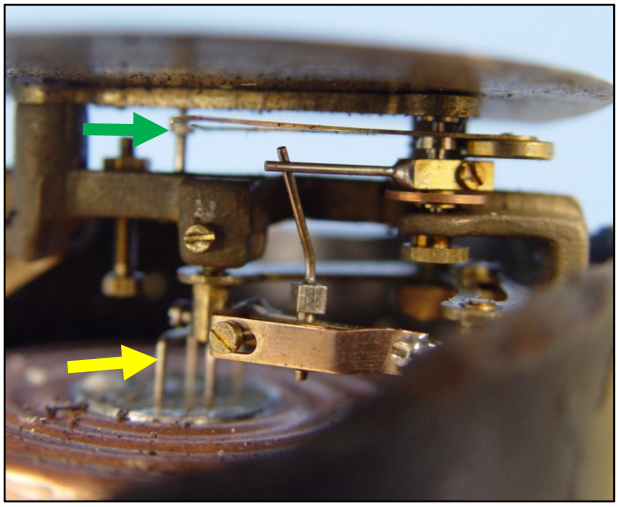


Figure 2. The airspeed indicator received for examination (left) and an internal view (right).

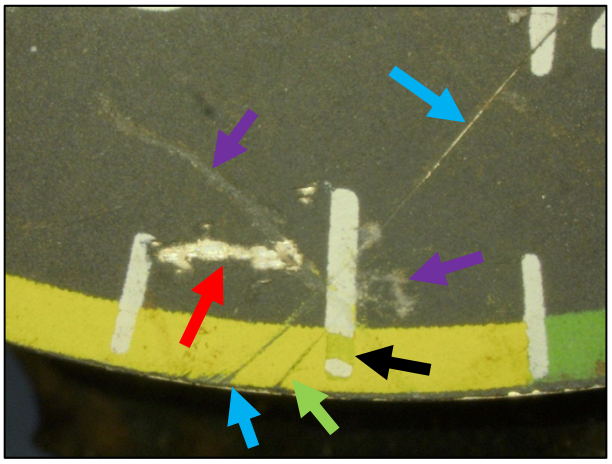


Figure 3. The dial of the airspeed indicator (left) and a closer view in the vicinity of the yellow arrow (right).

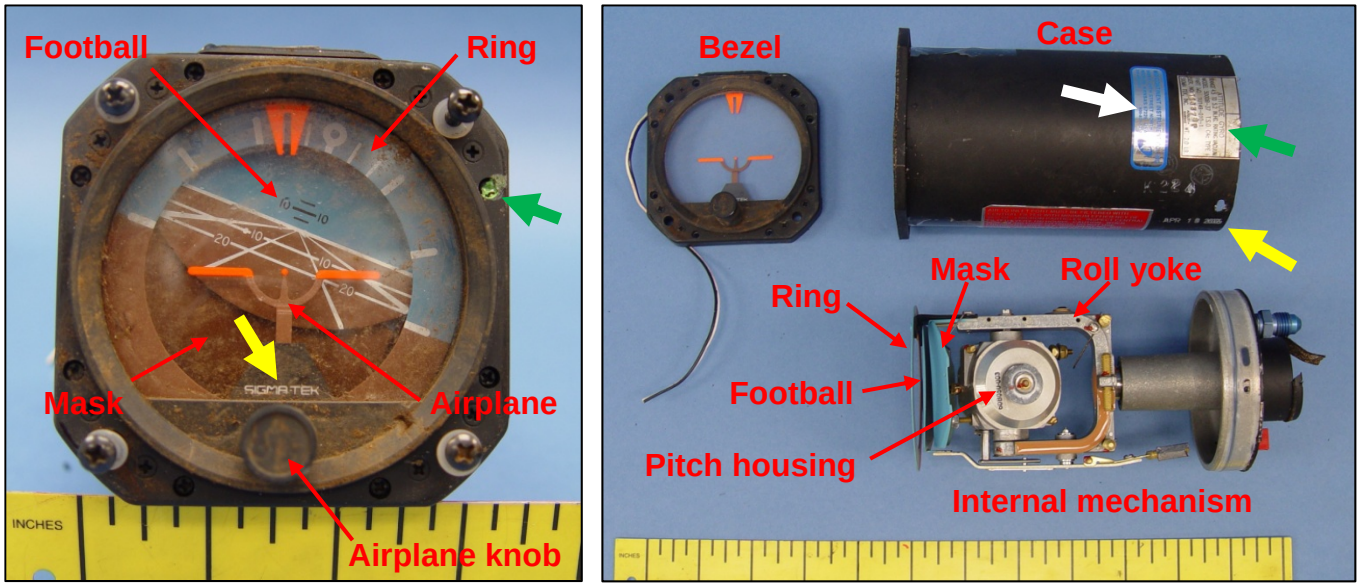


Figure 4. The face of the attitude gyro (left) and the gyro partially disassembled (right).

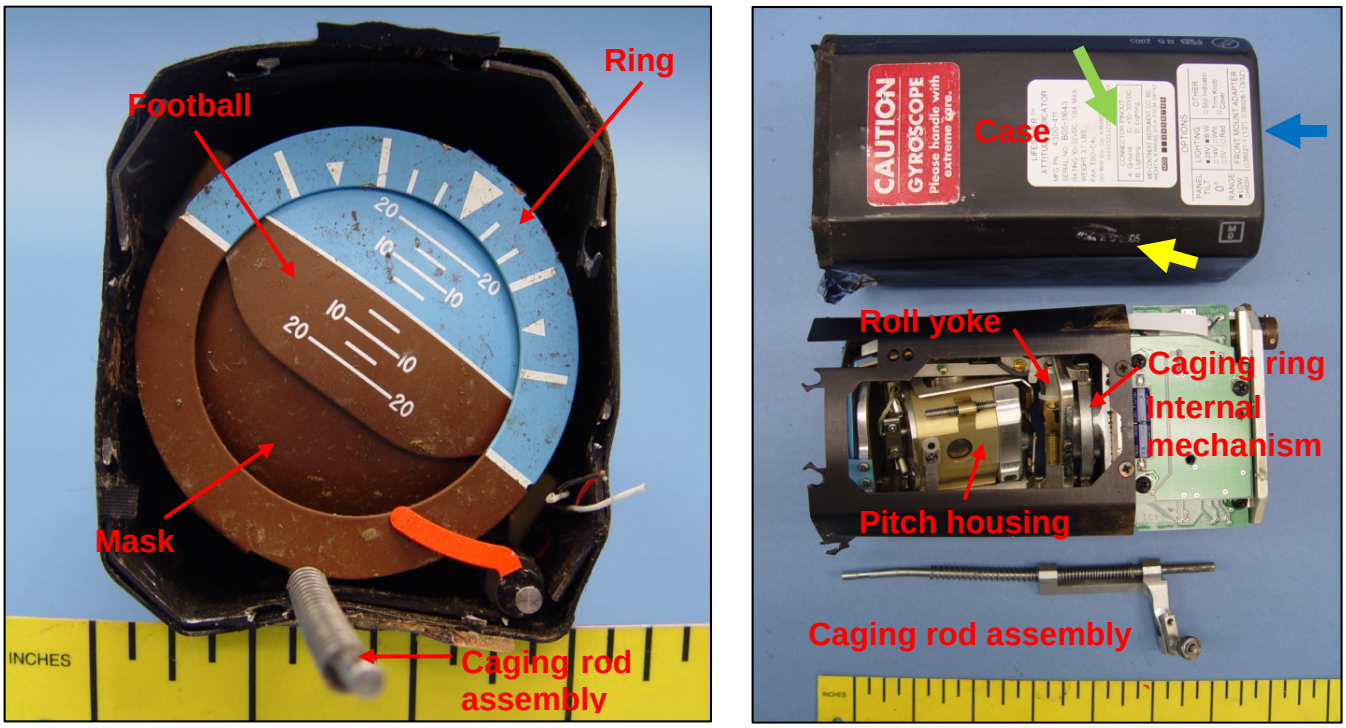


Figure 5. The face of the attitude indicator (left) and the indicator partially disassembled (right).

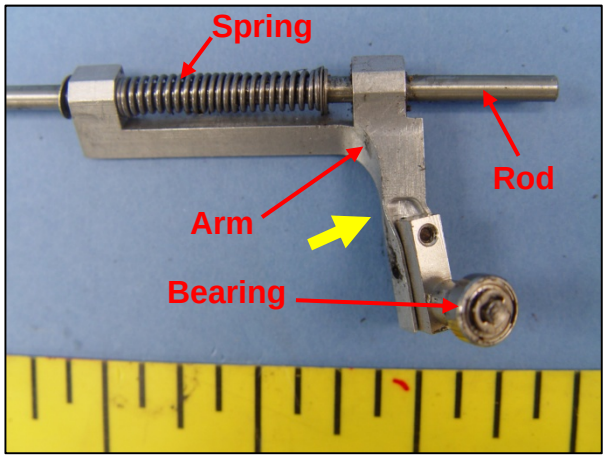


Figure 6. The twisted arm at the rear end of the caging rod assembly.

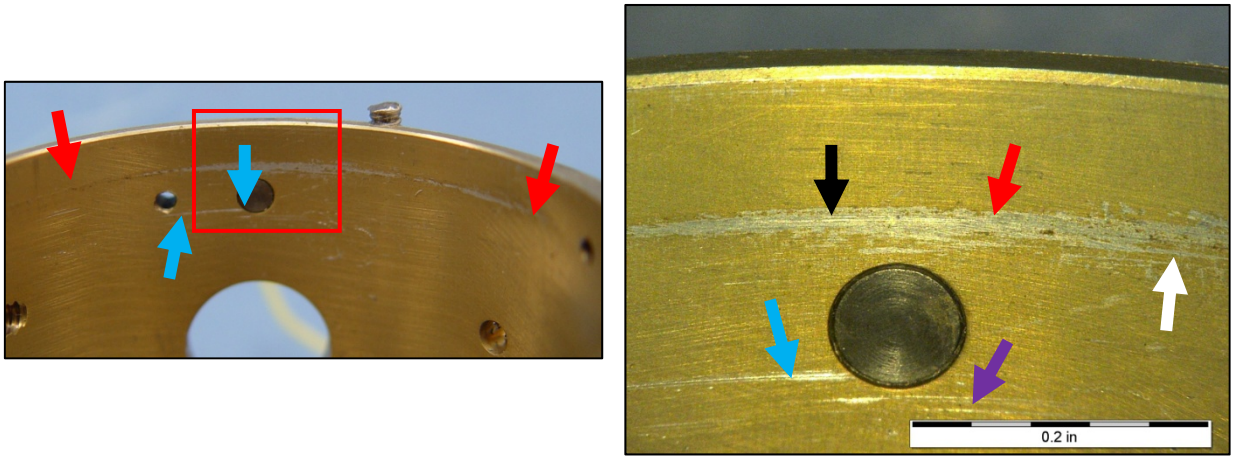


Figure 7. Markings on the inner surface of the rotor housing (left) and a closer view (right).

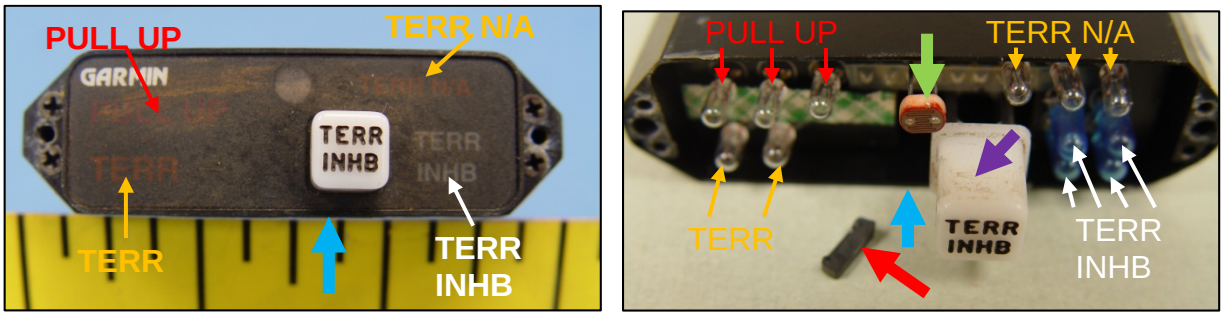


Figure 8. The display of the terrain awareness annunciator (left) and with the fascia plate removed (right).

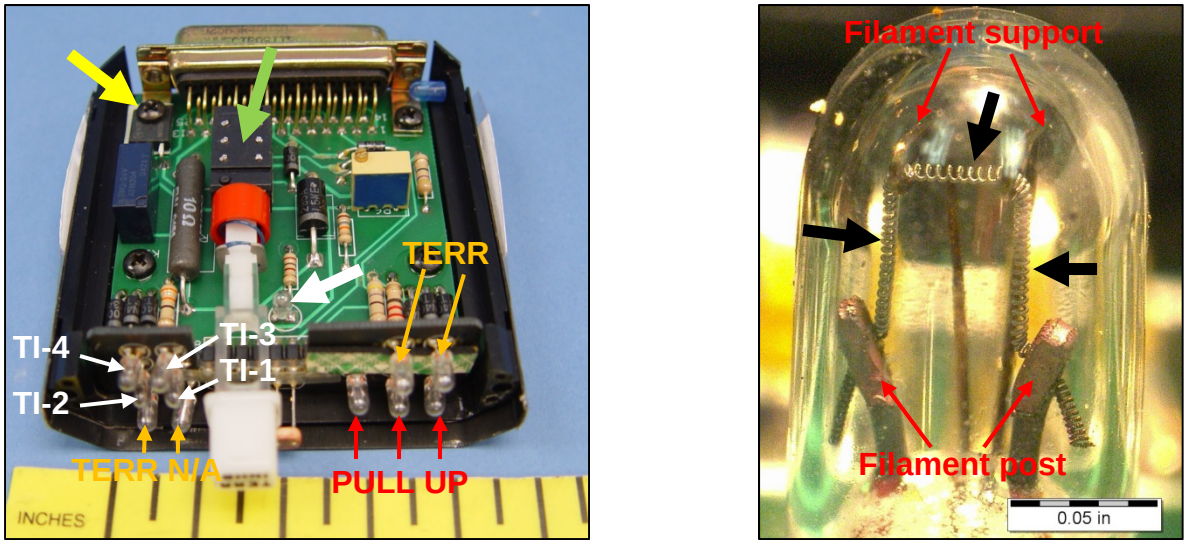


Figure 9. The circuit board and bulbs in the terrain awareness annunciator (left) and a typical bulb filament, except for the "TERR INHB" bulbs below, (right).

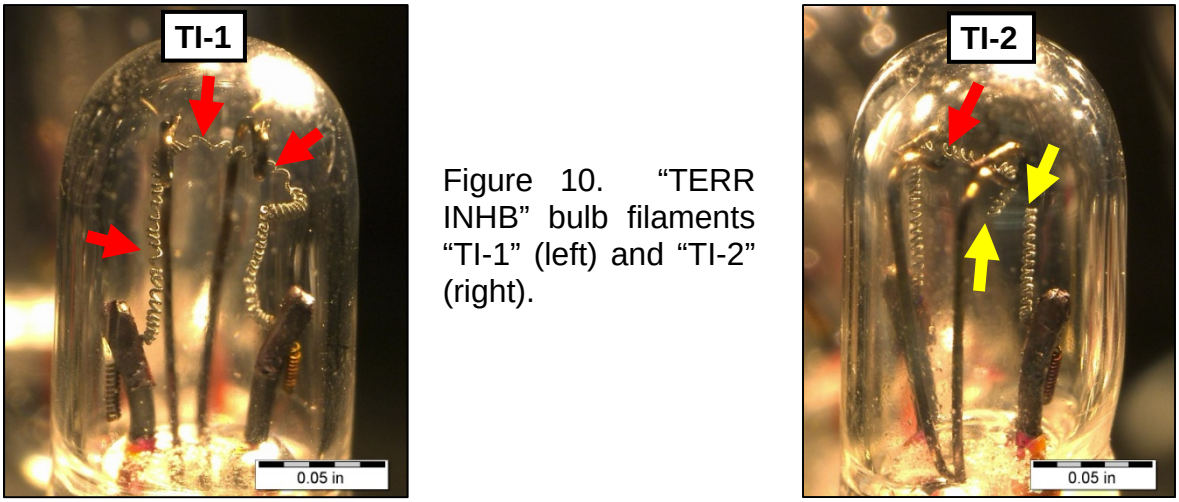


Figure 10. "TERR INHB" bulb filaments "TI-1" (left) and "TI-2" (right).

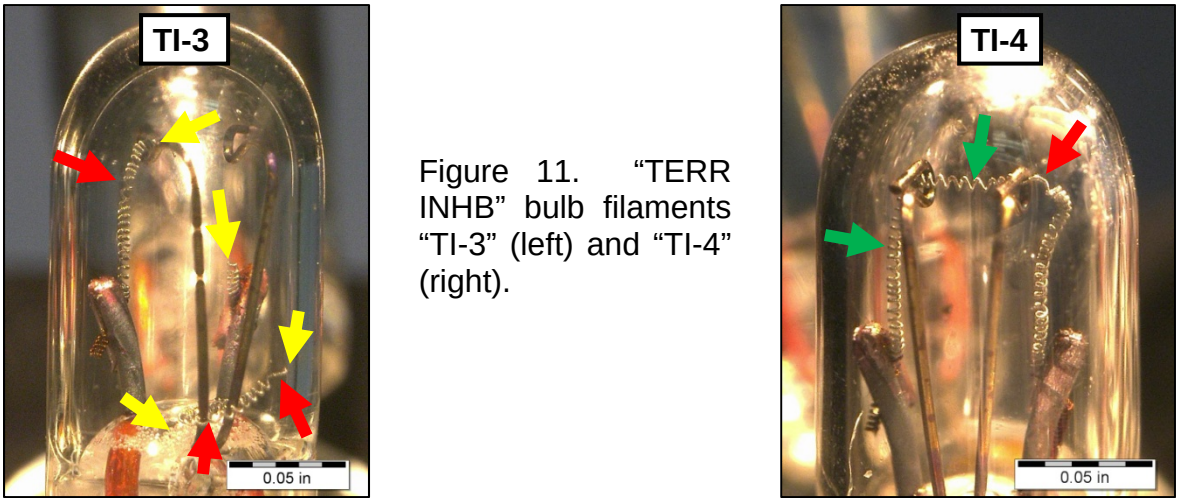


Figure 11. "TERR INHB" bulb filaments "TI-3" (left) and "TI-4" (right).

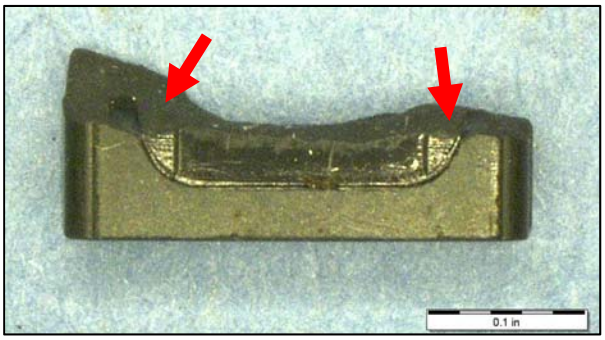


Figure 12. The loose item indicated by the red arrow in the right image in Figure 8.

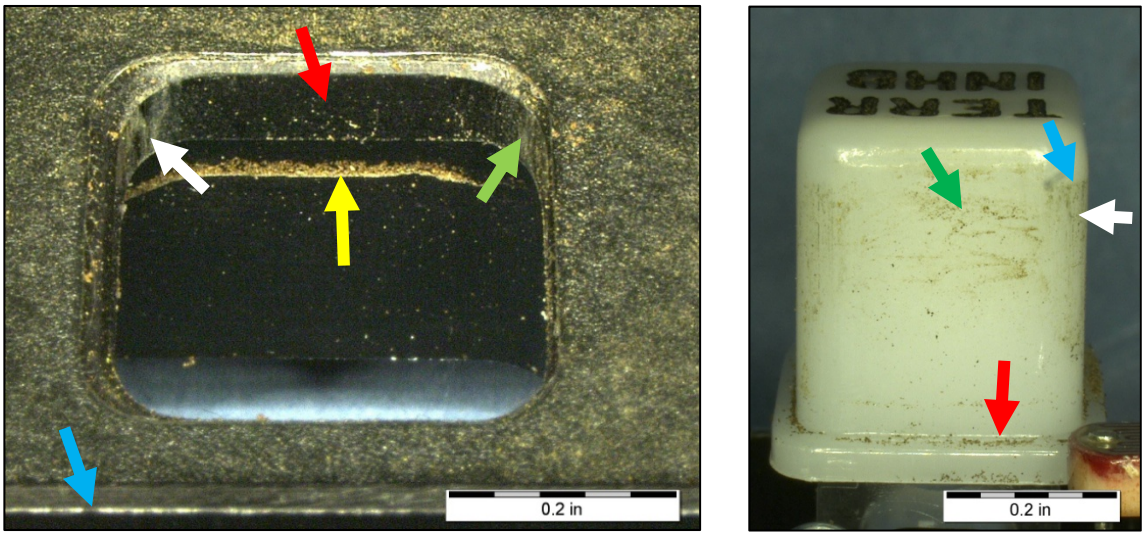


Figure 13. An inner surface of the terrain-inhibit switch fascia (left) and the normally adjacent side of the button (right).

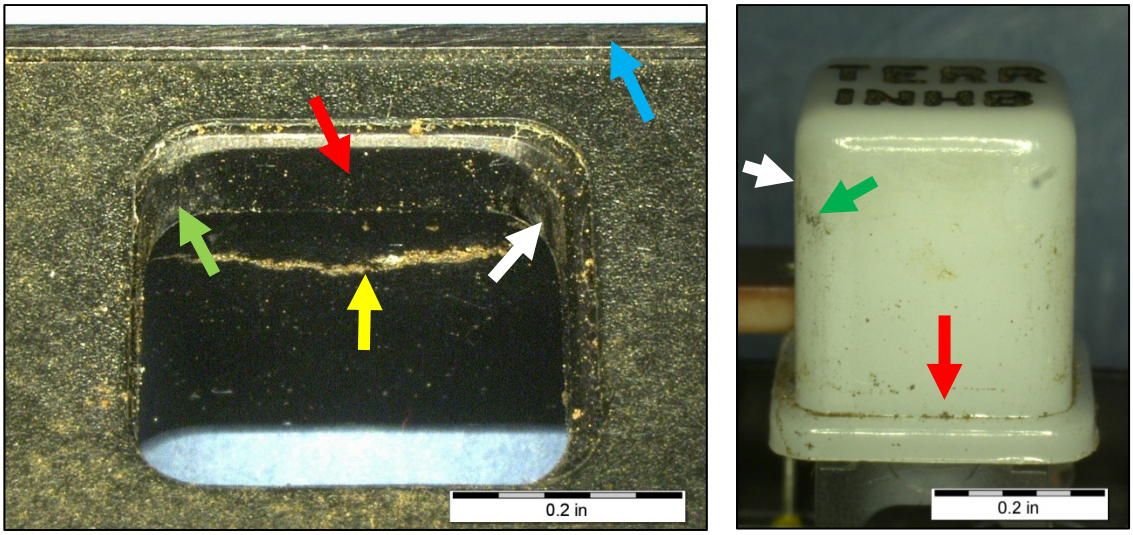


Figure 14. The inner surface of the terrain-inhibit switch fascia (left) opposite to the surface illustrated in Figure 10 and the normally adjacent side of the button (right).