

Found Objects

TIGHAR's case hinges upon the artifacts found on Nikumaroro. If they are random pieces of junk such as might be expected to litter any Pacific atoll, then the notion that the Earhart flight ended on this particular island is no more credible than the many other unsupported theoretical solutions to the mystery. If, however, there is reason to believe that just one object discovered on Nikumaroro came from the lost flight, then any answer to the riddle must explain how it got there and a concerted search for more evidence is certainly warranted.

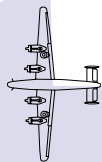
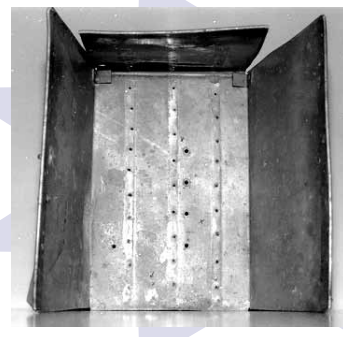
Man-made objects are not difficult to find on Nikumaroro. The atoll's quarter century (1938 to 1963) of habitation left the once-settled areas strewn with the kind of debris that is the essence of archaeology. Some of that trash—a very, very small proportion—came from at least two aircraft, even though from 1938 to the present, no aircraft of any description was ever wrecked, damaged or repaired at Nikumaroro. All of the airplane-related material has been found in the island's abandoned village and, in most

cases, shows clear signs of having been put to local use. Several of the objects, although undoubtedly from an airplane, are so generic as to defy connection with any particular make or model. A handful of other pieces can be reliably linked to the Consolidated Model 32 (B-24, PB4Y-1, etc.), the most ubiquitous of the WWII types which operated in the region. Other pieces of aircraft-related material found on the island do not appear to be from any wartime or later aircraft. They do, however, exhibit features consistent with a specific Lockheed Model 10E Special which is known to have been lost in that part of the Pacific in 1937.

The following is a description and evaluation of the twelve aircraft-related objects found on Nikumaroro to date. The artifacts are presented in the order in which they were discovered. In most cases, their physical properties have been established with the help of governmental or private laboratories. The opinions expressed about their probable origins are solely TIGHAR's. The map on page 22 shows where each artifact was found.



1. Navigator's Bookcase (TIGHAR Artifact 2-1)



Date Found: October 1989 during TIGHAR's NIKU I expedition.

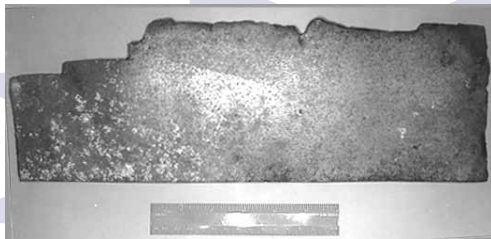
Materials analysis: Federal Bureau of Investigation (FBI) Laboratory Report date: December 31, 1990.

Description: An open box constructed of .040 inch aluminum with a single row of four .25 inch diameter holes offset left of center on the side facing the opening. Traces of a sloppily-applied greenish yellow coating are present on the interior surfaces. Stamped into the metal in three locations is the designation 28F4023.

Condition: One side of the box has been removed, possibly with a hack saw, and the remaining corners have been cut apart, apparently with the same tool. Interior fixtures once secured with #4 ($\frac{4}{32}$ inch) AN442 (flat head) rivets have been removed, leaving enlarged and deformed holes.

Identification: Artifact 2-1 is Consolidated Aircraft Part Number 28F4023, officially described as “Box–Furn., Navig. Book & Paper Stowage.” Although designed for the PBY (Consolidated Model 28), this particular bookcase has been modified for installation in a B-24 type airplane. Early examples of the Consolidated Model 32 (B-24C and some B-24D/PB4Y-1 aircraft, a total of 1,653 machines) were equipped with PBY bookcases. Later, Consolidated designed a special bookcase for the Liberator which carried a 32F** part number.

Commentary: At first, this artifact really had us stumped. It was obviously a PBY part, but the mounting holes indicated that it was never installed in a PBY. Could it have been aboard Earhart’s airplane? It took two years of research to determine that the answer is no, but knowing that it came from a B-24 became important in the light of later discoveries.



2. Sheet of aluminum with red paint (TIGHAR Artifact 2-2)

Date Found: October 1989 during TIGHAR’s NIKU I expedition.

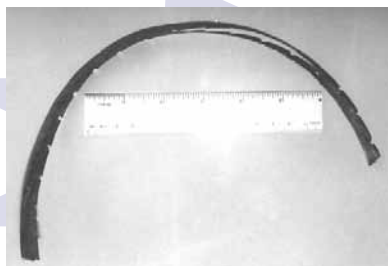
Materials analysis: National Transportation Safety Board (NTSB) Report date: March 5, 1992

Description: The sheet is about 5.25 inches wide by 15.5 inches long and is 0.032 inches thick. The long straight edge of the piece appears to have been an original manufacturer’s cut. The piece appears to have been further mechanically cut where right angle corners are evident. Magnified examination of the inside corner sections of these cuts revealed deformation patterns typical of cuts made with a pair of tin snips. The remaining edges of the sheet appear to be typical tearing fractures. One surface of the sheet has a rusty brown stain on about half of its area. The opposite surface has a faint red coloration over a portion of its surface. The material is 2024 (previously known as 24ST) aluminum but is not Alclad (a corrosion inhibiting treatment).

Condition: Even though the aluminum is not Alclad, the piece exhibits only mild surface corrosion. The area of apparent red paint on one surface may or may not be a result of local adaptive use.

Identification: unknown

Commentary: The absence of rivet holes along the original manufacturer’s cut edge, and the fact that it is not Alclad, argue against this piece ever having been part of the skin of an airplane. The small rectangular strips cut from one end suggest that this might be connected to an incident remembered by Coast Guard veteran Ernest Zehms who was stationed on the island in 1944. In 1992 Zehms recalled that one of his friends collected some small pieces of aluminum from a B-25 wreck on Canton Island and brought them to Nikumaroro for the purpose of making aluminum watch bands. However, when shown a photograph of this artifact Zehms did not recognize it. It is worth noting that an inventory of the Earhart aircraft taken after the March 20, 1937 crash in Hawaii lists “2 Pcs. Sheet metal Alcoa” (Item #66) as being among the spare parts carried.



3. Cut Strip of Aluminum (TIGHAR Artifact 2-3)

Date Found: October 1989 during TIGHAR's NIKU I expedition.

Materials analysis: NTSB. Report date: March 5, 1992

Description: This is a 14 inch long by $\frac{1}{2}$ inch wide strip of .040 inch nominal thickness aluminum alloy (Alclad). The strip has a manufactured edge along one side and an unidentified edge separation along the other side that intersects a line of $\frac{4}{32}$ inch diameter holes. The holes are nominally spaced $\frac{3}{4}$ inch on center. The strip is deformed in a spiraling curl suggestive of the waste side strip produced from cutting with a pair of tin snips.

Condition: One end of the strip exhibits exfoliated corrosion.

Identification: unknown

Commentary: Nowhere on a Lockheed Model 10 are there #4 rivets so closely spaced. The only other artifact found on Nikumaroro which exhibited exfoliated corrosion is Riveted Assembly 2-2-V-8, a known B-24 part.



4. Aluminum Plate (TIGHAR Artifact 2-5)

Date Found: October 1989 during TIGHAR's NIKU I expedition.

Materials analysis: NTSB

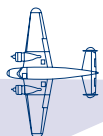
Report date: March 5, 1992

Description: This is a roughly rectangular piece of 2024 Alclad about 2 inches by 5 inches and 0.062 inches thick.

Condition: There is a straight sheared edge (manufacturer's cut) along one long side, a bending overstress fracture along one short edge, and the other two edges exhibit typical saw cut markings. A ragged hole went through one end of the plate as if cut by multiple strikes with a thin narrow instrument such as a small chisel or screwdriver. A second similar hole was cut partially through the plate.

Identification: unknown

Commentary: The plate is the same thickness as Riveted Assembly 2-2-V-8, a known B-24 part. There are no .062 skins on either the B-24 or the Lockheed 10. This is probably part of a structural member and may be part of 2-2-V-8.



5. Dado (TIGHAR Artifact 2-18)

Date Found: October 1989 during TIGHAR's NIKU I expedition.

Materials analysis: NTSB

Report date: March 5, 1990

Description: This aluminum sheet metal assembly is made up of at least four separate components, a wide web (0.032" thick), a narrow flat strip (0.022" thick), a 180° flange (0.022" thick), and a 90° flange 0.022" thick. Overall, the assembly is 16.75 inches long by 6.5 inches wide. All four edges of the web appear to be manufacturer's cuts with $\frac{3}{32}$ inch diameter rivet holes and remnants of rivets nearby. The 90 degree flange is attached to one long edge of the web by rivets spaced



This photo of the "long rivet tail" with "bluish woven fabric" at its base was taken prior to the NTSB's examination. It shows that the fabric was actually the top layer of a sandwiched structure which included .25 inch of kapok-

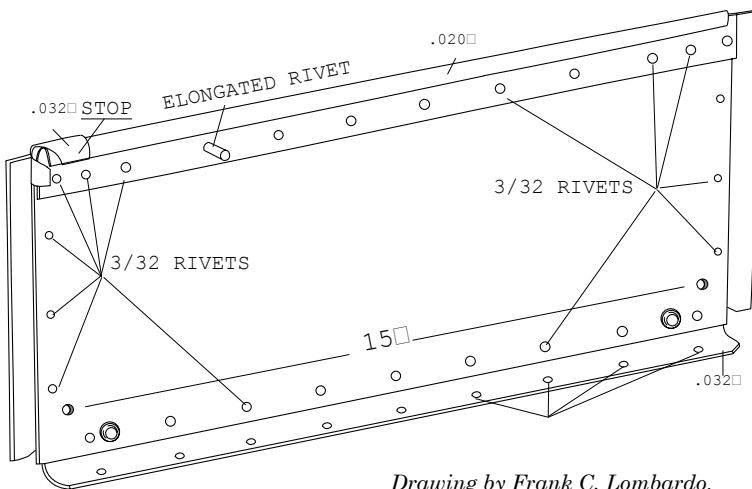
like material. Unfortunately, further analysis is not possible. The fabric and the material were lost during the NTSB's examination.

1.75 inches apart. The 180 degree flange and the flat strip were riveted to opposite sides of the other long edge of the web.

Condition: Corrosion of the assembly components is heavy with the areas of the 180 degree flange and flat strip showing perforations. The space between the flange, web, and strip was filled with what the NTSB judged to be corrosion products, but TIGHAR researcher Frank Lombardo has performed a more detailed inspection and believes that these "corrosion products" are, in fact, remnants of micarda stripping installed to inhibit corrosion. A long rivet tail is located in the area of severe corrosion. During optical examination, the NTSB noted small remnants of a bluish woven fabric around the rivet tail.

Identification: This type of assembly, known as a dado, was used in the interior finishing of small cabin-class airplanes to protect the juncture between the cabin wall and floor. Although we have the complete assembly, there is no part number as is found on military fixtures (for example, the Navigator's Bookcase) Military aircraft do not normally carry this type of interior furnishing.

Commentary: Because they are interior furnishings rather than structural components, dados can vary greatly depending upon the cabin configuration of the particular aircraft. The available plans for the Lockheed Model 10 are for the airline version and include structures similar, but not identical,



*Drawing by Frank C. Lombardo,
TIGHAR #1806*

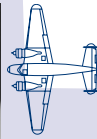
to the object found on Nikumaroro. No plans or photographs of the final configuration of the cabin of Earhart's airplane are known to exist. There are, however, several interesting observations which can be made about the artifact.

As shown in the reconstruction at left, the mounting holes by which the dado was affixed to the aircraft structure are exactly 15 inches apart. The Lockheed Model 10 fuselage is built on a 15 inch standard, with bulkheads, circumferentials and stiffeners spaced, on the average, 15 inches apart.

Specifications for the Lockheed

Model 10 call for the cabin area to be insulated with .25 inch kapok. The insulation, known by the trade name "Seapak," was often blue.

The 90° flange along the base of the dado was attached to the aircraft floor with screws in metal-floored aircraft or nails in airplanes with wooden flooring. On the artifact, pry marks on the underside of the flange at the holes indicate that, in this case, nails were probably used. The floor of the Lockheed 10 was made of wood.



6. Aircraft Skin (TIGHAR Artifact 2-2-V-1)

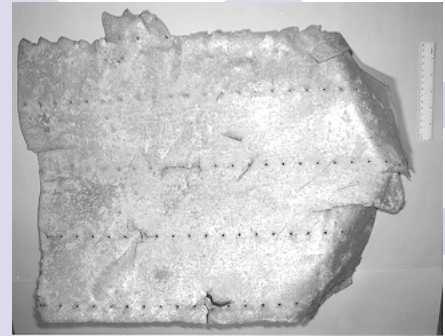
Date Found: October 1991 during TIGHAR's NIKU II expedition.

Materials analysis: NTSB

Report date: March 5, 1990

Description: This is a sheet of 0.032 Alclad measuring roughly 23 inches by 19 inches. There are four rows of evenly spaced $\frac{3}{32}$ inch diameter rivet holes with a 1 inch pitch (space between centers) and one row of $\frac{5}{32}$ inch diameter rivet holes with a nominal pitch

of 1.25 inches along its long dimension. There is no line of rivet holes across the width of the sheet. The rows of rivet holes are not parallel but show a slight angling toward the row of larger holes. Nominal spacing between rows is 4.25 inches at one end of the sheet and $\frac{1}{8}$ to $\frac{1}{4}$ inch closer at the other end. One rivet is still present. The length of the undeformed rivet shank (distance between the manufactured head and the formed head) indicates that the skin was previously attached to an underlying member approximately 0.06 inch in thickness. The faint outline of $\frac{1}{2}$ inch tall letters "AD" are present on what was the exterior surface of the skin. Also visible in this area is the streaked remnant of a much-degraded greenish coating.



Condition: The sheet is bounded by fractures on all four edges (no manufacturer's cut is present) and has a pronounced curvature across the short dimension. On one side the fracture runs generally along the line of $\frac{5}{32}$ rivet holes. The fracture intersects all of the $\frac{5}{32}$ inch diameter holes except for three unfractured holes which are unevenly spaced. The skin around the $\frac{3}{32}$ inch diameter rivet holes is dimpled inward toward the concave side of the sheet suggesting that the surface was area loaded from the concave side while the rivets and underlying structure were intact. Scratch marks on the interior (concave) surface adjacent to some of the rivet holes suggests the further removal of underlying structure by prying with a hand tool. Post-separation abrasion and erosion damage have obliterated the fracture faces and, in the opinion of the NTSB, positive determination of the modes of fracture can not be established. However, the NTSB did note that the fracture geometry along the line of $\frac{5}{32}$ rivet holes is consistent with tearing separations in both directions away from the area of the intact holes. Deformation adjacent to the fracture along one edge of the sheet indicated that it had been folded 90 degrees toward the convex side at least twice prior to separation. The only place on the sheet exhibiting significant corrosion is an area roughly 1.5 inches in diameter located immediately adjacent to the "tab" with the three undamaged $\frac{5}{32}$ rivet holes. The corrosion originated on the interior surface of the sheet and has perforated the exterior surface in three pinpoint-sized locations.

Identification: This is a forcibly removed section of aluminum which was once part of an airplane skin. The aircraft was of all-metal construction and was manufactured in the United States, probably before 1939. The surviving rivet is an AN 455 AD 3/3. The head style, known as the "brazier" head, was replaced in most applications by the "universal" head (AN470) sometime after 1940. The letters "AD" noted on the exterior (convex) surface are the last two letters in the word "ALCLAD" which was stamped onto the aluminum in red ink at the time of manufacture by Alcoa Aluminum as part of the product labeling. Complete examples of this same size and style of lettering (ALCLAD 24S T3) have been noted on aluminum used in repairs or modifications to two surviving Lockheed 10s: c/n 1015, recently rebuilt as a replica of Earhart's

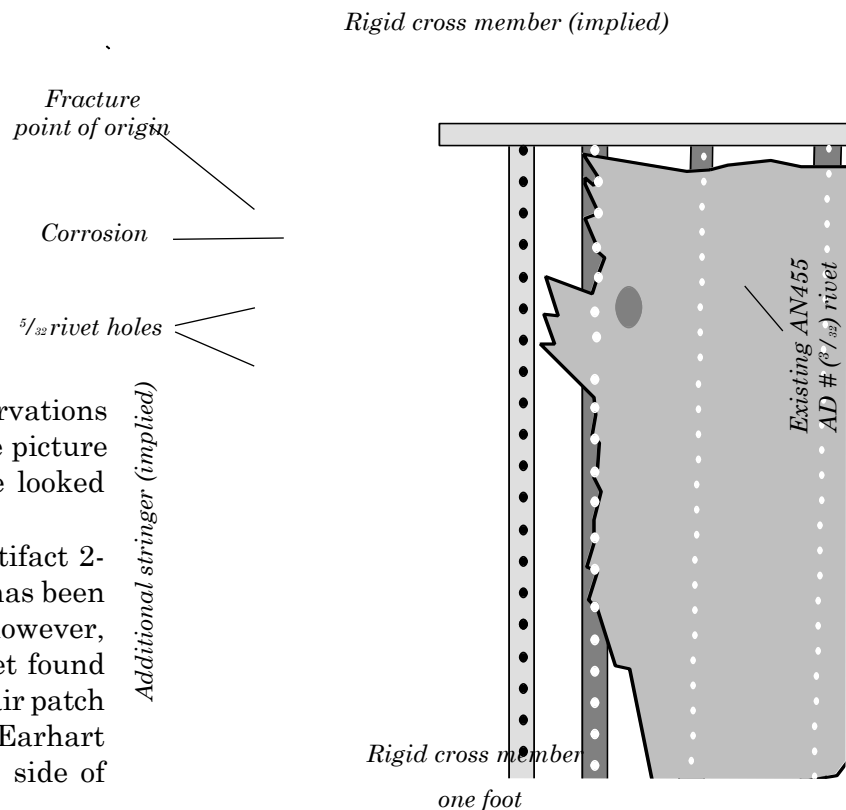
aircraft and currently registered NX72GT, and c/n 1052 in the New England Air Museum collection. Similar labeling has also been found on a small patch on the nose of a Douglas C-47 in the Dover AFB Museum collection. The font, or type style, of the lettering does not appear to match any of the styles used by Alcoa for aluminum manufactured during or after World War II. The fact that the lettering is not aligned with the grain of the metal indicates that the labeling was hand-stamped, a practice replaced by rolled-on labeling when aluminum production boomed after 1939.

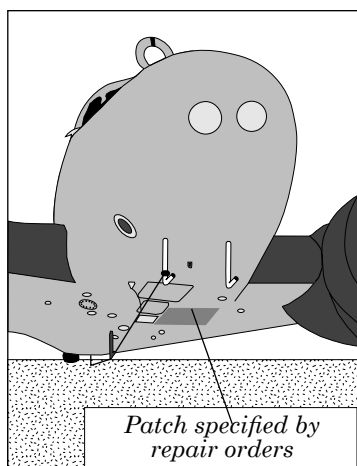
Commentary: This is, by far, the largest and most complex aircraft artifact found on Nikumaroro to date. It is also the most controversial. The skin's material components, dimensions and rivet pattern are similar, but not identical, to some portions of the Lockheed Model 10. TIGHAR initially noted the artifact's similarity to the underside of the Electra just forward of the cabin door and attributed the differences to changes made when the Earhart aircraft was repaired following its March 20, 1937 accident in Hawaii. Critics correctly pointed out that such structural changes could not have been made without a wholesale re-engineering of the aircraft for which there is no evidence. Subsequent research has identified another location on the Earhart aircraft which seems more promising.

2-2-V-1: Finding A Fit

The artifact has some distinctive aspects which provide important clues to its origin. The presence of $\frac{3}{32}$ inch diameter rivets (the smallest commonly available size) in a 0.032 inch (relatively thin) skin suggests an aircraft of moderate, rather than large, size. Also, the absence of a crossing row of rivets in the skin's 23 inch length is quite unusual. Other clues to the original structure come from the way in which the aluminum failed. The edge which has been fractured by being bent 90° exhibits a straight break indicative of a crossing internal structural member at that point. Likewise, in the lengthwise dimension, the change from $\frac{3}{32}$ to $\frac{5}{32}$ rivets suggests a boundary with a larger internal structural member. The peaked wave shapes in the "tab" protruding from the edge where the sheet tore along the line of $\frac{5}{32}$ rivet holes indicates the presence of another row of similarly sized and spaced rivets approximately 2 inches away. From these observations we can construct a more complete picture of what the structure must have looked like.

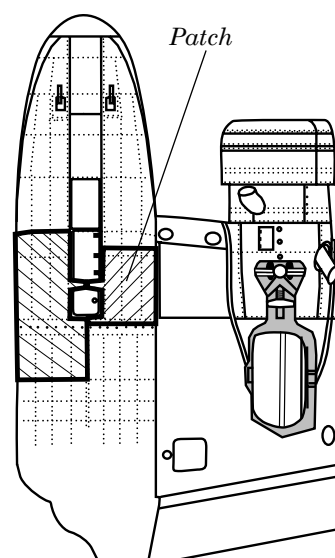
To date no exact match to Artifact 2-2-V-1 in materials and structure has been found on any aircraft. There is, however, evidence to suggest that the sheet found on Nikumaroro may be from a repair patch installed on the underside of the Earhart aircraft on the left-hand (pilot's) side of





the airplane just forward of the main beam (wing spar).

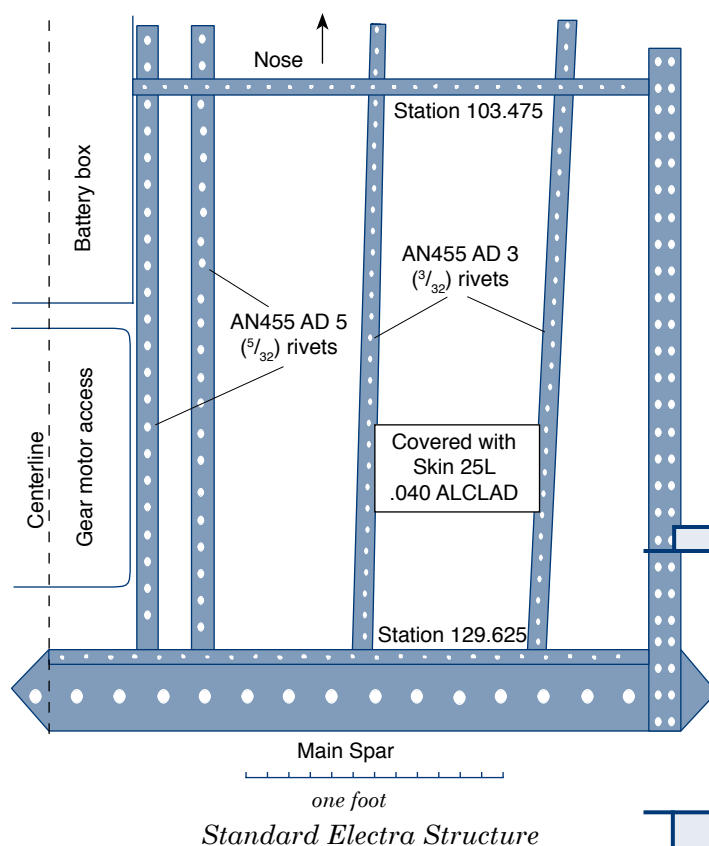
That such a patch was installed is documented in Lockheed Repair Orders for c/n 1055 (Earhart's Electra) signed off as completed on April 19, 1937. The belly of the Model 10, in this area, features two 0.040 inch Alclad skins, "25R" on the right and "25L" on the left. When Earhart groundlooped the airplane in Hawaii, the right side of the belly was virtually wiped out while much less damage was done to the left side skins. The repair orders call for the replacement of most of the right side



skins, including all of 25R. For 25L, the decision was made to replace only the damaged portion instead of replacing the entire skin. Fuselage Assembly repair item #6 says to "Replace left hand bottom skin from a point 9½ inches aft of

slanting bulkhead to main beam—rivet new skin in place with double row of rivets similar to joint in slanting bulkhead."

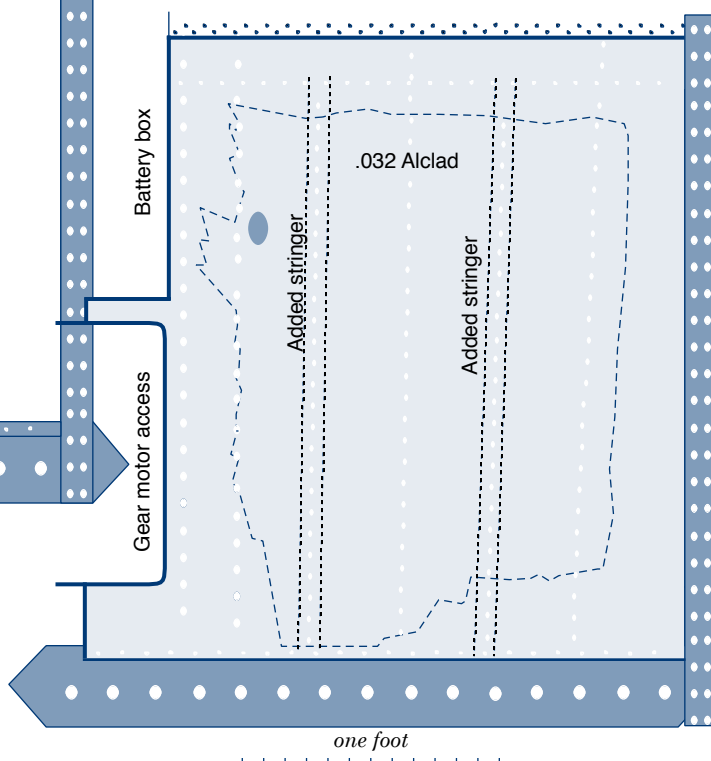
There is no documentation or known photograph which shows just how this repair was effected, but if the patch was constructed



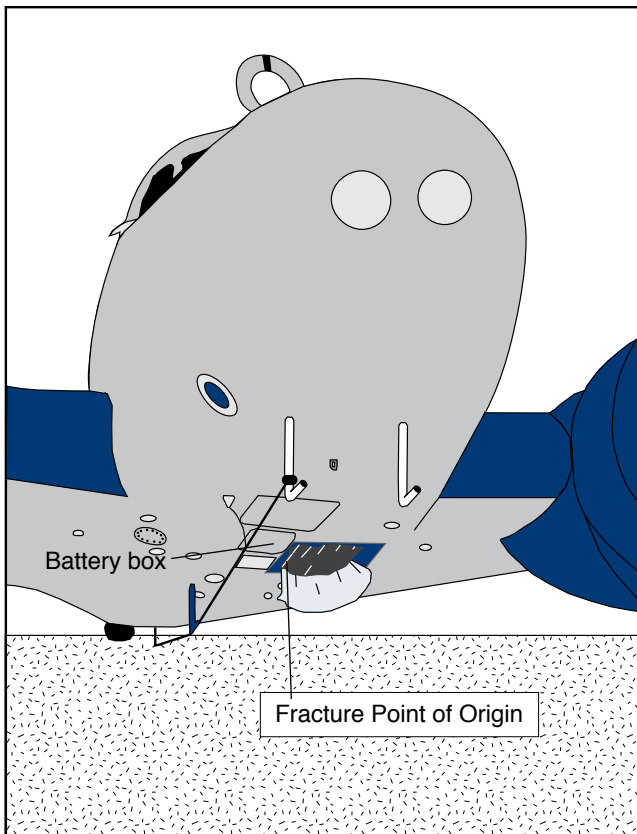
Standard Electra Structure

of 0.032 (rather than 0.040) Alclad and reinforced with two additional longitudinal stiffeners added between the standard stringers, the resulting structure would be an exact match to the sheet found on Nikumaroro.

Pursuing this hypothesis further, we know that the sheet failed due to area loading from the interior side—in other words, it was blown outward with sufficient force to rip the heads off many of the $\frac{3}{32}$ rivets and tear the skin through the larger $\frac{5}{32}$ rivet holes like paper torn through perfo-



Possible Repair Resulting in Exact Match to Artifact



rations. Walter Korsgaard, the FAA's explosives expert for its investigation of the PanAm 103 bombing, examined the artifact and felt that it showed deformation typical of a low-grade fuel/air explosion. If this sheet was once part of the patch on the belly of NR16020, directly above it was a 118 gallon fuel tank. Immediately adjacent, on the centerline of the aircraft, and nearest to the spot of anomalous corrosion on the artifact, was the main battery. A fuel leak which trapped vapors between the floor and the skin, ignited by a spark from the battery, or even an explosion of the battery itself, might result in the weakest part of the structure—the patch—fracturing in just the manner seen in the artifact. Such a scenario is entirely consistent with other evidence which indicates that the Earhart aircraft was landed successfully on Nikumaroro and sent radio distress calls for two days until the signals stopped abruptly late on the night of July 4, 1937. Still attached by its rearward edge and some remaining stringers, the hanging flap might present an inviting piece of metal for a later Gilbertese discoverer to break and pry off and carry back to the village.

Conclusion:

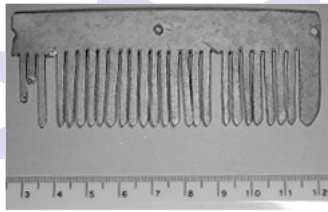
**Based upon the evidence presently available,
Artifact 2-2-V-1 appears to have once been part of the
Earhart aircraft.**

Caution: Don't Try This At Home

The drawings in this analysis will probably not match your neighborhood Lockheed 10. Of the 148 Electras built, at least a dozen survive today, all of which have had long and varied careers, often including accidents and modifications. To establish what the belly of Earhart's machine probably looked like, TIGHAR started with microfilmed engineering drawings for the standard airplane on file at the Smithsonian. We next tracked down every accessible surviving example of the Model 10. TIGHAR volunteers travelled to these aircraft and taped large sheets of paper to their bellies (the airplanes', not the volunteers') and made rubbings which traced every rivet, skin border, drain hole, access door, you name it, between the slanting bulkhead (Station 93) and the Main Beam (Station 129 5/8). TIGHAR researcher Frank Lombardo (#1806) then converted the tracings to mylar transparencies, enabling a full-scale, one to one comparison of the several aircraft.

We found considerable variation. C/N 1015, a 10A which was later converted to a 10E and has since been rebuilt as a replica of Earhart's c/n 1055, has a stiffener added at Station 114 creating a crossing line of rivets not present on the original aircraft. Another 10A, c/n 1052, features not only the added stiffener but also has larger rivets than the standard Electra. By contrast, the oldest surviving example, c/n 1011, has no stiffener at Station 114 and features the small AN455 AD3 rivets seen on the artifact. This aircraft also appears to have been repaired with thinner than standard skin beefed up with supplemental stringers.





7. Aluminum Comb (TIGHAR Artifact 2-2-V-5)

Date Found: October 1991 during TIGHAR's NIKU II expedition.

Materials analysis: NTSB

Report date: March 5, 1990

Description: The comb is crudely formed with parallel saw cuts separating the teeth. It is $3\frac{7}{8}$ inches long by $1\frac{3}{8}$ inches wide and is made from 0.032 Alclad sheet. Three $\frac{3}{32}$ inch diameter holes are nominally spaced $1\frac{7}{8}$ inches apart.

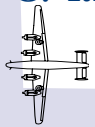
Condition: Although broken, the comb exhibits little or no damage from corrosion.

Identification: unknown

Commentary: The fashioning of such combs from aircraft aluminum was not uncommon in post-war Polynesia. Combs are specifically mentioned in the one account we have of the local use made of the crash at Sydney Island. When shown a photograph of this artifact, a former resident of Nikumaroro attributed it to the Sydney crash. Nowhere on a Lockheed 10 are #3 rivets found spaced $1\frac{7}{8}$ inches apart in 0.032 skin.



8. Riveted Assembly (TIGHAR Artifact 2-2-V-8)



Date Found: October 1991 during TIGHAR's NIKU II expedition.

Materials analysis: NTSB

Report date: March 5, 1990

Description: This assembly was made up of two aluminum alloy members. One member was roughly triangular in shape and appeared to be complete and relatively undamaged. The other member was severely damaged by exfoliation corrosion making it difficult to determine its original shape or configuration. However, there were four identifiable $\frac{5}{32}$ inch diameter rivet

holes along one edge with the formed tail portion of one rivet remaining. The two pieces of the assembly were connected by three large $\frac{3}{16}$ diameter intact rivets that were marked with a single dimple in their manufactured heads. A partially-legible part number was stamped into the structure—32B108?. (Note: The artifact was lost while in NTSB custody. It is believed to have been accidentally thrown out by the laboratory cleaning staff.)

Condition: As mentioned by the NTSB, portions of this artifact exhibited severe exfoliation. There was also evidence of extensive cutting and shearing caused by tools or implements.

Identification: This is, without question, a B-24 part. It could be part of one of the many belt-frame assemblies (Part Number 32B1081) in the rear fuselage or it could be part of the nose gear emergency release mechanism (Part Number 32B1089).

Commentary: Like several other artifacts found on the island, this appears to be a scrap left over from local use. It may be related to the Aluminum Plate (Artifact 2-5). The exfoliation seen on the Cut Strip (Artifact 2-3) suggests that it may have at one time been exposed to the same conditions (immersion in salt water?) as the Riveted Assembly.



9. Channel Section (TIGHAR Artifact 2-2-V-9 & 10)

Date Found: October 1991 during TIGHAR's NIKU II expedition.

Materials analysis: NTSB

Report date: March 5, 1990

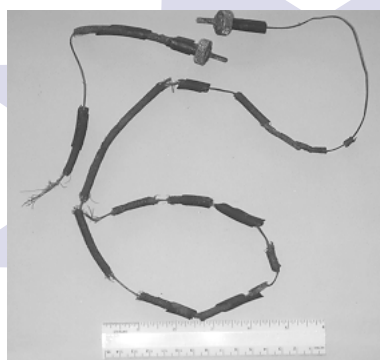
Description: This is a C shaped formed aluminum sheet channel approximately 7.25 inches long by 3 inches wide with a nominal material

thickness of 0.062 inch. The channel has a $2\frac{3}{8}$ inch wide web and two $\frac{3}{4}$ inch wide flanges, one at 90 degrees and the other at 110 degrees. The 110 degree flange has three $\frac{5}{32}$ inch diameter holes containing rivet pieces and also has three complete $\frac{3}{16}$ inch rivets. A portion of the flange or bracket is riveted to the inside surface of the web with two $\frac{3}{16}$ inch rivets. The long axis of the bracket piece is set at an approximate 80 degree angle to the longitudinal direction of the channel. Two strips of aluminum, catalogued together as Artifact 2-2-V-10, fit both with each other and with Artifact 2-2-V-9. The strips each have a single line of $\frac{5}{32}$ rivets with irregular spacing.

Condition: One end of the channel has been transversely saw cut through the entire cross section. The other end also exhibits saw cut marks but only partially through the section thickness. The remaining section thickness was bent and broken at the cut. The bracket piece was severely damaged by exfoliation corrosion.

Identification: unknown

Commentary: This artifact was once part of an aircraft's internal structure, but no match is apparent to any component in the Lockheed 10. The proportions of the piece suggest that the B-24 is a more likely candidate and the presence of exfoliation corrosion would appear to strengthen that possibility.



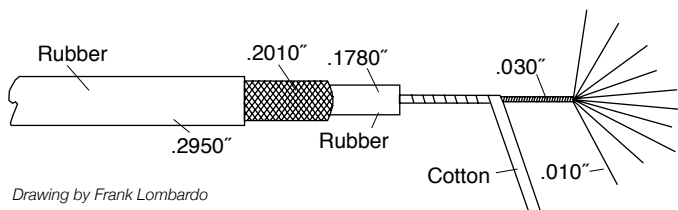
10. Cables (TIGHAR Artifact 2-3-V-1)

Date Found: February 1996 during TIGHAR's NIKU III Preliminary expedition.

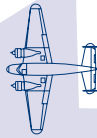
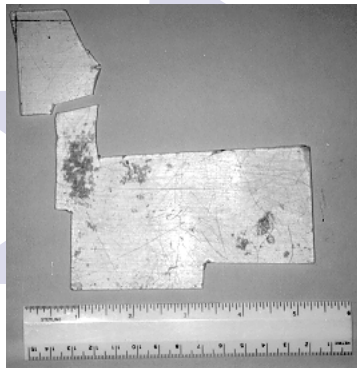
Description: These are two lengths of coaxial cable totalling 40.35 inches in length. Each end has a single-pin connector with a knurled tightening nut. The cable consists of an outer layer of rubber insulation covering a shielding braid of tinned copper wire over another layer of rubber insulation. The core is made up of ten twisted strands of wire wrapped with cotton.

Identification (partial): The connectors are Howard P. Jones Series 101 plugs manufactured from the mid-1930s onward and used on certain models of Western Electric, Bendix and Sperry receiving equipment. The construction of the cables indicates aviation use and matches the description of 70 or 72 ohm coaxial cable used for antenna lead-ins for radio receivers.

Condition: Various components of the cable are missing in many areas, but entire cross-sections survive to permit a full description of the original make-up. The connectors are in remarkably good condition.



Commentary: Specifications for military-approved coaxial cable in 1941 begin with a 12-strand core. It may be that the 10-strand cable found on Nikumaroro is an earlier civilian type. Documentation is being sought. The Earhart aircraft carried Western Electric and (possibly) Bendix receivers.



11. Plexiglas (TIGHAR Artifact 2-3-V-2)

Date Found: February 1996 during TIGHAR's NIKU III Preliminary expedition.

Materials analysis: Winterthur Museum Analytical Laboratory

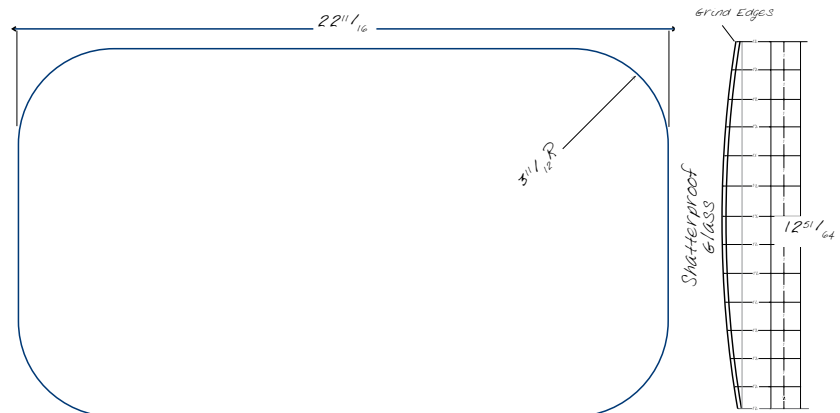
Report date: February 22, 1996

Description: This is an irregularly shaped sheet of transparent polymethyl methacrylate (PMMA), tradename Plexiglas. It measures nominally 4.75 inches long by 2.5 inches wide and is $\frac{1}{8}$ inch thick. A second fragment is roughly 1.75 inches long by 1.5 inches wide and fits a fractured edge of the larger piece. Both pieces exhibit a slight but uniform curvature over the surface.

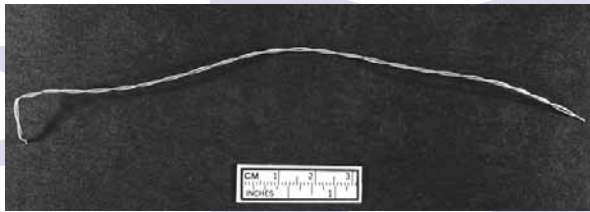
Condition: The convex surface of the sheet exhibits a number of shallow scratches, while the concave surface has only a few. One edge appears to be an original manufactured edge. The others exhibit saw marks. There is no evidence of heat damage. Because PMMA must be heated to at least 90°C to be formed, the curve of the surface on this sheet is probably original.

Identification: This appears to be a scrap from Lockheed Model 10 Part Number 40552—Window Glass, Fuselage, Cabin.

F	SEE CHANGE NOTICE	1-19-37	R.N.G.	NOTES	10	10	
E	THICKNESS $\frac{1}{8}$ WAS $\frac{5}{32}$	1-19-37	S.D.P.	MATERIAL FINISH NO. REQUIRED	PER GRP	PER ACT	
D	SHATTERPROOF WAS PLATE GLASS	2-12-35	L.I.C.				
C	$\frac{1}{8}$ SPAD $\frac{1}{8}$ HRTPO						
B	PLATE GLASS WAS SHATTERPROOF	3-21-36	R.L.S.				
A	CHANGE	DATE	BY	HT/IR			



Commentary: Lockheed engineering drawings show that the material, the curvature, and the thickness of the artifact match those specified for the cabin windows of the Electra. A number of changes were made to the material and thickness specifications for the windows over the production-life of the Model 10 (1934 to 1941). Of particular interest is a change specified for January 15, 1937 at which time the window thickness was reduced from $\frac{5}{32}$ to $\frac{1}{8}$ inch. The date is significant because it was just at that time that the cabin windows in Earhart's airplane were replaced and additional special windows were installed as part of her world flight preparations. The curvature and thickness of the Plexiglas found on Nikumaroro exactly matches Lockheed's specifications for Electra cabin windows at the same time Earhart's new windows were installed. They do not match any window on the B-24.



12. Aircraft Safety Wire (TIGHAR Artifact 2-3-V-3)

Date Found: February 1996 during TIGHAR's NIKU III Preliminary expedition.

Materials analysis: United Technologies, Hamilton Standard Propeller Division

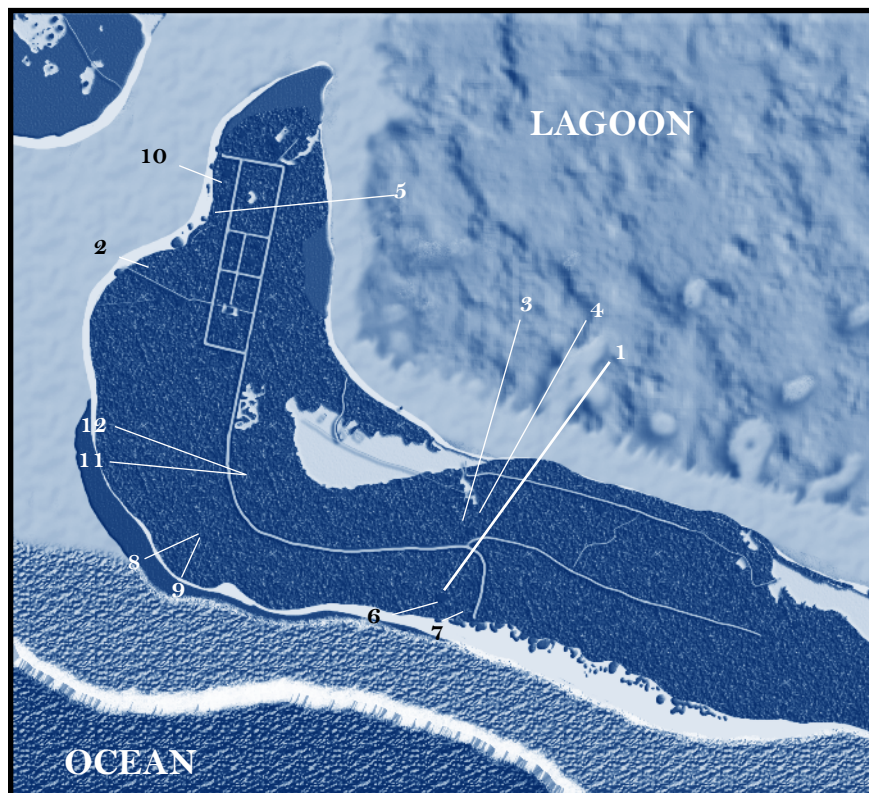
Report date: August 26, 1996

Description: This is a length of 304 stainless steel wire 6.75 inches long comprised of two strands of .010 inch wire twisted together in a very even left-hand twist with an average pitch of .564 inches. There is a 90 degree bend located approximately .582 inch from one end.

Condition: Both ends of the wire have been cut. There is no evidence of failure from fatigue or high tensile loading. The wire is in excellent condition.

Identification: This is aircraft safety wire, also known as lock wire, of a type widely available from the 1930s onward.

Commentary: Although as innocuous an artifact as could be imagined, this is yet another object found on Nikumaororo which was, at one time, part of an airplane. The only clues to its origin may be its somewhat unusually long tail and the fact that its twist may have been hand-done rather than twirled with special safety wire pliers. Early mechanics prided themselves on the precision of their lock wire work.

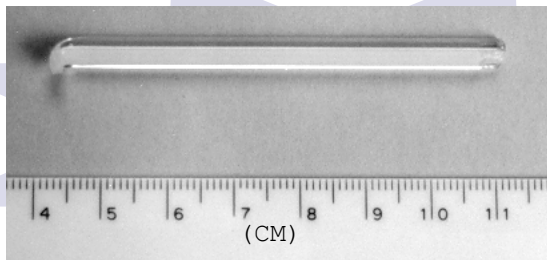


The numbers on this map refer to the artifact numbers in the text above. For general orientation see island map, page 28.

There is another category of physical evidence found on Nikumaroro which may be connected to the Earhart disappearance. The objects found near the lagoon shore on the island's southeastern arm, known as Aukaraime (south) district, differ in both character and circumstance from the aircraft-related pieces encountered in the village. The material recovered from the once-settled area was purposely brought there and put to local use. In contrast, the artifacts found on Aukaraime appear to have arrived by accident rather than intention, and show no sign of having been used for anything but the purpose intended by the manufacturer. While the aircraft artifacts were found during walk-through searches of the village aimed at finding just such objects, the discovery of the Aukaraime objects was pure serendipity.

On October 6, 1989, the last day of TIGHAR's NIKU I expedition, three team members came upon a small grave near the lagoon shore in the unsearched area southeast of Bauareke Passage. When subsequent research determined that this was the same area where island folklore said the bones of a white man and woman had been found in 1938, the decision was made to examine the grave upon our return in 1991. An archaeological excavation was conducted with the permission of I-Kiribati authorities and the grave was found to contain the bones of a very small, possibly stillborn, infant. No evidence was found which might connect the grave or its contents to the Earhart disappearance. (A popular rumor that Amelia was pregnant lacks any credible foundation.)

The grave excavation required six days (October 13–17, 1991). On October 15 a team member noticed a broken thermometer on the ground in an area of coral rubble approximately 100 feet northeast of the grave. Further inspection of the area revealed the presence of an aluminum bottle cap with a distinguishable logo. Nothing else was found in this spot.



13. Thermometer, broken (TIGHAR Artifact 2-2-G-5)

Date Found: October 1991 during TIGHAR's NIKU II expedition.

Description: This is a clear glass rod $2\frac{5}{8}$ inches in length with a diameter of $\frac{5}{32}$ inch. One end has a formed right-angle hook $\frac{1}{16}$ inch in length. The rod is triangular in

cross-section and appears to be constructed of two bonded, concentric layers with a white opaque band imbedded between the layers along one side of the triangle. A minute (less than pin-hole sized) opening runs the length of the rod at its approximate center and terminates in a bulb at the hooked end.

Condition: The rod is broken at both ends. No trace of markings or gradations are visible on the white band or the rod. The external surface of the glass is smooth and shows no sign of abrasion. There is a trace of foreign material at the straight break and a few flecks have found their way into the central tube to a depth of about 5mm.

Identification: The object is clearly a thermometer of some kind.

Commentary: No match has been found to any specific type of thermometer. The hook at the end is particularly puzzling. Thermometers are easily broken, but this one is broken at both ends. How did that happen? The glass shows no sign of having been tumbled about on the rough coral as one might expect if it had been washed ashore from the lagoon. But if it was simply dropped, where is the rest of it? And how did foreign material get 5mm down into the central tube?



14. Threaded metal cap (TIGHAR Artifact 2-2-G-6)

Date Found: October 1991 during TIGHAR's NIKU II expedition.

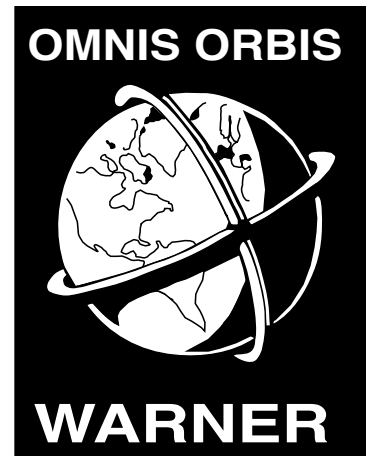
Identification Assistance: Warner-Lambert Company

Description: This is a threaded aluminum bottle cap 2 inches in diameter. Traces of white or cream-colored paint are visible on its exterior surface and there is a logo, faded but legible, centered on the top of the cap.

Condition: Most of the paint has bleached off but corrosion damage to the underlying surface is minimal. The top is very slightly dimpled in several places and its circular shape has been deformed by flattening along one side, with a corresponding bulge opposite. There is a reddish-brown discoloration or stain along part of the edge and top.

Identification: This is the cap from a bottle of patent medication manufactured by William R. Warner & Company of New York. Beginning in 1932, Warner used this particular logo on the caps of three products: Agoral, a laxative; Cal-Bisma, a stomach-settler similar to Pepto-Bismol, and Alka-Zane, a remedy for indigestion similar to Alka-Seltzer. The logo remained in use into the early 1950s.

Commentary: There are, of course, a number of possible explanations for the bottle cap's presence on the island. However, because Earhart is known to have suffered from stomach trouble during the world flight, and because the cap was used on products contemporaneous to that time, and with so much other evidence pointing to Earhart's presence not only on this island but on this specific part of the island, the artifact deserves a close inspection.



Several observations raise interesting questions. The slight indentations on the top of the cap suggest light tapping with a hard, somewhat pointed instrument. The flattened side indicates either a sharp blow or deliberate compression, perhaps to dislodge a stuck cap from the bottle. But where's the bottle? No glass (except for the thermometer) was found anywhere nearby. The reddish-brown stain is particularly intriguing and merits chemical analysis.

On the morning of October 16, another team member was sitting on the ground changing his boots about 40 feet southwest of the grave. As he watched a land crab scuttle by, its legs knocked aside a leaf revealing an old shoe heel on the ground. The surrounding area was cordoned off and meticulously examined. Over the next two days various remnants of two shoes were discovered.

15. Shoe parts (TIGHAR Artifact 2-2-G-7)

Date found: October 1991 during TIGHAR's Niku II expedition.

Identification assistance: Cat's Paw, a division of The Biltrite Corporation.

The many fragments which make up this artifact have been cataloged under 9 separate sub-headings based upon the nature of the material or object, and the specific spot where it was found.

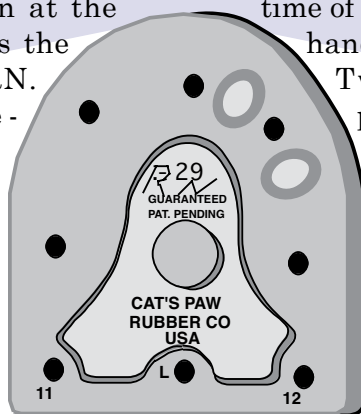


Artifact 2-2-G-7/1, Cat's Paw heel

Description: This is a rubber shoe heel 3 inches long by $2\frac{7}{8}$ inches across its greatest width. It is nominally $\frac{1}{4}$ inch thick and is pierced by 8 ferrous nails. The exterior (bottom) surface is considerably worn. The interior surface exhibits a number of codes and markings molded in at the time of manufacture, plus the hand-written letters RN.

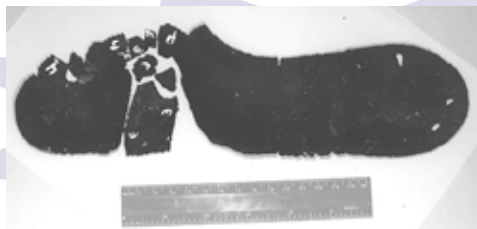


Condition: The rubber is hard and probably somewhat contracted. Remnants of all eight nails are extant but severely oxidized. The washers surrounding the nails are present in six of the holes.



Two shallow depressions anchors for white rubber "traction

Identification: This is a Cat's Paw replacement heel manufactured in the United States in the mid-1930s for a left shoe of either a large woman's or small man's size. The hand-written RN may be stock coding applied by the repair person.



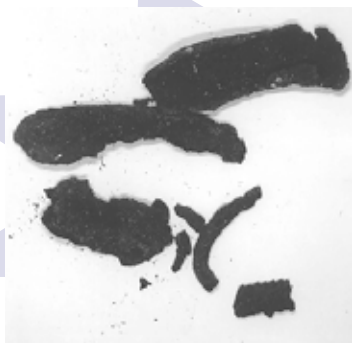
Artifact 2-2-G-7/2 through 5, Sole

Description: These are fragments of a rubber shoe sole nominally $\frac{1}{4}$ inch in thickness. The largest fragment is $6\frac{7}{8}$ inches in length and measures roughly $2\frac{1}{2}$ inches wide across the narrowest part of the instep. When reassembled, the suggested length of the sole is approximately $10\frac{7}{8}$ inches. Eight holes are present where the heel was once attached and the

alignment precisely matches the nails in Artifact 2-2-G-7/1 (see above). Holes along the edge where the uppers were stitched to the sole are spaced $\frac{3}{16}$ inch apart.

Condition: The rubber is hard, brittle and probably somewhat contracted.

Identification: This is the sole of a woman's left shoe of a style known as a blucher oxford. The location of the stitching holes establish the style and the tightness of the stitches (even allowing for contraction) indicate a woman's shoe. The length and width indicate a woman's size $8\frac{1}{2}$ or 9 narrow. The Cat's Paw replacement heel (Artifact 2-2-G-7/1) found with the fragments was almost certainly once attached to this sole.



Artifact 2-2-G-7/6 through 8

Description: These are fragments of an unknown material (possibly leather) approximately $\frac{1}{8}$ inch in thickness.

Condition: The material is hard, brittle and, in some cases, has curled inward along its edges.

Identification: Unknown. These may be pieces of the layered base which goes between the sole and the replaceable part of the heel.



Artifact 2-2-G-7/9, Brass eyelet

Description: This is a brass eyelet with a diameter of $\frac{5}{16}$ inch and a depth of $\frac{1}{16}$ inch. The hole has a diameter of $\frac{1}{8}$ inch.

Condition: Tarnished but otherwise undamaged.

Identification: Such an eyelet might have many uses but the context in which it was found suggests that it was employed as a shoelace grommet. The aperture is too small to accommodate the laces of a man's shoe but exactly match the usual $\frac{1}{8}$ inch laces for women's shoes.

General Commentary: The shoe from which Artifact 2-2-G-7 originated was a woman's blucher oxford with brass eyelets and a replacement heel manufactured in the United States in the mid-1930s. The size was $8\frac{1}{2}$ or 9 narrow. The style and size of shoe worn by Amelia Earhart at the time of her disappearance is shown in this detail from a photo taken in

Bandoeng, Java about 10 days before her final flight. Amelia is wearing a woman's blucher oxford with brass eyelets. There are many photos of AE wearing these shoes. The slightly lighter color at the bottom portion of the heel first appears in photos taken just prior to the first world flight attempt in March, 1937 and may indicate a replacement heel. The size of the shoe is readily determined. The rows of rivets visible on the Lockheed's wing are nominally 2.5 inches apart. The shoe in the photo is slightly over 10 inches in length, in other words, a size $8\frac{1}{2}$ or 9.

Since the discovery of Artifact 2-2-G-7 was announced in 1992, there has been a great deal of discussion about Amelia's shoe size. A pair of size 6 dancing slippers in a Kansas museum and the recollections of Earhart's sister have been cited as evidence that AE had tiny feet. AE was 5 feet 8 inches tall and of thin and lanky build. Whatever size shoes she may have worn as a girl, there can be little doubt about the size of shoe worn by the 39 year old woman standing on the Lockheed's wing. It is also difficult to dismiss as coincidence the oft-repeated story of how, in late 1938, the first Gilbertese work party on Nikumaroro came upon the skeletal remains of a white man and woman on the same part of the atoll where TIGHAR found shoe fragments 53 years later. According the old story, the woman's skeleton was wearing American shoes, size nine narrow.



16. Artifact 2-2-G-8, Shoe heel

Date found: October 1991 during TIGHAR's Niku II expedition.

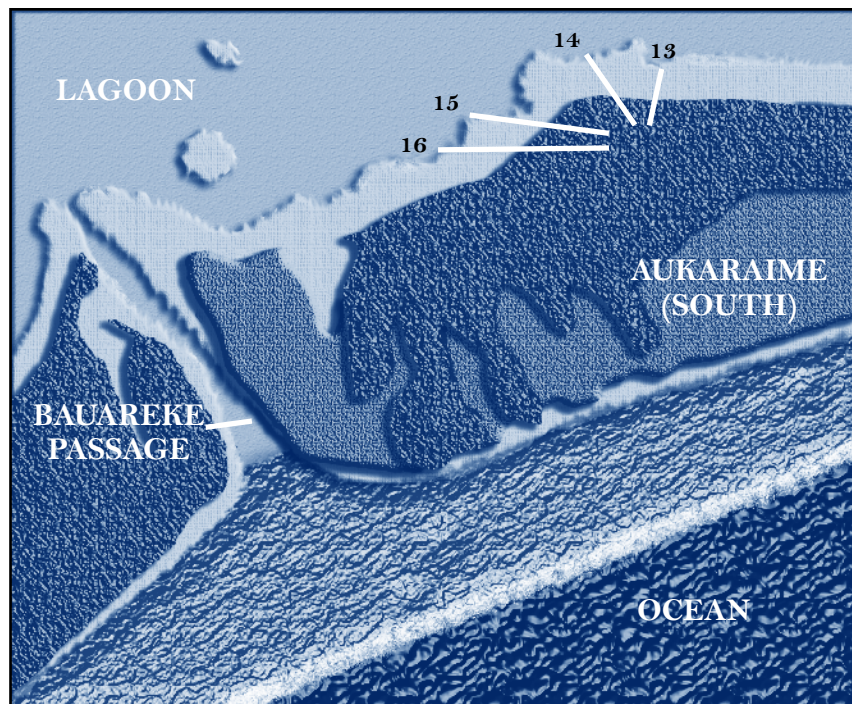
Identification assistance: Cat's Paw, a division of The Biltrite Corporation.

Description: This is a rubber shoe heel measuring $3\frac{1}{8}$ inches in length by $2\frac{7}{8}$ inches across its greatest width. It is nominally $\frac{3}{16}$ inch thick and is pierced by 8 nail holes in which remnants of the washers are still present. The nails appear to have rusted completely away and one nail did not penetrate all the way through the heel. The exterior (bottom) surface is considerably worn, especially on one side toward the rear. The interior surface exhibits no discernable codes or markings.

Condition: The rubber is hard and exhibits the same degree of degradation seen in 2-2-G-7/1, the Cat's Paw heel.

Identification: This is an original heel, slightly larger and more worn than the replacement heel found in the same area. Re-heeling, by necessity, is done to both shoes of a pair. It seems apparent then, that this heel is from a second pair of shoes.

Commentary: The presence of any shoe in this location would be remarkable. The site is far from any settled part of the island and the hot, hard coral rubble is hardly conducive to barefoot strolling. Rubber shower shoes and an occasional sneaker can be found washed up on the ocean beach, but this location is much too far inland for that explanation. That two pair of shoes (one of them belonging to an American woman) should have been abandoned or lost in this place is odd in the extreme. At the same time, the distribution of the fragments and the absence of the other two shoes suggests at least some scattering from the original point of deposition (assuming all four shoes started out in roughly the same place). Because all of the recovered fragments float, water would seem to be the most logical agent of distribution—specifically, flooding of the lagoon about 200 feet away. Logically then, the shoes were originally deposited somewhere between the point of discovery and the lagoon shore. This also tracks with the old island story of a woman's skeleton with American shoes found under the bushes about five feet from the shore.



1,000 feet

Conclusion:

The various shoe fragments are most probably from the shoes said to have been found in this location with the bones of a white woman and man in 1938. It is very likely that the shoes, and the bones, belonged to Amelia Earhart and Fred Noonan.