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SUBJECT: A Galvanic Corrosion Problem Associated with the Preparation of Multimetallic Beryllium Samples

TO: Distribution

FROM: D. M. Hewette, II

ABSTRACT

Artifacts have been noticed in the microstructure of multimetallic beryllium samples that were polished on the Syntron vibratory polisher. These artifacts were at first erroneously attributed to diffusion of beryllium into the dissimilar metal. The real cause of the effect is thought to be due to a galvanic corrosion which takes place during polishing. Small additions of sodium nitrate to the polishing slurry have been found to eliminate the corrosion.

NOTICE

DISCLAIMER

A GALVANIC CORROSION PROBLEM ASSOCIATED WITH THE PREPARATION OF MULTIMETALLIC BERYLLIUM SAMPLES

INTRODUCTION

Artifacts have been noticed in the microstructures of multimetallic beryllium samples when polished in a manner described below. The samples include beryllium brazed to stainless steel, nickel-clad beryllium, and nickel-plated beryllium.

PROCEDURE

Samples are ground on a motor-driven belt grinder using a 240-grit belt and then on 320- through 600-grit papers by hand. The samples are polished on Syntron vibratory polishers in two steps. The first step involves polishing on a silk or nylon cloth in a slurry of ethylene glycol and 0.3μ alumina abrasive. In the second step a deep nap cloth and a slurry of ethylene glycol, alcohol, and 0.1μ alumina abrasive is used. Ethylene glycol is used instead of water as a vehicle for the abrasive, since water reacts with inclusions such as beryllium carbide.

RESULTING MICROSTRUCTURES

All of the samples polished by the technique described above appeared to be etch-polished with heavier attack taking place at the beryllium-dissimilar metal interface.

The attack at the interface of a beryllium-type 430 stainless steel braze is shown in Fig. 1. The same type of effect was noted on a nickel-clad beryllium tube. This attack was eventually judged to be a galvanic corrosion effect. However, at first the effect was blamed on the diffusion of beryllium into the adjacent braze metal or nickel, since both samples had been heated at elevated temperatures.

The clue that suggested a corrosion effect was the appearance of the microstructure of a nickel-plated beryllium sheet. A simple experiment had been made to determine how effective nickel plating was in the preservation of the edge of a beryllium sample. A beryllium sheet was cut in two, and one-half was nickel plated while the other half was not. The plated sheet and unplated sheet were mounted in bakelite as shown in Fig. 2. This specimen was polished in the same manner as the brazed and clad specimens.

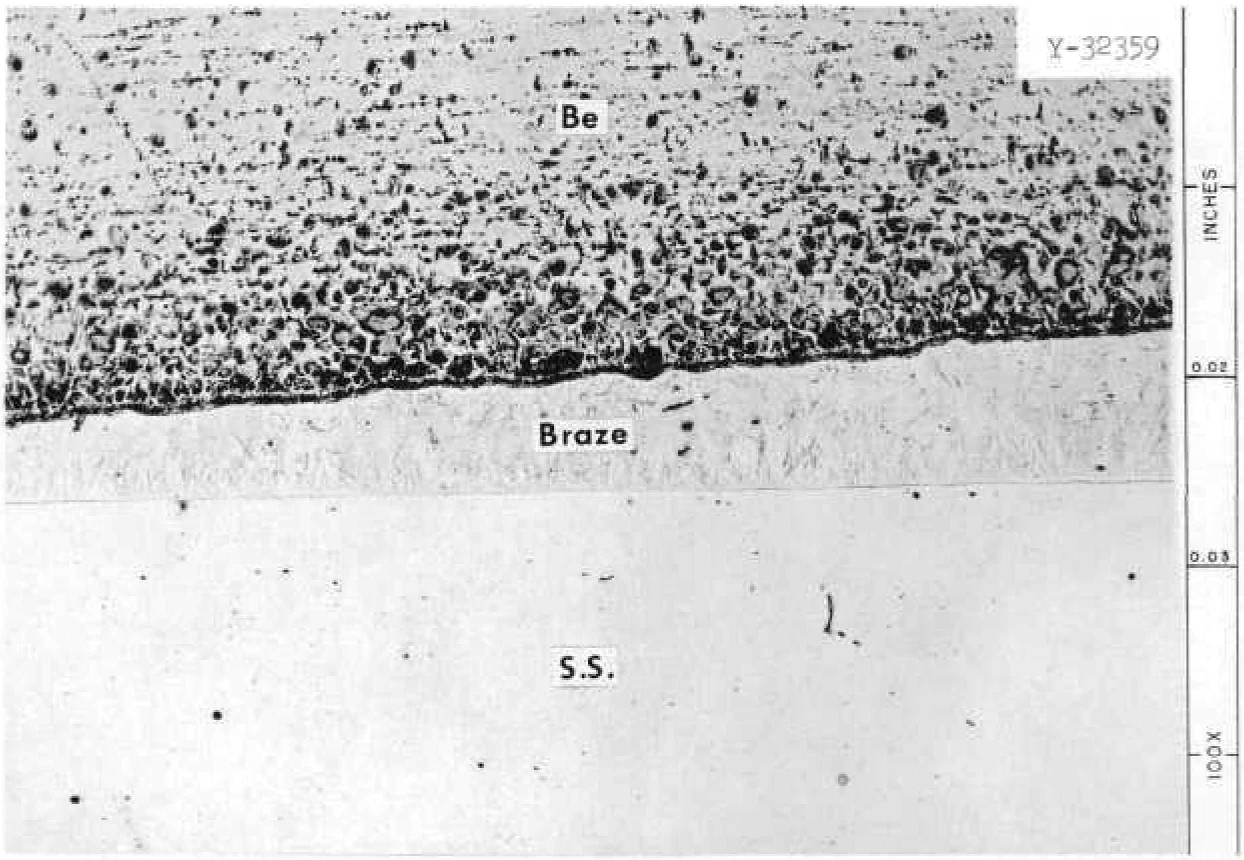

Fig. 1 Beryllium-Type 430 Stainless Steel Braze – Brazed with 49% Ti–49% Cu–2% Be. Note the peculiar appearance of the beryllium at the beryllium-braze metal interface. This appearance has been proven to be due to galvanic corrosion taking place during polishing with the beryllium being anodic to the braze metal and stainless steel. As-polished, bright field, 100X.

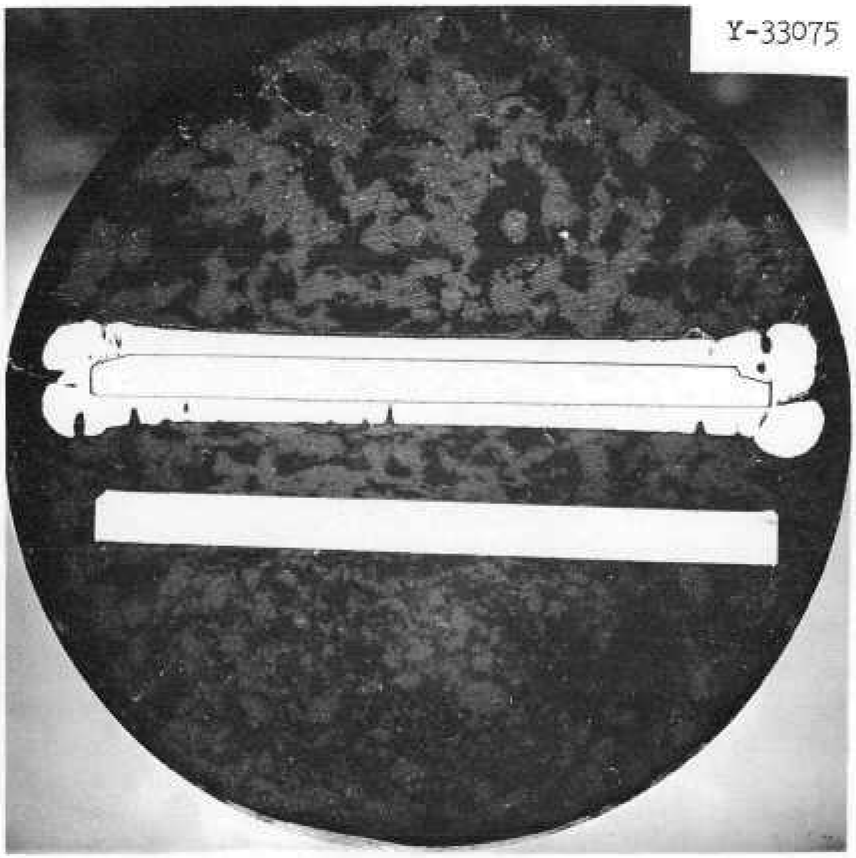

Fig. 2 Cross Section of a Mounted Nickel-Plated and Unplated Beryllium Sheet. As-polished without $NaNO_3$ inhibitor. This sample was prepared to examine how effective nickel plating is in the preservation of the edge of a beryllium sample. Approximately 3-1/2X.

The appearance of the nickel-beryllium interface of the nickel-plated sheet was similar to the appearances of the beryllium-dissimilar metal interface of the clad and brazed samples as shown in Figs. 3a and 4a. The unplated sheet exhibited a homogeneous microstructure as shown in Figs. 3b and 4b. The effect at the beryllium-dissimilar metal interface in this case could not be due to diffusion of beryllium into the nickel because the sample was never heated above the specimen mounting temperature of approximately 160°C.

The attack at the beryllium-dissimilar metal interface was therefore thought to be due to the setting up of a galvanic cell within the sample during polishing with the beryllium being anodic to the stainless steel or nickel. In corrosion studies on beryllium in contact with other metals, J. L. English found that extruded beryllium metal was attacked preferentially when in contact with type 347 stainless steel and exposed at 85°C in quiescent demineralized water containing small amounts of hydrogen peroxide.[1] English found that additions of 5 ppm sodium nitrate completely eliminated pitting-type corrosion in extruded beryllium exposed to the same conditions as given above.

Based on these findings, it was expected that the addition of sodium nitrate to the abrasive slurry might possibly eliminate the attack at the interface. The brazed, nickel-clad, and nickel-plated beryllium samples were re-prepared in the same manner as before except that 1 g of sodium nitrate per 300 ml of solution was used in the abrasive slurry of the last polishing operation. The attack at the beryllium-dissimilar metal interface was eliminated. The contrast of the appearance of the microstructure of the stainless steel-beryllium braze polished with and without the inhibitor is shown in Fig. 5.

Unfortunately the sodium nitrate reacted with some components of the samples as seen in Fig. 5, the beryllium-stainless steel braze, where a diffusion layer has been stained black. In addition, the nickel-plated beryllium sheet was pitted considerably. The pitting took place generally throughout the plated sheet and not preferentially at the nickel-beryllium interface.

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[1] J. L. English, "Corrosion of Beryllium in Water," The Metal Beryllium, American Society for Metals, 1955, p. 546.

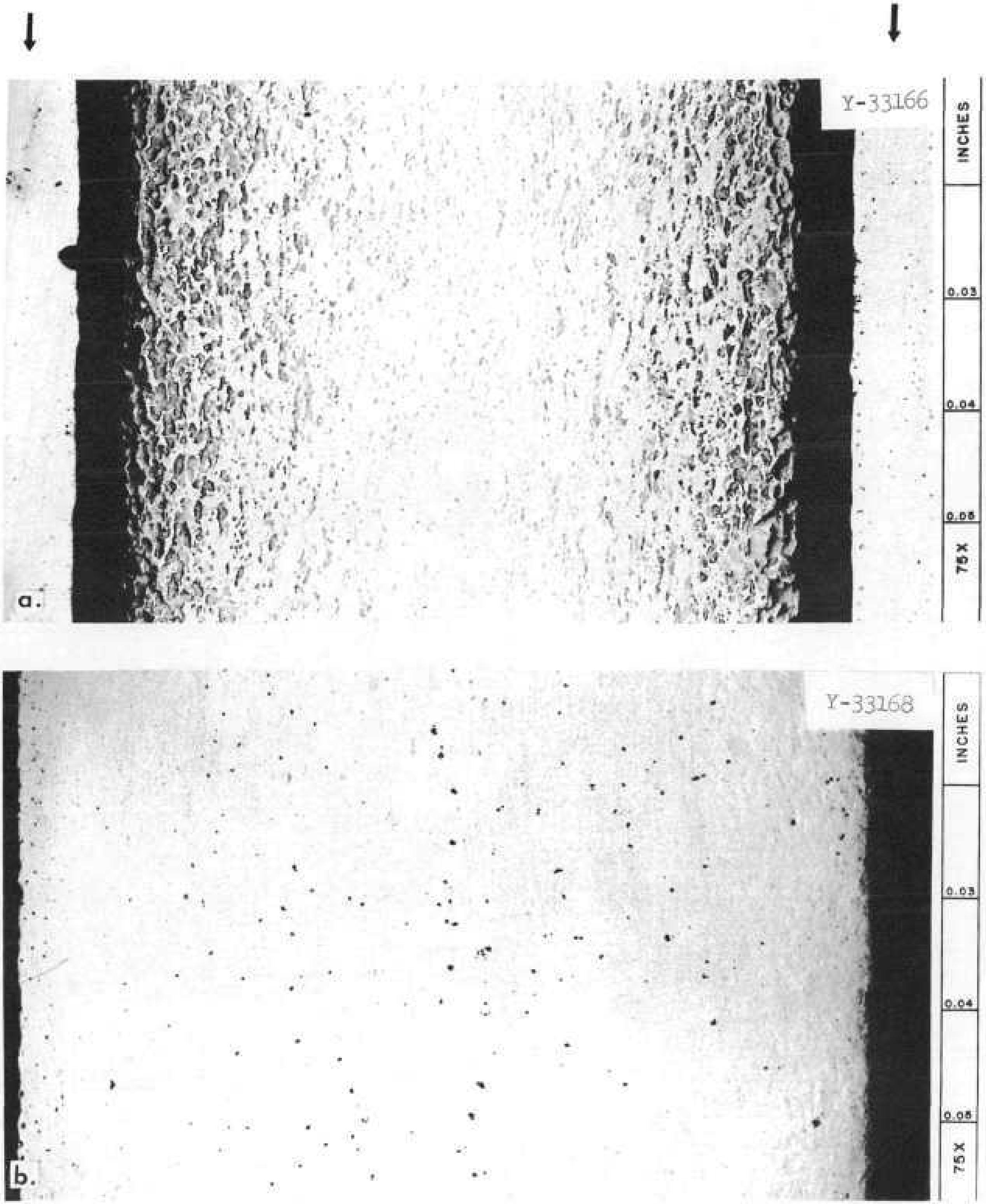


Fig. 3 (a) Nickel-Plated Beryllium Sheet, (b) Unplated Beryllium Sheet. Arrows point out the nickel plate. Note the attack at the beryllium sheet adjacent to the nickel plate. As-polished, 75X.

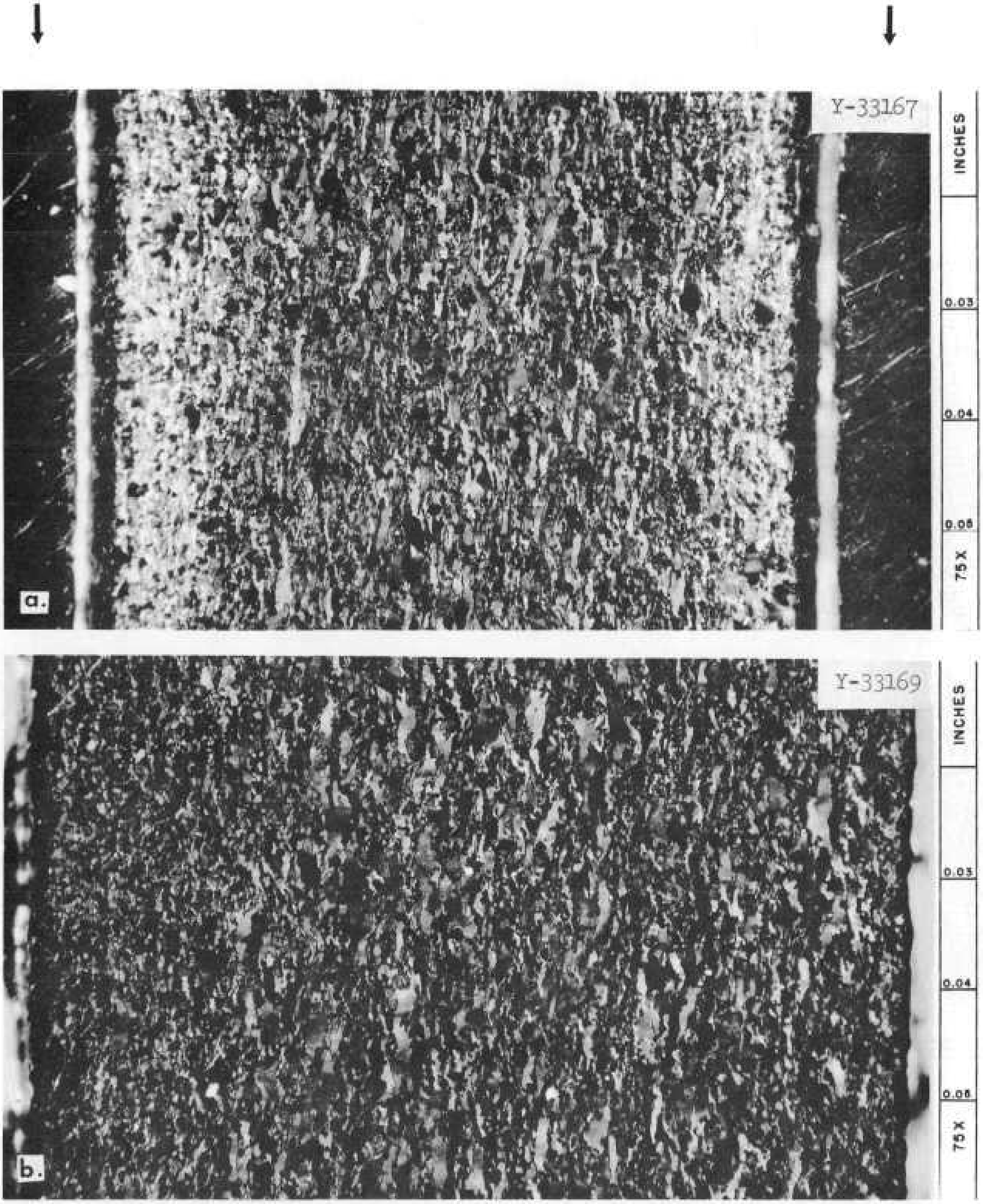
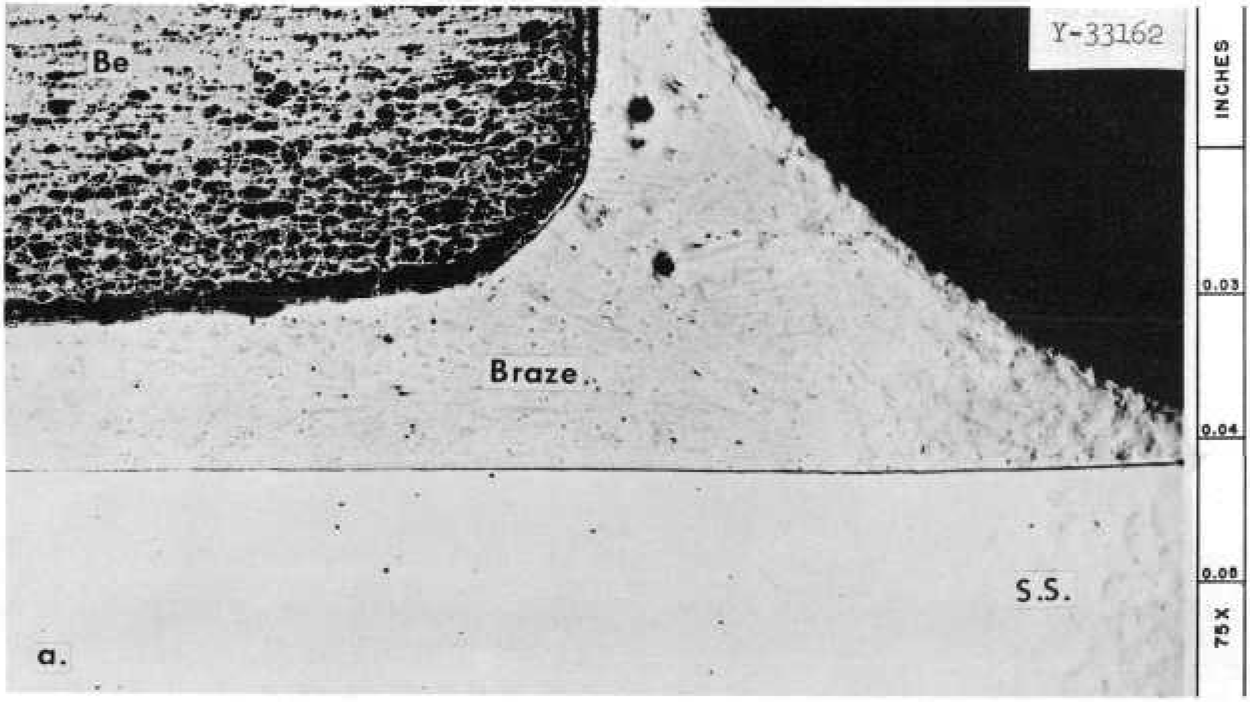


Fig. 4 (a) Nickel-Plated Beryllium Sheet, (b) Unplated Beryllium Sheet. Arrows show the nickel plate. Note the specular appearance of the plated beryllium. As-polished, polarized light, 75X.



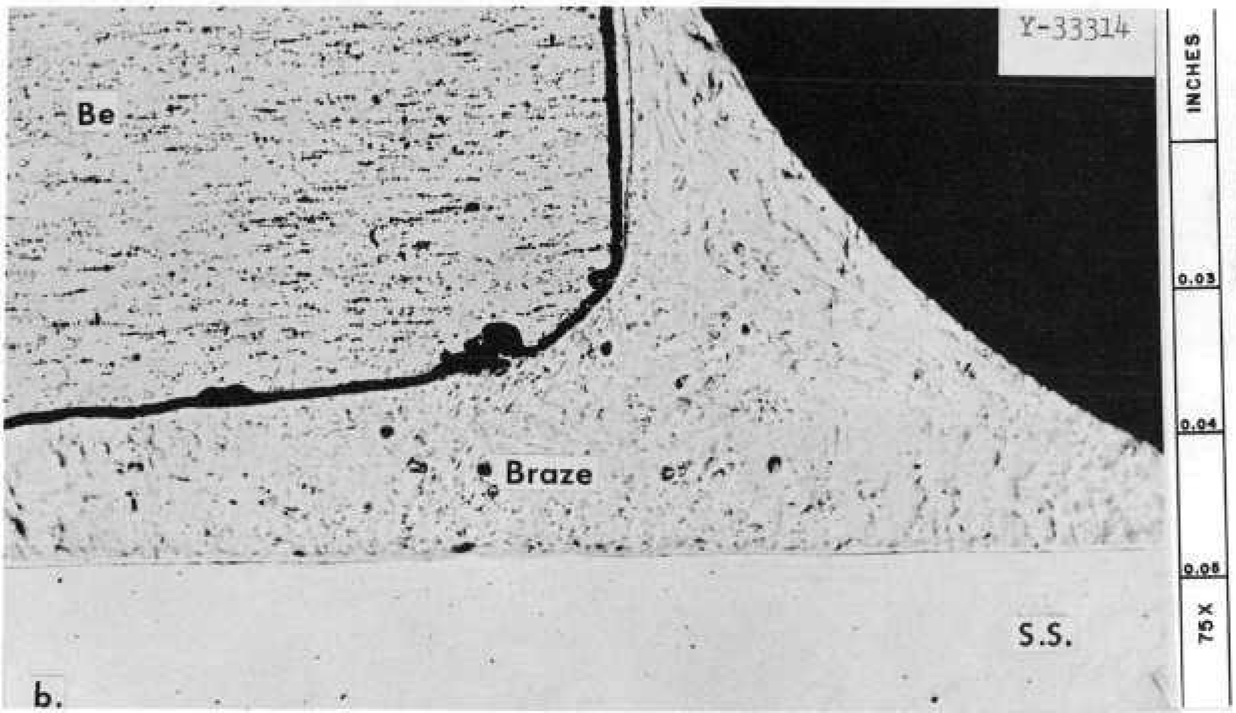


Fig. 5 Contrast Between Microstructures of Type 430 Stainless Steel-Beryllium Braze, (a) As-Polished Without Inhibitor, (b) As-Polished With Inhibitor. The sodium nitrate has reacted with a diffusion layer, located between the beryllium and the braze, staining it black. 75X.

CONCLUSIONS

Artifacts have been noted in the microstructures of heat-treated multimetallic beryllium samples at the beryllium-dissimilar metal interface. These artifacts were at first erroneously attributed to diffusion of beryllium into the dissimilar metal. The real cause of the effect was found to be a galvanic corrosion with the beryllium being attacked preferentially to the other metals.

The effect has been noted only with samples prepared on the Syntron vibratory polisher. This is due to the fact that polishing takes place relatively slowly on the Syntron and there is time enough for galvanic corrosion to take place.

The attack on the beryllium was eliminated by the addition of small amounts of sodium nitrate to the abrasive slurry. This is not the ultimate solution to the problem, for the sodium nitrate reacts unfavorably with some components of the samples.

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