UTILIZATION OF LASERS IN THE JOINING OF GOLD AND PLATINUM FOR JEWELRY

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ABSTRACT

Small, flexible lasers are available to jewelers. This study was undertaken to evaluate laser welds and compare them to braze joints with the same materials and geometry. Bend tests, metallography and the scanning-electron microscope were chosen to evaluate the joints. Materials joined were Pt-4.8Ru and 18kt gold, both rolled strip and castings. Bevel and butt joints were used for geometries. The thickness of the materials were 0.030 to 0.075 inches. The bend test results are discussed in terms of the resulting microstructure.

KEY WORDS

Gold, platinum, jewelry, laser, braze weld, solder, joining.

TEXT

The practice of using gold or silver solders to join gold in forming ornamental items has its roots going back an estimated 2800 years and probably longer. Gold-silver and gold-copper-silver alloys were used as filler metals. Though these and parallel silver alloys are termed gold or silver solders, they are by definition, brazing alloys. This is based on the definition that brazing is a welding process wherein a joint is produced by heating to a suitable temperature and using a filler metal that must have a liquidus temperature above 800°F but below that of the base metal. Therefore, in this presentation, though the term soldering may normally be used in the jewelry industry, it will be termed brazing.

Brazing is still the principle method of joining used by jewelers. Though the process requires limited capital to set up, there are drawbacks, especially in joining a high melting point material such as platinum. Perhaps the most significant drawback is the skill and training required to make reproducible, high quality brazes. There is also the damage that can be done to gem stones or the possibility of overheating and destroying the piece of jewelry as well as the cleaning that has to be done to remove firescale and flux from the jewelry after brazing.

There are many different joining and welding techniques available. Among these are friction welding, fusion welding, electron beam welding and arc welding, to name some. Many of these do not have the flexibility or adaptability to make them of interest to jewelers or platinum smiths. A technique that theoretically gives localized, controllable high heat input was the laser. However, initially, they were very large, costly and did not have the flexibility required by the jeweler. The laser welders required significant tooling and setup time to obtain an acceptable weld. In recent years, however, laser welders have gotten smaller and more portable, to the point where they occupy less space than a jewelers bench. They can be operated by anyone with a steady hand and a sharp eye. Their cost has come down considerably also, from several hundred thousand dollars to under 50 thousand dollars. These advancements now allow lasers to be used on a wide scale in jewelry production.

There are many seemingly obvious advantages to laser welding. First, there is very little heat generated outside the beam contact/weld area. This eliminated the need for any fluxes and leaves the piece bright and clean. The lack of heat generation also means that welding can be done very close to stones, a plus when repairing prongs. Because the pieces do not heat up to any great degree, unless rapid fire pulsing is used, the operator can hold the pieces he's joining with his hands, eliminating the need for fixturing, clamping and the like. There is no worry of melting small pieces, and several joining operations can be done without worrying about reflowing previous joints. Repairs are done with filler, when needed, of the same composition of the base alloy, eliminating the worry of color mismatch between piece and filler. Since no torch is used, there isn't the need to have compressed gases. This can be useful in small store operations where local codes may prohibit such things.

The disadvantages of laser welding are that it does take longer than traditional brazing, which can be a concern in a production environment. In addition, not all joints can be joined by laser welding. Welded joints are very different in appearance from brazed joints, which have a smooth seamless appearance due to the capillary flow and wetting of filler into the joint. Welded joints have a bulbous overlap look that can only be smoothed by grinding. If the joint is in a hard to reach area, this cleaning can be difficult if not impossible. It is not known either whether laser welded joints are stronger than traditionally brazed joints. This paper will attempt to answer that question.

The present study set out to compare braze and laser welded joints in the Pt-4.8Ru alloy and 18kt gold. It was decided to use the ASTM E290-81 standard method for semi-guided bend test for ductility of metallic materials to evaluate the joints. The semi-guided bend test is used to evaluate the quality of metals or welds as a function of ductility as evidenced by their ability to resist cracking during bending (Ref 1).

Additional techniques to be used in evaluating the braze or laser weld quality will include metallography of weld cross-sections, visual examination of fracture surfaces and scanning-electron-microscopy.

Experimental Procedure

The materials selected for the study were the platinum alloy containing 4.8 Ruthenium and 18kt gold. The braze material used was a experimental Pt-5%Au filler for our platinum alloy. Samples were also done with a commercially available 1700 braze. The approximate makeup of this braze is shown in Table I. For our gold sample, a commercially available "medium" solder was used. The approximate composition of this braze is shown in Table II. Both rolled-annealed and cast samples were prepared in triplicate for each condition tested. The rolled-annealed samples were supplied as 0.5 inch wide x 1.0 inch long coupons. The inch length was parallel to the rolling direction. Two different thicknesses, 0.030 inch and 0.075 inches, were used in the evaluation, though most of the studies were done on the 0.030 inch materials. These thicknesses were chosen in that they represent the range of thicknesses most commonly joined in the manufacture of jewelry.

Two different joint configurations were used. One is termed butt and the other, bevel. Schematics of these two joint configurations are shown in Figures 1 and 2, respectively.

A coupon from the rolled samples was used as a model for making the cast samples. The coupon was sprued and a silicone mold was made. Silicone was used to reduce shrinkage factors. Waxes were shot from the silicone molds and samples were cast in both Pt-4.8Ru and 18kt gold. Samples were desprued and cleaned with a fiber wheel. Difference in thickness between cast and rolled samples was about 5% due to casting shrinkage and cleaning of cast samples.

Both cast and rolled coupons were cut in half across their width with a jeweler's hand saw. Half of the cut samples were then beveled on the cut

TABLE 1
Composition of the 1700 Solder

Element	Weight Percentage
Au	34
Pd	44
Pt	22

TABLE II

Composition of the 18kt Gold Medium Solder

Element	Weight Percentage
Ag	5
Au	75
Cu	10
In	2
Zn	3

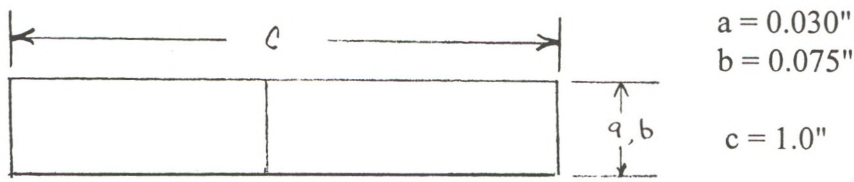

Figure 1. Drawn sketch of a butt joint.

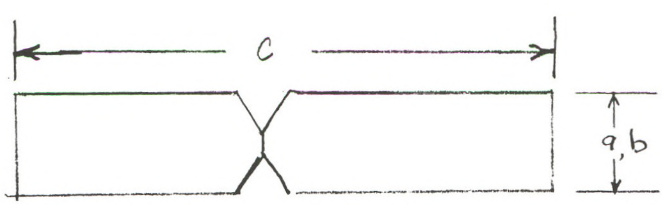

Figure 2. Drawn sketch of a bevel joint.

edge with a hand file. Both sides of the cut were beveled. Bevel angles were not determined. All cutting and filing operations were done by hand to simulate bench conditions.

Samples were laser welded using a ALS 35S laser welder, pictured in Figure 3, from Alpha Laser Gmbh. These lasers utilize a Nd: YAG crystal generating light pulses at 1064 manometers. They generate a maximum average power of 35W with a pulse power of 9Kw. Welding usually involves two passes. The first pass is aimed at deep penetration and filling while the second pass spreads and smoothes out the weld bead. First passes were done using a beam diameter of 0.4mm while second passes were done with a beam width of 1.0mm. Voltages were set at 250V for the Pt alloy and 300V for the 18kt gold alloy. Pulse time was kept at 5.0ms for all operations. Filler material, in the form of 0.012 wire, was identical to the base material being welded.

Platinum samples were brazed using a Pt-5%Au alloy. This alloy was based upon a common practice of jewelers to create their own braze material by mixing some casting alloy with 1700F platinum braze material. Analysis of this homemade material showed a composition of mainly Pt with a few percentage points of gold. In addition, samples were prepared using the 1700 braze as supplied without any alteration. A gas oxygen torch with a single orifice was used. No flux was utilized.

Gold samples were brazed using a 18kt medium solder with a self-pickling solder flux containing boric acid. A gas oxygen flame with a single orifice torch was also used for this operation. Samples were then cleaned, pickled and steamed.

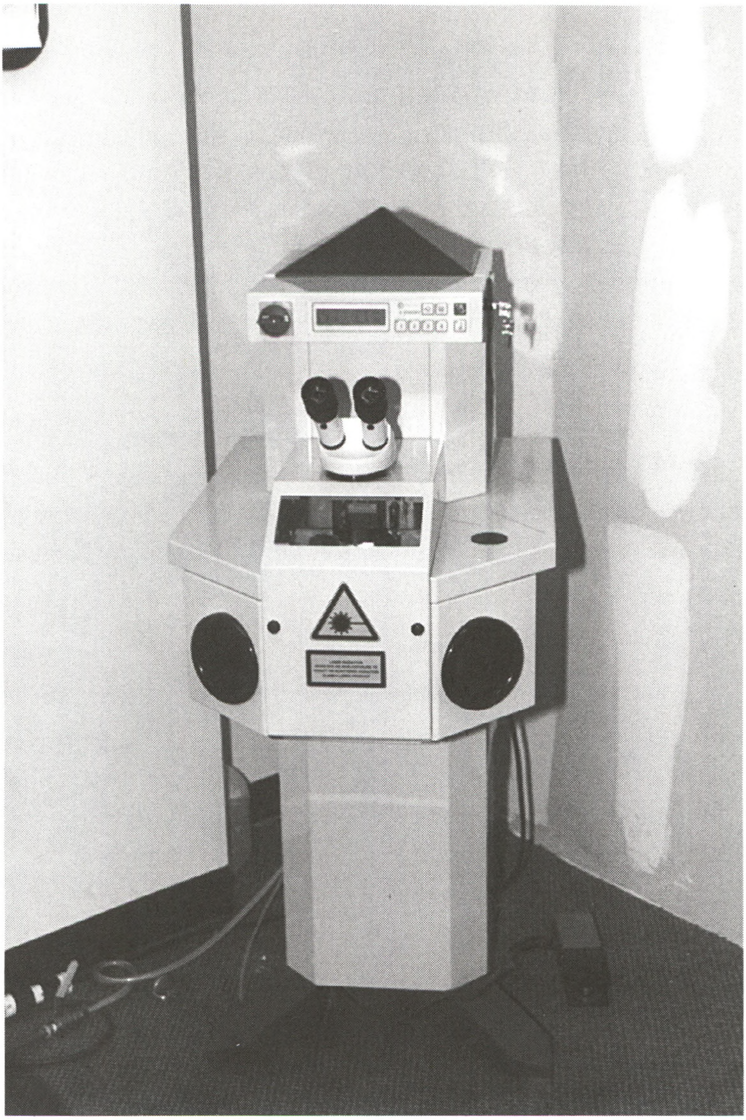

Figure 3. Photograph of the laser used in the study.

Bend Test

The bend test was performed around a 1T mandrel. One end was clamped in place and the sample was bent with the joint in the center of the braze or weld. One of the three samples, a section 5/16 inch wide at one end and 1/8 inch wide at the other end, was sheared. It was done at an angle to increase the weld or braze joint view. The sample was mounted, polished and examined under the microscope. Photomicrographs were taken to show the base material and the section joined.

The bend samples were examined and photographs taken. Many of the fracture surfaces were examined further with the scanning-electron-microscope. The combination of the metallography, bend sample examination and scanning-electron microscopy gives a good insight into the brazing and laser welding of the Pt-4.8Ru and the 18kt gold.

Results

Photographs of a typical laser weld and braze of the Pt-4.8Ru alloy are shown in Figures 4 and 5, respectively. The laser weld is typified by a raised bead and a shiny appearance. The braze is flush with the surface of the parent material but has a very dull, oxidized appearance.

The bend test data for the Pt-4.8Ru alloy is summarized in Table III. The table presents data for three different conditions of the alloy. These are rolled strip 0.030 inches thick, cast pieces 0.030 inches thick and rolled strip 0.075 inches thick. As described earlier, two different joint configurations were studied. First, the data for the 0.030 inch thick rolled strip will be examined. All of the samples that were laser welded passed the 1T bend tests. In contrast, all the samples that were brazed, failed the bend test. This was independent of the filler material used, whether it was the Pt-5Au material or the more conventional 1700 solder.

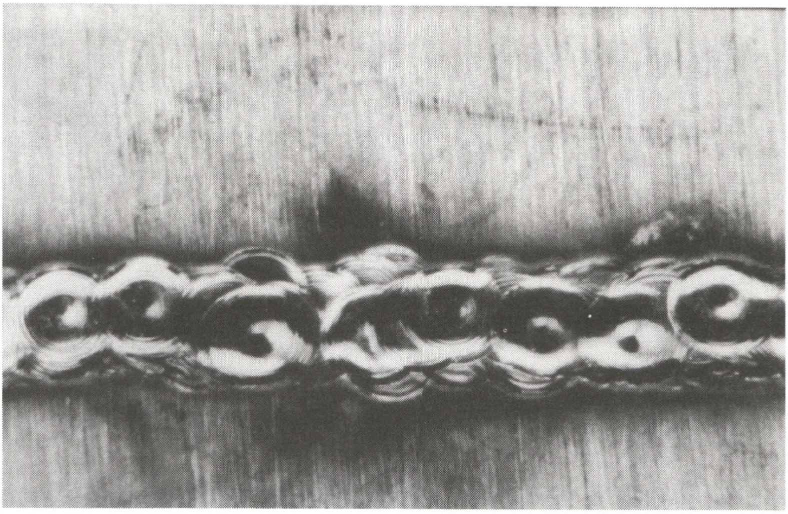

Figure 4. Photograph of the laser weld of a bevel joint of the 0.030 inch thick, Pt-4.8Ru alloy at 15x.

Figure 5. Photograph of the brazed bevel joint of the 0.030 inch thick, Pt-4.8Ru alloy at 15x.

TABLE III

Pt-4.8Ru ALLOY
Bend Test Data

MATERIAL FORM	THICKNESS (Inches)	CUT	JOINING TECHNIQUE	1T BEND
Rolled Strip	0.030"	Bevel	Laser Weld	P,P,P
Rolled Strip	0.030"	Butt	Laser Weld	P,P,P
Rolled Strip	0.030"	Bevel	Braze/Pt-5Au	F,F,F
Rolled Strip	0.030"	Butt	Braze/Pt-5Au	F,F,F
Rolled Strip	0.030"	Butt	Braze/1700 Solder	F,F
Casting	0.030"	Bevel	Laser Weld	F,F,F
Casting	0.030"	Butt	Laser Weld	P,P,P
Casting	0.030"	Bevel	Braze/Pt-5Au	F,F,F
Casting	0.030"	Butt	Braze/Pt-5Au	F,F,F
Rolled Strip	0.075"	Bevel	Laser Weld	P,F,P
Rolled Strip	0.075"	Butt	Laser Weld	F,F,F
Rolled Strip	0.075"	Bevel	Braze/Pt-5Au	F,F,F
Rolled Strip	0.075"	Butt	Braze/Pt-5Au	F,F,F

A photograph of the 1T bend of the laser welded bevel joint is seen in Figure 6. The rough surface of the bend is evident, but no cracking was detected. Photomicrographs of the laser welded bevel and butt joints appear in Figures 7 and 8, respectively. The bevel joint shows slight porosity and a complete weld. The butt weld was not complete but obviously sufficient to prevent failure during bending. The fine grain of the rolled strip can be seen adjacent to the weld and indicates the localized heating of the laser.

The photograph of the failed bend sample from the brazed bevel joint is displayed in Figure 9. The joint completely separated. Closer examination of the fracture surface is seen in the scanning-electron-micrograph of Figure 10. Large voids are present in the fracture. Likewise, the fractured bend sample and the scanning-electron-micrograph of the brazed butt joint are shown in Figures 11 and 12. Areas of porosity and poor wetting are seen. Photomicrographs of the weld cross-sections for the two types of joints are displayed in Figures 13 and 14. The first feature that stands out is the much larger grains of the strip next to the brazed bevel joint compared to the laser weld and then the even larger grains of the butt joint. The bevel character of the bevel is clearly evident along with the porosity present at the interface with the filler metal. The lack of wetting of the interface is seen with the butt joint. The photograph of the failed bend sample, the scanning-electron-micrograph of the fracture and the photomicrograph of the braze cross-section for the 1700 solder are seen in Figures 15 through 18. The difference between the braze joints with the 1700 solder and the Pt-5Au filler metal is, there is less grain growth in the strip due to the lower melting point, conversely, there is less alloying and wetting.

The next set of data to be discussed are the cast Pt-4.8Ru samples 0.030 inches thick. The only condition to pass the bend test was the laser welded butt joint. This was surprising in that it would be anticipated the bevel joint should be better than the butt joint. The photograph of the failed bend test in Figure 19 gives no indication in that a ductile appearing

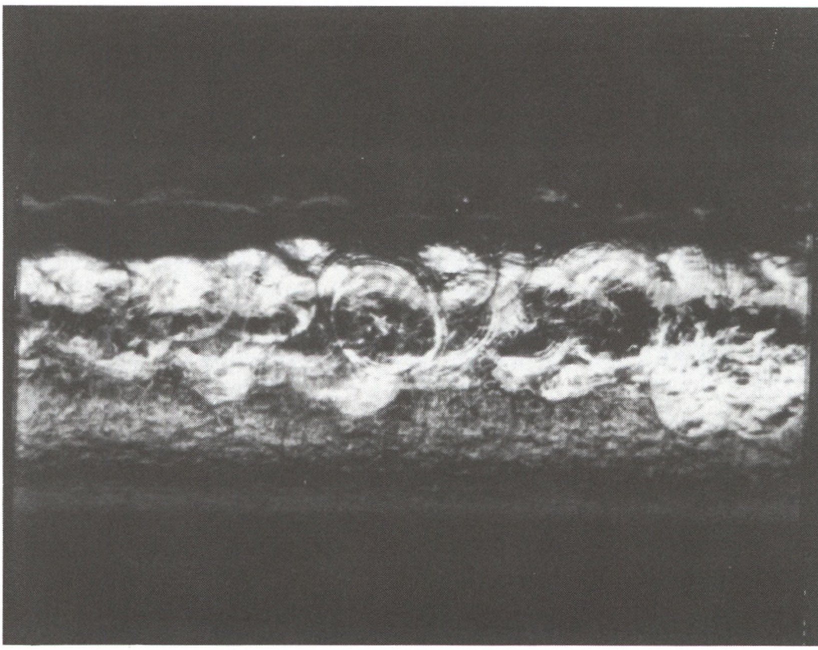

Figure 6. Photograph of the 1T bend of the laser-welded bevel joint of the 0.030 inch thick, Pt-4.8Ru strip at 15x.

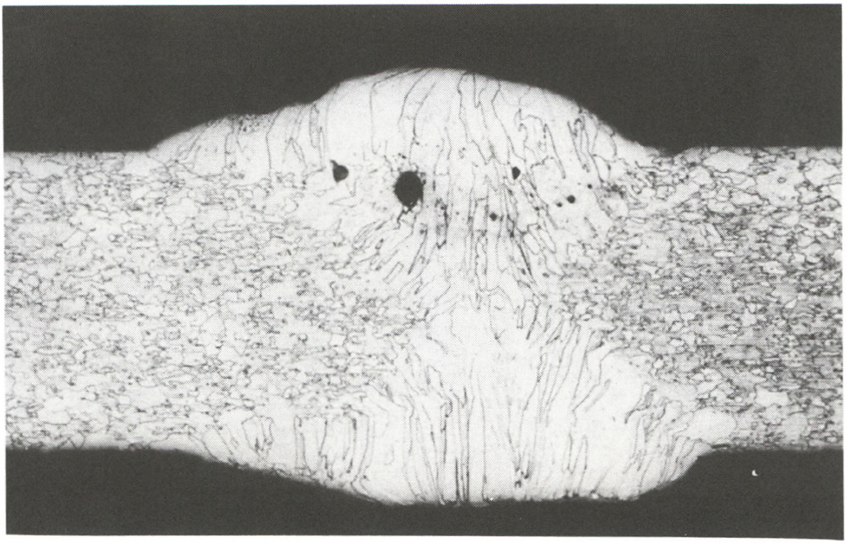

Figure 7. Photomicrograph of the laser-welded bevel joint, cross-section of the 0.030 inch thick, Pt-4.8Ru alloy strip at 50x.

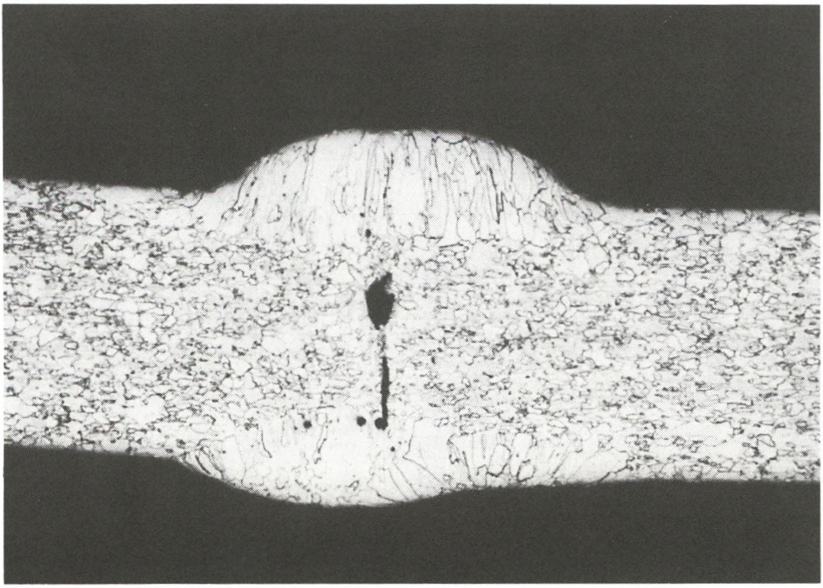

Figure 8. Photomicrograph of the laser-welded butt joint, cross-section of the 0.030 inch thick, Pt-4.8Ru strip at 50x.

Figure 9. Photograph of the 1T bend of the brazed bevel joint of the 0.030 inch thick, Pt-4.8Ru strip at 15x.

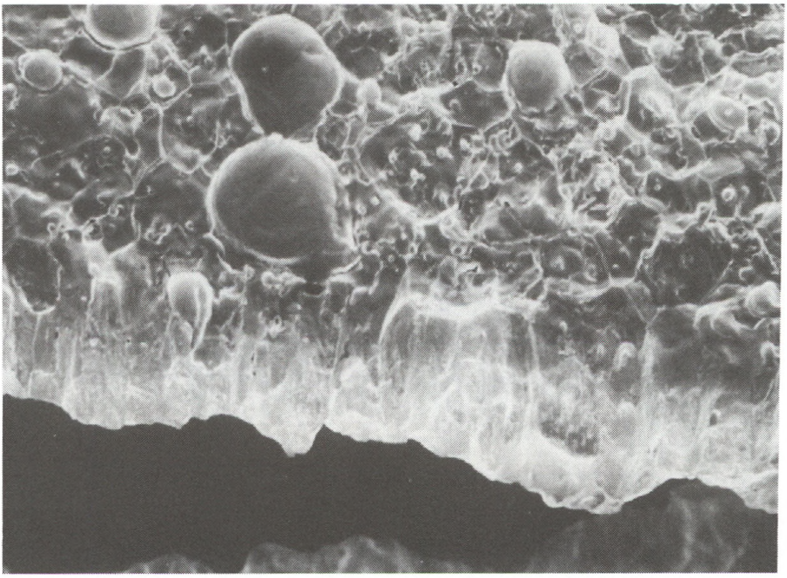

Figure 10. Scanning-electron-micrograph shows the fracture surface of the 1T bend from the brazed bevel joint of the 0.030 inch thick, Pt-4.8Ru strip at 15x.

Figure 11. Photograph of the 1T bend of the brazed butt joint of the 0.030 inch thick, Pt-4.8Ru strip at 15x.

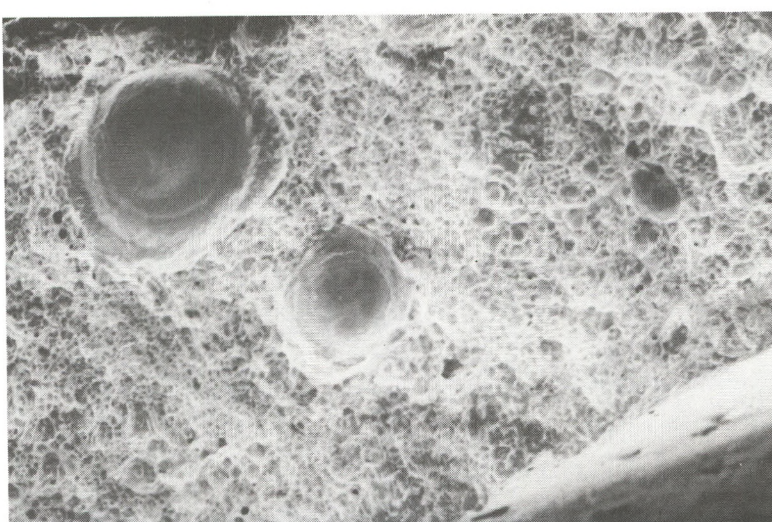

Figure 12. Scanning-electron-micrograph shows the fracture surface of the 1T bend from the brazed butt joint of the 0.030 inch thick, Pt-4.8Ru strip at 100x.

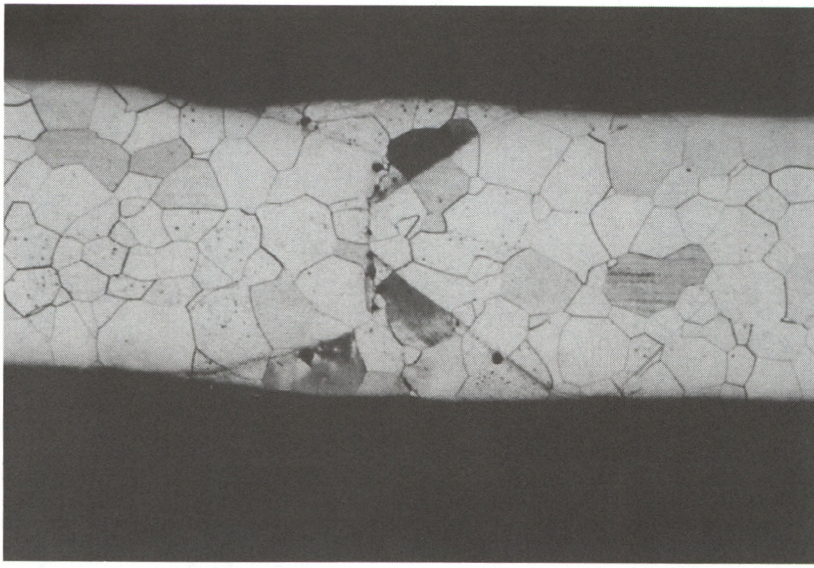

Figure 13. The photomicrograph of the brazed bevel joint, cross-section of the 0.030 inch thick, Pt-4.8Ru alloy strip at 50x.

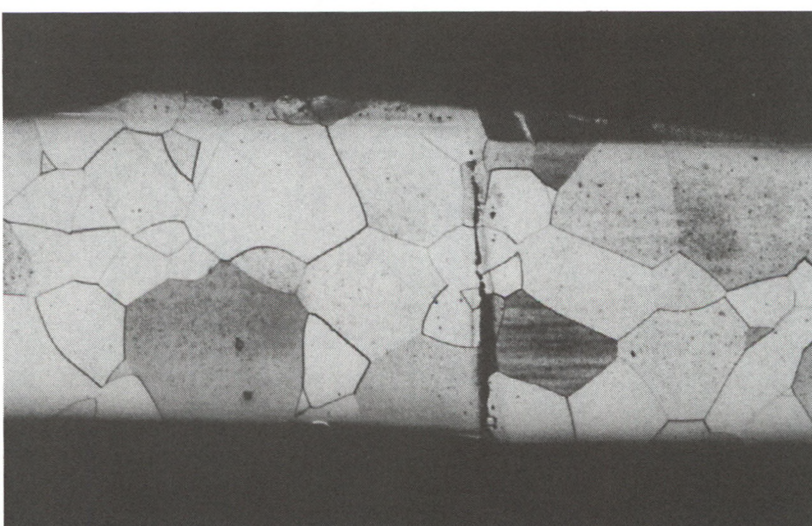

Figure 14. The photomicrograph of the brazed butt joint, cross-section of the 0.030 inch thick, Pt-4.8Ru alloy strip at 50x.

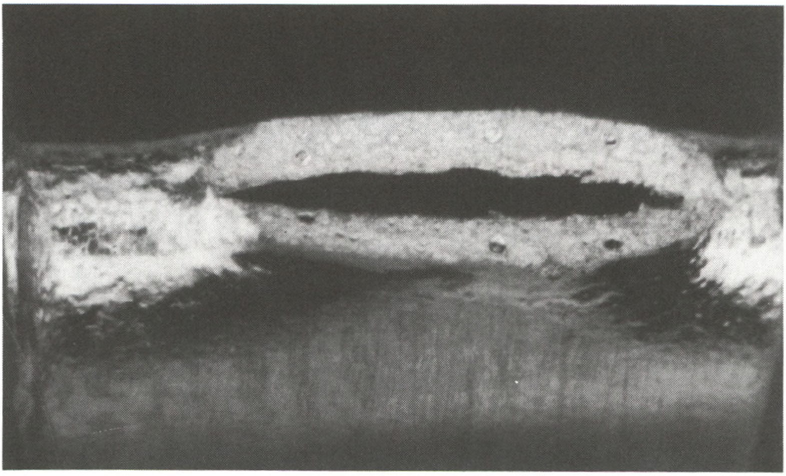

Figure 15. Photograph of the 1T bend of the brazed butt joint using 1700 Pt solder on the 0.030 inch thick, Pt-4.8Ru alloy strip at 10x.

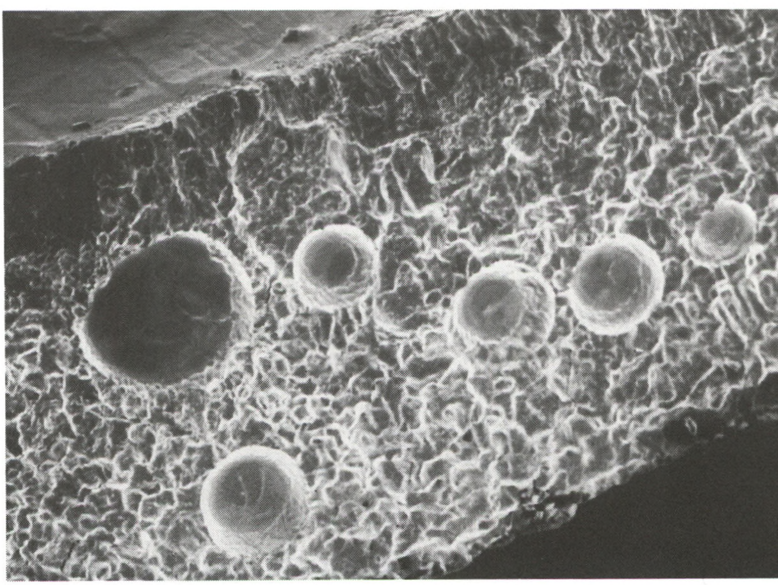

Figure 16. Scanning-electron-micrograph shows the fracture surface of the 1T bends from the brazed butt joint using 1700 Pt solder on the 0.030 inch thick, Pt-4.8Ru alloy strip at 100x.

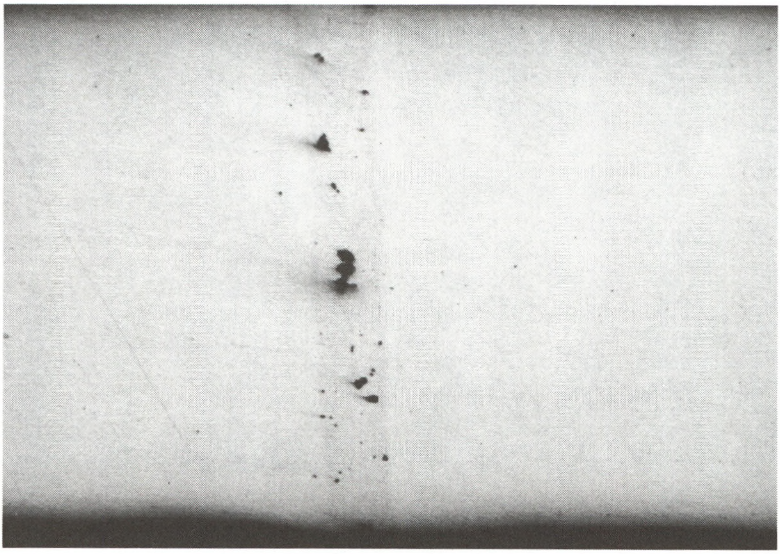

Figure 17. The photomicrograph of the 1700 Pt solder brazed butt joint, cross-section of the 0.030 inch thick, Pt-4.8Ru alloy strip at 100x.

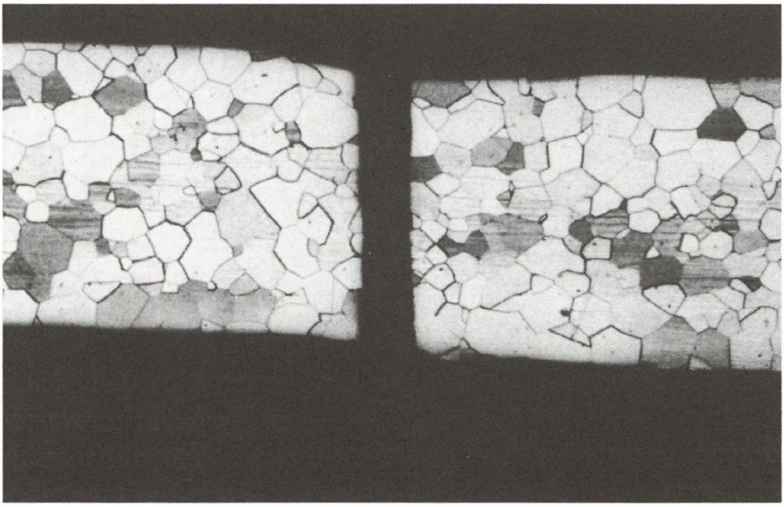

Figure 18. Same as Figure 17 only etched and 50x.

fracture with no porosity is seen. However, the explanation is seen in the photomicrographs of the weld cross-sections.

The bevel joint is such that the grain boundaries are aligned with the unwelded area to create a clear fracture path. This does not occur with the butt joint as can be seen examining Figures 20 through 22.

The examination of the fracture surfaces of the brazed joints of the cast materials indicate two very different modes. The scanning-electron-micrograph of the bevel joint in Figure 23 shows a very irregular, faceted surface, while the photograph and scanning-electron-micrograph of the butt joint is relatively smooth with some porosity in evidence. These are shown in Figures 24 and 25. The photomicrographs of the cross-sections of the joints help to explain the phenomenon. A very good braze joint is seen in Figure 26 for the bevel joint but the sample has a large grain and traces of porosity. The butt joint is a poor braze with poor wetting and large porosity (Figure 27).

The bend results for the 0.075 inch thick rolled Pt-4.8Ru strip summarized in Table III, is the next data to be examined. Two of the three laser welded bevel joints passed, but the remainder of the joints failed. Photographs and scanning-electron-micrographs of the laser welded butt joints indicate they failed due to lack of penetration. This can be observed in Figures 28 and 29. The photomicrographs of the weld cross-sections confirm the poor penetration with the butt joint and improved penetration with the bevel joint. The inconsistency with the bevel joint would appear to be differing amounts of penetration amongst the three samples. The weld photomicrographs occupy Figures 30 and 31.

The photograph and scanning-electron-micrograph of the 0.075 inch brazed bevel joint in Figures 32 and 33 show evidence of poor wetting and the presence of porosity. Likewise, evidence of poor wetting is noted in the photograph of the corresponding butt joint in Figure 34. The

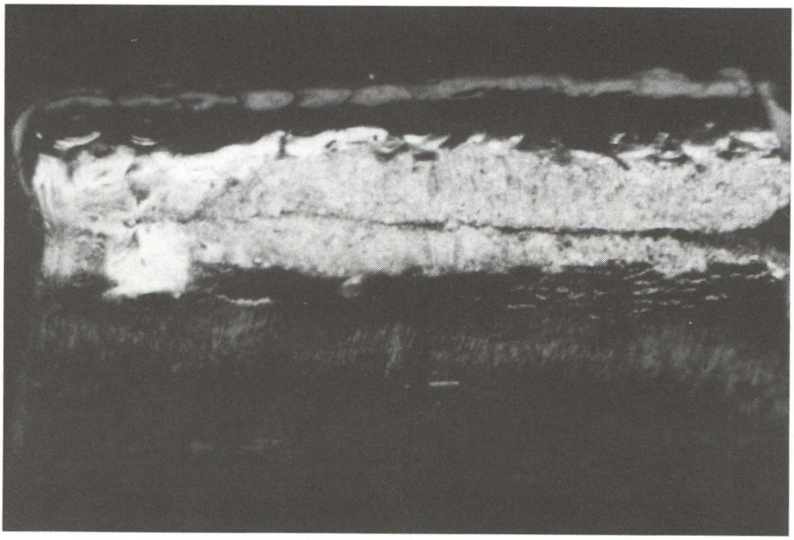

Figure 19. Photograph of the 1T bends of the laser-welded bevel joint of the 0.030 inch thick, Pt-4.8Ru alloy casting at 10x.

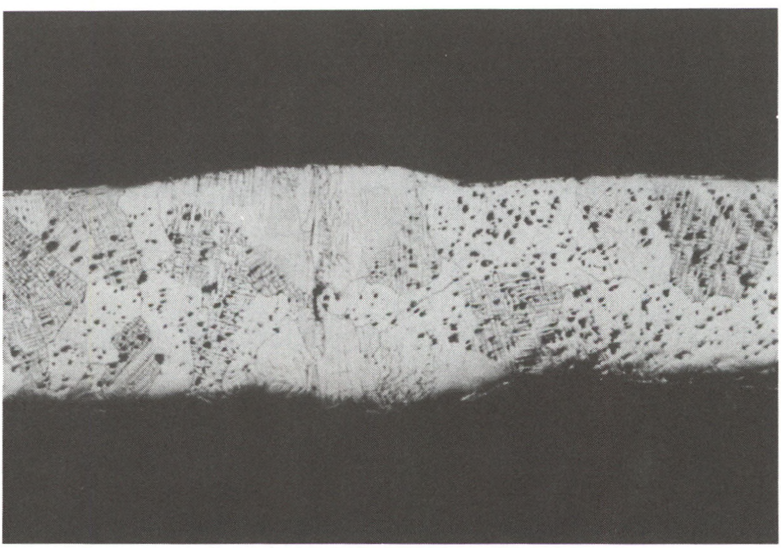

Figure 20. Photomicrograph of the laser-welded bevel joint of the 0.030 inch thick, Pt-4.8Ru alloy casting at 25x.

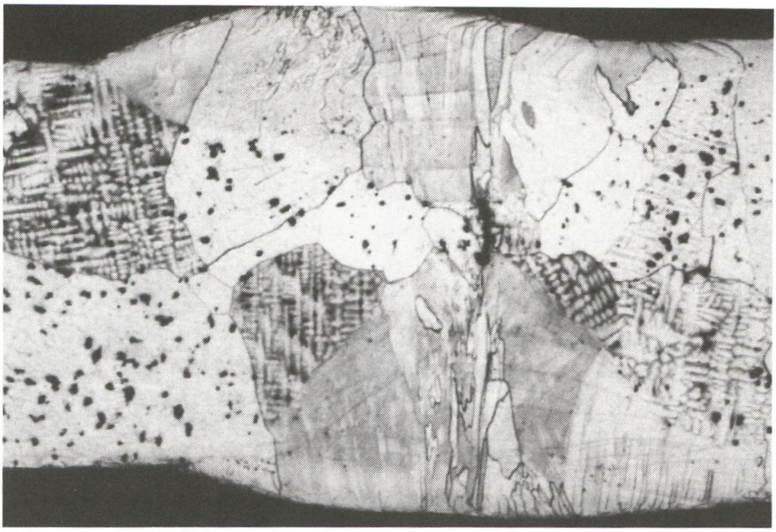

Figure 21. Same as Figure 20 at 50x.

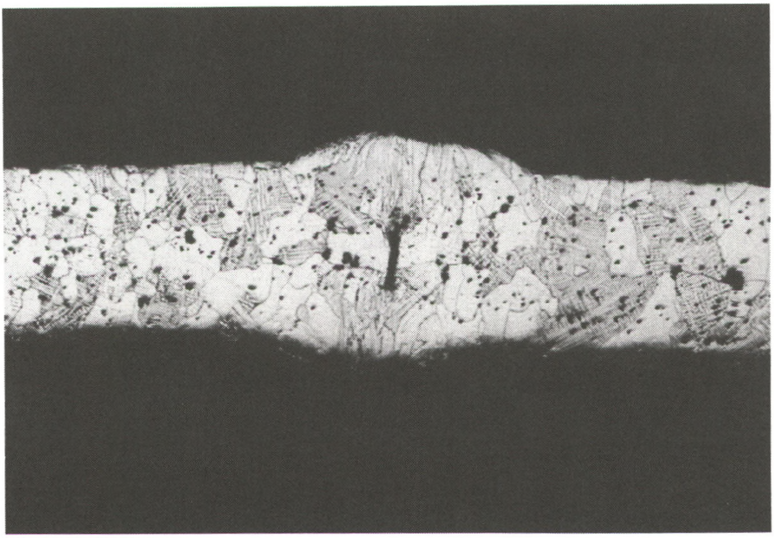

Figure 22. Photomicrograph of the laser-welded butt joint of the 0.030 inch thick, Pt-4.8Ru alloy casting at 25x.

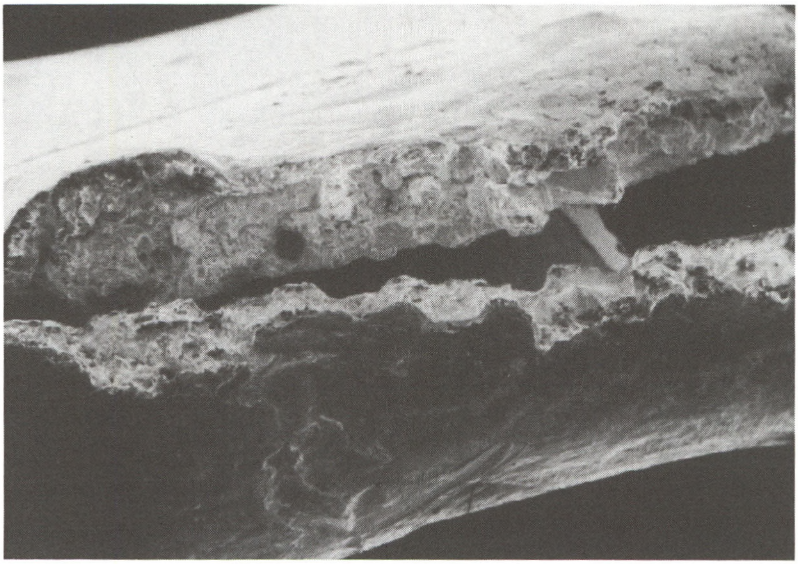

Figure 23. Scanning-electron-micrograph show the fracture surface of the brazed bevel joint of the 0.030 inch thick, Pt-4.8Ru alloy casting at 12x.

Figure 24. Photograph of the 1T bend of the brazed butt joint of the 0.030 inch thick, Pt-4.8Ru alloy casting at 10x.

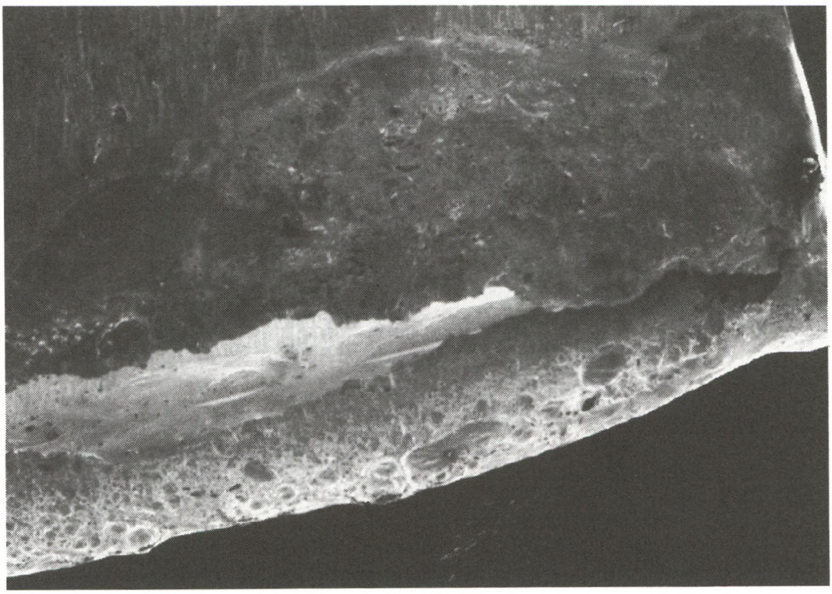

Figure 25. Scanning-electron-micrograph show the fracture surface of the brazed butt joint of the 0.030 inch thick, Pt-4.8Ru alloy casting at 11x.

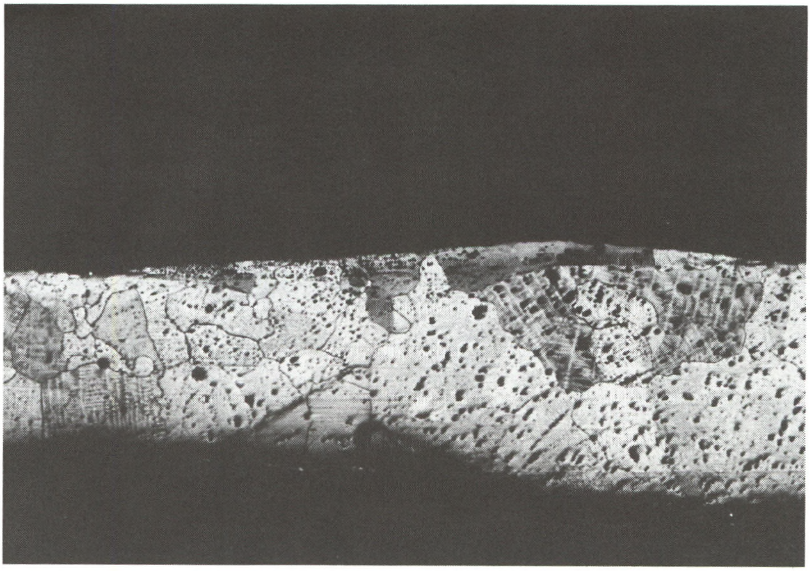

Figure 26. Photomicrograph of the brazed bevel joint, cross-section of the 0.030 inch thick, Pt-4.8Ru alloy casting at 25x.

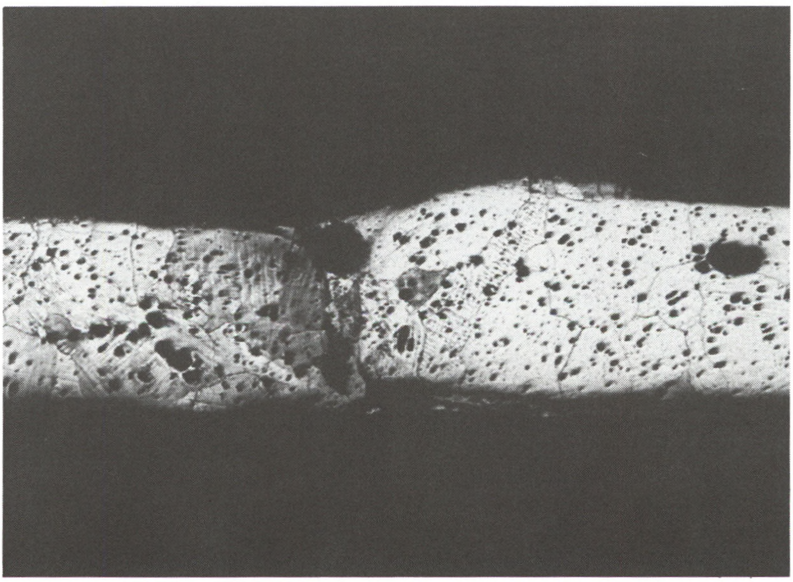

Figure 27. Photomicrograph of the brazed butt joint, cross-section of the 0.030 inch thick, Pt-4.8Ru alloy casting at 25x.

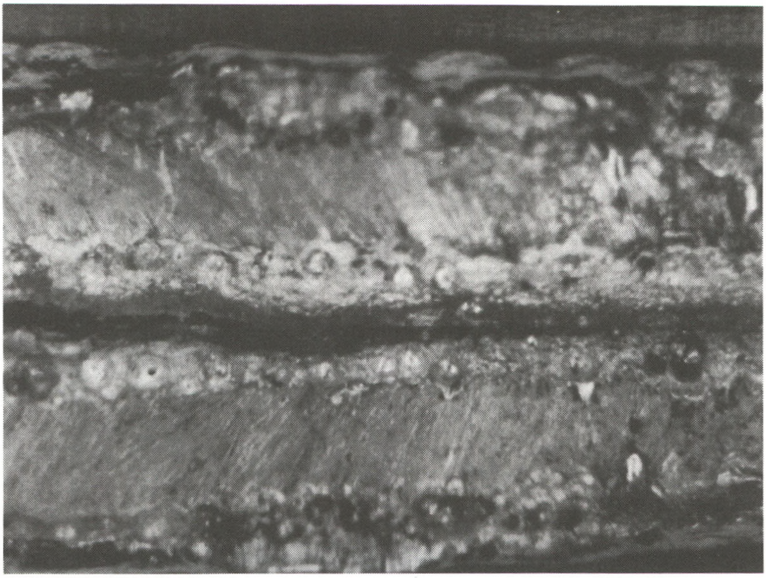

Figure 28. Photograph of the 1T bend of the laser-welded butt joint of the 0.075 inch thick, Pt-4.8Ru strip at 15x.

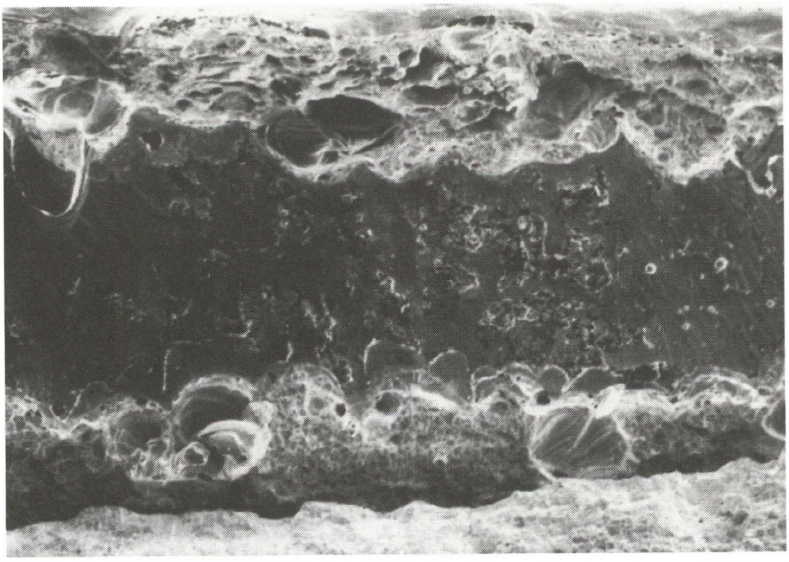

Figure 29. Scanning-electron-micrograph shows the fracture surface of the laser-welded butt joint of the 0.075 inch thick, Pt-4.8Ru strip at 36x.

Figure 30

Figure 31

Figure 30. Photomicrograph of the laser-welded bevel joint, cross-section of the 0.075 inch thick, Pt-4.8Ru strip at 50x.

Figure 31. Photomicrograph of the laser-welded butt joint, cross-section of the 0.075 inch thick, Pt-4.8Ru strip at 50x.

Figure 32. Photograph of the 1T bend of the brazed bevel joint of the 0.075 inch thick, Pt-4.8Ru strip at 15x.

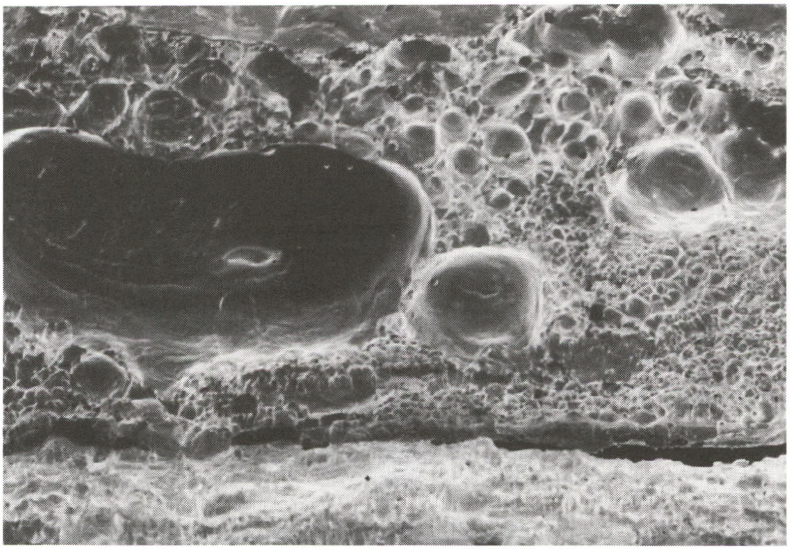

Figure 33. Scanning-electron-micrograph of the fracture surface from the brazed bevel joint of the 0.075 inch thick, Pt-4.8Ru strip at 15x.

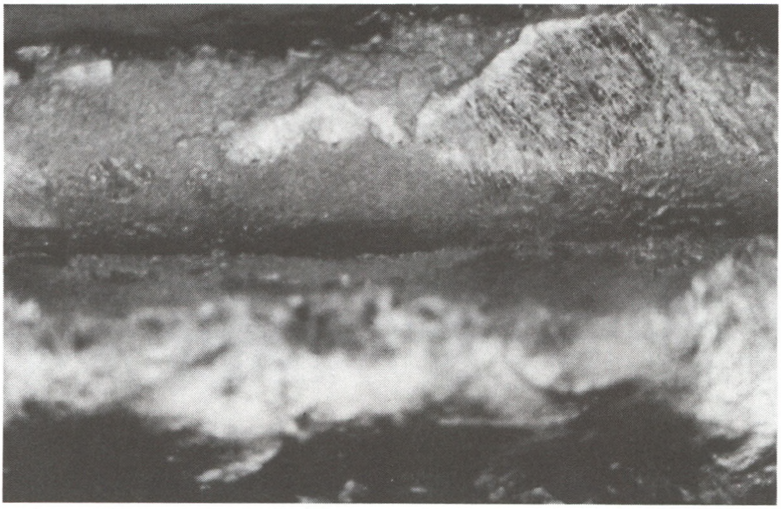

Figure 34. Photograph of the 1T bend of the brazed butt joint of the 0.075 inch thick, Pt-4.8Ru strip at 15x.

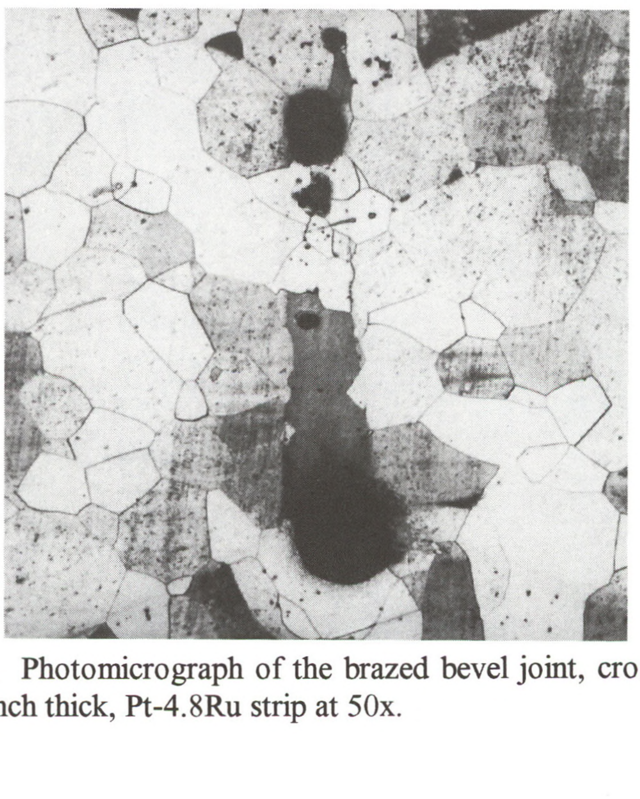

Figure 35. Photomicrograph of the brazed bevel joint, cross-section of the 0.075 inch thick, Pt-4.8Ru strip at 50x.

photomicrographs of the braze cross-sections confirm these observations as seen in Figures 35 and 36.

The next results to be presented are in Table IV for the 1T bend test data for the 18kt gold strip 0.030 inch thick. The rolled strip showed the following: All of the laser welded butt joints passed and one out of three of the bevel joint laser welded and the bevel joint brazed. All of the brazed butt joints failed. The failure of the laser welded bevel joint did not occur in the weld but in the zone next to the weld (See Figure 37). The photomicrographs of the weld cross-sections both etched and unetched as shown in Figures 38 through 40 show excellent welds with little or no porosity. The major difference is the shape of the weld. The bevel joint gives a clear fracture path, while the butt joint with its hour-glass-shaped profile gives a more difficult fracture path.

The fracture behavior of the brazed 18kt gold is more difficult to explain. The photographs of the beveled bend samples are shown in Figures 42 and 43. Examination of the photomicrographs of the brazed cross-sections both etched and as polished, indicate a greater amount of porosity in the bevel joint than the butt joint. The braze of the butt joint appears to be of good quality. However, the butt joint sample shows some grain growth and a band is noted in the unetched sample. Therefore, it is postulated, a heat-affected zone was formed within the butt joint material. The photomicrographs are seen in Figures 44 through 47.

The last results to be discussed are the 1T bend test data for the 18kt gold castings 0.030 inches thick summarized in Table IV. The data appears to be inconsistent with the data for the 18kt gold strip that was just discussed in that only one of the twelve bend samples failed and this was a bevel braze sample. However, if we examine the photomicrographs of the weld and braze cross-sections shown in Figures 48 through 55, the braze joints and to some extent, the weld joints have a very different appearance than the same joints for the 18kt gold strip samples. The laser welded bevel and butt joints both have the hour-glass shape and not the

TABLE IV

18kt Gold
Bend Test Data

MATERIAL FORM	THICKNESS (Inches)	CUT	JOINING TECHNIQUE	1T BEND
Rolled Strip	0.030”	Bevel	Laser Weld	P,F,F
Rolled Strip	0.030”	Butt	Laser Weld	P,P,P
Rolled Strip	0.030”	Bevel	Braze	P,F,F
Rolled Strip	0.030”	Butt	Braze	F,F,F
Casting	0.030”	Bevel	Laser	P,P,P
Casting	0.030”	Butt	Laser	P,P,P
Casting	0.030”	Bevel	Braze	P,F,P
Casting	0.030”	Butt	Braze	P,P,P

Figure 36. Photomicrograph of the brazed butt joint, cross-section of the 0.075 inch thick, Pt-4.8Ru strip at 50x.

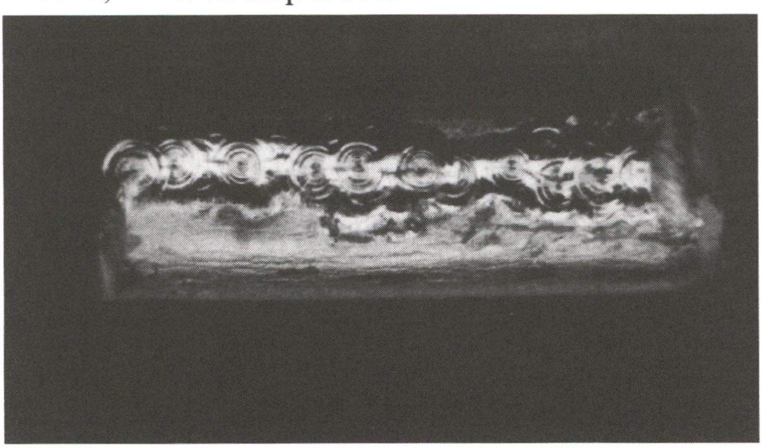

Figure 37. Photograph of the 1T bend of the laser-welded bevel joint of the 0.030 inch thick, 18kt gold strip at 10x.

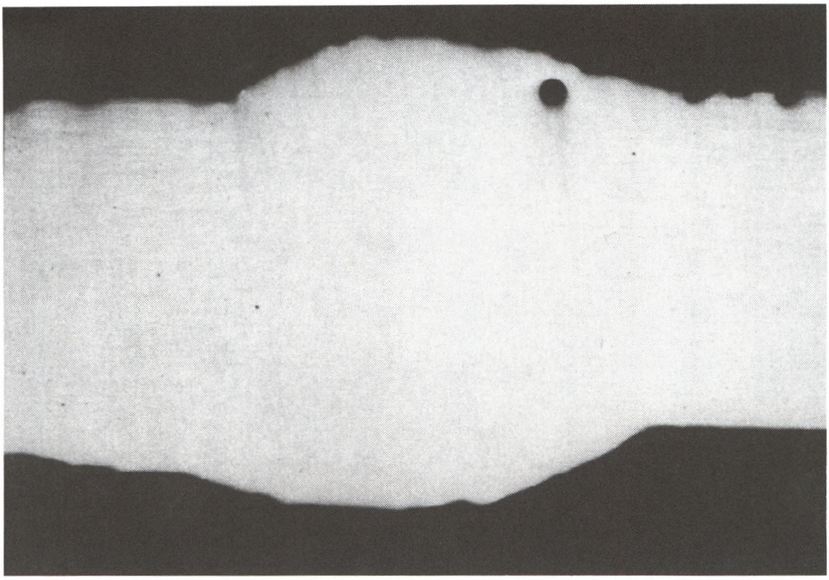

Figure 38. Photomicrograph of the laser-welded bevel joint, cross-section of the 0.030 inch thick, 18kt gold strip as polished at 50x.

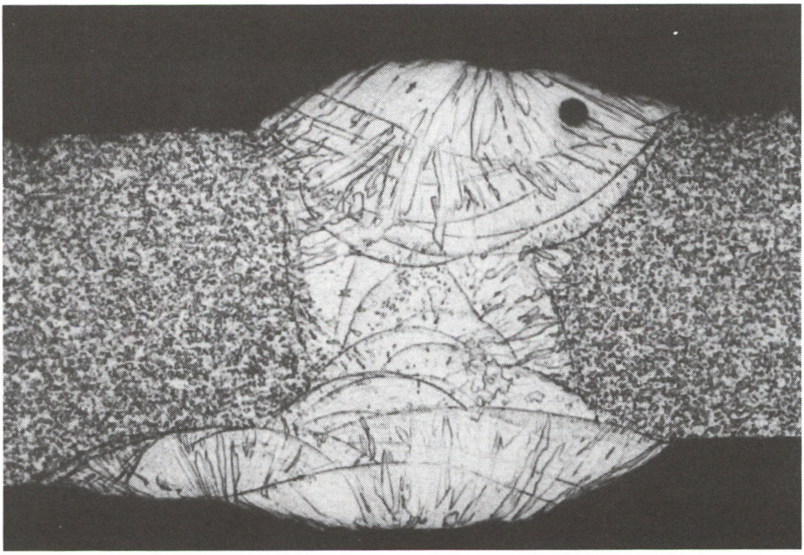

Figure 39. Same as Figure 38 except etched.

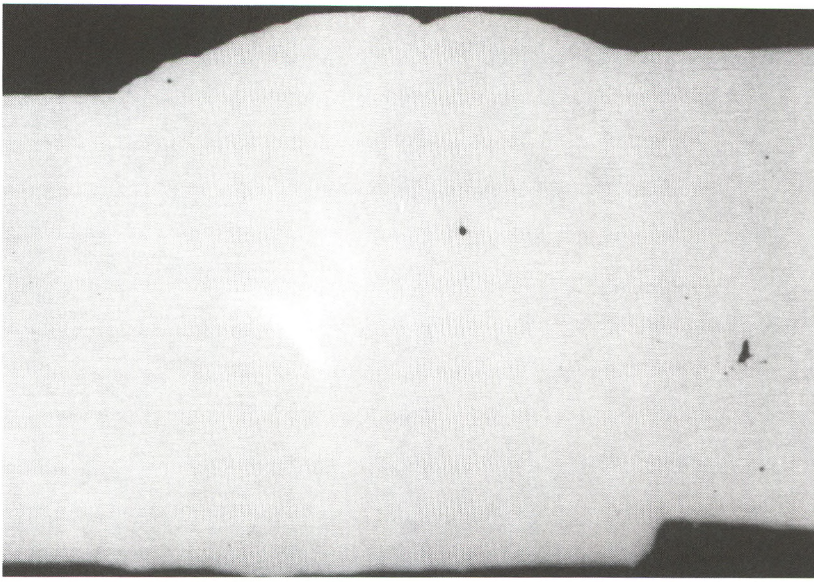

Figure 40. Photomicrograph of the laser-welded butt joint, cross-section of the 0.030 inch thick, 18kt gold strip as polished at 50x.

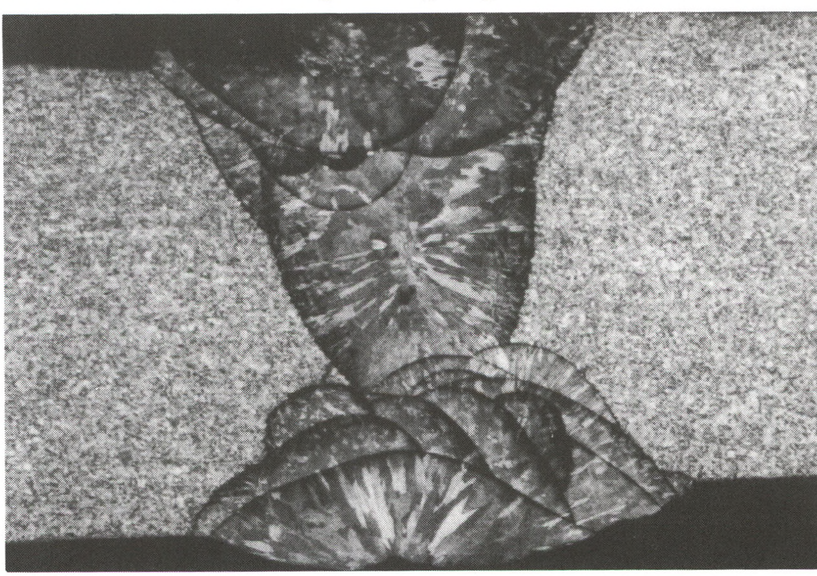

Figure 41. Same as Figure 40 except etched.

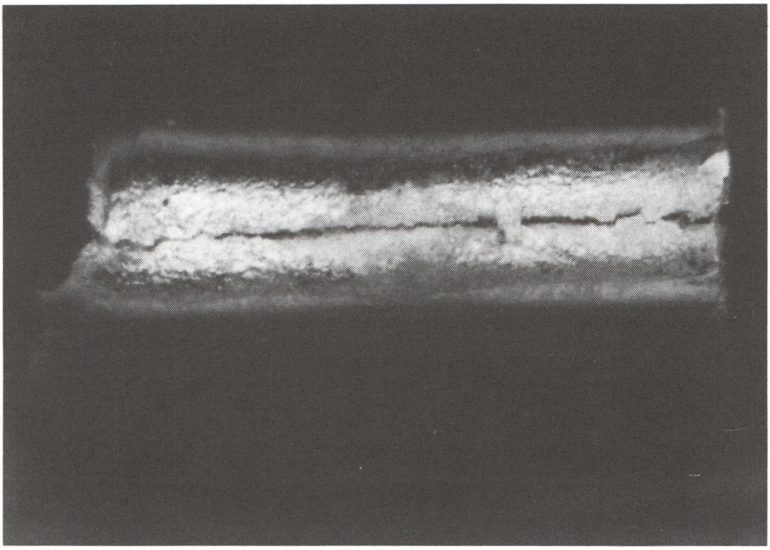

Figure 42. Photograph of the 1T bend of the brazed bevel joint of the 0.030 inch thick, 18kt gold strip at 10x.

Figure 43. Photograph of the 1T bends of the brazed butt joint of the 0.030 inch thick, 18kt gold strip at 10x.

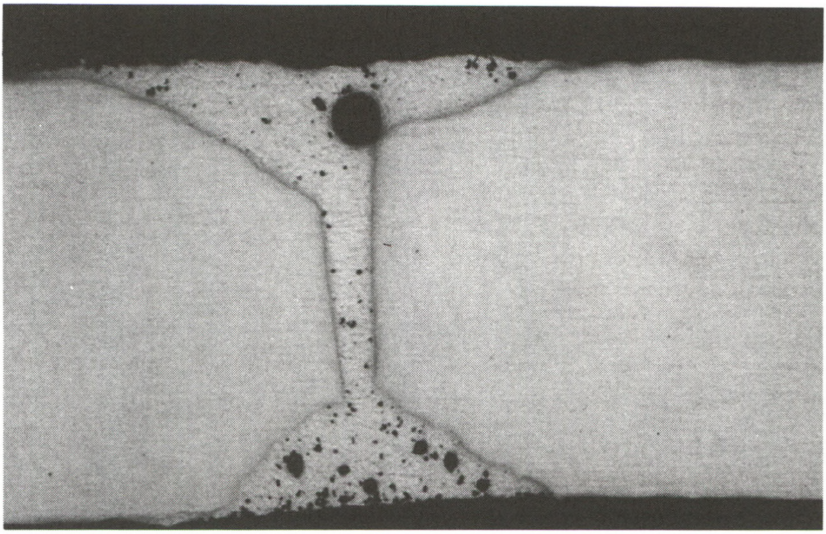

Figure 44. Photomicrograph of the brazed bevel joint, cross-section of the 0.030 inch thick, 18kt gold strip as polished at 50x.

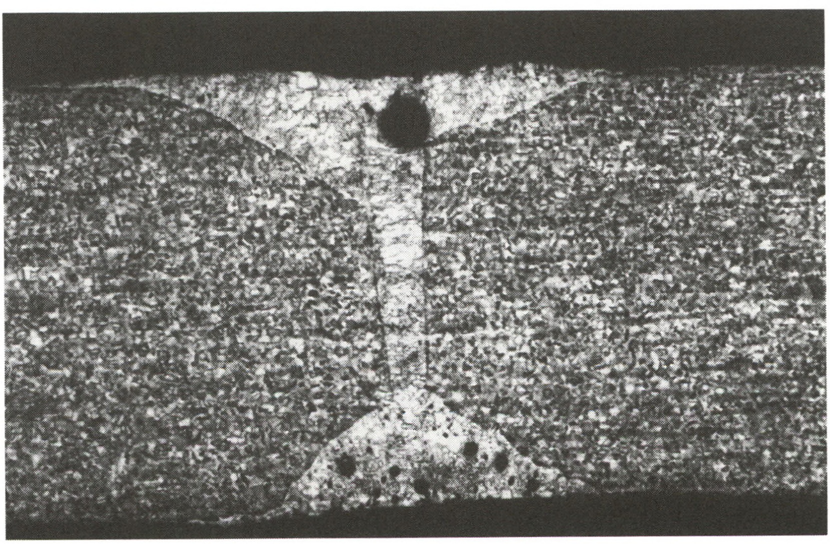

Figure 45. Same as Figure 44 except etched.

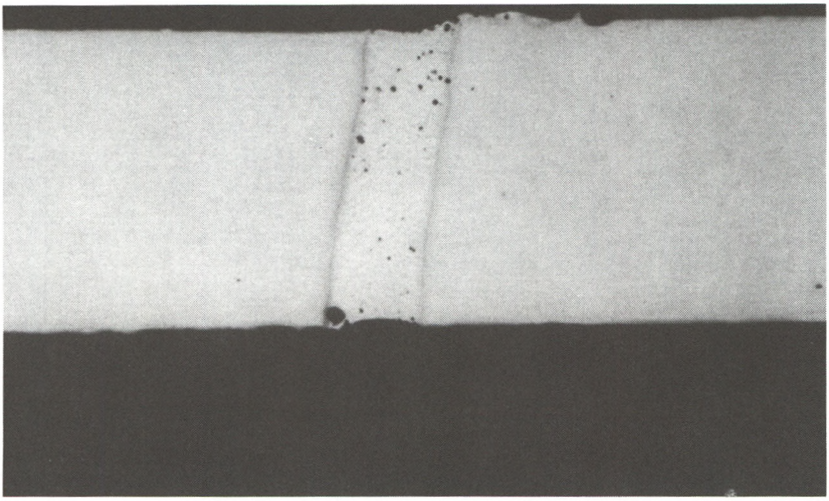

Figure 46. Photomicrograph of the brazed butt joint, cross-section of the 0.030 inch thick, 18kt gold strip as polished at 50x.

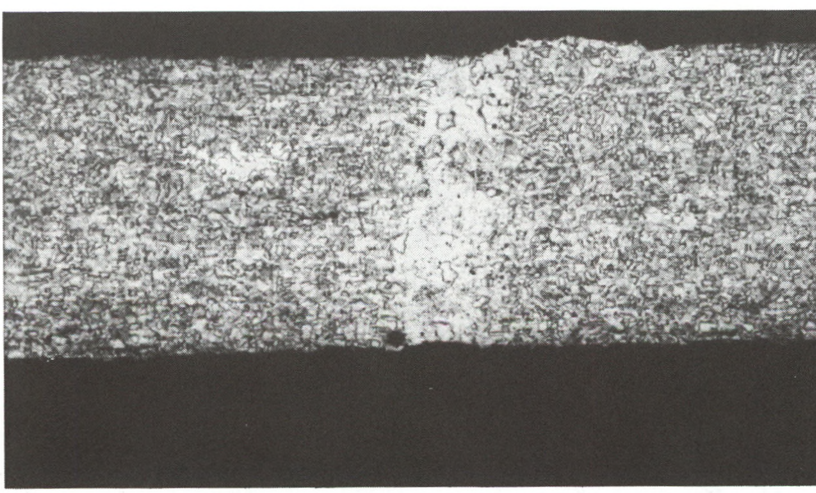

Figure 47. Same as Figure 46 except etched.

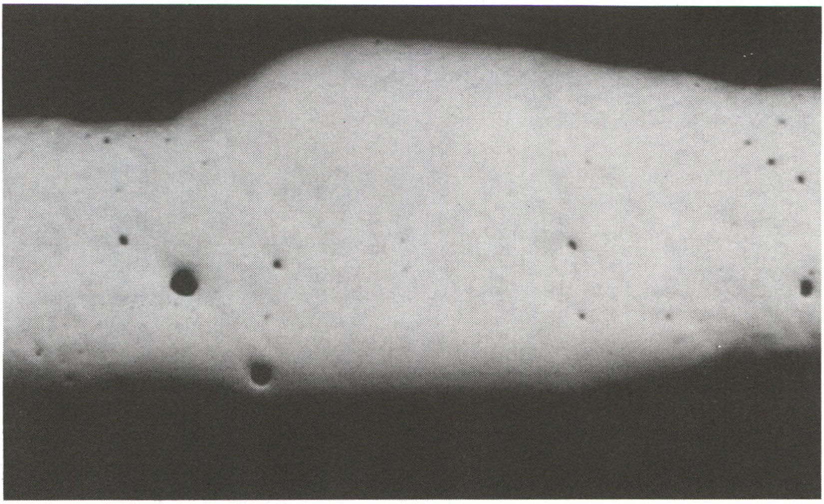

Figure 48. Photomicrograph of the laser-welded bevel joint, cross-section of the 0.030 inch thick, 18kt gold casting as polished at 50x.

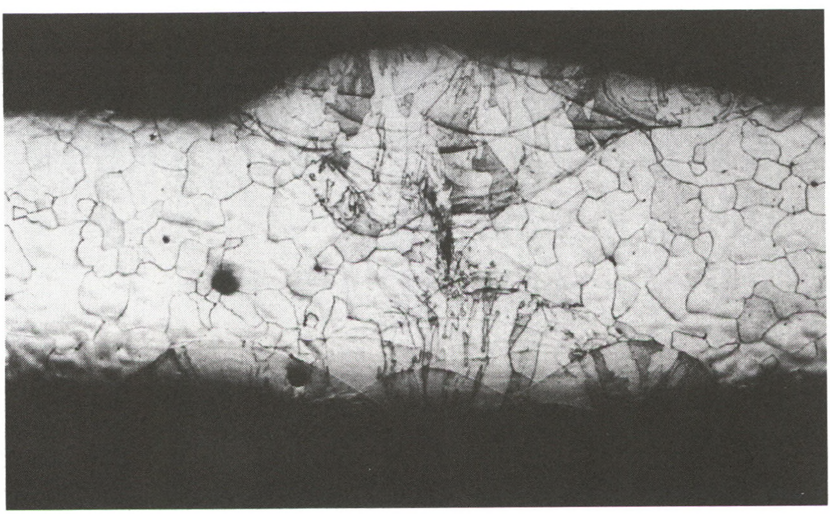

Figure 49. Same as Figure 48 except etched.

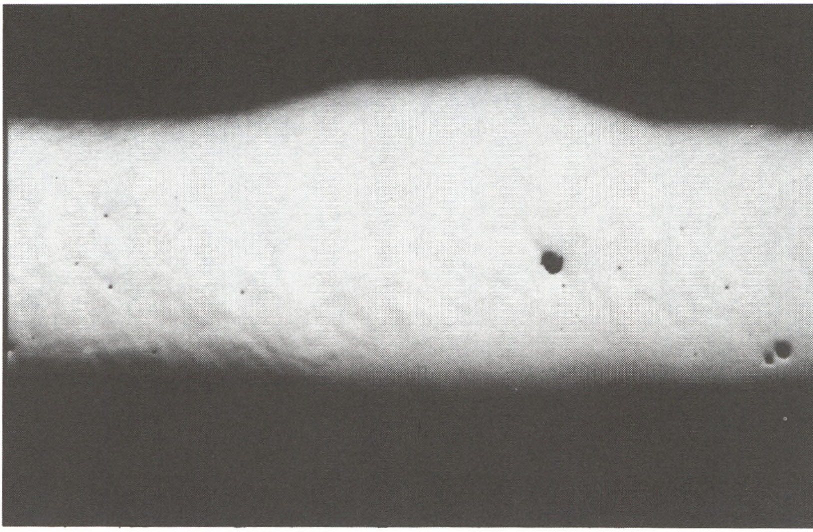

Figure 50. Photomicrograph of the laser-welded butt joint, cross-section of the 0.030 inch thick, 18kt gold casting as polished at 50x.

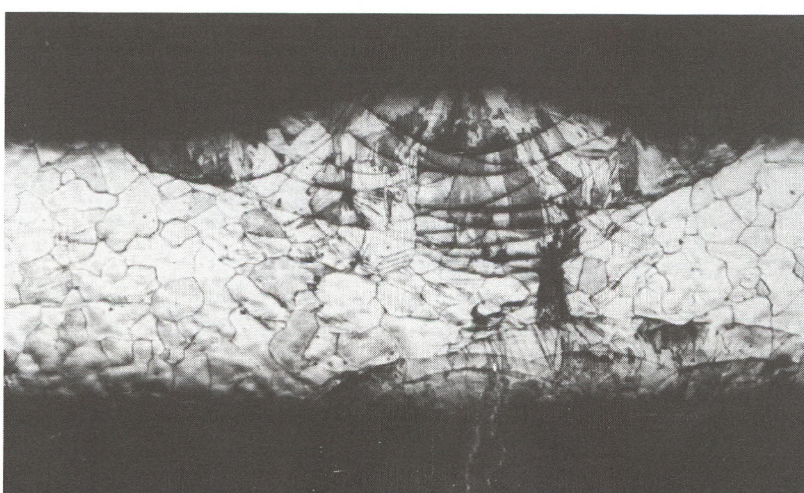

Figure 51. Same as Figure 50 except etched.

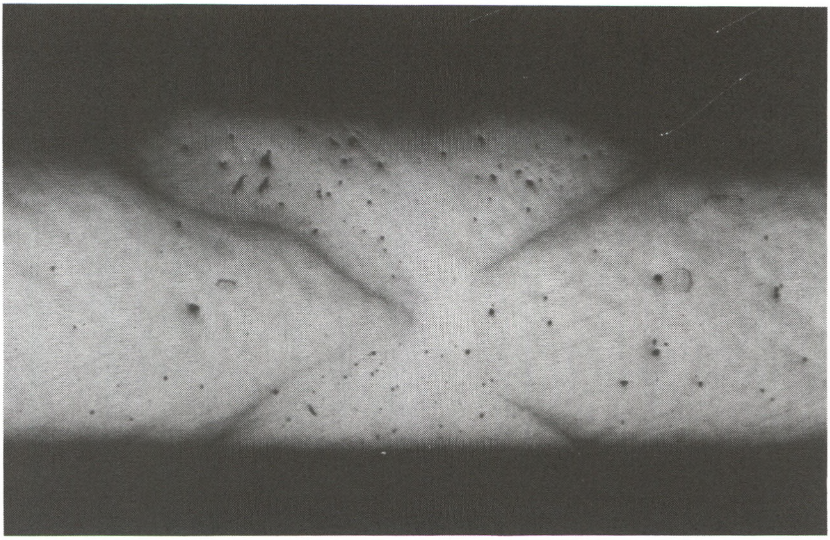

Figure 52. Photomicrograph of the brazed bevel joint, cross-section of the 0.030 inch thick, 18kt gold strip as polished at 50x.

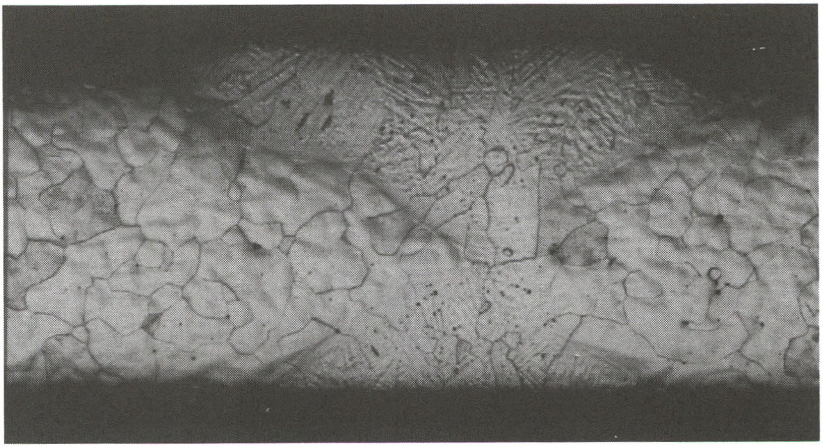

Figure 53. Same as Figure 52 except etched.

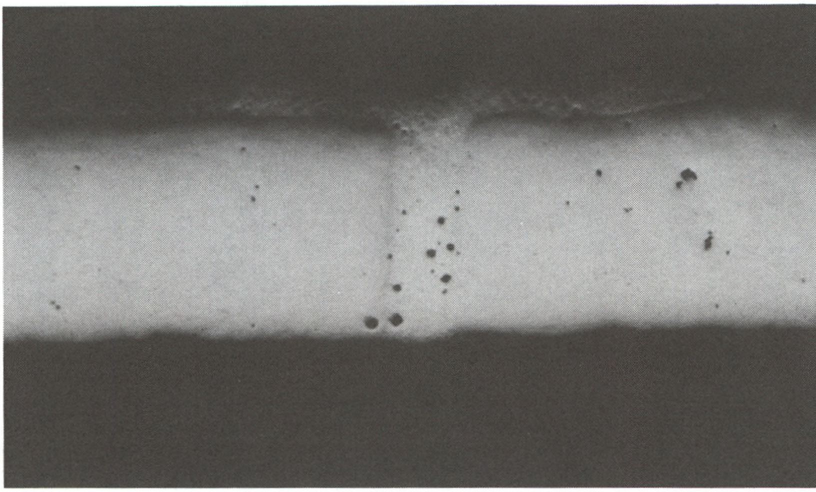

Figure 54. Photomicrograph of the brazed butt joint, cross-section of the 0.030 inch thick, 18kt gold strip as polished at 50x.

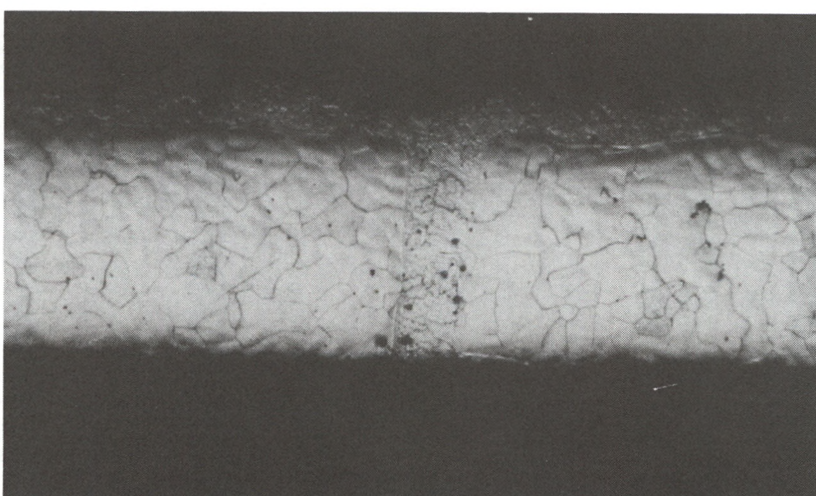

Figure 55. Same as Figure 54 except etched.

straight sided shape which caused the bend failure of the laser welded strip bevel joint. The difference in the brazed joints are the decrease in porosity, the thicker joint area and more fusion of the parent and filler metal. The joints were made by the same jeweler only on different days.

Discussion

In the course of performing the experiment, it was noted that laser welding is a longer process than traditional brazing techniques. Initially, this would seem to be a serious downside, especially in a production environment. However, the results of the experiments show that a laser weld is superior to a brazed joint in strength and quality (i.e., porosity). This fact might offset the longer process time.

There are several possible explanations for laser joints showing higher strength characteristics than similarly brazed ones. In the case of our platinum samples, the intense heat required to braze platinum by torch has a negative effect on the grain structure, enlarging them to a point where they compromise the strength of the metal. In addition, any small contamination in the metal along with oxidized alloying elements will congregate at the grain boundaries, further promoting failure of the joint. It was also noted that there was very poor wetting and flow of the braze material with the base alloy. This can be attributed to poor technique, however, the high temperatures encountered does not allow the use of flux, which could eleviate the problem. While the commercially available braze could form oxides which prevent wetting, even our experimental Pt-5Au filler material, which was used for the experiment, showed poor wetting and flow. The combination of these two conditions, enlarged grains and poor wetting, caused failure of our brazed pieces. Our laser welded butt edged pieces which failed at the larger thickness (.075") shows a need for beveling thicker pieces before welding to insure a thick enough weld bead to survive not only finishing operations, but also and mechanical stress the piece might undergo.

Our gold samples showed the same pattern of failure between brazed and welded joints but perhaps for different reasons. The brazed joints showed good wetting and flow, no doubt due to the lower temperatures and the use of flux and braze containing wetting agents. The grain structure of the base metal did not seem to be compromised by the brazing process. However, the filler material itself was laden with porosity, both gas and shrinkage types. This porosity was severe enough to compromise the strength of the joint.

Laser welded platinum showed much better wetting between base and filler material, which additionally is the same composition as the base. Brazed platinum samples showed poor wetting. This can be caused by poor technique. Once again, the gold samples showed much better wetting and flow, due to the use of flux.

The gold brazed samples apparently failed for very different reasons. As the etched cross-sections showed, the solder joints contained quite a bit of porosity, a common problem with brazing the gold. The porosity, caused mainly by entrapped gas, severely weakens the joint. This also can be caused by poor soldering technique.

One of the laser welded gold samples failed and this was probably due to the large elongated grains in the weld bead. Failure probably occurred along the grain boundaries. All the laser welded samples of both gold and platinum showed enlarged grains. This can be improved by hammering the weld bead, a common practice.

There may be comments on the use of the bend test in that there were many failures of the type of joints that have been used in jewelry making over the years with success. The point is that the test does not indicate whether the joining technique should be used for a specific application but it does give a relative measure of the ductility of a given joint. The bend test, along with other metallurgical techniques, certainly gives an indication of improvements that can be made by process or mechanical changes.

The study also points to the fact that 18kt gold is still easier to work with than the Pt alloys. Greater skill is required to successfully join the Pt-4.8Ru alloy. However, the laser welder appears to level the stringent requirements.

References

1. ASTM E290-81, "Method for Semi-Guided Bevel Test for Ductility of Metallic Materials", Volume 03.01, 1986 Annual Book of ASTM Standards, Philadelphia, PA.

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