APPENDIX C—DESTRUCTIVE ANALYSIS OF JT9D TURBINE EXHAUST CASE (TEC)

C.1 PLAN.

Two JT9D-7 TECs (Turbine Exhaust Case) were available for this investigation (see section 2.1.4). Case S/N CD8893 was selected for cut up analysis. This case had been operated by Japan Airlines for 63,887 hours and 12,934 cycles. Metallographic samples were removed from the outer ring front flange, rails, mount lugs, and rear flange and from the case walls at the forward, middle, and rearward wall sections. Samples were also removed from one of the struts, the inner ring walls and inner ring flanges. Examples of the assembly welds were also examined. Besides examining general microstucture and possible defects, hardness measurements were made at several of the locations.

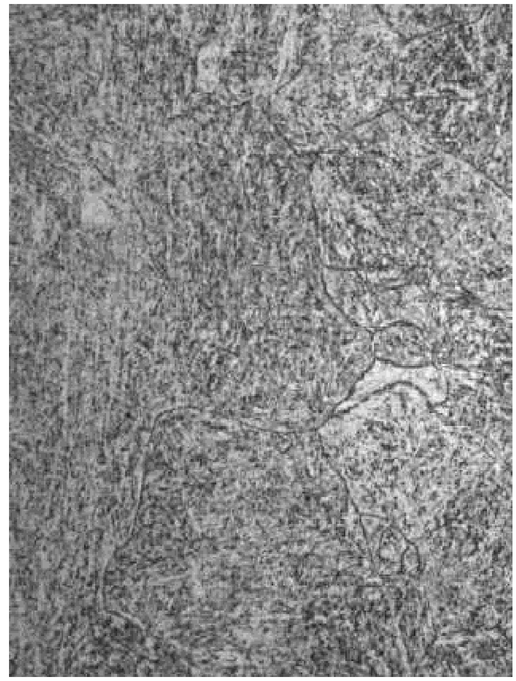
C.2. RESULTS.

The inner ring and struts displayed typical martensitic structure with the strut sheet material (AMS 5596) having a measurably finer grain size than the inner ring. Strut-to-case attachment welds were even finer grained. Deep notches were discovered at the strut/case attachment welds within the hollow struts. It is not known if these were present at completion of construction of the case as a new assembly or occurred subsequent to initiation of commercial service. The microstructure of the outer ring displayed a more sensitized like microstructure with grain boundaries that are heavily decorated with carbides. The grain structure of the outer ring was also coarser than the inner ring. No significant difference in microstructure was observed among different areas of the same detail, suggesting that whatever differences in temperature exposure that may have existed during engine operation, they were sufficiently similar as to not create microstructural differences.

Representative photographs of these microstructures are shown in figures C-1 through C-14.

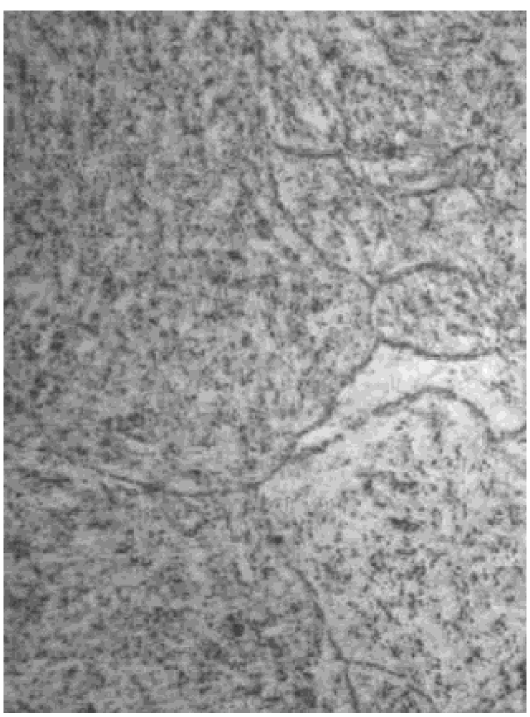
The coarser grain and sensitized microstructure of the outer ring is attributed to its size and the heat treat procedures used with the case. The outer ring is substantially thicker in cross section than the inner ring and sheet metal struts. It would be expected that this hot-rolled ring forging would display a relative coarse grain relative to the thin sheet details and smaller thinner inner ring. Multiple tempers may lead to a sensitized microstructure, but the other case details would also be affected. The more probable cause is that the case experienced a more than typical slower cool from solution than experienced with test material. Most test material, including that used in this program, is hardened by a liquid quench from the solution temperature. However, large structural assemblies such as the TECs cannot be liquid quenched because they would experience severe distortion. Typically the TECs are solution heat treated followed by a forced gas cool, which is not as fast as a liquid quench. The forced gas cool most probably produced the sensitized microstructure. Quantitative metallography was not performed on the case samples, but qualitatively, the outer ring forward areas appeared to be more sensitized than the other case areas. These areas are the hottest operating and the microstructure may reflect this fact. Delta ferrite and other stringers were observed but not to any great degree.

Outer Ring Front Flange 100X

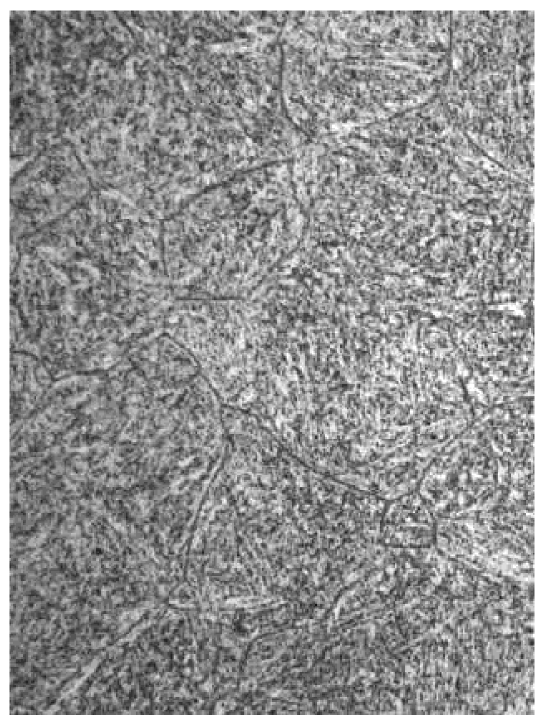


Outer Ring Front Flange 500X

FIGURE C-1. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST CASE OUTER FLANGE



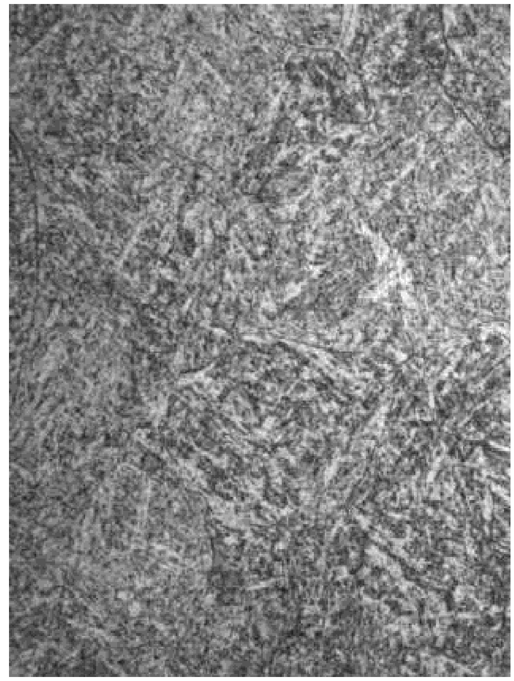
Outer Ring Front Flange 1000X



Outer Ring Front Wall 500X

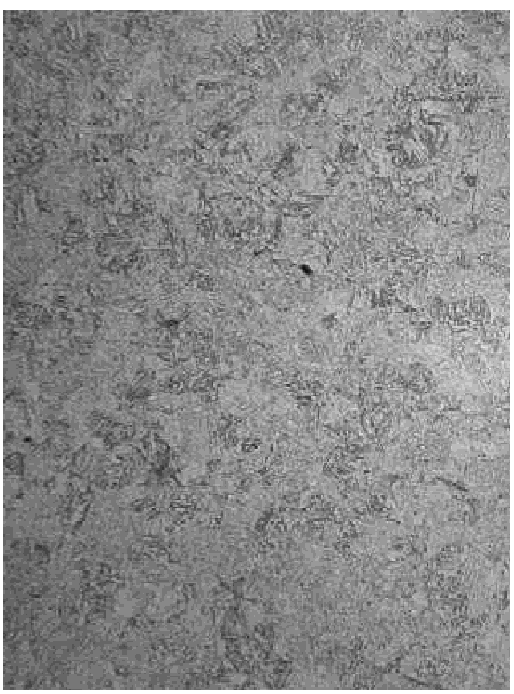
FIGURE C-2. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST CASE OUTER RING FRONT FLANGE AND FRONT WALL

Outer Ring Mid-Wall 100X

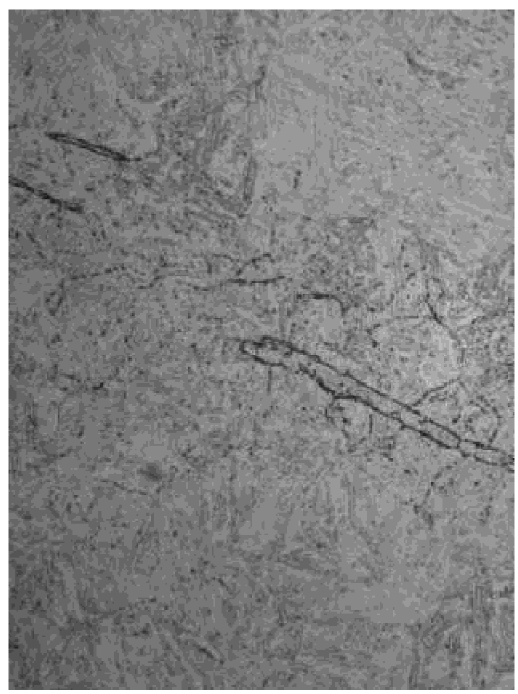


Outer Ring Mid-Wall 500X

FIGURE C-3. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST CASE OUTER RING MID-WALL



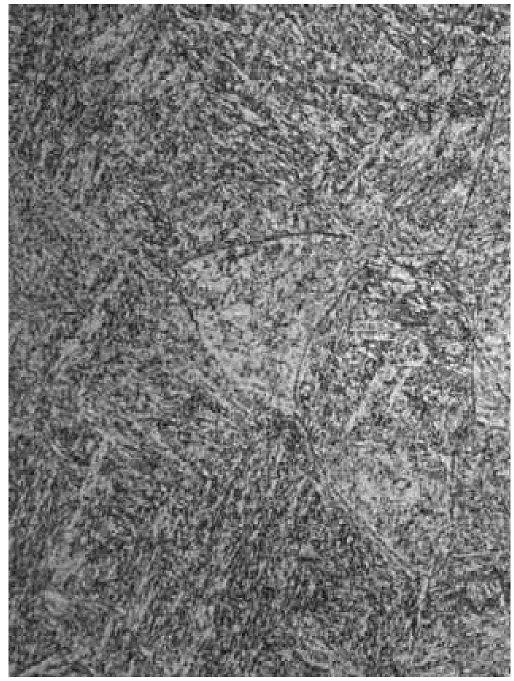
Outer Ring Rear Rail 100X



Outer Ring Rear Rail 500X

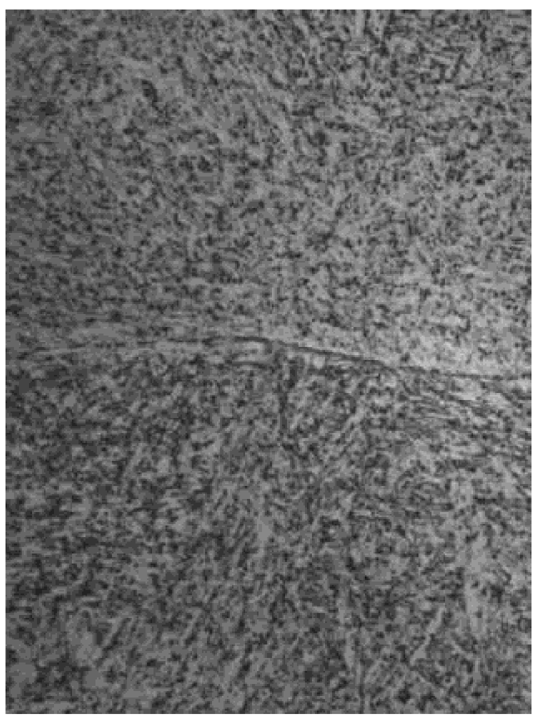
FIGURE C-4. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST CASE OUTER RING REAR RAIL

Outer Ring Mount Lug 100X



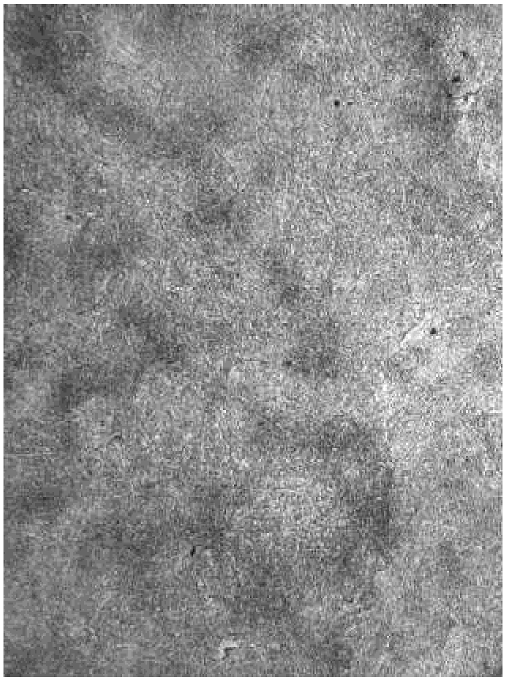
Outer Ring Mount Lug 500X

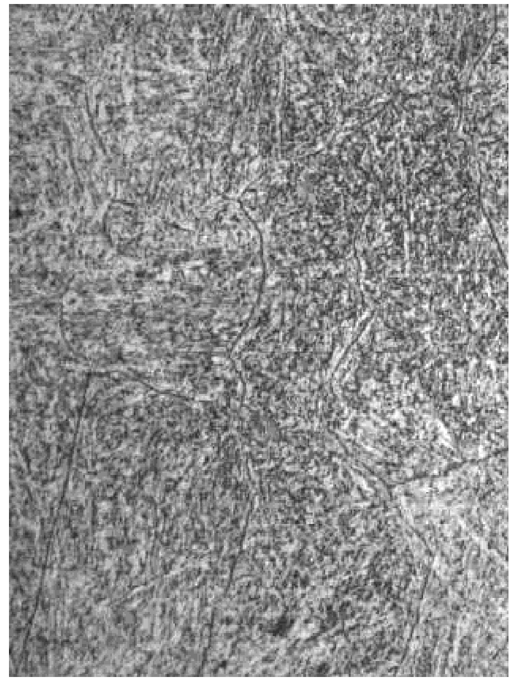
FIGURE C-5. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST CASE OUTER RING MOUNT LUG



Outer Ring Mount Lug 1000X

FIGURE C-6. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST CASE OUTER RING MOUNT LUG

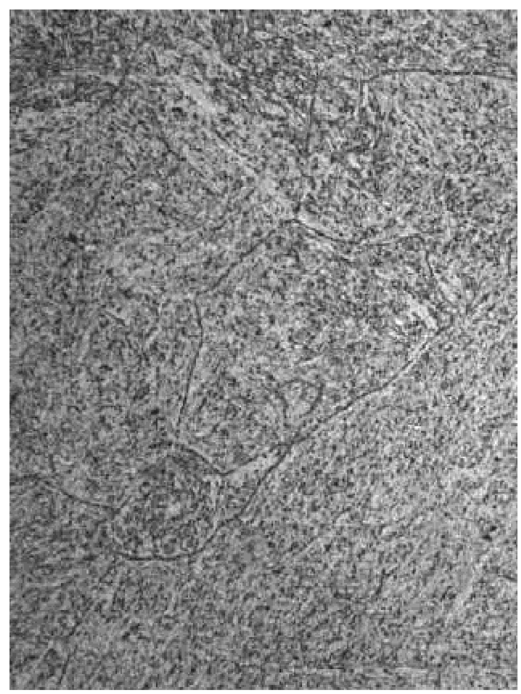




Outer Ring Rear Wall 100X

Outer Ring Rear Wall 500X

FIGURE C-7. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST CASE OUTER RING REAR WALL

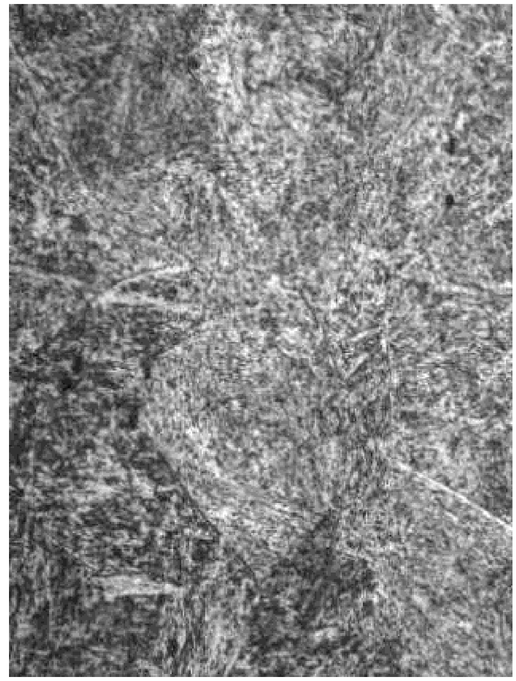


Outer Ring Rear Flange 100X

Outer Ring Rear Flange 500X

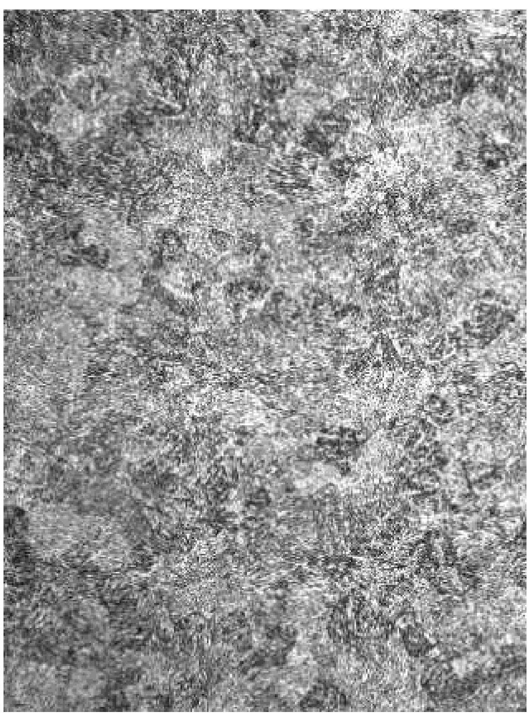
FIGURE C-8. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST CASE OUTER RING REAR FLANGE

Inner Ring Mid-Wall 100X



Inner Ring Mid-Wall 500X

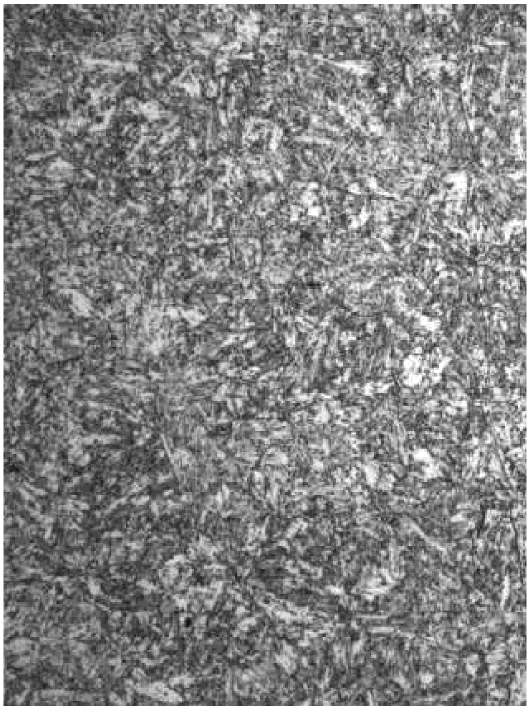
FIGURE C-9. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST CASE INNER RING MID-WALL



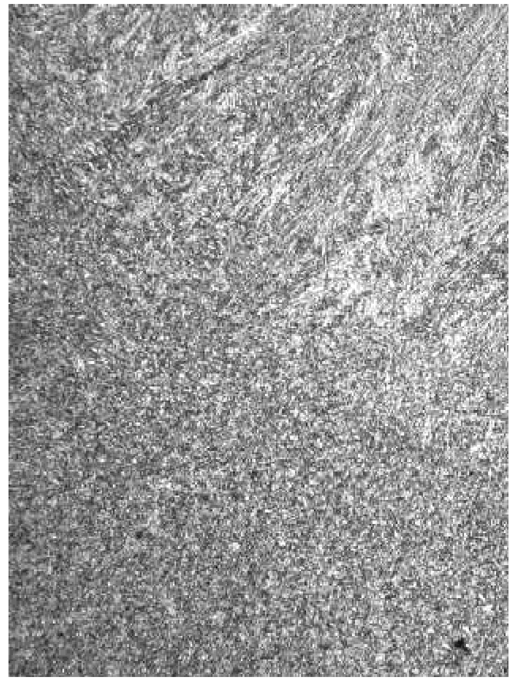
Inner Ring Rear Wall 100X

Inner Ring Rear Wall 500X

FIGURE C-10. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST CASE OUTER RING REAR WALL



Strut Sidewall 500X



Strut (lower left) Weld 100X

FIGURE C-11. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST STRUT

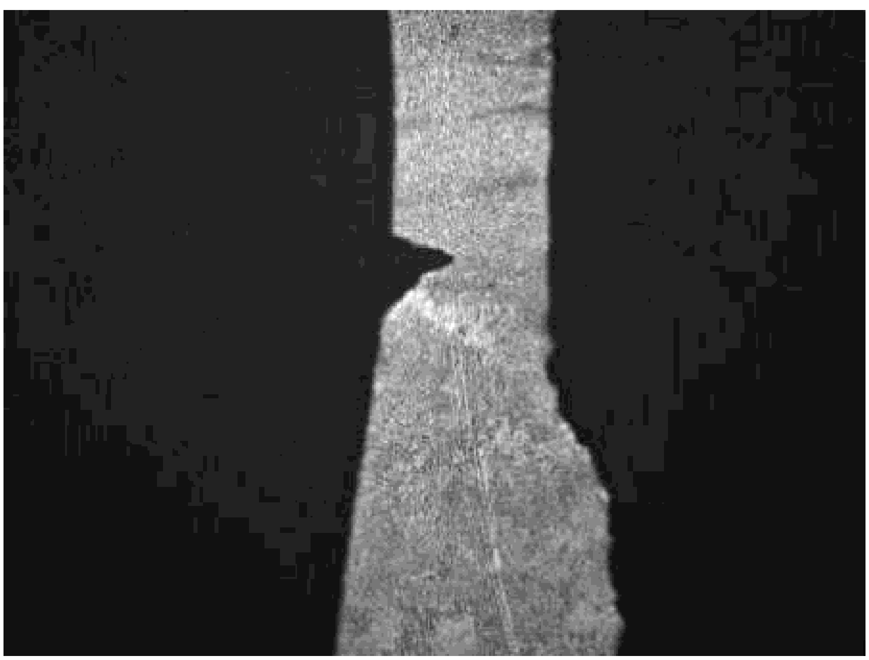
Case (upper right) Weld 100X

Typical Weld 500X

FIGURE C-12. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST CASE WELD

Strut (lower)/Case Weld 50X

FIGURE C-13. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST CASE LOWER STRUT/CASE WELD



Strut (Upper)/Case Weld 25X

FIGURE C-14. GENERAL MICROSTRUCTURE OF JT9D TURBINE EXHAUST CASE UPPER STRUT/CASE WELD