DOCKET NO. SA-515

EXHIBIT NO. 8D

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, DC

PRATT & WHITNEY RESEARCH REPORT
704297-2440

April 5, 1982

(9 PAGES)

By: Unsigned

PRATT & WHITNEY AIRCRAFT CONTROLLED

R-97106
R-03693

PRATT & WHITNEY AIRCRAFT GROUP
Commercial Products Division

MATERIALS ENGINEERING
&
RESEARCH LABORATORY

ACCOUNT NO.	704297-2440
LAB. NO.	82-200-0061-Z
DATE REQUESTED	2/22/82
DATE RELEASED	APR - 5 1982

REQUESTED BY	DEPARTMENT
P.E. Rowe	Engineering

SEND REPORTS TO

P.S. Hopper, H.L. Lemasters, R.J. Milkay, J.B. Moore, A.W. Oberg, P.E. Rowe, H.C. Schatta R.J. Bergenholtz, J.J. Carino, W.E. Cockerille, R.F. Conway, T.G. Figlioli, R.H. Haines,

PART NAME	MATERIAL	
Hub - Front Compressor Front	PWA 1215 (6Al-4V) Titanium-base Alloy	
PART NUMBER	**HEAT CODE**	**SERIAL NO.**
749701C	WENS-2028	5A5786
ENGINE TYPE / **NO.**	**MFG.**	
JT8D-7B / P-654892	Forging: Wyman-Gordon Machining: PWA - North Haven	
PART TIME	**OPERATED BY**	
12,634 Hours/9,360 Cycles	Pan Am (PA)	

WORK REQUESTED:

Determine cause of fracture.

Details of Examination:

See attached sheet.

Conclusions:

Radial fracture through front compressor front hub was due to low cycle fatigue (LCF) which progressed from origins at a circumferential groove at rear end of one tie rod hole. Groove was up to 0.125" wide and 0.025" deep and had a very rough, smeared appearance typical of abusive machining. Scanning electron microscope (SEM) examination revealed 7300 (±10%) fatigue striations. Work affected material, up to 0.025" deep and as hard as HRC 55, was present along surface of groove and adjacent machined surface of tie rod hole. Presence of worked material below finish machined and honed hole surface adjacent to groove indicates that damage occurred prior to final machining operations. Hub material away from groove conformed to hardness and composition requirements.

(1)

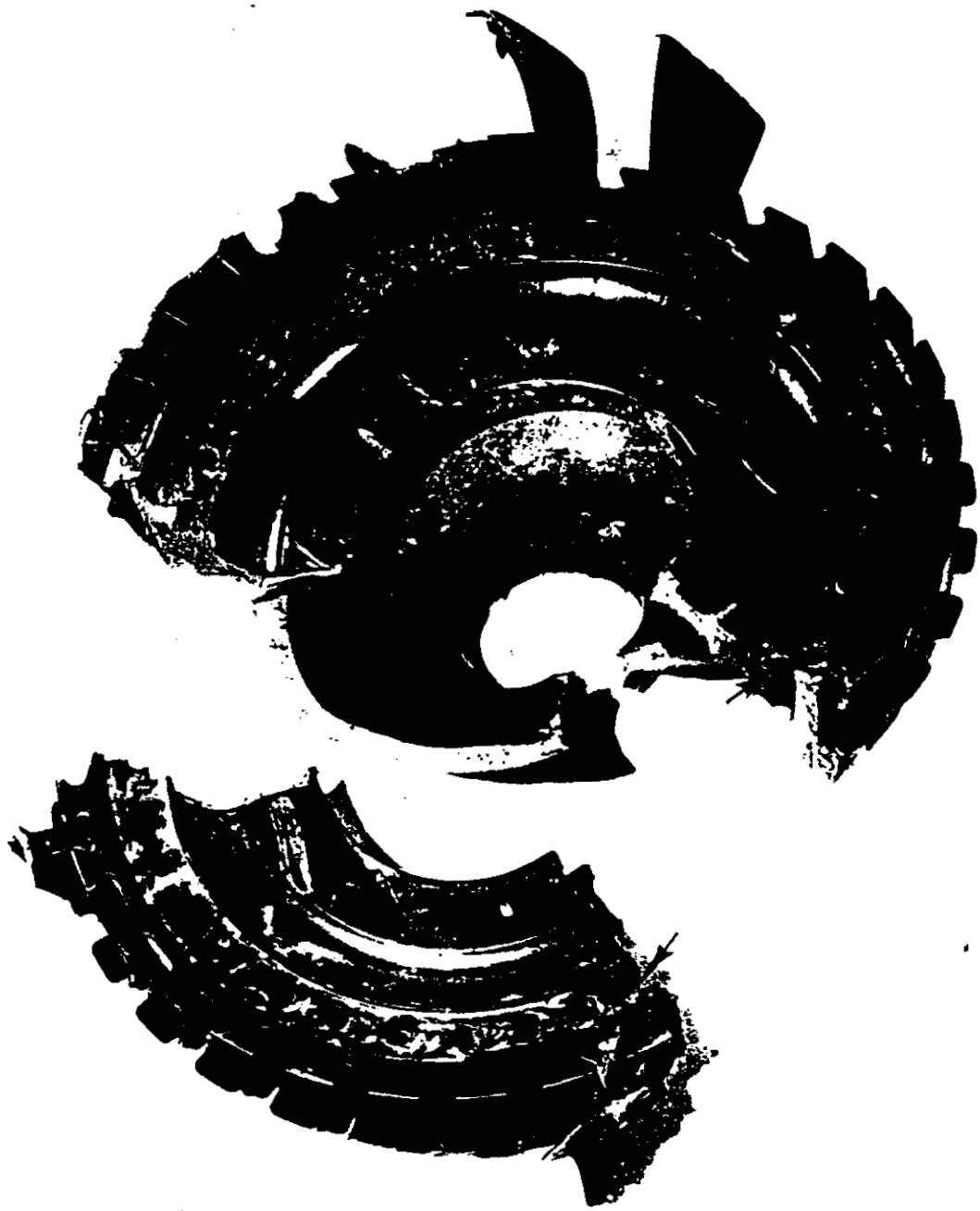
REPORTED BY

Details of Examination:

Front compressor front hub fractured radially through bore and rim in two locations releasing two sections comprising approximately 120^{0} and 240^{0} of circumference, respectively (Figure 1). Binocular examination of one radial fracture revealed fatigue which progressed from a circumferential groove at rear end of one tie rod hole (Figure 2). Fatigue extended approximately 1.25" inboard toward bore and 0.035" outboard toward rim (Figure 3). Remainder of fractures were typical of rapid tensile breaks. Material in groove at origin exhibited a very rough, smeared appearance with numerous axial cracks (Figures 4 and 5). Optical comparator dimensional inspection of replicas of groove measured a maximum groove width of 0.125" and depths of 0.010-0.025" below tie rod hole surface. Some narrow areas between groove and rear edge break of the tie rod hole were apparently machined flush with tie rod hole surface. Surface of the hole outside of the groove exhibited pattern typical of honing operation as required by the process sheet. Scanning electron microscope (SEM) examination of fracture surface revealed striations typical of low cycle fatigue (LCF). Striation count analysis revealed 7300 ($\pm$10%) striations of fatigue progression. X-ray emission spectroscopic (XES) examination of groove and surface of tie rod hole revealed small amounts of iron, possibly from contamination. There was no evidence of contamination from contact with tie rod (i.e. nickel or cadmium from plating).

Quantitative chemical analyses revealed that hub material conformed to PWA 1215 composition requirements. Hardness of hub material away from groove, HRC 34-36, conformed to specification requirement of HRC 39, maximum. Diameters of tie rod holes adjacent to fractured hole conformed to drawing requirements. An accurate measurement of fractured tie rod hole diameter was not possible due to deformation which occurred during fracture.

Metallographic examination of sections through fatigue origins revealed transgranular fracture path. Axial sections through tie rod hole surface and groove at fatigue origins exhibited work affected microstructure at surface of groove and along machined surface of hole up to 0.25" from rear face of hub (Figure 6). Work affected material extended up to 0.025" below surface of groove. Hardness of work affected material was as high as HRC 55 (HV conv.). Planar section through groove exhibited numerous axial cracks in heavily worked material (Figure 7). Microstructure away from tie rod hole surface was typical of PWA 1215 titanium-base alloy processed below the beta transus temperature and conformed to the requirements of Materials Control Laboratory (MCL) Manual Section E-72.

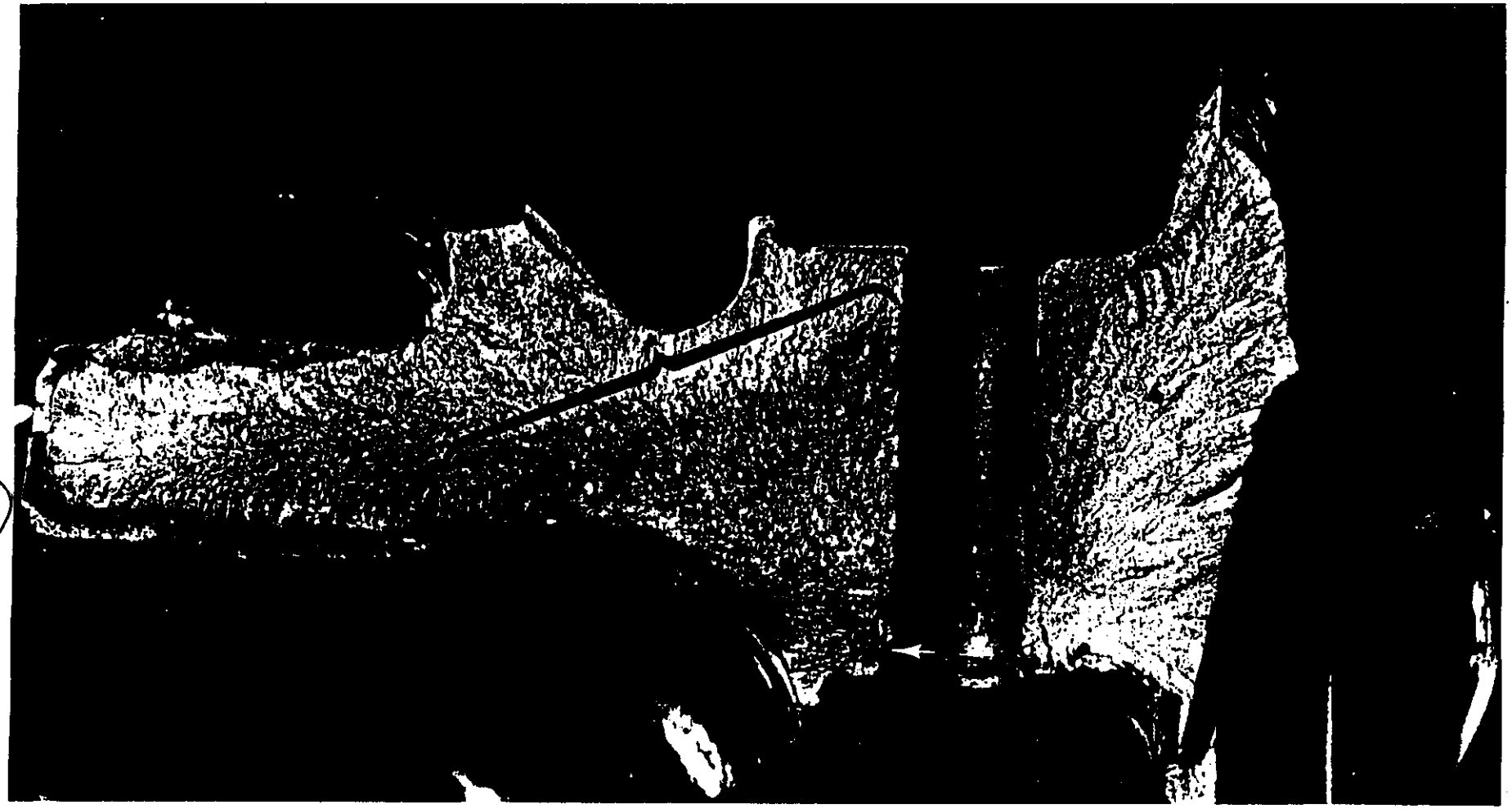


UNITED TECHNOLOGIES PRATT&WHITNEY AIRCRAFT

FIGURE 1

MAG: 0.3X

JT8D-7B FRONT COMPRESSOR FRONT HUB, 749701C, S/N 5A5786, HEAT CODE WENS-2028, AFTER TOTAL PART TIME OF 12,634 HOURS/9,360 CYCLES (TIME SINCE OVERHAUL 4909 HOURS/2782 CYCLES) SHOWING LOCATION OF RADIAL FATIGUE FRACTURE WHICH PROGRESSED FROM ONE TIE ROD HOLE (ARROWS). HUB HAD BEEN OPERATED 7725 HOURS/6578 CYCLES IN NATIONAL ENGINE P-655019, THEN FOR 4909 HOURS 2782 CYCLES IN PAN AM ENGINE P-654892 PRIOR TO FRACTURE.



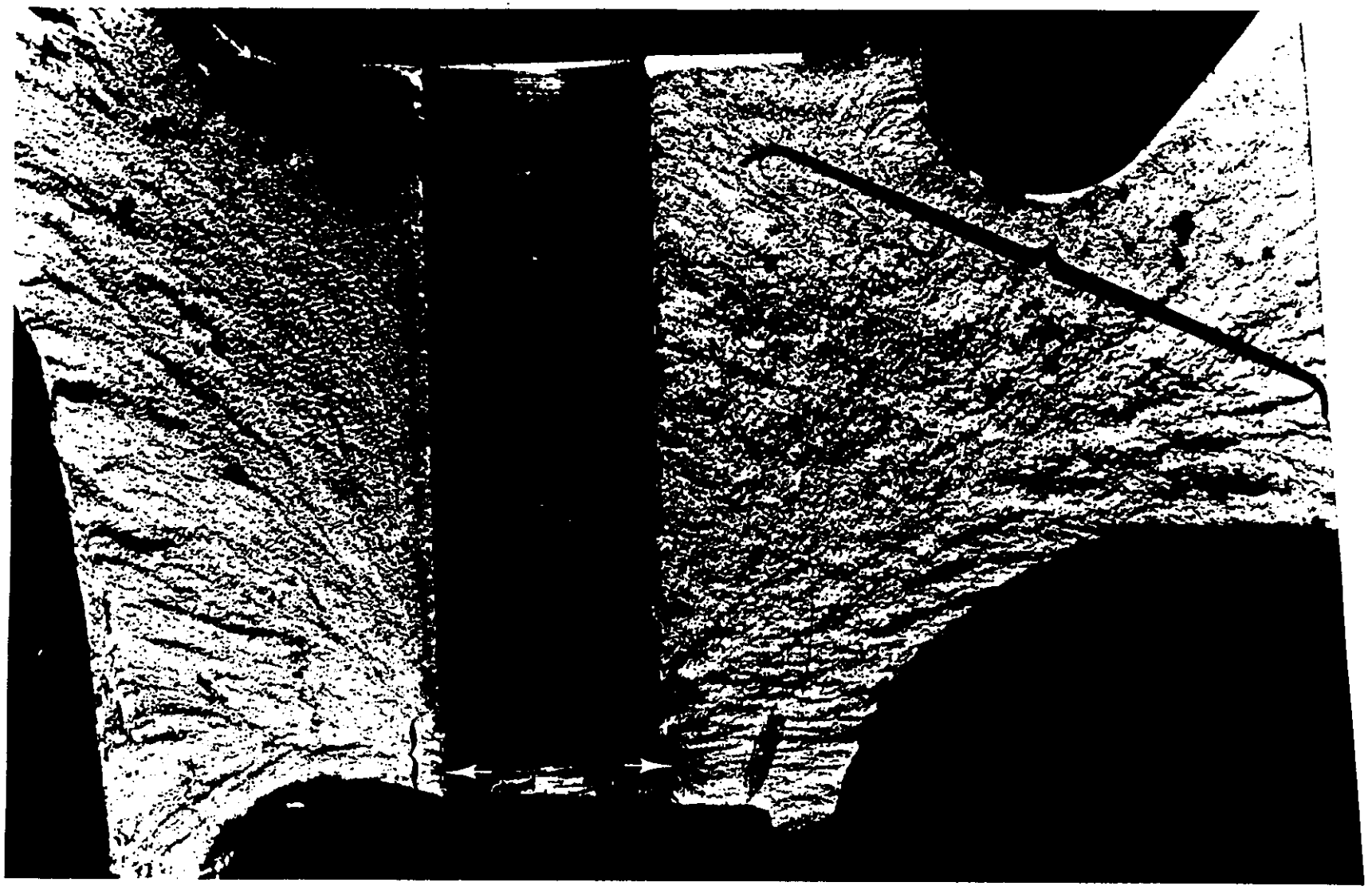
UNITED TECHNOLOGIES PRATT&WHITNEY AIRCRAFT

FIGURE 2 MAG: 1.8X

CLOSE-UP OF RADIAL FRACTURE SHOWING FATIGUE (BRACKETS) WHICH PROGRESSED FROM ORIGINS (ARROWS) AT GROOVE AT REAR END OF TIE ROD HOLE.

82-200-0061-Z

82A6005-002



UNITED TECHNOLOGIES PRATT & WHITNEY AIRCRAFT

FIGURE 3

MAG: 3.2X

CLOSE-UP OF RADIAL FRACTURE SHOWING FATIGUE (BRACKETS) WHICH PROGRESSED FROM ORIGINS (ARROWS) AT GROOVE AT REAR END OF TIE ROD HOLE.

UNITED TECHNOLOGIES PRATT & WHITNEY AIRCRAFT

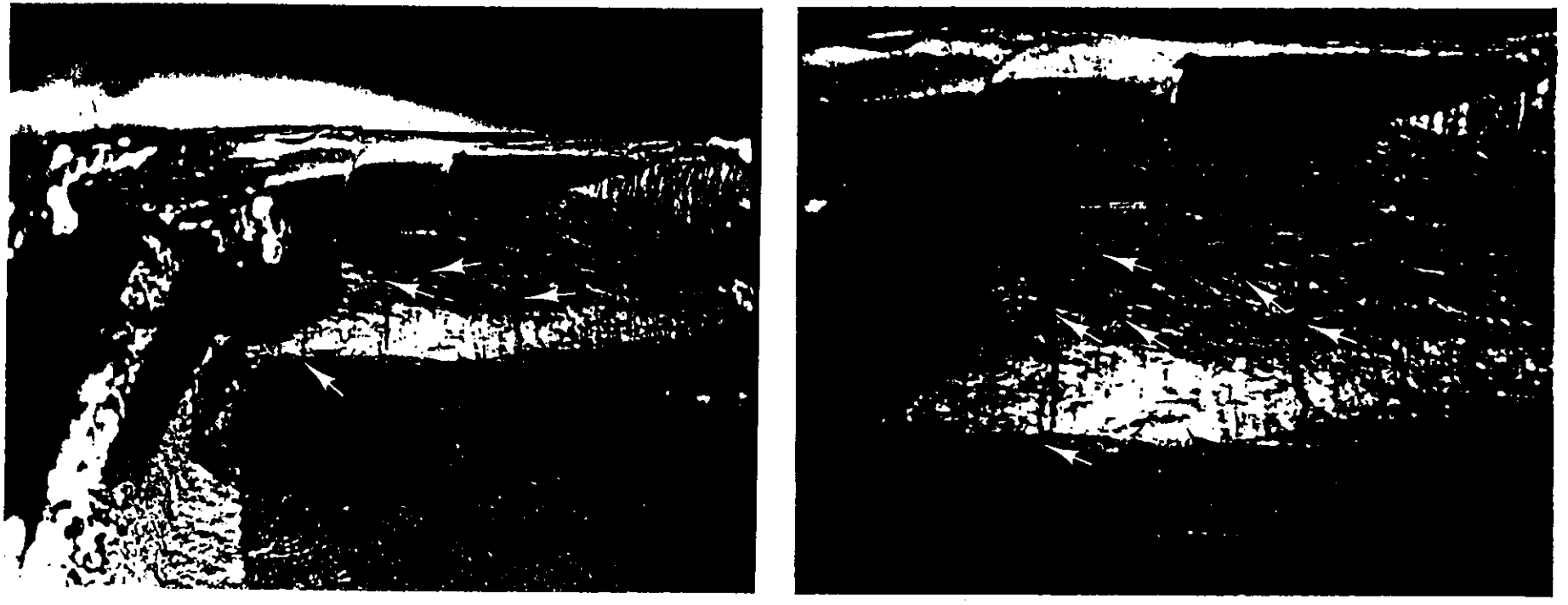
FIGURE 4

MAG: 6.2X

CLOSE-UP OF GROOVE AT REAR END OF TIE ROD HOLE SHOWING LOCATION OF FATIGUE ORIGINS (ARROWS) AND ROUGH, SMEARED APPEARANCE OF GROOVE SURFACE.

82-200-0061-Z

82A6005-004



UNITED TECHNOLOGIES PRATT&WHITNEY AIRCRAFT

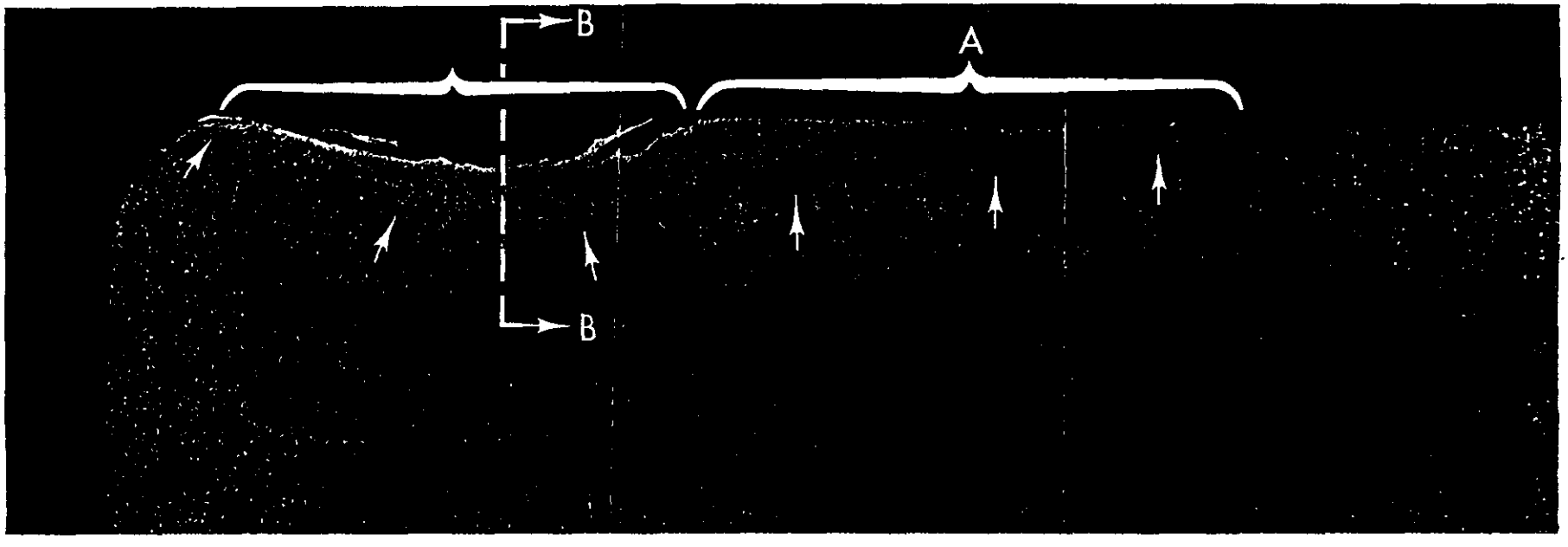
FIGURE 5

MAG: 10X-LEFT 20X-RIGHT

CLOSE-UPS OF GROOVE SHOWING NUMEROUS AXIAL CRACKS (ARROWS) IN ROUGH, SMEARED APPEARING MATERIAL.

82-200-0061-Z

82A6005-005



UNITED TECHNOLOGIES PRATT&WHITNEY AIRCRAFT

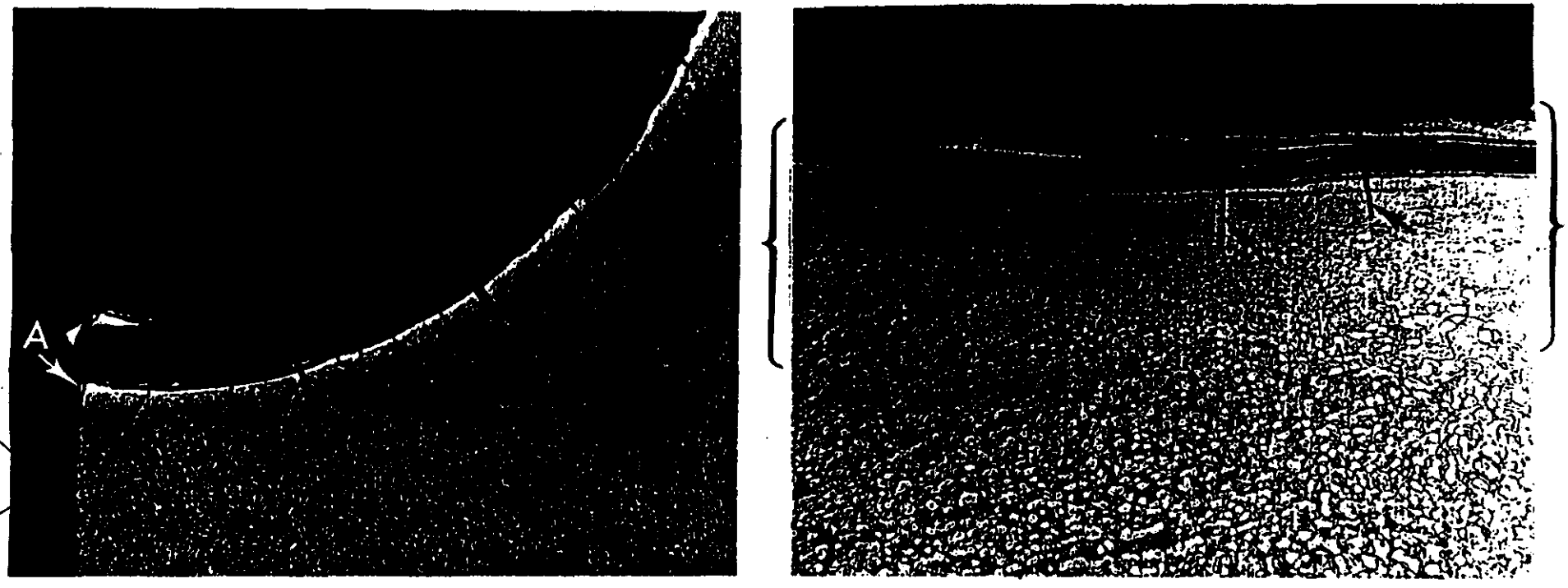
ETCHANT: KROLL'S
REAGENT + 1% HF

FIGURE 6

MAG: 25X

PHOTOMICROGRAPH OF AXIAL SECTION THROUGH TIE ROD HOLE NEAR FATIGUE ORIGINS SHOWING LAYER OF HARD, WORK AFFECTED MATERIAL (ARROWS) ALONG SURFACE OF GROOVE (BRACKET) AND ADJACENT FINISH MACHINED HOLE SURFACE (BRACKET A), SUGGESTIVE OF ABUSIVE MACHINING. PHOTOMICROGRAPHS OF SECTION B-B ARE SHOWN IN FIGURE 7.

82A6005-006



UNITED TECHNOLOGIES PRATT&WHITNEY AIRCRAFT

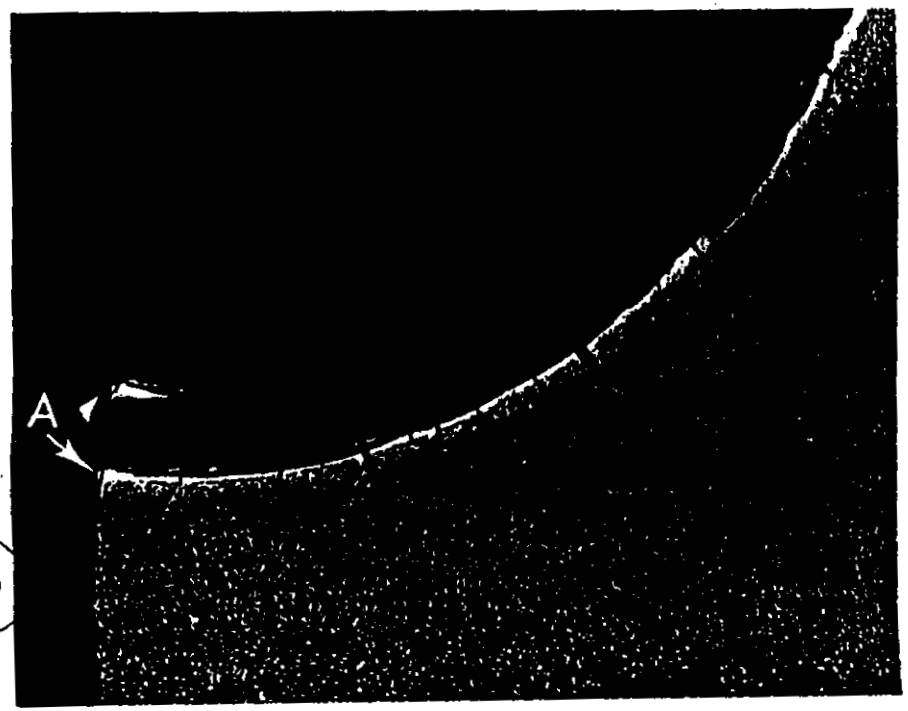
ETCHANT: KROLL'S
REAGENT + 1% HF

FIGURE 7

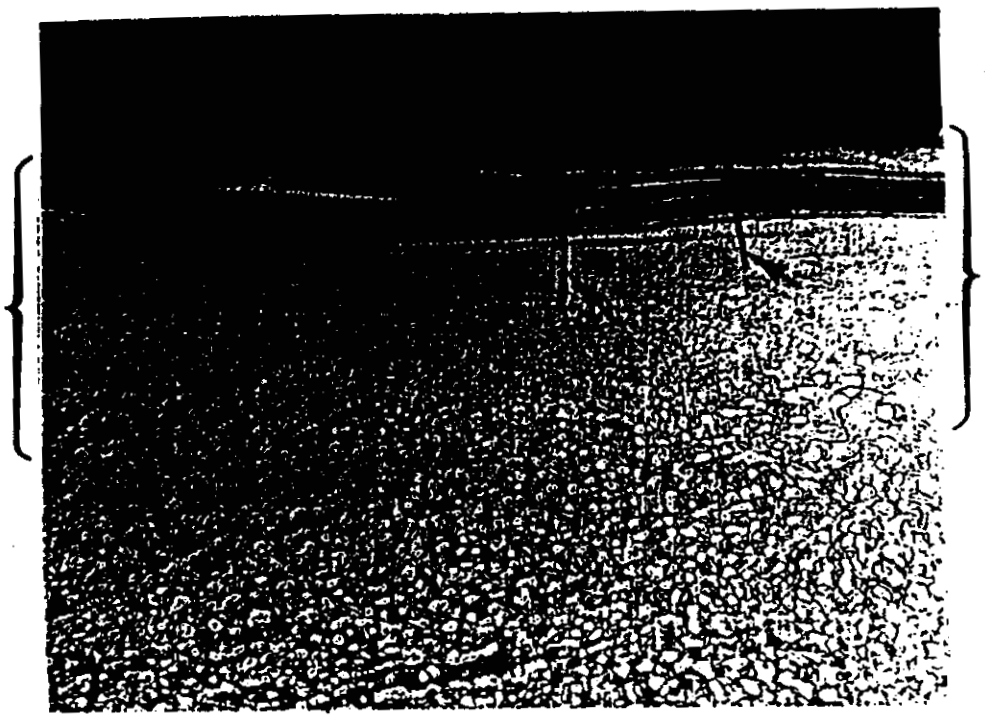
15X-LEFT
MAG: 100X-RIGHT

PHOTOMICROGRAPHS OF PLANAR SECTION (SECTION B-B SHOWN IN FIGURE 6) THROUGH GROOVE IN TIE ROD HOLE AT FATIGUE ORIGIN (ARROW A - LEFT) SHOWING DEFORMED AND WORK AFFECTED MICROSTRUCTURE (BRACKETS - RIGHT) AND MULTIPLE AXIAL CRACKS (ARROWS - LEFT AND RIGHT) SUGGESTIVE OF ABUSIVE MACHINING.

82A6005-007



(b)



UNITED TECHNOLOGIES PRATT&WHITNEY AIRCRAFT

ETCHANT: KROLL'S
REAGENT