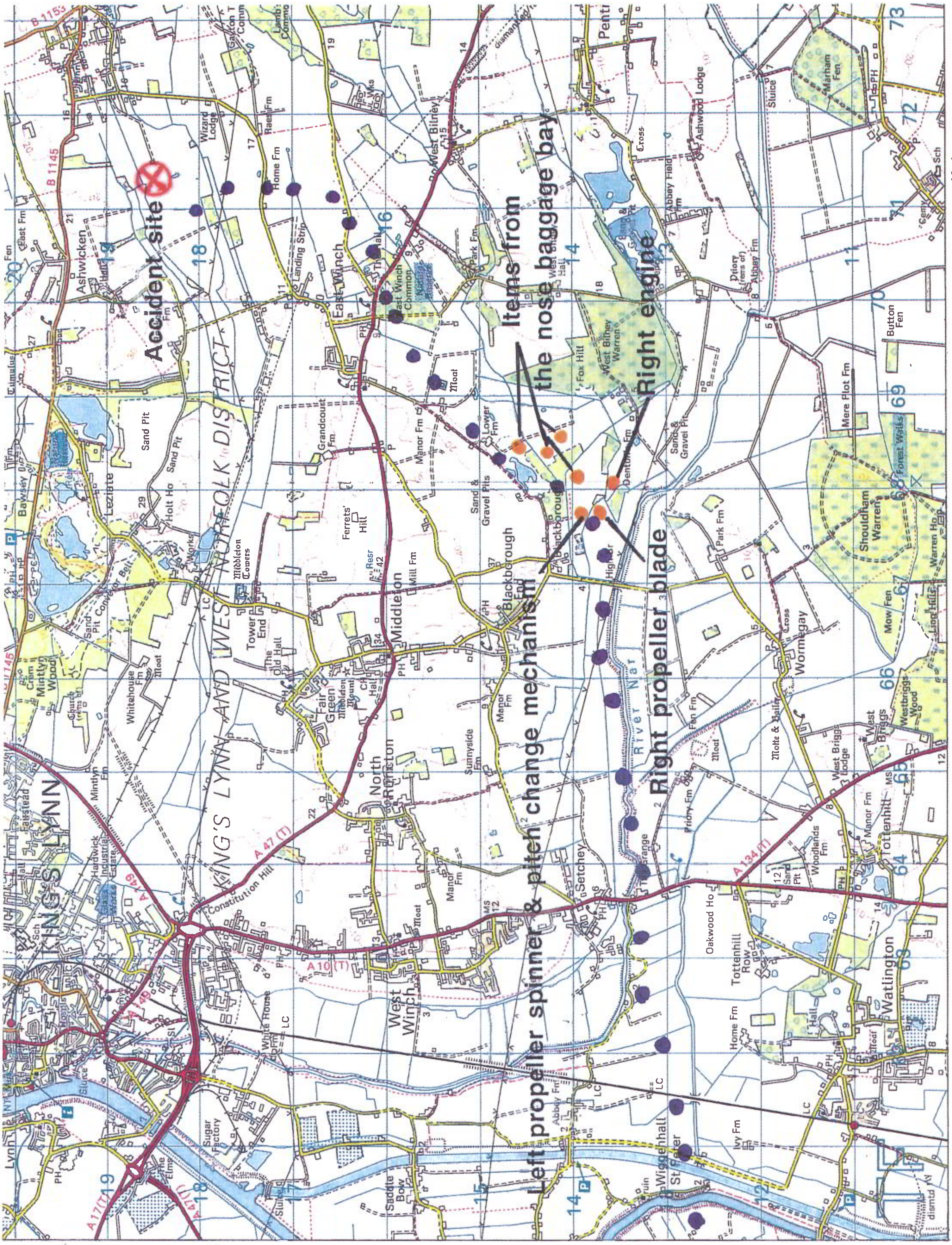
APPENDIX 1



Radar plot of the aircraft's track and the wreckage plot

A-LAB CORP.
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513/293-0333 • 1/800/462-2522 • FAX 513/294-6667

REPORT TO: Hartzell Propeller, Inc.
One Propeller Place
Piqua, Ohio 45356
Attn: Mr. Dick Edinger

DATE: November 22, 1993

LAB REPORT NO: 93-090805

P.O. NUMBER: 71251

REPORT ON: Re-evaluation of hub failure - Reference: A-Lab report #93-090805.

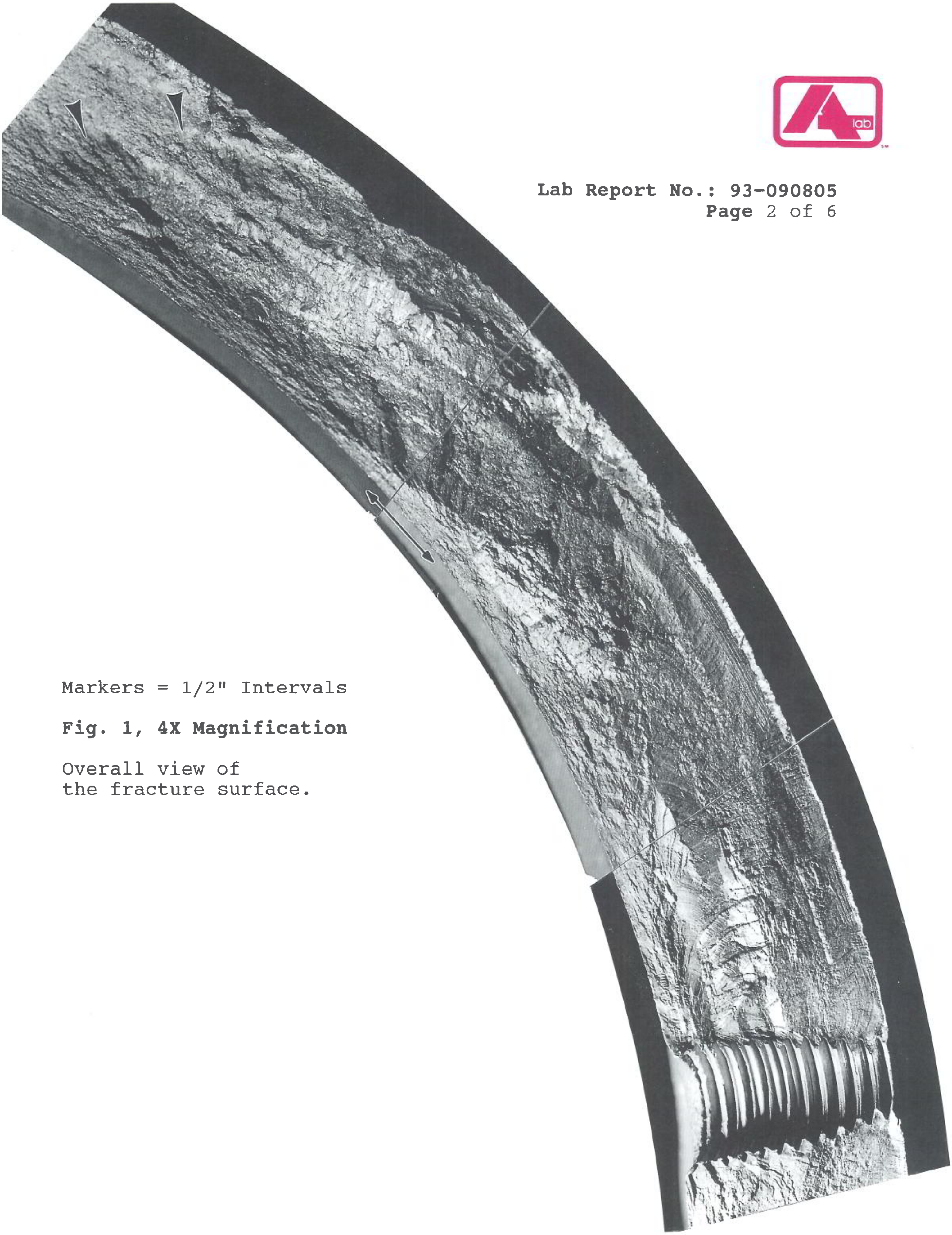
SAMPLE IDENTIFICATION: Fracture surfaces of Aluminum Hub from PA 31-325 G-BMGH.

BACKGROUND INFORMATION:

This report is intended as a follow-up to the previous report and to show stronger photographic evidence to support its findings.

DISCUSSION:

Concerning HT consultants report of this same fracture surface, I feel that the macro examination did not fully represent the nature of the failure. Significantly the progression of the crack after breaking through to the outside surface. The fatigue crack had progressed significantly farther than was stated in their report. In all fairness, the macro-examination is a highly useful tool of failure evaluations, however the true and exact nature of the failure should also be examined on a micro scale.



Markers = 1/2" Intervals

Fig. 1, 4X Magnification

Overall view of
the fracture surface.

Fig. 2, 8X Magnification
View of Section 1 of Fig. 1

The origin of the fatigue is located at the last thread in the grease nipple hole and initiated in a shot peened surface.

The fatigue striation near the fracture origin are relatively uniform, i.e. equal distance along the inside surface as through the cross section. This condition is constant till about 3/16" from the origin. The fatigue striations from this point on, elongated, or progressed, faster on the inside until they became parallel to the outside surface. Considering two fatigue striations (A & B in Fig. 2) striation A exhibits a relatively uniform progression through the thickness as along the inside surface. Striation B exhibits a 2 to 1 ratio in length along the inside surface as through the thickness.

Between striation A and B the fatigue striations are 90 degrees to the inside surface. As the crack front approaches striation B however, the angle becomes more acute. This crack progression is necessary for the crack to become parallel to the outside surface.

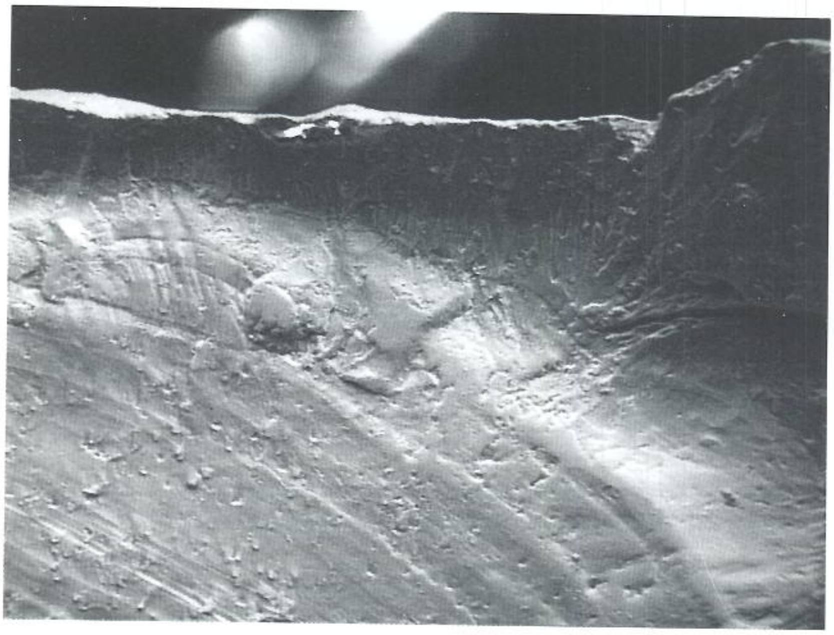


Fig. 3, 100X Magnification

View near the top right edge of the fracture shown in Fig. 2 (near threads)

Referring to Fig. 3, the crack arrested prior to breaking through to the outside surface. The applied stresses on the hub are primarily surface tensile stresses and the residual stresses of the shot peened surface.

Referring to Fig. 1 again, the last striation runs relatively parallel to the fracture surface until about the end of Area 2.

Referring to Fig. 1, the fatigue striations at the outside surface begin to descend towards the inner surface in the latter part of Section 2. The bracket in section 3 suggests the location of the last whole fatigue prior to the crack opening up at the surface. From this observation we can see that the crack on the outside surface become apparent when the crack on the inside was approximately 1 1/4" long. Furthermore the crack on the outside at this time was approximately the same length.

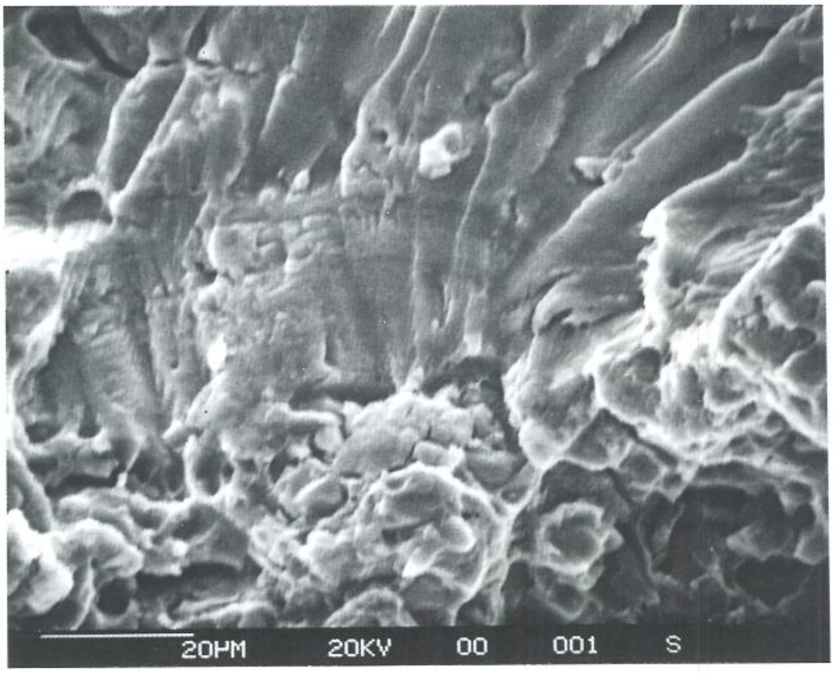


Fig. 4, 1000X Magnification

Scanning Electron Image of the fracture in section 4 and 5 of Fig. 1. Small fatigue zones such as this were observed throughout the area until about mid-way through section 5.

Referring to Fig. 1 again the arrows indicate the boundary between fatigue and instantaneous overload. The fatigue in this latter part of the crack, sections 4 and 5, is made up of numerous small fatigue fronts such as Fig. 4. These small fronts combine as one large progressing crack which is observed macroscopically as a faint semi-circular indication (arrows section 5 of Fig. 1)

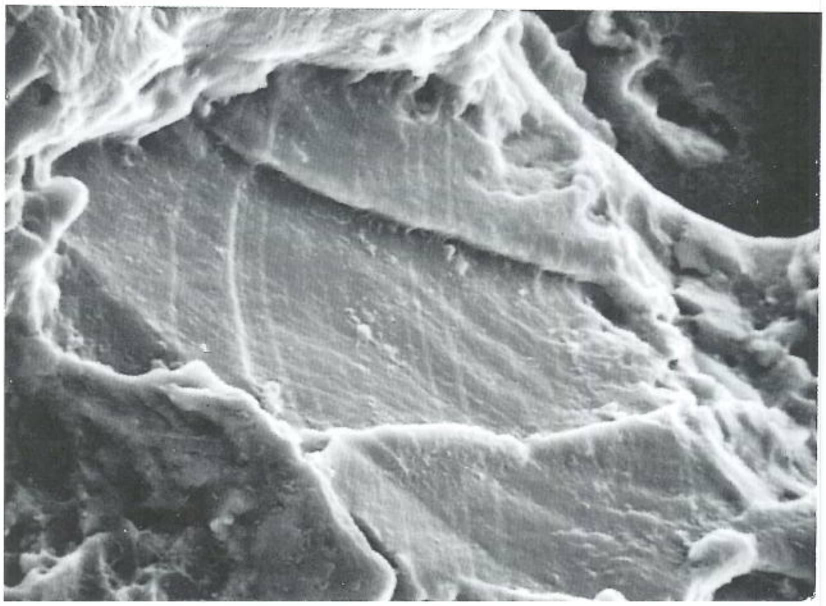


Fig. 5, 1000X Magnification

Additional photomicrograph of the fatigue observed in sections 4-5. The fineness of the striations suggest the mode of crack propagation is high cycle low stress in this area.

From these observations, the approximate length of the crack prior to instantaneous overload can be measured. Referring to Fig. 1 again, using the 1/2" markers, the length of the crack on the outside was approximately 2 1/4" long and was approximately the same length on the inside.

HT consultants conclusion that "the progressing fatigue crack would not have been visible on the external surface of the hub until about 10 flight before blade detachment", I feel is negated by the proof observed in this report. Also, in my opinion, I feel that the fracture surface does not reveal significantly enough evidence to determine the number of flights prior to instantaneous or catastrophic failure.

Respectfully submitted,

James G Fulton

James G. Fulton, Supervisor
Metallurgical Testing

JGF/cjm

APPENDIX 3

Oakfield House,
Lower Morton,
Thornbury,
Bristol,
BS12 1LD

11th January 1994

Attn: Mr R Parkinson
Department of Transport
Air Accidents Investigation Branch
T75 Blbg
DRA Farnborough
Farnborough
Hants
GU14 6TD

STRESS ANALYSIS OF PROPELLER HUB FOR FAILED PIPER ENGINE

by T.K. Hellen

Summary

During a flight on 7th June 1993, a Piper Navajo G-BMGH plane suffered the loss of one of the three propeller blades from the starboard engine. The blade loss was caused by a fracture through the hub at the root of the blade. The crack emanated by fatigue from the inner end of a grease nipple hole. A stress analysis of the hub containing this hole has been made assuming the predominant loading to be the centrifugal loading of the propeller blade. A high stress concentration is seen to exist at the crack propagation site. Another analysis is made when the grease nipple hole lies in the thicker flange region of the hub. There, a reduction in the stress concentration is observed. The results are obtained by three dimensional finite element analysis, from which stresses may be obtained at all locations in the hub. Thus, stresses away from stress raisers like the hole may be compared.

1. Introduction

The objective of the stress analysis was to investigate the predominant stress component at the grease nipple hole, in the hub subjected to the main loading. The finite element method was used, whereby models of the actual structure were made by an assemblage of elements and nodes. Using prescribed loadings and boundary conditions, computer analysis provides stresses and strains at all nodes and other reference points throughout the structure. Elastic conditions were assumed for the present analysis. The BERSAFE finite element system was used and run on a SUN workstation.

Due to the complicated nature of the hub assembly, it was only possible to model some part of the hub, so that thicker attachments such as flanges had to be ignored. A full three dimensional analysis was used with the basic finite elements being 20 node bricks (suitably distorted), which have previously been used to solve many similarly complicated three dimensional shapes with great success. The predominant loading is centrifugal loading, which is due to the propeller and which is transmitted from the blade to the hub via a blade housing section, which is in turn an end section adjacent to the hub region. In order to work out this load transfer, an initial axisymmetric analysis was conducted including the housing and the hub, to assess the stress distribution across the hub for the three dimensional model. This axisymmetric model ignored thicker flange parts, but was suitable for most of the hub, e.g. where the 45^0 grease nipple hole was. Holes were also ignored.

Two three dimensional analyses were conducted, the first with the 45^0 grease nipple hole and the second with the hole in the flange region.

2. Hub/Propeller Assembly

The axisymmetric analysis was conducted including the housing and the hub, but ignoring the thicker flange attachments which occurred in the regions where the two parts of the hub assembly were connected together. Figure 1 shows this outline. The blade centrifugal loads are applied across section AB, from which stresses across BC were evaluated and applied in the three dimensional analyses (which concentrated on the hub, BCDE). The end section DE was assumed to be fully fixed, since beyond DE was a considerably thicker part of the assembly.

Both three dimensional analyses modelled the hub and the thicker flange attachments in the regions where the two parts of the hub assembly were connected together. Only one half of the complete ring was modelled, assuming mirror-image symmetry. The first model included the grease nipple hole at 45^0, and the second with the grease nipple hole in the flange on the axis of symmetry. Both placings of the holes are shown in the structure as analysed in figure 2. Although the actual flange holes are a few degrees above the symmetry plane, their analysis would have required a complete ring mesh which would have been unnecessarily expensive on model generation and computer time, and the key results would have been little different.

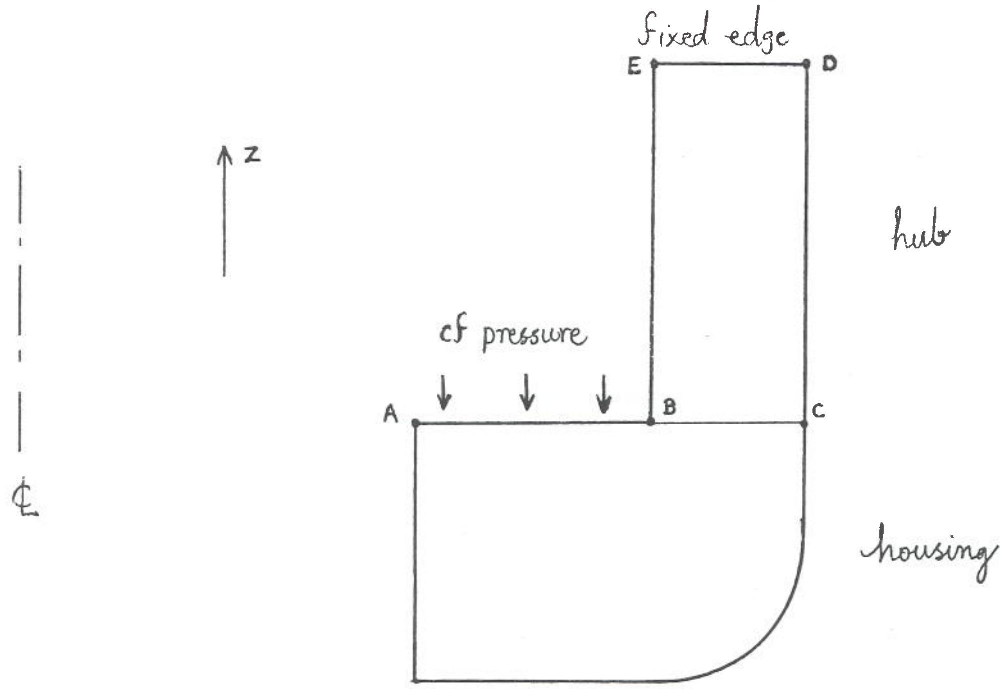


Figure 1 *Hub/housing Section for Axisymmetric Analysis*

For both three dimensional meshes, as in the axisymmetric analysis, the front face equivalent to ED of figure 1 was fully fixed, and the loads over BC were assumed around the back face as calculated by the axisymmetric analysis.

The material properties assumed for the 2014-T6 aluminium were:

For Young's modulus, 70000 MPa
For Poisson's ratio, 0.3

3. Load Calculation

The centrifugal load due to the blade was calculated as:

$$cf = \int \rho r \omega^2 / g dV$$

A concise evaluation of this integral is not possible without detailed drawings of the blade, but a good representation can be deduced by considering the blade to be two lumped masses, one representing the heavier inner part and the other the lighter outer part.

Given that $g = 9810mm/sec^2$, the blade weight $= 7.3kgs$, and a rotational velocity of $2600RPM(43.3333RPS)$, this gives the cf load as:

$$cf = 376780.49units$$

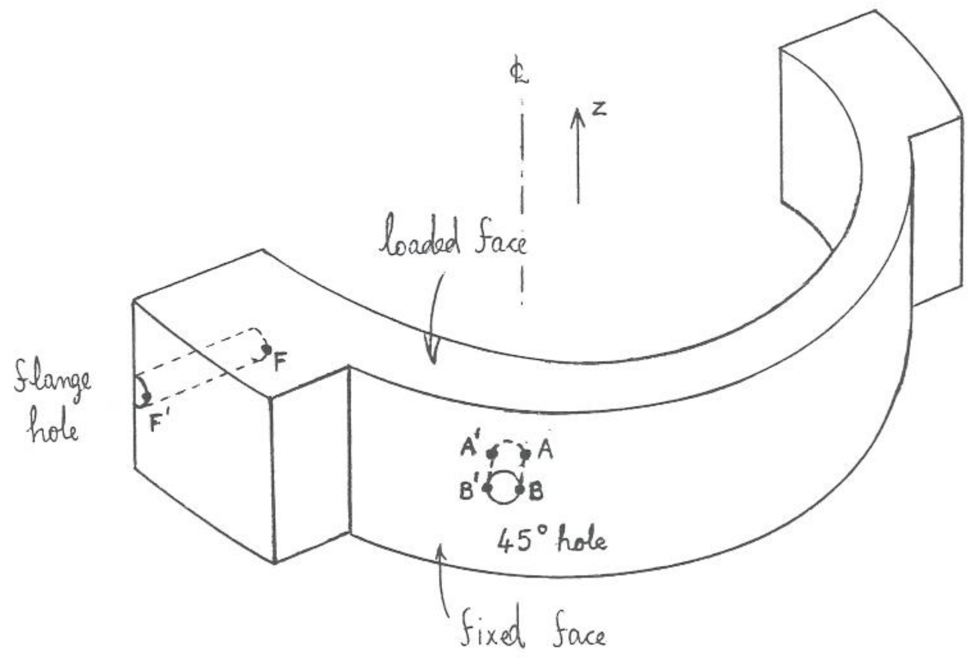


Figure 2 Three dimensional Hub Structure Used

This force is applied across the blade housing section (AB of figure 1) which has a total area of $5933.086mm^2$. The cf pressure is therefore the cf load divided by this area, i.e.:

$$cfpressure = 63.505MPa(N/mm^2)$$

This was applied as a constant pressure to the axisymmetric model of figure 1. The z components of stress across section BC were evaluated. Since in the three dimensional model, 3 elements were to span the thickness BC, the z-stresses were lumped at the centres of each of these elements with the three values of 263 MPa (nearest B), 62 MPa (middle) and -104 MPa (nearest C). This applied to all elements around the hub with a loaded face. The outer, negative, stresses were due to the high degree of bending which the centrifugal forces exert into the hub. This also accounts for the inner grease nipple holes having much higher stresses that at the outer surface.

The three dimensional results, described below, are given in terms of the z-stresses since these are the dominating components of interest at the hole. Extra load, e.g. overloads, would simply increase these stresses. Extra loads in other directions, such as lift-off bending, would affect other components of stress which would not have a direct bearing on the stress concentration at the hole.

4. Finite Element Results

4.1 Finite element models and approximations implied

The finite element method is, as with any other technique of stress analysis, subject to errors. In the present analyses, based on much previous experience, it is unlikely that the errors in the calculated stresses are more than a few percent. The stress concentration factors given should also contain a similar error. The version of BERSAFE used (Version 6) has been subject to rigorous software quality assurance as in the British Standard BS 5750.

The three finite element meshes required were all designed with sufficient numbers of elements to give results of acceptable accuracy. This is a subjective process since the method does not give errors for given mesh refinements. However, the meshes used were devised based on experience gained from previous similar analyses.

The axisymmetric mesh used to model the hub/housing section comprised 58 axisymmetric quadratic displacement elements, each suitably distorted to fit the assembly shape, with 199 nodes and 398 degrees of freedom.

The three dimensional mesh for the 45^0 hole in the hub comprised 248 solid quadratic displacements elements, as 20 node bricks or 15 node wedges and again suitably distorted to fit the assembly shape, with 1365 nodes and 4095 degrees of freedom.

The three dimensional mesh for the flange hole in the hub comprised 160 solid elements, with 1023 nodes and 3063 degrees of freedom.

In all analyses, the assumption was made that the back face, where fixings were made to represent attachment to the rest of structure, had all degrees of freedom therein constrained to not deform.

The results from the two three dimensional analyses are given in terms of the z component of stress. Although the holes were analysed in separate analyses, they are both illustrated in figure 3 with key points highlighted.

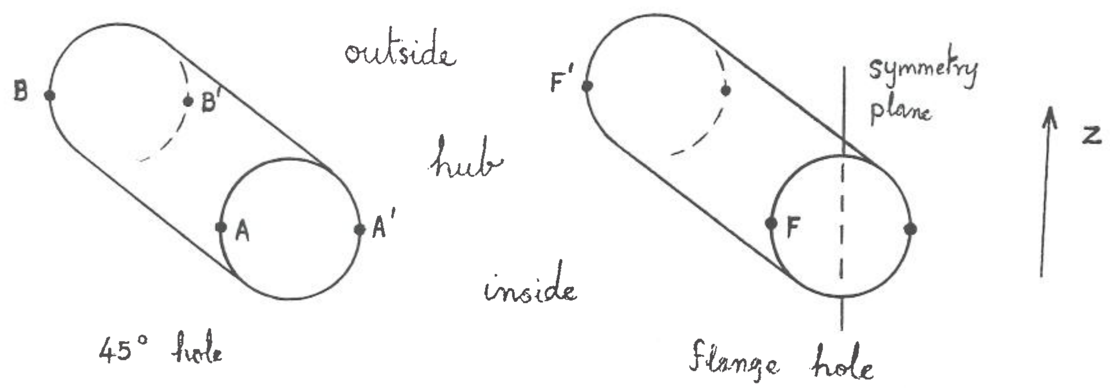


Figure 3 Details of 45^0 Hole and Flange Hole

The reason for considering the z component of stress instead of other components is because the predominant loading is in the z direction, and it is well known that a hole in a predominantly uniaxial stress field gives rise to stress concentrations along the edges AB and A^1B^1 (or FF^1), and these concentrations are in the local tangential direction.

For the 45^0 hole, the points A and A^1 lie on the inside surface of the hub. Points B and B^1 lie on the outside surface. Similarly, for the flange hole, point F lies on the inside surface and point F^1 on the outside. There is no need to consider the two points opposite F and F^1 since by symmetry they give the same results as F and F^1, respectively.

4.2 Results for the 45^0 *hole*

For the 45^0 hole, the z-stresses are:

At A: 546 MPa
At A^1: 558 MPa
At B: -171 MPa
At B^1: -176 MPa

This clearly shows the effect of the bending in that the outer layers of the hub are in compression. The differences between A and A^1, and B and B^1, are only small.

If no hole were present, the results at equivalent locations are:

At A: 252 MPa
At B: -80 MPa

These results were derived from nodes at positions at the -45^0 position of the hub in the same finite element run, which, being 90^0 round from the hole, are in regions where the stress raisers due to the hole no longer have any effect. They can thus be considered as typical hub stresses in the absence of the hole.

4.3 Results for the flange hole

For the flange hole, the z-stresses are:

At F: 432 MPa
At F^1: -109 MPa

If no hole were present, the results at the -45^0 locations are:

At A: 238 MPa
At B: -67 MPa

These results were derived from nodes at positions at the -45^0 position as used in the previous case. Again, these are in regions where the stress raisers due to the hole no longer have any effect, and can be considered as typical hub stresses in the absence of the hole.

At the opposite flange, where there is no hole, the corresponding results are:

At F: 183 MPa
At F^1: -49 MPa

4.4 Discussion of these results

The results show clearly that the highest z-stress occurs at point A on the inside surface of the 45^0 degree hole. This stress equals 558 MPa. This can be expressed as a stress concentration factor (SCF) if it is divided by the corresponding z-stress if no hole were present, i.e. the hub stress value of 252 MPa.

Thus, the 45^0 hole SCF is 2.21.

The highest stress in the flange hole, point F, equals 432 MPa, which is 77% of the 45^0 degree hole highest stress. This can again be expressed as a stress concentration factor (SCF) if it is divided by the z-stress at the -45^0 position (no hole) i.e. the hub stress value of 238 MPa.

Thus, the flange hole SCF is 1.82.

The loading used has been the centrifugal load of the propeller blade rotating at $2600RPM(43.3333RPS)$. This loading has been passed through the housing to the end section of the hub, and applied to the three dimensional analyses as end face bending loads. This gives negative, or compressive, z-stresses on the outer surface of the hub and at the outer sites of both hole positions. The inside locations of these holes are the highest stressed points. For the 45^0 hole, crack propagation commences at this site. The outer, compressive, stresses prevent the crack propagating straight to the outside surface. Because of the shot peening on the inside surface, compressive surface layer stresses due to plasticity exist there. This again has a tendency to locally stop crack propagation, i.e. the crack will be forced away from the inside surface. This explains why the observed crack propagation stays inside and grows through the body of the hub away from both surfaces for some time before the final failure.

The stresses due to other values of RPM are proportional to the square of the rotational speed, and so could grow quite rapidly if a severe overload occurred.

Fatigue crack growth rates are proportional to a higher power of stress, typically of order 4 or 5, so again small increases in this maximum stress can induce rapid increases in growth rate.

Other modes of loading, e.g. lift-off bending of the propeller plane, would affect other components of stress other than the z-component, and so would have only minor influence on the hole SCF and the crack growing mechanism.

5. Conclusions

The results of the finite element analysis show that for the three dimensional analysis of the hub with the 45^0 hole, the maximum z component of stress is on the inside hub surface at the hole and equals 558 MPa under centrifugal loading at 2600 RPM. Without the hole, the corresponding z-stress is 252 MPa, hence the hole gives rise to a stress concentration factor of 2.21.

For the corresponding finite element analysis for the hole situated in the flange, the highest stress calculated is again on the inside hub surface at the hole, but now equals 432 MPa, which is only 77% of the 45^0 degree hole highest stress. Without the hole, the z-stress at the -45^0 position (no hole) is 238 MPa, so the stress concentration factor is now 1.82

These stresses are proportional to the square of the rotational velocity, so increases in load could cause severe increases in stress. This effect would be even more severe to fatigue crack propagation rates, which are proprotional to higher powers of stress.

History of aircraft hours and sectors flown

Date	Hours	Total hours	Sectors	Total sectors	Maintenance
7 Jun 93	2:50		4		
6 Jun 93	0:35	3:25	1	5	
4 Jun 93	5:00	8:25	5	10	
31 May 93	1:25	9:50	2	12	
28 May 93	0:45	10:35	1	13	Check 1
10 May 93	0:15	10:50	1	14	
6 May 93	1:00	11:50	1	15	
5 May 93	1:35	13:25	1	16	
29 Apr 93	0:40	14:05	2	18	
24 Apr 93	0:40	14:45	1	19	
23 Apr 93	2:10	16:55	2	21	
20 Apr 93	1:05	18:00	2	23	
13 Apr 93	3:35	21:35	2	25	
8 Apr 93	1:00	22:35	1	26	
7 Apr 93	0:50	23:25	1	27	
30 Mar 93	2:10	25:35	2	29	
25 Mar 93	2:05	27:40	2	31	Check 1
21 Mar 93	1:50	29:30	2	33	
19 Mar 93	1:25	30:55	1	34	
18 Mar 93	0:35	31:30	1	35	
17 Mar 93	2:35	34:05	2	37	
16 Mar 93	1:20	35:25	1	38	
23 Feb 93	0:55	36:20	1	39	
22 Feb 93	1:25	37:45	2	41	
30 Jan 93	1:00	38:45	2	43	
29 Jan 93	0:35	39:20	2	45	
25 Jan 93	1:05	40:25	2	47	
17 Jan 93	2:00	42:25	1	48	
15 Jan 93	2:00	44:25	1	49	
7 Jan 93	0:30	44:55	1	50	
5 Jan 93	0:35	45:30	1	51	
31 Dec 92	2:00	47:30	2	53	
30 Dec 92	2:10	49:40	2	55	
29 Dec 92	0:50	50:30	1	56	
23Dec 92	2:55	53:25	2	58	
22Dec 92	2:05	55:30	2	60	
20 Dec 92	0:10	55:40	1	61	
16 Dec 92	1:40	57:20	2	63	
15 Dec 92	0:10	57:30	1	64	
13 Dec 92	1:40	59:10	2	66	
11 Dec 92	0:20	59:30	1	67	
10 Dec 92	1:15	60:45	1	68	
8 Dec 92	1:30	62:15	1	69	Check 3
9 Sep 92	0:50	63:05	1	70	C of A
4 Sep 92	1:40	64:45	1	71	
23 Aug 92	2:20	67:05	1	72	
19 Aug 92	2:20	69:25	3	75	
18 Aug 92	1:05	70:30	1	76	
14 Aug 92	0:55	71:25	1	77	
7 Aug 92	1:10	72:35	1	78	
6 Aug 92	4:15	76:50	3	81	
5 Aug92	1:50	78:40	2	83	

30 Jul 92	1:15	79:55	1	84	
19 Jul 92	1:45	81:40	2	86	
10 Jul 92	1:15	82:55	1	87	Check 1
28 Nov 91	0:30	83:25	1	88	
27 Nov 91	1:05	84:30	1	89	
22 Nov 91	1:00	85:30	1	90	
15 Nov 91	1:25	86:55	3	93	
14 Nov 91	2:15	89:10	3	96	
13 Nov 91	1:10	90:20	1	97	
11 Nov 91	1:00	91:20	1	98	
10 Nov 91	0:55	92:15	1	99	
9 Nov 91	0:50	93:05	1	100	
6 Nov 91	0:50	93:55	1	101	
4 Nov 91	0:40	94:35	1	102	
30 Oct 91	0:15	94:50	1	103	
24 Oct 91	1:00	95:50	2	105	
21 Oct 91	0:50	96:40	1	106	
14 Oct 91	1:00	97:40	1	107	
11 Oct 91	6:30	104:10	6	113	
30 Sep 91	2:05	106:15	3	116	
27 Sep 91	1:20	107:35	2	118	
22 Sep 91	1:20	108:55	2	120	
20 Sep 91	3:05	112:00	5	125	
19 Sep 91	0:50	112:50	1	126	
17 Sep 91	1:05	113:55	2	128	
15 Sep 91	1:25	115:10	2	130	
12 Sep 91	1:50	117:00	2	132	
10 Sep 91	5:05	121:05	5	137	
9 Sep 91	0:50	121:55	1	138	
7 Sep 91	2:00	123:55	2	140	
6 Sep 91	1:50	125:45	2	142	
4 Sep 91	0:55	126:40	2	144	
3 Sep 91	1:40	128:20	3	147	
2 Sep 91	3:05	131:25	4	151	
1 Sep 91	1:25	132:50	2	153	
31 Aug 91	3:15	136:05	4	157	
30 Aug 91	1:35	137:40	2	159	

At this time a Check 4 and Certificate of Airworthiness maintenance was carried out. The right-hand propeller was fitted to this aircraft after having been removed from another aircraft that was on a maintenance check.

HARTZELL PROPELLER INC.
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Piqua. Ohio 45356-2634 U.S.A.
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Telex: 4332032
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HARTZELL SERVICE BULLETIN

SERVICE BULLETIN 165 FAA Approved October 3, 1989
CODE: C

SUBJECT:

Inspection for Cracks in Certain Three Blade "Y" Shank Aluminum Hubs

EFFECTIVITY:

HC-( )3Y( )-( ) propellers with the model designations and serial number range listed below **AND**:
installed on aircraft with Lycoming (L)TIO-540 series engines or;
installed on agricultural aircraft regardless of engine type.

Propeller Serial Number Range:

Basic Hub Model	Propeller Serial Number Range
EHC-G3YF-2( )	FJ1 through FJ101
PHC-C3YF-1R( )	EE1 through EE1461
PHC-J3YF-1R( )	FP1 through FP37
PHC-L3YF-1R( )	FD1 through FD7
PHC-C3YF-2( )	EB1 through EB1980
PHC-J3YF-2( )	ED1 through ED3289
HC-C3YF-1R( )	EC1 through EC1020
HC-C3YF-5R( )	FR1 through FR73
HC-C3YN-2( )	DG1 through DG624
HC-C3YF-2( )	EY1 through EY3
HC-H3YF-3( )	ET1 through ET4
HC-H3YN-2( )	DV1 through DV153
HC-C3YK-1R( ) or HC-C3YR-1R( )	DY1 through DY1897
HC-C3YK-2( ) or HC-C3YR-2( )	CK1 through CK3510
HC-C3YK-4( ) or HC-C3YR-4( )	EL1 through EL67
HC-E3YK-1( ) or HC-E3YR-1( )	FM1 through FM487
HC-E3YK-2( ) or HC-E3YR-2( )	DF1 through DF79
HC-E3YK-2A( ) or HC-E3YR-2A( )	DJ1 through DJ7787
HC-F3YK-2( ) or HC-F3YR-2( )	DA1 through DA1586
HC-F3YK-1( ) or HC-F3YR-1( )	DB1 through DB137
HC-I3YK-2( ) or HC-I3YR-2( )	FS1 through FS24

Aircraft Models: The above propellers are installed on, but not limited to:

<u>agricultural aircraft</u>
Fletcher FU24-950
Cessna A188 Agwagon modified by STC SA895SO
Piper PA-36-300 Pawnee
PA-36 Pawnee modified by STC SA3952WE
Transavia Airtruk

(continued)

Aircraft Models (continued):

<u>aircraft with (L)TIO-540 series engines</u>

Cessna 310, 320 modified by Riley STC SA2082WE
Gulfstream 700 (formerly Rockwell 700, Fuji FA-300-12)
Helio H-700
Piper PA-23-250, PA-E23-250 (with TIO-540 only)
Piper PA-31 Navajo (with TIO-540 only)
Piper PA-31-325 Navajo C/R
Piper PA-31-350 Navajo "Chieftain"
Piper PA-31P-350 Mohave
Piper T-1020 (same as PA-31-350)
Piper PA-32(R)-301T Turbo Saratoga
Piper PA-60-600, 601, 602 Aerostar modified by Machen STC
Piper PA-60-700P Aerostar 700P

NOTE: This Bulletin is applicable ONLY to propellers that are listed in hub model/serial number list AND are also installed on either: any aircraft using (L)TIO-540 series engine or any agricultural aircraft (regardless of engine). Other aircraft installations, even though they use listed propeller models/serial numbers, are not affected.

DISCUSSION:

There have been incidents of hub cracks in Hartzell three blade "compact" aluminum hub propellers. Cracks typically originate in the threads of a grease fitting hole on the side of the hub. The cracks are external and believed to be observable with careful visual examination. As the cracks propagate around the blade arm of the hub, their progression accelerates and results in failure of one hub half which can then, potentially, progress to blade separation.

COMPLIANCE:

Inspection is required within the next 25 hours of operation from the effective date of this Bulletin, and thereafter at intervals not to exceed 50 hours of operation from the last inspection.

NOTE: During 1983, a hub design change relocated the grease fitting holes near the hub parting line (see Figure 1). The earlier design hubs are listed as affected serial numbers. However, there may be a few hubs listed that are of the later type. Any hub found to be of the current configuration, does <u>not</u> require compliance with this Bulletin.

PROCEDURE:

The following procedure may be accomplished by either a certificated aircraft mechanic or propeller repair station.

1. Remove spinner dome.

2. If present, remove any paint*, grease or other matter which may hinder visual examination.

3. Use 10X magnifying glass to perform careful visual inspection of the hub for hairline cracks in the general vicinity of blade retention bearings, but primarily, inspect the grease fitting areas as shown in Figure 1.

NOTE: Each hub has six (6) grease fittings.

4. If no cracks are found, re-install spinner dome and make logbook entry indicating compliance.

5. If there are any indications of a crack, hub replacement (by an approved propeller repair station) must be accomplished prior to further flight.

* If paint removal is required, chemical stripper must be used carefully to prevent it from accumulating in the cavity between the hub and blade. Paint removal from the entire hub is not required, an area within approximately two inches of each grease fitting is adequate. Before returning to service, the exposed area of the aluminum hub must have either an anodized surface or be protected with approved chemical film treatment such as Alodine. Also, the area which has had paint removed should remain unpainted to allow future inspection (approved deviation from Hartzell Service Instruction 144F).

PUBLICATIONS AFFECTED:

This bulletin is now considered part of Hartzell Manuals 113B and 117D.

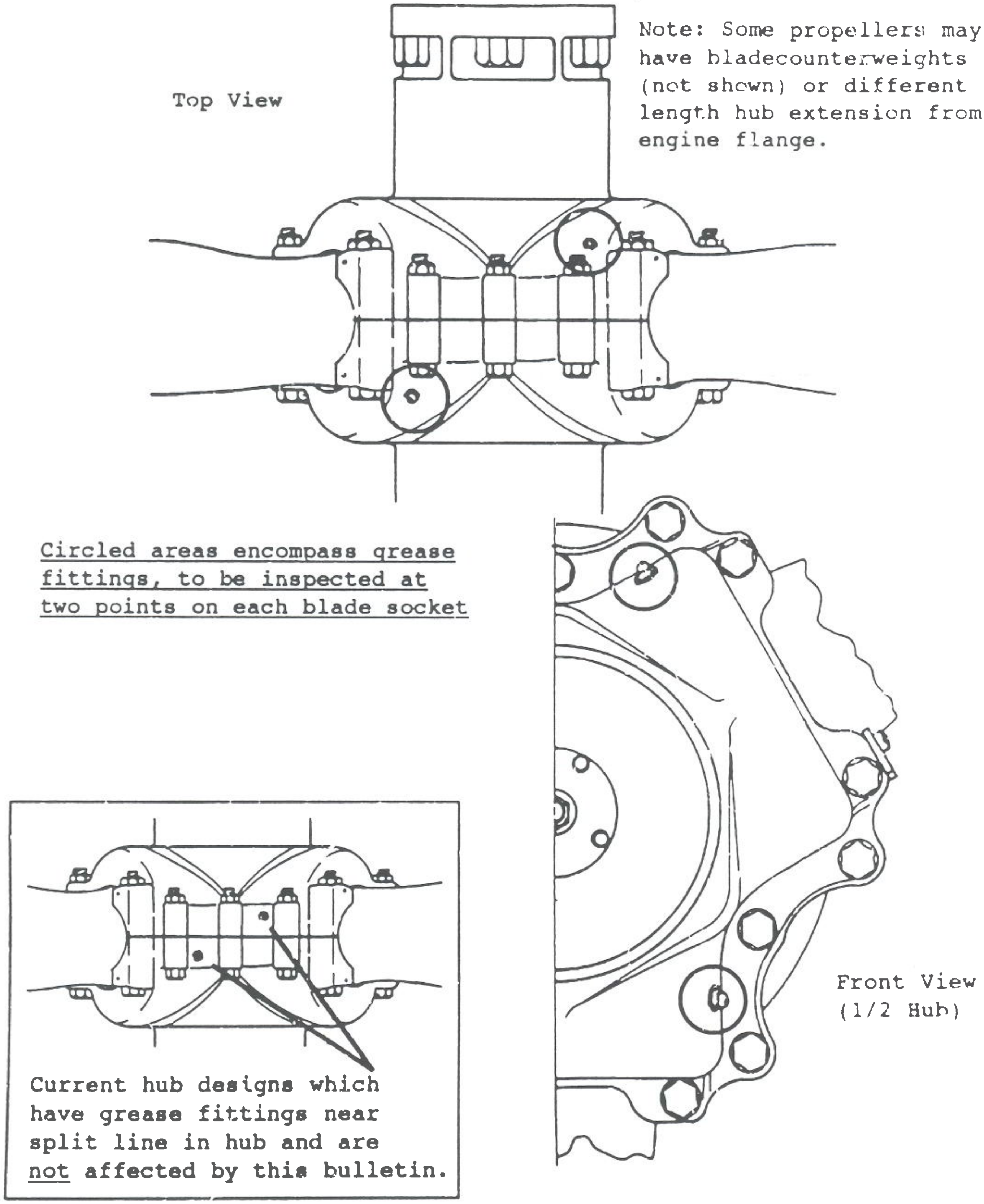

Figure 1. Hub Grease Fittings

EMERGENCY AIRWORTHINESS DIRECTIVE

U.S. Department
of Transportation
Federal Aviation
Administration

AVIATION STANDARDS NATIONAL FIELD OFFICE
P.O. BOX 26460
OKLAHOMA CITY, OKLAHOMA 73125

October 20, 1989

This Priority Letter is being distributed to all owners and operators of Hartzell Model ( )HC-( )3Y( )-( ) series propellers, installed on aircraft with Lycoming (L)TIO-540 series engines or on agricultural aircraft regardless of engine type, including, but not limited to:

Fletcher FU24-950
Cessna A188 Agwagon (modified by STC SA895SO)
Piper: PA-36-300 Pawnee; PA-36 Pawnee (modified by STC SA3952WE)
Transavia Airtruk
Cessna 310, 320 (Modified by Riley STC SA2082WE)
Gulfstream 700 (Formerly Rockwell 700, Fuji FA-300-12)
Helio H-700
Piper: PA-23-250; PA-E23-250 (with TIO-540 only); PA-31 NAVAJO (with TIO-540 only); PA-31-325 NAVAJO C/R; PA-31-350 NAVAJO "Chieftain"; PA-31P-350 Mohave; T-1020 (same as PA-31-350); PA-32(R)-301T Turbo Saratoga; PA-60-600, -601, 602 Aerostar (modified by Machen STC); and PA-60-700P Aerostar 700P.

Pursuant to the authority of the Federal Aviation Act of 1958, delegated to me by the Administrator, the following Priority Letter AD 89-22-05 applicable to Hartzell Model ( )HC-( )3Y( )-( ) series propellers, installed on aircraft with Lycoming (L)TIO-540 series engines or agricultural aircraft regardless of engine type is issued October 20, 1989 and is effective immediately upon receipt.

This priority letter AD is necessary because of possible propeller hub failure, and requires initial and repetitive visual inspections of the propeller hub for cracks on Hartzell Model ( )HC-( )3Y( )-( ) series propellers. There have been 12 occurrences in which the hub forward face was found to be cracked. In one instance blade separation occurred resulting in loss of the aircraft. Typically these cracks originated in the threads of the hub grease fitting holes and can be seen by visual examination.

89-22-05 HARTZELL PROPELLER, INC.: Priority Letter AD issued October 20, 1989 is effective immediately upon receipt.

Applicability: Propeller models are as follows:

PROPELLER MODELS	PROPELLER SERIAL NUMBER RANGE
EHC-G3YF-2( )	FJ1 through FJ101
PHC-C3YF-1R( )	EE1 through EE1461
PHC-J3YF-1R( )	FP1 through FP37
PHC-L3YF-1R( )	FD1 through FD7
PHC-C3YF-2( )	EB1 through EB1980
PHC-J3YF-2( )	ED1 through ED3289
HC-C3YF-1R( )	EC1 through EC1020
HC-C3YF-5R( )	FR1 through FR73
HC-C3YN-2( )	DG1 through DG624
HC-C3YF-2( )	EY1 through EY3
HC-H3YF-3( )	ET1 through ET4
HC-H3YN-2( )	DV1 through DV153
HC-C3YK-1R( ) or HC-C3YR-1R( )	DY1 through DY1897
HC-C3YK-2( ) or HC-C3YR-2( )	CK1 through CK3510
HC-C3YK-4( ) or HC-C3YR-4( )	EL1 through EL67
HC-E3YK-1( ) or HC-E3YR-1( )	FM1 through FM487
HC-E3YK-2( ) or HC-E3YR-2( )	DF1 through DF79
HC-E3YK-2A( ) or HC-E3YR-2A( )	DJ1 through DJ7787
HC-F3YK-2( ) or HC-F3YR-2( )	DA1 through DA1586
HC-F3YK-1( ) or HC-F3YR-1( )	DB1 through DB137
HC-I3YK-2( ) or HC-I3YR-2( )	FS1 through FS24

Compliance: Required within the next 25 hours time-in-service, after receipt of this Priority Letter AD, unless already accomplished within the last 25 hours time-in-service and, thereafter, at intervals not to exceed 50 hours time-in-service from the last inspection.

To prevent propeller hub failure which can result in blade separation and lead to possible engine separation and loss of aircraft control, accomplish the following:

(a) Visually inspect the affected propeller hub, in accordance with Hartzell Service Bulletin (SB) No. 165, dated October 3, 1989.

(b) If any indication of a crack or other unairworthy condition is found, remove propeller assembly and replace with a serviceable propeller assembly prior to further flight.

(c) Report cracks or other unairworthy conditions found in writing to the Manager, Chicago Aircraft Certification Office, within 10 days of the inspection.

Information collection requirements contained in Section 39.13 of this regulation have been approved by the Office of Management and Budget (OMB) under the provisions of the Paperwork Reduction Act of 1980 (Pub. L. 96-511) and have been assigned OMB Control Number 2120-0056.

(d) Aircraft may be ferried in accordance with the provisions of Federal Aviation Regulations (FAR) 21.197 and 21.199 to a location where compliance with the AD can be accomplished.

(e) Upon submission of substantiating data by an owner or operator, through an FAA Airworthiness Inspector, an alternate method of compliance with the requirements of this priority letter AD or adjustments to the compliance time specified in this priority letter AD may be approved by the Manager, Chicago Aircraft Certification Office, Small Airplane Certification Directorate, Aircraft Certification Service, Federal Aviation Administration, 2300 East Devon Avenue, Des Plaines, Illinois 60018.

Documents pertinent to this priority letter AD may be obtained from Hartzell Propeller, Inc., One Propeller Place, Piqua, Ohio 45356, or may be examined at the Office of Assistant Chief Counsel, Federal Aviation Administration, ATTN: Rules Docket No. 89-ANE-41, 12 New England Executive Park, Burlington, Massachusetts 01803.

This Priority Letter AD 89-22-05 issued October 20, 1989, is effective upon receipt.

FOR FURTHER INFORMATION CONTACT:

Tim Smyth, Chicago Aircraft Certification Office, Propulsion Branch, ACE-140C, Small Airplane Certification Directorate, Aircraft Certification Service, Federal Aviation Administration, 2300 East Devon Avenue, Des Plaines, Illinois 60018; telephone (312) 694-7130.

HARTZELL HC-()3Y()-() COMPACT PROPELLER HUB FAILURE SUMMARY BY AIRCRAFT

	AIRCRAFT MODEL	ENGINE TYPE	RATING SHP/RPM	PROPELLER HUB SR NO.	BLADE MODEL	PROPELLER ROTATION LEFT/RIGHT	BLADE SEPARATION	FAILURE INITIATION	HUB HALF	DATE	TOTAL TIME	TIME SINCE OVERHAUL	NOTES
1	Beech 58	TSIO-520-C	285/2700	ED1441	FC7663-2R	R	N	Hub Arm	Rear	1/92	3079	611	Forging flaws noted
2	Cessna 188B	IO-520-D	285/2700	EC989	F9587C-17S	R	N	Zerk Base	Rear	7/87	1249.5	12	
3	Piper PA-60-700P	LTIO-540-U2A	350/2500	CK3410	FJC7451R	L	N	Zerk Base	Rear	2/85	320		
4	Piper PA-60-700P	LTIO-540-U2A	350/2500	CK3453	FJC7451R	L	N	Zerk Base	Rear		480		N22BA
§5	Piper PA-31-350	LTIO-540-J2BD	350/2575	DJ3998	FJC8468-6R	L	N	Hub Base	Rear	3/89		238.5	Forging lap, unusual
§6	Piper PA-31-350	LTIO-540-J2BD	350/2575	DJ1709	FJC8468-6R	L	Y	Zerk Base	Fwd	10/82	3421.9	707.4	N74 HP
§7	Piper PA-31-350	TIO-540-J2BD	350/2575	DJ1855	FC8468-6R	R	N	Zerk	Rear				
§8	Piper PA-31-350	LTIO-540-J2BD	350/2575	DJ4152	FJC8468-6R	L	N	Zerk					
§9	Piper PA-31-350	LTIO-540-J2BD	350/2575	DJ4212	FJC8468-6R	L	Y	Zerk Base	Fwd	8/82	1600	131.6	N123 CB
§10	Piper PA-31-325	LTIO-540-F2BD	325/2575	DJ4256	FJC8468-?R	L	Y	Zerk Int	Fwd	6/93	5000	508	G-BMGH 10.5 Hr after SB165
§11	Piper PA-31-350	TIO-540-J2BD	350/2575	DJ4655	FC8468-6R	R	N	Zerk Ext.	Fwd	9/90	7774	1526	Found on 50 Hr A D Inspectio
§12	Piper PA-31-350	LTIO-540-J2BD	350/2575	DJ5699	FJC8468-6R	L	Y	Zerk Base	Fwd				N3589B
§13	Piper PA-31-350	LTIO-540-J2BD	350/2575	DJ6075	FJC8468-6R	L	Y	Zerk Ext	Fwd		3973	1126	
§14	Piper PA-31-350	TIO-540-J2BD	350/2575	DJ6169	FC8468-6R	R	N?						
§15	Piper PA-31-325	LTIO-540-F2BD	325/2575	DJ6333	FJC8468-6R	L	N	Zerk Base	Rear	5/87		835.3	ZF 520
§16	Piper PA-31-350	LTIO-540-J2BD	350/2575	DJ7259	FJC8468-6R	L	Y	Zerk	Fwd	12/91	7056	504	Found on 50 Hr AD inspectio
§17	Piper PA-31-350	LTIO-540-J2BD	350/2525	DJ6625	FJC8468-6R	L	Y	Zerk Base	Rear	4/87		24	N506 ES Crankshaft counterweights not fitted
§18	Piper PA-31-(?)						N			9/93			29 Hr after 50 Hr visual
§19	Piper PA-32(?)-301T												found by eddy current check
*20	Piper PA-36-300	IO-540-K1G5	300/2700	DY854	F8468A-6	R	N	Fillet	Fwd		390		
*21	Piper PA-36-300	IO-540-K1G5	300/2700	DY568	F8468A-6	R	N	Bearing	Rear	8/82	886	0.6	N3636E
*22	Piper PA-36 STC	IO-720-A1B	400/2650	DY784	F8475R	R	Y	Fillet	Fwd	7/84	1506		N57593
*23	Fletcher FU-24	IO-720-A1A	400/2650	DY791	F8475R	R	N	O-ring	Fwd	9/81	621		
*24	PL12 Airtruck	IO-540-K1A/B5	300/2700	DY941	F8468A-2R	R	Y	Fillet	Fwd	2/93	3061	1561	VH - JS0

§ 'EXTENDED' MODEL HUB
* SINGLE ENGINE AGRICULTURAL AIRCRAFT

Previous major failures of the Hartzell HC-()3Y()-() propeller hub castings which initiated at the grease nipple (zerk) hole.

1. Piper PA 31-350 N74HP Jan 82 Lycoming LTIO-540 series engine

   Shortly after lift-off the right-hand propeller detached from the aircraft. The propeller hub plus two blades were found on the runway, the third blade was not found. Metallurgical examination showed the hub to have failed due to fatigue originating from the root of the threaded grease fitting (zerk) hole on the inside diameter of the hub.

2. Piper PA 31-350 N123CB Apr 82 Lycoming LTIO-540 series engine

   While descending a loud bang was heard followed by vibration and a violent yaw to the right. The right-hand engine had broken away from its mountings but had remained attached to the airframe by cables. The pilot made a successful forced landing. The propeller hub had failed from fatigue that had originated at a threaded grease fitting. A set of incorrect counterweights were found on the propeller.

3. Piper PA 60-700P N22BA Nov 84 Lycoming LTIO-540 series engine

   A slight vibration was noted in the climb. A severe crack was found in the right-hand propeller hub. Metallurgical examination found that the propeller hub failed by high cycle moderate stress fatigue cracking which originated at a roughened unpeened surface at the base of a tapped hole for a grease fitting (zerk).

4. Piper PA 31-350 N506ES Apr 87 Lycoming LTIO-540 series engine

   During the climb the aircraft lost one blade from the right-hand propeller. The pilot made a successful precautionary landing with the right engine hanging from the aircraft by one engine mounting and various pipes and wires. Examination of the propeller hub revealed a fatigue fracture that originated at a hub arm grease nipple hole within the rear half of the hub casting. Examination of the engine showed that the crankshaft counterweight bushings were not installed which had allowed a high frequency vibration to occur causing the failure of the hub.

5. Piper PA 31-350 ZF 520 May 87 Lycoming LTIO-540 series engine

   During examination on the ground following reported airborne vibration the right-hand propeller hub was found to be extensively cracked in the blade arm retention area. Metallurgical examination showed a high cycle fatigue failure which originated from a minor flaw, that was considered to be less than significant, in the final thread root on the underside of the grease nipple (zerk) hole.

6. Cessna A188B Registration not known Jul 87 Continental IO-520 series engine

   The propeller was reported to have started a vibration on approach to land. Subsequent inspection of the propeller revealed a hub fracture. Metallurgical examination showed a high cycle fatigue fracture which originate at an inner thread of the grease nipple (zerk) hole. The crack appeared to initiate in an area of what was identified as a slight blemish potentially caused by metal being dragged through the thread during manufacture.

7. Piper PA 31-350 N3589B Aug 88 Lycoming LTIO-540 series engine

   Shortly after lift-off one blade from the right-hand propeller detached from the propeller hub which was followed by the remainder of the propeller. Examination revealed a fracture which resulted from fatigue cracks that initiated at the grease holes in the forward half of the propeller hub.

8. Piper PA 31-350 N70PE Sep 89 Lycoming LTIO-540 series engine

   The propeller hub separated from the right engine during the initial climb. Examination of the wreckage revealed that the propeller hub fractured resulting in one of the three propeller blades detaching from the hub. The rest of the propeller hub separated from the engine striking the right front of the fuselage. Metallurgical examination of the failed propeller hub revealed fatigue emanating from the threaded hole for the grease fitting. The threads had been deformed by shot peening, resulting in increased stress concentrations at the threads.

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HARTZELL SERVICE BULLETIN

SERVICE BULLETIN 165E
CODE: C

January 21, 1994

SUBJECT:

Inspection for Cracks in Certain Three Blade "Y" Shank Aluminum Hubs

EFFECTIVITY:

HC-( )3Y( )-( ) propellers with the model designations and serial number range listed below **AND** installed on aircraft with Lycoming (L)TIO-540* series engines; or installed on agricultural aircraft regardless of engine type.

NOTE: This Bulletin is applicable ONLY to propellers that are listed in hub model/ serial number list AND are also installed on either: any aircraft using (L)TIO-540 series engine or any agricultural aircraft (regardless of engine). Other aircraft installations, even though they use listed propeller models/ serial numbers, are not affected.

* Some aircraft applications have "IO-540" series engines with a turbocharger added by the airframe manufacturer or STC holder or other FAA approved data. The intent of the Bulletin is that all aircraft with turbocharged 540 series engines are affected even if the engine data plate says "IO".

Propeller Serial Number Range:

Basic Hub Model	Propeller Serial Number Range		
PHC-C3YF-1R( )	EE1	through	EE1461
PHC-J3YF-1R( )	FP1	through	FP37
PHC-L3YF-1R( )	FD1	through	FD7
HC-C3YF-1R( )	EC1	through	EC1020
HC-C3YK-1( )	CT1	through	CT101
HC-C3YK-1R( ) or HC-C3YR-1R( )	DY1	through	DY1897
HC-C3YK-2( ) or HC-C3YR-2( )	CK1	through	CK3510
HC-C3YK-4( ) or HC-C3YR-4( )	EL1	through	EL67
HC-E3YK-1( ) or HC-E3YR-1( )	FM1	through	FM487
HC-E3YK-2( ) or HC-E3YR-2( )	DF1	through	DF79
HC-E3YK-2A( ) or HC-E3YR-2A( )	DJ1	through	DJ7787
HC-F3YK-2( ) or HC-F3YR-2( )	DA1	through	DA1586
HC-F3YK-1( ) or HC-F3YR-1( )	DB1	through	DB137
HC-I3YK-2( ) or HC-I3YR-2( )	FS1	through	FS50

(continued)

Aircraft Models: Propellers listed on page 1 are installed on, but not limited to:

Agricultural Aircraft

Fletcher FU24-950
Cessna A188 Agwagon modified by STC SA895SO
Piper PA-36-300 Pawnee
PA-36 Pawnee modified by STC SA3952WE
Transavia Airtruk

Aircraft with (L)TIO-540* Series Engines

Cessna 310 and 320 modified by Riley STC SA2082WE
Gulfstream 700 (formerly Rockwell 700, Fuji FA-300-12)
Helio H-700
Piper PA-23-250 and PA-E23-250 (with TIO-540 only)
Piper PA-31 Navajo (with TIO-540 only)
Piper PA-31-325 Navajo C/R
Piper PA-31-350 Navajo "Chieftain"
Piper PA-31P-350 Mohave
Piper T-1020 (same as PA-31-350)
Piper PA-32(R)-301T Turbo Saratoga
Piper PA-60-600, PA-60-601, and PA-60-602 Aerostar's all modified by Machen STC (turbocharged)
Piper PA-60-700P Aerostar 700P

DISCUSSION:

Recent metallurgical information has increased concern that there may be little operational time from the time that a crack becomes detectable (at the hub exterior surface) until subsequent crack growth results in blade separation. Because of this, this revision, Bulletin 165E, imposes an even more stringent compliance requirement for certain aircraft models to require repetitive eddy current inspections at 10 hour intervals.

Hartzell recognizes that such demanding inspection requirements will cause added difficulty in meeting aircraft operational commitments. However, we believe that such requirements are necessary in order to maintain flight safety. Hartzell is, and has been, attempting to dramatically increase the production rate of replacement hubs which, when installed, will eliminate the requirements of this Bulletin.

An alternate means of compliance is also provided with this Bulletin which can increase the repetitive inspection to initially 400 hours with 100 hour intervals thereafter; however, it also requires disassembly and rework of the propeller. This option would be of practical use only to high utilization aircraft which would have difficulty in compliance with the more stringent repetitive inspections and cannot obtain a replacement hub in the near term.

This Bulletin imposes severe repetitive inspection requirements. The more restrictive requirements are placed on aircraft models which have a history of cracked or failed hubs. Other models, such as the PA-31 (310 hp), have had no failures but are addressed in this Bulletin because of their similarity to applications which have a history. These models have a more liberal inspection requirement.

In Hartzell three blade "compact" aluminum hub propellers, cracks typically originate in the threads of a grease fitting hole on the inside of the hub. As the cracks propagate around the blade arm of the hub, their progression accelerates and results in failure of one hub half. Several incidents have continued to progress to blade separation.

WARNING: UNEXPLAINED VIBRATION OR GREASE LEAKAGE INCIDENTS, WHERE THE CONDITION INITIATED SUDDENLY, DEMAND IMMEDIATE INSPECTION FOR POSSIBLE CRACKED HUB.

COMPLIANCE:

NOTE: During 1983, a hub design change relocated the grease fitting holes near the hub parting line (see Figure 1). The earlier-design hubs are listed as affected serial numbers, however, there may be a few hubs listed that are of the later type. Any hub found to be of the current configuration does not require compliance with this Bulletin. Any hub with the old configuration requires compliance.

For all affected aircraft, if any abnormal or unexplained changes occur in propeller vibration or grease leakage, eddy current inspection per PROCEDURE 1 must be performed prior to further flight. (This issue must be made known to flight crew members as well as maintenance personnel.)

REQUIRED ACTION **for Piper PA-31-325, PA-31-350, T-1020; Aerostar PA-60-700P; and Agricultural aircraft** must be performed in accordance with either Option 1 or Option 2 below:

OPTION 1:

Within the next 10 hours of operation from the last SB 165 inspection or within 10 hours of operation from the effective date of this Bulletin, whichever occurs first, perform a combination of visual and eddy current inspection (PROCEDURE 1). Repeat inspection at intervals not to exceed 10 hours of operation.

OPTION 2:

Within the next 10 hours of operation from the last SB 165 inspection or within 10 hours of operation from the effective date of this Bulletin, whichever occurs first, disassemble the propeller, internally inspect, and rework the hub grease fitting holes per PROCEDURE 2 of this Bulletin. Repeat disassembly and internal inspection with both dye penetrant and eddy current per PROCEDURE 2 (except chamfering procedure need not be repeated) within 400 hours of operation (initially) and thereafter at intervals not to exceed 100 hours of operation.

REQUIRED ACTION **<u>for all other affected aircraft</u>** must be performed in accordance with either Option 1 or Option 2 below:

OPTION 1:

Within the next 50 hours of operation from the last SB 165 inspection or within 50 hours of operation from the effective date of this Bulletin, whichever occurs first, perform a combination of visual and eddy current inspection (PROCEDURE 1). Repeat inspection at intervals not to exceed 50 hours of operation.

OPTION 2:

Within the next 50 hours of operation from the last SB 165 inspection or within 50 hours of operation from the effective date of this Bulletin, whichever occurs first, disassemble the propeller, internally inspect, and rework the hub grease fitting holes per PROCEDURE 2 of this Bulletin. Repeat disassembly and internal inspection with both dye penetrant and eddy current per PROCEDURE 2 (except chamfering procedure need not be repeated) within 400 hours of operation (initially) and thereafter at intervals not to exceed 100 hours of operation.

TERMINATING ACTION:

Replacement with later style hub (post 1983) is terminating action for this Bulletin. Retirement of affected hubs on Piper PA-31-325, PA-31-350, T-1020; Aerostar PA-60-700P; and agricultural aircraft is required during propeller overhaul or by January 1, 1995, whichever occurs first. Manufacturing capabilities are limited. If later style replacement hubs are not available at the time of overhaul, to avoid aircraft grounding, it is acceptable to temporarily (for up to six months) continue operation with old style hubs.

NOTE: To encourage operators to replace hubs, special reduced pricing has been established for replacement hubs and/or propeller assemblies. <u>Old style hubs removed from service are to be retired rather than used on other applications not affected by this Bulletin</u>. (See retirement procedures, Service Instruction 114A.)

PROCEDURE 1:

The following procedure may be accomplished by either a certificated aircraft mechanic or propeller repair station personnel with experience and training in eddy current inspection.

1. Remove spinner dome and, as necessary, engine cowling to expose propeller hub. Remove rubber caps from grease fittings.

2. In a majority of cases, traces of grease coming from a crack have been the means of crack discovery. Make a visual inspection for traces of grease prior to cleaning. Then, if present, remove any paint, grease or other matter which may hinder visual examination.

   NOTE: If paint removal is required, chemical stripper must be used carefully to prevent it from accumulating in the cavity between the hub and blade. Paint removal from the entire hub is not required, an area within approximately two inches of each grease fitting is adequate. Before returning to service, the exposed area of the aluminum hub must have either an anodized surface or be protected with approved chemical film treatment such as Alodine. Also, the area which has had paint removed should remain unpainted to allow future inspection (approved deviation from Hartzell Service Instruction 144G).

   NOTE: The Aeroshell #6 grease used in propellers is mildly fluorescent. Although not a requirement, inspection using a black light (as is used with dye penetrant inspection) was found to be a useful aid in performing in performing visual inspections.

CAUTION: A VISUAL INSPECTION IS, IN ITSELF, NO LONGER CONSIDERED ADEQUATE. AN EDDY CURRENT INSPECTION MUST ALSO BE PERFORMED.

3. Use 10X magnifying glass and light source to perform careful visual inspection of the hub for hairline cracks in the general vicinity of blade retention bearings, but primarily inspect the grease fitting areas as shown in Figure 1. Perform inspections with grease fittings installed.

   NOTE: Typically, cracks begin at the grease fitting and propagate perpendicular to blade around the blade arm barrel. Cracks may initiate on either hub half from any of the six (6) grease fittings.

4. Perform external eddy current inspection:

   a. Tools Required:

      1) Magnaflux ED-520 or ED-530; or HALEC Mk II eddy current instrument (with instruction manual) are recommended. Other eddy current instruments capable of operating within a frequency range of 50 KHZ to 250 KHZ are acceptable.

         NOTE: Hartzell has tested and can recommend Magnaflux ED-520, ED-530 and HALEC Mk II eddy current equipment. Other manufacturers of eddy current devices are capable of providing suitable results. Use of other types of eddy current equipment is acceptable to Hartzell if approved by local airworthiness authorities (FAA or foreign equivalent).

2) Eddy Current Probe - A small diameter "pencil" type, shielded eddy current probe is required. Also, some aircraft models may require use of an eddy current probe with a 90 degree angle in order to inspect the fitting hole on the aft side of the hub (between hub and spinner bulkhead). Recommended probe - 1/8 inch diameter, 90 degree probe with 1/2 inch drop, 6 inches long, shielded (Absolute - 200 KHZ).

NOTES: 1) An unshielded probe is not recommended due to possible background noise.
2) The probe is used on a shot peened surface. To prevent premature wear of the probe element, the element end may be covered with 0.003 inch thick teflon tape.

3) Calibration/Reference Standard - 1-1/4 inch by 3 inch aluminum block 5/16 inch thick with 0.008, 0.020, and 0.040 inch deep reference notches that are 0.003 to 0.005 inch wide.

Sources of eddy current probes and reference standards:

Company	Probe P/N	Reference Standard P/N
Centurion NDT, Inc. (formerly Magnaflux Electronic Products) 707 Remington Rd. Suite 9 Schaumberg, Illinois 60173	223695MP	207066
NDT Products Engineering 7056 South 220th Kent, Washington, 98032	MP905-60P	SRS0824A
NDT Equipment & Supply, Inc. 10728 S. Pipeline, Suite D Hurst, Texas 76053	NDT 905-60	TB-AL

CAUTION: EFFECTIVE EDDY CURRENT TESTING REQUIRES EXPERIENCED, WELL-TRAINED PERSONNEL WHO ARE FAMILIAR WITH PROPER PROCEDURES FOR INSTRUMENT CALIBRATION AND USAGE OF THE EQUIPMENT.

b. Calibration Procedure:

1) Calibrate/balance the eddy current instrument in accordance with the instrument manufacturer's procedures.

2) Check eddy current instrument lift off settings by placing a 0.003 inch lift off shim or smooth piece of transparent tape on an area of the reference standard away from any reference notches. Place the probe on the shim or tape and slide the probe off to the bare metal. The meter deflection must be in accordance with the eddy current instrument manufacturer's calibration/balance procedures.

3) Place the eddy current probe on the aluminum reference standard and slide probe over 0.020 inch notch and note meter deflection or phase shift. The eddy current gain/sensitivity control must be adjusted to display a 150 microampere deflection minimum on the Magnaflux ED 520/530; 50% deflection on the Hocking Locator UH and UH-B; and a 50% amplitude signal on phase analysis instruments.

c. Scanning and indexing criteria:

1) Place eddy current probe on hub, positioned against the grease fitting and note the instrument readings and adjust balance or zero controls to bring needle on meter, if required. The active area of the probe must remain nearly perpendicular to the surface during all calibration and scanning procedures.

2) Scan probe gradually around each of the six grease fittings on the propeller hub. See Figure 1, scan probe in a manner to cross typical crack indications (rather than scanning in strokes that may be parallel to typical crack indications). The center of the probe tip <u>must</u> pass within 1/4 inch of the grease fittings and outward from the fitting as far as practical (up to 2 inches). The initial scanning around the grease fitting should consist of a circle with the probe as close to the grease fitting hole as possible. Perform subsequent scans of concentric circles around the grease fitting with no more than 1/10 inch spacing between circles.

NOTE: If a large or blunt eddy current probe is used, removal of grease fittings may be required in order to pass the center of the probe tip within 1/4 inch of the edge of the grease fitting hole.

d. Evaluation:

1) Any rapid eddy current indication that exceeds 150 microampere deflection on a ED 520/530; 50% deflection on a Hocking Locator; or 50% amplitude signal on a phase analysis eddy current instrument must be evaluated further.

2) All hubs with suspect indications are to be sent to the Hartzell Product Support Department for further evaluation.

5. If no cracks are found, re-install rubber caps on grease fittings, re-install spinner dome and make logbook entry indicating compliance.

6. If there are any indications of a crack, hub replacement (by an approved propeller repair station) must be accomplished prior to further flight.

ALTERNATIVE METHOD for external Eddy Current Inspection (Option 1 only):

Step 4 in PROCEDURE 1 calls for eddy current inspection method. Localized application "on aircraft" of fluorescent dye penetrant is acceptable in lieu of eddy current if accomplished in strict accordance with procedures provided in Hartzell Standard Practices Manual 202A (visible dye method is not authorized). An initial (one-time) pre-penetrant etching treatment is required. Etching is considered an IMPORTANT step in making a tight crack detectable with fluorescent dye penetrant, ref. Hartzell Manual 202A, p. 309, para. 6. Careful, localized application of caustic/nitric solutions are acceptable, but also grease fittings would have to be removed afterward for cleaning to prevent accumulation of solutions in the threads.

PROCEDURE 2:

The following procedure must be accomplished by a propeller repair station.

1. Disassemble propeller per Manual 117D (or subsequent revision).
2. Perform eddy current inspection of the hub in the area of the grease fitting holes, both internally and externally, in accordance with PROCEDURE 1 in this Bulletin. If there are any indications of a crack, hub replacement must be accomplished prior to further flight.
3. Using a 6 fluted, 45° chamfering tool (Hartzell part number 57BST5845), cut a chamfer to 0.429 to 0.500 inch diameter on the inside of the hub at each grease fitting location. Using the same tool, also cut a chamfer 0.304 to 0.357 inch diameter on the external side of each grease fitting hole. See Figure 2.
   a. Chamfering may be performed with a hand-held variable speed drill. Vary the RPM and force on the drill to minimize tool chatter. Testing on a scrap hub is recommended prior to performing this operation.
   b. Check diameter of chamfer using a dial caliper. Hub retirement is required if chamfer exceeds maximum diameter.
4. Polish any sharp edges created by the chamfering tool with 320 grit (or finer) emery cloth or sandpaper.
5. Perform dye penetrant inspection of the hub per Manual 202A. This includes etching of the surface prior to penetrant inspection. Since a complete overhaul is not required for compliance with this Bulletin, localized etching and penetrant inspection in the area of the grease fitting holes is permissible.
6. Provide corrosion preventative treatment, either anodize or chemical conversion coating, in accordance with Manual 202A.
7. Reassemble propeller per Manual 117D.
8. Using a metal impression stamp, stamp the letter "E" as a suffix to the propeller assembly serial number on each half of the hub.
9. Make a logbook entry to indicate compliance with this portion of Bulletin 165E and that "Option 2" Compliance criteria is applicable to this hub.

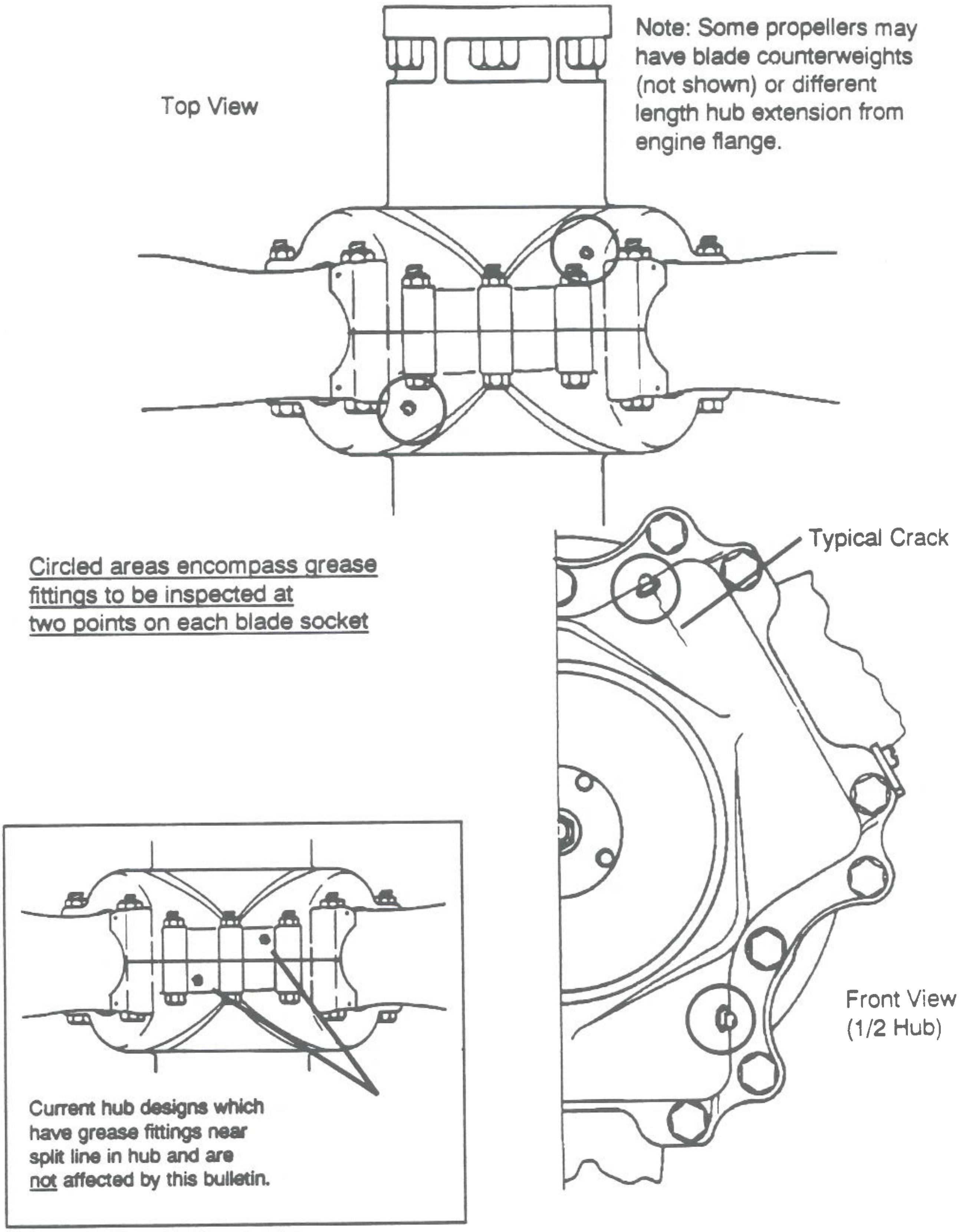


Figure 1. Hub Grease Fittings

PUBLICATIONS AFFECTED:

This Bulletin replaces Service Bulletin 165D dated August 6, 1993. This bulletin is now considered part of Hartzell Manuals 113B and 117D.

APPROVAL:

Federal Aviation Administration (FAA) approval has been obtained on technical data in this publication that affects type design. This revision has been coordinated with the manager of the Chicago Aircraft Certification Office 2300 E. Devon Ave. Des Plaines, Illinois 60018 and is approved as an alternate means of compliance with Airworthiness Directive AD 93-16-14.

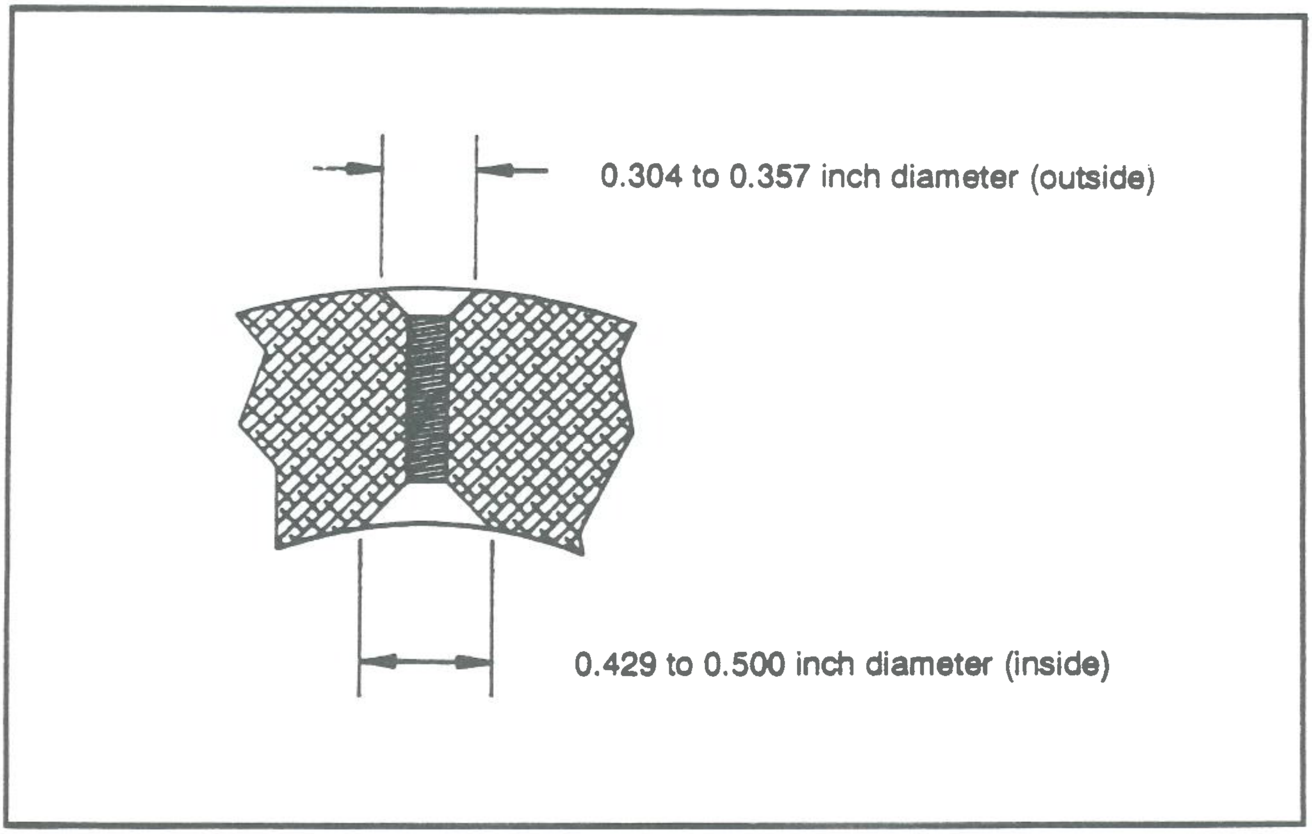
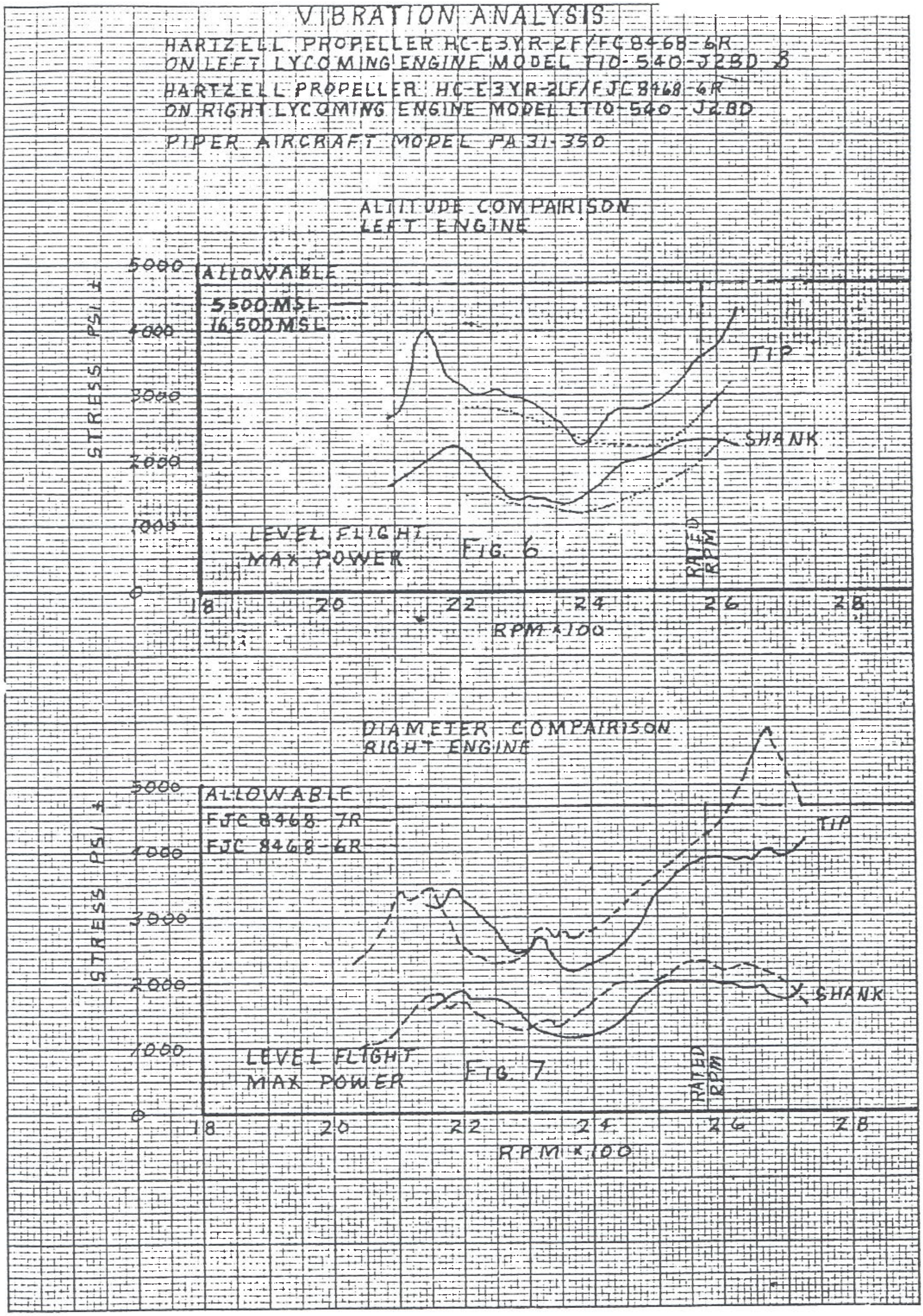


Figure 2. Hub Rework

APPENDIX 9


VIBRATION ANALYSIS
HARTZELL PROPELLER HC-E3YR-2F/FC8468-6R
ON LEFT LYCOMING ENGINE MODEL TIO-540-J2BD
HARTZELL PROPELLER HC-E3YR-2LF/FJC8468-6R
ON RIGHT LYCOMING ENGINE MODEL LTIO-540-J2BD
PIPER AIRCRAFT MODEL PA31-350
ALTITUDE COMPAIRISON
LEFT ENGINE
5000
ALLOWABLE
5500 MSL
16,500 MSL
4000
3000
2000
1000
0
STRESS PSI ±
TIP
SHANK
LEVEL FLIGHT
MAX POWER
FIG. 6
RATED RPM
18
20
22
24
26
28
RPM x100
DIAMETER COMPAIRISON
RIGHT ENGINE
5000
ALLOWABLE
FJC 8468-7R
FJC 8468-6R
4000
3000
2000
1000
0
STRESS PSI ±
TIP
SHANK
LEVEL FLIGHT
MAX POWER
FIG. 7
RATED RPM
18
20
22
24
26
28
RPM x100

VIBRATION ANALYSIS

HARTZELL PROPELLER HC-E3YR-2F/FCB468-6R
ON LEFT LYCOMING ENGINE MODEL TIO-540-J2BD
HARTZELL PROPELLER HC-E3YR-2LF/FJC8468-6R
ON RIGHT LYCOMING ENGINE MODEL LTIO-540-J2BD
PIPER AIRCRAFT MODEL PA 31-350

LEFT ENGINE (SR)*

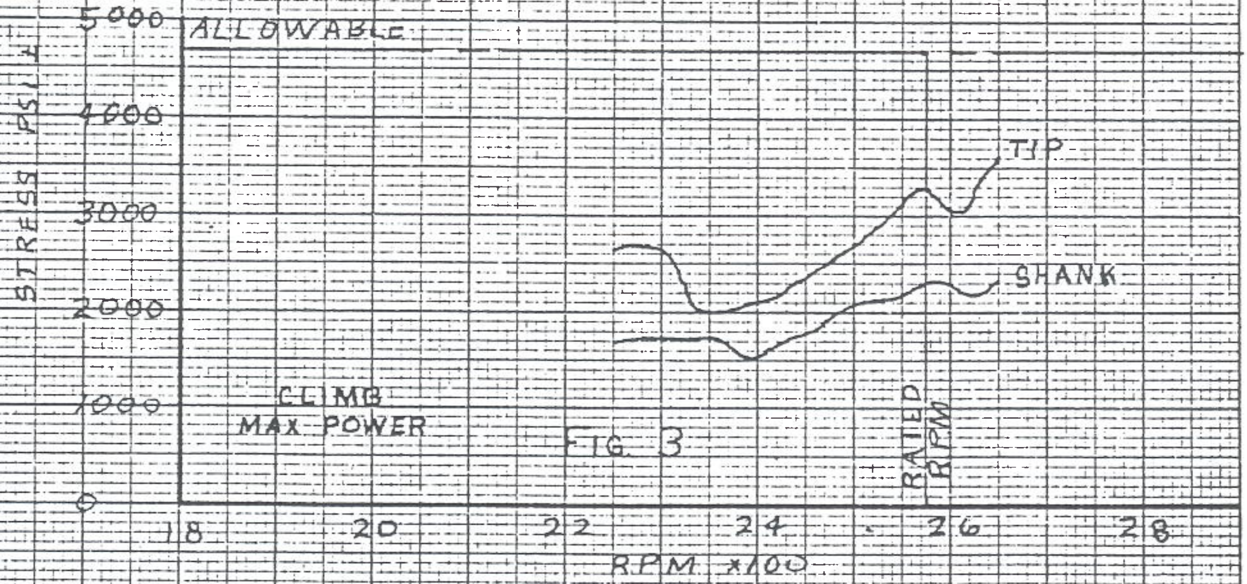


FIG. 3

RIGHT ENGINE (CR)*

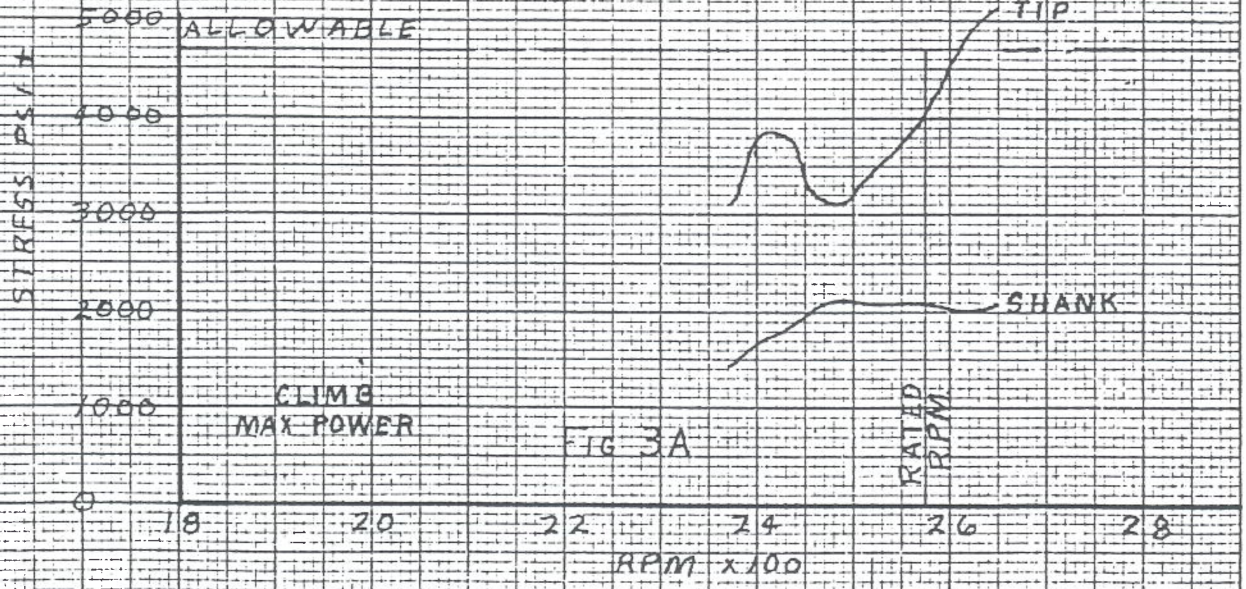


FIG 3A

* SR = STANDARD ROTATION
CR = COUNTER ROTATION

VIBRATION ANALYSIS

HARTZELL PROPELLER HC-E3YR-2F/FC 8468-6R
ON LEFT LYCOMING ENGINE MODEL TIO-540-J2BD &

HARTZELL PROPELLER HC-E3YR-2LF/FJC 8468-6R
ON RIGHT LYCOMING ENGINE MODEL LTIO-540-J2BD

PIPER AIRCRAFT MODEL PA 31-350

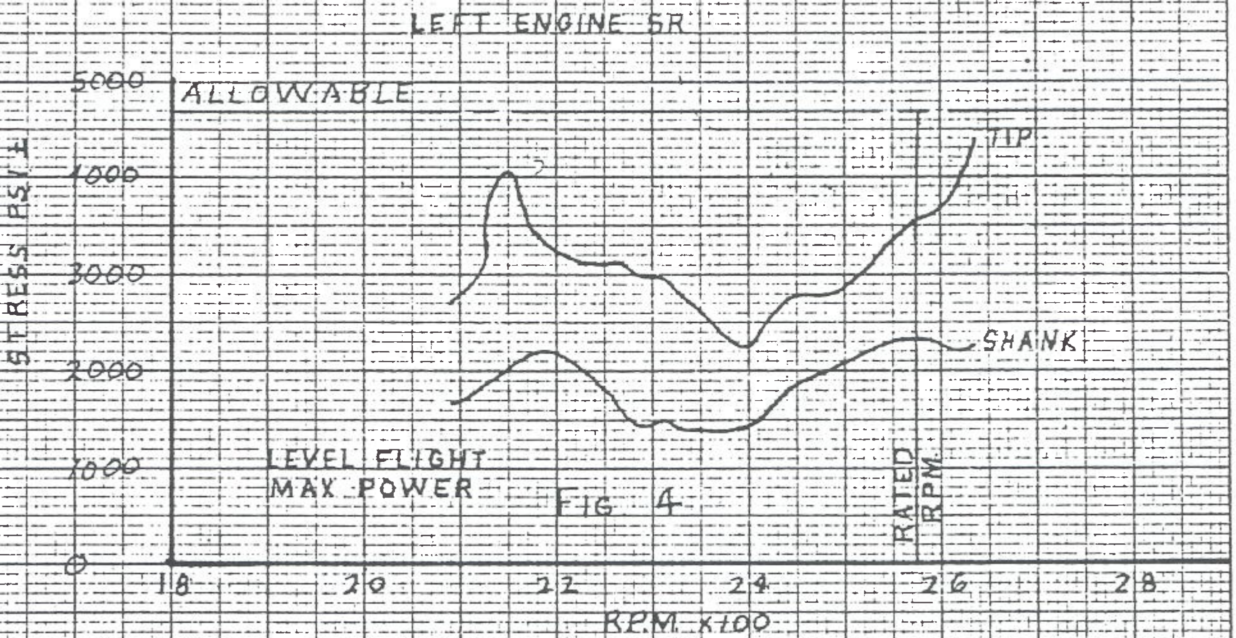


FIG 4

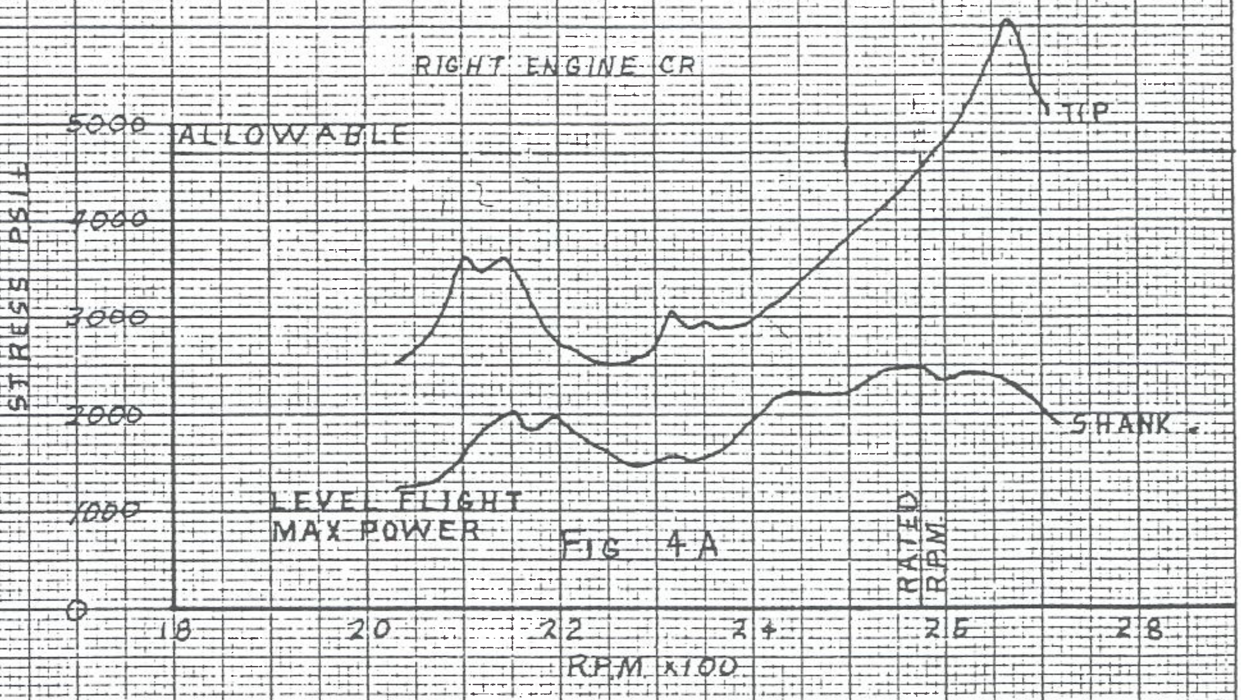


FIG 4A

VIBRATION ANALYSIS

HARTZELL PROPELLER HC-E3YR-2F/FC 8468-6R
ON LEFT LYCOMING ENGINE MODEL TIO-540-J2BD &

HARTZELL PROPELLER HC-E3YR-2LF/FJC 8468-6R
ON RIGHT LYCOMING ENGINE MODEL LTIO-540-J2BD

PIPER AIRCRAFT MODEL PA31-350

LEFT ENGINE 6R

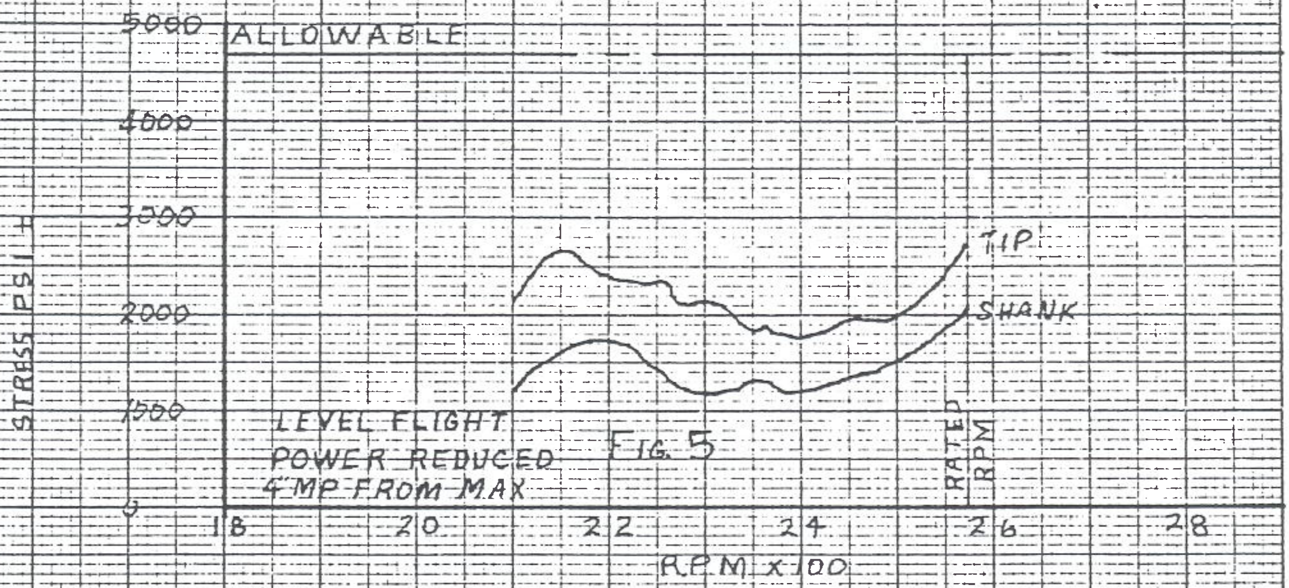


FIG. 5

RIGHT ENGINE CR

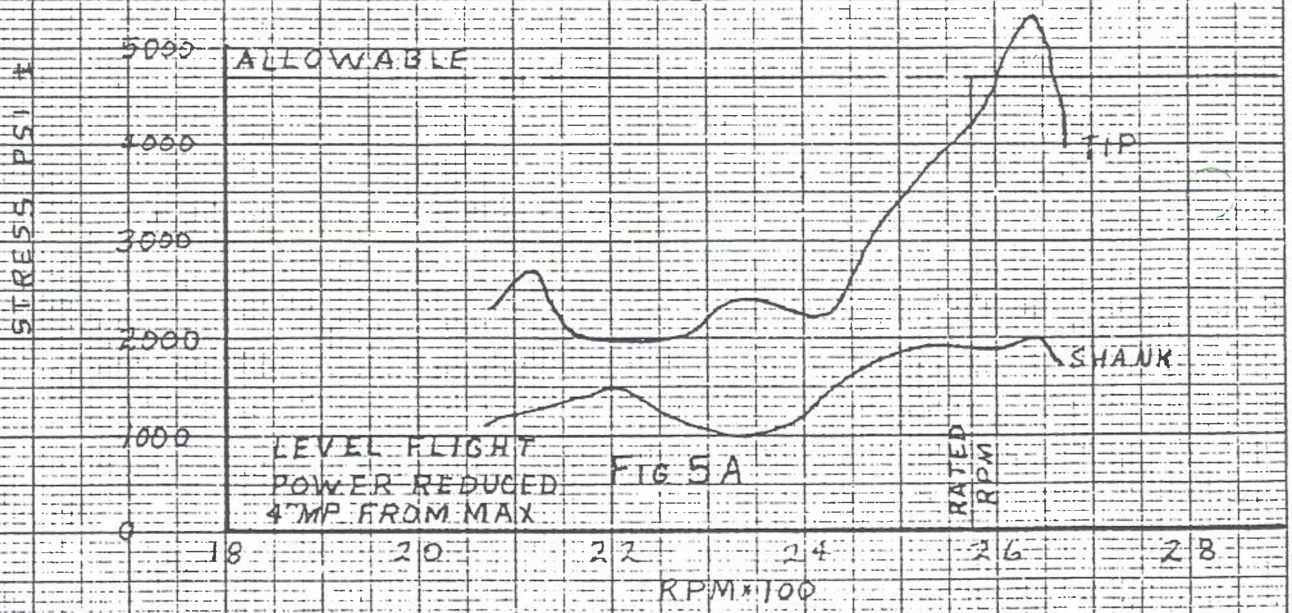


FIG 5A

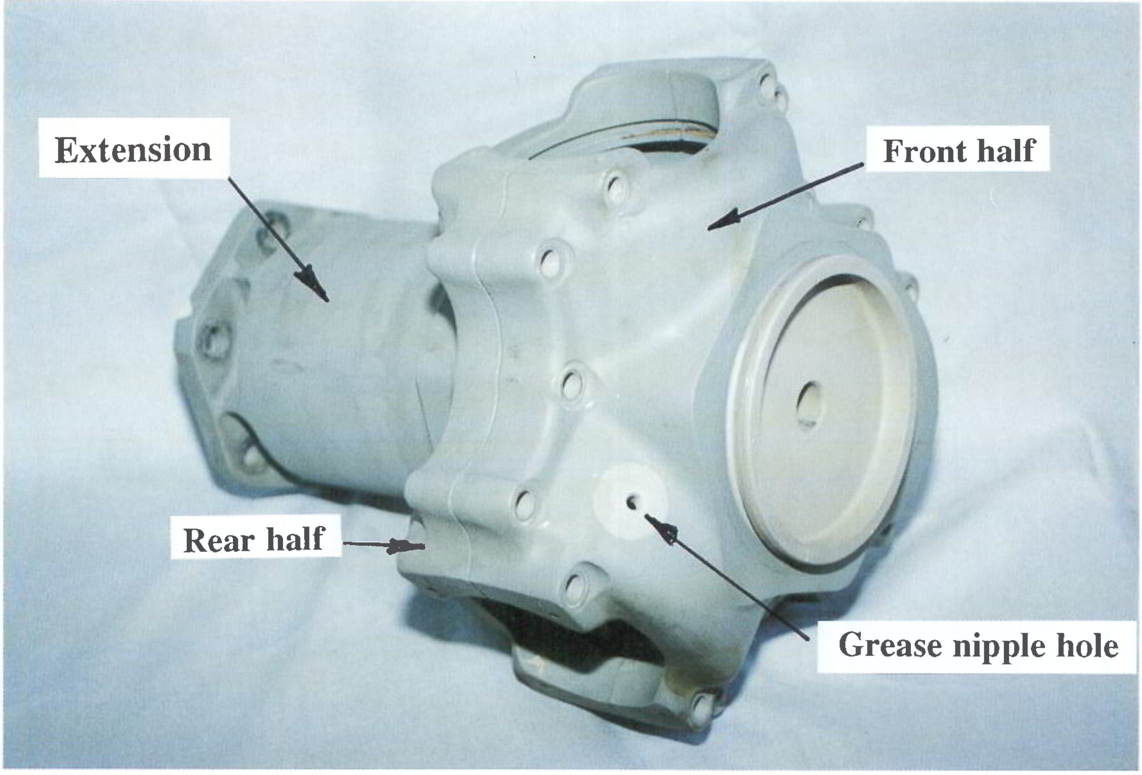


Figure 1 The pre 1983 Hartzell HC-()3Y()-() three bladed propeller hub

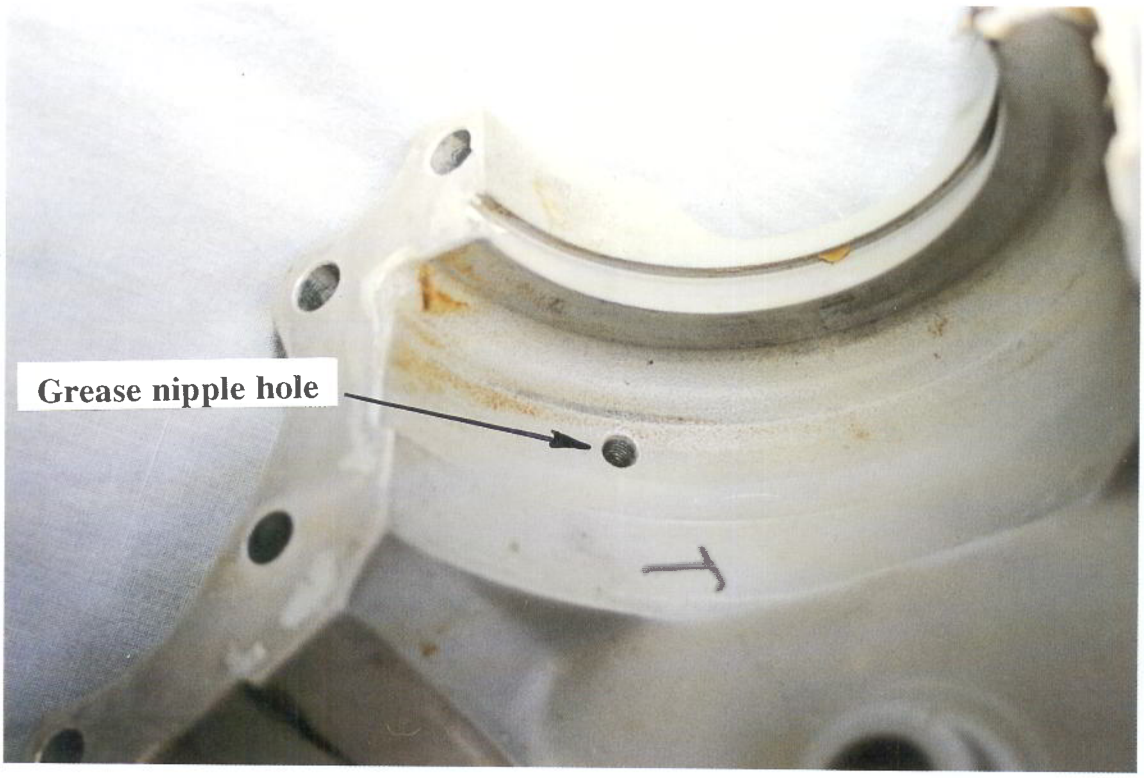


Figure 2 Inside view of the pre 1983 Hartzell HC-()3Y()-() propeller hub

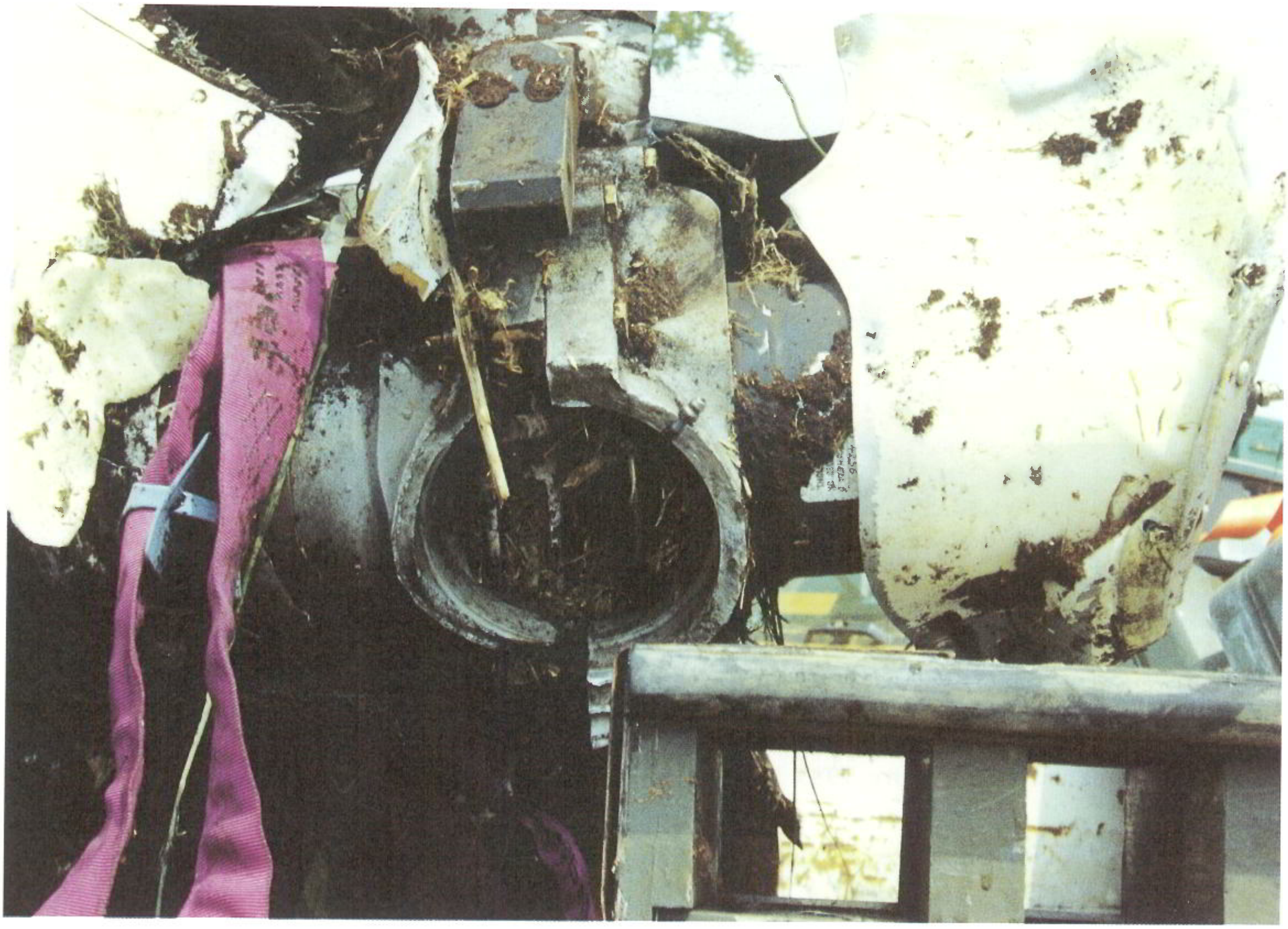


Figure 3   View of the failed propeller hub at the accident site

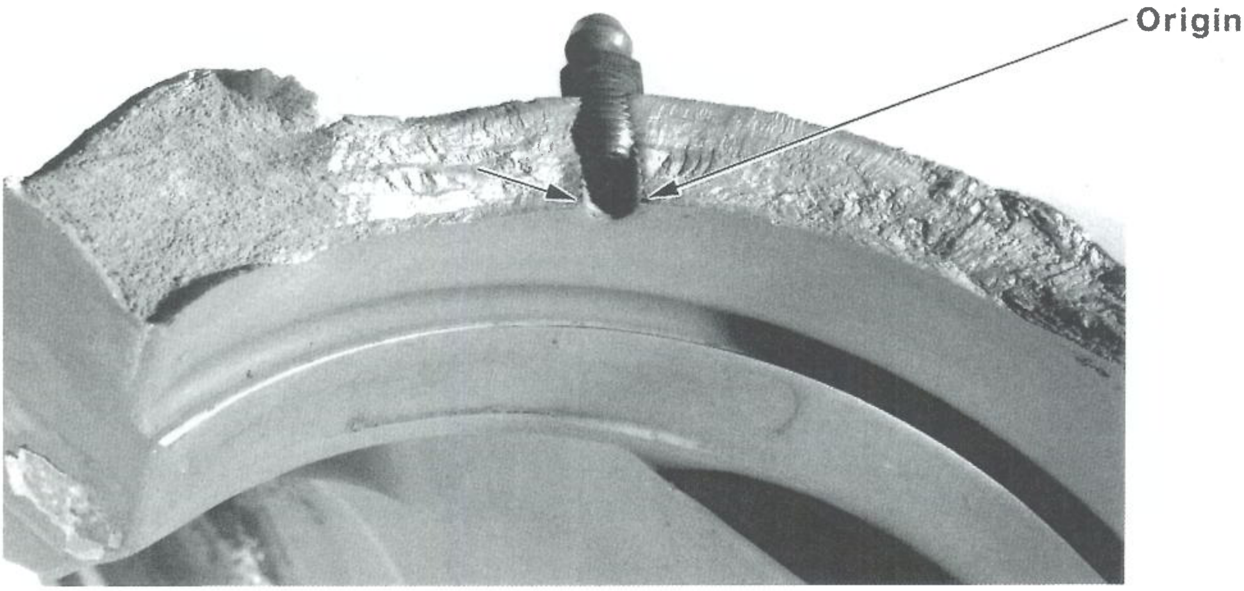


Figure 4   Fatigue cracked region on the inner half of the hub fracture

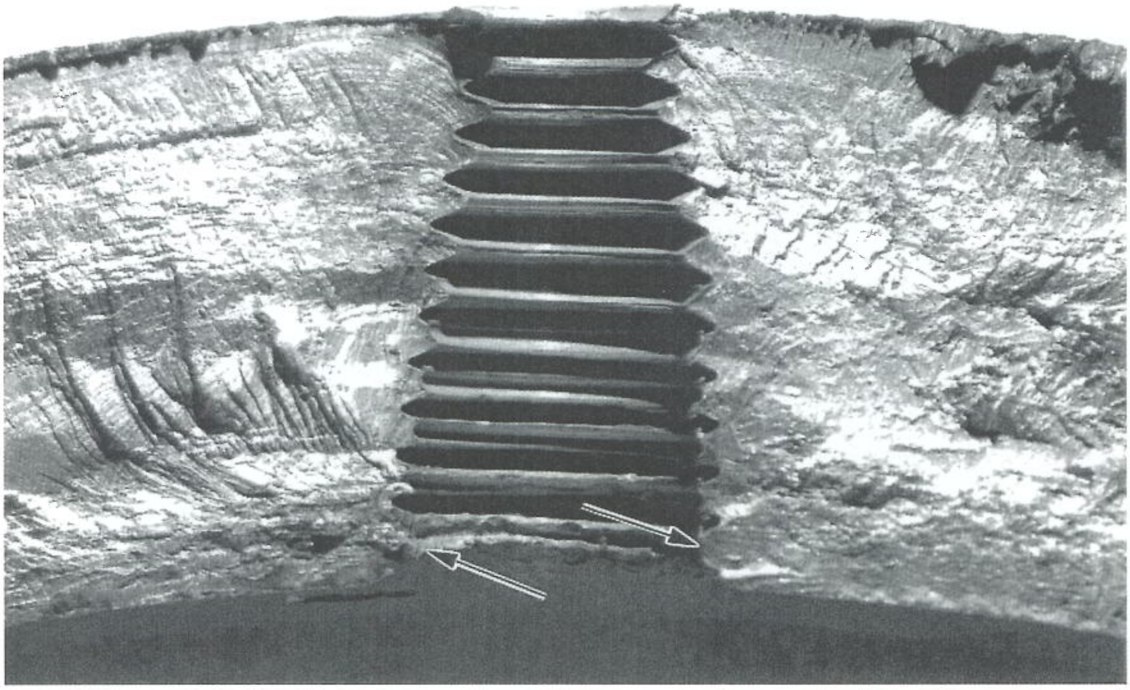


Figure 5 Detail showing the fatigue origins at the inner end of the damaged thread (outer half of the fracture) x6.5

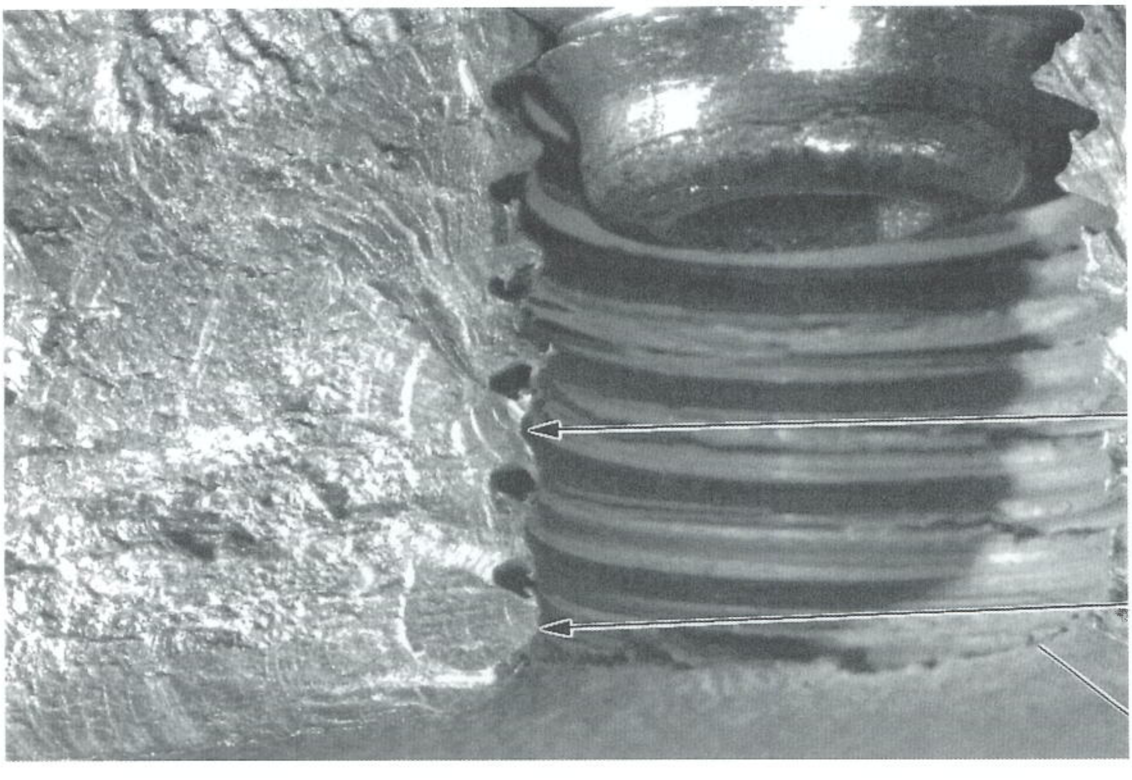


Figure 6 Detail of the features on one side of the hole (inner half)

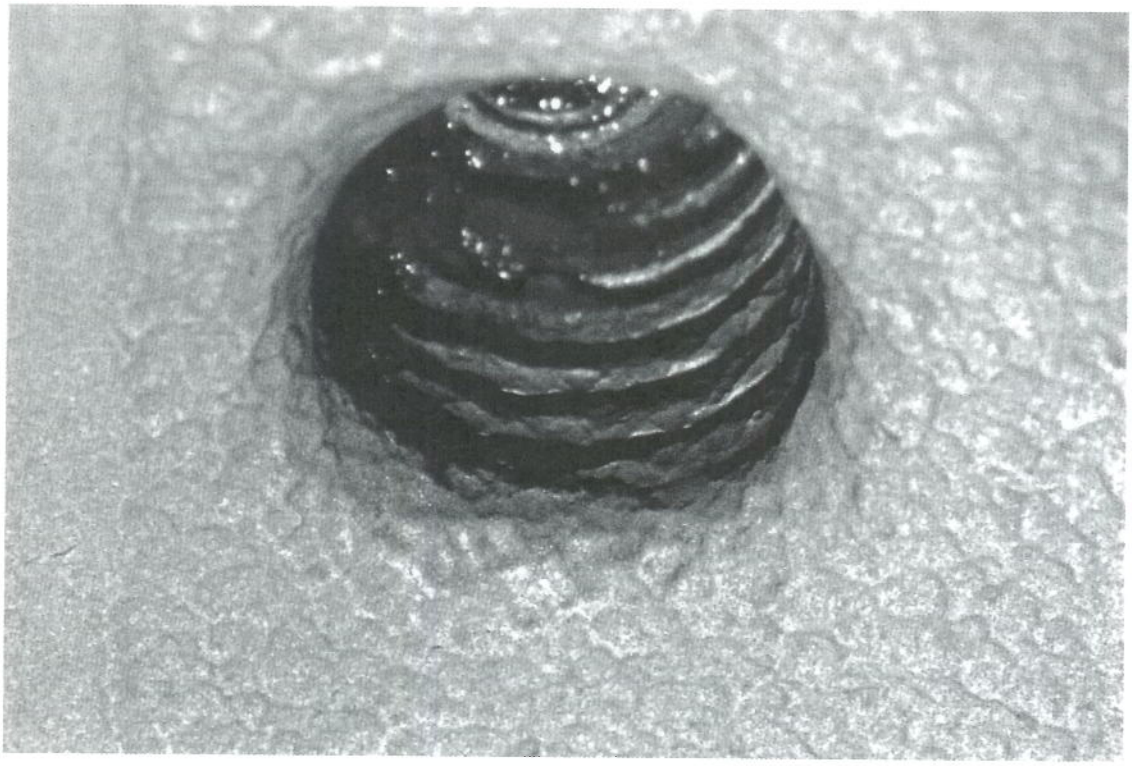


Figure 7 Showing the peening effect as exhibited by other grease nipple holes in the hub

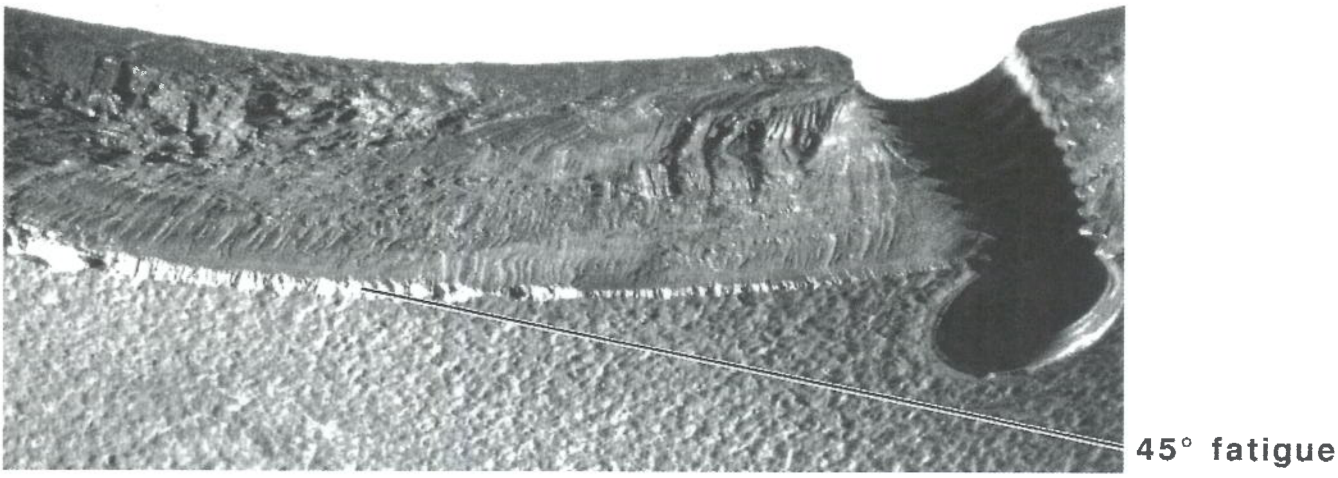


Figure 8 45° fatigue around the outer edge of the crack (inner half)

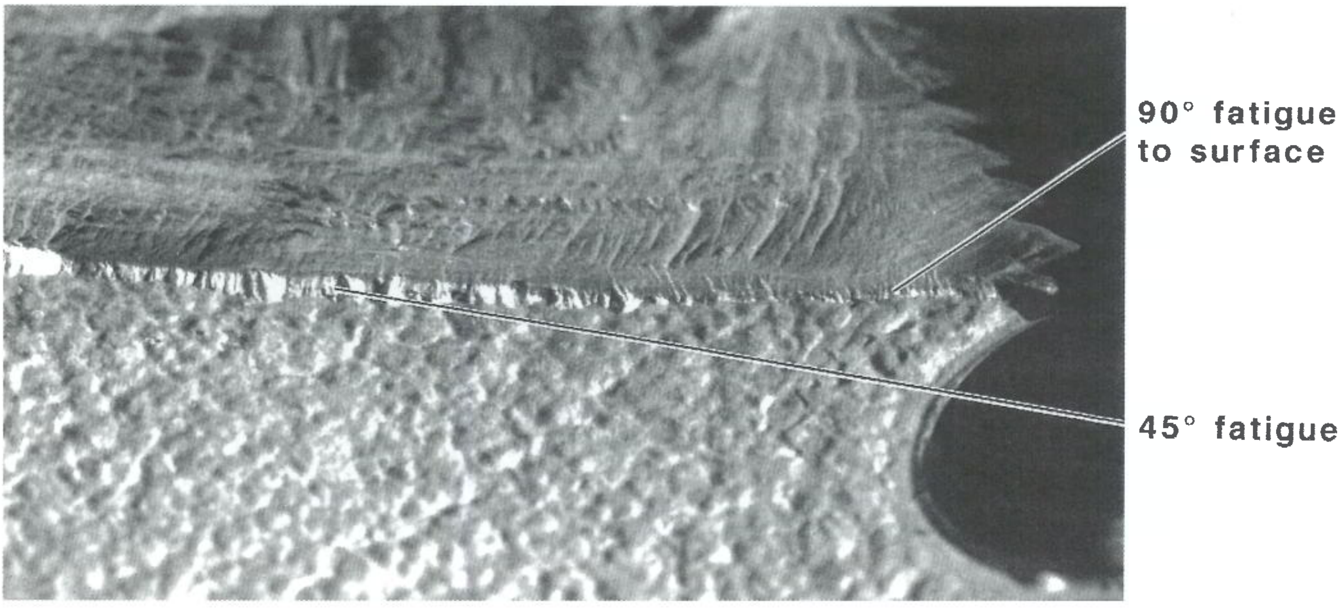


Figure 9 Detail showing the absence of the 45° fatigue close to the grease nipple hole

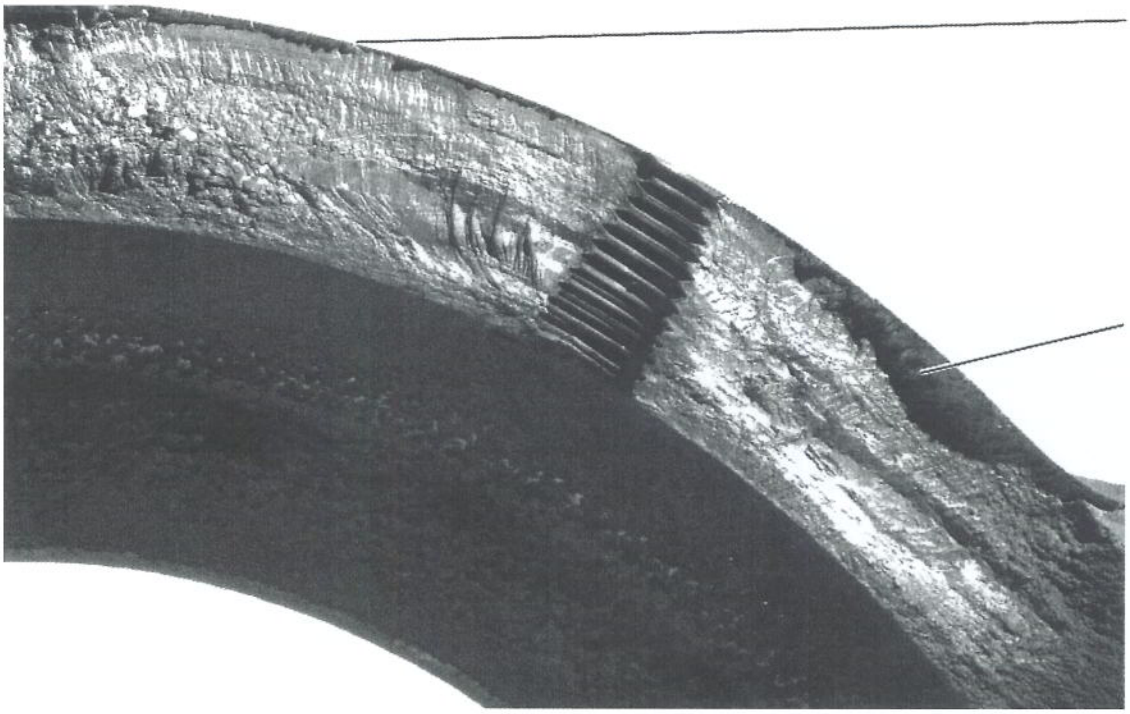


Figure 10 View showing the raised lip on the outer half of the fracture

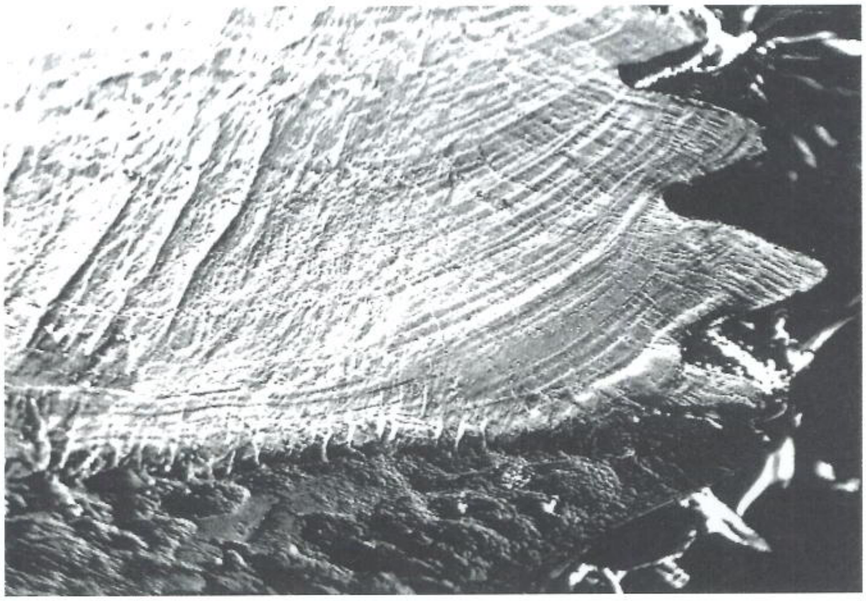


Figure 11 SEM view of the 90° fatigue close to the hole x25

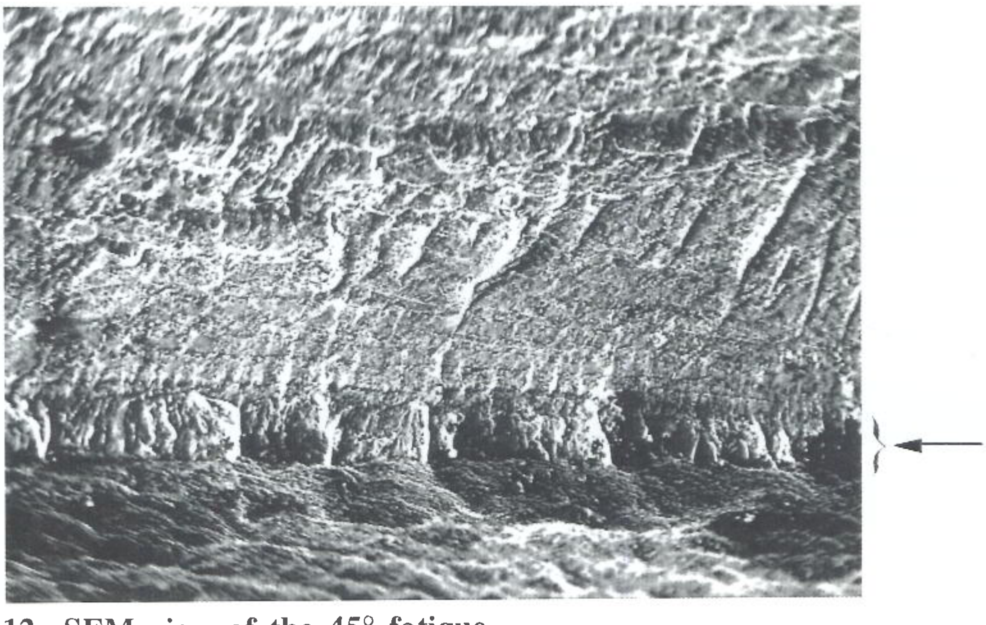


Figure 12 SEM view of the 45° fatigue x25

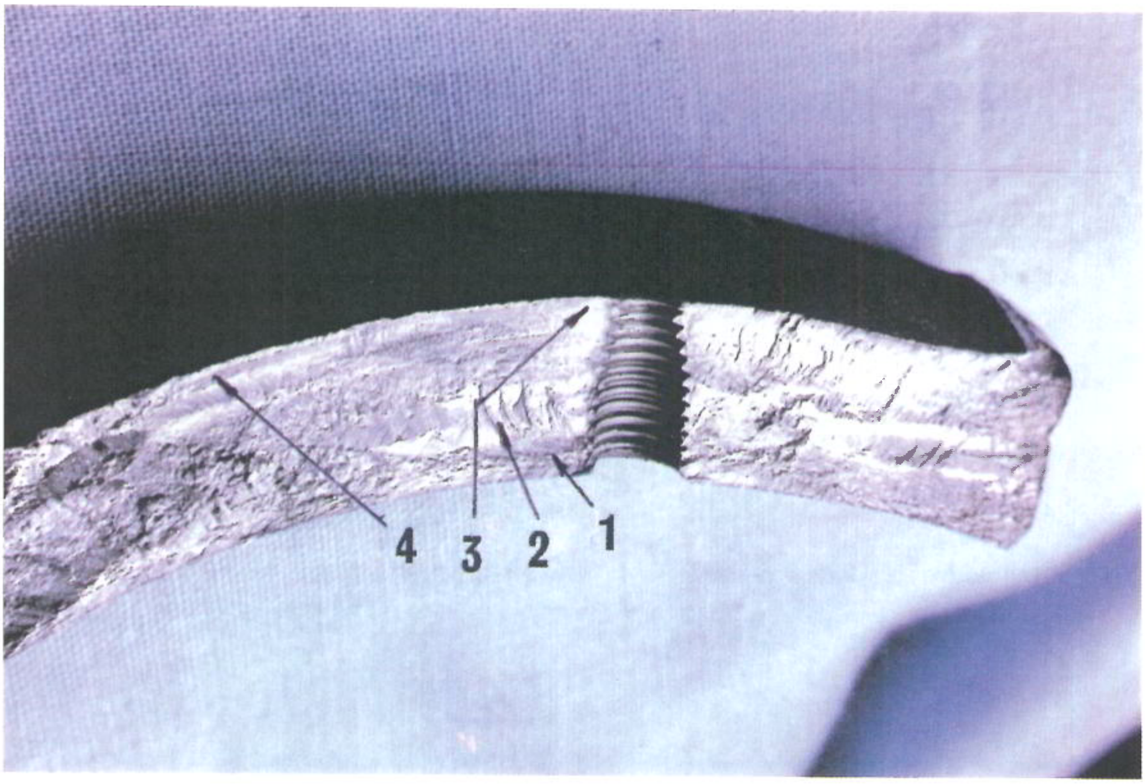


Figure 13 General view of the fracture face on which the progression count was carried out x2.06

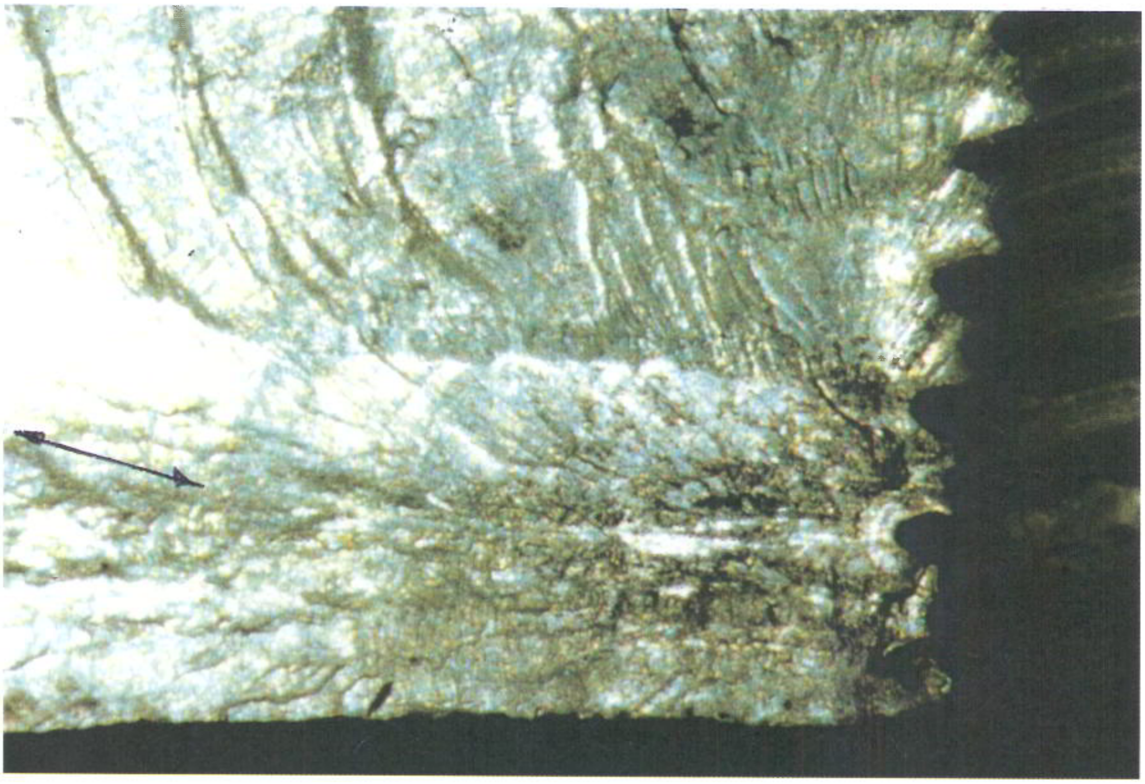


Figure 14 Position 1 on figure 13. First count adjacent to the initiation region - 12.3 events in 0.1"

0·1"

0.1"

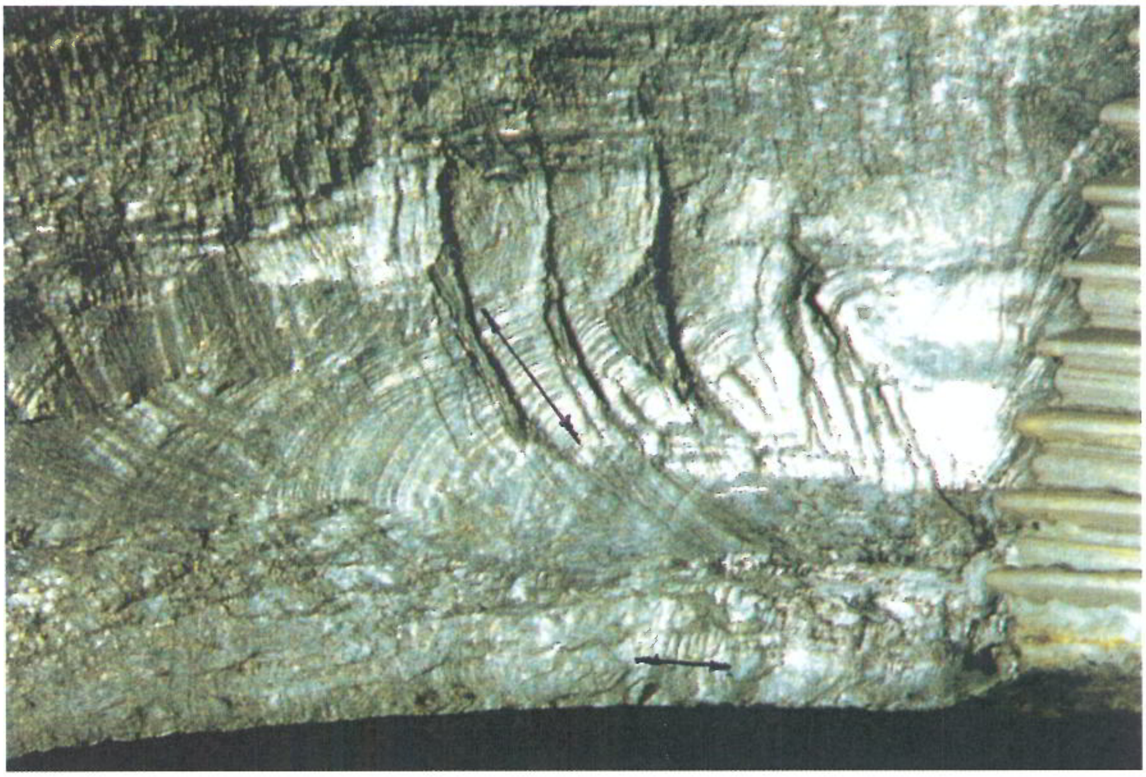


Figure 15 Position 1 on figure 13. Additional counts adjacent to the initiation region - 21 and 22.5 events in 0.1"

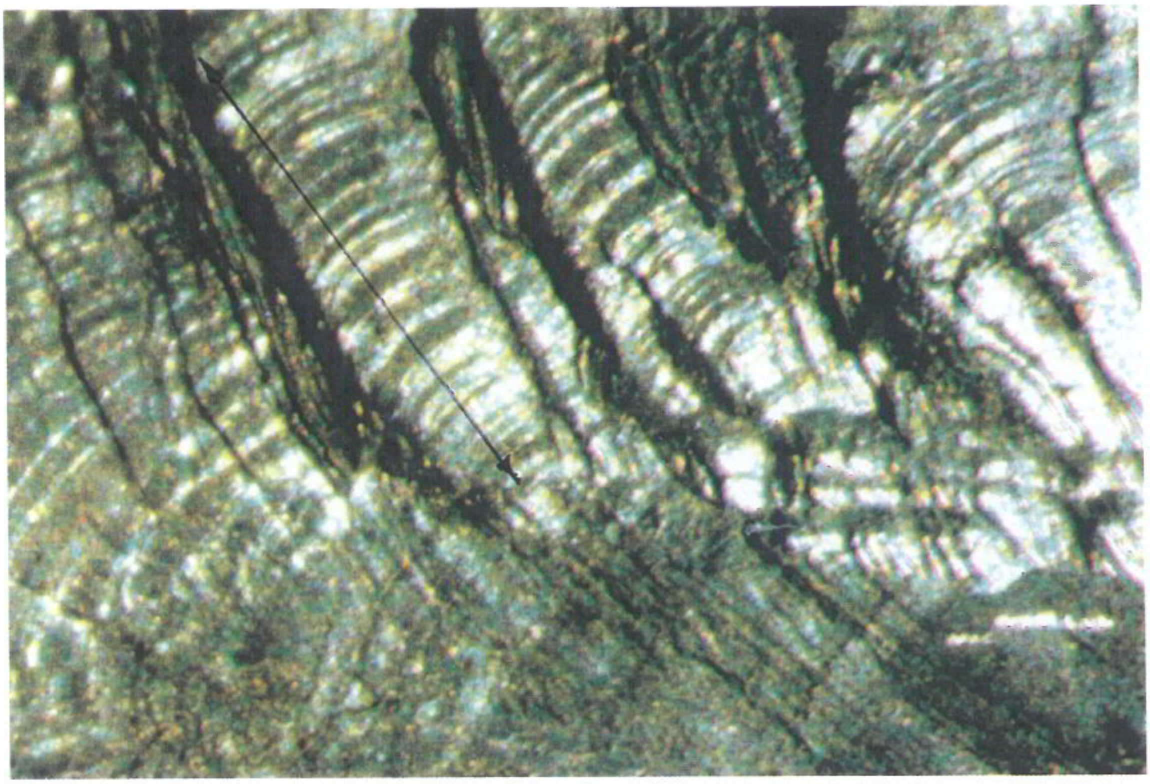


Figure 16 Count at position 2 on figure 13 - 18 events in 0.1"

0.1"

0.1"

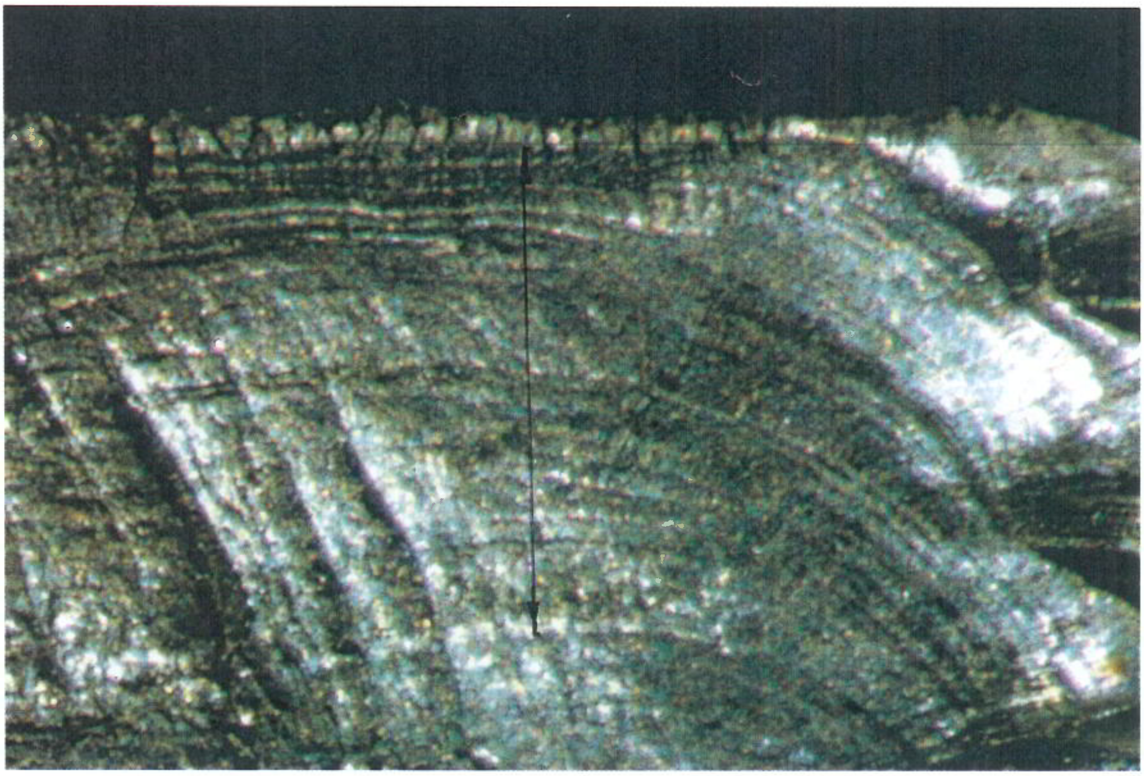


Figure 17 Count at position 3 on figure 13 - 33.8 events in 0.1"

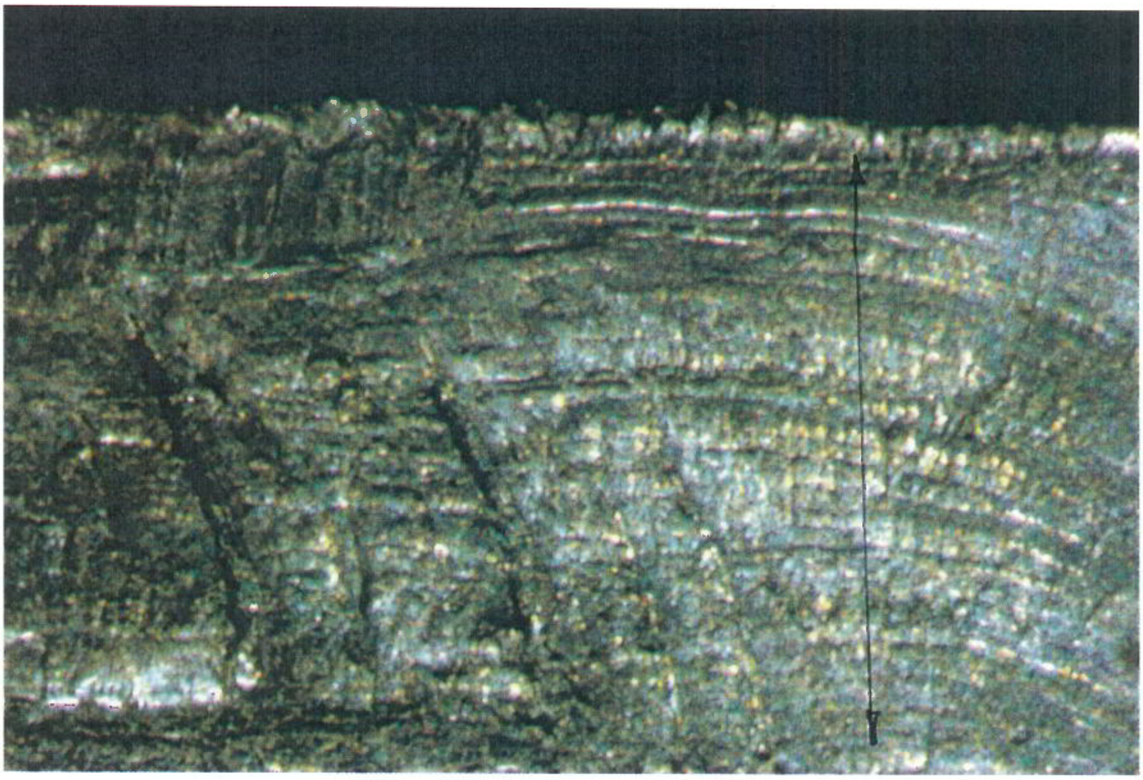


Figure 18 Additional counts at position 3 on figure 13 - 34.1 events in 0.1"

0.1"

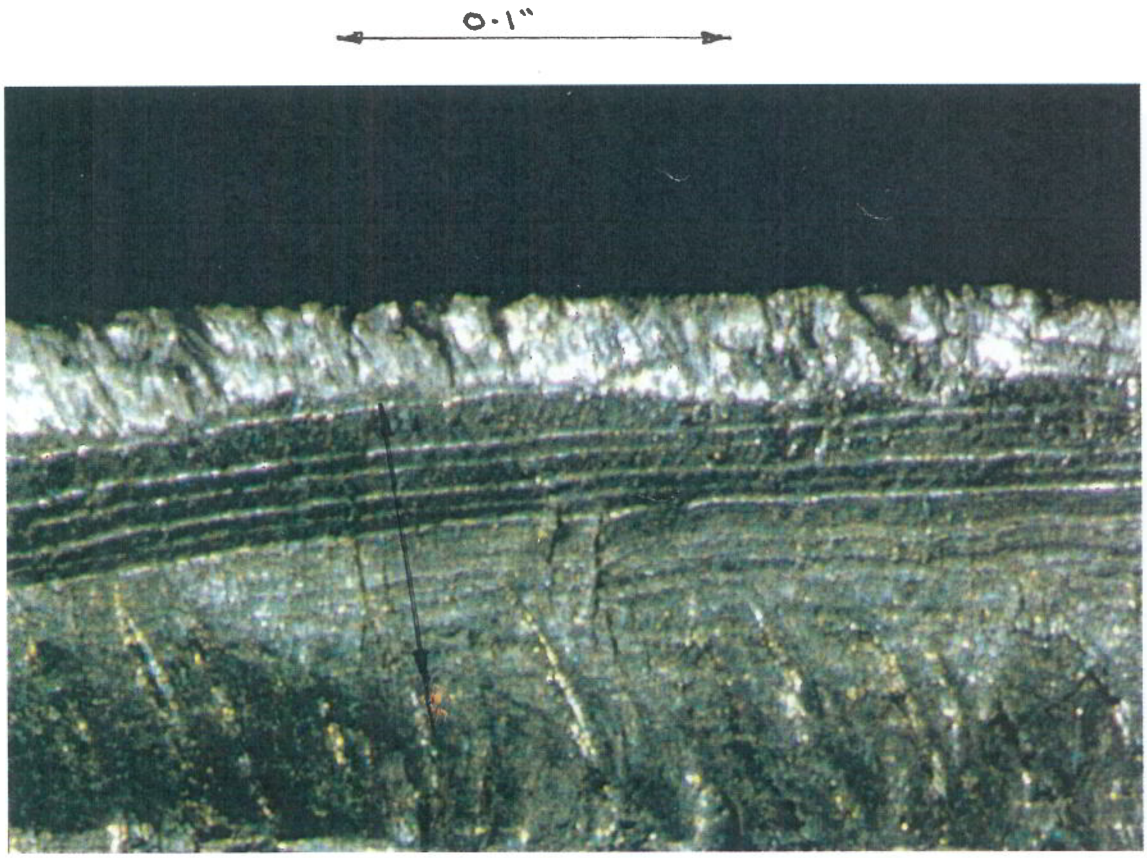


Figure 19 Count at position 4 on figure 13 - 18.6 events in 0.1"

Figure 20 Typical view of the fatigue progression in the fracture face on the opposite side of the hole. The progression rates are very similar to those shown on figures 14 to 19

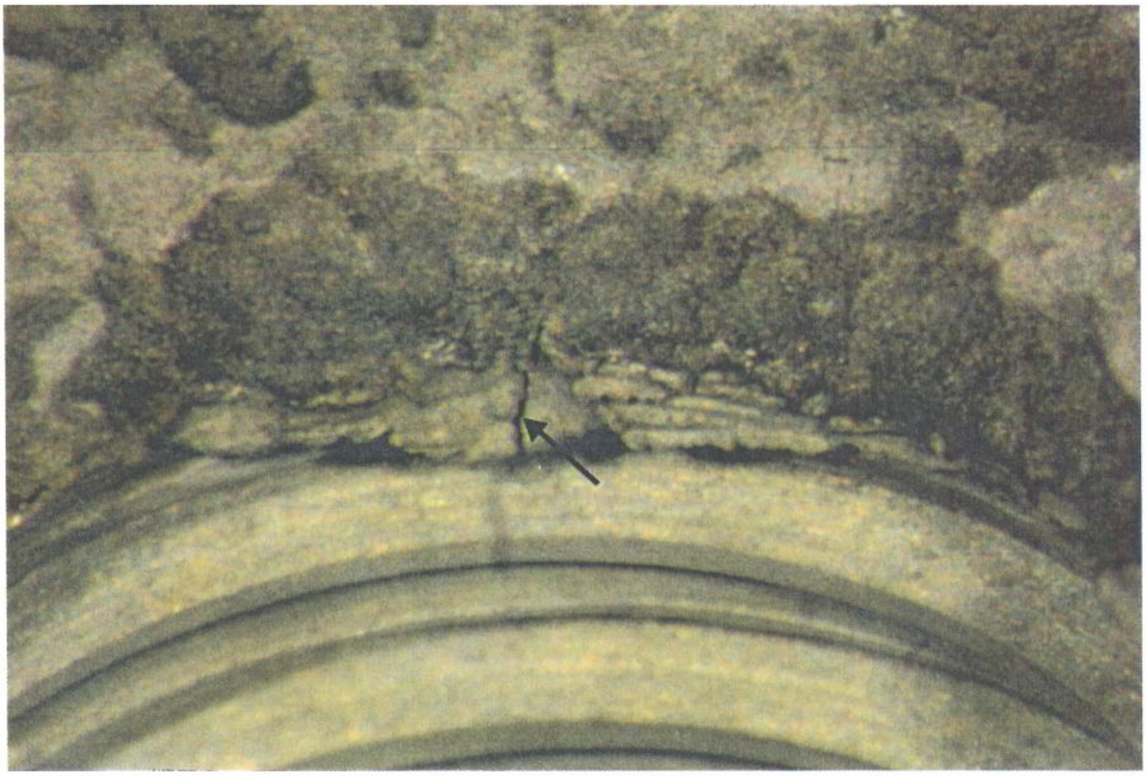


Figure 21 45° view on the inner end of the grease nipple hole showing a radial crack in the material grossly deformed by shot peening x36

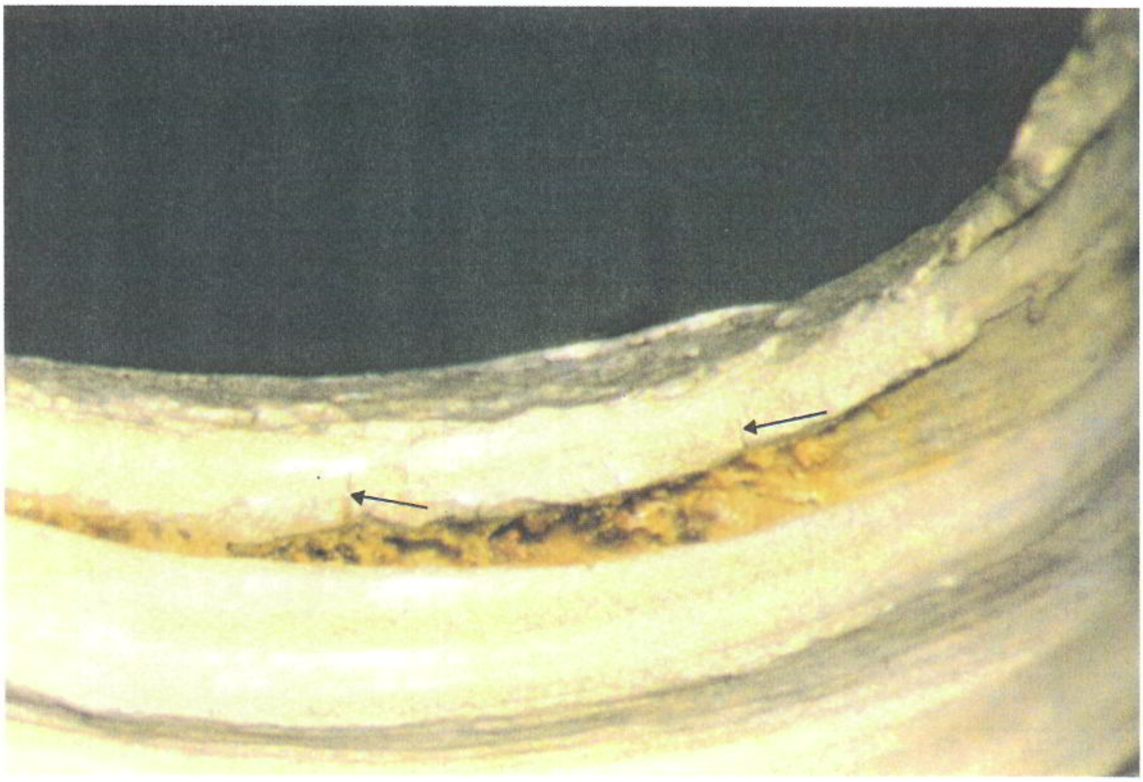


Figure 22 Two other radial cracks in the inner end of the same hole as that shown on figure 21 x36

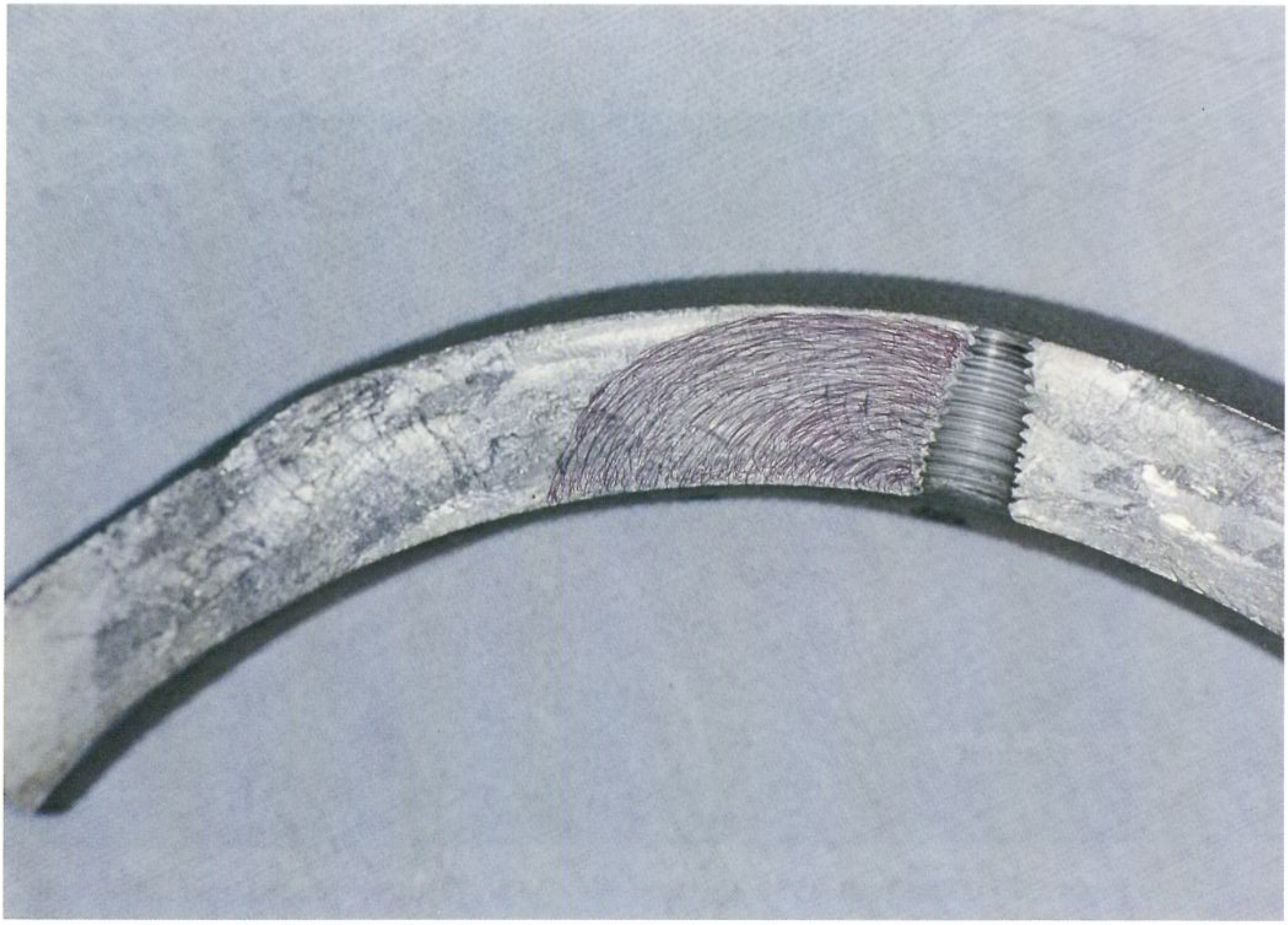


Figure 23 The fracture progression seen in the failure that is the subject of this report

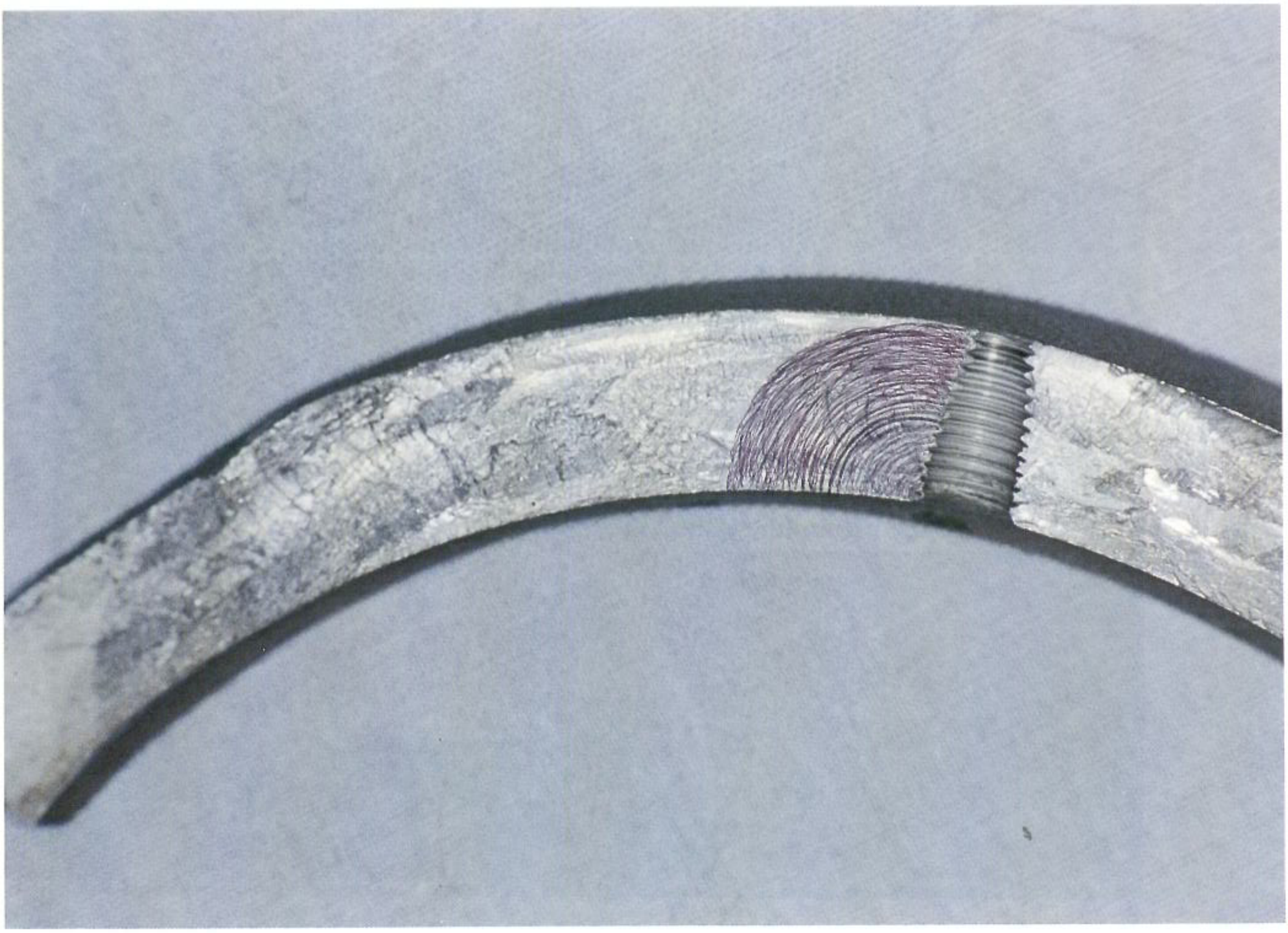


Figure 24 The fracture progression seen in photographs of previous hub failures

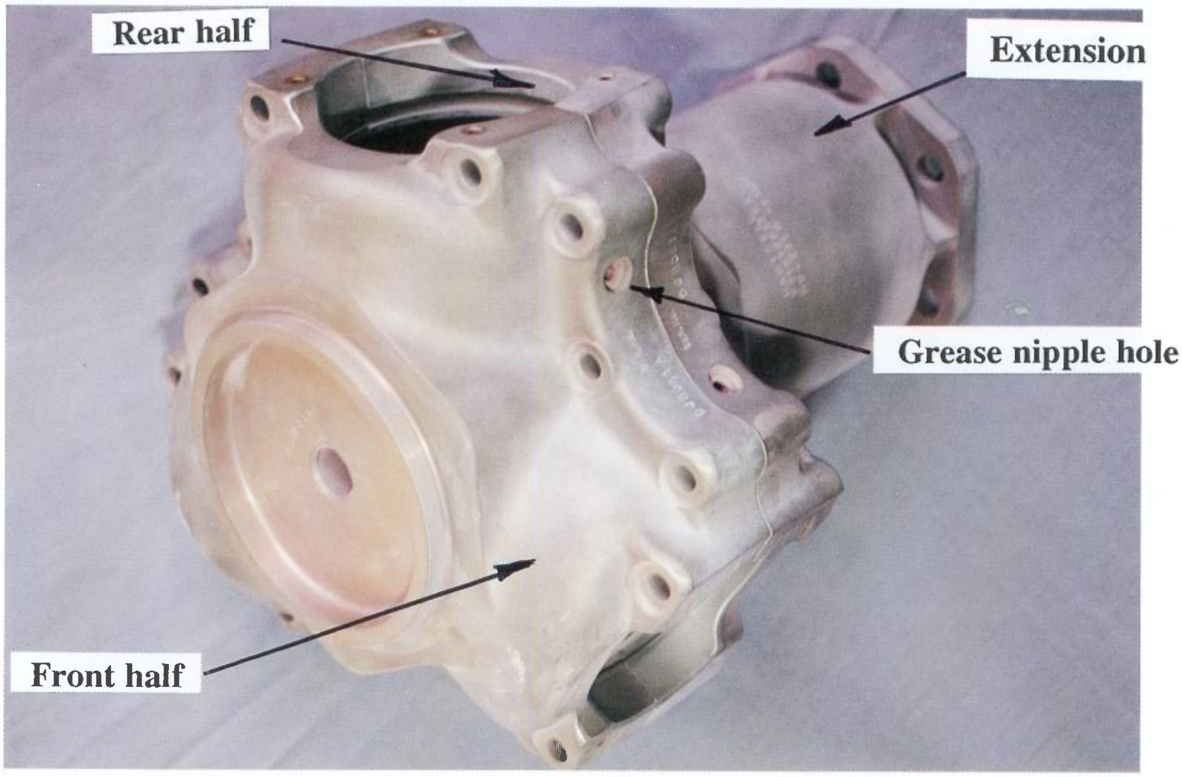


Figure 25 The post 1983 Hartzell HC-()3Y()-() three bladed propeller hub

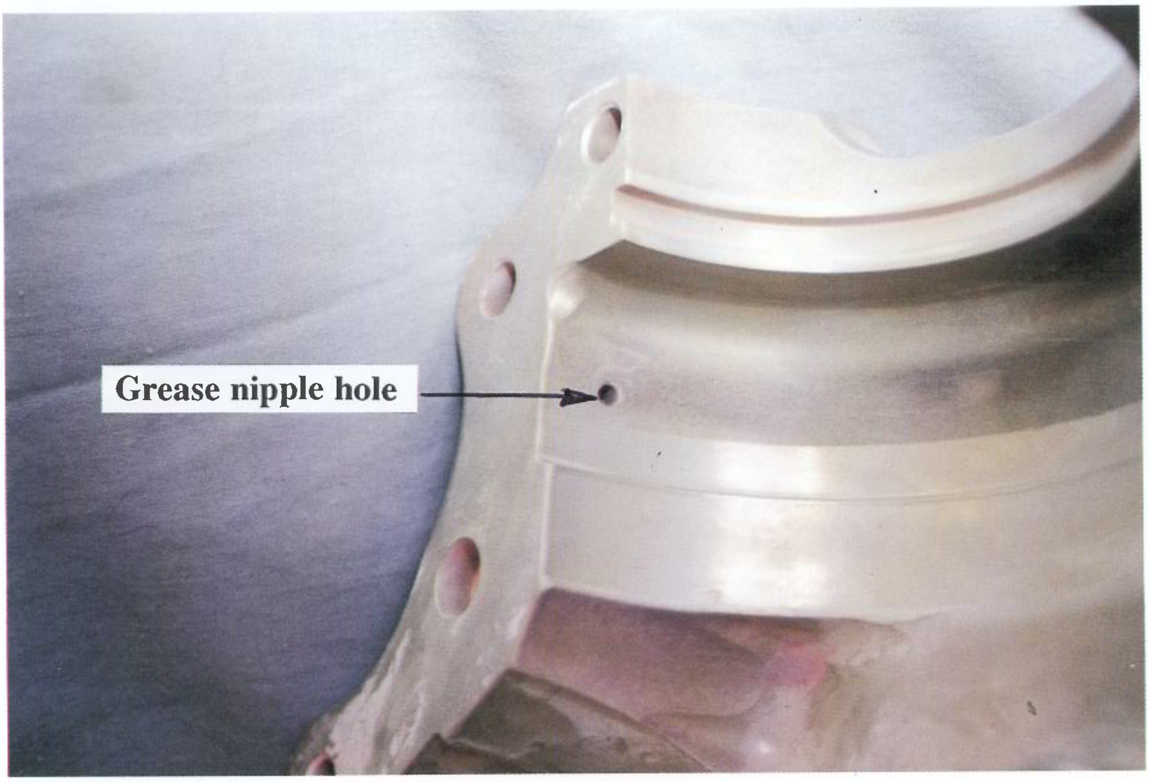


Figure 26 Inside view of the post 1983 Hartzell HC-()3Y()-() propeller hub