File.

FILE COPY

O T T A W A March 23, 1945.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1819.

Metallurgical Examination of Broken Section of 4-Wheel Drive Rear Axle Shaft.

(Copy No. 10.)

O T T A W A March 23, 1945.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1819.

Metallurgical Examination of Broken Section of 4-Wheel Drive Rear Axle Shaft.

Origin of Material and Object of Investigation:

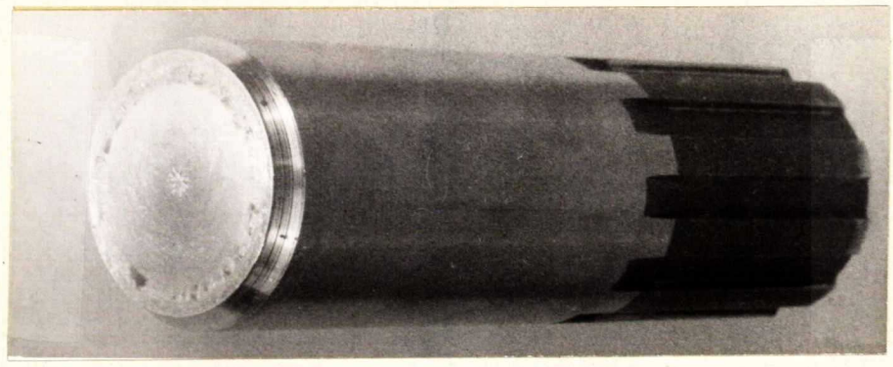
On January 29, 1945, one broken section of a four wheel drive rear axle shaft, Drawing 68543, Model H.A.R., (see Figure 1) was submitted for metallurgical examination by the Division of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario. Requisition No. 686 (A.E.D.B. Lot No. 580, Report 13, Test No. 68) requested that the cause of failure be determined.

The material specified on Drawing 68543 was SAE 4340, Brinell 375-425, Grain Size 6 to 8.

(Continued on next page)

(Origin of Material and Object of Investigation, cont'd) -

Figure 1.



BROKEN SECTION OF 4-WHEEL DRIVE REAR AXLE SHAFT.

Note coarse machining of fillet and lack of deformation at fracture.

(Approximately ¾ full size).

Visual Examination:

Visual examination revealed that very little deformation accompanied the fracture which occurred at the fillet. It was also noted that the fillet had been machined very poorly. The grooves resulting from this rough machining can be seen in Figure 1.

Macro-etching:

A longitudinal section of the shaft was etched in 50 per cent HCl for 30 minutes. Flow lines developed ran in the axial direction.

Chemical Analysis:

The results of the chemical analysis and specified composition for SAE 4340 steel are listed in Table I.

(Continued on next page)

(Chemical Analysis, cont'd) -

TABLE I.

	As Found	Specification SAE 4340
	- Per Cent -	
Carbon -	0.39	0.35-0.45
Manganese -	0.72	0.50-0.80
Silicon -	0.35	
Sulphur -	0.013	
Phosphorus -	0.025	
Nickel -	1.29	1.50-2.00
Chromium -	0.71	0.50-0.80
Molybdenum -	0.31	0.30-0.40
Vanadium -	Nil.	

Hardness Examination:

A hardness examination was made with a Vickers hardness tester employing a 30-kilogram load. The results are given in Table II.

TABLE II.

Vickers (30-kg. load)	Rockwell "C" (converted)	Brinell (converted)
385 to 406	39.5 to 41	365 to 385

Drawing No. 68543 specifies 375 to 425 Brinell.

McQuaid-Ehn Test:

The McQuaid-Ehn grain size was found to be 6 to 7, as shown in Figure 2 (etchant, boiling sodium picrate).

Microscopic Examination:

Figure 3, taken at X750 magnification, shows the microstructure of the steel to be tempered martensite.

Discussion and Observations:

The chemical content of the steel satisfactorily complies with the specifications for SAE 4340 steel, with the exception of the nickel which is 0.21 per cent under the specified minimum. However, this slight deficiency would not

(Discussion and Observations, cont'd) -

account for the failure.

The hardness, which ranged from 365 to 385 Brinell, may be considered satisfactory when compared with the required 375 to 425 Brinell.

The grain size of 6 to 7, as revealed by the McQuaid-Ehn test, satisfactorily complies with the specifications.

Microscopic examination indicated a structure which is normal for quenched and drawn SAE 4340 steel. Very little distortion of the metal at the fracture was evident, thus indicating failure in either fatigue or impact. The nature of the fractured surface strongly indicates the former. The normal quantity and distribution of inclusions was noted.

Since the flow lines occurred axially, failure cannot be attributed to the forging operation.

It is thought that the condition of the fillet was at least a contributing cause of failure, since the roughness of the surface would materially lower the fatigue strength.

The radius of the fillet was 3/8 inches, as called for by the drawing, and may be considered satisfactory.

Conclusions:

1. The axle was found to be metallurgically sound.

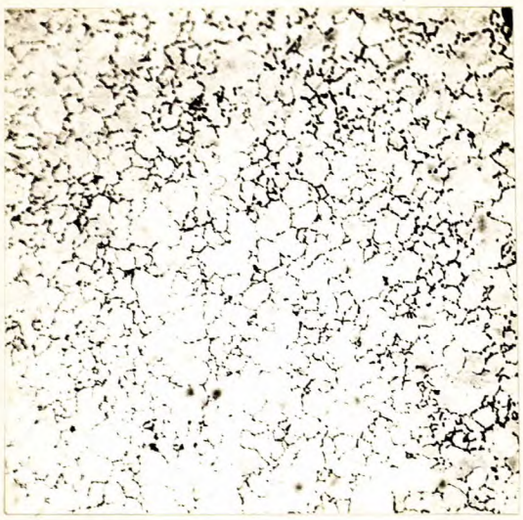
2. Failure can be attributed to overstressing. This may well have been local, due to the faulty machining of the fillet.

3. Failure of the type encountered in this investigation may be minimized by (a) careful machining, and (b) employment of a large radius fillet.

oooooooooo
ooooo
o

AF:GHB.

Figure 2.



X100, sodium picrate etch.

McQUAID-EHN TEST

Grain size - 6 to 7.

—

Figure 3.

X750, nital etch.

MICROSTRUCTURE OF AXLE AS RECEIVED.

Tempered martensite.

—

AF:GHB.