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OTTAWA May 21, 1945.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1871.

Metallurgical Examination of Steering End Ball Sockets from Armoured Truck.

(Copy No. 14.)

Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

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Origin of Material and Object of Investigation:

On April 20, 1945, the Division of Metallurgy, of the Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario, submitted for metallurgical examination three (3) steering end ball sockets which had failed in service. These three failed ball sockets were submitted under Requisition No. 695 and designated as follows:

No.

1 - A.E.D.B. Lot No. 588, Ford Motors.
2 - " " " 588, " "
3 " " " 589, General Motors supply.

On May 1, 1945, two additional ball sockets which had given satisfactory service for over 19,000 miles were submitted. The two satisfactory sockets were submitted under Requisition No. 696 and designated as:

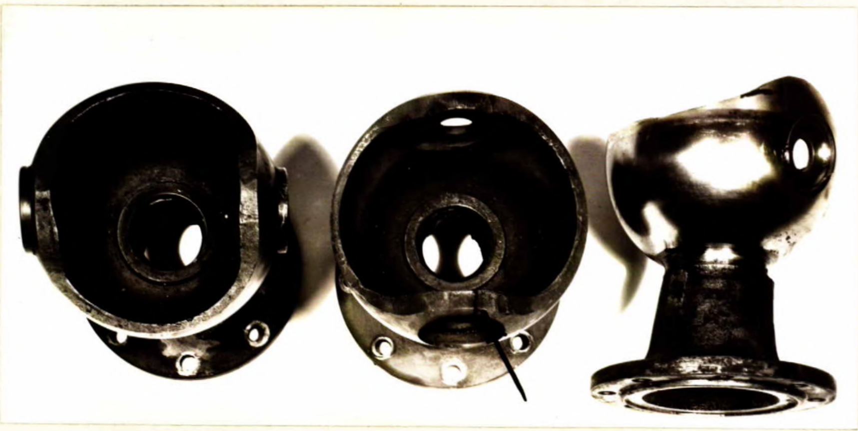
No.

4 - A.E.D.B. Lot No. 590.
5 - " " " 590.

(Continued on next page)

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

Figure 1.



THE THREE FAILED STEERING END BALL SOCKETS
AS RECEIVED.

Figure 2.

CRACK IN BALL SOCKET NO. 2 (see
arrow, Figure 1), ENLARGED.

Hardness:

Brinell hardness readings were taken on the neck of each casting.

(Continued on next page)

(Hardness, cont'd) -

TABLE I. - Hardness Readings.

Ball Socket No.		Brinell Hardness, (3,000-kg. load)
1	-	220-229
2	-	200-201
3	-	197-201
4	-	179-183
5	-	192-197

Chemical Analysis:

TABLE II. - Chemical Analysis.

		Socket No. 1	Socket No. 2	Socket No. 3	Socket No. 4	Socket No. 5
Carbon	-	0.38	0.41	0.52	0.34	0.34
Manganese	-	0.80	0.77	0.93	0.65	0.63
Silicon	-	0.30	0.27	0.35	0.33	0.33
Phosphorus	-	0.044	0.056	0.032	0.029	0.034
Sulphur	-	0.043	0.050	0.060	0.042	0.041
Copper	-	0.24	0.11	0.34	0.09	0.08

Mechanical Properties:

Two tensile specimens, 0.282-inch in diameter, were prepared from each casting. The mechanical properties determined are shown in Table III.

TABLE III. - Mechanical Properties.

Socket No.	Maximum stress, p.s.i.	Yield strength, p.s.i.	Elongation, per cent in 1 inch	Reduction in area, per cent	Vickers hardness on specimen
1.	93,200	82,300	6.0	11.3	233
	81,600	77,800	6.0	3.2	
2.	91,300	64,500	5.0	14.5	206-209
	83,900	62,200	4.0	8.0	
3.	100,600	75,500	20.0	22.8	206
	99,400	77,400	14.0	22.5	
4.	77,400	-	*	-	215-224
	113,900	84,200	*	-	
5.	93,200	70,300	*	-	235-253
	103,900	71,600	8.0	9.7	

* Broke outside gauge mark.

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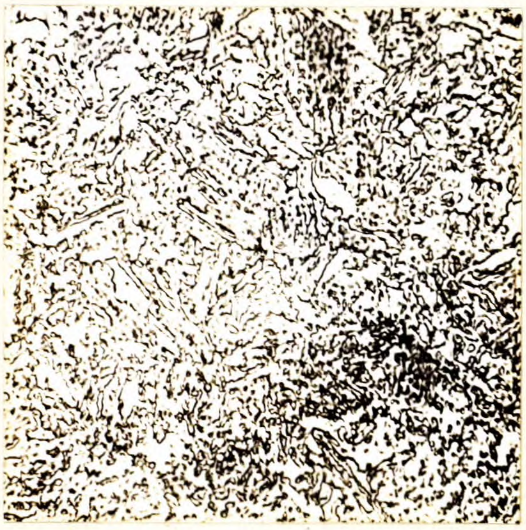
Microscopic Examination:

Microscopic examination of specimens cut from each ball socket disclosed that the three castings submitted because of failure had a similar microstructure, consisting of spheroidized carbides in a spheroidized matrix, produced, no doubt, by drawing at a temperature just under the lower critical. These microstructures are illustrated in Figures 3 and 4, photomicrographs at 1000 and 1500 diameters of Sockets Nos. 2 and 3 respectively.

There was no decarburization at the surface of the unsatisfactory castings.

The microstructures of the satisfactory sockets (Nos. 4 and 5) were different in two respects: (a) they consisted of ferrite and tempered martensite, as shown in Figure 5 (a photomicrograph, at X1000, of Socket No. 4); and (b) both sockets were decarburized to a depth of 0.040 inch.

Figure 3.



X1000, etched in
2 per cent nital.

Ball Socket No. 2.

Drawn martensite and
spheroidized carbides.

Figure 4.

X1500, etched in
2 per cent nital.

Ball Socket No. 3.

Note spheroidized
carbides.

(Continued on next page)

(Microscopic Examination, cont'd) -

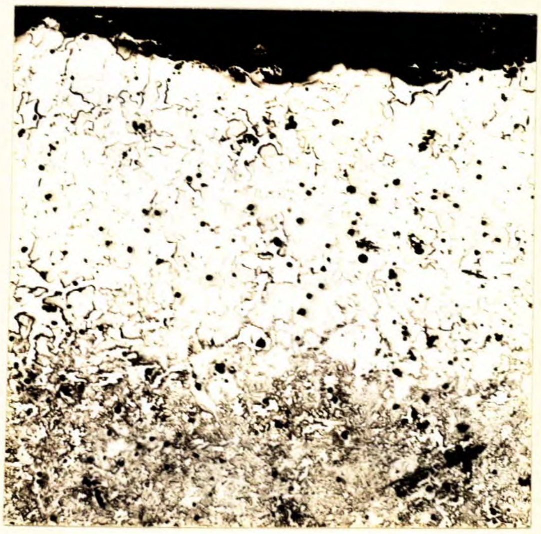
Figure 5.

X1000, etched in
2 per cent nital.

Ball Socket No. 4.

Ferrite and drawn
martensite.

Figure 6.



X50, etched in
2 per cent nital.

Surface of Ball Socket No. 5.

Partial decarburization,
to depth of 0.040 inch.

Discussion:

It should be first pointed out that the sockets submitted have been arbitrarily classified as being either good or bad, and that while differences in material might be responsible for the socket's classification it is also possible that sockets rated as good were only so classified because they were not so severely tested. Where three out of five articles are rated defective the whole production must be suspect.

Chemical analyses and hardness and tensile testing have not shown any significant difference between sockets rated satisfactory and those classed as unsatisfactory. Deformation of the former class in service, however, definitely shows that the castings lack sufficient yield strength to withstand loads imposed. Tests made on tensile

(Discussion, cont'd) -

test bars cut from the casting do not show any significant difference between the yields of the "satisfactory" and unsatisfactory castings. This may be due to the known fact that results obtained from tensile test bars cut from castings may not be dependable. As pointed out above, it may also indicate that the so-called satisfactory castings might have proved unsatisfactory under somewhat more severe service.

The only discoverable significant difference in the two classes of sockets is in their microstructure, the "satisfactory" castings certainly showing less spheroidization of the carbide phase and possibly a somewhat higher ferrite content. Definitely, then, the "satisfactory" castings were drawn at a lower temperature. In mass production heat treatment one would expect that the drawing temperature would be held constant. The structural difference, then, might be due to the fact that the temperature of the furnace varies from point to point despite the temperature control arrangements provided. This is very likely in a large box type electric furnace not provided with air circulation. The fact that Casting No. 3 has approximately the same hardness as castings which have at least 0.15 lower percentage of carbon, however, definitely indicates that the draw temperature has been adjusted to control the effects of composition variations.

Castings Nos. 4 and 5 definitely contain free ferrite and the other castings probably do, the ferrite areas in these latter cases being masked by the spheroidal matrix. The presence of this ferrite definitely indicates either too low a hardenability or a poor quench. Previous work in these Laboratories has shown that a casting of the

(Discussion, cont'd) -

same type and approximate composition can be properly quenched, so long as sufficient volume and agitation of water are provided. If conditions are such that this latter cannot be guaranteed the composition of the steel should be adjusted to provide for higher hardenability. If this should be necessary a manganese-molybdenum composition is suggested.

Surface decarburization is responsible for the differences in the hardnesses reported for Sockets Nos. 4 and 5 in Tables I and III respectively as the 0.040 partial decarburization shown in Figure 6 had not been completely removed before hardness testing. Brinell surface hardness tests taken on the neck of the sockets (Table I) have been recorded in this report as this is the mode of inspection testing. This surface decarburization would lower the fatigue strength of the casting but in this particular case this is not of importance as failure is not produced by the action of alternating stress.

If improved service is to be obtained from ball socket joints of this design the yield strength must be increased despite all consideration of the effect of higher hardness on machinability. This can only be obtained by making the quench more severe or changing to a composition which would produce higher hardenability. If machinability of the casting cannot be altered, a design change will have to be made.

Incidentally, the practice of specifying only the Brinell hardness for a part in which the yield strength is the criterion of quality is not considered sound, as materials of the same hardness can have wholly different yield strengths.

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