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April 18th, 1945.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1843.

Heat Treatment of Jungle Track Link Connectors
to Increase Surface Hardness.

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Origin of Material and Object of Investigation:

On March 26, 1945, the Directorate of Development of Vehicles and Small Arms, Department of National Defence (Army) Ottawa, Ontario, submitted link connectors (dumbbells and bushings) from two pilot sets of jungle track, requesting in an accompanying letter, File HQS 8928-11-61 (DVSA), that these connectors be heat-treated to increase the surface hardness. It was reported that the dumbbells were made from N.E. 8620 steel, the bushings from SAE 1035 steel, and that both sets were in the unheat-treated condition.

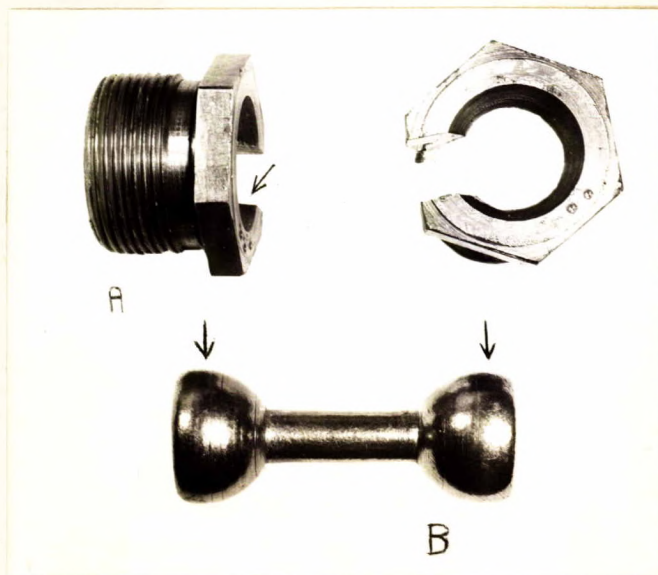
A field test had been attempted with one set of these connectors in a jungle track but had had to be discontinued after approximately 30 miles because of excessive wear on both bushings and dumbbells. The other set of connectors had not been used.

General:

The bushings and dumbbells and their function as jungle track link connectors are shown in Figures 1 and 2. Each pilot set of jungle track contained approximately 400 bushings and 200 dumbbells.

After the first thirty miles of field test, the bearing surfaces (shown by arrows in Figure 1) were badly scored and had worn away rapidly and unevenly.

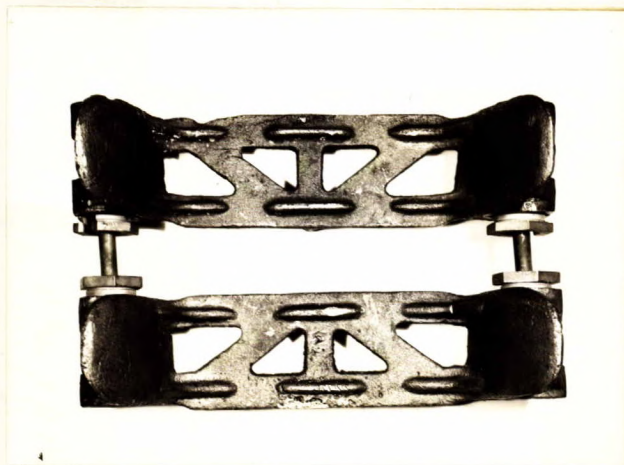
Figure 1.



(A) BUSHING (UNUSED).
(B) DUMBELL (UNUSED).

Arrows indicate wearing surfaces where excessive wear occurred during first 30 miles of field test.

Figure 2.



TWO LINKS OF JUNGLE TRACK,
WITH CONNECTORS IN PLACE.

Chemical Analysis:

One bushing and a dumbbell were selected at random for chemical analysis. Table I compares the results obtained with the reported specifications.

TABLE I. - Chemical Analysis.

| | <u>Bushing</u> | <u>SAE 1035 Specification</u> | <u>Dumbell</u> | <u>N.E. 8620 Specification</u> |
|------------|---------------------|-----------------------------------|----------------|------------------------------------|
| | | - P e r C e n t - | | |
| Carbon | - 0.15 [Ⓢ] | 0.32-0.38 | 0.21 | 0.18-0.23 |
| Manganese | - 0.33 [Ⓢ] | 0.60-0.90 | 0.80 | 0.70-0.95 |
| Sulphur | - 0.04 | 0.050 max. | -- | -- |
| Nickel | - - | - | 0.57 | 0.40-0.60 |
| Chromium | - - | - | 0.50 | 0.40-0.60 |
| Molybdenum | - - | - | 0.19 | 0.15-0.25 |

[Ⓢ] Not in agreement with reported composition.

Hardness of Connectors As Received:

| | <u>Vickers Hardness (10-kg. load)</u> | <u>Brinell Hardness</u> |
|------------|---|-----------------------------|
| Bushings - | 160-170 | 160-170 |
| Dumbells - | 170-190 | 170-190 |

Heat Treatment:

After trials to determine the heat treatment that would give minimum warpage and optimum hardness, it was decided to water-quench the dumbells and to case-harden the bushings (which were lower in carbon). Details of these heat treatments are as follows:

Dumbells -

45 minutes at 1575° F. in neutral atmosphere of Vapocarb furnace, quenched in water, drawn for 1 hour at 400° F.

Resultant surface hardness, 35-38 Rockwell "C" (332-352 Brinell).

Bushings -

Gas-carburized 1½ hours in Vapocarb furnace at 1675° F., cooled in furnace in neutral atmosphere to 1400° F., quenched in oil at 110° F., drawn for 1 hour at 500° F.

Resultant surface hardness, 72-75 Rockwell "A" (430-470 Brinell).

Microscopic Examination:

The results of heat treatment were checked by microscopic examination. The microstructures of bushings and dumbbells "as received" are shown in Figures 3 and 4. Both are in the annealed condition and consist of a mixture of ferrite and pearlite, the higher carbon content of the dumbbells being evident by the greater proportion of pearlite (dark constituent) in Figure 4.

Microstructures after heat treatment are shown in Figures 5 and 6. A high-carbon martensitic case 0.020 to 0.030 inch in depth has been obtained on the bushings. The dumbbells have a uniform structure of tempered martensite.

Figure 3.

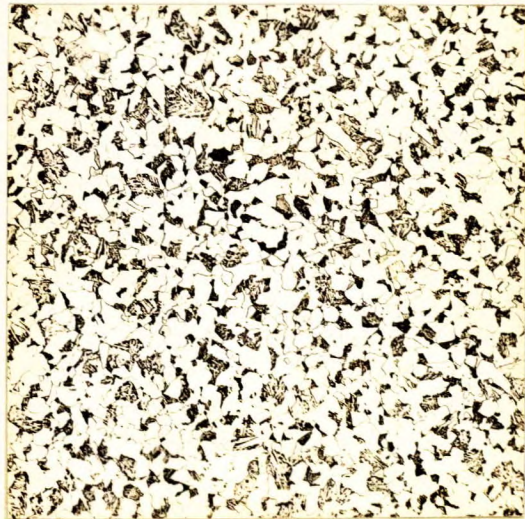


X100, etched in
2 per cent nital.

MICROSTRUCTURE OF UNHEAT-
TREATED BUSHING.

Hardness, 160-170 Brinell.

Figure 4.



X100, etched in
2 per cent nital.

MICROSTRUCTURE OF UNHEAT-
TREATED DUMBELL.

Hardness, 170-190 Brinell.

(Microscopic Examination, cont'd) -

Figure 5.

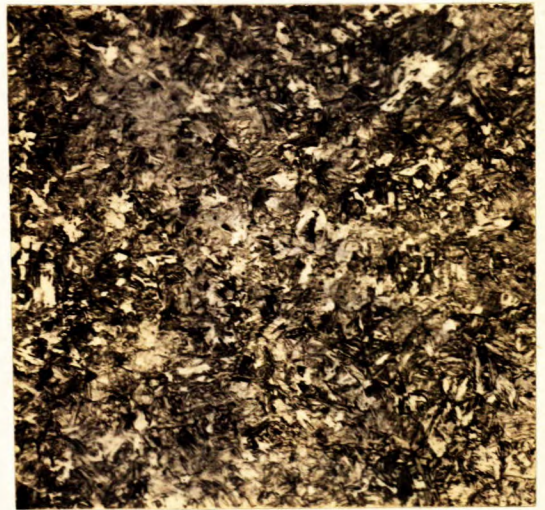


X50, etched in
2 per cent nital.

CASE-HARDENED SURFACE OF
HEAT-TREATED BUSHING.

Case, 0.025 to 0.030 inch deep;
hardness at surface, 430-470 Brinell.

Figure 6.



X500, etched in
2 per cent nital.

MICROSTRUCTURE OF
HEAT-TREATED DUMBELL.

Hardness, 330-350 Brinell.

Discussion:

The two sets of jungle track link connectors, comprising approximately 800 bushings and 400 dumbells, have been heat-treated to a surface hardness which will give greatly improved resistance to wear during service.

At the writing of this report one set had been installed in a track and after 68 miles of field test appears to be wearing well. The bearing surfaces are polishing rather than scoring as they did before heat treatment.

Although the connectors will give better service with the increased surface hardness, neither the present steel nor its hardness is considered suitable for parts, such as these, which are subject to severe wear as well as considerable stress.

It is recommended that both bushings and dumbells

(Discussion, cont'd) -

be made from a steel of sufficient hardenability and carbon content to be homogeneously hardened to Rockwell "C" 45 \pm 3 by oil-quenching and tempering. Suitable steel specifications for this purpose would include N.E. 8650 and SAE 4140, 4340, 3140, and 3250.

Conclusions:

(1) Two pilot sets of jungle track link connectors have been heat-treated to the following surface hardness:

Dumbbells, 35-38 Rockwell "C".
Bushings, 72-75 Rockwell "A".

The connectors are expected to give much better service than when used in the unheat-treated condition.

(2) It is considered that the jungle track link connectors may be improved by changing from the present type of steel and heat treatment to a steel which could be homogeneously hardened to Rockwell "C" 45 \pm 3.

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