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O T T A W A July 12th, 1944.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1677.

Examination of Broken Bolts from Snowmobile Track.

(Copy No. 10.)

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Division of Metallic
Minerals.
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Ore Dressing
and Metallurgical
Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

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Abstract

Metallurgical examination of broken bolts from snowmobile track indicates that failure is due to fatigue.

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Origin of Material and Object of Investigation:

On June 29th, 1944, Prof. J. U. MacEwan, of the Division of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario, submitted specimens of broken bolts (Drawing A39752) which had failed after approximately 800 miles of service in a snowmobile. Requisition No. 653, A.E.D.B. Lot No. 546, Report No. 107, Section "D", Test No. 15, requested that the chemical analysis and physical condition of the bolts be determined.

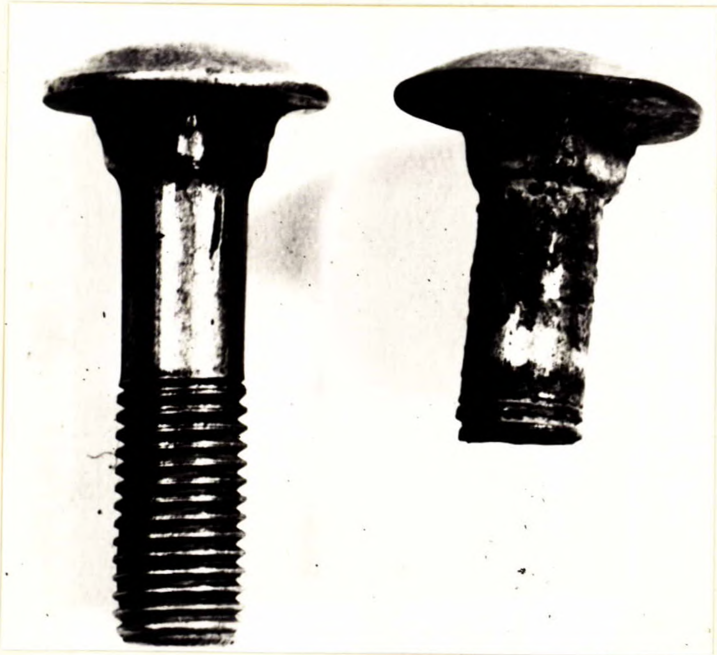
Chemical Analysis:

		As Found	S.A.E. 1035 Specification
		- Per cent -	
Carbon	-	0.35	0.32-0.38
Manganese	-	0.61	0.60-0.90
Silicon	-	0.24	0.15-0.30
Phosphorus	-	0.012	0.040 max.
Sulphur	-	0.027	0.050 max.

Macroscopic Examination:

The bolts are of the rolled-thread type. The point of failure was located at the second thread in all specimens, and fractures are of the duplex type typical of fatigue failures. (See Figures 1 and 2).

Figure 1.



BROKEN AND UNBROKEN BOLTS.

(Approximately three times actual size).

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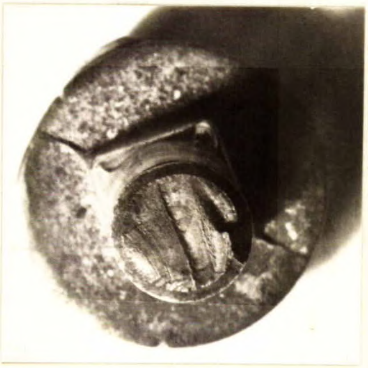
Figure 2.



FATIGUE-TYPE FRACTURE.

(Approximately three times actual size).

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Hardness Survey:

Two bolts were sectioned longitudinally and Vickers hardness readings, using a 10-kilogram load, were taken across the sections. Readings varied from 251 to 256 Vickers (251 to

(Hardness Survey, cont'd) -

255 Brinell).

Microscopic Examination:

Microscopic examination of bolts sectioned longitudinally revealed a homogeneous sorbitic structure (see Figure 3, a photomicrograph at X250 magnification). Careful examination of all surfaces failed to show any decarburization.

Figure 3.

X250, etched in
2 per cent nital.

MICROSTRUCTURE OF BOLT.

Discussion:

The bolts have a chemical composition which meets S.A.E. 1035 specifications, and are suitably heat-treated to the specified hardness (200-260 Brinell). The fractures at the points of failure show that breaking is caused by fatigue as the result of relatively high alternating stresses. This is further substantiated by the fact that the bolts had withstood 800 miles of service and then started to fail in considerable numbers. These bolts, being of the rolled-thread type and free from decarburization, have a fatigue limit which approaches the optimum for their present hardness. No metallurgical

(Discussion, cont'd) -

defects were discovered. Consequently, it is concluded that the bolts did not have the strength required to resist the alternating service stresses.

Increase in fatigue life of a part operating under alternation stresses can be achieved (1) by increasing the endurance limit of the steel or (2) by lowering tension stress concentration. The former would be achieved by increasing the bolt hardness, possibly requiring a change to a suitably heat-treated alloy steel; however, it should be noted that this procedure, for a bolt, might conceivably increase stress concentration at the base of the thread since the material although stronger would be more notch-sensitive (i.e., would not relieve stresses by plastic deformation) at the point of marked stress concentration than a softer material. As a result, the material, although stronger, is subject to a much higher unit stress and consequently would fail before the softer material. Laboratory tests designed to simulate service and field tests would show whether the fatigue strength would be increased or decreased if the former treatment were given the bolts. The possibility of increasing bolt life by some type of surface treatment should not be overlooked.

Fatigue failure is usually produced by tensile stress. It is thought that the range of tensile stress alternation would be reduced if the bolt were tightened under a greater torque than is used at present, because if the original tensile strength of the bolt is high the percentage of stress that is alternating is reduced (as added stress is not only supported by the bolt but by the material against which the bolt is pressed). Stress concentration might also be reduced by using a bolt with a shank section of lesser diameter than the section at the base of the threads. It is also thought that better

(Discussion, cont'd) -

service would be obtained if the bolt were run through a steel sleeve and placed in tension against the shoulders of the sleeve.

CONCLUSIONS:

1. Chemical composition agrees with S.A.E. 1035 specifications.

2. The bolts have been suitably heat-treated to the specified hardness.

3. Failure was caused by fatigue.

4. Better service in the field most probably would be obtained with a bolt of higher endurance limit, i.e., by increasing the hardness of the present steel or by the adoption of a suitable alloy steel. There is a possibility, however, that a weaker and less notch-sensitive material would give better service. Only properly designed tests will show which procedure should be adopted.

Recommendations:

1. A bolt of higher hardness could be expected to have a higher fatigue life, consequently bolts with a hardness of from 300 to 350 Brinell should be tried on the vehicle. If these bolts fail more rapidly in fatigue, a softer bolt than used at present would likely give better service.

2. The possibilities of surface treatments should be investigated.

3. A laboratory fatigue test should be developed that will give a measurement of the fatigue life of the bolts.

4. Conditions of assembly in the field should be investigated, to eliminate as much of the alternating stresses as possible. This may be accomplished by increasing bolt tension but may also involve design changes.

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