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OTTAWA May 13th, 1944.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1642.

Metallurgical Examination of Three Sizes of Pivot Mechanisms for Fuze No. 208.

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(Copy No. 10.)

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

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

OTTAWA May 13th, 1944.

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Origin of Request and Object of Investigation:

On April 25th, 1944, a quantity of small gears for Fuze No. 208 were submitted, under Analysis Requisition O.T. 4180, by Mr. J. M. Gilmartin, I.O.M., for Inspector of Materials, Inspection Board of United Kingdom and Canada, Ottawa, Ontario.

A covering letter (File 12/4/3) stated that trouble had been experienced with the pivots breaking off the gears and requested a metallurgical examination to determine whether the failures were due to some inherent defect in the steel or to improper heat treatment. Mr. Gilmartin stated that the fuze components submitted were made from L.D.H. steel (trade mark name of the Crucible Steel Company). When the failures were noted a change was made to SAE X1335 steel, but it is not known whether this has removed the cause of failure.

Macroscopic Examination:

Several gears of each of three sizes were submitted. Figure 1 shows a representative gear, in good condition, of each size. Figure 2 is a photograph of gears of all three sizes, showing various types of failure. Figures 3, 4, 5 and 6, at a magnification of 10 diameters, show cross-sections of the various sizes of gears. These photographs show no signs of failure at any of the shoulders. Figures 5 and 6 must be combined to give a complete gear of the largest size.

Visual examination of all the gears submitted showed that by far the most common location of failure was the breaking off of the short pivot (portion 4, sketch page 3). In most cases the pivot broke off flush with the gear face, but in a few instances it broke so that a very small section remained as a projection from the gear.

Chemical Analysis:

The chemical analysis as determined is shown below, together with the nominal analysis for this type of steel:

		Nominal	As Found
		- Per Cent -	
Carbon	-	1.24	1.21
Manganese	-	0.28	0.30
Phosphorus	-	0.012	0.014
Sulphur	-	0.063	Not determined.
Silicon	-	0.16	0.22
Molybdenum	-	0.11	0.06
Nickel	-	Residual.	Trace.
Chromium	-	Residual.	Nil.

Hardness Tests:

Because of their size it was found impossible to make Vickers hardness determinations on the pivots of the two smaller sizes of gears. The hardness of the largest size of gear was 277 V.H.N. (average of 9 readings, using a 10-kg. load).

Representative gears of all three sizes were mounted and polished for micro hardness determinations. Table I shows

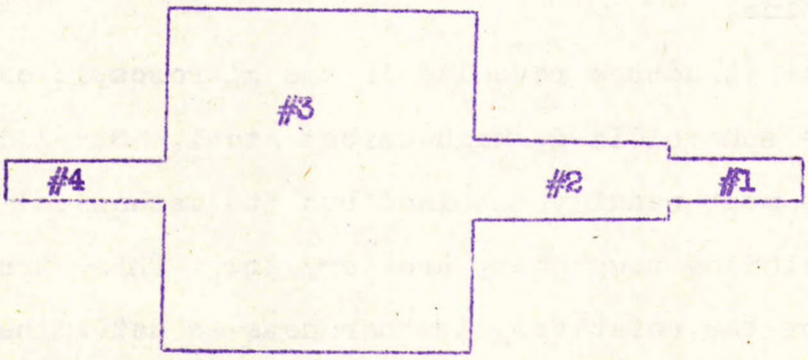
(Hardness Tests, cont'd) -

the Vickers hardness numbers obtained, by calculation, from the micro hardness results on the various sections of the three sizes of gears. It should be noted that the hardness values are very similar on each size of gear, although there is a slight difference between the various sizes. The results obtained are somewhat lower than those obtained using a Vickers hardness testing machine with a 10-kilogram load. In all cases the hardness of the pivots is similar to the hardness of the gear itself.

TABLE I. - VICKERS HARDNESS NUMBERS.

SIZE OF GEAR	LOCATION (as per sketch) No. 1 No. of determ.	No. 1 Avge. V.H.N.	No. 2 No. of determ.	No. 2 Avge. V.H.N.	No. 3 No. of determ.	No. 3 Avge. V.H.N.	No. 4 No. of determ.	No. 4 Avge. V.H.N.
Large	3	224	2	230	5	224	4	225
Medium	3	257	4	259	6	262	2	260
Small	2	276	3	278	6	282	3	276

SKETCH TO SHOW SECTIONING OF GEARS FOR MICRO HARDNESS DETERMINATIONS.



Microscopic Examination:

Specimens of all sizes of gears were hand polished, etched in 4 per cent picral for 20 seconds, and examined under a microscope. The structure in all cases was similar. This structure is shown in Figure 7, at a magnification of 1,000 diameters. It will be noted that it consists entirely of spheroidized carbides in a ferrite matrix.

Discussion of Results:

The chemical analysis agrees with the nominal analysis for this type of steel.

The macroscopic examination showed no evidence of failure at the shoulders on any of the gears examined. The corners are all very sharp and these may act as stress raisers, thus contributing to the failures.

The micro hardness determinations showed that there was no difference in hardness anywhere on the gears, including the pivots. The results obtained were in close agreement on each size of gear, in both the good and failed conditions, although there was some variation in the hardness as recorded on the different sizes. The Vickers hardness of the largest size of gear was 277 V.H.N., as determined on a Vickers hardness testing machine.

The structure revealed in the microscopic examination is that of a spheroidized, high-carbon steel. Steel in this condition is most readily machined but its mechanical properties, including toughness, are very low. This structure also explains the relatively low hardness as determined by the Vickers hardness machine.

Conclusions and Recommendations:

The spheroidized condition of this steel could be a contributory cause to the failure of the pivot since in this condition the steel is relatively weak and lacks toughness.

It is understood that these fuze components are now being made from SAE X1335 steel. There is a possibility of brittleness in this steel which might give rise to the same failures as found in the gears under examination; that is, the breaking-off of the pivots.

SAE 1335 steel would seem to be the most suitable steel for these pivot mechanisms but if, because of stocks on hand or for some other reason, it is necessary to use a high carbon steel, austempering of the parts is recommended. This relatively complex treatment is not recommended unless a high-carbon steel has to be used. SAE 1335 steel should be found satisfactory.

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ELC:GHB.

Figure 1.

Full size.

GEARS IN GOOD CONDITION.

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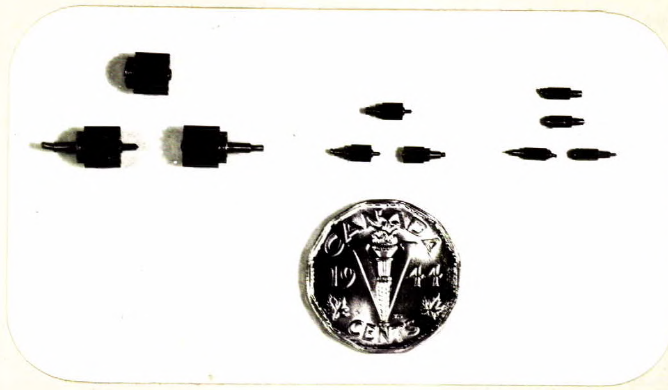
Figure 2.



Full size.

GEARS OF ALL THREE SIZES, SHOWING VARIOUS TYPES OF FAILURE.

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Figure 3.

X10.

SMALL-SIZED GEAR.

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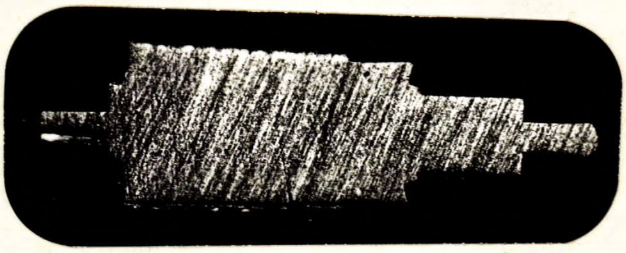
Figure 4.



X10.

MEDIUM-SIZED GEAR.

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Figure 5.

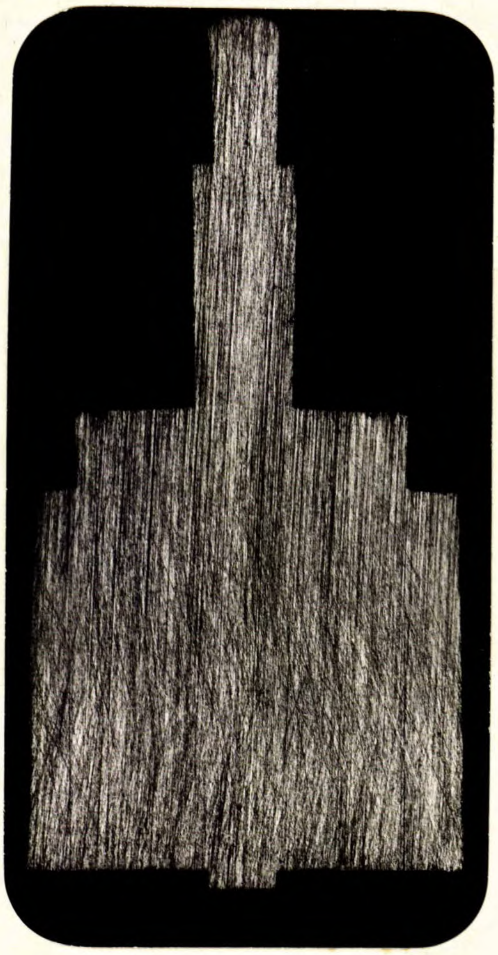
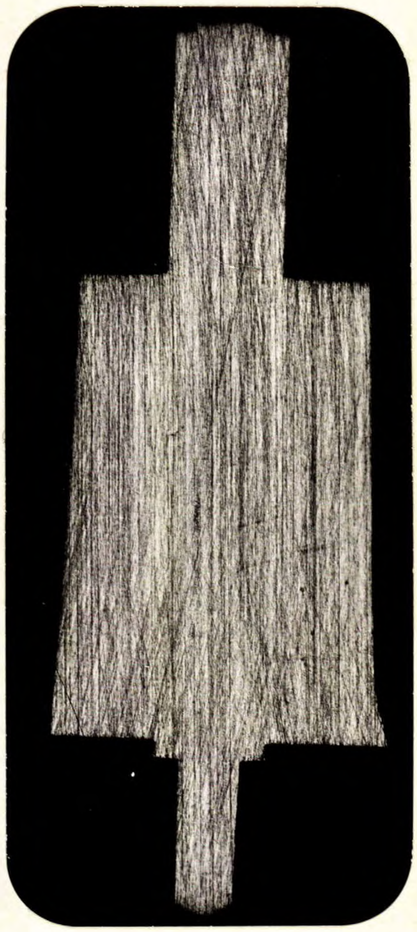


Figure 6.



X10.

COMBINED TO SHOW COMPLETE
LARGE-SIZED GEAR.

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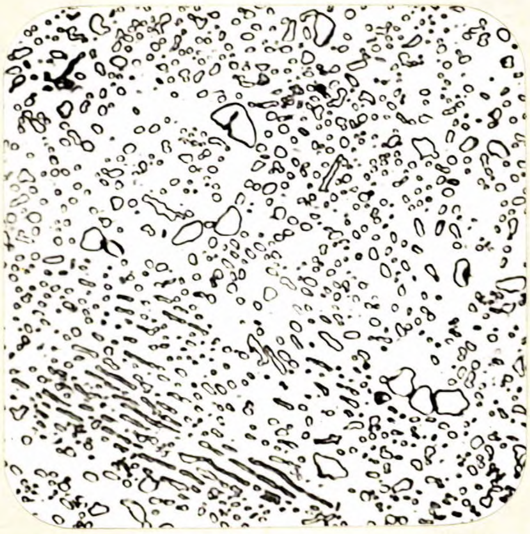
Figure 7.



X1000, picral etch.
STRUCTURE OF GEARS.
Note spheroidal carbides.

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ELC:GHB.