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OTTAWA March 7th, 1944.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1607.

Examination of Welded Feeder Levers for Oerlikon Gun.

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(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals.

Ore Dressing
and Metallurgical
Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

O T T A W A March 7th, 1944.

R E P O R T

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Examination of Welded Feeder
Levers for Oerlikon Gun.

Origin of Material:

On February 28th, 1944, Sub-Lieut. L. E. Sibley, on behalf of the Director of Technical Research, Department of National Defence, Naval Services, Ottawa, Ontario, submitted samples of welded feeder levers for Oerlikon guns for examination. On March 2nd, 1944, Sub-Lieut. R. G. McFarlane visited these Laboratories to bring additional samples and supply further information. The following is a résumé of the information so secured.

The original completed feeder levers were made by an unknown manufacturer. When the levers were put into service it was found that they were too short to function satisfactorily. Since between 6,000 and 7,000 were in stock, it was decided to attempt salvage by welding an extension to the end of the lever. This work is being done by Island Industries Limited, Montreal, Quebec. The tip of the lever is cut off, the edge veed, and a

(Origin of Material, cont'd) -

low-carbon extension strip is welded on from one side only, using the oxy-acetylene process and Airco No. 1 welding electrode. After welding, the lever is machined to the proper dimensions. Since it is desired to achieve a blue-black gunmetal finish on this part it is heated by the oxy-acetylene torch to a dull red heat and then quenched in oil.

The levers were then shipped to the Naval Ordnance Depot in Halifax. Here, a rough check on the impact resistance of the weld was made, by clamping the part in a vise and dropping a one-pound weight from a height of one foot onto the welded end. This test resulted in 23 out of the first 100 breaking in or near the weld.

Failure of a lever in service means that a gun is out of action. Under these circumstances it is, of course, highly desirable that this difficulty be cleared up with a minimum of delay.

Object of Investigation:

(1) To determine the cause of cracking of feeder levers.

(2) To make recommendations to eliminate cracking.

Procedure:

(1) The two original and one welded (cracked) levers were given a careful visual examination. Figure 1 shows the original and the salvaged levers. Figure 2 is a close-up of the cracked area of the salvaged lever.

(2) The cracked lever was sectioned through the centre in a longitudinal direction. Figure 3 shows this section after a light etch in 20 per cent nitric acid and alcohol solution.

(3) A transverse section through the weld and crack was polished, etched, and examined under a microscope. Figure 4

(Procedure, cont'd) -

shows the normal structure of the extension material. Figure 5 shows the structure of the heat-affected zone of the original lever material. Figure 6 shows the structure of the normal original lever material.

(4) Chemical analysis samples were machined from the extension material and the original lever material. The results of these analyses are shown in the table below, together with the stated analysis of the welding electrode used:

		Extension Material	Original Lever Material	Airco No. 1 Electrode
			- Per cent -	
Carbon	-	0.09	0.56	0.03-0.25
Phosphorus	-	0.008	0.017	0.035 max.
Sulphur	-	0.041	0.024	0.04 max.
Manganese	-	0.37	0.82	0.30-0.60
Silicon	-	Trace.	0.22	0.10-0.30
Chromium	-	Nil.	Nil.	0.30 max.
Nickel	-	Nil.	1.09	1.0-1.50
Molybdenum	-	Nil.	Trace.	Nil.

(5) Hardness readings were taken, using a Vickers machine and a 10-kilogram load. The table below lists the results obtained, in Vickers hardness numbers:

Normal Extension Material	Original Lever Material		Weld Metal
	Heat-affected zone	Normal	
118	251	191	131

Discussion:

A visual examination of the cracked lever reveals evidence of lack of complete penetration. Sections of this sample, examined under the microscope, confirm that this defect is present. It therefore seems highly probable that the cracking of this particular sample is due to the stress-raising effect of this defect. However, the widespread cracking of other levers

(Discussion, cont'd) -

is not necessarily due to the presence of this defect and it might be dangerous to attempt to draw sweeping conclusions on the basis of examination of this one lever.

The high percentage of failure in the levers tested indicates that the procedure for extending the length of these levers is faulty. It should be borne in mind that the oxy-acetylene process of welding such a thin section permits a wide variation of heating and cooling rates. Considerable difference of heat input may result from personal variations between individual welders. It is, then, highly probable that an examination of various welded levers would reveal considerable difference of structure, hardness, etc.

The analysis of the extension material indicates that it is an SAE 1010 steel. The use of this material cannot be criticised, since it is too low in carbon and manganese contents to have a detrimental response to the thermal cycle of welding. The use of Airco No. 1 welding electrode cannot be criticised. The analysis given by its manufacturer indicates the development of physical properties fully adequate for this job. The analysis of the original lever material does not conform to any S.A.E., A.I.S.I., or N.E. grade of steel. The composition most closely approaches that of an SAE 1050 with 1 per cent nickel content. This steel in welding should be handled with caution since the carbon, manganese and nickel contents are conducive to making the steel sensitive to rapid cooling rates and, consequently, prone to brittleness.

As shown by the cracked sample, a coarse-grained Widmanstätten structure has been developed in the original lever material adjacent to the weld. This microstructure has a tendency towards brittleness and, assuming a sound weld, impact

(Discussion, cont'd) -

may readily cause failure in the Widmanstätten area. This structure is the result of fairly rapid cooling through the critical range, and slightly higher cooling rates will result in the formation of hard, brittle martensite. This clearly indicates the necessity of a controlled process which will permit reproducible results from day to day independent of the human variable.

The welding procedure is open to criticism in that welding is done entirely from one side of the lever. This increases the probability of lack of fusion at the root of the weld and also incomplete penetration. To eliminate these defects and their stress-raising effects, a sealing bead should be run across the back of the joint. This sealing bead need not be thick but should ensure the flowing together of unfused edges of the joint and provide a small reinforcement.

The method of securing the desired gunmetal finish is high undesirable. Hand-operated and eye-controlled heating is inefficient and dangerous. Here, again, the results obtained by individual operators will vary widely. As pointed out above, the lever material is of such a composition as to be rendered sensitive to fairly rapid cooling rates. This is aggravated by the thinness of the section. It is quite possible for the lever blade to be heated to too high a temperature and then embrittled by the subsequent oil quench.

CONCLUSIONS:

1. Cracking of the lever examined is due to the stress-raising effect of incomplete penetration at the root of the weld.

2. The extension material is SAE 1010 steel.

3. The welding electrode used is quite suitable for the job.

4. The lever is made from a steel which does not conform to any S.A.E., A.I.S.I., or N.E. specification. Its composition most closely approaches that of an SAE 1050 steel with a 1 per cent nickel addition.

5. The lever material composition is such as to necessitate caution in welding.

6. The welding procedure of welding on one side only of the joint is open to criticism.

7. The method of securing a gunmetal finish is unsatisfactory.

Recommendations:

1. A sealing bead should be run on the back of the joint, to eliminate lack of fusion and incomplete penetration at the root of the weld. This sealing bead should be only thick enough to provide a small reinforcement, in order not to increase machining costs unduly.

2. After welding and subsequent machining, the levers should be normalized at 1550° F. for 1¼ hours. This will eliminate any undesirable structure adjacent to the weld. This treatment can be made to serve a double purpose of normalizing and obtaining a gunmetal finish. The levers, when the normalizing time has expired, can be cooled slowly to 1100° F. in the furnace and then oil-quenched. This treatment will produce the blue black oxide on the surface of the steel.

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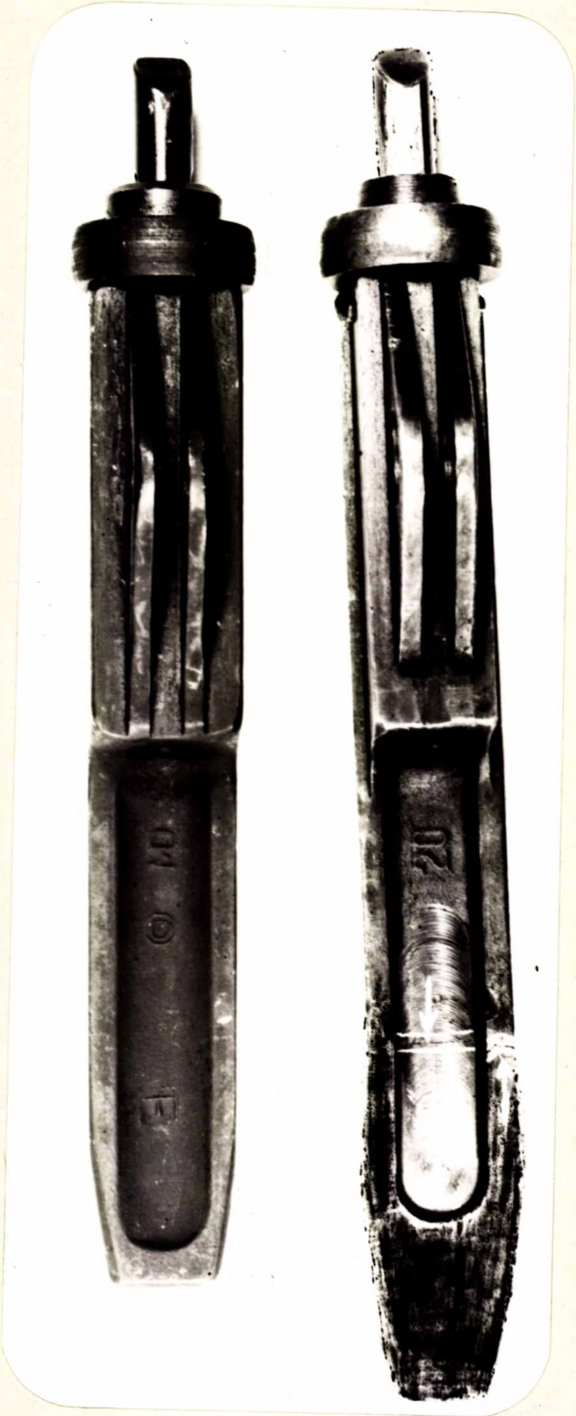
HJN:GHB.

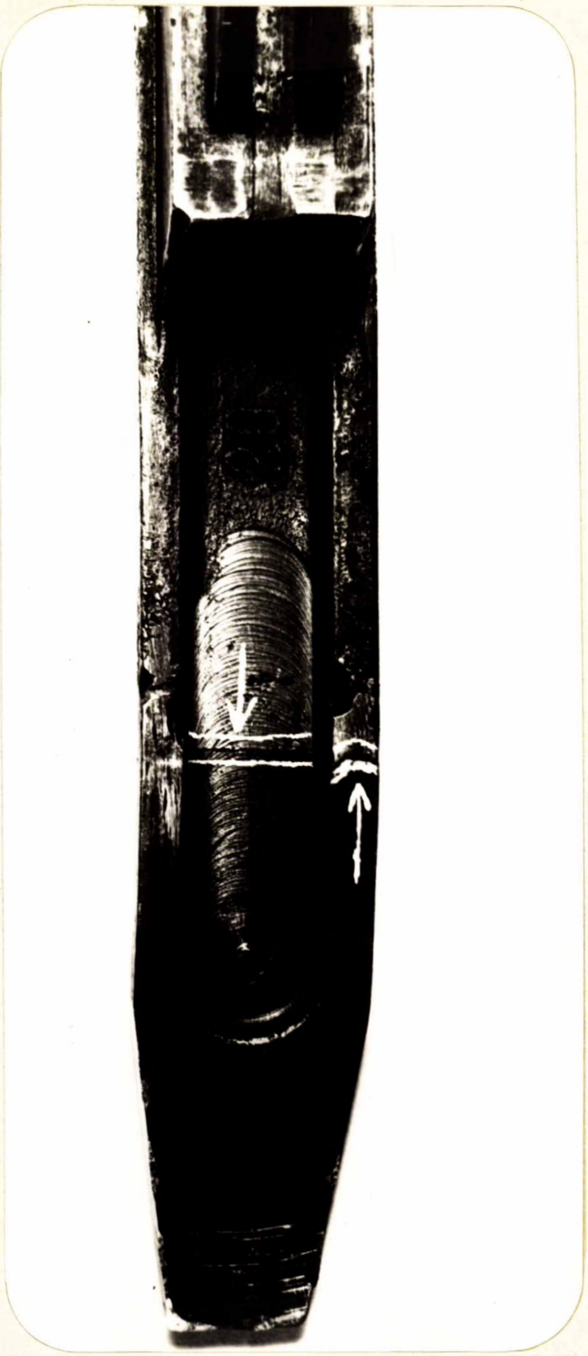
Figure 1.



ORIGINAL AND SALVAGED LEVERS.

White lines indicate the areas of cracking.

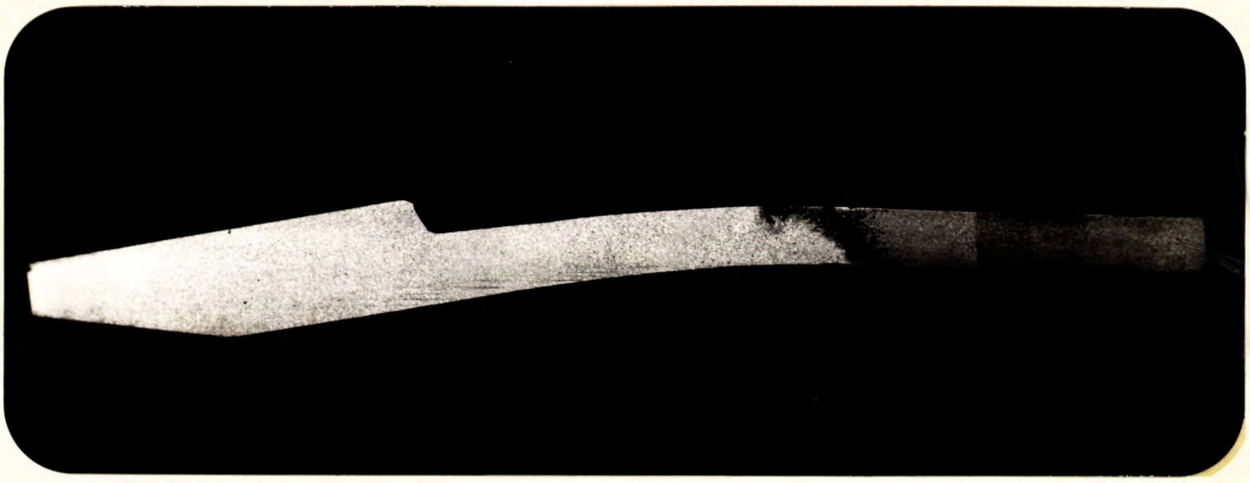
Figure 2.



"CLOSE UP" OF CRACKED SALVAGED LEVER.

White arrow points to crack.

Figure 3.



X10, etched in 20 per cent nital.

LONGITUDINAL SECTION OF CRACKED LEVER.

Note crack and coarse-grained area in original lever material adjacent to weld.

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Figure 4.

X100, etched in 2 per cent nital.

NORMAL STRUCTURE OF SAE 1010 EXTENSION MATERIAL.

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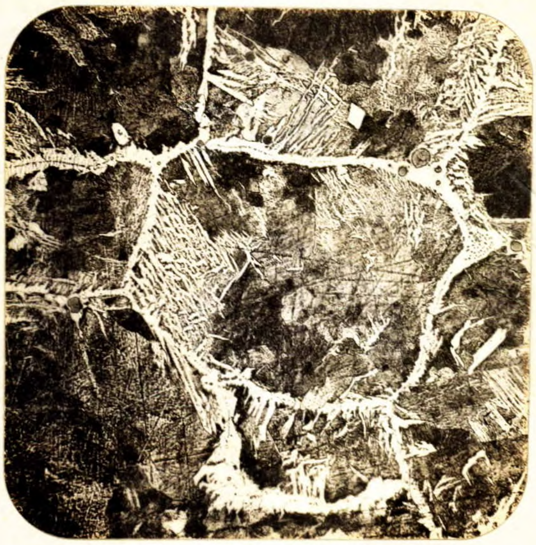
Figure 5.



X100, etched in 2 per cent nital.

WIDMANSTÄTTEN STRUCTURE OF HEAT-AFFECTED ZONE OF ORIGINAL LEVER MATERIAL.

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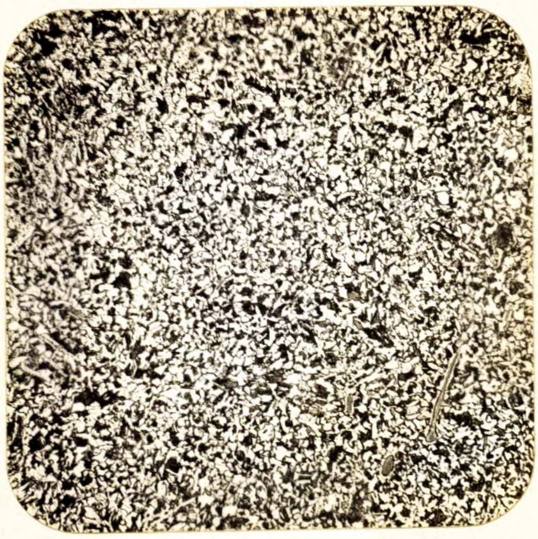
Figure 6.



X100, etched in 2 per cent nital.

NORMALIZED STRUCTURE OF NORMAL ORIGINAL LEVER MATERIAL.

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