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OTTAWA January 6, 1945.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1773.

Metallurgical Examination of Armour Welds of a Sexton 25-Pdr. Self-Propelled Gun Mount.

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Division of Metallic
Minerals
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Physical Metallurgy
Research Laboratories

Canada

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

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Origin of Material:

On December 1, 1944, E. W. Shaw, Inspecting Officer, for the Director of Tanks and M. T., Inspection Board of United Kingdom and Canada, Ottawa, Ontario, submitted four samples of welds from a Sexton 25-Pdr. S.P.M. for examination. The covering letter provided the following information:

> The samples are from the upper hull of the Sexton and are numbered 1, 15, 19 and 24 respectively. The numbers are from the drawing A.D. Tech. (M) 167, Sheet 1 (also submitted and which identifies the location of the weld in the hull).
>
> Welds 1 and 24 represent normal plant practice, which involves root bead preparation by chipping and grinding. Welds 15 and 19 represent root bead preparation by arc gouging and subsequent grinding. This is done by maintaining a long arc between a steel welding rod and the joint; a high

(Origin of Material, cont'd) -

current is used and the joint positioned vertically. A Wilson No. 98, 5/32"-diam. electrode is used, operating at 350 amps. and 43 volts.

Welds 1 and 15 are the same welds but from opposite sides of the hull. Similarly, Welds 19 and 24 are from opposite sides of the hull but are the same weld.

Object of Investigation:

To determine whether the arc gouging method of root bead preparation has produced any undesirable effects on the armour plate.

Procedure:

(1) The samples submitted were subjected to a careful visual examination. No evidence of cracking was obtained in or near the welds.

(2) All samples were magnafluxed. No evidence of cracking or of root defects was found.

(3) Macro sections were machined from each sample, polished, etched, and photographed. Figures 1 and 2 show the samples after these operations.

(4) Macro sections were repolished and etched and subjected to examination under a microscope. Figures 3 to 6 show the structures at the roots of Welds 1, 15, 19 and 24 respectively. No evidence of cracking was found in the samples.

(5) Hardness surveys were made of each sample, using a Vickers machine and a 20-kilogram load. The following table lists the results secured:

(Continued on next page)

(Procedure, cont'd) -

VICKERS HARDNESS NUMBERS

Weld No.	Unaffected Armour Plate	Heat-Affected Zone	Root Area	Weld Interface
1	363	341-476	423-476	191
15	341	333-502*	321-435	208
19	323	319-509*	298-353	217
24	280	327-502*	327-404	207

* Readings in excess of 500 Vickers were all found in the heat-affected zone of the last pass of the weld, where the cooling rate is the highest.

Discussion:

Examinations by various means fail to reveal any evidence of cracking in any of the samples. The macro-examination of sections of the welds reveal no appreciable differences in the widths of the heat-affected zones of the two root bead preparations. There is a slightly greater width of weld metal in the roots of the welds prepared by arc gouging, indicating a more thorough cleaning-out of this area before welding proceeded.

A microscopic examination revealed no significant differences in structures in the heat-affected zones of the welds. Those samples which are representative of normal practice have slightly higher average root-bead hardness than those representative of the arc-gouging method, as might be expected of the microstructures in these areas. The structure at the root area of Sample No. 19 is considerably different from all others in that it is mainly fine pearlite, which indicates a considerably slower cooling rate than is usual.

Normal root preparation has resulted in tempered martensitic structures in the root areas whereas arc gouging has resulted in either fine pearlite (Sample No. 19) or a mixture of fine pearlite and tempered martensite. This

(Discussion, cont'd) -

indicates a slower cooling rate than usual in these areas with arc gouging which might be expected from the preheating affect of this process.

It would seem, from the weld interface hardnesses obtained, that there has been little or no dilution of the weld metal by the material from the gouging electrode. This indicates a good cleaning grind after the gouging operation.

The high hardnesses found in the heat-affected zones of the top passes of the welds are unusual. It is quite true that the cooling rate at this area is higher than for any other pass since the weld metal is spread out over a large area and consequently heat is abstracted at a higher rate. However, hardnesses of this order are frequently associated with cracking difficulties and the cracks may not be detected until some time after welding is completed. A higher heat input for this last pass would tend to overcome this difficulty.

Conclusions:

1. No evidence was found of cracks in any of the samples.

2. Root hardnesses are lower in those samples in which the arc gouging process was used.

3. Normal root preparation has resulted in tempered martensitic structures in the root area. In the arc gouging method structures of fine pearlite or mixtures of fine pearlite and tempered martensite have resulted.

4. There is no evidence of dilution of the austenitic weld metal by the gouging electrode.

5. Hardnesses in the heat-affected zones are not

(Conclusions, cont'd) -

abnormal, except in the area adjacent to the top pass. Here the hardnesses are in the order that is usually associated with cracking troubles.

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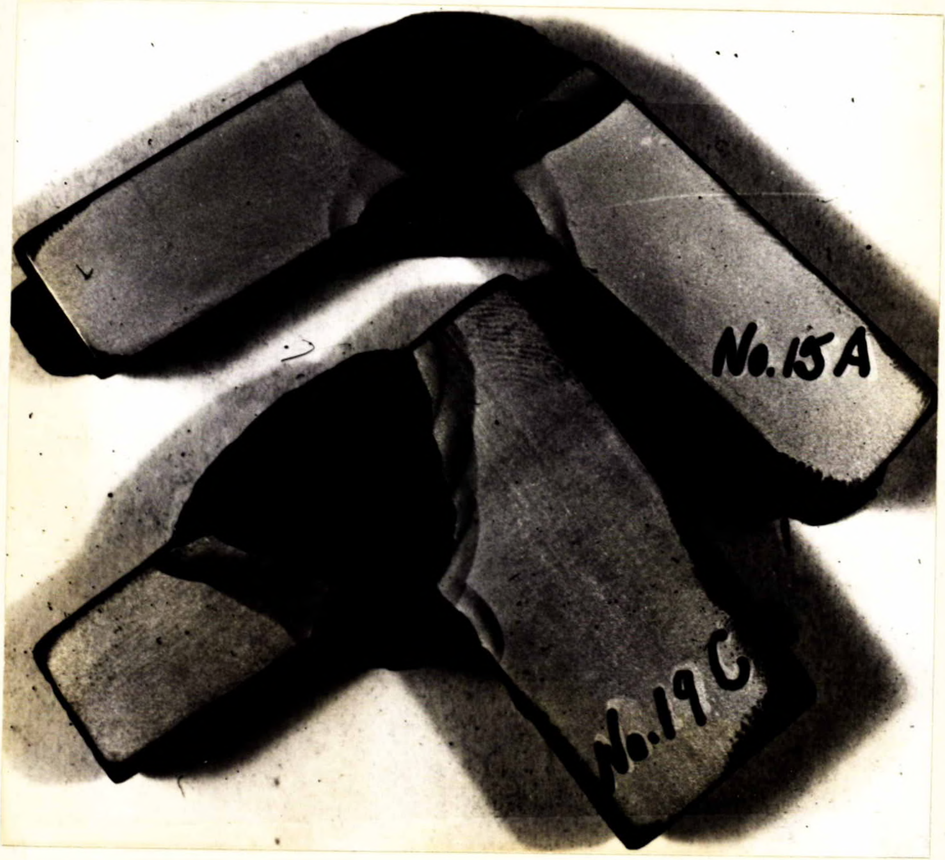
Figure 1.

1.25 X.

MACRO SECTIONS OF WELDS 24 AND 1,
REPRESENTATIVE OF NORMAL ROOT BEAD PREPARATION.

Note widths of root bead and heat-affected zones.

Figure 2.



1.25 X.

MACRO SECTIONS OF WELDS 15 AND 19, REPRESENTATIVE OF ARC GOUGING METHOD OF ROOT BEAD PREPARATION.

Compare with Figure 1. Note greater widths of root bead and heat-affected zones.

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Figure 3.

X500, etched in 1 per cent HCl and 4 per cent picric acid in alcohol.

STRUCTURE OF HEAT-AFFECTED ZONE ADJACENT TO ROOT BEAD OF WELD 1.

Coarse tempered martensite.

Figure 4.

X500, etched in 1 per cent HCl and 4 per cent picric acid in alcohol.

STRUCTURE OF HEAT-AFFECTED ZONE ADJACENT TO THE ROOT BEAD OF WELD 15.

Structure is a composite of tempered martensite and fine pearlite.

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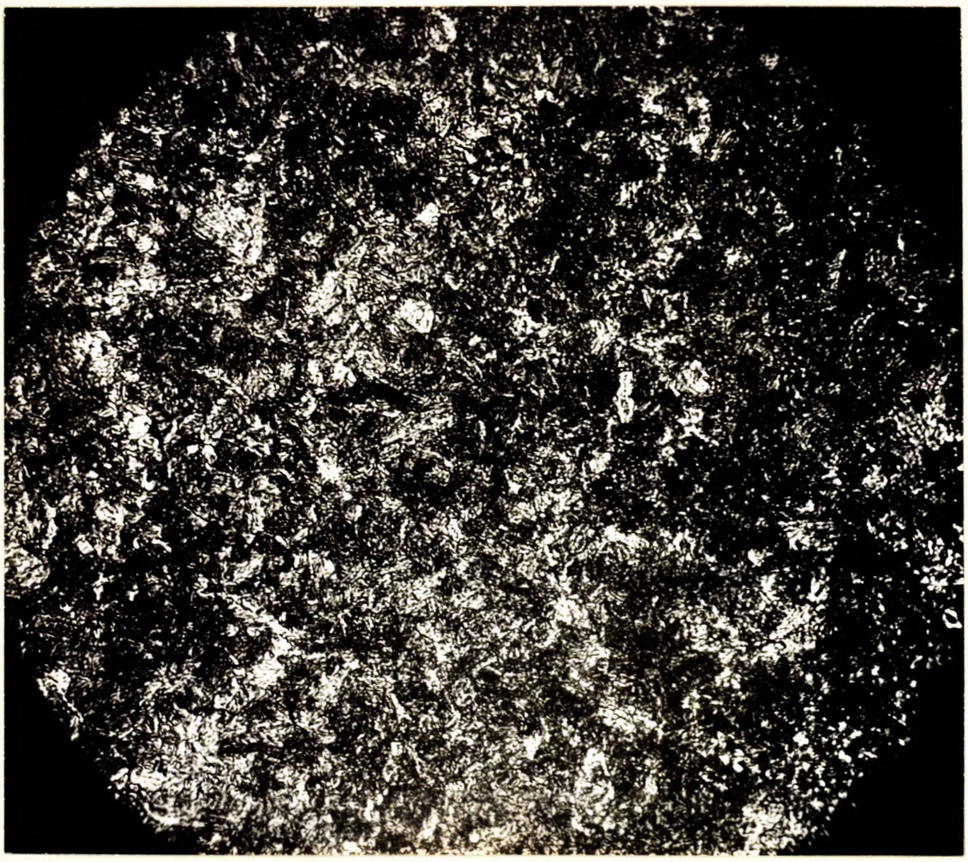
Figure 5.

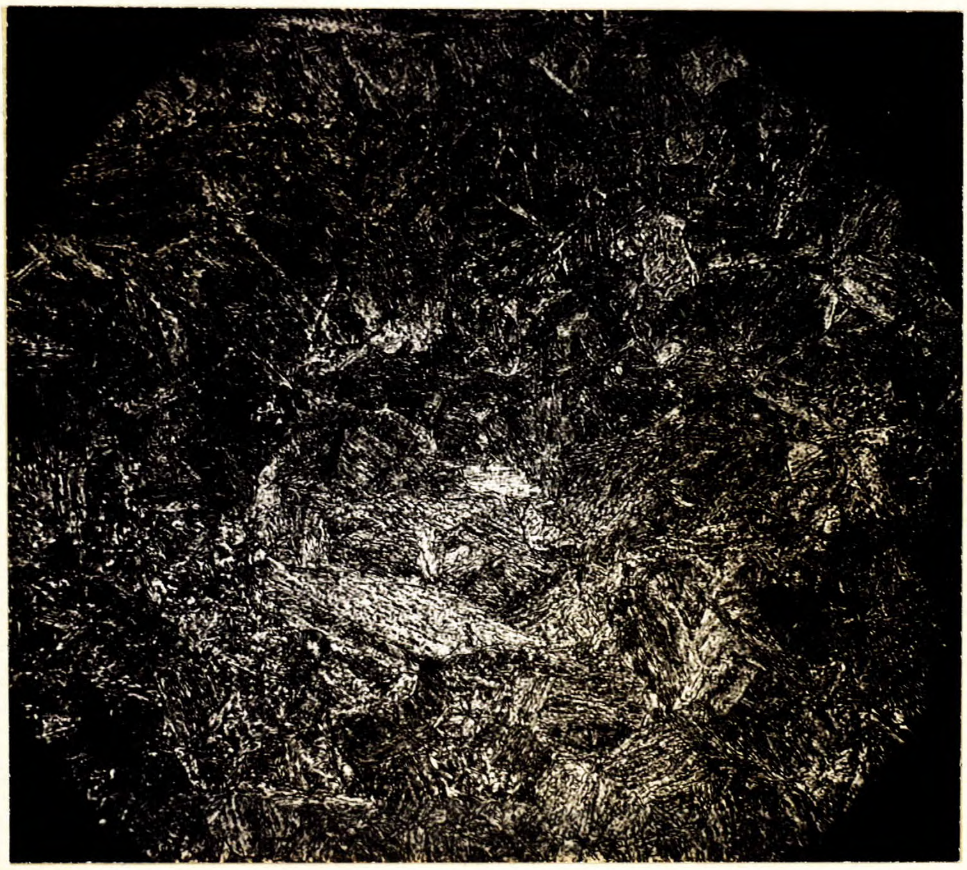


X500, etched in 1 per cent HCl and 4 per cent picric acid in alcohol.

STRUCTURE OF HEAT-AFFECTED ZONE ADJACENT TO THE ROOT BEAD OF WELD 19.

Fine pearlite.

Figure 6.



X500, etched in 1 per cent HCl and 4 per cent picric acid in alcohol.

STRUCTURE OF HEAT-AFFECTED ZONE ADJACENT TO THE ROOT BEAD OF WELD 24.

Tempered martensite with some fine pearlite.

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