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O T T A W A August 13th, 1942.

# R E P O R T

OF the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1272.

A Metallographic Study of
Three Spot Welds.

(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

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### Origin of Samples:

The three welds covered by this report were submitted in June, 1942, by Mr. Moss, of the British Bureau of Ships, Washington, D. C. These welds were made by the Progressive Welding Company, of Detroit, Michigan, by forge welding. The following extract from the company literature describes the process:

(Origin of Samples, cont'd) -

"In principle, the process harks back to, and derives its name from, the original art of welding; heating, forging, and re-heating, re-forging, etc. In effect, it is a modernized version of the 'blacksmith' type of forge welding. In contract, however, this latest method, which easily handles work of 1" x 1", requires a matter of seconds and no skilled operator.

A set-up similar to the standard Multi-Duty pedestal welder is used. Pressure from the lower piston of the compound air-hydraulic booster (mounted on the upper arm immediately above the electrodes) supplies the initial pressure which, together with interrupted welding current, brings the surfaces of the work into intimate contact. The upper piston of the booster is then brought into a rapidly repeating action impacting 'hammer' blows directly on the upper electrode. Thus, the weld is 'forged' by the action of the upper piston of the booster while still being held under pressure.

During this operation the current is usually interrupted synchronously with the application of the hammering, although for certain metal thicknesses, etc., the current will be applied alternately."

Arrangements are also available for heat treating the welds in this apparatus. Of the samples submitted, number one was not heat treated, while samples numbers two and three had been subjected to one and two heat treatments, respectively.

Object of Study:

An investigation of the hardness and microstructure of the welds was made to obtain some information with regard to the merit of the forge welding process.

Analysis:

Sample number two was found by chemical analysis to be plain low carbon steel. It contained 0.20 per cent carbon, 0.55 per cent manganese, and 0.17 per cent silicon.

Macro Examination:

Each sample consisted of three ¼-inch plates spot-welded together. All were sectioned through the weld. A 4 per cent picric acid etch was applied. This brought out the various zones of the welds and illustrated the disintegration of the weld structure by heat treatment. This is shown in Figures 1 and 2.

Physical Examination:

A survey of the hardness of the samples was taken on a Vickers machine with a thirty-kilogram load. The results of these tests are shown in Figures 1 and 2.

Microstructures:

The three samples were polished and etched in a 4 per cent solution of picric acid in alcohol. Photomicrographs, at 250 diameters, were taken of every distinctive phase from the parent metal to the weld interior. These pictures are numbered progressively beginning with the parent metal and proceeding to the centre of the weld.

In the centre of sample number one a cavity about 1/8 inch long was seen. A portion of this is shown in photomicrograph, Figure 18. Some slag, possibly oxide, can be seen in the crack. These cavities or cracks are also present in the other samples but are very small. Only one was found in weld number two.

A large round, glassy inclusion was discovered in both samples one and three; smaller inclusions of this type are present in all the welds. The largest, which is pictured at a magnification of 100 (Figure 19), appeared in weld number one. Its

(Microstructures, cont'd)

diameter was approximately four times as great as that of the largest inclusion in number three. Those of number two are very much smaller but more numerous. In all of the samples these inclusions seem to predominate along the lines of the joining of the plates.

Discussion of Results:

The examination of the welds showed that they were all thoroughly made. The fact that the cavities in welds two and three were much smaller than in number one indicates that the heat treatments, which were probably followed by forging, had closed them up. The greater depths of the crimps in samples number two and number three support this theory, as does the fact that sample number two, which showed a greater crimp than sample number three, was sound. The glassy inclusions may be caused by flux. It should be emphasized that all welds are excellent and the defects shown in Figures 18 and 19 are distinctly not representative. Particularly is this true for welds two and three, which are for all practical purposes completely sound.

The one heat treatment received by sample number two broke up the weld structure to some extent but the centre was still coarse. The two heat treatments given sample number three completed the transformation. The refinement of the structure apparent in samples two and three is caused by the temperature to which they were reheated. Obviously, mere repetition of the welding cycle would not result in this refinement. Hardness tests confirm the fact that heat treatment improved the welds and that maximum improvement was obtained by the double heat treatment.

If welds examined are representative of what may be obtained in forge welding it would seem that reliance could be placed in this method of fabrication.

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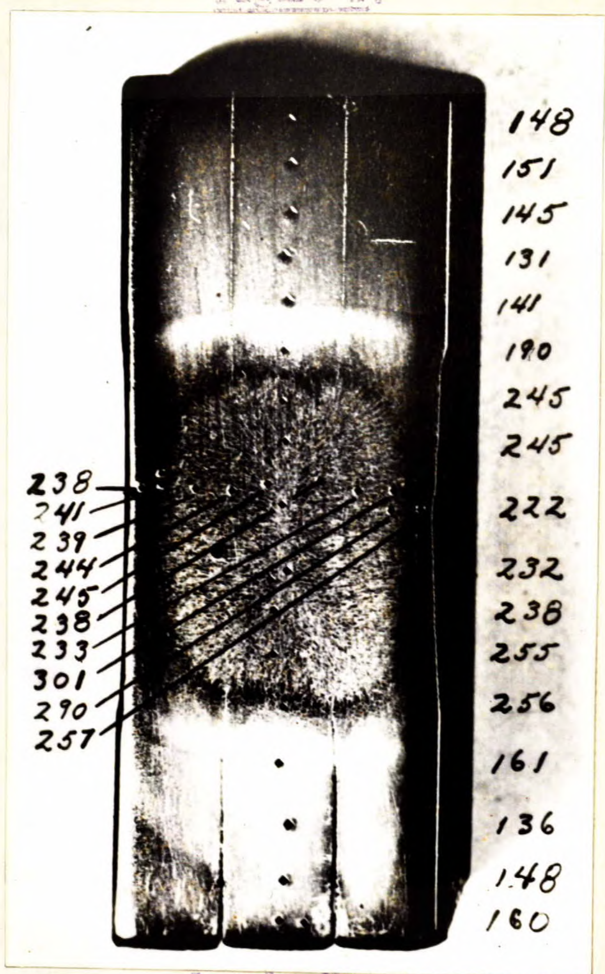
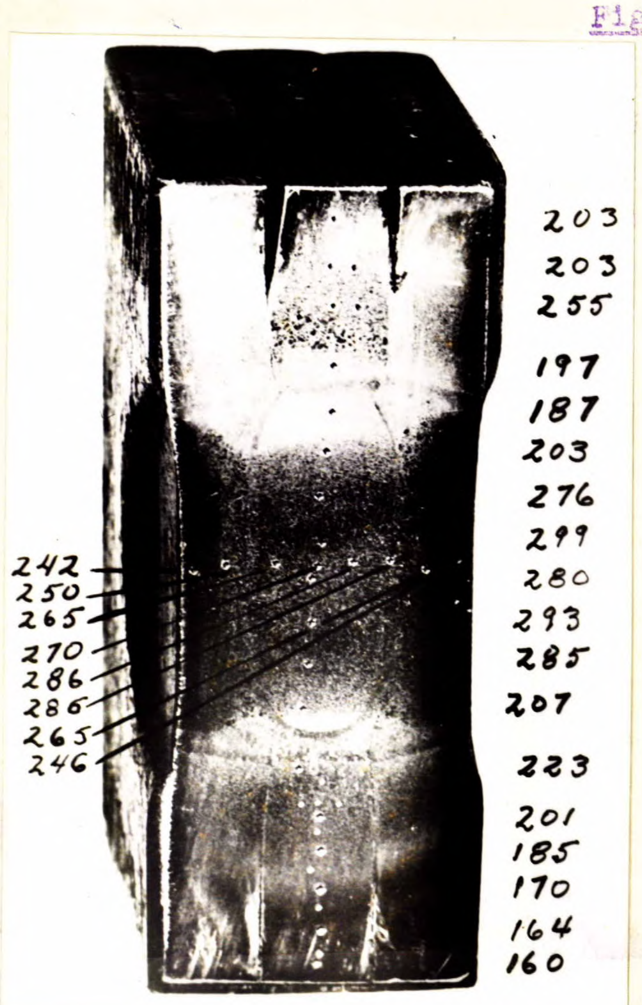
Figure 1.

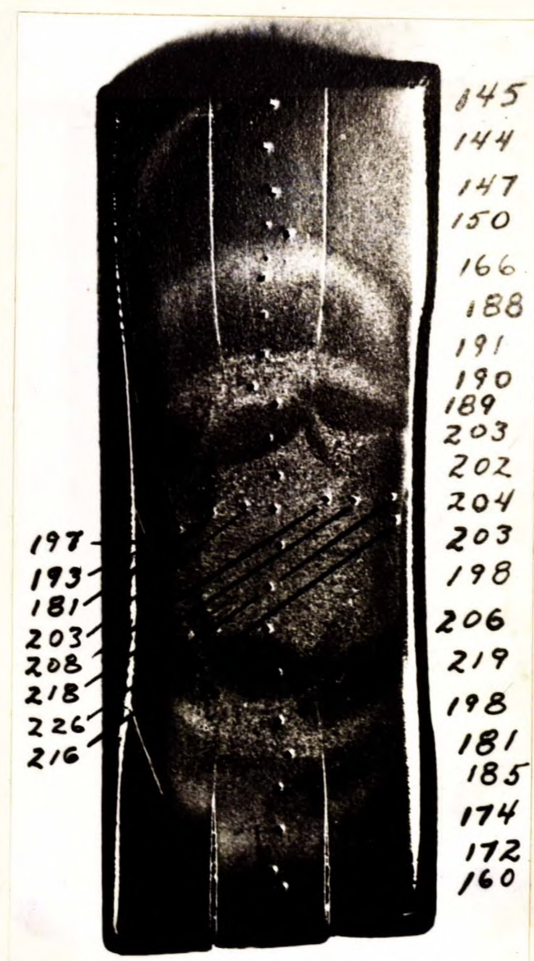



Sample No. 1.
UNTREATED WELD.

Figure 2.

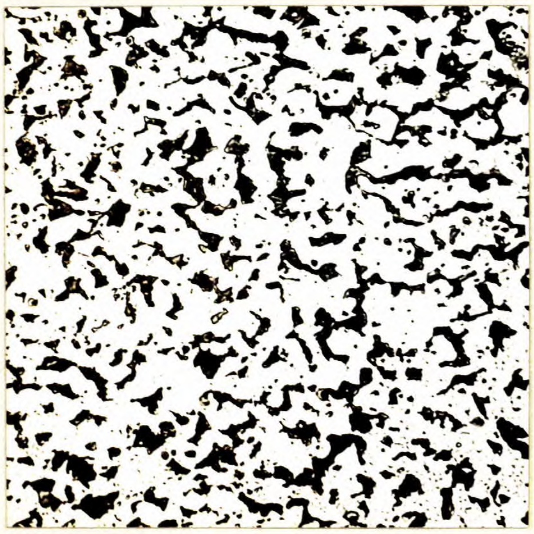



Sample No. 2.
ONE HEAT TREATMENT WELD.



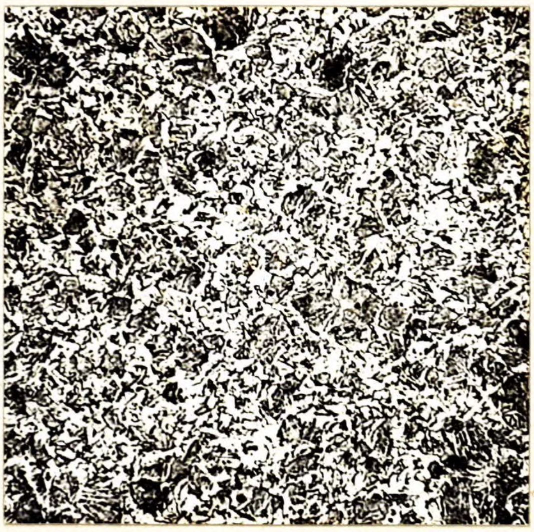

Sample No. 3.
TWO HEAT TREATMENT WELD.

Figure 3.



X250, picral etch.

Figure 4.

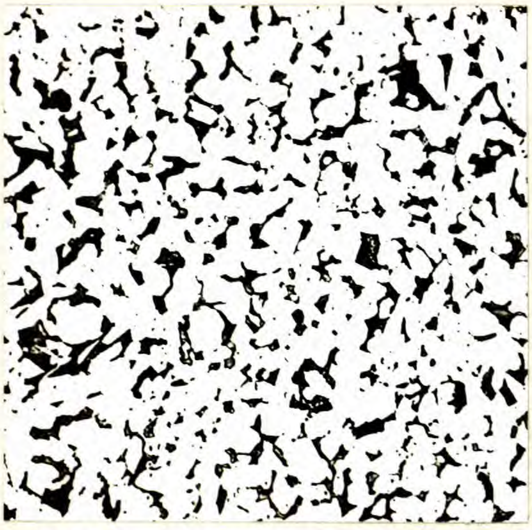


X250, picral etch.

Figure 5.

X250, picral etch.
UNTREATED WELD.

Figure 6.



X250, picral etch.

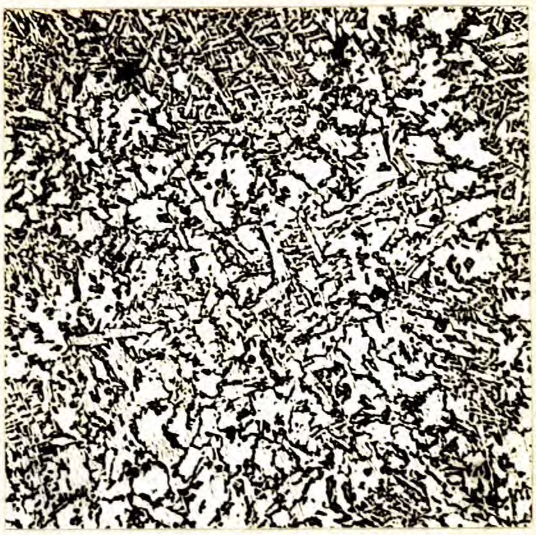
Figure 7.

X250, picral etch.

Figure 8.

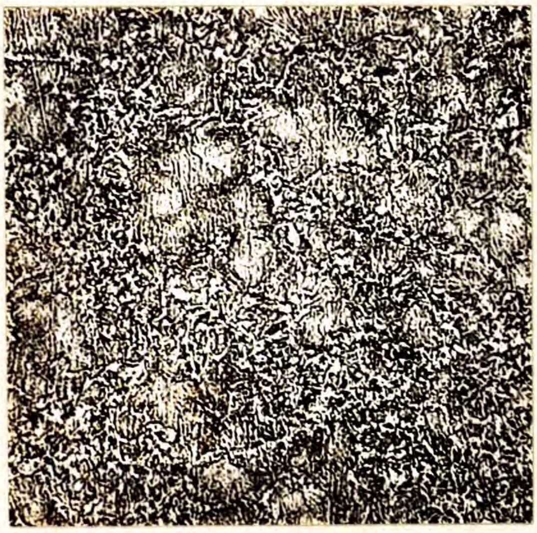
X250, picral etch.

Figure 9.



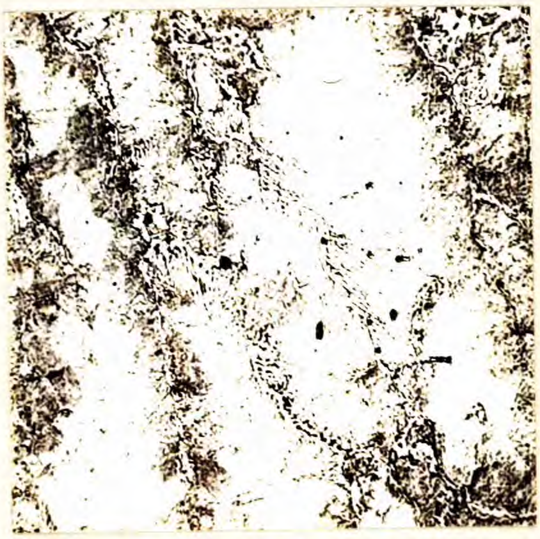
X250, picral etch.

Figure 10.



X250, picral etch.

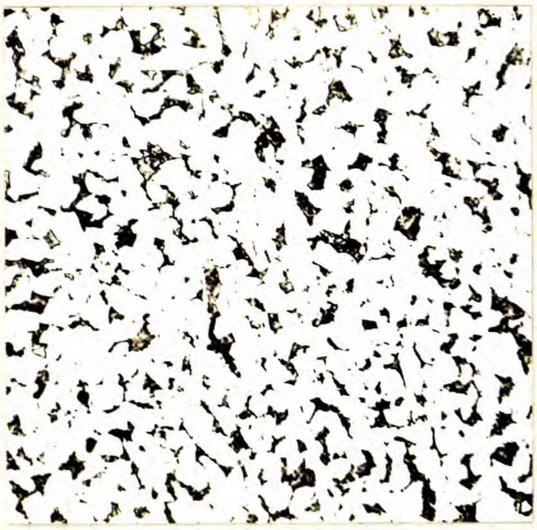
Figure 11.



X250, picral etch.

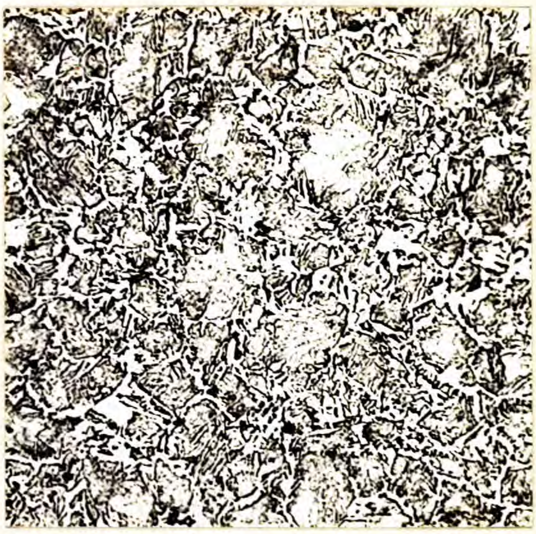
ONE HEAT TREATMENT WELD.

Figure 12.



X250, picral etch.

Figure 13.



X250, picral etch.

Figure 14.

X250, picral etch.

Figure 15.

X250, picral etch.

Figure 16.

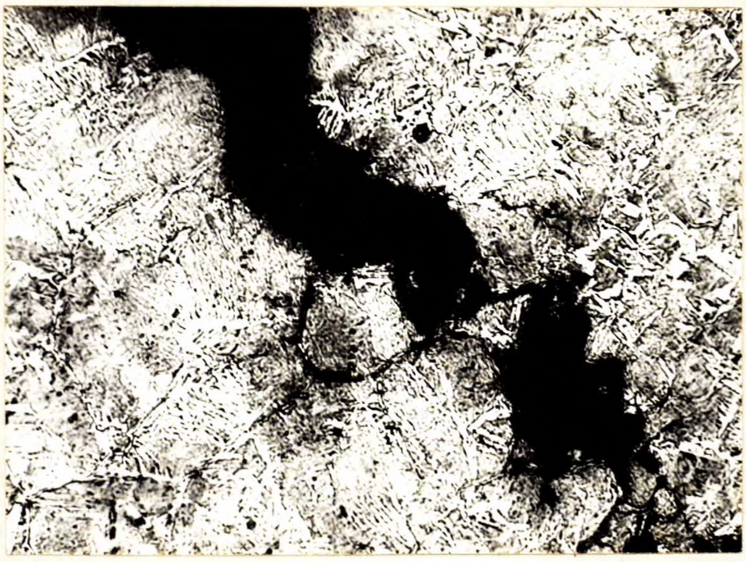
X250, picral etch.

Figure 17.

X250, picral etch.

TWO HEAT TREATMENT WELD.

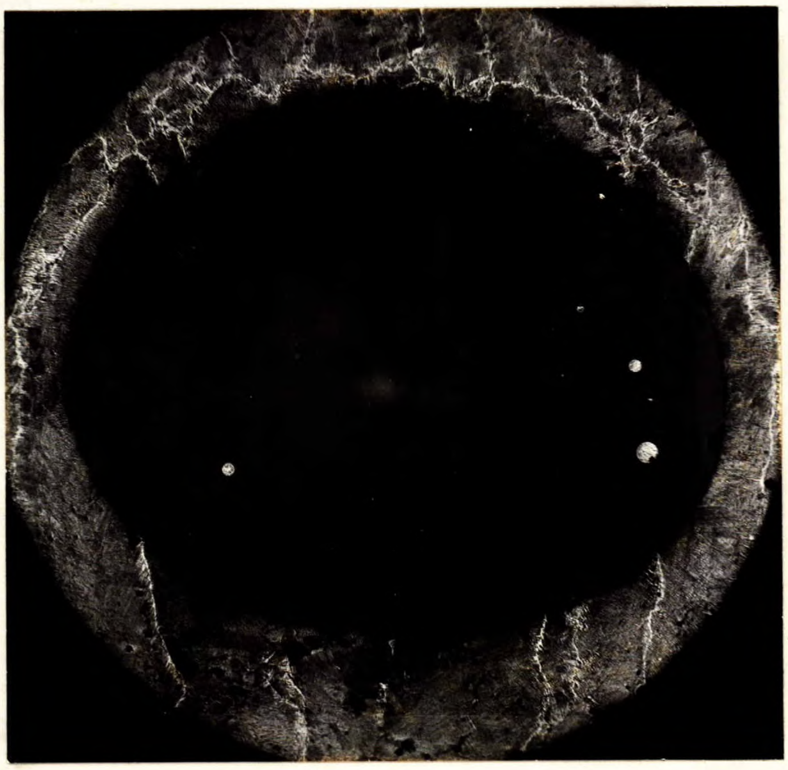
Figure 18.



X250, picral etch.

PICTURE OF DEFECTIVE PORTION OF WELD NUMBER ONE.

Figure 19.



X100, picral etch.

PICTURE OF INCLUSION IN WELD NUMBER ONE.

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