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WELDING TESTS WITH X-9035 1-1/2" HOMOGENEOUS ARMOR PLATE

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X-9135 1½ IN. HOMOGENEOUS ARMOR PLATE

Abstract: This report describes the welding procedure and metallurgical results with automatic welding of heat treated X-9135 homogeneous armor plate. This is a preliminary report and no attempt has been made to proof fire the resultant joint nor plate.

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The program of additional work with X-9135 homogeneous armor plate (outlined in our report of December 10, 1941) has been continued and preliminary welding tests made with 1½ in. plate of that composition. Through the courtesy of Mr. Charles Laufle, Manager, Alloy Division, Great Lakes Steel Corporation, Ecorse, Michigan, samples of 1½ in. armor plate were received, which originated from heat number J-12626, of the following chemical composition.

Carbon, %	0.38
Manganese, %	0.65
Silicon, %	0.85
Phosphorus, %	0.019
Sulphur, %	0.020
Chrome, %	0.59
Molybdenum, %	0.19
Zirconium, %	0.16

From the samples submitted, two plates 18 in. x 8½ in. x 1½ in. were flame-cut. Both specimens were then heat treated in order to find how this heavier material reacts to heat treatment and so as to approach actual welding of armor conditions. The heat treatment follows:

1. Heat to 1550° F., hold 2½ hrs.
2. Quench in water.
3. Draw immediately to 1050° F. for 3 hrs.
4. Cool outside of furnace.

The hardness of the two samples was 195 and 187 B.H.N. as received. After quenching, the hardness rose to 477 and 444 B.H.N. Both plates were again checked in five spots. After tempering, the hardness ranged from 293 to 302 B.H.N. This hardness is somewhat lower than anticipated, but apparently the mass effect became evident during this operation.

The heat treated plates were then flame-scarfed to form a double "V" joint. The joint preparation is shown on the attached Figure #1. The flame-cut surfaces were not machined any further.

Automatic welding was carried out in our large Unionmelt Department under the following conditions.

	First Weld	Second Weld
Depth of bevel, in.	11/16	9/16
Diameter of electrode, in.	5/16	5/16
Type of electrode	Oxweld #41	Oxweld #41
Velocity, inches per min.	12	12
Voltage	50	50
Intensity at transformer, Amp.	1750	1550
Flux used	Unionmelt #94	Unionmelt #94
Wire feed	130	120
General appearance of weld	100% Penetration, no cracks	100% Penetration, no cracks
Height of melt above the plate, in.	$1\frac{1}{2}$	$1\frac{1}{2}$

Prior to automatic welding, a bead of manually deposited 19-9 stainless steel was applied. The final weld looked sound, completely penetrated and no cracks were visible.

A study of the metallurgical characteristics of the joint was then made. Two cross-sectional plates were cut from the original sample plate, ground on both sides and etched with an aqueous solution of 20% ammonium persulphate. The cross section of this macro-specimen is shown in Figure #1. This illustration indicates also the exact location of impressions made by means of Rockwell and Brinell hardness testing apparatus. The results of the Rockwell survey are shown on the diagram in Figure #2. The averages for the various parts of the joint are shown on the attached Table #1. Additional tests were made by removing one inch square bars about 8 in. long from the parent metal, the first and second welds, from which standard 0.505 in. diameter test bars were machined. The obtained values are compiled in Table #2. A microscopic examination concluded the metallographical program. The appearance of the weld indicated standard deposit of 25-20 stainless steel which is also indicated by the very high elongation in 2 in.

In summing up this work, it is quite apparent that X-9135 armor plate may successfully be welded by the automatic process. In order to conclude this work, we hope to weld at least two plates 36 in. x 36 in. x $1\frac{1}{2}$ in. immediately upon their receipt from Ecorse by exactly the same procedures outlined above, which specimens shall subsequently be sent to Aberdeen for proof firing. A final report on this work shall be given after receiving that information from the U. S. War Department.

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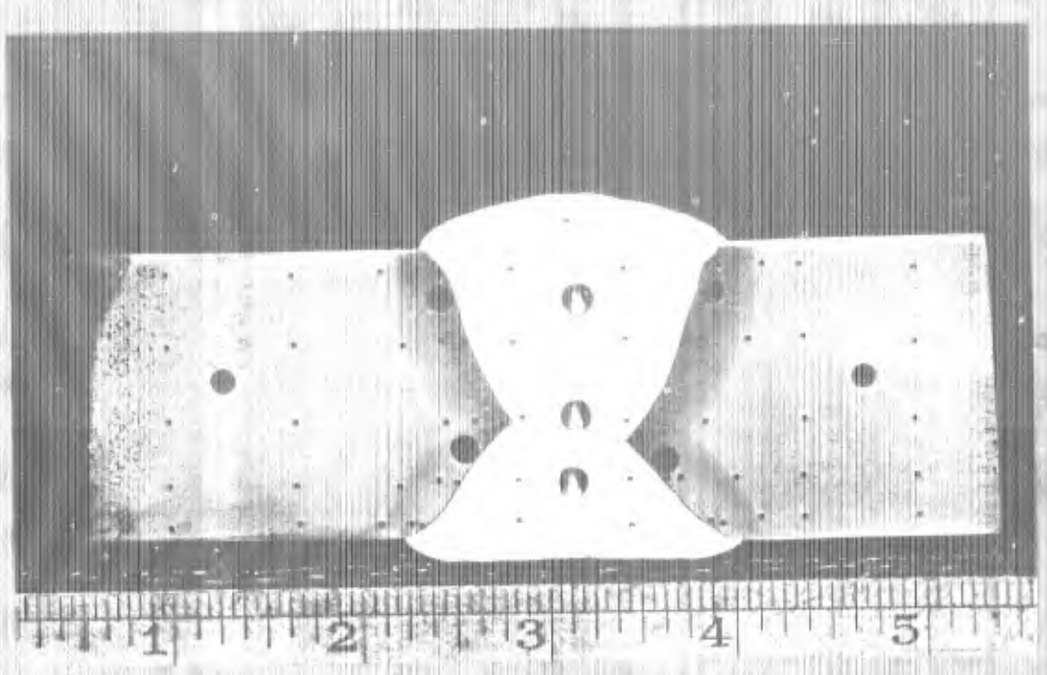

Figure #1

Figure #2

HARDNESS SURVEY OF WELDED AREAS

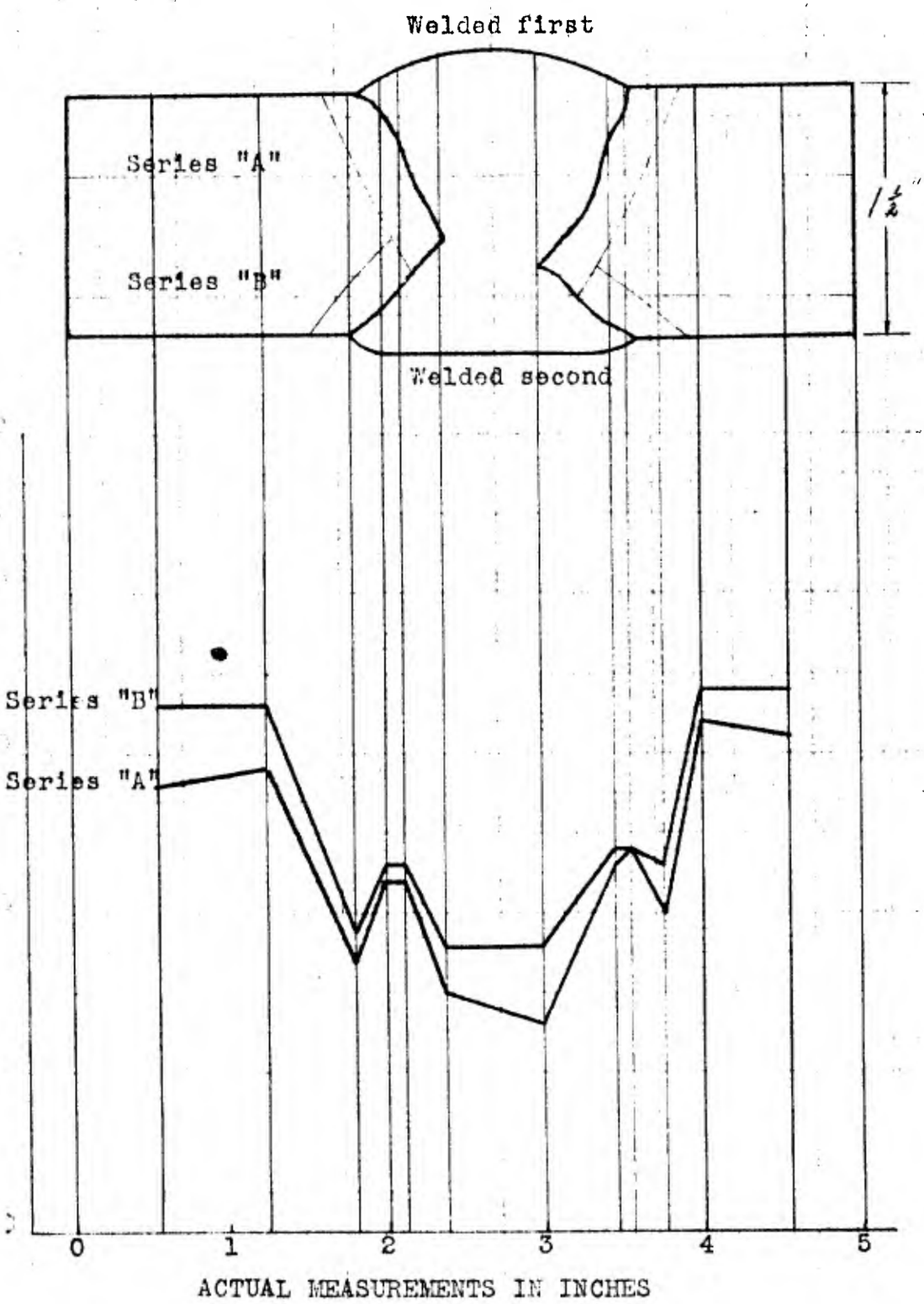

Table #1

CROSS SECTIONAL HARDNESS OF

25-20 WELDED JOINT

	Rockwell Hardness	Brinell Hardness
Parent Metal, center	31	269 - 285
Parent Metal, 1/8" from surface	34	-
Thermal Zone, first weld	25	255 - 262
Thermal Zone, second weld	23	223 - 241
Fusion Line, first weld	24	-
Fusion Line, second weld	24	-
Weld Metal, first weld	13	170 - 187
Weld Metal, second weld	17	197

Table #2

TENSILE PROPERTIES OF WELD AND PARENT METALS

	Test Bar Taken From		
	Parent Metal	Second Weld	First Weld
Test No.	1342	1343	1344
Tensile strength, psi.	147,550	101,060	102,360
Yield point, psi.	99,250	60,750	58,500
Elongation in 2", %	16.9	31.3	41.0
Reduction of area, %	48.4	26.1	32.8
Brinell hardness	278	196	178
Charpy Impact Res., ft.lb.	17.6	-	-