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Memorandum Report No. 630/16

ARC WELDING OF ARMOR

Straight Gap Butt Welds Made With A Ferritic Type Wire Electrode

By

W. L. Warner
Welding Engineer

June 3, 1942

WATERTOWN ARSENAL
WATERTOWN, MASS.

[redacted]

FOR RECORD ONLY

NOTICE

This Report has been prepared for laboratory record only. It has not been approved by the Report Review Board and no distribution outside of the laboratory has been made.

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Memorandum Report No. 642/16
Watertown Arsenal

June 3, 1942

ARC WELDING OF ARMOR

Straight Gap Butt Welds Made With A Ferritic Type Alloy Electrode

OBJECT

To investigate the resistance to penetration, during ballistic testing, of straight gap butt welds made with a ferritic type alloy electrode in 1" homogeneous armor plate.

CONCLUSIONS

1. The resistance to penetration, by .50 caliber A.P. ammunition, of a straight gap butt weld made with a ferritic type alloy electrode containing chromium, manganese, and silicon is approximately 2200 f/s.

2. The resistance to penetration, by .50 caliber A.P. ammunition, of a similar weld with a hard facing surface layer is approximately 2400 f/s.

3. The high hardness in the heat affected zone of the weld and the tendency toward opening up of cracks during penetration test indicate that this type of joint would fail under ballistic shock.

W. L. Warner,
Welding Engineer.

Approved:

H. H. Zornig,
Colonel, Ordnance Dept.,
Director of Laboratory.

INTRODUCTION AND TEST PROCEDURE

One-inch thick rolled homogeneous armor plate from Henry Disston & Sons Company was used for the tests. The chemical composition was approximately as follows: 0.49% C, 0.56% Mn, 0.23% Si, 0.019% P, 0.019% S, 1.22% Cr, 0.060% Mo and 0.20% V.

A ferritic type electrode, Murex Cromansil #18B, which deposits a weld metal containing chromium, manganese, and silicon was used.

Two straight gap joint welds about 12" long were made. Plate edges were unbevelled, separated by a gap of 5/8", and backed with a strip of 1/4" mild carbon steel. Figure 1 shows the approximate arrangement of weld metal deposition. Approximately half the length of Weld No. 2 was given a hard surface layer of Rollex #600, weld metal.

Cross sections of the welds were macroetched and surveyed for Rockwell C hardness.

The welds were ballistically tested at the Watertown Arsenal range to determine resistance to penetration of .50 caliber A.P. projectiles.

DATA AND DISCUSSION

TABLE I

Welding Data

Plate	Electrode	Size	No. of Passes	Current
No. 1	Molex	5/32"	2 fillets	130 amps. D.C.
	Cromansil 18B	1/4"	7 weave	300 amps. A.C.
	" "	3/16"	3 weave	250 " "
No. 2	Molex	5/32"	2 fillets	130 " "
	Cromansil 18B	1/4"	7 weave	200 " "
	" "	3/16"	3 weave	250 " "
	Rollex #600	3/16"	1 hard facing	150 " "

TABLE II

Hardness Survey (Rockwell C)

Plate	Weld Metal	Heat-affected Zone	Base Metal	Electrode
No. 1	20	45	48	Cromansil #18B
No. 2	22	45	47	Cromansil #18B
	44	53	47	Rollex #600

Figure 2 shows cross sections of the weld joint as prepared for macroexamination. Cracks were present in the fusion zone of the weld in Plate No. 2.

TABLE III

Ballistic Data

Plate	Ballistic Data On Plate	Ballistic Data On Weld	Spec. Bal. Limit	Bal. Eff. In Weld %	Electrode
No. 1	2700 f/s	2200 f/s	2250 f/s	97	Cromansil #18B
No. 2	2750 f/s	2200 f/s	2250 f/s	97	Cromansil #18B
	2750 f/s	2400 f/s	2250 f/s	106	Cromansil #18B Rollex #600

Figures 3 and 4 are photographs of the front and back of Plate No. 1 after ballistic test. Face and back spalling of the weld metal and a large crack in the plate, initiated in fusion zone, are shown. Figures 5 and 6 are photographs of the front and back of Plate No. 2 after ballistic test. The upper half of the weld was hard faced with a layer of Rollex #600. As shown in Table III the weld with hard facing had a higher ballistic efficiency. Cracks developed between the weld and plate metal during welding and the hard facing weld metal cracked after it had cooled. These cracks were ground out and repaired. A few very small cracks were detected after repair and the firing tests opened them up, as shown in Figure 5.

The tendency toward cracking indicates that this ferritic electrode is unsatisfactory for straight gap butt welds in armor plate of the type tested.

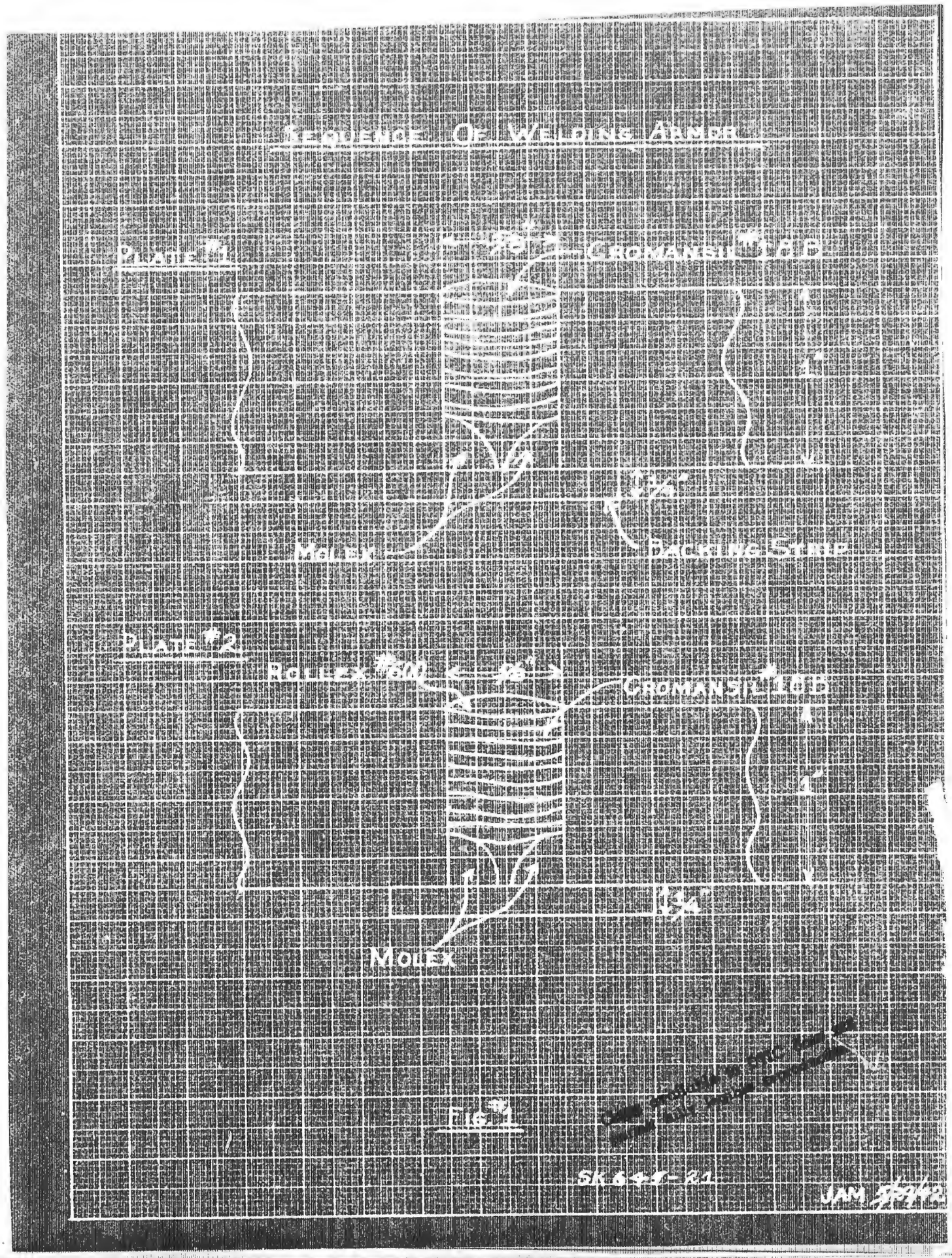
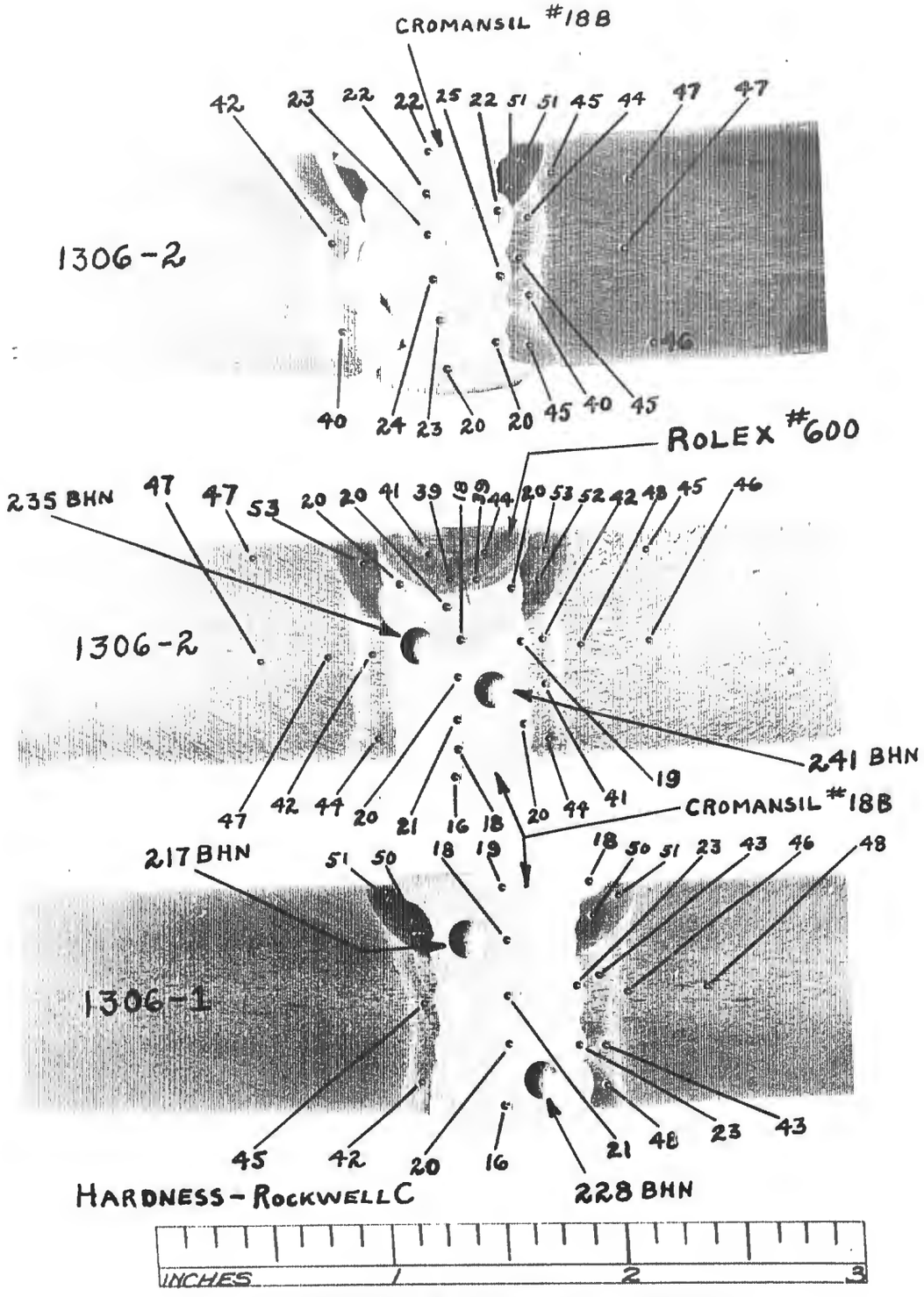

SEQUENCE OF WELDING ARMOR
PLATE #1
CROMANSIL
MOLIEX
BACKING STRIP
PLATE #2
ROLLEX
CROMANSIL
MOLIEX
SHOT-R1
JAN

Figure 2

Macroexamination and Hardness Surveys of Cross Sections of Straight Gap Butt Welded Joints.



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BUTT WELD SECTIONS 1" HOMOGENEOUS
ARMOR PLATE Nov. 26, 1940 WA 639-2619

Figure 3

Front View of Plate No. 1 after Ballistic Test. Note cracked plate and weld spall.

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ARMOR PLATE 12x12x1
October 30,1940 W.A.711-7 Mb

Figure 4

Rear View of Plate No. 1 after Ballistic Test.

Note spalling.

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ARMOR PLATE 1"x12"x1
October 0,1941 T. .711-7 05

Figure 5

Front View of Plate No. 2 after Ballistic Test. Upper half of weld completed with hard surface layer of Rollex #600. Note weld and plate cracks.

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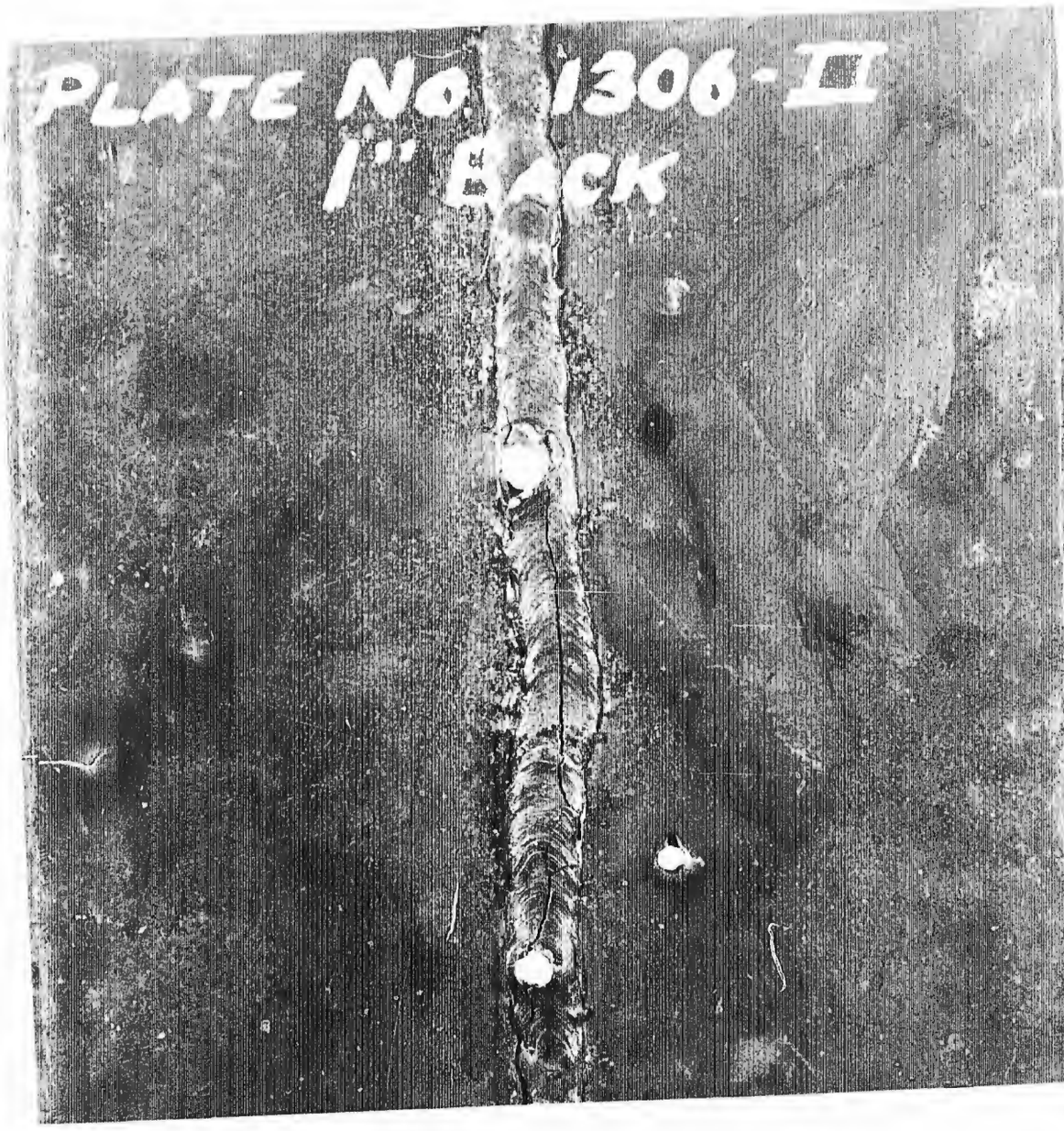
AI WOI PLATE 12x12x1
October 30,1940 P.A.710-707

Figure 6

Back View of Plate No. 2 after

Ballistic Test. Note weld crack.



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WATERTOWN ARSENAL
ARMOR PLATE 12x12x1
October , 194 .A.71)-7 8