

UNCLASSIFIED

AD NUMBER: ADA953337

CLASSIFICATION CHANGES

TO: Unclassified

FROM: Confidential

LIMITATION CHANGES

TO:
Approved for public release; distribution is unlimited.

FROM:
Distribution authorized to U.S. Defense agencies only; Test and Evaluation;
9 Nov 1944. Other requests shall be referred to the Army Watertown
Arsenal, Materials Tech Lab, Watertown, MA 02172

AUTHORITY

C to U: 30 Nov 1965, DoDD 5200.10, gp-4
E/4 to A/1: 29 Jun 1984, per document marking

THIS PAGE IS UNCLASSIFIED

UNCLASSIFIED

AD NUMBER: ADA953337

CLASSIFICATION CHANGES

TO:

Confidential

FROM:

Restricted (Nov 1944)

AUTHORITY

5 Nov 1953, EO 10501

THIS PAGE IS UNCLASSIFIED

~~RESTRICTED~~

UNCLASSIFIED

①

cyff 2a

WAL 640/140

AD-A953 337



WATERTOWN ARSENAL LABORATORY

EXPERIMENTAL REPORT

NO. WAL. 640/140

WELDING OF ARMOR

.40% C Experimental 1-1/2 Inch Thick
Rolled Homogeneous Armor Plate

DISTRIBUTION STATEMENT A

Approved for public release;
Distribution Unlimited

BY

S. A. Herres
1st Lt., Ord. Dept.

JUN 29 1984

B

DTIC FILE COPY

UNCLASSIFIED

DECLASSIFIED
DOD DIR 5200.9

DATE 9 November 1944

WATERTOWN ARSENAL
WATERTOWN, MASS

~~RESTRICTED~~

Watertown Arsenal Laboratory
Report No. WAL 640/140
Problem No. D-13.1

~~RESTRICTED~~
UNCLASSIFIED

9 November 1944

WELDING OF ARMOR

.40% C Experimental 1-1/2 Inch Thick
Rolled Homogeneous Armor Plate

OBJECT

To determine ballistic shock performance of subject armor as welded with a commercial austenitic electrode and an experimental ferritic electrode.

SUMMARY OF RESULTS

1. Two .40% C "H" Plates welded with a commercial 19% Cr, 9% Ni austenitic electrode (no preheat) and the usual type of butt weld armor joint design, showed excessive ballistic cracking in the weld metal immediately adjacent to the weld-plate interface. A .26% C "H" plate with an identical weld joint design failed in a similar manner by fusion zone cracking. It is not believed that these failures were associated with base metal composition or properties.

2. Two .40% C "H" plates welded with the same austenitic electrode (no preheat) and having a weld joint design modified to decrease susceptibility to fusion zone failure had extremely good ballistic shock resistance. A .26% C "H" plate similarly welded also performed exceptionally well.

3. None of the austenitic welded "H" plates (four .40% C and two .25% C) passed radiographic inspection, but none of the radiographic defects appeared to influence ballistic performance. There may be a greater tendency for development of fine weld metal cracks (not discernible until radiographic inspection) during welding of .40% C steel, but this cracking should be avoidable by slight modification in the welding technique or electrode composition.

4. Two .40% C "H" plates welded with an alloy (2% Mn, .4% Mo) ferritic electrode with a stainless type coating showed very good ballistic shock resistance. However, it was necessary to preheat these plates to 300° F. in order to avoid weld metal cracking in the root bead passes.

S. A. Herres
S. A. Herres
1st Lt., Ord. Dept.

APPROVED:

N. A. MATTHEWS
Major, Ordnance Dept.
Acting Director of Laboratory

~~RESTRICTED~~
UNCLASSIFIED

UNCLASSIFIED

INTRODUCTION

An important consideration in the specification of armor for Ordnance fabrications is weldability, but since almost any steel can be welded satisfactorily provided enough precautions are observed, the adoption of exact specification limits for armor to be welded by practical commercial procedures is a difficult matter. Since increase in carbon content of any steel is accompanied by a decrease in the ease of welding, a maximum carbon content is a primary consideration. In accordance with the best opinion of industrial representatives and Ordnance Department personnel a limit of .30% maximum C (ladle analysis) has been adopted in the specification for armor plate; Steel, Rolled, Homogeneous (AXS-488), which covers all armor over 1/2 inch gage which is to be fabricated by metal arc welding.

This limit is believed by many to be an unnecessary restriction on steel-making practice and best ballistic properties of armor for certain applications. The establishment of the .30% C limit was undoubtedly influenced by the knowledge that underbead cracking difficulties increase markedly with higher carbon contents in hardenable alloy steels welded with heavily coated ferritic electrodes. Since this type of cracking has been demonstrated to be associated with the cellulose and moisture contents of the electrode coating⁽¹⁾ this consideration can be discounted for welds made with electrodes having suitable (lime or titania base) stainless electrode type coatings. On the other hand, it has been shown⁽²⁾ that the tendency to develop intergranular "hot tears" in the weld heat-affected base metal of very high carbon and alloy steels (.52 C, .6 Mn, 2.5 Cr, .6 Mo) necessitates preheating even when welding with austenitic electrodes.

Recent evaluations^(3, 4) of shock properties of a number of welded armor joints indicate that ballistic shock failures in current armor compositions can be associated with definite metallurgical and joint design factors, none of which are associated directly with excessive carbon or alloy content of the armor plate. While a number of armor weldments have been made from relatively high carbon armor plate

- (1) Report No. WAL 642/115, "Arc Welding of Alloy Steels - Study of Base Metal Cracks Associated with Effects of Arc Welding Process," S. A. Herres, 12 June 1943.
- (2) Report No. WAL 710/542, "Armor and Welding - Metallurgical Examination of Armor and Welded Joints from German PzKw VI Tank," P.V. Riffin and S. A. Herres, 23 February 1944, p. 11.
- (3) Report No. WAL 648/5, "Evaluation of Shock Properties of Welded Armor Joints - Examination of Samples from 33 Commercially Welded, Ballistically Shock Tested 'H' Plates," S.A. Herres and A.M. Turkalo, 10 June 1944.
- (4) Report No. WAL 648/6, "Evaluation of Shock Properties of Welded Armor Joints at Subnormal Temperatures - Examination of Samples from 31 Commercially Welded 'H' Plates Ballistically Shock Tested as part of the 1942-1943 Canadian Cold Test Program," S.A. Herres and A.M. Turkalo, 9 August 1944.

UNANNOUNCED



Dist

Avail and/or
Special

A-1

des

(e.g. .50 C Cr-Mo-Va homogeneous armor, series of .42 C Mn-Cr-Mo-Si armor H plates ballistically tested during winter of 1942-1943, and present grades of aircraft armor), the circumstances of welding and testing have not permitted adequate comparisons with ballistic shock performance of armor grades covered by Specification AXS-488. The purpose of the subject investigation was to determine ballistic shock characteristics of 1-1/2 inch thick rolled homogeneous armor of approximately .40% C as welded with commercial austenitic electrodes and an experimental Mn-Mo ferritic electrode having a stainless type coating.

DATA AND DISCUSSION

Primary Armor Test Data

Steel of 1-1/2 inch gage for test plates was procured from Republic Steel Corporation from a heat of type NE-8740 with a check analysis of .405% C. Complete data as to chemical composition and processing, together with results of ballistic tests of unwelded plate, are given on the first data sheet of Appendix A. This steel had a fracture test rating of B (small laminations present but well distributed and not concentrated in any one plane; no lamination exceeding 1/2 the thickness of plate) which indicates relatively good steel quality. As heat treated to approximately 269 Brinell the steel was entirely satisfactory in primary ballistic tests for penetration and shock.

For comparison purposes, 1-1/2 inch gage Jones & Laughlin Mn-Mo .26% C plate was used. Complete data as to chemical composition, processing and results of primary ballistic testing of this steel are given on the second data sheet of Appendix A. Fracture test rating was B, and as heat treated to approximately 277 Brinell, the steel was entirely satisfactory in primary ballistic tests for penetration and shock.

Welded Armor Test Data

On Charts 1 through 4 (Appendix A) are tabulated welding procedure and ballistic test data for the six .40% C and the two .26% C H plates fired under this program. Also included in Appendix A are a key to tabulation methods and symbols and a summary of current specification requirements (AXS-497, Rev. 5, December 1943) for H plates welded with austenitic electrodes. There follows a narrative discussion of the welding and ballistic test program.

The first welding was attempted with a lot of an approved brand of 19% Cr, 9% Ni, Mo modified electrode. It was found impossible to deposit the root of the weld because of excessive root bead weld metal cracking. Subsequent tests proved that this electrode could not even be used for 1015 steel and the shipment was returned to the electrode manufacturer who reported (Wtn. File No. 470.5/9180) that the core wire of this shipment was outside their specification for the Cr-Ni ratio. Plate WA1 was partially welded and scrapped in the course of experiments with this electrode brand.

Plates WA2 and WA3 were welded with the electrodes and welding procedures indicated on Chart 1 (Appendix A). Joint design is shown in more detail on extract from WAS-2 Forms (Appendix A). The joint set-up and welding procedure was selected by the Watertown Arsenal representative and Mr. A. J. Raymo, who supervised the welding of these two plates at Baldwin Locomotive Works, as typical of the best armor welding practice. The use of nose beads at the root of the weld was intended to minimize weld metal cracking in this zone.

On ballistic shock testing at Aberdeen Proving Ground excessive cracking developed in the fusion zone of the weld (see Chart 1). The plates were unsatisfactory on radiographic inspection because of small weld metal cracks, which were not detected during welding. These cracks did not appear to influence the path or extent of ballistic fracture in any way.

The plates were returned to Watertown Arsenal Laboratory for examination. Figure 1 shows a macroetched transverse section through the ballistic fracture, an edge photograph of a ballistic fracture (weld metal side), and a macroetched section through an undamaged portion of the weld. Bend fracture tests* were made on bars taken across undamaged sections of the welds in these plates. These bars reproduced the ballistic fracture which proceeded almost entirely through weld metal, approximately .002 inches from the bond metal. A thin scale of weld metal was visible on the plate metal side of the fracture (see Figures 1 and 2). This type of failure has been identified in two other investigations of samples from commercially welded armor joints⁽⁵⁾, and found to proceed through an area where very fine non-metallics are precipitated parallel to the fusion line in austenitic weld metal (Figure 2). This condition, which will be discussed more fully in a forthcoming report, does not appear to be related to the carbon content or hardenability of the experimental .40% C armor plate.

Almost identical fractures were obtained in bend fracture tests from joints made with similar joint design and welding procedure in Carnegie and Jones & Laughlin armor plates of approximately .26% C. An attempt was next made to improve the bend fracture by changes in the joint design. The use of a 60° rather than a 45° included angle did not change the type of failure. The use of larger beads (3/16 instead of 5/32 inch diameter electrodes) at the weld plate junction for both crowns of the double V joints, did effect considerable improvement both for .26% C Carnegie and Jones & Laughlin and the experimental .40% C armor plates. A further improvement was brought about by grinding additional bevels (1/4 inch wide) at the top corners of the crowns, and continuing the use of the 3/16 inch diameter electrode for the corner beads. Photographs of three bend fracture bars from this series of welds are shown in Figure 3. The improvement is obviously a result of relocating the stress-concentrating notch, which is unavoidably present at the junction of the weld and plate surfaces, so that failure is not initiated in the fusion zone, and of breaking up the straight line fusion zone contour observed in the photomicrographs of Figures 1 and 2. It is well established that if ballistic cracking is

* Test method described in Appendix B.

(5) See Footnotes 3 and 4.

forced into tough austenitic weld metal or properly made armor plate, the extent of failure will be markedly reduced.

It was therefore decided to weld two additional H plates of .40% C experimental armor with the improved joint design developed in the bend fracture tests and two H plates of .26% C Jones & Laughlin armor (see preceding section on primary armor test data) - one with joint design used on first two plates and one with improved joint design. Two H plates (WA5 and WA6) welded at Baldwin Locomotive Works were not ballistically tested because small weld metal cracks disclosed in radiographic examination were unsuccessfully repair welded.

"H" plates WA9 and WA11 of .40% C Republic armor plate and plate WA12 of .26% C Jones & Laughlin armor plate were welded at Watertown Arsenal with the improved geometry described in Charts 2 and 3 (Appendix A). Joint design is shown in more detail in extracts from WAS-2 Forms (Appendix A). Plate WA10 of .26% C Jones & Laughlin armor was welded with the same crown bead technique employed for plates WA2 and WA3.

On ballistic shock testing at Aberdeen Proving Ground the Jones & Laughlin plate with original joint geometry developed excessive ballistic cracking in the fusion zone, while the two experimental .40% C and the one .26% C Jones & Laughlin plates made with improved joint geometry showed very superior ballistic shock resistance. The maximum length of cracking was 3 inches for any one of a total of twelve impacts placed on the latter three plates with 75 mm. test projectiles at 1200 f/s velocity.

Figures 4 through 9 show photographs of the two Jones & Laughlin and one experimental plates after ballistic testing; macroetched sections through ballistic impacts; macroetched sections through undamaged portions of welds; bend fracture tests from undamaged portions of Jones & Laughlin welds; and nick-break fracture*. The limited depth of ballistic cracks which appear to have initiated in the tempered band at the outer edge of the weld heat-affected base metal, and the favorable bend fracture for plate with improved joint design may be noted. The nick-break fracture test was made for comparison purposes and will be discussed in a later section on ferritic welds.

None of the austenitic plates was satisfactory on radiographic inspection because of small weld metal cracks and incomplete fusion which were not detected during welding, but these defects did not affect the ballistic shock test performance. It is probable that an increase in carbon content of the base metal would tend to increase root bead cracking, and in accordance with the current theory on this subject (6), a decrease in nickel content or an increase in Cr or Mo contents of the filler metal would tend to compensate for the increased C pickup and improve this situation. The use of Mo instead of Mn modified austenitic electrodes would be a desirable first step. Also, slight modification of the welding procedure, such as use of heavier root bead passes, might be effective. The

* Test method described in Appendix B.

(6) Field, A.L., F.K. Bloom, and G.E. Linnert (Rustless Iron & Steel Corp.), "Progress Report on Development of Armor Welding Electrodes: The Effect of Variations in Cr-Ni Ratio and Mo Content of Austenitic (20 Cr-10 Ni) Electrodes on Properties of Armor Weldments," OSRD 3034, Serial M-182, 14 December 1943.

four plates welded at Watertown Arsenal were held to a 150° F. maximum interpass temperature and allowed to cool to room temperature overnight between the three successive days of welding on each plate, which practice may have increased weld metal cracking tendency.

Two "H" plates, WA7 and WA8, were welded at Baldwin Locomotive Works with ferritic electrodes. The Harnischfeger AW2C electrode with stainless type (lime base) coating was used. Preliminary welding on plate WA4 indicated that a 200° F. preheat was insufficient to prevent excessive weld metal cracking (detectable during welding) and this plate was abandoned after being partially welded. The supervisor of welding research for the National Research Council was consulted since his office has sponsored a large amount of development welding with this electrode. Mr. H. J. Zoog of the N.R.C. Welding Research Staff was appointed to supervise welding of plates WA7 and WA8. The two plates were welded with a joint design and welding procedure (see Chart 4 and extract from WAS-2 Form - Appendix A) selected by Mr. Zoog. A preheat of 300° F. and an interpass temperature of 350° - 400° F. were maintained during this welding. Results of firing tests at Aberdeen Proving Ground indicated very excellent ballistic shock resistance for both of the plates (see Chart 4 - Appendix A). A photograph of one of the plates after ballistic testing is shown in Figure 10. Photographs of a macroetched section, and nick-break and bend-fracture specimens are shown in Figure 11. The bend-fracture showed weld metal failure after considerable deformation. The nick-break test was made to see if the relatively high preheat and interpass temperatures had caused loss of toughness in the heat-affected zone (as a result of slow cooling after being heated above the critical hardening temperature during the welding operation). However, comparison with the nick-break fracture specimen for the austenitic weld (Figure 9) indicates that this very severe test developed no crystalline (slack-quench, shock-deficient) structure in either weld heat-affected zone. The ferritic weld metal itself developed only a very small amount of crystallinity and may therefore be judged as relatively tough.

Plate WA8 passed radiographic inspection, but WA7 failed because of 3/4 inch of incomplete fusion. This defect happened to be immediately adjacent to ballistic impact No. 2; so three transverse sections 3/4 inch wide were taken through this impact, macroetched and photographed (see Figure 12). The defect may be observed at the root of the weld in two of the sections. The severe ballistic impact did not initiate cracking at this defect.

GENERAL COMMENTS

It is evident that ballistic failure of .40% C experimental 1-1/2 inch thick rolled homogeneous armor plate welded with austenitic electrodes is of the same type as that occurring in armor plate of .26% C and may, therefore, be minimized by the same precautions which should be used for weldments made with current armor compositions. Very excellent ballistic shock performance was obtained for "H" plates made with the subject .40% C armor and no tendency for ballistic failure associated in any way with the hardened weld heat-affected base metal observed.

A probable tendency for increased root bead cracking of austenitic weld metal during the welding of high carbon base metal may be disclosed by radiographic inspection. It is believed that such cracking may be prevented by observing established principles with regard to C-Mn-Cr-Mo balance in chemical composition of the weld metal.

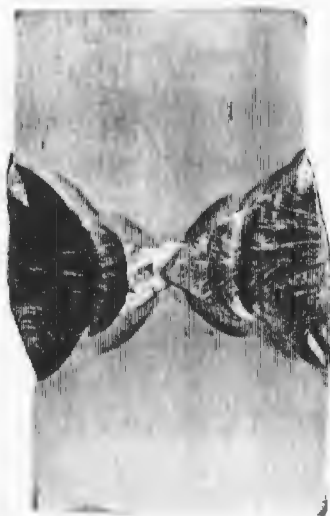
A tendency for increased root bead cracking of alloy ferritic weld metal when welding the .40% C armor plate may be prevented by utilizing slightly higher preheat and interpass temperatures. Very excellent ballistic shock performance was obtained for H plates of .40% C experimental armor welded with Mn-Mo ferritic electrode having a stainless-type (lime base) electrode coating.

Results of bend-fracture tests permit qualitative prediction of ballistic shock performance of 1-1/2 inch thick H plates.

Minor radiographic defects which caused H plates welded under this program to be judged unsatisfactory on X-ray examination did not affect location or extent of ballistic cracking.

Acknowledgements

The assistance of Mr. A. J. Raymo, Welding Superintendent of Baldwin Locomotive Works, in supervising welding of plates in his shop, and of Mr. H. J. Zoog and Mr. G. S. Mikhalapov, of the Welding Research Staff of National Research Council, in supervising welding of the two plates welded with ferritic electrodes, is appreciated. Particular appreciation is expressed to Major M. A. Matthews of Watertown Arsenal for assistance in procuring the armor and for his interest and helpful suggestions.



Macroetched transverse section through undamaged portion of weld joint.



Macroetched transverse section through ballistic fracture.

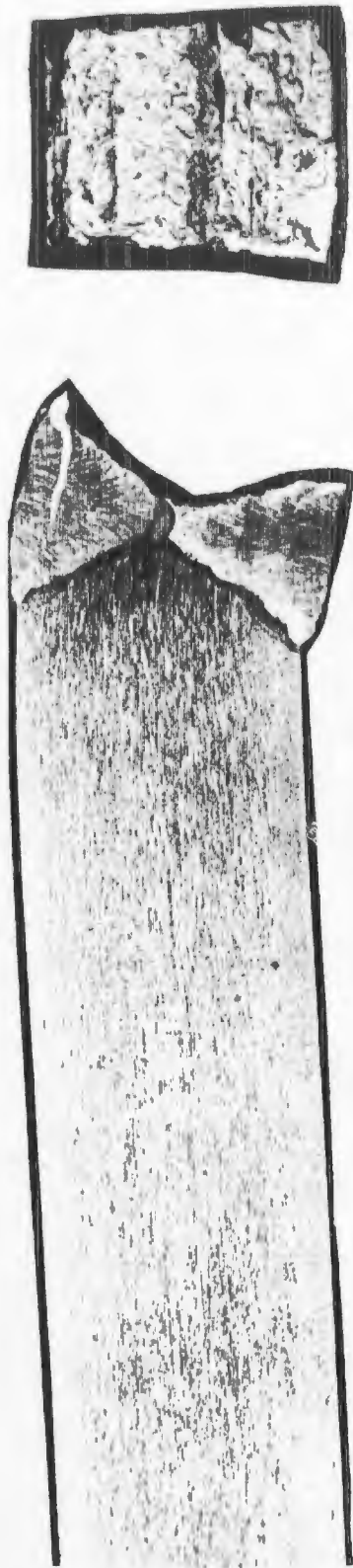


Ballistic fracture surface, weld metal side.

Macroetched Section and Ballistic Fractures from 1 1/2 Inch Thick Austenitic Hand Welded .40% C Republic Armor "H" Plates - Initial Joint Design.

WTN.639-7462

Figure 1



Bend bar fracture of 1-1/2 inch thick austenitic hand welded "H" plate WA-2



Plate metal



Plate metal



Weld metal



Weld metal



Nickel plate



Nickel plate

X500
Picral
Nonmetallics precipitated in aus-
tenitic weld metal near fusion line
of weld joint in "H" plate WA-2.

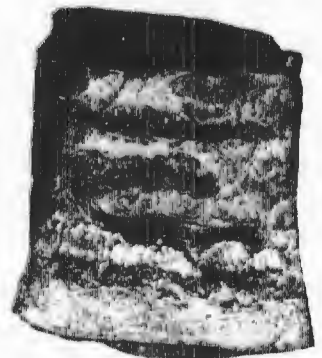
X500
Picral
Bend bar fracture path through area
of nonmetallics.



.26 C JONES AND LAUGHLIN ARMOR -45° DV BEVEL -
GEOMETRY IMPROVED WITH LARGER ANNEALING BEADS.



.40 C REPUBLIC ARMOR -45° DV BEVEL
GEOMETRY IMPROVED WITH LARGER ANNEALING BEADS.



.40 C REPUBLIC ARMOR -45° DV BEVEL -
GEOMETRY IMPROVED BY BEVELING CORNERS TO
GIVE A $67\frac{1}{2}^{\circ}$ ANGLE AT CROWN.

WATERTOWN ARSENAL

FIG. 3 BEND BAR FRACTURES OF $\frac{1}{4}$ INCH THICK ROLLED AUSTENITIC HAND WELDED ARMOR PLATE
SHOWING INFLUENCE OF WELD JOINT GEOMETRY ON PATH OF FAILURE. WTN.121-595



WATERTOWN ARSENAL

WA-10 H PLATE 1 1/2" J&L ARMOR, STRAIGHT GEOMETRY BUTT JOINT DESIGN, WELDED WITH MCKAY
 AS AUSTENITIC ELECTRODE, TESTED WITH 3 ROUNDS 75MM T21 PROOF PROJECTILE AT IMPACT
 VELOCITIES AS SHOWN. *HHH* INDICATES LOCATION AND EXTENT OF CRACKING. TESTED 4 AUG
 1944. 28 SEPT 1944 WTN.121-591

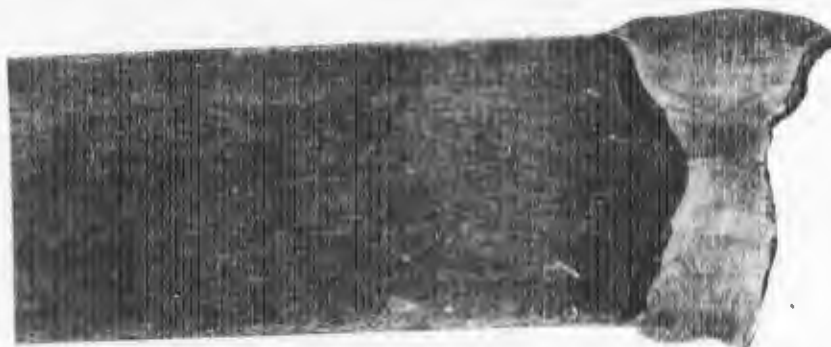
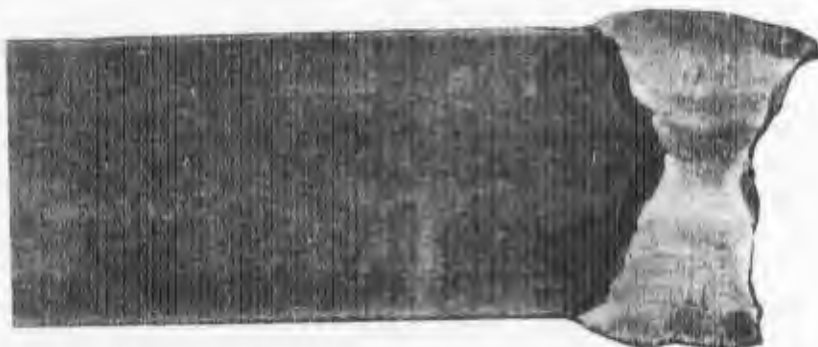
FIG. 4



Macroetched transverse section through undamaged portion of weld joint.



Macroetched transverse section through ballistic fracture.

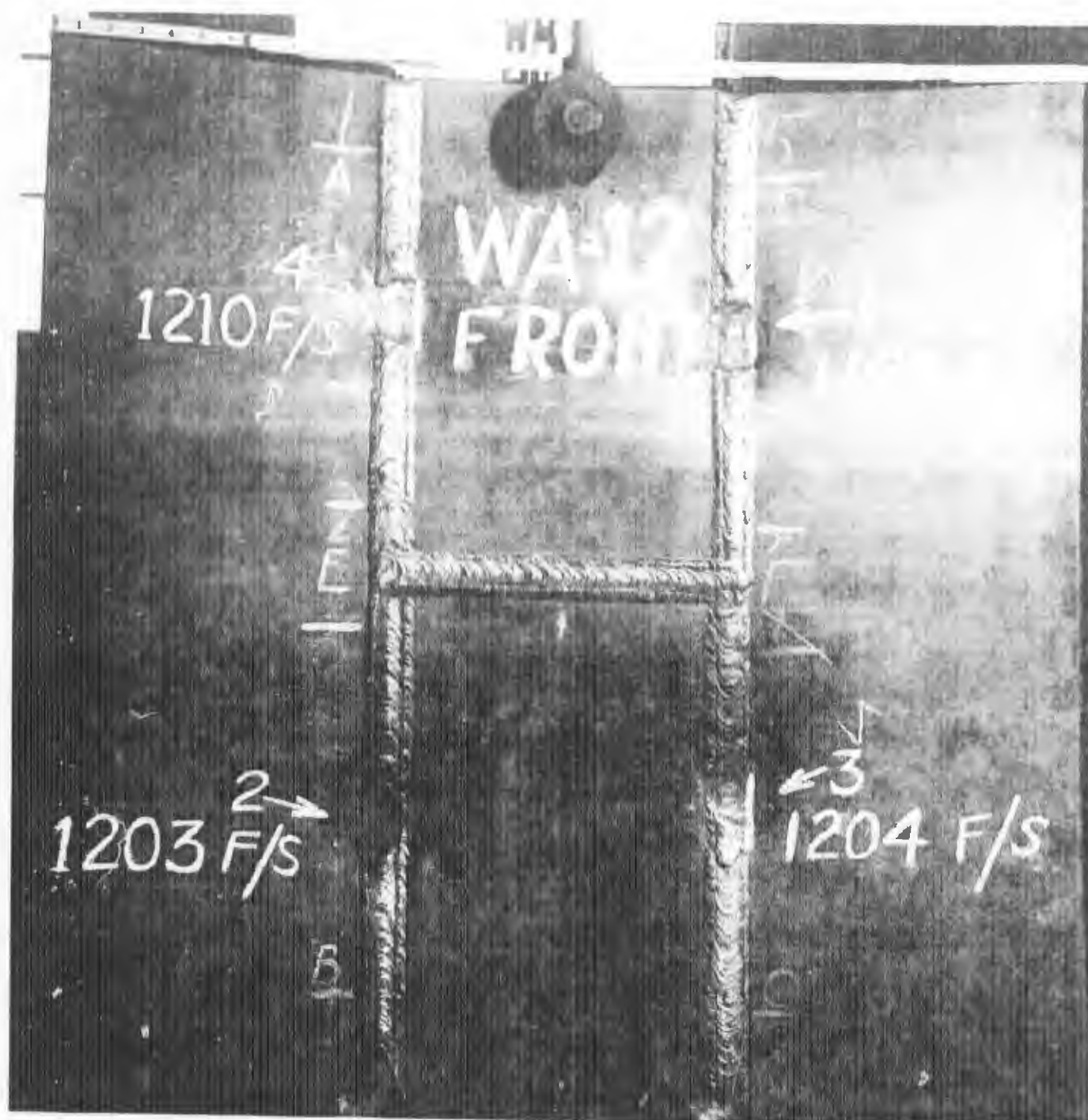


Bend bar fractures.

Macroetched Sections and Bend Bar Fractures from 1 1/2 Inch Thick Austenitic Hand Welded .26% C Jones and Laughlin Armor "H" Plate WA-10 - Initial Joint Design.

Figure 5

WTN.639-7463



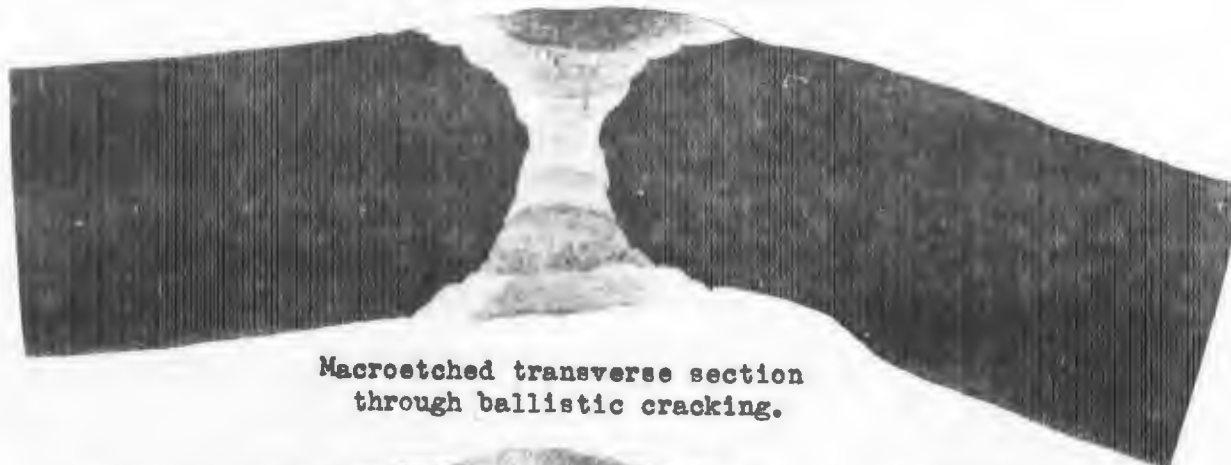
WATERTOWN ARSENAL

WA-12 H PLATE 1 1/2" J&L ARMOR, IMPROVED BUTT JOINT DESIGN, WELDED WITH MCKAY AS
AUSTENITIC ELECTRODE. TESTED WITH 4 ROUNDS 75MM T21 PROOF PROJECTILE AT IMPACT
VELOCITIES AS SHOWN. ——— INDICATES LOCATION AND EXTENT OF CRACKING. TESTED
4 AUG 1944. 28 SEPT 1944 WTN.121-592

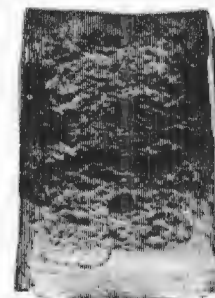
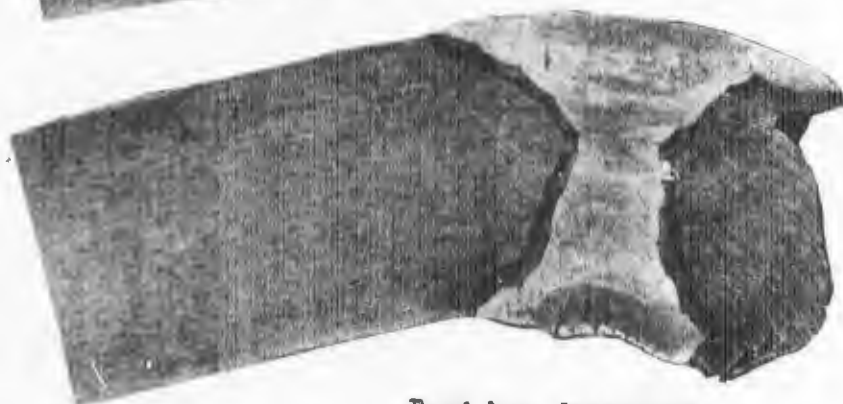
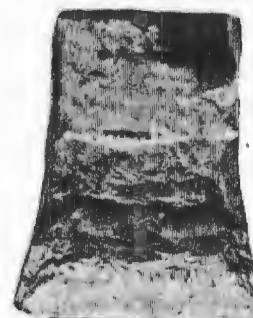
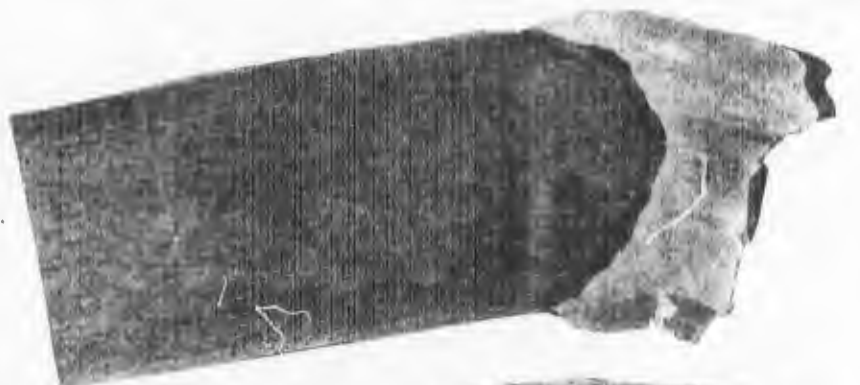
FIG. 6



Macroetched transverse section through undamaged portion of weld joint.



Macroetched transverse section through ballistic cracking.



Bend bar fractures.

Macroetched Sections and Bend Bar Fractures from 1 1/2 Inch Thick Austenitic Hand Welded .26% C Jones and Laughlin Armor "H" Plate WA-12 - Improved Joint Design.

WTN.639-7464

Figure 7



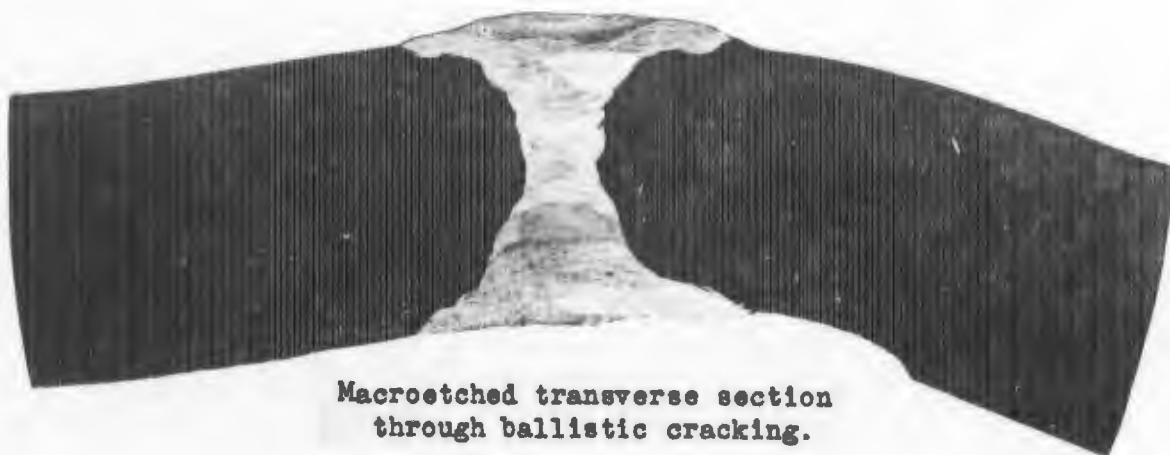
WATERTOWN ARSENAL

WA-9 H PLATE $1\frac{1}{2}$ " 0.40% C. EXPERIMENTAL ARMOR, IMPROVED BUTT JOINT DESIGN, WELDED WITH MCKAY A5 AUSTENITIC ELECTRODE. TESTED WITH 4 ROUNDS 75MM T21 PROOF PROJECTILE AT IMPACT VELOCITIES AS SHOWN 4 AUG 1944 ——— INDICATES LOCATION AND EXTENT OF CRACKING. 28 SEPT 1944 WTN.121-590

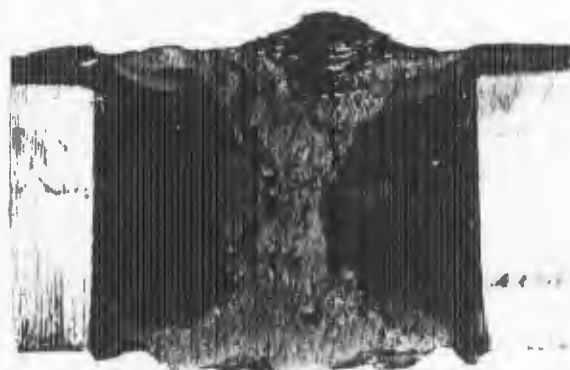
FIG. 8



Macroetched transverse section through undamaged portion of weld joint.



Macroetched transverse section through ballistic cracking.

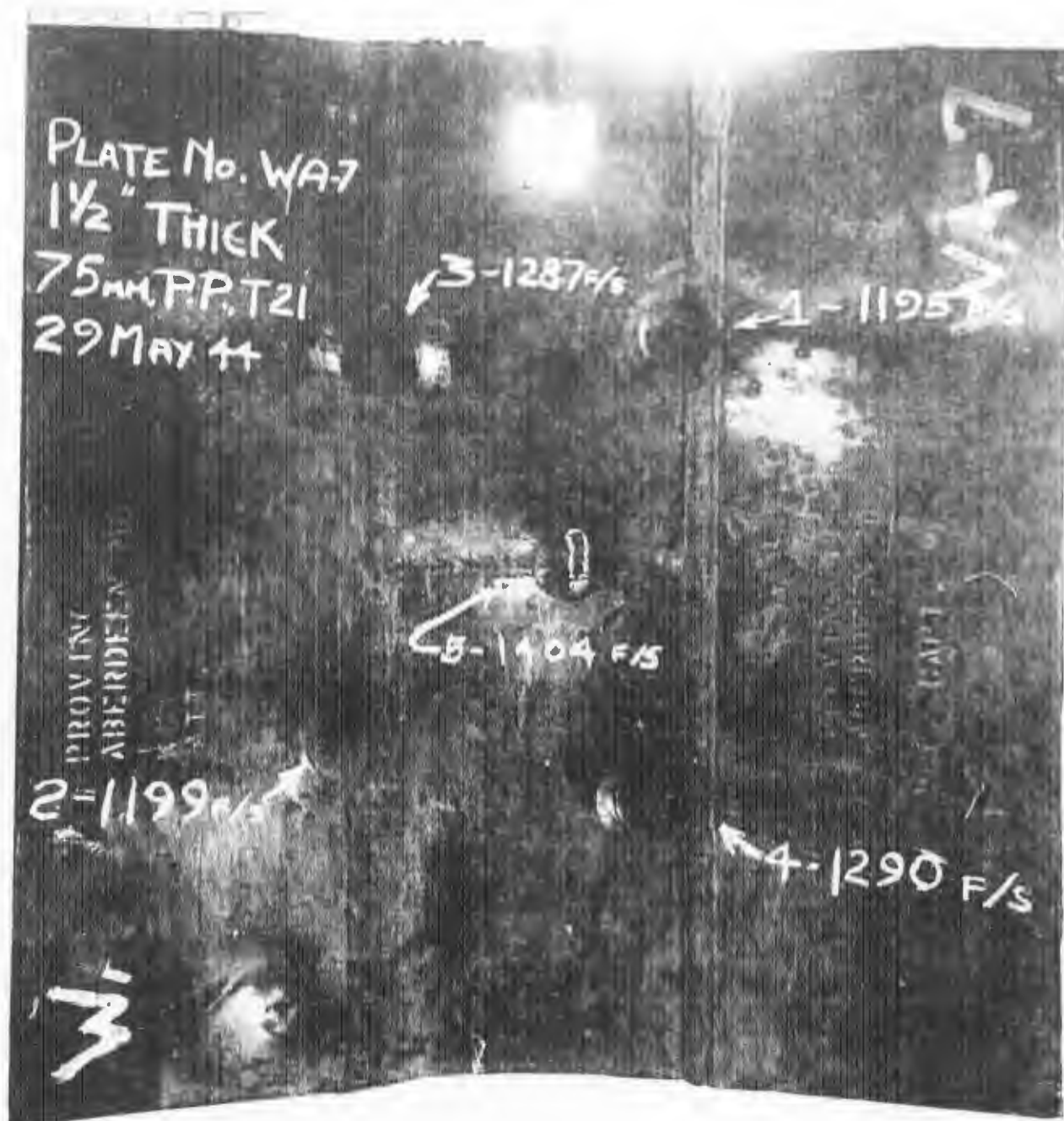


Nick-break fracture.

Macroetched Sections and Nick-Break Fracture from 1 1/2 Inch Thick - Austenitic Hand Welded .40% C Republic Armor "H" Plate WA-9 - Improved Joint Design.

Figure 9

WTN.639-7465



WATERTOWN ARSENAL

1/2" PLATE 1 1/2" 0.40% C EXPERIMENTAL ARMOR WELDED WITH HARNISCHFEGER
AW-2C ELECTRODE. TESTED WITH 5 ROUNDS 75MM T-21 PROOF PROJECTILES,
1 JULY 1944 WTN.121-583

FIG. 10



Macroetched transverse section through undamaged portion of weld joint.



Bend bar fracture.

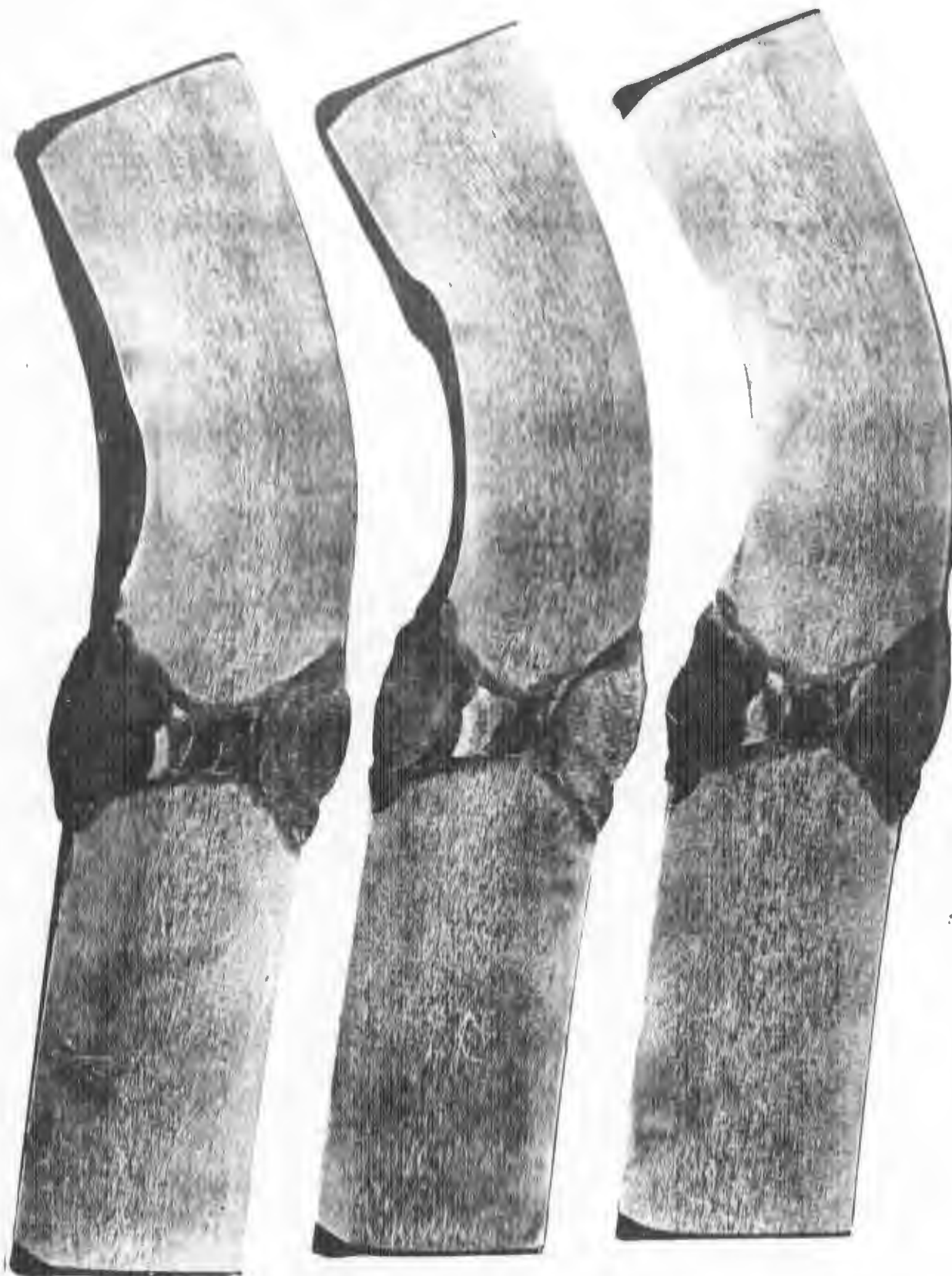


Nick-break fracture.

Macroetched Section and Fracture Specimens from 1 1/2 Inch Thick Ferritic Hand Welded .40% C Republic Armor "H" Plate WA-7.

WTN.639-7466

Figure 11



WATERTOWN ARSENAL

SECTIONS THROUGH AREA OF INCOMPLETE PENETRATION AND ADJACENT BALLISTIC IMPACT IN
1 1/2 INCH THICK "H" PLATE WA-7 (.40C ARMOR AND AW-2C FERRITIC ELECTRODE; 75MM TEST
PROJECTILE FIRED AT 1290 F/S.) MAG. XI. 24 AUGUST 1944 WTN.121-520

FIG. 12

APPENDIX A

1. Firing Record data for primary armor test plates.
 .40% C Republic
 .26% C Jones & Laughlin
2. Key to tabulation of H plate welding procedure and ballistic test data.
3. Specification requirements for H plates welded with austenitic electrodes.
4. Tabulation charts of Firing Record data for eight welded H plates.
5. Form No. WAS-2, Sheet 1 for WA2, WA8, and WA9.

Ord. Dist. Cleveland

EPG

Rec'd 9/7/43

ARMOR DATA

A21008-145745

MFR Republic Steel Corp. PRIMARY CONTRACTOR

LOC. Massillon, Ohio

DATE 9-18-43

SHP VIA ~~FBI EXP TRK~~TO ~~EPG~~ Watertown ArsenalTYPE ~~ROLL~~ HOMO ~~STEEL~~SAMPLE PRIMARY ~~STEEL~~

STEEL SOURCE

Republic Steel Corp.
Canton, Ohio

DATE 9/24/43

AXS SPECIFICATION 488

CONTRACT W952ord7736

OBJ ACCEPTANCE ~~INSTEAD OF~~
~~EXCISE TAX~~

PERTAINS TO VEH OR PAR

	PROJECTILE	OBL	THICKNESS		LOW C	HIGH P	B L	SPECIFIED LIMIT	THICK	REMARKS
			NOM	ACT						
1	37mm V74AP	Oo	1-1/2	1.52"	1414	1399	1406	1339		
	75mm T21	Oo						1260	1247	Medium bulge
	37mm M74AP	Oo						2550	2518	Ex. Dia. 2-5/16" x 2-11/32"
2	75mm T21	Oo						1412	1405	L.B. 3" Horz. Crack

PROOF FACILITY SIGNATURE

BY:

P. E. RUNDALL
Col., Ord. Dept.
CommandingC. L. Sidinger
C. L. SIDINGER
Major, Ord. Dept.
Chief Proof OfficerH. H. ABRAM
Capt., Ord. Dept.
Proof OfficerPOSITION OF PLATE ~~1~~ ~~2~~ ~~3~~ ~~4~~ ~~5~~ ~~6~~ ~~7~~ ~~8~~ ~~9~~ ~~10~~ ~~11~~ ~~12~~ ~~13~~ ~~14~~ ~~15~~ ~~16~~ ~~17~~ ~~18~~ ~~19~~ ~~20~~ ~~21~~ ~~22~~ ~~23~~ ~~24~~ ~~25~~ ~~26~~ ~~27~~ ~~28~~ ~~29~~ ~~30~~ ~~31~~ ~~32~~ ~~33~~ ~~34~~ ~~35~~ ~~36~~ ~~37~~ ~~38~~ ~~39~~ ~~40~~ ~~41~~ ~~42~~ ~~43~~ ~~44~~ ~~45~~ ~~46~~ ~~47~~ ~~48~~ ~~49~~ ~~50~~ ~~51~~ ~~52~~ ~~53~~ ~~54~~ ~~55~~ ~~56~~ ~~57~~ ~~58~~ ~~59~~ ~~60~~ ~~61~~ ~~62~~ ~~63~~ ~~64~~ ~~65~~ ~~66~~ ~~67~~ ~~68~~ ~~69~~ ~~70~~ ~~71~~ ~~72~~ ~~73~~ ~~74~~ ~~75~~ ~~76~~ ~~77~~ ~~78~~ ~~79~~ ~~80~~ ~~81~~ ~~82~~ ~~83~~ ~~84~~ ~~85~~ ~~86~~ ~~87~~ ~~88~~ ~~89~~ ~~90~~ ~~91~~ ~~92~~ ~~93~~ ~~94~~ ~~95~~ ~~96~~ ~~97~~ ~~98~~ ~~99~~ ~~100~~ ~~101~~ ~~102~~ ~~103~~ ~~104~~ ~~105~~ ~~106~~ ~~107~~ ~~108~~ ~~109~~ ~~110~~ ~~111~~ ~~112~~ ~~113~~ ~~114~~ ~~115~~ ~~116~~ ~~117~~ ~~118~~ ~~119~~ ~~120~~ ~~121~~ ~~122~~ ~~123~~ ~~124~~ ~~125~~ ~~126~~ ~~127~~ ~~128~~ ~~129~~ ~~130~~ ~~131~~ ~~132~~ ~~133~~ ~~134~~ ~~135~~ ~~136~~ ~~137~~ ~~138~~ ~~139~~ ~~140~~ ~~141~~ ~~142~~ ~~143~~ ~~144~~ ~~145~~ ~~146~~ ~~147~~ ~~148~~ ~~149~~ ~~150~~ ~~151~~ ~~152~~ ~~153~~ ~~154~~ ~~155~~ ~~156~~ ~~157~~ ~~158~~ ~~159~~ ~~160~~ ~~161~~ ~~162~~ ~~163~~ ~~164~~ ~~165~~ ~~166~~ ~~167~~ ~~168~~ ~~169~~ ~~170~~ ~~171~~ ~~172~~ ~~173~~ ~~174~~ ~~175~~ ~~176~~ ~~177~~ ~~178~~ ~~179~~ ~~180~~ ~~181~~ ~~182~~ ~~183~~ ~~184~~ ~~185~~ ~~186~~ ~~187~~ ~~188~~ ~~189~~ ~~190~~ ~~191~~ ~~192~~ ~~193~~ ~~194~~ ~~195~~ ~~196~~ ~~197~~ ~~198~~ ~~199~~ ~~200~~ ~~201~~ ~~202~~ ~~203~~ ~~204~~ ~~205~~ ~~206~~ ~~207~~ ~~208~~ ~~209~~ ~~210~~ ~~211~~ ~~212~~ ~~213~~ ~~214~~ ~~215~~ ~~216~~ ~~217~~ ~~218~~ ~~219~~ ~~220~~ ~~221~~ ~~222~~ ~~223~~ ~~224~~ ~~225~~ ~~226~~ ~~227~~ ~~228~~ ~~229~~ ~~230~~ ~~231~~ ~~232~~ ~~233~~ ~~234~~ ~~235~~ ~~236~~ ~~237~~ ~~238~~ ~~239~~ ~~240~~ ~~241~~ ~~242~~ ~~243~~ ~~244~~ ~~245~~ ~~246~~ ~~247~~ ~~248~~ ~~249~~ ~~250~~ ~~251~~ ~~252~~ ~~253~~ ~~254~~ ~~255~~ ~~256~~ ~~257~~ ~~258~~ ~~259~~ ~~260~~ ~~261~~ ~~262~~ ~~263~~ ~~264~~ ~~265~~ ~~266~~ ~~267~~ ~~268~~ ~~269~~ ~~270~~ ~~271~~ ~~272~~ ~~273~~ ~~274~~ ~~275~~ ~~276~~ ~~277~~ ~~278~~ ~~279~~ ~~280~~ ~~281~~ ~~282~~ ~~283~~ ~~284~~ ~~285~~ ~~286~~ ~~287~~ ~~288~~ ~~289~~ ~~290~~ ~~291~~ ~~292~~ ~~293~~ ~~294~~ ~~295~~ ~~296~~ ~~297~~ ~~298~~ ~~299~~ ~~300~~ ~~301~~ ~~302~~ ~~303~~ ~~304~~ ~~305~~ ~~306~~ ~~307~~ ~~308~~ ~~309~~ ~~310~~ ~~311~~ ~~312~~ ~~313~~ ~~314~~ ~~315~~ ~~316~~ ~~317~~ ~~318~~ ~~319~~ ~~320~~ ~~321~~ ~~322~~ ~~323~~ ~~324~~ ~~325~~ ~~326~~ ~~327~~ ~~328~~ ~~329~~ ~~330~~ ~~331~~ ~~332~~ ~~333~~ ~~334~~ ~~335~~ ~~336~~ ~~337~~ ~~338~~ ~~339~~ ~~340~~ ~~341~~ ~~342~~ ~~343~~ ~~344~~ ~~345~~ ~~346~~ ~~347~~ ~~348~~ ~~349~~ ~~350~~ ~~351~~ ~~352~~ ~~353~~ ~~354~~ ~~355~~ ~~356~~ ~~357~~ ~~358~~ ~~359~~ ~~360~~ ~~361~~ ~~362~~ ~~363~~ ~~364~~ ~~365~~ ~~366~~ ~~367~~ ~~368~~ ~~369~~ ~~370~~ ~~371~~ ~~372~~ ~~373~~ ~~374~~ ~~375~~ ~~376~~ ~~377~~ ~~378~~ ~~379~~ ~~380~~ ~~381~~ ~~382~~ ~~383~~ ~~384~~ ~~385~~ ~~386~~ ~~387~~ ~~388~~ ~~389~~ ~~390~~ ~~391~~ ~~392~~ ~~393~~ ~~394~~ ~~395~~ ~~396~~ ~~397~~ ~~398~~ ~~399~~ ~~400~~ ~~401~~ ~~402~~ ~~403~~ ~~404~~ ~~405~~ ~~406~~ ~~407~~ ~~408~~ ~~409~~ ~~410~~ ~~411~~ ~~412~~ ~~413~~ ~~414~~ ~~415~~ ~~416~~ ~~417~~ ~~418~~ ~~419~~ ~~420~~ ~~421~~ ~~422~~ ~~423~~ ~~424~~ ~~425~~ ~~426~~ ~~427~~ ~~428~~ ~~429~~ ~~430~~ ~~431~~ ~~432~~ ~~433~~ ~~434~~ ~~435~~ ~~436~~ ~~437~~ ~~438~~ ~~439~~ ~~440~~ ~~441~~ ~~442~~ ~~443~~ ~~444~~ ~~445~~ ~~446~~ ~~447~~ ~~448~~ ~~449~~ ~~450~~ ~~451~~ ~~452~~ ~~453~~ ~~454~~ ~~455~~ ~~456~~ ~~457~~ ~~458~~ ~~459~~ ~~460~~ ~~461~~ ~~462~~ ~~463~~ ~~464~~ ~~465~~ ~~466~~ ~~467~~ ~~468~~ ~~469~~ ~~470~~ ~~471~~ ~~472~~ ~~473~~ ~~474~~ ~~475~~ ~~476~~ ~~477~~ ~~478~~ ~~479~~ ~~480~~ ~~481~~ ~~482~~ ~~483~~ ~~484~~ ~~485~~ ~~486~~ ~~487~~ ~~488~~ ~~489~~ ~~490~~ ~~491~~ ~~492~~ ~~493~~ ~~494~~ ~~495~~ ~~496~~ ~~497~~ ~~498~~ ~~499~~ ~~500~~ ~~501~~ ~~502~~ ~~503~~ ~~504~~ ~~505~~ ~~506~~ ~~507~~ ~~508~~ ~~509~~ ~~510~~ ~~511~~ ~~512~~ ~~513~~ ~~514~~ ~~515~~ ~~516~~ ~~517~~ ~~518~~ ~~519~~ ~~520~~ ~~521~~ ~~522~~ ~~523~~ ~~524~~ ~~525~~ ~~526~~ ~~527~~ ~~528~~ ~~529~~ ~~530~~ ~~531~~ ~~532~~ ~~533~~ ~~534~~ ~~535~~ ~~536~~ ~~537~~ ~~538~~ ~~539~~ ~~540~~ ~~541~~ ~~542~~ ~~543~~ ~~544~~ ~~545~~ ~~546~~ ~~547~~ ~~548~~ ~~549~~ ~~550~~ ~~551~~ ~~552~~ ~~553~~ ~~554~~ ~~555~~ ~~556~~ ~~557~~ ~~558~~ ~~559~~ ~~560~~ ~~561~~ ~~562~~ ~~563~~ ~~564~~ ~~565~~ ~~566~~ ~~567~~ ~~568~~ ~~569~~ ~~570~~ ~~571~~ ~~572~~ ~~573~~ ~~574~~ ~~575~~ ~~576~~ ~~577~~ ~~578~~ ~~579~~ ~~580~~ ~~581~~ ~~582~~ ~~583~~ ~~584~~ ~~585~~ ~~586~~ ~~587~~ ~~588~~ ~~589~~ ~~590~~ ~~591~~ ~~592~~ ~~593~~ ~~594~~ ~~595~~ ~~596~~ ~~597~~ ~~598~~ ~~599~~ ~~600~~ ~~601~~ ~~602~~ ~~603~~ ~~604~~ ~~605~~ ~~606~~ ~~607~~ ~~608~~ ~~609~~ ~~610~~ ~~611~~ ~~612~~ ~~613~~ ~~614~~ ~~615~~ ~~616~~ ~~617~~ ~~618~~ ~~619~~ ~~620~~ ~~621~~ ~~622~~ ~~623~~ ~~624~~ ~~625~~ ~~626~~ ~~627~~ ~~628~~ ~~629~~ ~~630~~ ~~631~~ ~~632~~ ~~633~~ ~~634~~ ~~635~~ ~~636~~ ~~637~~ ~~638~~ ~~639~~ ~~640~~ ~~641~~ ~~642~~ ~~643~~ ~~644~~ ~~645~~ ~~646~~ ~~647~~ ~~648~~ ~~649~~ ~~650~~ ~~651~~ ~~652~~ ~~653~~ ~~654~~ ~~655~~ ~~656~~ ~~657~~ ~~658~~ ~~659~~ ~~660~~ ~~661~~ ~~662~~ ~~663~~ ~~664~~ ~~665~~ ~~666~~ ~~667~~ ~~668~~ ~~669~~ ~~670~~ ~~671~~ ~~672~~ ~~673~~ ~~674~~ ~~675~~ ~~676~~ ~~677~~ ~~678~~ ~~679~~ ~~680~~ ~~681~~ ~~682~~ ~~683~~ ~~684~~ ~~685~~ ~~686~~ ~~687~~ ~~688~~ ~~689~~ ~~690~~ ~~691~~ ~~692~~ ~~693~~ ~~694~~ ~~695~~ ~~696~~ ~~697~~ ~~698~~ ~~699~~ ~~700~~ ~~701~~ ~~702~~ ~~703~~ ~~704~~ ~~705~~ ~~706~~ ~~707~~ ~~708~~ ~~709~~ ~~710~~ ~~711~~ ~~712~~ ~~713~~ ~~714~~ ~~715~~ ~~716~~ ~~717~~ ~~718~~ ~~719~~ ~~720~~ ~~721~~ ~~722~~ ~~723~~ ~~724~~ ~~725~~ ~~726~~ ~~727~~ ~~728~~ ~~729~~ ~~730~~ ~~731~~ ~~732~~ ~~733~~ ~~734~~ ~~735~~ ~~736~~ ~~737~~ ~~738~~ ~~739~~ ~~740~~ ~~741~~ ~~742~~ ~~743~~ ~~744~~ ~~745~~ ~~746~~ ~~747~~ ~~748~~ ~~749~~ ~~750~~ ~~751~~ ~~752~~ ~~753~~ ~~754~~ ~~755~~ ~~756~~ ~~757~~ ~~758~~ ~~759~~ ~~760~~ ~~761~~ ~~762~~ ~~763~~ ~~764~~ ~~765~~ ~~766~~ ~~767~~ ~~768~~ ~~769~~ ~~770~~ ~~771~~ ~~772~~ ~~773~~ ~~774~~ ~~775~~ ~~776~~ ~~777~~ ~~778~~ ~~779~~ ~~780~~ ~~781~~ ~~782~~ ~~783~~ ~~784~~ ~~785~~ ~~786~~ ~~787~~ ~~788~~ ~~789~~ ~~790~~ ~~791~~ ~~792~~ ~~793~~ ~~794~~ ~~795~~ ~~796~~ ~~797~~ ~~798~~ ~~799~~ ~~800~~ ~~801~~ ~~802~~ ~~803~~ ~~804~~ ~~805~~ ~~806~~ ~~807~~ ~~808~~ ~~809~~ ~~810~~ ~~811~~ ~~812~~ ~~813~~ ~~814~~ ~~815~~ ~~816~~ ~~817~~ ~~818~~ ~~819~~ ~~820~~ ~~821~~ ~~822~~ ~~823~~ ~~824~~ ~~825~~ ~~826~~ ~~827~~ ~~828~~ ~~829~~ ~~830~~ ~~831~~ ~~832~~ ~~833~~ ~~834~~ ~~835~~ ~~836~~ ~~837~~ ~~838~~ ~~839~~ ~~840~~ ~~841~~ ~~842~~ ~~843~~ ~~844~~ ~~845~~ ~~846~~ ~~847~~ ~~848~~ ~~849~~ ~~850~~ ~~851~~ ~~852~~ ~~853~~ ~~854~~ ~~855~~ ~~856~~ ~~857~~ ~~858~~ ~~859~~ ~~860~~ ~~861~~ ~~862~~ ~~863~~ ~~864~~ ~~865~~ ~~866~~ ~~867~~ ~~868~~ ~~869~~ ~~870~~ ~~871~~ ~~872~~ ~~873~~ ~~874~~ ~~875~~ ~~876~~ ~~877~~ ~~878~~ ~~879~~ ~~880~~ ~~881~~ ~~882~~ ~~883~~ ~~884~~ ~~885~~ ~~886~~ ~~887~~ ~~888~~ ~~889~~ ~~890~~ ~~891~~ ~~892~~ ~~893~~ ~~894~~ ~~895~~ ~~896~~ ~~897~~ ~~898~~ ~~899~~ ~~900~~ ~~901~~ ~~902~~ ~~903~~ ~~904~~ ~~905~~ ~~906~~ ~~907~~ ~~908~~ ~~909~~ ~~910~~ ~~911~~ ~~912~~ ~~913~~ ~~914~~ ~~915~~ ~~916~~ ~~917~~ ~~918~~ ~~919~~ ~~920~~ ~~921~~ ~~922~~ ~~923~~ ~~924~~ ~~925~~ ~~926~~ ~~927~~ ~~928~~ ~~929~~ ~~930~~ ~~931~~ ~~932~~ ~~933~~ ~~934~~ ~~935~~ ~~936~~ ~~937~~ ~~938~~ ~~939~~ ~~940~~ ~~941~~ ~~942~~ ~~943~~ ~~944~~ ~~945~~ ~~946~~ ~~947~~ ~~948~~ ~~949~~ ~~950~~ ~~951~~ ~~952~~ ~~953~~ ~~954~~ ~~955~~ ~~956~~ ~~957~~ ~~958~~ ~~959~~ ~~960~~ ~~961~~ ~~962~~ ~~963~~ ~~964~~ ~~965~~ ~~966~~ ~~967~~ ~~968~~ ~~969~~ ~~970~~ ~~971~~ ~~972~~ ~~973~~ ~~974~~ ~~975~~ ~~976~~ ~~977~~ ~~978~~ ~~979~~ ~~980~~ ~~981~~ ~~982~~ ~~983~~ ~~984~~ ~~985~~ ~~986~~ ~~987~~ ~~988~~ ~~989~~ ~~990~~ ~~991~~ ~~992~~ ~~993~~ ~~994~~ ~~995~~ ~~996~~ ~~997~~ ~~998~~ ~~999~~ ~~1000~~ ~~1001~~ ~~1002~~ ~~1003~~ ~~1004~~ ~~1005~~ ~~1006~~ ~~1007~~ ~~1008~~ ~~1009~~ ~~1010~~ ~~1011~~ ~~1012~~ ~~1013~~ ~~1014~~ ~~1015~~ ~~1016~~ ~~1017~~ ~~1018~~ ~~1019~~ ~~1020~~ ~~1021~~ ~~1022~~ ~~1023~~ ~~1024~~ ~~1025~~ ~~1026~~ ~~1027~~ ~~1028~~ ~~1029~~ ~~1030~~ ~~1031~~ ~~1032~~ ~~1033~~ ~~1034~~ ~~1035~~ ~~1036~~ ~~1037~~ ~~1038~~ ~~1039~~ ~~1040~~ ~~1041~~ ~~1042~~ ~~1043~~ ~~1044~~ ~~1045~~ ~~1046~~ ~~1047~~ ~~1048~~ ~~1049~~ ~~1050~~ ~~1051~~ ~~1052~~ ~~1053~~ ~~1054~~ ~~1055~~ ~~1056~~ ~~1057~~ ~~1058~~ ~~1059~~ ~~1060~~ ~~1061~~ ~~1062~~ ~~1063~~ ~~1064~~ ~~1065~~ ~~1066~~ ~~1067~~ ~~1068~~ ~~1069~~ ~~1070~~ ~~1071~~ ~~1072~~ ~~1073~~ ~~1074~~ ~~1075~~ ~~1076~~ ~~1077~~ ~~1078~~ ~~1079~~ ~~1080~~ ~~1081~~ ~~1082~~ ~~1083~~ ~~1084~~ ~~1085~~ ~~1086~~ ~~1087~~ ~~1088~~ ~~1089~~ ~~1090~~ ~~1091~~ ~~1092~~ ~~1093~~ ~~1094~~ ~~1095~~ ~~1096~~ ~~1097~~ ~~1098~~ ~~1099~~ ~~1100~~ ~~1101~~ ~~1102~~ ~~1103~~ ~~1104~~ ~~1105~~ ~~1106~~ ~~1107~~ ~~1108~~ ~~1109~~ ~~1110~~ ~~1111~~ ~~1112~~ ~~1113~~ ~~1114~~ ~~1115~~ ~~1116~~ ~~1117~~ ~~1118~~ ~~1119~~ ~~1120~~ ~~1121~~ ~~1122~~ ~~1123~~ ~~1124~~ ~~1125~~ ~~1126~~ ~~1127~~ ~~1128~~ ~~1129~~ ~~1130~~ ~~1131~~ ~~1132~~ ~~1133~~ ~~1134~~ ~~1135~~ ~~1136~~ ~~1137~~ ~~1138~~ ~~1139~~ ~~1140~~ ~~1141~~ ~~1142~~ ~~1143~~ ~~1144~~ ~~1145~~ ~~1146~~ ~~1147~~ ~~1148~~ ~~1149~~ ~~1150~~ ~~1151~~ ~~1152~~ ~~1153~~ ~~1154~~ ~~1155~~ ~~1156~~ ~~1157~~ ~~1158~~ ~~1159~~ ~~1160~~ ~~1161~~ ~~1162~~ ~~1163~~ ~~1164~~ ~~1165~~ ~~1166~~ ~~1167~~ ~~1168~~ ~~1169~~ ~~1170~~ ~~1171~~ ~~1172~~ ~~1173~~ ~~1174~~ ~~1175~~ ~~1176~~ ~~1177~~ ~~1178~~

Ord: Dist. Pittsburgh

ARMOR DATA-~~CONFIDENTIAL~~

FIRING RECORD NO. 146051

FILLED IN BY SUPPLIER		MFR. Standard Steel Spring										PRIMARY CONTRACTORS										FIRING RECORD NO. 146051																																																																																																																																																																	
		LOC. Coraopolis, Pa.																				A 21053																																																																																																																																																																	
		DATE Sept. 21, 1943																				DATE 9/23/43																																																																																																																																																																	
		SHP VIA- FRTD EXR TRK.																				SPECIFICATION																																																																																																																																																																	
		TO ARE RIA ERIE																				AXS- 885 Spec. A cc. Spec.																																																																																																																																																																	
		TYPE CAST ROLLED																				Fire under AXS-488																																																																																																																																																																	
FILLED IN BY PROVING GROUND		NO.		SAMPLE PRIMARY CHECK																				OBJ. CONTRACT																																																																																																																																																															
				PERTAINS TO VEHICLE OR PART																				ACCEPTANCE																																																																																																																																																															
FILLED IN BY PROVING GROUND		NO.		BALLISTIC RECORD																																																																																																																																																																																			
FILLED IN BY PROVING GROUND		NO.		<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <th>PROJECTILE</th> <th>OBL</th> <th colspan="2">THICKNESS</th> <th>LOW C.</th> <th>HIGH P.</th> <th>B.L.</th> <th>SPECIFIED LIMIT</th> <th>SHOCK</th> <th>PTP</th> <th>REMARKS</th> </tr> <tr> <th></th> <th></th> <th>NOM.</th> <th>ACT.</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> </tr> <tr> <td>37 mm M74 AP</td> <td>0°</td> <td></td> <td>1.50"</td> <td>1413</td> <td>1369</td> <td>1391</td> <td>1325</td> <td></td> <td></td> <td></td> </tr> <tr> <td>75 mm T21</td> <td>0°</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>1250</td> <td>1252</td> <td></td> <td>Medium Bulge</td> </tr> <tr> <td>37 mm M74 AP</td> <td>0°</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>2550</td> <td></td> <td>2556</td> <td>Ex. dia. 2-3/32</td> </tr> <tr> <td>75 mm T21</td> <td>0°</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>1400</td> <td>1393</td> <td></td> <td>2-3/16. Large Bulge</td> </tr> <tr> <td>37 mm M74 AP</td> <td>0°</td> <td></td> <td>1.51"</td> <td>1450</td> <td>1412</td> <td>1431</td> <td>1332</td> <td></td> <td></td> <td></td> </tr> <tr> <td>75 mm T21</td> <td>0°</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>1255</td> <td>1248</td> <td></td> <td>Medium Bulge</td> </tr> <tr> <td>37 mm M74 AP</td> <td>0°</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>2550</td> <td></td> <td>2546</td> <td>Ex. dia. 2-3/16 x 4</td> </tr> <tr> <td>75 mm T21</td> <td>0°</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>1406</td> <td>1367</td> <td></td> <td>2-5/32. Medium Bulge</td> </tr> <tr> <td>37 mm M74 AP</td> <td>0°</td> <td></td> <td>1.49"</td> <td>1403</td> <td>1380</td> <td>1391</td> <td>1312</td> <td></td> <td></td> <td></td> </tr> <tr> <td>75 mm T21</td> <td>0°</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>1242</td> <td>1255</td> <td></td> <td>Medium Bulge</td> </tr> <tr> <td>37 mm M74 AP</td> <td>0°</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>2550</td> <td></td> <td>2563</td> <td>Ex. dia. 2-15/32 x 4</td> </tr> <tr> <td>75 mm T21</td> <td>0°</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>1394</td> <td>1394</td> <td></td> <td>2-1/2. Medium Bulge</td> </tr> </table>																										PROJECTILE	OBL	THICKNESS		LOW C.	HIGH P.	B.L.	SPECIFIED LIMIT	SHOCK	PTP	REMARKS			NOM.	ACT.								37 mm M74 AP	0°		1.50"	1413	1369	1391	1325				75 mm T21	0°						1250	1252		Medium Bulge	37 mm M74 AP	0°						2550		2556	Ex. dia. 2-3/32	75 mm T21	0°						1400	1393		2-3/16. Large Bulge	37 mm M74 AP	0°		1.51"	1450	1412	1431	1332				75 mm T21	0°						1255	1248		Medium Bulge	37 mm M74 AP	0°						2550		2546	Ex. dia. 2-3/16 x 4	75 mm T21	0°						1406	1367		2-5/32. Medium Bulge	37 mm M74 AP	0°		1.49"	1403	1380	1391	1312				75 mm T21	0°						1242	1255		Medium Bulge	37 mm M74 AP	0°						2550		2563	Ex. dia. 2-15/32 x 4	75 mm T21	0°						1394	1394		2-1/2. Medium Bulge
				PROJECTILE	OBL	THICKNESS		LOW C.	HIGH P.	B.L.	SPECIFIED LIMIT	SHOCK	PTP	REMARKS																																																																																																																																																																									
		NOM.	ACT.																																																																																																																																																																																				
37 mm M74 AP	0°		1.50"	1413	1369	1391	1325																																																																																																																																																																																
75 mm T21	0°						1250	1252		Medium Bulge																																																																																																																																																																													
37 mm M74 AP	0°						2550		2556	Ex. dia. 2-3/32																																																																																																																																																																													
75 mm T21	0°						1400	1393		2-3/16. Large Bulge																																																																																																																																																																													
37 mm M74 AP	0°		1.51"	1450	1412	1431	1332																																																																																																																																																																																
75 mm T21	0°						1255	1248		Medium Bulge																																																																																																																																																																													
37 mm M74 AP	0°						2550		2546	Ex. dia. 2-3/16 x 4																																																																																																																																																																													
75 mm T21	0°						1406	1367		2-5/32. Medium Bulge																																																																																																																																																																													
37 mm M74 AP	0°		1.49"	1403	1380	1391	1312																																																																																																																																																																																
75 mm T21	0°						1242	1255		Medium Bulge																																																																																																																																																																													
37 mm M74 AP	0°						2550		2563	Ex. dia. 2-15/32 x 4																																																																																																																																																																													
75 mm T21	0°						1394	1394		2-1/2. Medium Bulge																																																																																																																																																																													
FILLED IN BY SUPPLIER		NO.		CHEMICAL COMPOSITION - %										O.H. ACID ELEC. BASIC										PLATE NO.																																																																																																																																																															
FILLED IN BY SUPPLIER		NO.																																																																																																																																																																																					
FILLED IN BY SUPPLIER		NO.																																																																																																																																																																																					
FILLED IN BY SUPPLIER		NO.																																																																																																																																																																																					
FILLED IN BY SUPPLIER		NO.																																																																																																																																																																																					
FILLED IN BY SUPPLIER		NO.																																																																																																																																																																																					
FILLED IN BY SUPPLIER		NO.																																																																																																																																																																																					
FILLED IN BY SUPPLIER		NO.																																																																																																																																																																																					
FILLED IN BY SUPPLIER		NO.																																																																																																																																																																																					
FILLED IN BY SUPPLIER		NO.																																																																																																																																																																																					
FILLED IN BY SUPPLIER		NO.																																																																																																																																																																																					
FILLED IN BY SUPPLIER		NO.																																																																																																																																																																																					
FILLED IN BY SUPPLIER		NO.																																																																																																																																																																																					
FILLED IN BY SUPPLIER</																																																																																																																																																																																							

ARMOR DATA-~~CONFIDENTIAL~~

FORM NO. C.A.S. NO. 2

N.B. TO BE FILLED IN ON TYPEWRITER (CARBON BACKED) OR BY HAND USING INDIA INK

SHEET _____ OF _____ SHEETS

Key to Tabulation of "H" Plate Welding
Procedure and Ballistic Test Data

Armor Data

B.O.H. - basic open hearth.
B. Elec. - basic electric

Joint Design

DV - double vee

Deposition Types

Figure 1 shows how the weld is broken up into root, body, and crown types. Passes are divided into two kinds: (a) layer, if pass bridges the gap, and (b) bead, if the pass does not bridge the gap.

Ballistic Results

H - hit
F/S - feet per second
L.L. - left leg
R.L. - right leg
CB. - crossbar
LOC. - location
R - right of
L - left of
X - on weld
U - above
D - below
IMP - running from or through impact
O - not running from or through impact

Cracking Types

I - weld (includes weld, fusion zone, and heat-affected zone cracking within 1/8 inch from weld)
IV - star plate cracking
V - linear plate cracking

Cracking is measured on the back of the plate.

SPECIFICATION REQUIREMENTS FOR "H" PLATES
WELDED WITH AUSTENITIC ELECTRODES

Figure ii shows the construction and intended aiming points for the ballistic shock test plate.

The requirements for the shock test at normal temperature as given by Specification AXS-497, Rev. 3, August, 1942, were as follows:

<u>Armor</u>	<u>Projectile</u>	<u>Striking Velocity</u> <u>(± 25 f/s)</u>	<u>Maximum Allowable Weld</u> <u>(inches)</u>	<u>Cracking Plate</u>
1-1/2" rolled	75 mm. T21	1100	15	8
1-1/2" cast	"	1050	15	8
1" rolled	"	775	18	8

There were no requirements specified for 1/2 inch plate, but for these cold tests the 37 mm. M54 H.E. projectile at 2600 f/s velocity was used. A limit of 12 inches of weld cracking was used as a criterion of acceptability of the welded joint. The limit on plate cracking was 8 inches.

From 3 May 1944 to the present the following requirements have been in effect (as abstracted from Specification AXS-497, Rev. 5, 15 December 1943):

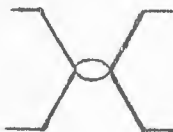
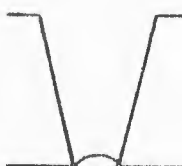
"F-3. Ballistic tests. Test plates required by paragraph F-2a(1)a shall be supported solidly on each of the two sides parallel to the longest welds and with these welds upright. The plate shall be tested for compliance with the requirements of Table II.

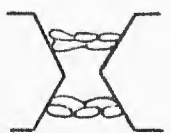
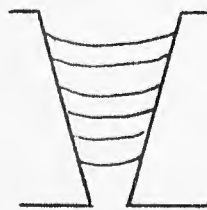
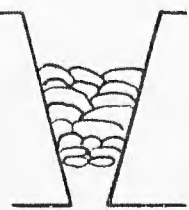
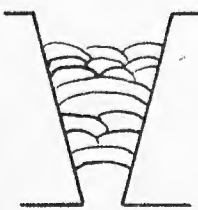
TABLE II

<u>Thickness of shock test plate, inches</u>	<u>Type of homogeneous armor</u>	<u>Projectile</u>	<u>Striking velocity f/s, plus or minus 25 f/s</u>	<u>Allowable weld crack- ing, inches, maximum</u>
1-1/2	rolled	75 mm. T21	1200	15
1-1/2	cast	"	1050	10
1	rolled	"	725	17
1	cast	57 mm. T1	975	6
3/4	rolled	"	800	12
1/2	rolled	37 mm. H.E. M54	2525	15

"F-3a. Cracks in the armor parallel to the weld and within 1/8 inch of the edge of the weld shall be considered in the total weld cracking.

"F-3b. All impact velocities specified for cast homogeneous armor are subject to variation depending on the actual armor thickness. This variation shall be based on the velocities specified for testing primary armor and results in velocity of 6 f/s for each increase of 0.01 inch in armor thickness.

Root types	Type I	Type II
Double V bevel	 Single root bead at center of root	 etc. More than one bead at root
Single V bevel	 Single bead bridging root gap	 etc. More than one bead bridging root gap

Body types	Type I	Type II	Type III	Type IV	Type V
Double V bevel	 Layers only	 Beads only	 Layers & beads	Unionmelt	Special
Single V bevel	 Layers only	 Beads only	 Layers & beads	Unionmelt	Special

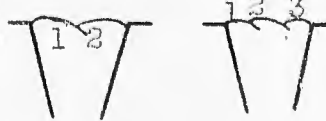
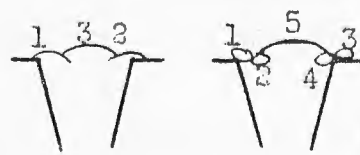
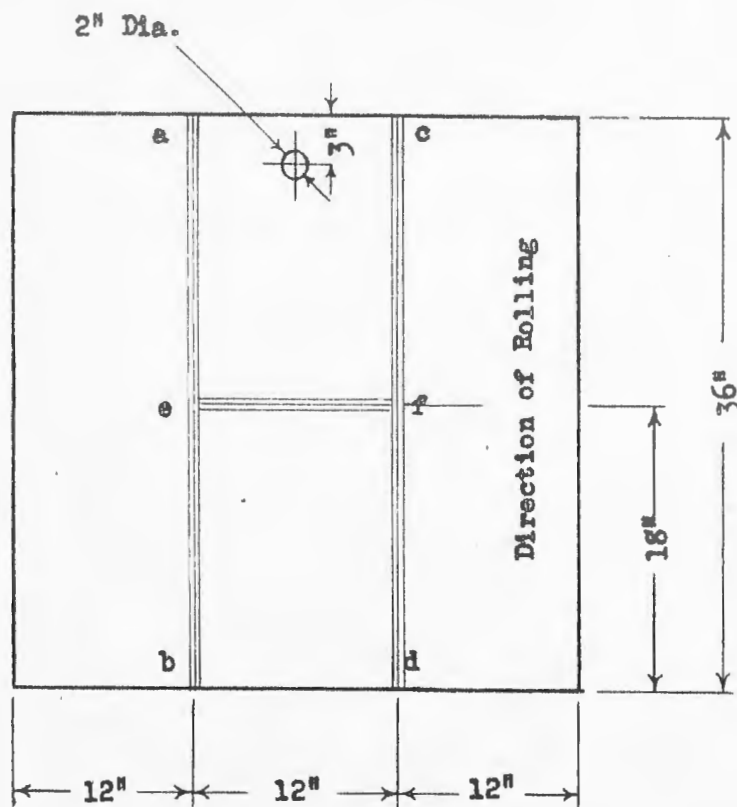
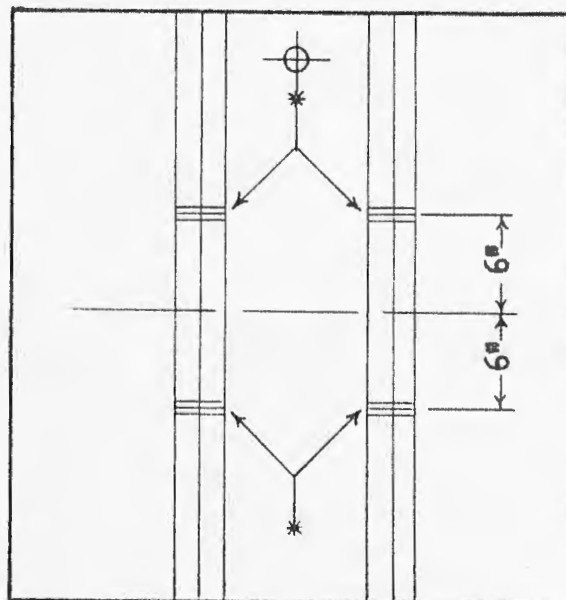
Crown types	Type I	Type II	Type III
Double V & Single V bevel	 Single Crown Single pass bridges gap	 Multiple Crown Last bead touches parent metal	 etc. Multiple Crown Last bead does not touch parent metal

Fig. 1 Weld Metal Deposition Types

Weld Sequence:
ab, cd, fe.



QUALIFICATION SHOCK TEST PLATE



* Intended Aiming Points

FIG. 11

IDENTIFICATION		ANODE DATA		ELECTRODE DATA		JOINT DESIGN		WELDING PROCEDURE		BEAT		BALLISTIC RESULTS					REMARKS ON CRACKING						
A. FIRING RECORD NO.	B. DATE OF TEST	A. PLATE THICKNESS	C. CARBON CONTENT	A. TYPE	B. TRADE NAME	A. GROOVE, INCLUDED	B. ANGLE, ROOT FACE	A. BACKING	B. DEPOSITION SIZE EL. NO. TYPE AMP. V.	A. PRE	B. POST	H	VEL. F/S	LOC. L.L.	LOC. R.L.	C.B.	LOC. TYPE	CRACKING TYPE	AMT				
A. A11310	B. 12/16/43	A. 1 1/2"	B. Rolled (Special)	A. Austenitic	B. Armory A5 (5/32" dia) (.14C)	A. 45° DV	B. 1/4"	A. None	B. Nose bead 5/32" 1b 125 26 1. II 5/32" 1a 125 26 1/4" 1a 280 28 2. III 1/4" 6a 280 28 3. III 1/4" 4b 280 28 5/32" 4b 125 26	A. None	B. None	1	2	1282	1231	X	10" IMP U	7 1/2" IMP D	I	18 1/2"	38 1/2"	Failed	
C. WA-2	D. Republic	C. .84mm, .23S1, .0185, .015P, .55Cr, .48Ni, .22Mo	D. 0.40% C, 289 B.Elect. F. 1600° F. 3 H ₂ O 1200° F. 3 1/2 Air	C. 4.58mm, .45S1, .0135, .025P, 18.87Cr, 8.88Ni, .05Mo, .014V, .14Cu	D. Armory A6 (1/4" diam.) (.10C, 1.63mm, .28S1, .010S, .034P, 16.43Cr, 9.6Ni, 1.86Mo, .32Cu)	C. Flame cutting, grinding; nose bead on one side	B. 1/4"	C. 14 hrs., 70° - 125°F. 1-2" cracking in nose bead; back chipped out.															Incomplete penetration and slag; 2 1/2" cracking in crossbar.
E. McKay	F. Baldwin Locomotive																						
A. A11310	B. 12/16/43	A. 1 1/2"	B. Rolled (Special)	A. Austenitic	B. Armory A5 (5/32" dia) (.14C)	A. 45° DV	B. 1/4"	A. None	B. Nose bead 5/32" 1b 125 26 1. II 5/32" 1a 125 26 1/4" 1a 280 28 2. III 1/4" 6a 280 28 3. III 1/4" 4b 280 28 5/32" 4b 125 26	A. None	B. None	1	2	1175	1190	X	9 1/2" IMP U	8- IMP 3/8" D	I	18 1/2"	38 1/2"	Failed 1/2" crack in crossbar	
C. WA-3	D. Republic	C. .84mm, .23S1, .0185, .015P, .55Cr, .48Ni, .22Mo	D. 0.40% C, 289 B.Elect. F. 1600° F. 3 H ₂ O 1200° F. 3 1/2 Air	C. 4.58mm, .45S1, .0135, .025P, 18.87Cr, 8.88Ni, .05Mo, .014V, .14Cu	D. Armory A6 (1/4" diam.) (.10C, 1.63mm, .28S1, .010S, .034P, 16.43Cr, 9.6Ni, 1.86Mo, .32Cu)	C. Flame cutting, grinding; nose bead on one side	B. 1/4"	C. 14 hrs., 70° - 175°F. 1-2" cracking in nose bead; back chipped.															
E. McKay	F. Baldwin Locomotive																						
</																							

The Baldwin Locomotive Works

No Back-up

~~XXXXXXXXXXXXXXXXXXXX~~ JAN 7 1968

Flat

XXXXXXXXXX

TRAINING TIME, 3-1/2 hrs.

None

Nose Bead (#1) on one side

70° F.

* S - STRINSEN, R - DEAN W. WARE, FW - 111 WEAVE

DATE: 30 June 1944

PLATE NO: WA-8

TYPE: Rolled Armor

THICKNESS: 1-1/2"

SPECIFICATION: AXS-488

ORDNANCE MATERIAL CONCERNED

AXS-488

WELDED BY: Robert Andrews

Baldwin Locomotive

OBJECT: Development

Baldwin Locomotive Works

Eddystone, Pennsylvania

W9520RD7736

ON A DIMENSIONED SKETCH OF THE
DEPOSIT SEQUENCE (2) ADDITION

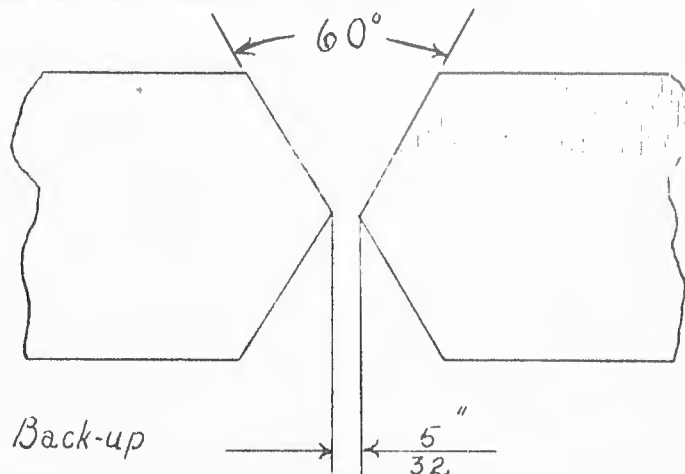
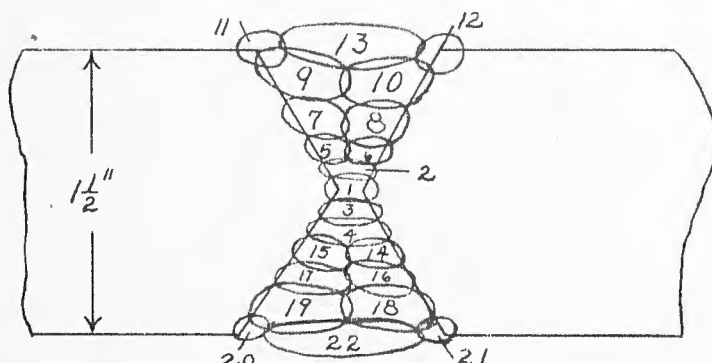


PLATE PREPARATION: FLAME

POSITION OF PLATE: Horizontal

AUTOMATIC OR HAND WELDING

TOTAL WELDING TIME 12 hrs.

PREHEAT: 300 degrees F.

PEENING: None

TEMP OF PLATE AT TIME OF WELDING 300 degrees F.

Horizontal

None

None

8 hrs. 30 min.

PASS	ELEC SIZE	TYPE	AM			
1.	3/16"	W	210	28	None	Craters
2.	3/16"		"	"	"	"
3.	3/16"		"	"	"	"
4.	3/16"		"	"	"	"
5.	1/4"		290	"	"	"
6.	1/4"		"	"	"	"
7.	1/4"		"	"	"	"
8.	1/4"		"	"	"	"
9.	1/4"		"	"	"	"
10.	1/4"		"	"	"	"
11.	3/16"		210	"	"	"
12.	3/16"		"	"	"	"
13.	1/4"		290	"	"	"
14.	1/4"		"	"	"	"
15.	1/4"		"	"	"	"
16.	1/4"		"	"	"	"

20 & 21
17 & 18
19 & 22

* S- STRINGER, B- BEAD, W- WEAVE, FW- FULL WELD

FORM NO. WAS-2 SHEET 1

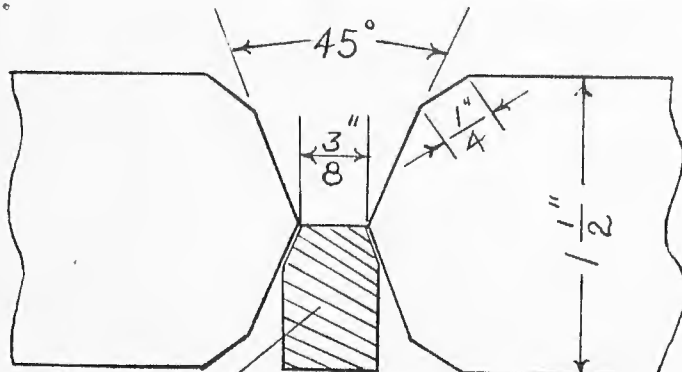
DATE 22 June 1944
 PLATE NO. WA-9
 TYPE Rolled Homogeneous
 THICKNESS 1-1/2"
 SPECIFICATION AIS-497-5
 ORDNANCE MATERIAL
 WELDED BY H.H. Strid
 OBJECT Development

Watertown Arsenal Lab.
 Watertown 72, Massachusetts

Watertown Arsenal

ON A DIMENSIONED
 DEPOSIT

WELDED TO INDICATE THE
 TAIL STRIP OR BACK UP



COPPER BACKUP BAR

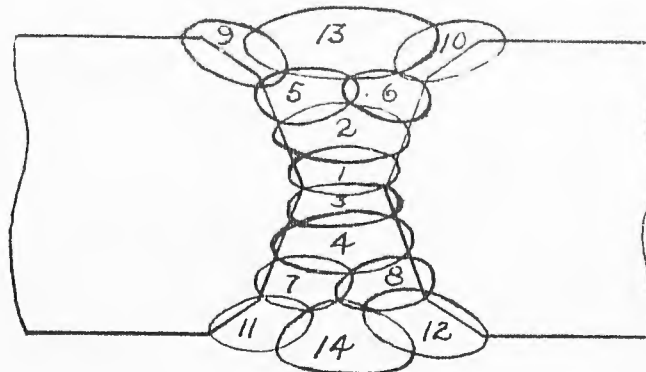


PLATE PREPARATION PLATE NO. XXXXXXXXXXXXXXXXXXXX GRINDING
 POSITION OF PLATE DURING WELDING Flat

XXXXXXXXXXXXXXXXX HAND WELDING P. T. A. T. Y. XXXXXXXX REV XXXXXXXX DO

TOTAL WELDING TIME TOTAL CHIPPING OR GRINDING TIME

PREHEAT None POST HEAT None

PEENING None BUTTERING None

TEMP OF PLATE AT TIME OF WELDING 70° F.

PASSELEC SIZE	TYPE	AMP	NO	CRACKING	XXXXXXXX GRIND	INTERPASS TEMP
1. 3/16"	W	160	24	None	on back for No. 3	70° F.
2. 1/4"	W	240	24	"	None	100° F.
3. 1/4"	W	240	24	"	"	125° F.
4. 1/4"	W	240	24	"	"	150° F.
5. 1/4"	W	240	24	"	"	150° F.
6. 3/16"	W	160	24	"	"	150° F.
7. 1/4"	W	240	24	"	"	125° F.
8. 3/16"	W	160	24	"	"	125° F.
9. 3/16"	S	160	24	"	"	125° F.
10. 3/16"	S	160	24	"	"	150° F.
11. 3/16"	S	160	24	"	"	125° F.
12. 3/16"	S	160	24	"	"	150° F.
13. 1/4"	W	240	24	"	"	100° F.
14. 1/4"	W	240	24	"	"	125° F.
15.						
16.						

* S- STRINGER, B- BEAD, W- WEAVE, FW- FULL WEAVE

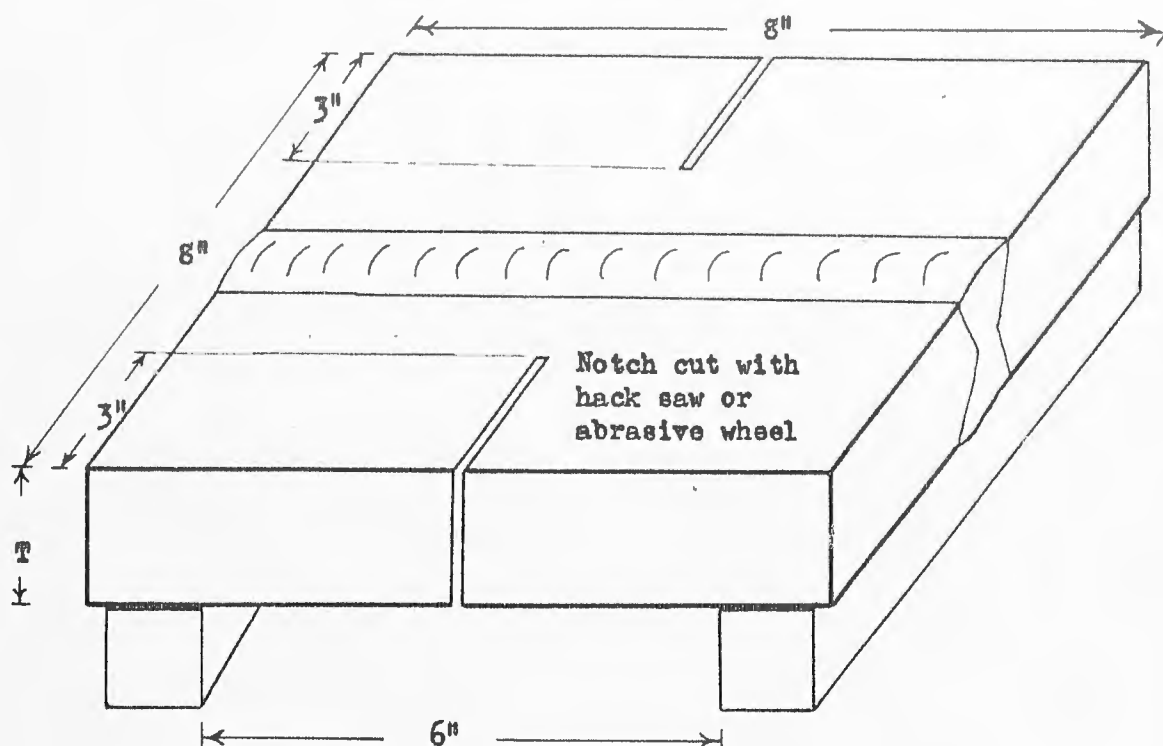
FORM NO. WAS-2 SHEET 1

42-4450

APPENDIX B

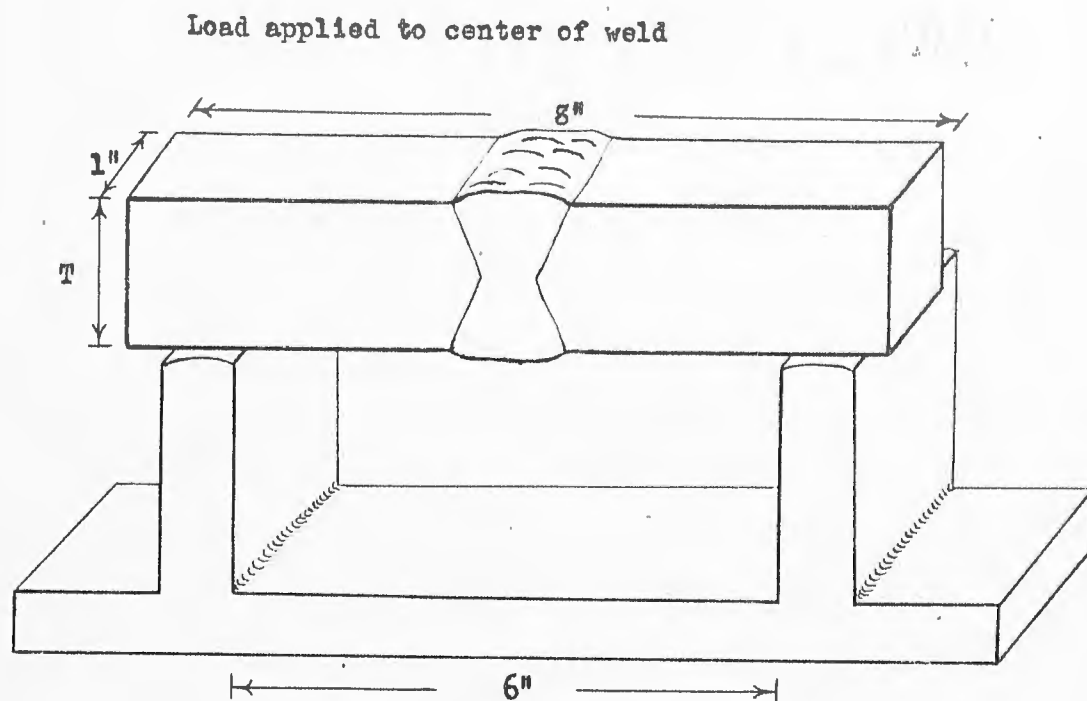
Description of Nick-Break and
Bend Fracture Tests

1/2 x 1/2 x 4 inch bar used as striking
block. 1 x 6 x 6 inch plate placed on
top of bar to prevent damage to steam
hammer or drop weight.



Supported on six-inch span; broken with one
blow of drop weight or steam hammer

Figure 1. Nick-Break Fracture Test of Weld Joint



Supported on six-inch span; bars of 1 inch and 1 1/2 inch thickness broken in a steam press; bars of lesser thickness broken with one blow of drop weight

Figure 2. Bend Fracture Test of Weld Joint