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REPORT NO. 642/22A



ARC WELDING OF ARMOR

SINGLE VEE AND DOUBLE VEE BUTT WELDS IN

1" HOMOGENEOUS ARMOR

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by

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March 9, 1942  
WATERTOWN ARSENAL  
WATERTOWN, MASS.

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Report No. 642/22  
Watertown Arsenal  
(Ex.O. 50-A5)

March 9, 1942.

ARC WELDING OF ARMOR

Single Vee and Double Vee Butt Welds in  
1" Homogeneous Armor

OBJECT

To determine and compare the resistance to penetration and the resistance to impact of a single vee and a double vee butt joint in 1" homogeneous armor plate welded with the bevels preclad with 25/20, a filler metal of 25/20, and a hard facing electrode on the surface layers.

CONCLUSIONS

1. The resistance to penetration of the single vee butt joint and the double vee butt joint is approximately the same; there being but 6 f/s difference in the maximum resistance of the two joints fired at with .50 cal. A.P. ammunition. The ballistic limit obtained was 2619 f/s for a single vee joint and 2625 f/s for a double vee joint.

2. The resistance to shock of the single vee and double vee butt joints in this test could not be definitely determined

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because the homogeneous armor (Brinell 444) shattered, leaving the weld intact. The striking velocity of the 37 m/m A.P. projectile used was 1886 f/s. (Aberdeen Report #167 Test on Thin Armor).

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## INTRODUCTION

For the purpose of determining the ballistic properties of single vee and double vee butt joints using the precladding method, four pieces of 1" homogeneous armor plate were used.

This armor was of the following composition -

|            |       |            |      |
|------------|-------|------------|------|
| Carbon     | 0.49  | Chromium   | 1.22 |
| Manganese  | 0.56  | Molybdenum | 0.60 |
| Silicon    | 0.23  | Vanadium   | 0.20 |
| Phosphorus | 0.019 |            |      |
| Sulphur    | 0.019 |            |      |

Two pieces were machined to a 45° bevel on their edges and a layer of 25/20 stainless weld metal deposited on the machined surfaces with the plate in the annealed condition. The remaining two plates were machined on the edges to a 45° bevel to form a double vee butt joint. The machined surfaces of this joint were also preclad with a layer of 25/20 stainless welding electrode. For this precladding operation the plates were in the annealed condition. After precladding the plates were heat treated to a Brinell of 444. The single vee butt joint (Plates A and B Fig. 1) was welded with 25/20 stainless welding electrode. After a few layers were deposited the weld was water cooled. When the filler metal of 25/20 was within two layers of the surface of the plate a hard facing electrode was used for the two final face layers.

The double vee butt joint was welded after the plates (Plates C and D Fig. 1) were heat treated. A filler of 25/20 stainless electrode was used. The last two layers on both sides of the plate were made with a hard facing electrode. Periodically during the welding water was poured onto the plate to prevent excessive heating of the plate alongside the weld.

### RESULTS AND DISCUSSION

The plates were given a firing test with .50 cal. armor piercing ammunition to determine the resistance to penetration of the butt welds. The difference in the resistance to penetration of the single vee and double vee was so slight that no advantage was noted. (Table II).

After penetration tests the plates were shipped to Aberdeen Proving Ground for shock tests.\* Shock tests were made using a 37 m/m projectile at a distance of 100 yards. Due to brittleness the plate shattered on impact. When the plate shattered part of the weld was broken off, but the rest remained intact.

In the penetration test it was noted that no spalling, cracking, or separation of the weld occurred. A similar condition was noted on the shock tests.

Cross sections of the welded joints were taken for hardness surveys and macro-examination. (See Fig. 1). It was noted that no high hardness existed in the weld metal. The heat-affected

\* Aberdeen Report #167 - Test on Thin Armor.

zones were comparatively small due to the precladding.

The butt joints were welded in the manner described in the following table.

TABLE I.  
WELDING DATA

| <u>PLATE</u> | <u>ELECTRODE</u>        | <u>SIZE</u> | <u>JOINT</u>     | <u>CURRENT</u><br>Amperes | <u>REMARKS</u>                                         |
|--------------|-------------------------|-------------|------------------|---------------------------|--------------------------------------------------------|
| #1<br>A&B    | 25/20 Page<br>Allegheny | 5/32"       | Pre-<br>cladding | 120                       | On annealed<br>plate                                   |
|              | 25/20 Page<br>Allegheny | 5/32"       | Single<br>Vee    | 120                       | On Heat Treated<br>Plate<br>First 2 layers<br>quenched |
|              | Hollup #450             | 5/32"       | Facing           | 150                       | Two Layers<br>quenched                                 |
| #2<br>C&D    | 25/20 Page<br>Allegheny | 5/32"       | Pre-<br>cladding | 120                       | On annealed<br>plate                                   |
|              | 25/20 Page<br>Allegheny | 5/32"       | Double<br>Vee    | 120                       | On Heat Treated<br>Plate                               |
|              | Hollup #450             | 5/32"       | Facing           | 150                       | On back and<br>face of plate<br>2 layers each          |

The firing test for resistance to penetration and resistance to shock is given in the following table.

(Data for resistance to shock was taken from Aberdeen Report, APG #167-Test on Thin Armor).



TABLE II.

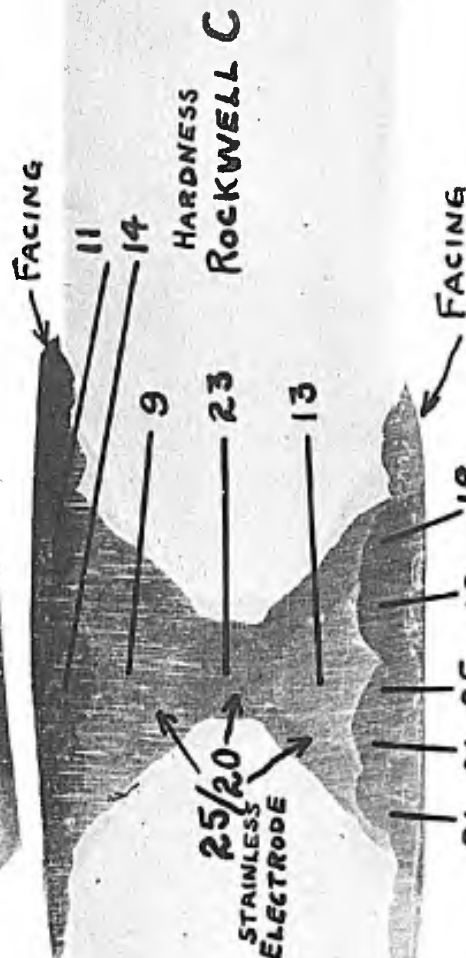
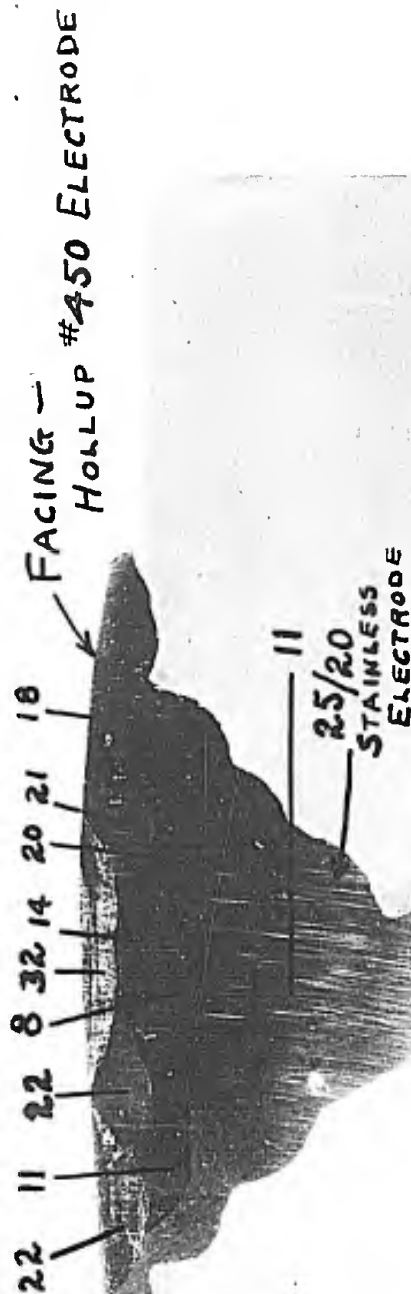
PENETRATION TESTS .50 CAL. A.P.

| <u>PLATE</u> | <u>BALLISTIC LIMIT</u>       |                | <u>JOINT</u>  | <u>BAL. EFF.</u><br><u>Actual</u> | <u>REMARKS</u>         |
|--------------|------------------------------|----------------|---------------|-----------------------------------|------------------------|
|              | <u>On Plate</u>              | <u>On Weld</u> |               |                                   |                        |
| #1<br>A&B    | (A) 2904 f/s<br>(B) 2904 f/s | 2619 f/s       | Single<br>Vee | 90.3%                             | Weld not<br>penetrated |
| #2<br>C&D    | 2940 f/s                     | 2675 f/s       | Double<br>Vee | 89.3%                             | Weld not<br>penetrated |

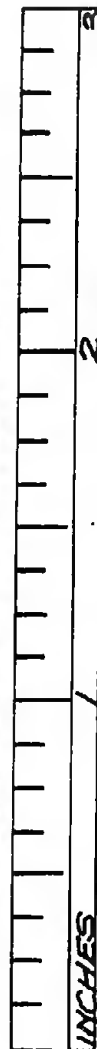
SHOCK TESTS 37 m/m A.P. SHOT M-39

|           |                              |  |               |  |                                                                                                                      |
|-----------|------------------------------|--|---------------|--|----------------------------------------------------------------------------------------------------------------------|
| #1<br>A&B | (A) 2004 f/s<br>(B) 1909 f/s |  | Single<br>Vee |  | Partial penetra-<br>tion. Cracked<br>plate on right<br>(B) and broke a<br>piece of left<br>plate (A). Weld<br>sound. |
| #2<br>C&D | 2022 f/s                     |  | Double<br>Vee |  | Shattered both<br>plates.                                                                                            |

As noted in Table II the butt joint resisted penetration up to 89% of the actual velocity withstood by the plate. The shock tests showed no defects in the weld, but due to the brittleness the plate shattered breaking the weld. The remaining weld showed no evidence of failure due to shock.



1" HOMOGENEOUS ARMOR



ORDNANCE DEPT. U.S.A.  
WATERTOWN ARSENAL

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