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UNCLASSIFIED



WATERTOWN ARSENAL
LABORATORY

EXPERIMENTAL REPORT

NO. 101

SYSTEMS ENGINEERING DEPT.

PART OF ELECTRONIC WARFARE DIVISION

AS PART OF THE RESEARCH AND DEVELOPMENT PROGRAM

ADMINISTERED BY THE ARSENAL ENGINEERING CENTER

UNCLASSIFIED

WATERTOWN ARSENAL
WATERTOWN, MASSACHUSETTS 02154

V. J. ...
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MAR 13 1985
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Report No. 64/4
Watertown Arsenal
(Ex.O. 50-A5)

January 29, 1942

RESISTANCE WELDING OF ARMOR

Study of Ballistic Properties and Hardnesses
of 1/4" Face Hardened and 1/4" Rolled Homogeneous
Armor Plate Spot Welded by Progressive Welder Co.

OBJECT

To determine the ballistic properties and the effect of spot
welding on the hardness of the plate used in lap joints and butt
strap joints of 1/4" face hardened armor and 1/4" rolled homo-
geneous armor.

This 1942 report concludes that:

CONCLUSIONS

- (1) The ballistic limits obtained with .30 Cal. A.P. M2 ammuni-
tion from 1/4" face-hardened armor spot welded with the method used
by the Progressive Welder Co. are satisfactory; and (2)
- 2. The method of spot welding as used by the Progressive
Welder Co. on joints in 1/4" face-hardened armor does not adversely
affect the hardness of the carburized face.

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Unannounced	<input type="checkbox"/>
Justification	
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A1 24	

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APPROVED:

H. H. ZORNIG
Col., Ord. Dept.,
Director of Laboratory.



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Summary of Results

1. Ballistic Limits of Joints

<u>Plate</u>	<u>Type of Joint</u>	<u>Ballistic Limit (F/S)</u> (Cal. .30 A.P.)	
		<u>Actual</u>	<u>Specification</u>
Face Hardened 1/4"	Lap	2300	1975
" " 1/4"	1/8" Butt Strap	1789	"
Homogeneous 1/4"	Lap	2281	1050
" " 1/4"	1/8" Butt Strap	1681	"

2. Shock Resistance of Joints

The burst of ten rounds of Cal. .30 A.P. ammunition machine gun fire caused no separation of any of the spots in any of the joints.

3. Hardnesses

The average maximum hardness values of the weld nuggets as compared with the armor plate are:

Average Maximum Hardnesses

1/4" Face Hardened Armor

<u>Plate#</u>	<u>Face</u>		<u>Body</u>		<u>Weld Nugget</u>
	<u>Unaffected</u>	<u>Spot Area</u>	<u>Unaffected</u>	<u>Spot Area</u>	
PWC#100	505	625	440	440	625
PWC#200	515	480	450	350	460
PWC#300	510	500	446	405	425

1/4" Homogeneous Armor

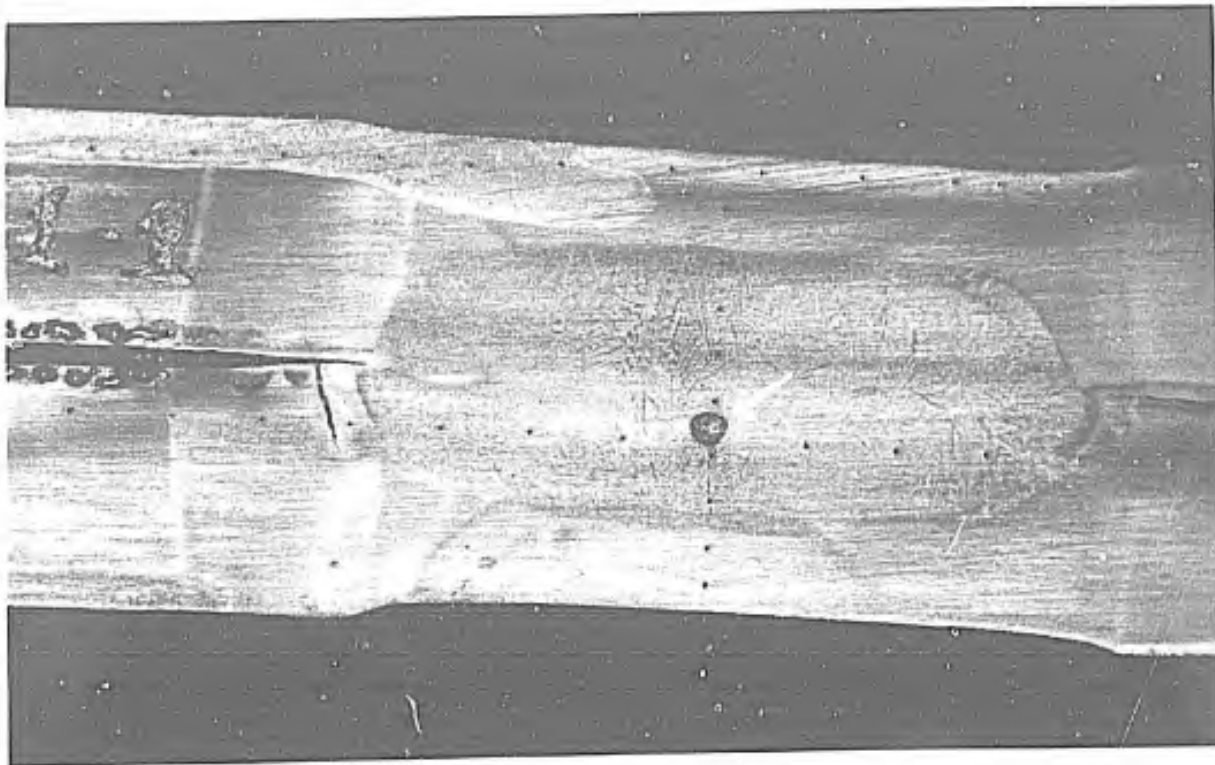
PWC#400			350	700	475
PWC#500			350	475	475

Size of Welds

The average size of the spots on the face of the plate was .8" in diameter. The average size of the nugget was .7" in diameter and .26" in thickness.

Ballistic tests of spot welded lap and butt strap joints in 1/4" face hardened armor plate which have been subsequently made indicate that spot welds, of which the nuggets are smaller in diameter than those examined in this present study, do not possess satisfactory shock resistance even though the hardnesses of the nuggets and heat affected areas are very similar in magnitude.

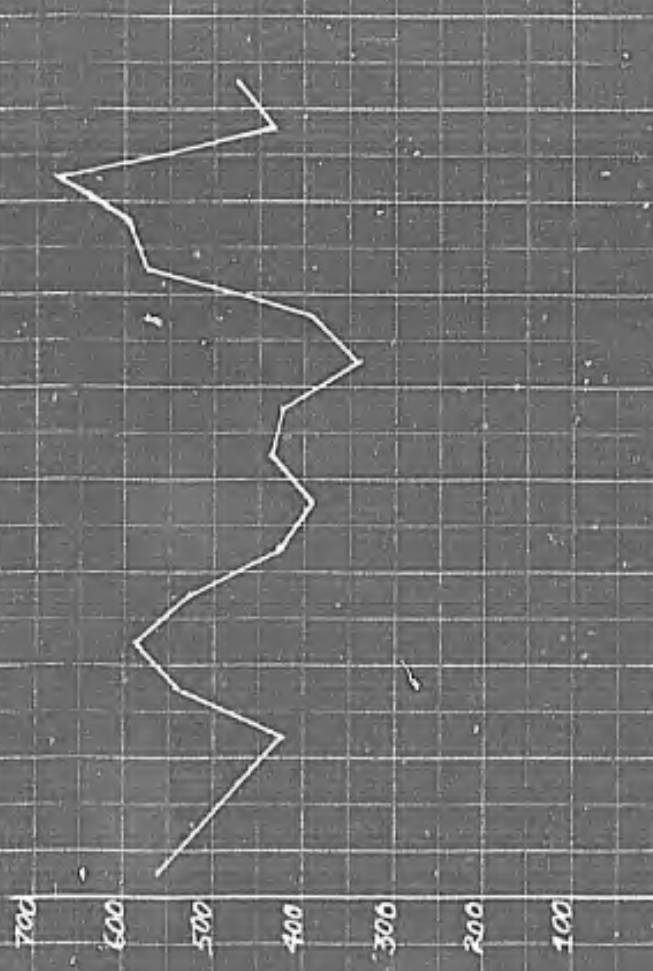
Macrophotos and Hardness Charts



SPECIMEN PW 1-1

LAP JOINT SPOT WELDED DIEBOLD FACE HARDENED ARMOR.
NOTE POROSITY.

W.A.710-1497

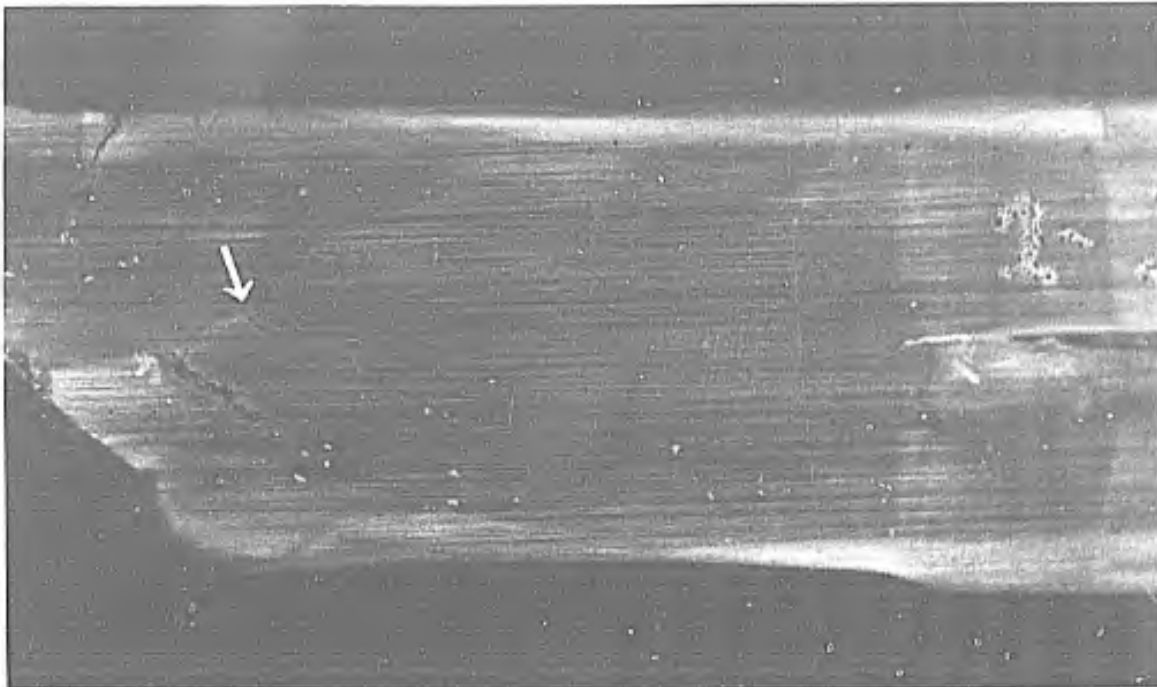


1/4" FACE HARDENED PLATE
LAP JOINT SPOT WELDED

SPOT WELDED DIEBOLD ARMOR
PROGRESSIVE WELDER CO.

SK 6452-1

JAN 12/18/41



SPECIMEN PW 1-3
LAP JOINT SPOT WELDED DIEBOLD ARMOR, FACE HARDENED.
W.A.710-1498

REPRODUCED FROM THE REPORT OF THE NATIONAL BUREAU OF STANDARDS
ON THE MECHANICAL PROPERTIES OF STEEL
1942
U.S. GOVERNMENT PRINTING OFFICE



PWC 1-3

700 600 500 400 300 200 100

700 600 500 400 300 200 100

VICKERS BRINELL HARDNESS

700 600 500 400

(1/2" FIRE HARDNESS D. TEST)

VICKERS BRINELL

700
600
500
400
300
200
100

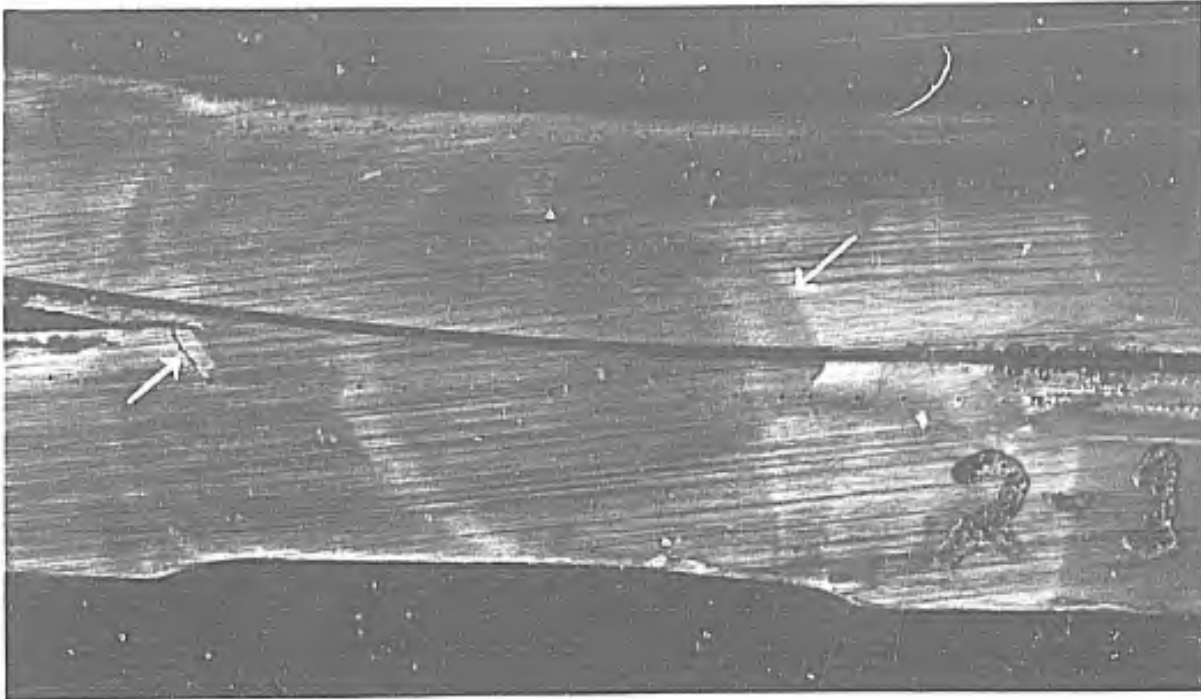


1/4" FACE HARDENED PLATE
LAP JOINT SPOT WELDED

SPOT WELDED DIEBOLD ARMOR
PROGRESSIVE WELDER CO.

SK6452-R

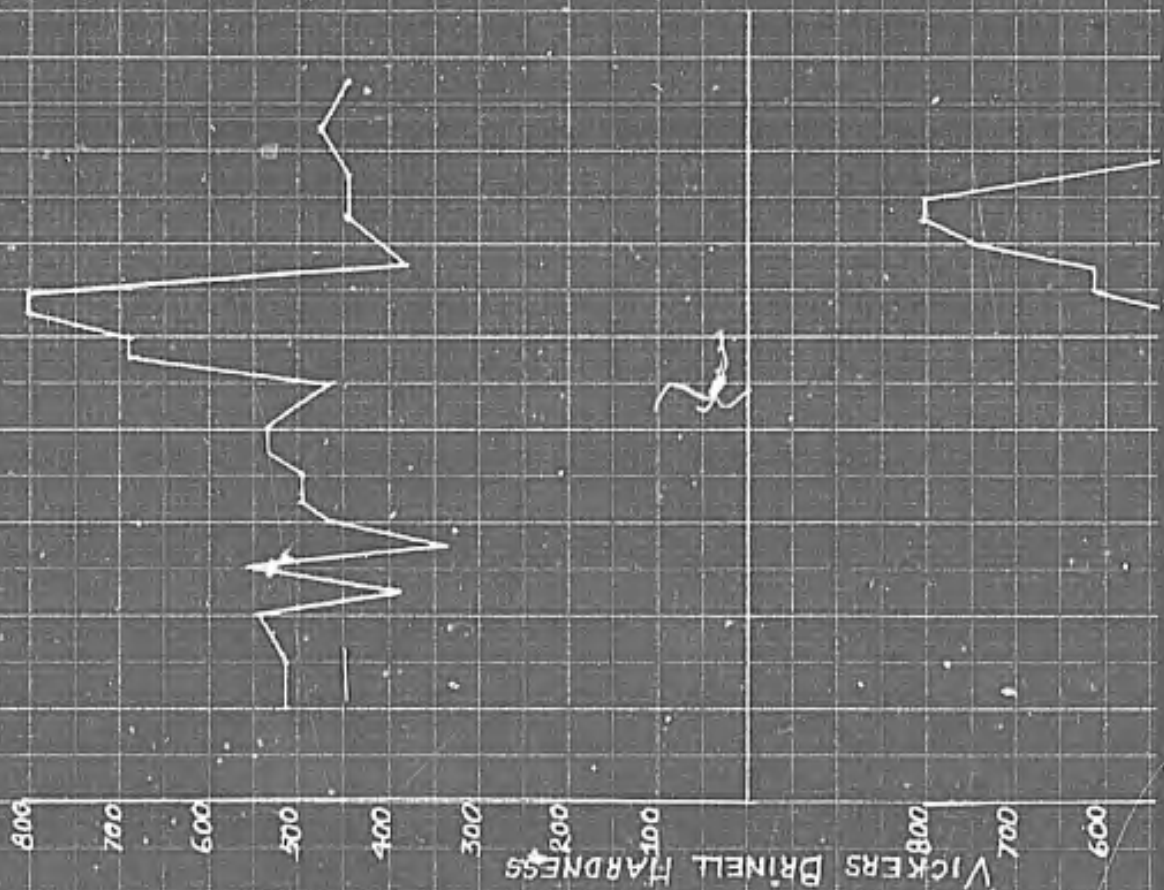
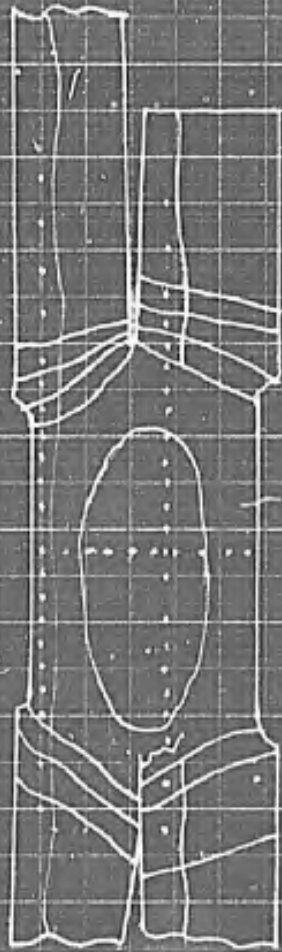
JAN 12/18/41



SPECIMEN PW 2-1

**LAP JOINT SPOT WELD IN 1/4" FACE HARDENED ARMOR PLATE.
ARROWS SHOW NUGGET AND CRACK.**

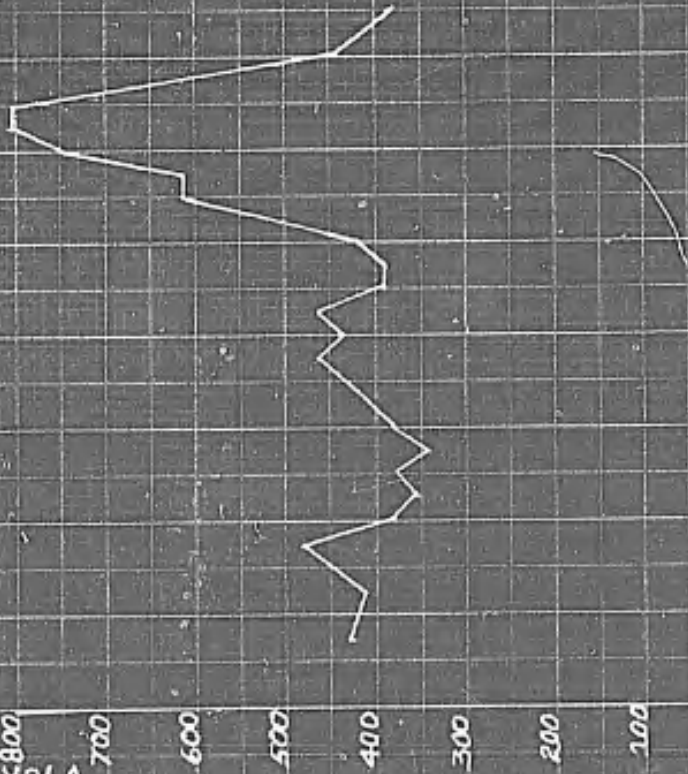
W.A.710-1501



PWC 2-1

1/4" FACE HARDENED PLATE
LAP JOINT SPOT WELDED

VICKERS BRINELL
800
700
600
500
400
300
200
100



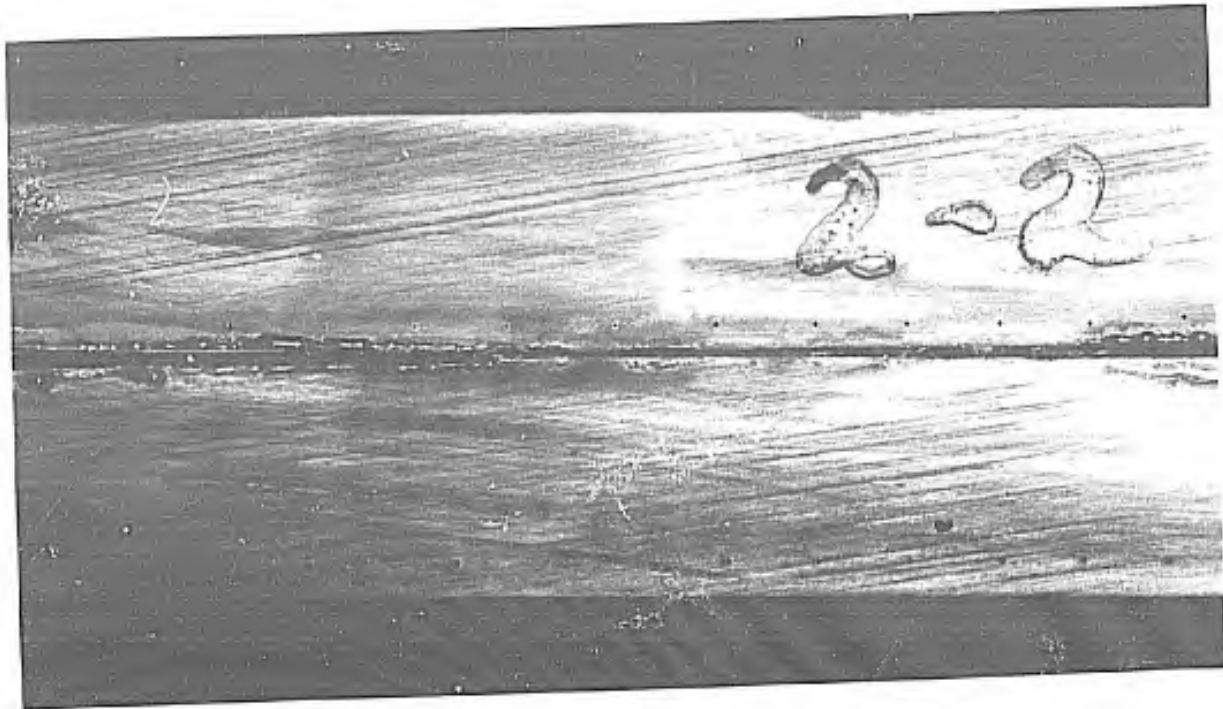
1/4" FACE HARDENED PLATE
LAP JOINT SPOT WELDED

SPOT WELDED DIEBOLD ARMOR

PROGRESSIVE WELDER CO.

SK 645.2-3

JAN 12/18/41



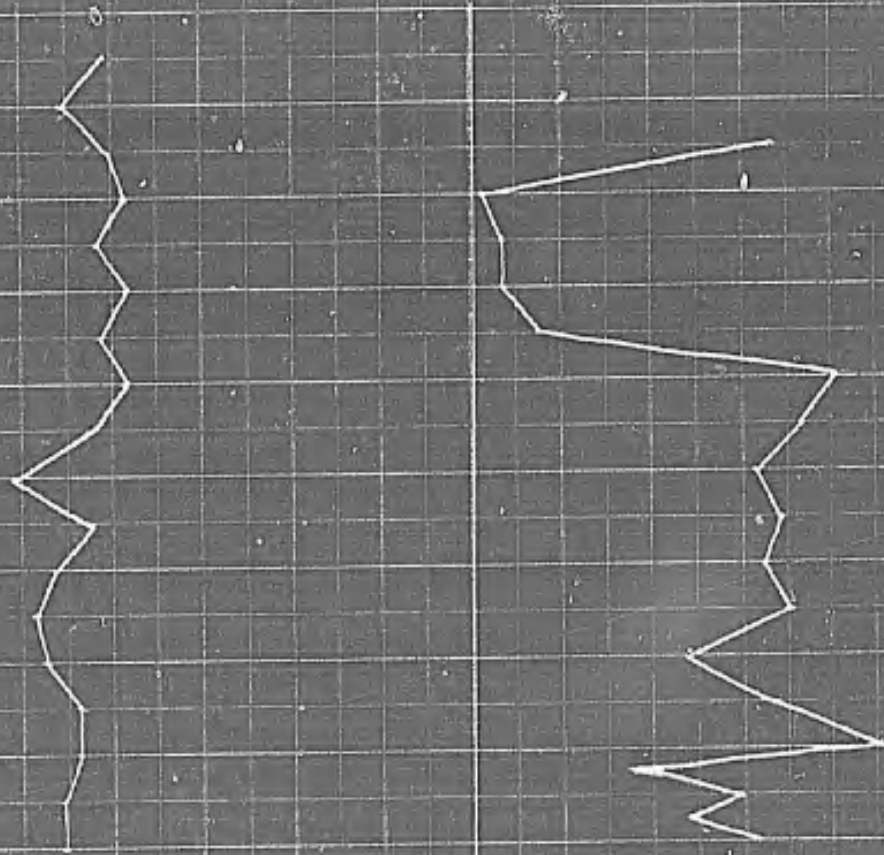
SPECIMEN PW 2-2

CROSS SECTION OF DIEBOLD ARMOR BETWEEN TWO SPOTS.
ARROW SHOWS HEAT ZONE OF ONE SPOT.

W.A.710-1499



600
500
400
300
200
100
700
600
500
400
300
200
100



PWR-2

1/4" FACE HARDENED ARMOR PLATE
LAP JOINT SPOT WELDED
HEAT AFFECT ZONE BETWEEN
TWO SPOT WELDS

3/4" FACE HARDENED ARMOR PLATE
LAP JOINT SPOT WELDED
HEAT AFFECT ZONE BETWEEN
TWO SPOT WELDS

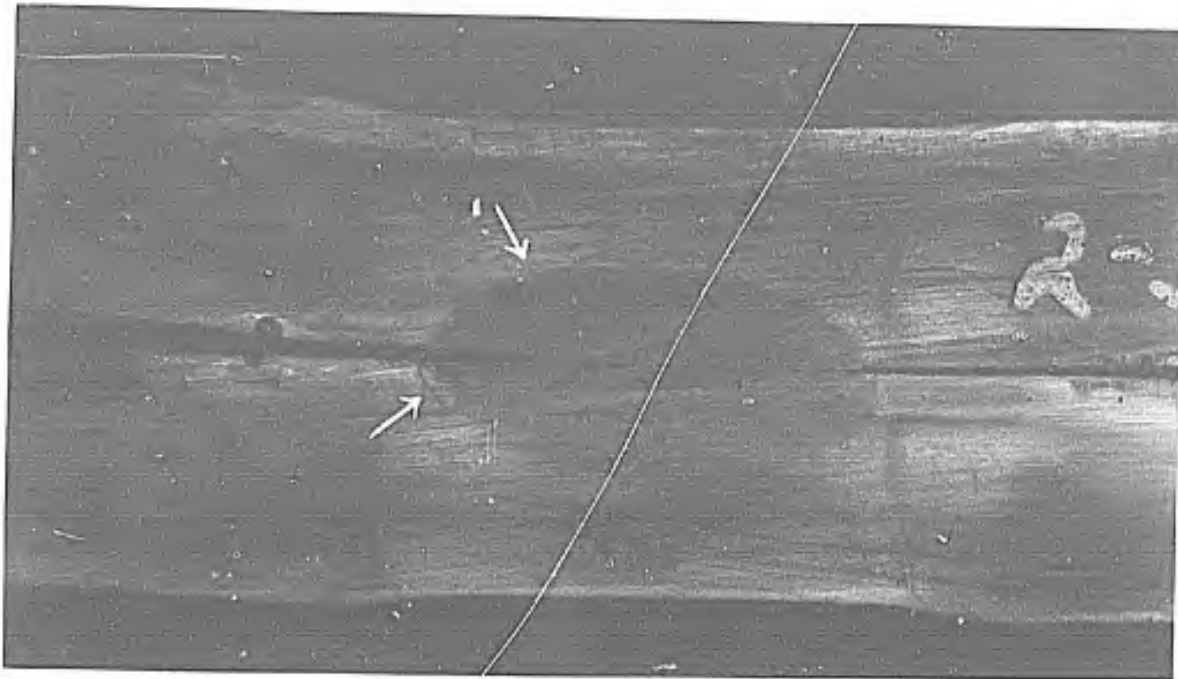
SPOT WELDED DIEBOLD ARMOR
PROGRESSIVE WELDER CO.

SK 6452-4

JAN 2/1/42

500
400
300
200
100

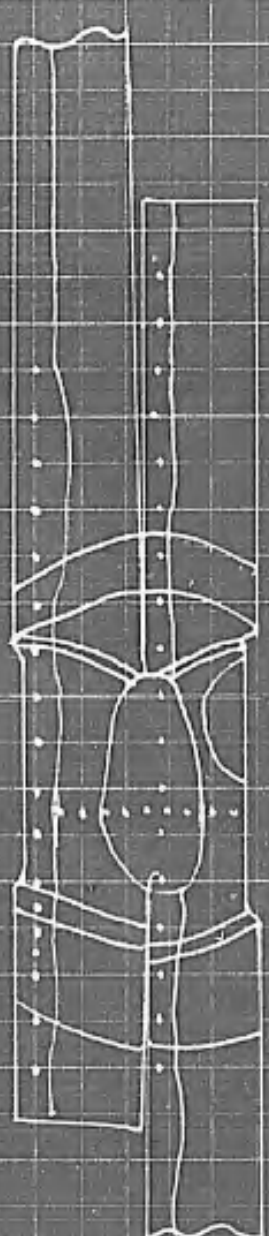




SPECIMEN PW 2-3
LAP JOINT IN DIEBOLD ARMOR. ARROWS SHOW CRACK AND NUGGET.

W.A.710-1500

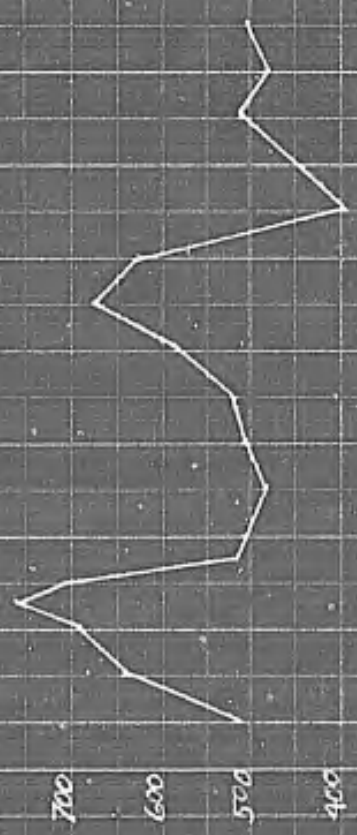
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100% RECYCLED PAPER



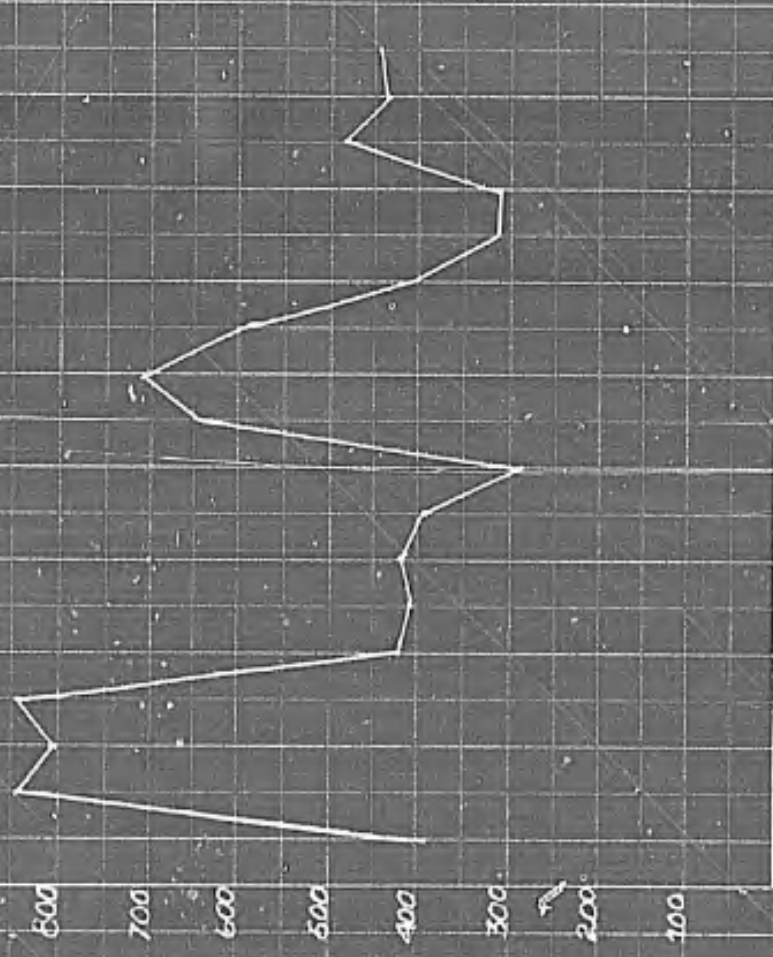
600 500 400 300 200 100

PWR-3

800
700
600
500
400
300
200
100
800
700
ICKERS DINELL HARDNESS



VICKERS BRINELL HARDI



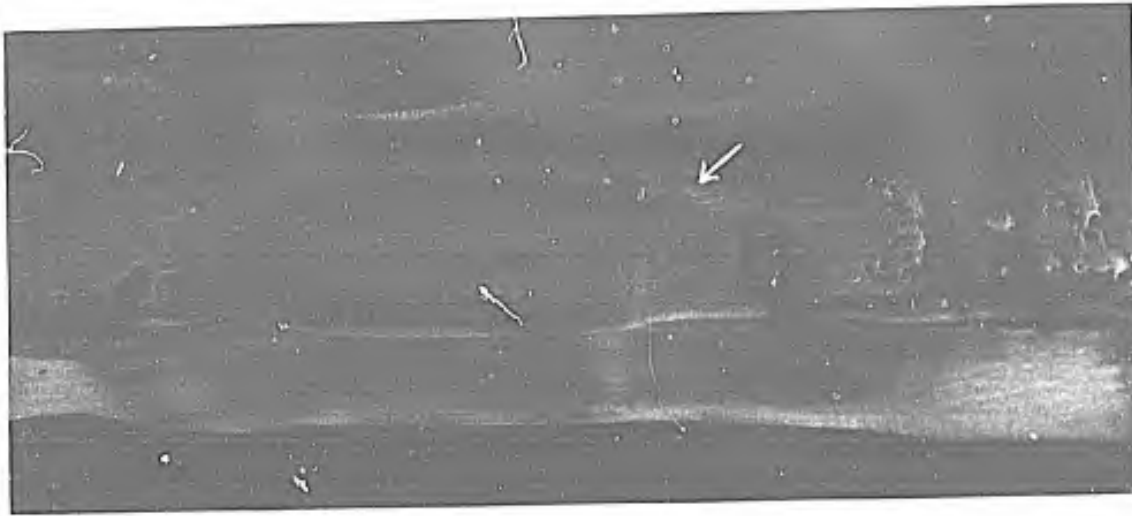
1/4" FACE HARDENED PLATE
LAP JOINT SPOT WELDED

SPOT WELDED DIEBOLD ARMOR

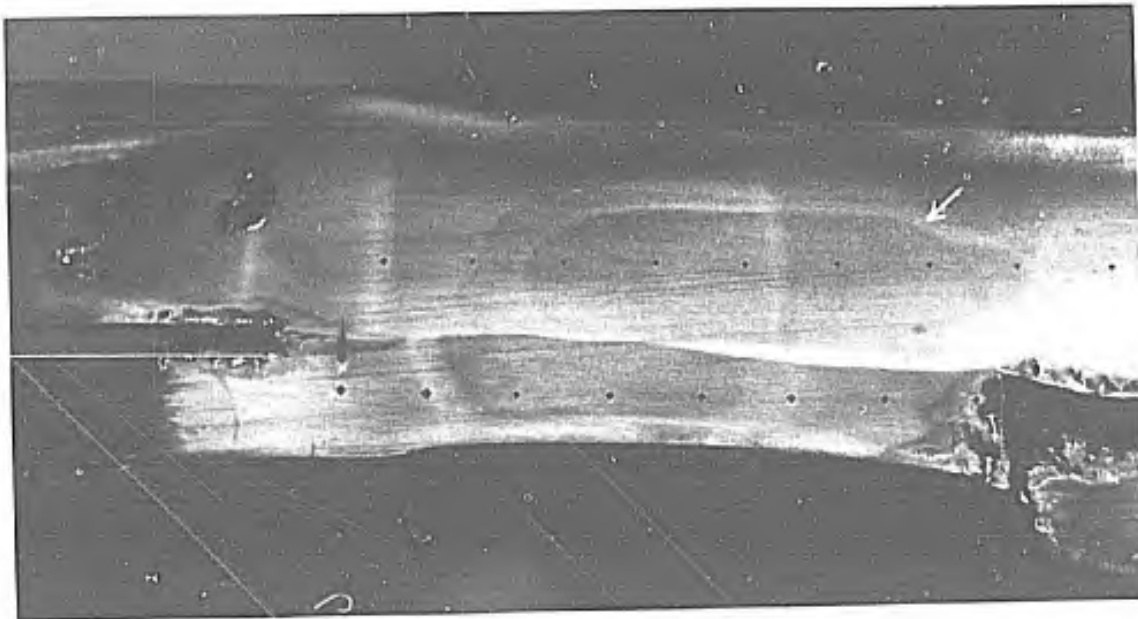
PROGRESSIVE WELDER CO

SK 645 R-5

JAN 12/28/41



SPECIMEN PW 3-1
STRAP BUTT JOINT IN 1/4" DIEBOLD ARMOR. ARROW DESIGNATES NUGGET,



SPECIMEN PW 3-3
STRAP BUTT JOINT IN 1/4" DIEBOLD ARMOR. ARROW DESIGNATES NUGGET.

W.A.710-1502

UNIT: POUNDS PER SQUARE INCH (PSI) OR KILOGRAMS PER SQUARE CENTIMETER (KG/CM²)



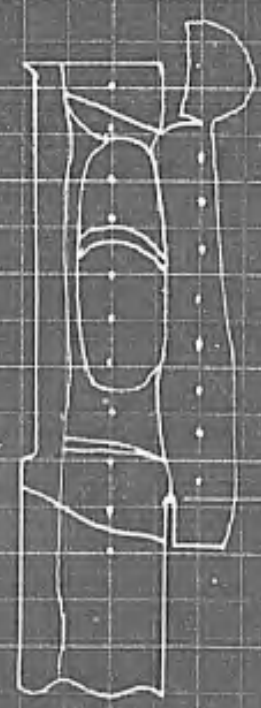
A

600
500
400
300
200
100



PW 3-1

1/4" FACE HARDENED PLATE
STRAP BUTT WELD
SPOT WELDED



500
400
300



PW 3-3

BSI

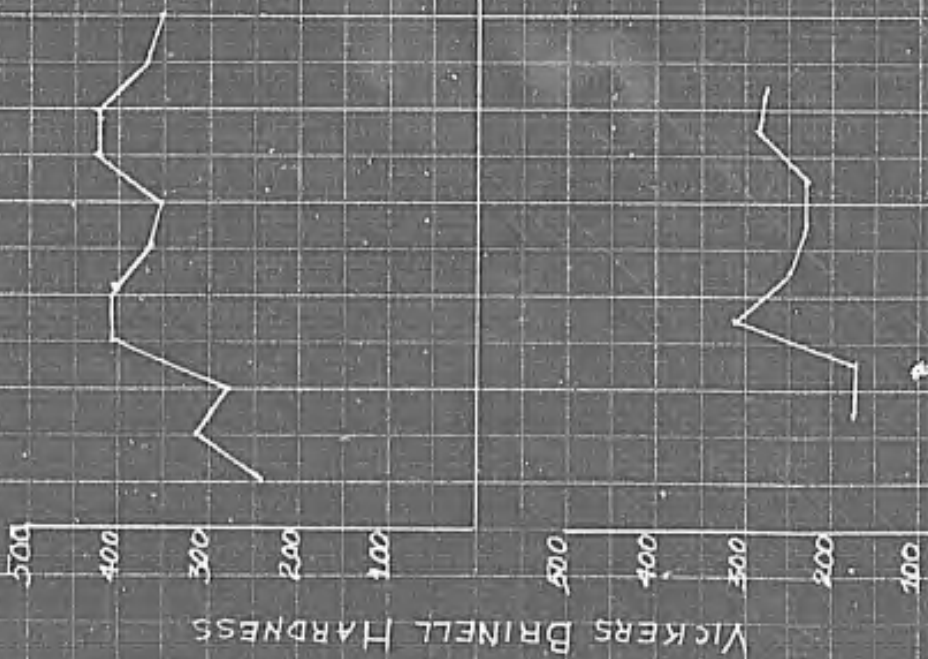
PW 3-3

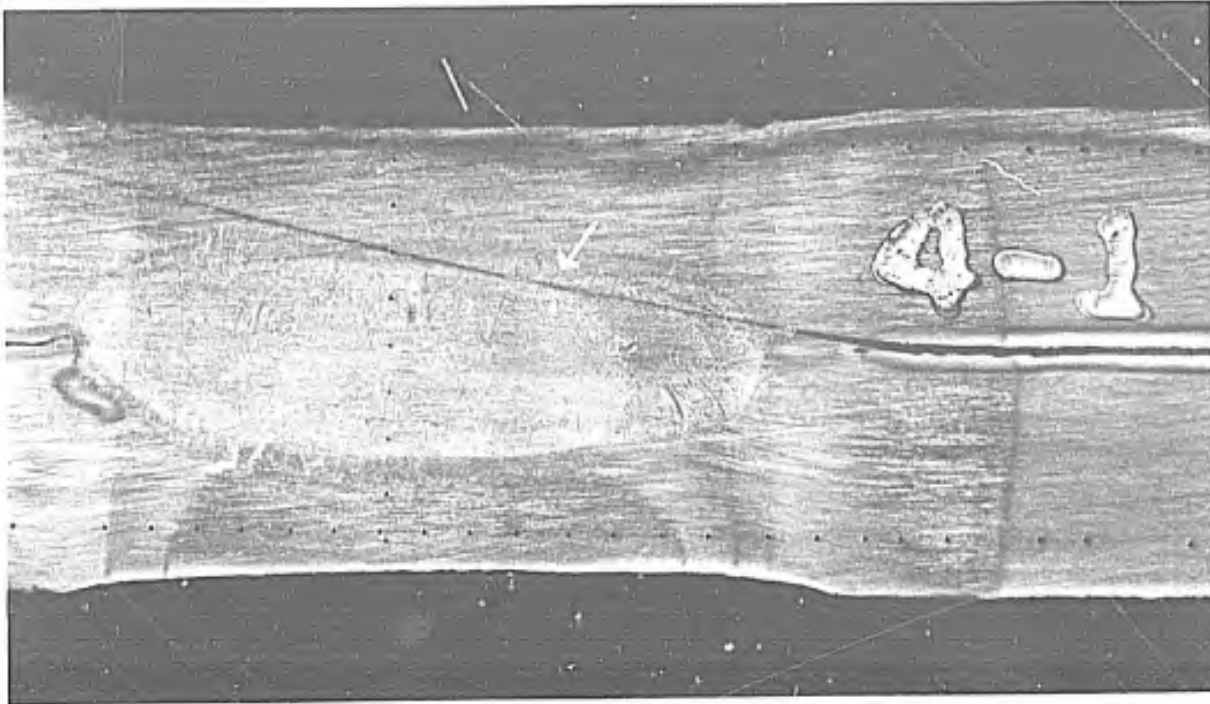
SPOT WELDED DIEBOLD ARMOR

PROGRESSIVE WELDER CO

JAN 12/20/41

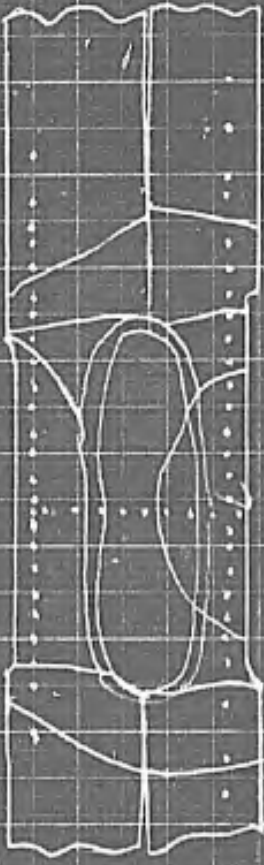
SK 645.2-6





SPECIMEN PW 4-1
LAP JOINT IN 1/4" SIMONDS ARMOR. ARROW SHOWS NUGGET.

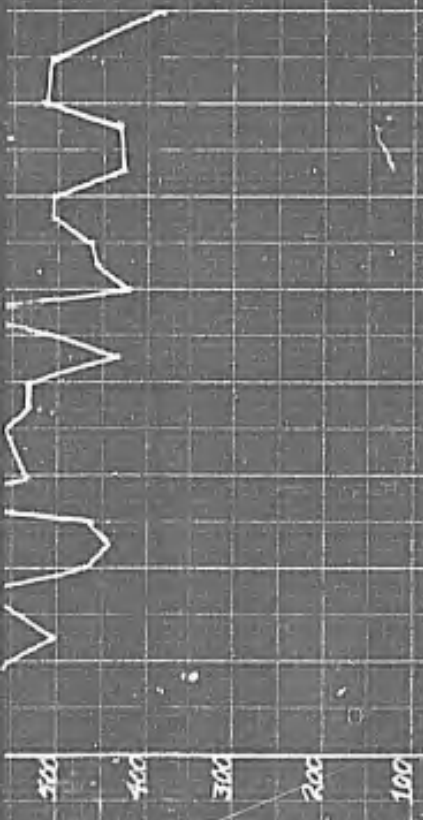
W.A.710-1503



PW 4-1

1/4" HOMOGENEOUS ARMOR PLATE
LAP JOINT SPOT WELDED

1/4 HOMOGENEOUS ARMOR PLATE
LAP JOINT SPOT WELDED

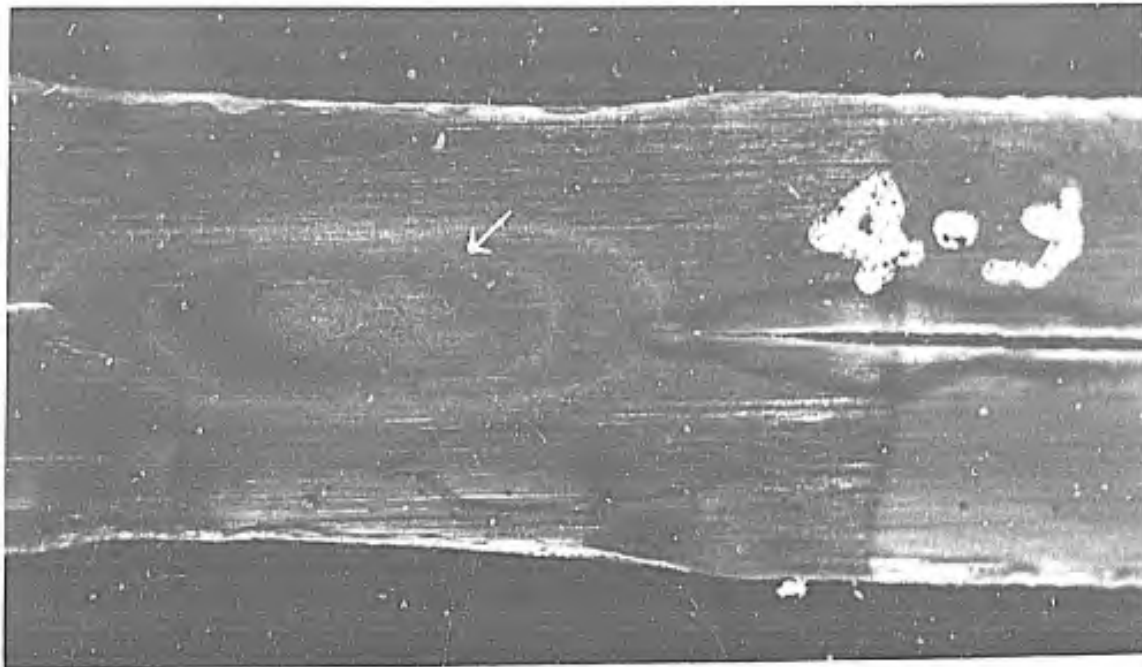


SPOT WELDED SIMONDS HOMOGENEOUS
ARMOR PLATE

PROGRESSIVE WELDER CO

SK 645.2-7

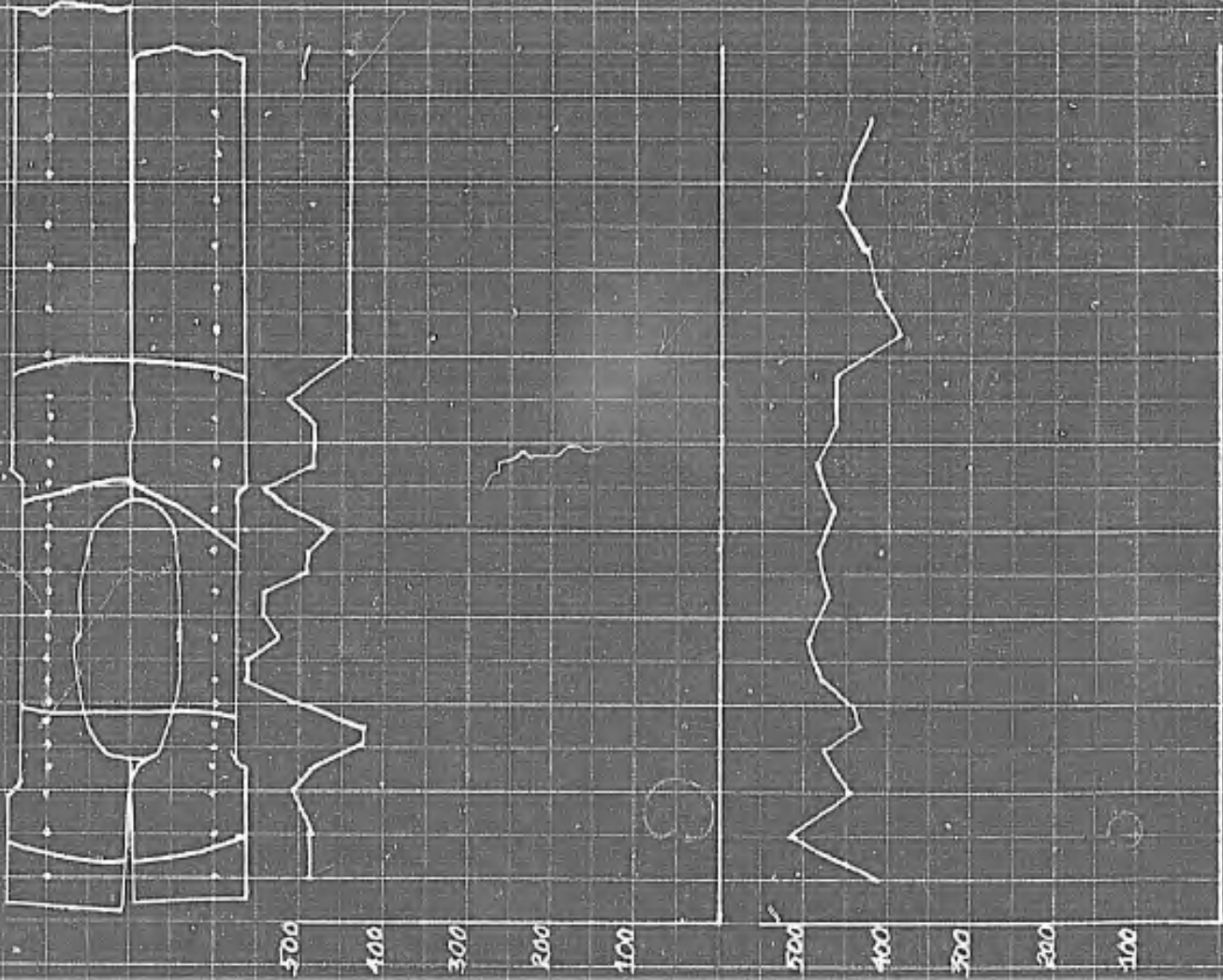
JAN 14 29/41



SPECIMEN PW 4-3
LAP JOINT IN 1/4" SIMONDS ARMOR PLATE. ARROW SHOWS NUGGET.

W.A. 710-1504

PW4-3



1/4" HOMOGENEOUS ARMOR PLATE
LAP JOINT SPOT WELDED

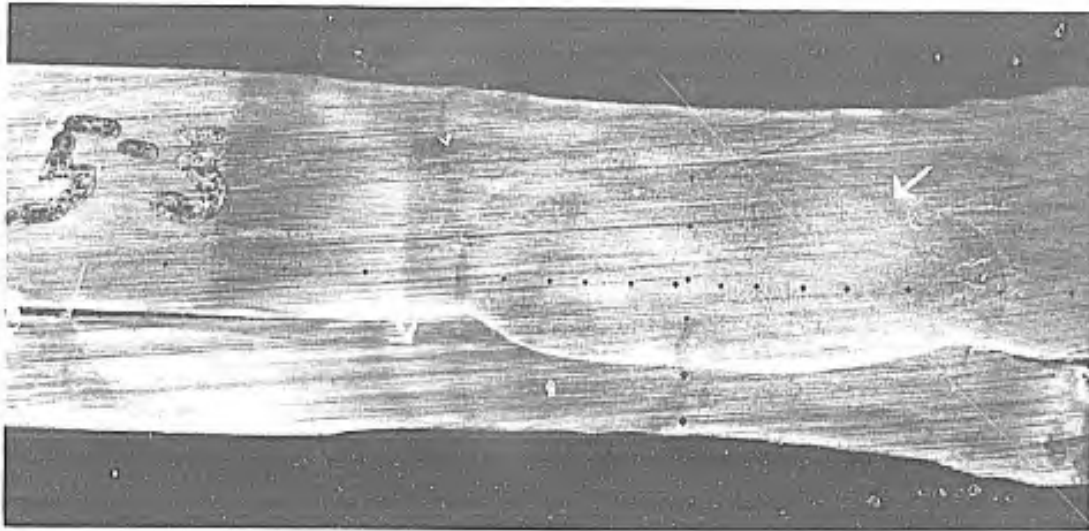
1/4" HOMOGENEOUS ARMOR PLATE
LAP JOINT SPOT WELDED

SPOT WELDED SIMONDS ARMOR
PROGRESSIVE WELDER CO.

JAN 1/1/42

SK 645.2-8

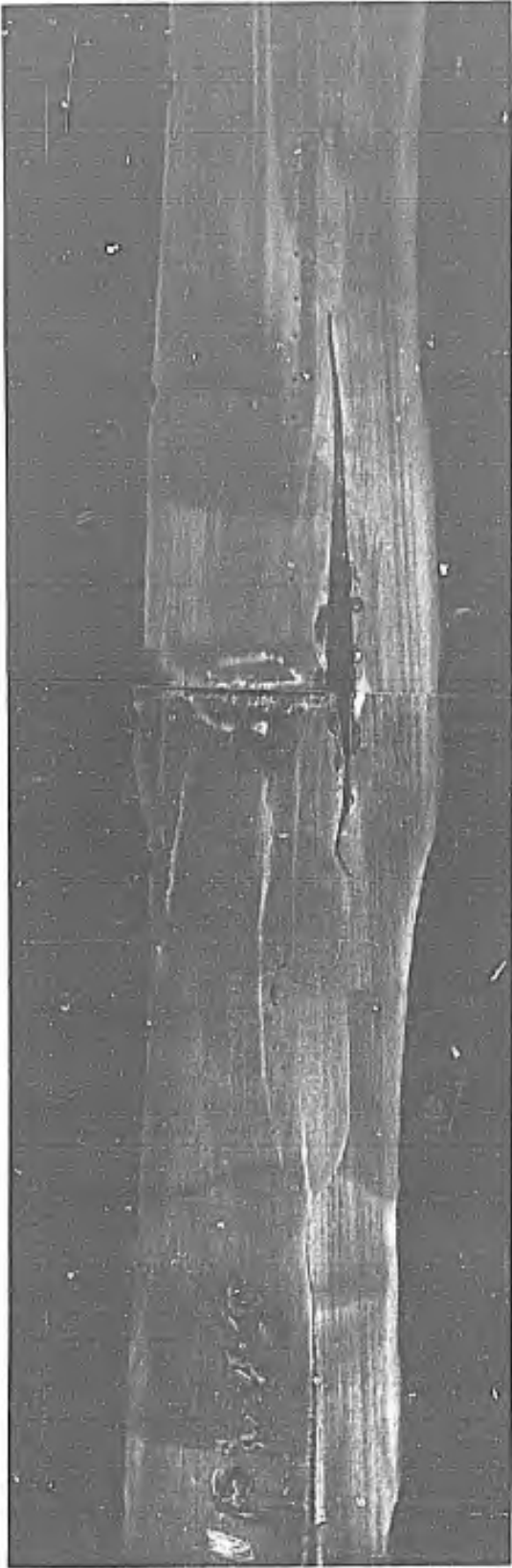
200
100



SPECIMEN PW 5-3

STRAP BUTT JOINT IN 1/4" SIMONDS ARMOR. ARROWS SHOW NUGGET
AND STRUCTURAL STEEL STRAP.

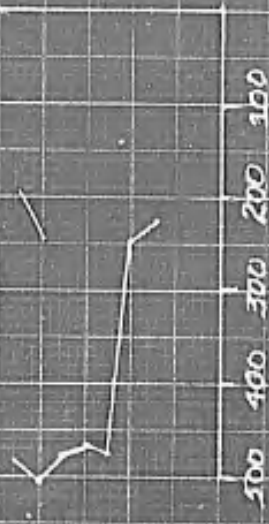
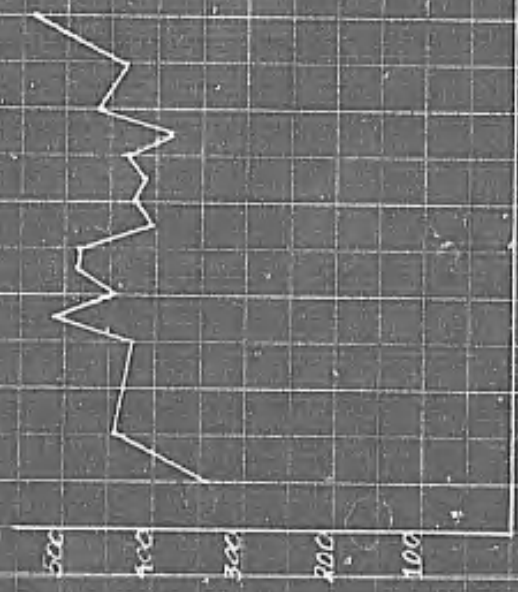
W.A.710-1505



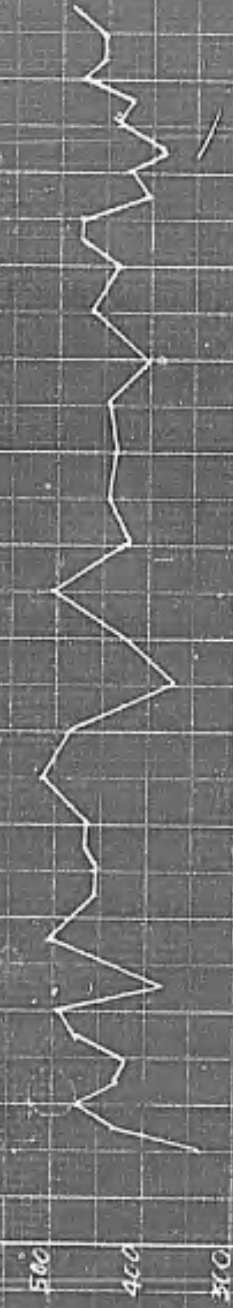
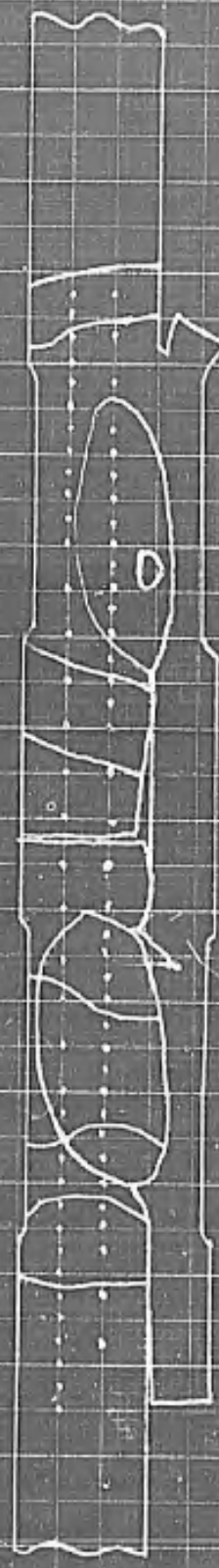
SPECIMEN PN 5-2

CROSS SECTION OF SPOT WELDED STRAP BUTT JOINT IN 1/4" SIMONDS ARMOR.

M.A. 710-1506

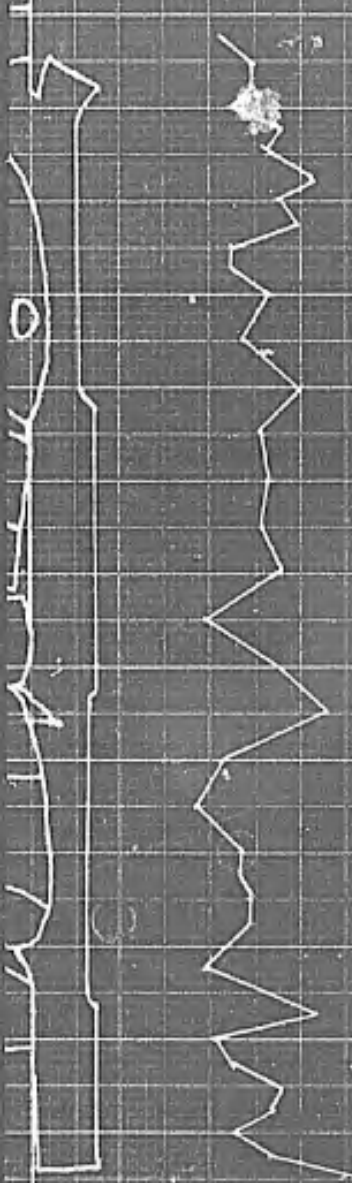


PW 5-3



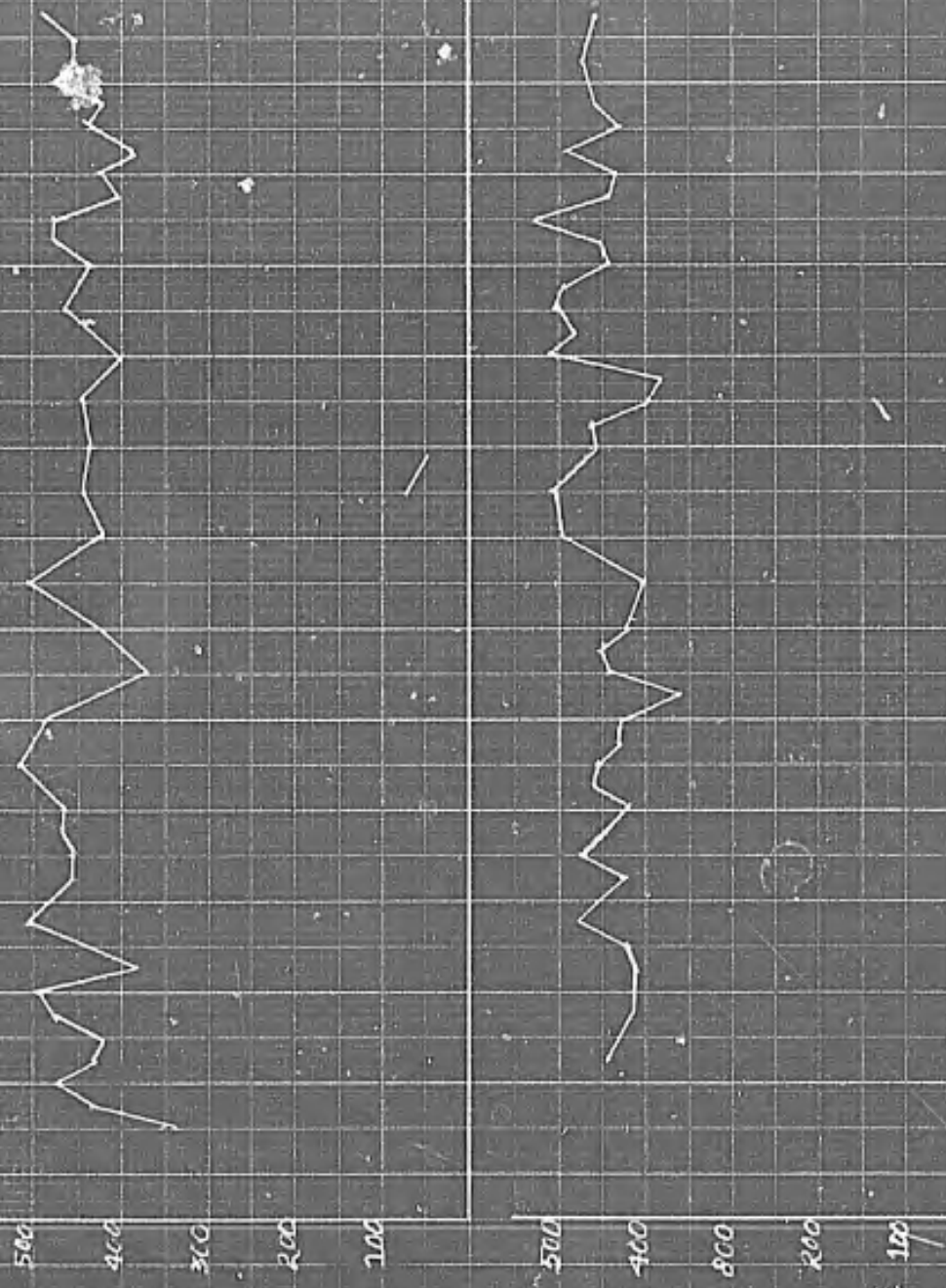
CKERS DRINELL HARDNESS

PW 5-2



VICKERS BRINELL HARDNI

PW 5-2

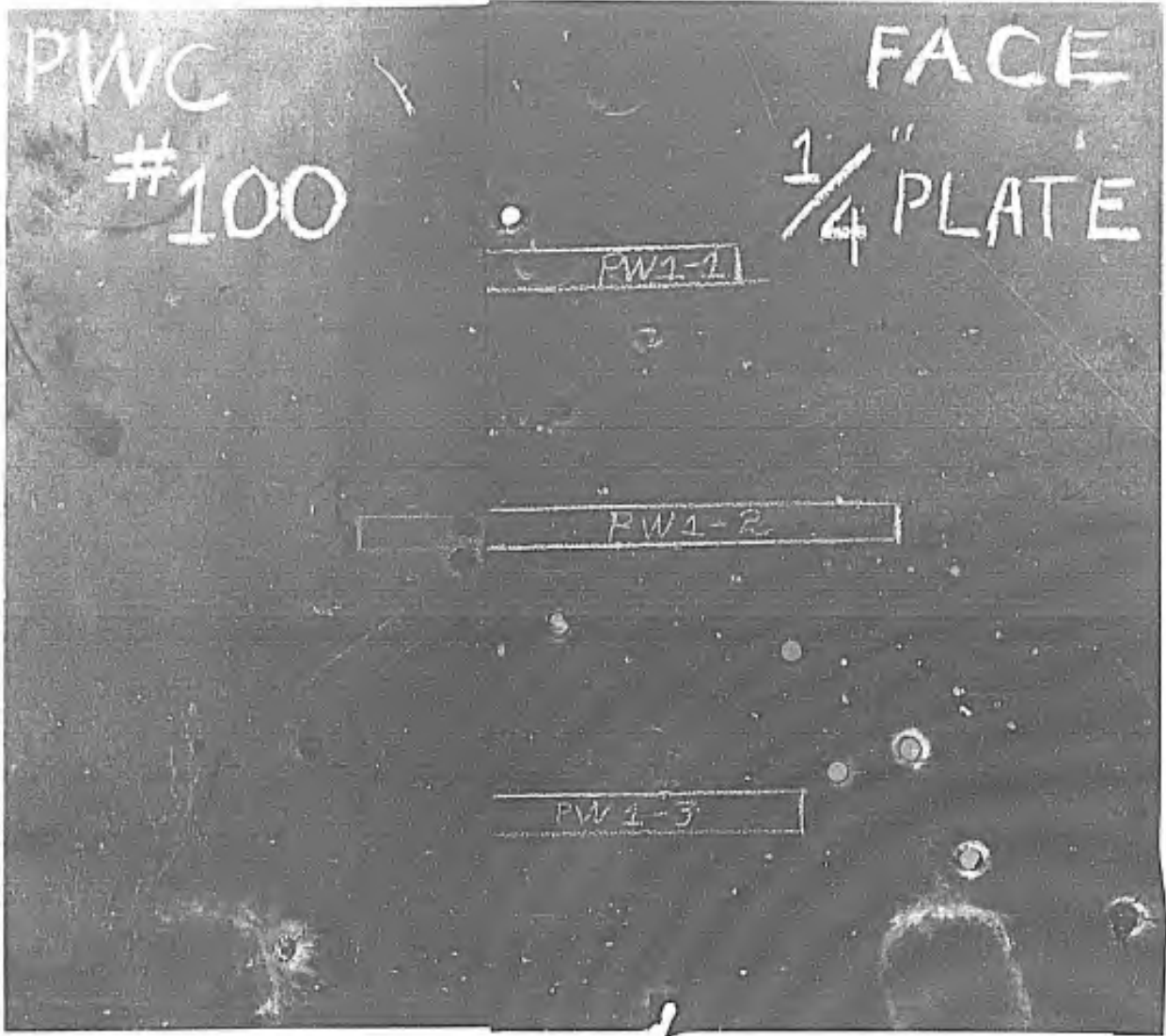


1/4" HOMOGENEOUS ARMOR PLATE
STRAP BUTT JOINT

SPOT WELDED SIMONDS ARMOR
PROGRESSIVE WELDER CO

SK 645.2-9

JAM 12/28/41

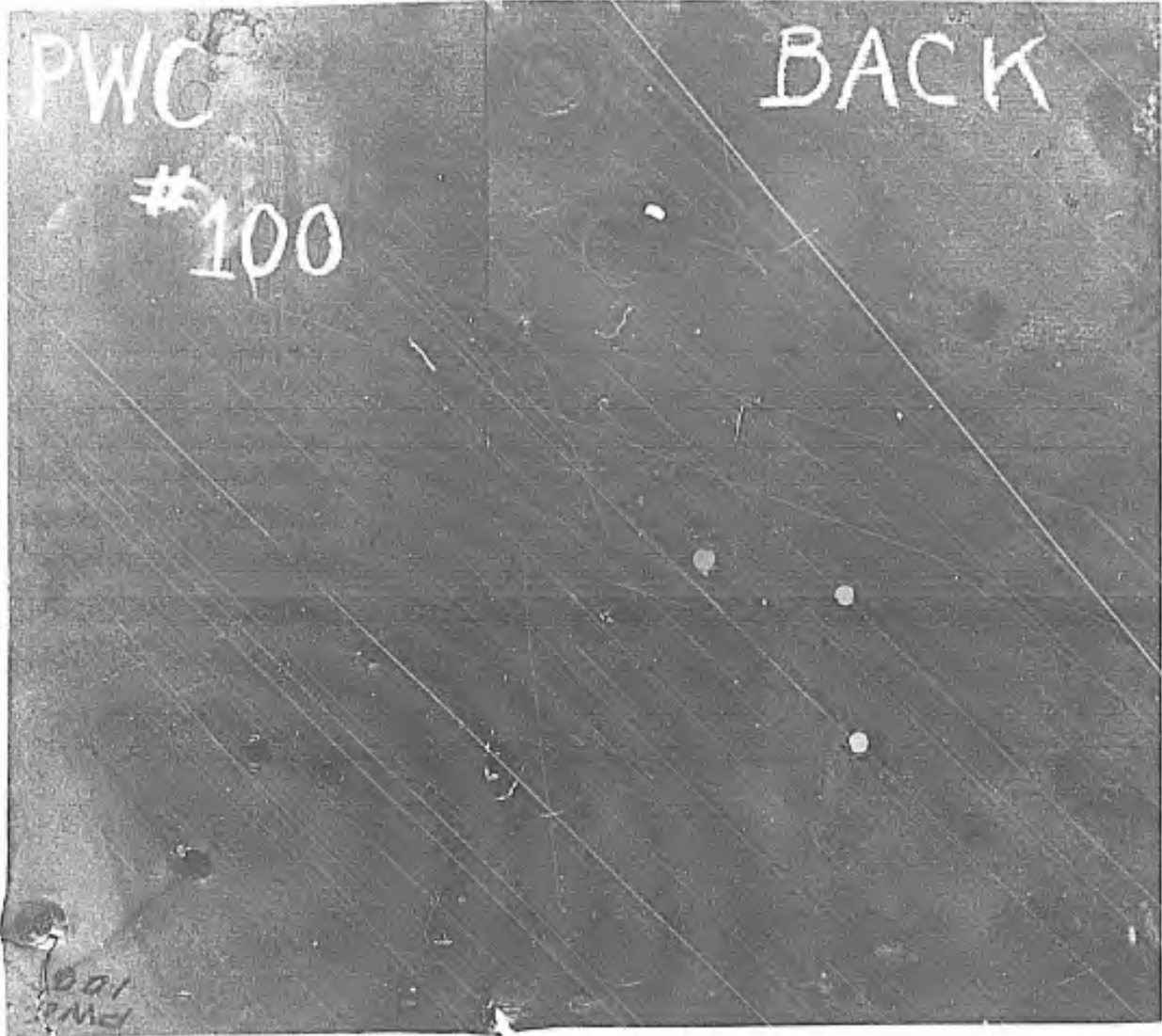


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INCHES

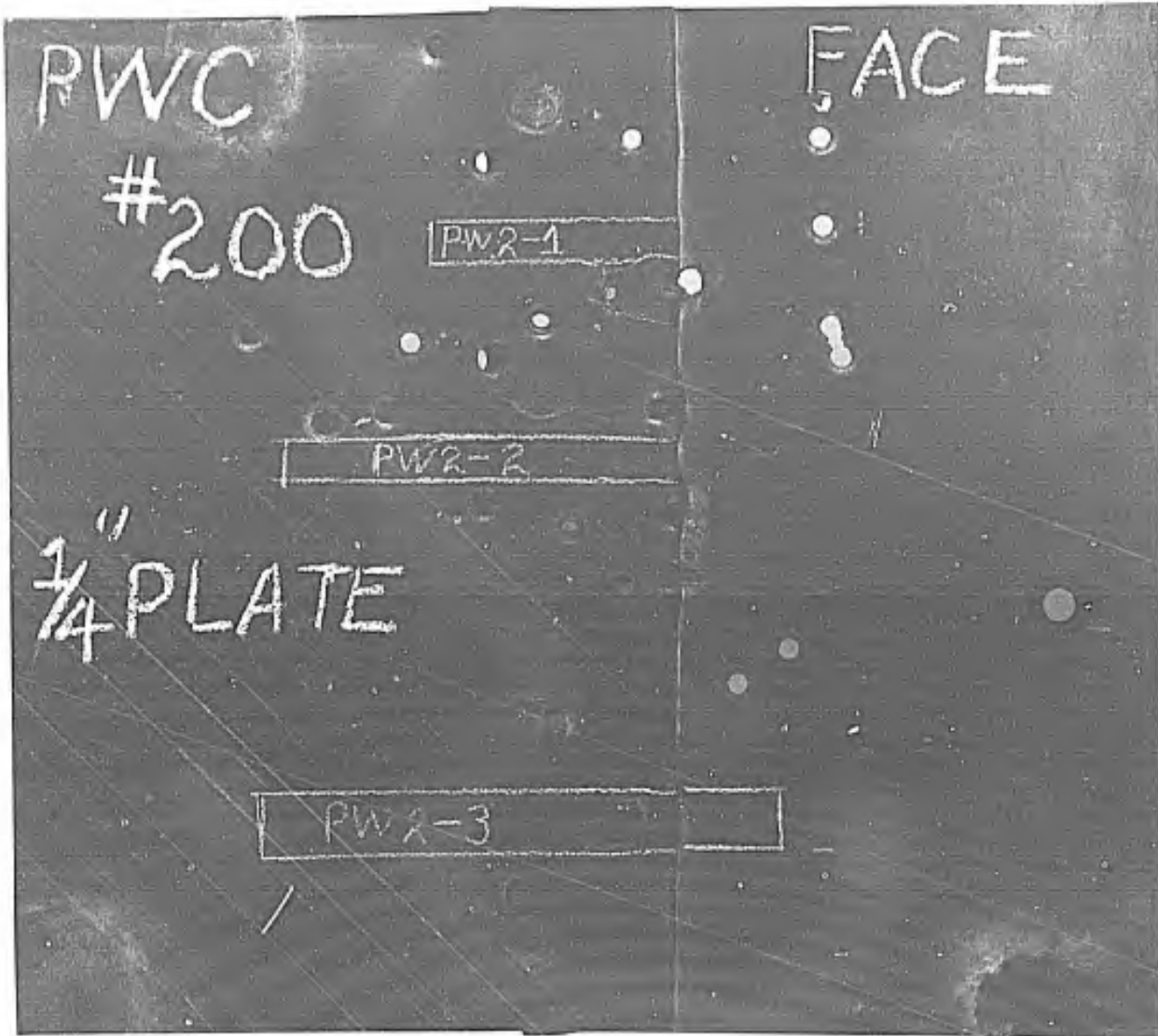
ENGINEERING TEST ROOM
MADE IN U.S.A.

1/4" FACE CARBON STEEL PLATE PWC # 100
MIL MILLED, 1/4" THICK, 10" X 10" FOR
TEST PURPOSES, 1950

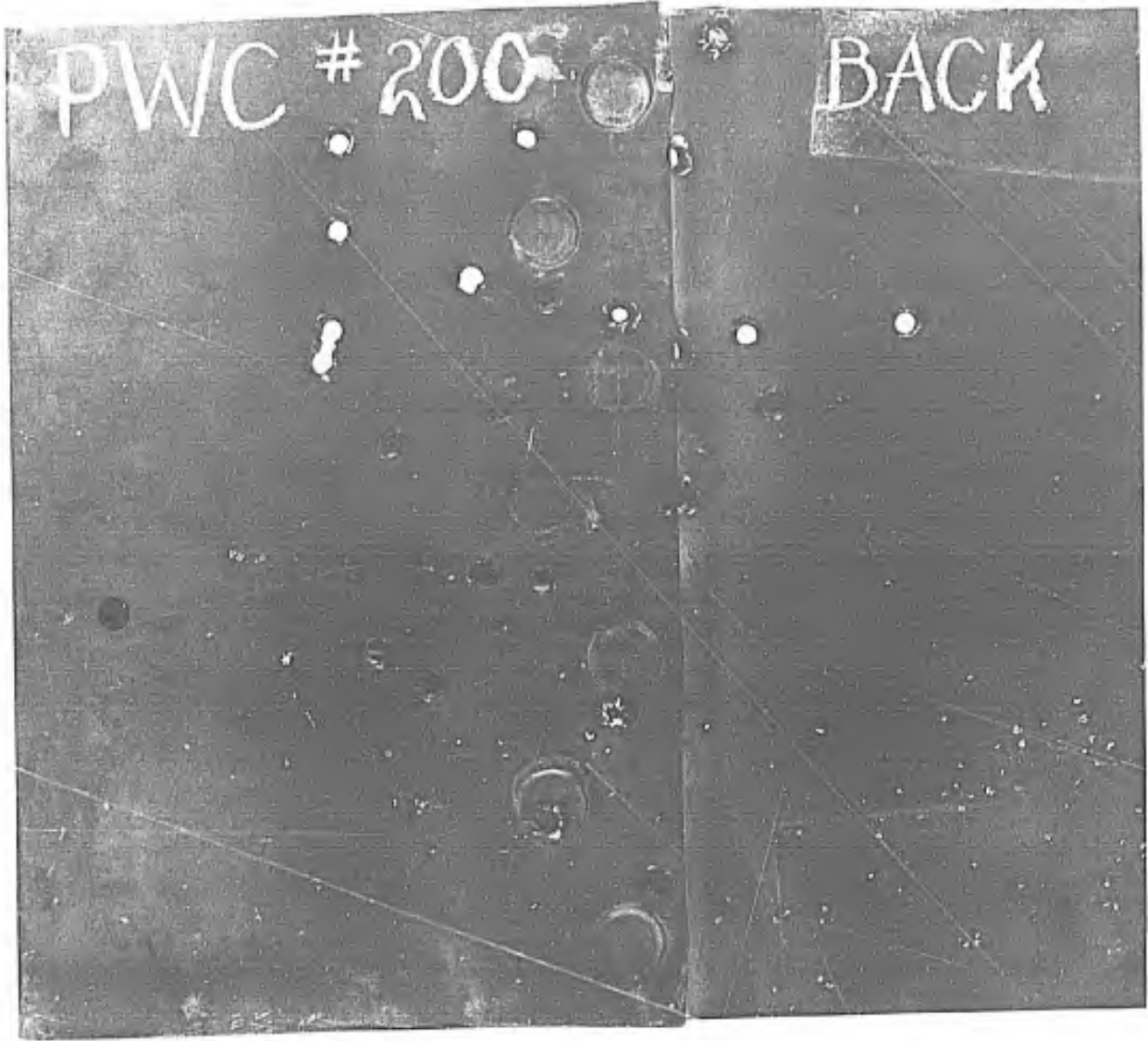
WALTONS



ORIGINAL COPY SENT
TO THE NATIONAL ARCHIVES
ON 10/10/2001



ORDONALLOY GILTY U.S.A.
1/4" FACE HARDENED ARMOR PLATE PWC # 200
ONE WELDED LAP JOINT SPECIMEN FOR
STUDY MARKED FRONT
PROPERTY R 1-11 W.S. 70-4152



PHOTOGRAPHED BY
U.S. AIR FORCE

PWC
#300

FACE
 $\frac{1}{4}$ " PLATE

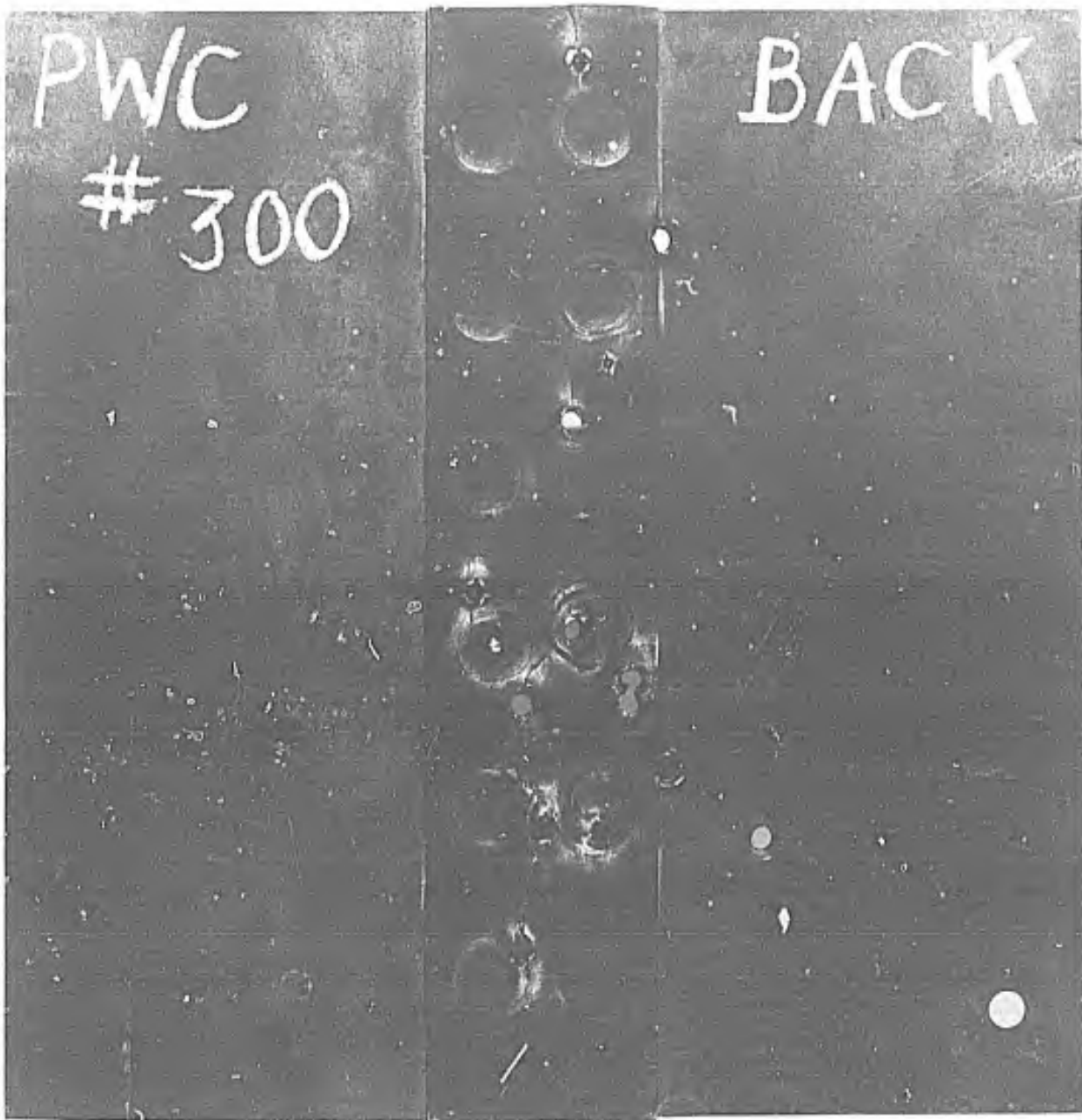
PW3-1

PW3-2

PW3-3



QUDDAK KEPT U.S.A.
WATERPROOF JOURNAL
1/4" FACE HARDENED ARMOR PLATE PWC # 300
SPOT WELDED. BUILT STRAP JOINT FRONT
SPECIMEN FOR STUDY MARKED. W.A. 710-1-36 1
DECEMBER 8 1941



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

SALES AND SERVICE DIVISION
GENERAL ELECTRIC COMPANY
Schenectady, N. Y. 12301

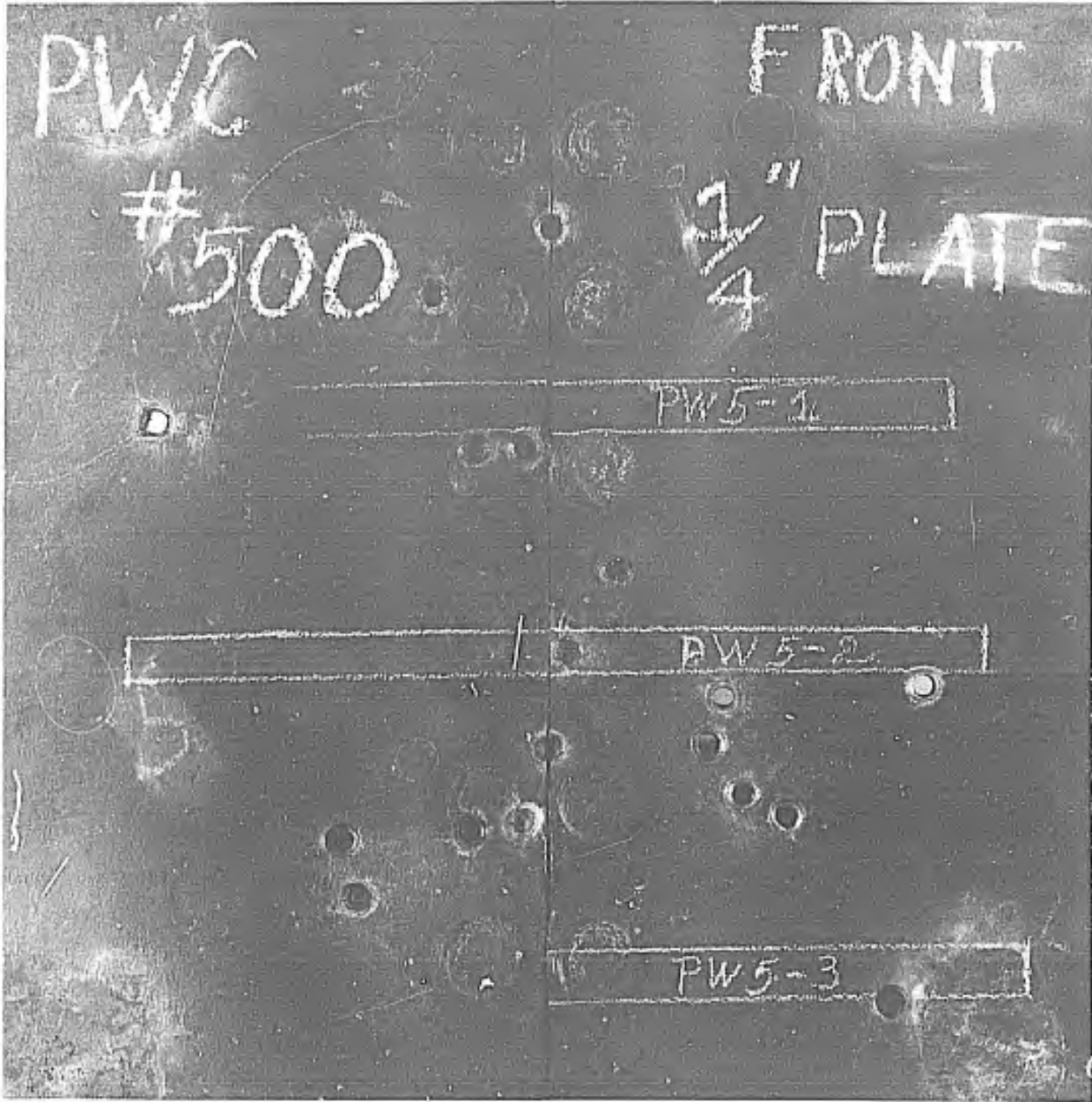


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WASHINGTON, D. C.

PWC #400

BACK

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U.S. AIR FORCE
SERIALS SECTION



ORDINANCE DEPT U.S.A.
WATER TOWNS ARSENAL
1/4" HOMOGENEOUS ARMOR PLATE PWC # 500
NOT WELDED BUTT STRAP JOINT
SPECIMEN FOR STUDY MARKED FRONT
OCTOBER 8 1941 V.6.710-1-555

