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AUTHORITY
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ahk

Report No. 640/51
Watertown Arsenal
(Ex. O. 41)

July 14, 1942

STRUCTURAL STEEL - WELDING

Qualification Test of Republic Steel Company's 1/4" Manganese-Copper-Molybdenum Structural Alloy Plate Welded With 3/16" dia. Murex Type FMP Electrode

OBJECT

To determine whether the yield strength of butt welded joints made with Republic 1/4" Mn-Cu-Mo plate, using 3/16" dia. Murex Type FMP electrode, complies with the requirements of Specification WXS-31 (Rev.10) April 15, 1941

REFERENCES

1. Teletype - TT23273, May 24, 1942 from Cleveland Ordnance District.
2. Teletype, May 25, 1942 from Watertown Arsenal, W.A. 400.273/499.

CONCLUSIONS

1. The yield strength of butt welds made with Republic 1/4" Mn-Cu-Mo plate and Murex FMP electrodes does comply with the requirements of Specification WXS-31.

2. The Republic 1/4" Mn-Cu-Mo plate of the approximate composition shown in this report does comply with the requirements of U.S.Army Specification 57-114-1, April 26, 1939 for Class B, Grade 2 material.

P.R. Woodward
Chief Laboratory Mechanic

APPROVED:

W.L. Warner
Welding Engineer

E. E. Lornig
Colonel, Ord. Dept.
Director of Laboratory

INTRODUCTION

Due to difficulty experienced in meeting requirements for welder qualification tests, twelve (12) test plates and sufficient Murex FHP electrodes for welding these plates were forwarded to Watertown Arsenal from the Union Metal Manufacturing Company, Canton, Ohio, with a request by teletype from Cleveland Ordnance District that Watertown Arsenal conduct welding tests with the plates and electrodes submitted, and that the Cleveland Ordnance District be advised of the results.

Information had been obtained to the effect that the welder qualification test plates were welded at the plant of the Union Metal Manufacturing Company with a single V, 120° included angle, and when the physical tests were made the specimens broke in the weld, producing yield strength values below the requirements of Specification WAB-31.

TEST PROCEDURE

Plate Analysis

C	Mn	Ni	Cr	Mo	Cu
0.23	0.92	--	0.015	0.32	0.33

Butt Joint Preparation

The butt joints were prepared with single V, 60° included angle and single V, 120° included angle so as to obtain test data on the effect, if any, of different amounts of weld metal required to make the welded joints.

Welding Data

Weld	Plate	Joint	Electrode	Current	Arc Volts	No. of Passes
UM-1	1/4"	60° Single V Open 1/32"	3/16" FHP	190 Amps.	26	2-Face 1-Seal bead
UM-3	1/4"	120° Single V No opening	3/16" FHP	190 Amps.	26	3-Face 1-Seal bead

Inspection

All butt welds made for the tests covered by this report were radiographed and visually inspected. The X-ray films showed clear weld metal with no evidence of porosity, slag inclusions or incomplete penetration. There were no surface defects such as undercuts, poor fusion or unfilled craters.

Test Specimens

Tension test specimens with 1" and 2" gage lengths were prepared from these welds to obtain test data on the effect, if any, of a gage length different from the standard prescribed by Specification WES-31. Two standard .505" all weld metal tension specimens were made to obtain test data on the weld metal deposited by the electrodes submitted. Approximately 50% of the test specimens were tested in the "as rolled" and "as welded" condition, while the remainder were tested in the stress-relieved condition. For stress relieving, the machined test specimens were held at 1150° F. for four (4) hours and furnace cooled.

RESULTS

Unwelded Plate

Results obtained from tension tests of the unwelded plate material are given in Table 1. The yield strength values shown indicate that the plate material is Class B, Grade 2, Specification 57-114-1. Required yield strength, 50,000 psi min. at 0.05% offset.

TABLE 1

Tension Tests - Unwelded Plate

2" Gage Length

Plate	Spec. No.	Treatment	Y.S. psi 0.05% Offset	Y.S. psi 0.10% Offset	T.S. psi	Elongation 1"	Elongation 2"
UMP	T1	As Rolled	60,400	64,900	100,000	26.0	18.0
	T2	" "	65,200	67,900	100,000	25.0	17.5
	T3	Stress Relieved	72,000	72,000	93,200	15.5	20.5
	T4	" "	62,700	65,500	91,600	25.0	19.0
	T5	" "	70,800	70,800	88,400	29.0	19.0

1" Gage Length

T6	As Rolled	62,000	66,000	102,000	22.0	
T7	" "	64,800	66,000	98,000	22.0	
T8	Stress Relieved	70,000	70,000	92,000	25.0	
T9	" "	72,000	72,000	89,600	24.5	
T10	" "	68,300	68,300	88,800	25.0	

Butt Welds

Results obtained from tension tests of the 60° single V, and 120° Single V butt welds are given in Tables 2 and 3 respectively. All the butt welded specimens broke through the weld with clean fractures either shear or cup and cone, producing yield strength values equal to or better than the minimum specified for Class B, Grade 2 material. (One exception - Specimen UM-1, T9)

TABLE 2

Tension Tests - Butt Welds 60° V

2" Gage Length

Weld	Spec. No.	Treatment	Y.S. psi 0.05% Offset	Y.S. psi 0.10% Offset	T.S. psi	Elongation 1"	Elongation 2"
UM-1	T1	As Welded	54,400	56,800	84,000	16.0	9.5
	T2	" "	52,700	56,800	86,000	16.0	10.0
	T3	" "	54,800	57,500	88,400	13.0	10.0
	T4	Stress Relieved	52,300	53,500	81,600	20.0	12.0
	T5	" "	51,500	52,000	82,400	19.0	12.0
	T6	" "	51,500	53,100	81,600	21.0	12.0

[illegible]

1" Gage Length

Weld	Spec. No.	Treatment	Y.S. psi 0.05% Offset	Y.S. psi 0.10% Offset	T.S. psi	Elong. 1"
UM-1	T7	As Welded	51,600	54,800	89,200	16.0
	T8	" "	52,300	55,600	89,600	14.5
	T9	" "	49,200	53,500	88,400	14.0
	T10	Stress Relieved	56,000	56,000	84,800	22.0
	T11	" "	50,400	50,400	75,600	21.5
	T12	" "	55,600	55,600	82.000	19.5

TABLE 3

Tension Tests - Butt Welds 120° V

2" Gage Length

Weld	Spec. No.	Treatment	Y.S. psi 0.05% Offset	Y.S. psi 0.10% Offset	T.S. psi	Elongation 1"	2"
UM-3	T1	As Welded	57,900	59,600	86,000	19.0	11.0
	T2	" "	57,200	59,100	85,600	20.0	12.0
	T3	" "	58,800	60,300	86,000	21.0	11.5
	T4	Stress Relieved	54,400	55,200	79,200	27.0	15.0
	T5	" "	52,400	54,000	80,000	17.0	10.5
	T6	" "	52,400	54,800	79,200	24.0	14.0

1" Gage Length

UM-3	T7	As Welded	54,800	56,000	88,000	16.5	
	T8	" "	50,000	53,200	88,000	20.0	
	T9	" "	50,400	56,000	85,200	16.0	
	T10	Stress Relieved	55,200	57,600	80,000	16.5	
	T11	" "	54,000	54,000	80,000	26.0	
	T12	" "	54,400	54,400	80,800	26.0	

All Weld Metal Specimens

Results obtained from tension tests of .505" all weld metal specimens of Murex FHP electrode are given in Table 4.

TABLE 4

Tension Tests - All Weld Metal

.505" Std. Specimen

Spec.#	Treatment	Y.S. psi 0.05% Offset	Y.S. psi 0.10% Offset	T.S. psi	% Elon. 2"	Red. of Area	Fracture
FHP-1	As Welded	63,500	63,500	73,750	26.0	57.0	(Cupped, Ftd
FHP-2	Stress Relieved	56,000	56,000	66,500	27.5	58.0	(Fine Grain

NOTE - The stress-strain curves of all test specimens are included in Appendix B of this report.

DISCUSSION

The test results included in this report indicate that if Class B, Grade 2 plate material and Murex FEP electrodes are used in butt joints properly welded and properly stress-relieved, there will be no difficulty encountered in meeting the welder qualification requirements of Specification WES-31. The test results also indicate that the angle of bevel for the butt joints and the length of the straight section of the tension test specimens do not appreciably affect the yield strength value.

Information is not available as to the effect of stress relieving temperature and time at temperature on the yield strength of this plate material, but it is believed that the use of temperatures of 1200° F. and above would materially reduce the yield strength below the values shown in Table 1. If such were the case, then it would be expected that the yield strength of the welds, as shown by Tables 2 and 3, would be lowered proportionately thus disqualifying the welds.

APPENDIX A

TELETYPES

COPY - 7/27/42 - ahk

WATERTOWN ARSENAL AVS

CLEVE ORD DIST 5/24/42 11.55 AEVT JAS/AL ART TT23273

COMMANDING GENERAL
WATERTOWN ARSENAL

THIS OFFICE HAS EXPERIENCED DIFFICULTY ON WELDER QUALIFICATION TESTS THAT ARE BEING CONDUCTED AT THE UNION METAL MANUFACTURING COMPANY, CANTON, OHIO IN ACCORDANCE WITH SPECIFICATION WXS-31, REVISION 10. THESE TESTS HAVE BEEN CONDUCTED ON CLASS B, GRADE 2 MATERIAL, SPECIFICATION 57-11¼-1. THE FILLET WELDS ON THESE TESTS HAVE BEEN ACCEPTABLE. THE BUTT WELDS ON THIS MATERIAL HAVE FAILED TO MEET THE REQUIRED 50,000 LB. YIELD STRENGTH REQUIRED BY THE QUALIFICATION TESTS. ALL TESTS HAVE BEEN CONDUCTED WITH MUREX F.E.P. WELDING ROD. THE X-RAY REQUIREMENTS ARE SATISFACTORY. TWELVE TEST PLATES AND SUFFICIENT F.E.P. WELDING ROD HAVE BEEN FORWARDED TO HIS ARSENAL TO THE ATTENTION OF DR. WARNER. TEST PLATES AND WELDING ROD WERE SENT FROM THE UNION METAL MANUFACTURING COMPANY AT 7.00 PM, MAY 23, 1942 BY MAIL PLAINE AND SHOULD ARRIVE AT HIS ARSENAL MAY 24 OR MAY 25, 1942. IT IS REQUESTED THAT HIS ARSENAL CONDUCT WELDER QUALIFICATION TESTS ON THE TEST PLATES THAT HAVE BEEN SUBMITTED AND ADVISE THIS OFFICE OF THE ACCEPTABILITY OF MUREX F.E.P. ROD FOR WELDING CLASS B, GRADE 2 MATERIAL. IT IS CALLED TO HIS ATTENTION THAT THE WELDING TO BE DONE WITH MUREX F.E.P. ROD IS TO BE ON FILLET WELDS ONLY. TELETYPE REPLY IS REQUESTED AS TO HOW SOON HIS ARSENAL WILL CONDUCT WELDER QUALIFICATION TESTS AND HOW SOON RESULTS WILL BE OBTAINABLE. THIS INFORMATION URGENTLY REQUIRED.

KENDALL

WS

W.A. 400.273/497

COPY - 7/27/42 - alk

LABORATORY

WLW/gmf

MAY 25, 1942

DEPUTY DISTRICT CHIEF
CLEVELAND ORDNANCE DISTRICT, CLEVELAND, OHIO
COL. RENDALL

RE TT 23273 5/24/42 11.55 A.M. EWT JAS/AL ANT, WELDER QUALIFICATION TESTS. TESTS AT THIS ARSENAL ON SAMPLE PLATES SUBMITTED WITH F.E.P. ELECTRODE WILL REQUIRE ABOUT TWO TO THREE WEEKS AND ARE NOT BELIEVED NECESSARY IN THIS SITUATION. IF INSPECTOR IS SATISFIED THAT WELDER CAN MAKE FILLET WELDS AND BUTT WELDS WHICH ARE SATISFACTORY FROM VISUAL AND RADIOGRAPHIC INSPECTION STANDARDS PRESCRIBED AND FRACTURES OF THE WELDS IN THE TENSION TEST ARE FREE FROM MACROSCOPIC DEFECTS SUCH AS LACK OF PENETRATION, LACK OF FUSION, AND SLAG INCLUSIONS OR EXCESSIVE POROSITY, THE WELDER SHOULD BE CONSIDERED QUALIFIED TO USE THE WELDING PROCEDURE IN SPITE OF TENSION YIELD VALUES MEASURED. IN THE PRESENT CASE IT IS UNDERSTOOD THAT THE TENSILE STRENGTH OF PLATE METAL IS 90,000 TO 95,000. THIS IS REASON FINAL BREAK OCCURS IN WELD WHICH HAS A TENSILE OF ABOUT 75,000 TO 80,000. THE LOW YIELD MEASURED IS THAT OF THE PLATE AND NOT THAT OF THE WELD. THE VALUE IS LOW BECAUSE OF DOUBLE YIELDING OF THE PLATE METAL ON EITHER SIDE OF THE WELD, AND THIS MAY BE FURTHER AGGRAVATED BY THE USE OF HEAVY ELECTRODES FOR MAKING THE WELD WITH CONSEQUENT HEATING OF THE PLATE ALONGSIDE. TEST REPORT WILL BE FORWARDED WHEN TESTS ON SAMPLE PLATES ARE COMPLETED.

ZORNIG

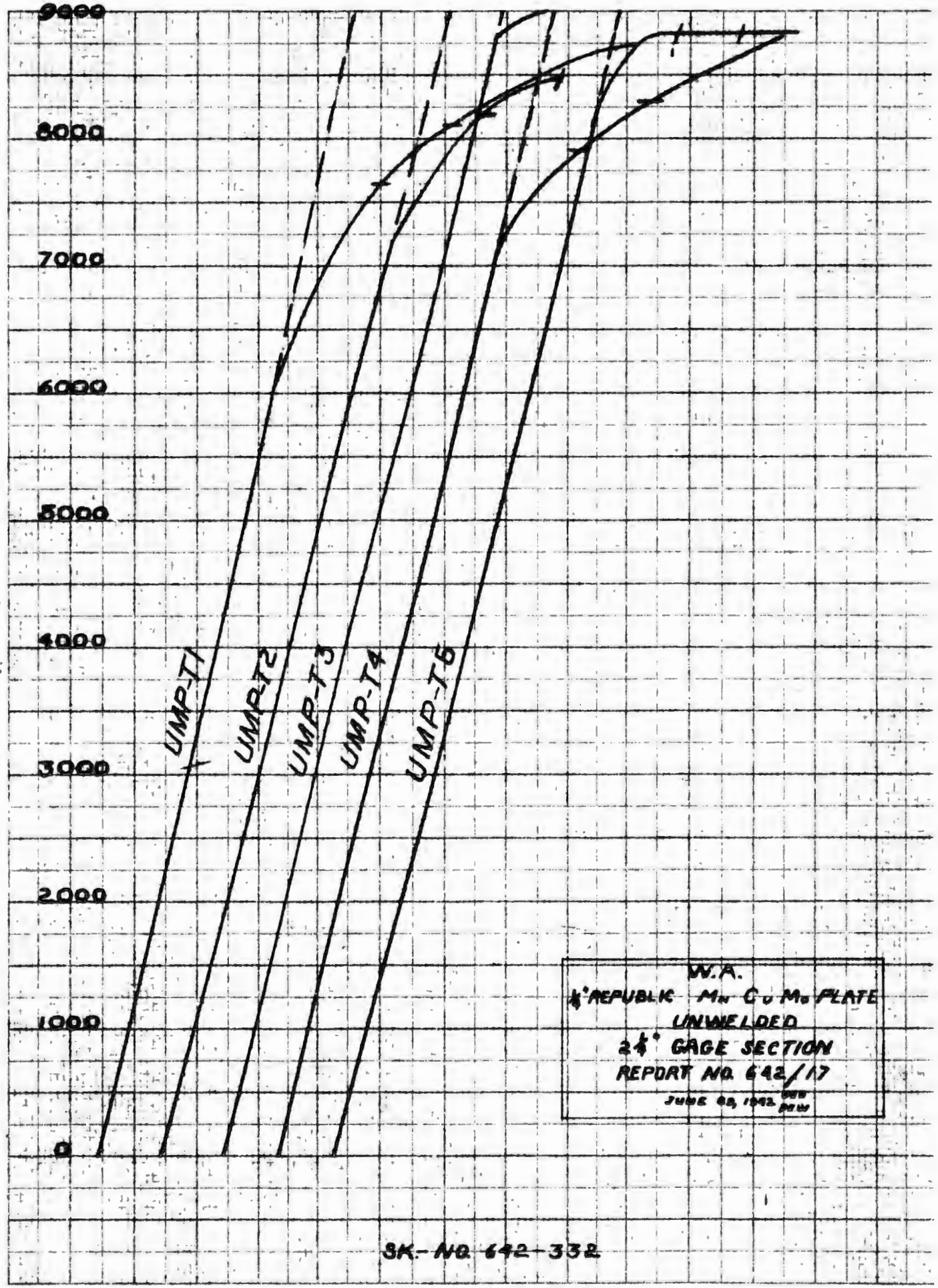
W.A. 400.273/499

H. A. WILLIS,
LT. COL., ORD. DEPT.,
ADMINISTRATIVE OFFICER

APPENDIX B

STRESS-STRAIN CURVES

TENSION TESTS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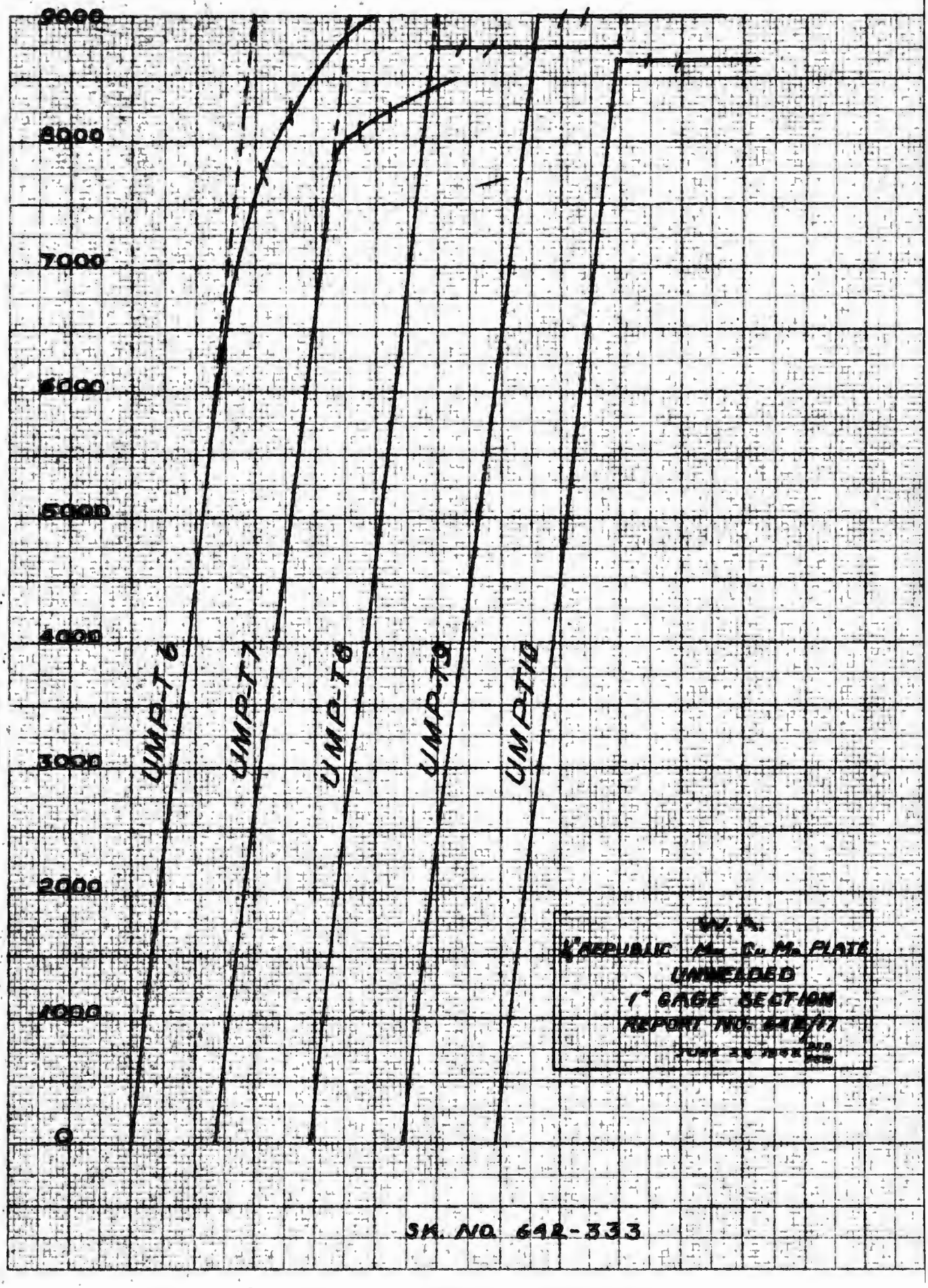
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
UMP-T1
UMP-T2
UMP-T3
UMP-T4
UMP-T5
W.A.
¼" REPUBLIC Mn C. Mo PLATE
UNWELDED
24" GAGE SECTION
REPORT NO. 642/17
JUNE 23, 1942
SK-NO. 642-332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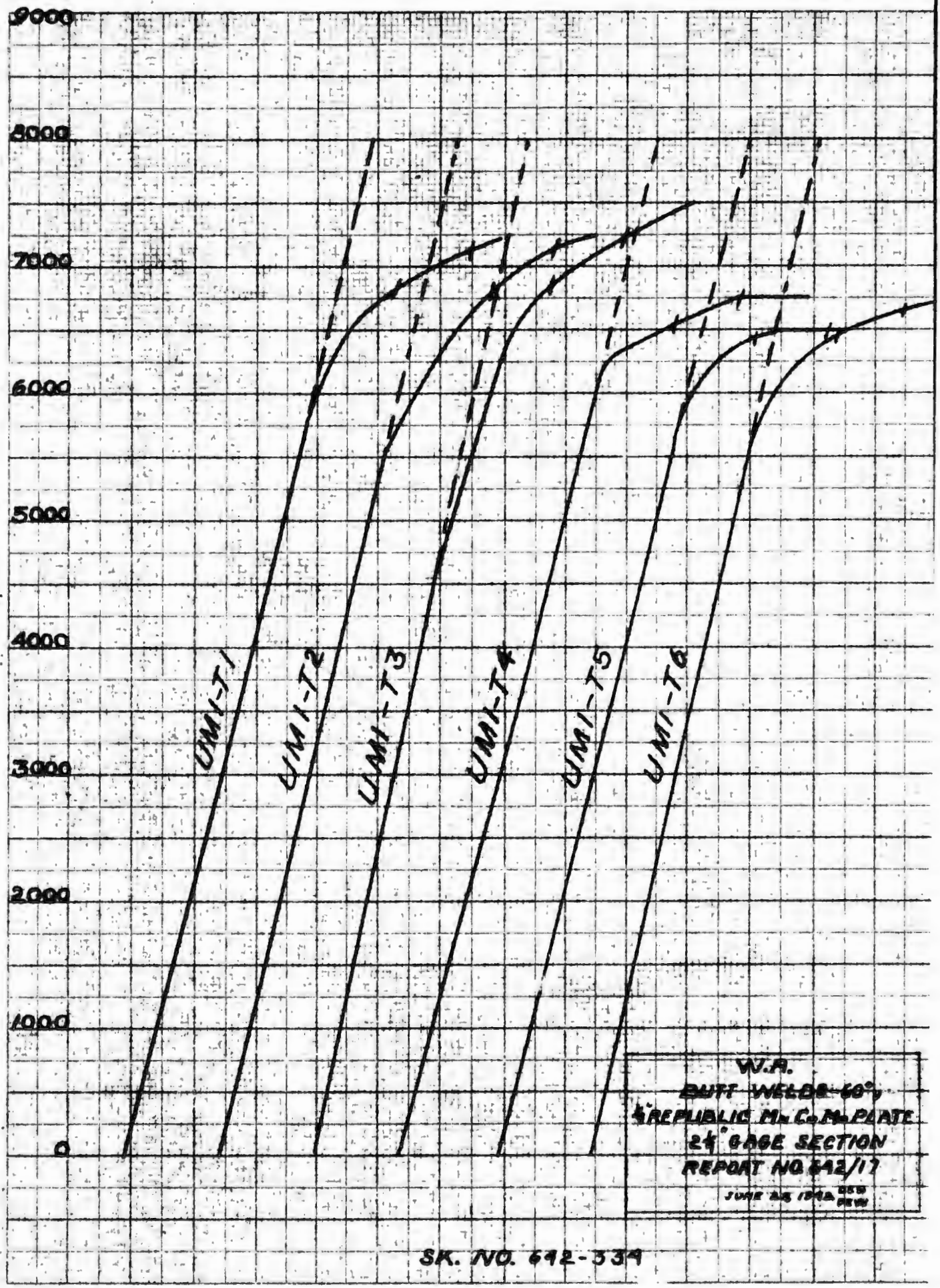
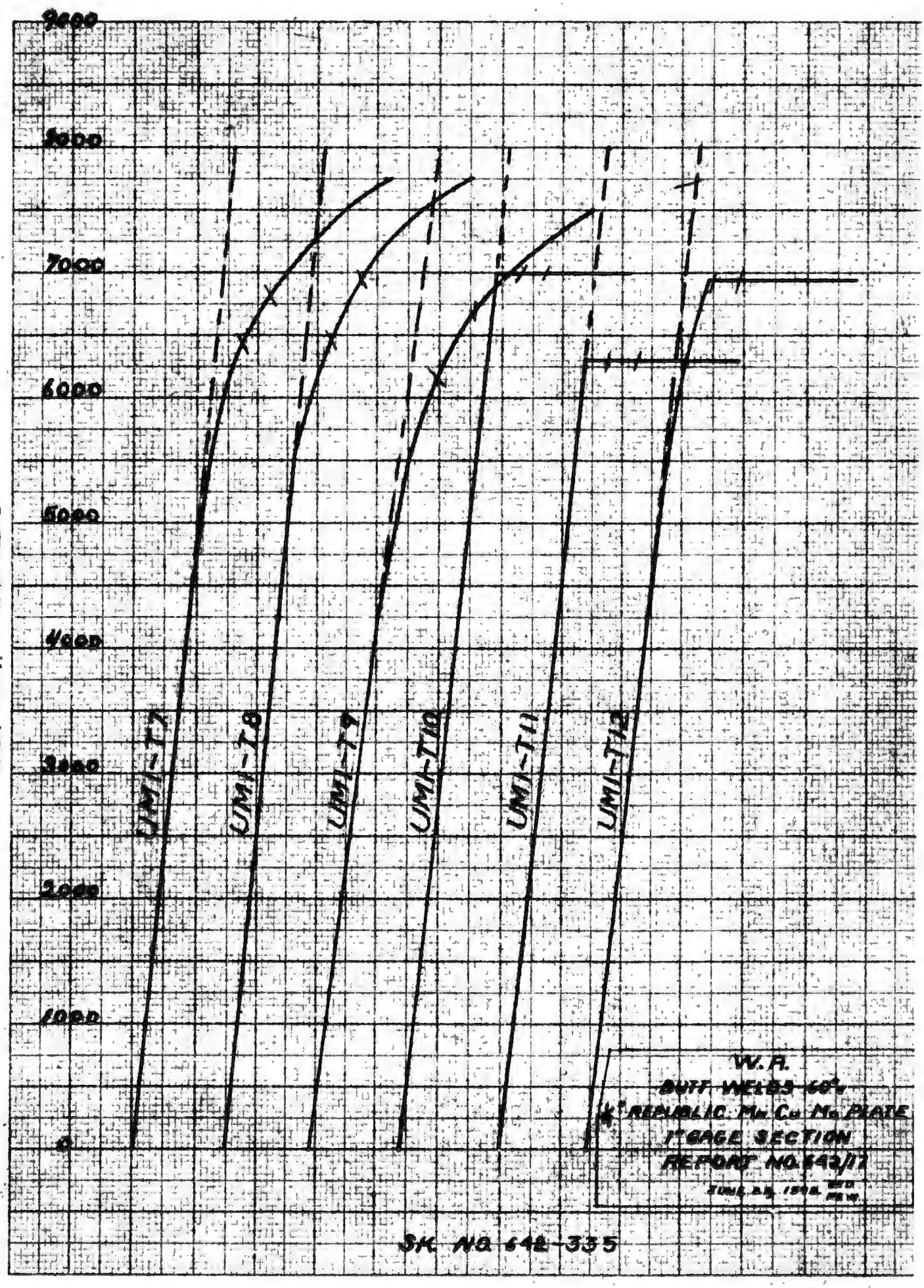
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
UMP-T6
UMP-T7
UMP-T8
UMP-T9
UMP-T10
W. P.
¼" REPUBLIC M... C... M... PLATE
UNWELDED
1" GAGE SECTION
REPORT NO. 648/11
JUNE 24 1955
SK. NO. 642-333


9000
8000
7000
6000
5000
4000
3000
2000
1000
0
LOAD – POUNDS
UMI-T1
UMI-T2
UMI-T3
UMI-T4
UMI-T5
UMI-T6
W.P.
BUTT WELDS 60°
¼" REPUBLIC M. C. M. PLATE
2¼" GAGE SECTION
REPORT NO. 642/17
JUNE 25, 1942
SK. NO. 642-339


LOAD, POUNDS
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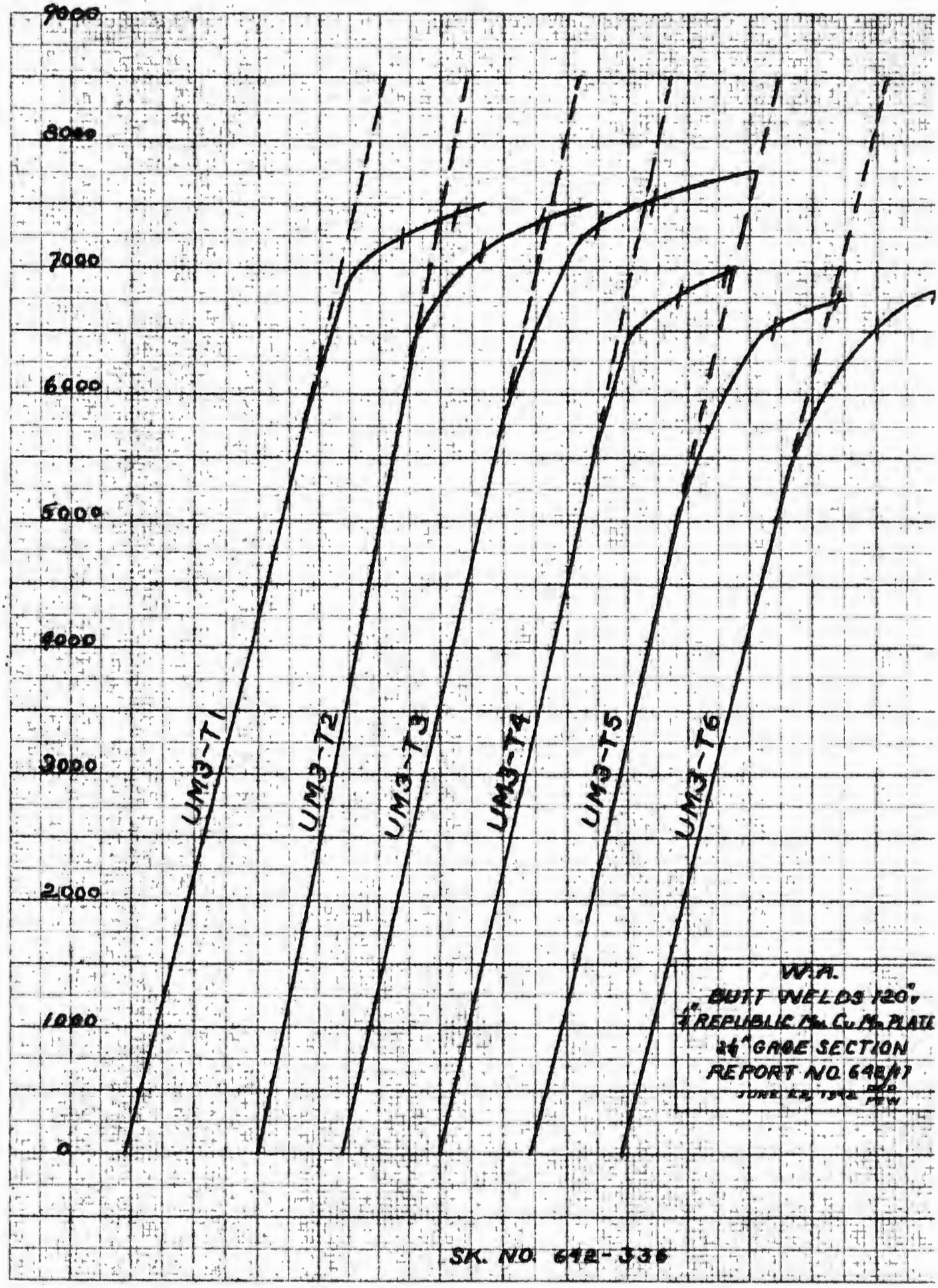
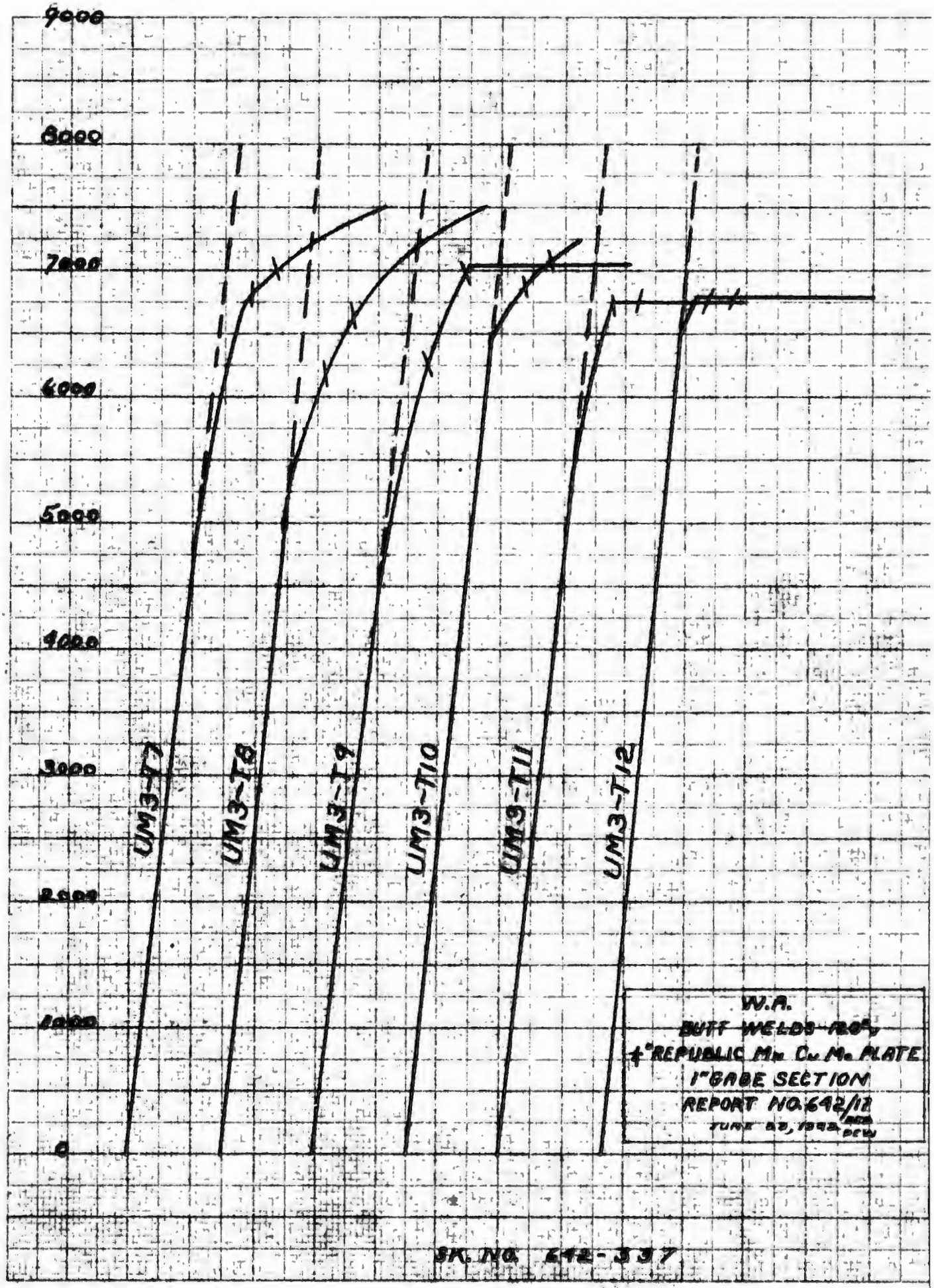
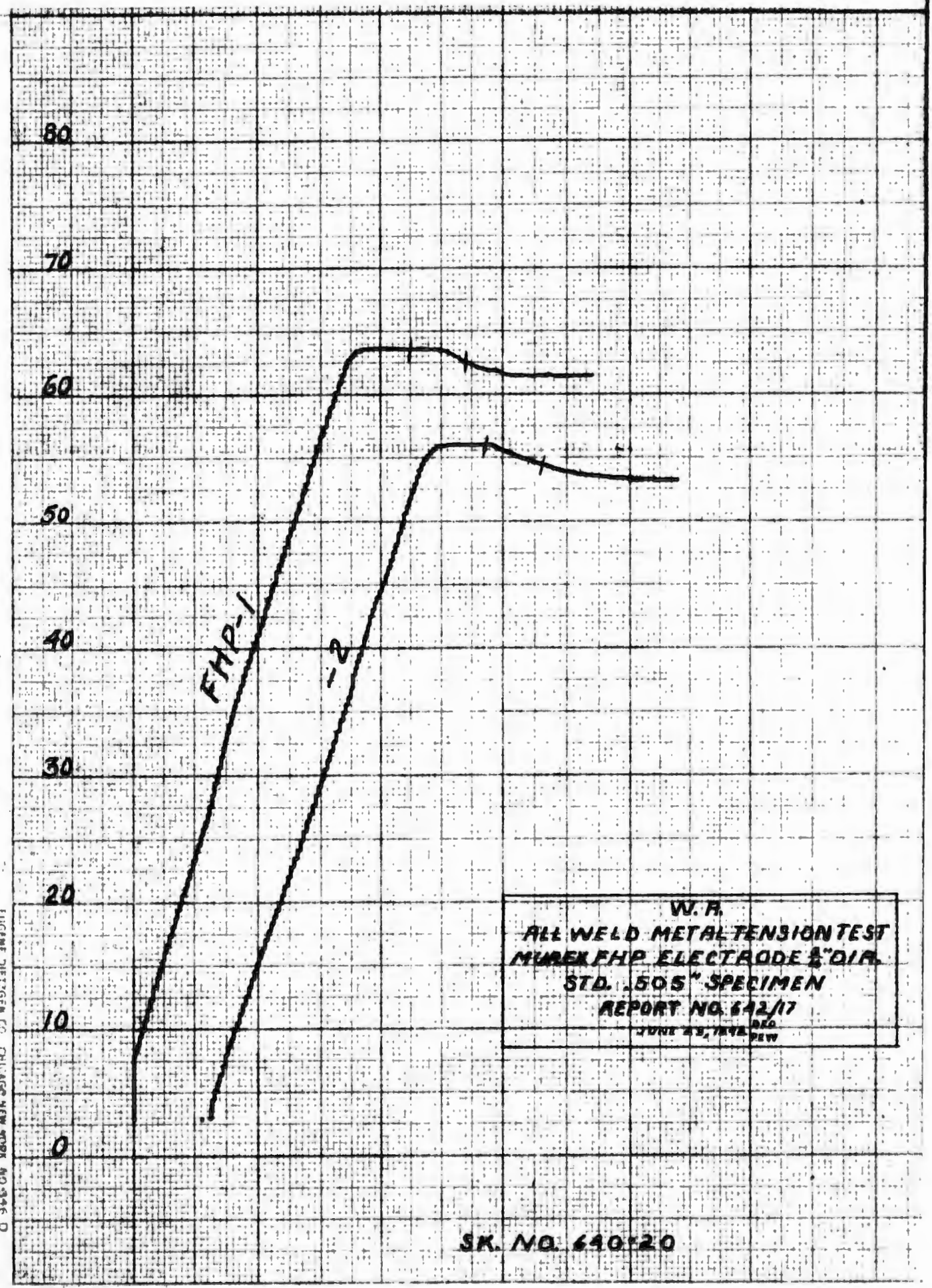
7000
6000
5000
4000
3000
2000
1000
0
UMI-T7
UMI-T8
UMI-T9
UMI-T10
UMI-T11
UMI-T12
W.P.
BUTT WELDS 60°
¼" REPUBLIC Mn Cu Mo PLATE
1" GAGE SECTION
REPORT NO. 542/17
SK NO 642-335


LOAD - POUNDS
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
UM3-T1
UM3-T2
UM3-T3
UM3-T4
UM3-T5
UM3-T6
W.A.
BUTT WELDS 120°
¼" REPUBLIC Mn. C. M. PLATE
24" GAGE SECTION
REPORT NO. 648/17
JUNE 22, 1942 DEC. FEW
SK. NO. 642-336


9000
8000
7000
6000
5000
4000
3000
2000
1000
0
LOAD - POUNDS
UM3-T7
UM3-T8
UM3-T9
UM3-T10
UM3-T11
UM3-T12
W.A.
BUTT WELDS-80°,
4" REPUBLIC Mn Cu Mo PLATE
1" GABE SECTION
REPORT NO. 642/12
JUNE 22, 1942 MCB DCW
SK. NO. E42-337


STRESS LBS. PER SQ. IN. X 1000
80
70
60
50
40
30
20
10
0
FHP-1
-2
W. R.
ALL WELD METAL TENSION TEST
MUREX FHP ELECTRODE 5/32" DIA.
STD. .505" SPECIMEN
REPORT NO. 642/17
JUNE 25, 1942 REG PEW
SK. NO. 640-20
EUGENE DIETZGEN CO. CHICAGO NEW YORK NO. 340 D