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NAVY DEPARTMENT

Report

of

Welding Test 182.

FR-1576

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

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ABSTRACT

A study was requested of the heating and cooling cycle of STS plate contiguous to bead welds from 25% Cr - 20% Ni electrodes and Grade EA electrodes to determine the average heating and cooling curves resulting from the use of these electrodes. The Laboratory's equipment for full automatic control of welding conditions was used in making all weld deposits. For the identical welding techniques used, Grade EA electrodes have a higher efficiency of deposition than 25% Cr - 20% Ni electrodes. The greater amount of weld metal deposited will tend to decrease the rate of cooling in the plate adjacent to the weld deposit for the Grade EA bead weld. A comparison of the heating and cooling curves in the plate contiguous to a bead weld with equivalent welding techniques melting equal amounts of plate metal show no difference in the heating and cooling cycles in the plate contiguous to bead welds deposited with Grade EA or 25% Cr - 20% Ni electrodes. The difference in ballistic behavior of Grade EA and 15% Cr - 10% Ni welds deposited on STS plate is definitely not based on differences in thermal conditions.

Table of Contents

<u>Subject</u>	<u>Page</u>
Abstract	
Authorization for Test	1
Object of Test	1
Description of Material under Test	1
Methods of Test	1
Data Recorded during Test	2
Conclusions and Recommendations	
(a) Facts Established	3
Summary and Conclusions	3

Appendices

Analysis of Plate Material (STS)	
Analysis of 25% Cr - 20% Ni Electrode	
Analysis of Bead Weld Deposit (25% Cr - 20% Ni)	Table 1
Time-Temperature Cycle Adjacent to a Bead Weld with Identical Welding Technique	Plate 1 2
Macro-section Showing Variation in Size of Bead for EA and 25% Cr - 20% Ni Electrodes for Identical Welding Techniques	3
Influence of Power Input on Area of Parent Metal Melted with EA and 25% Cr - 20% Ni Electrodes	4
Time-Temperature Cycle Adjacent to a Bead Weld with Equivalent Welding Technique	5 6
Maximum Temperature Attained Contiguous to a Bead Weld Using Equivalent Welding Technique	7

AUTHORIZATION FOR TLST

1. Welding test 182 was authorized by Bureau of Engineering letter, reference (a). Additional references pertinent to this problem are listed as references (b), (c) and (d).

Reference: (a) BuEng.ltr. JJ46-1/L5(4-2-Ds) of 4 April 1935.

(b) BuEng.ltr. QP/Welding/L5 (3-13-Ds) of 18 March 1939.

(c) BuC&R ltr. JJ46-1(19)(TB) to Director, NRL, via BuEng., of 13 March 1939.

(d) NRL Report No. E-1544, "Research of the Weldability of Iron Alloys," of 21 June 1939.

OBJECT OF TEST

2. Ballistic tests conducted by the Bureau of Construction and Repair indicate that attachments made to STS plates by arc welding using 25% Cr - 20% Ni electrodes are far superior to those made using Grade EA electrodes. The difference in the behavior of the weld is attributed to differences in the metallurgical structures obtained in the fusion areas.

3. A study was requested of the heating and cooling cycle of 3/4 STS plate contiguous to bead welds from 25% Cr - 20% Ni electrodes and Grade EA electrodes to determine the average heating and cooling curves resulting from the use of these electrodes.

DESCRIPTION OF MATERIAL UNDER TEST

4. STS plates of a size and quantity sufficient for the tests were supplied by the Bureau of Construction and Repair. The chemical analysis of this plate material is given in Table 1.

5. Two 5-pound boxes of 25% Cr - 20% Ni electrodes 3/16" in diameter, heavy-coated, were also supplied by the Bureau of Construction and Repair. Chemical analysis of the core wire is given in Table 1. For the Grade EA electrode the Laboratory's supply of No. 78 Airco, 3/16" in diameter, was used in these tests.

METHODS OF TEST

6. The Laboratory's equipment for full automatic control of welding conditions was used in making all weld deposits.

7. Thermal conditions have been established showing the cycle of temperature through which the metal adjacent to the deposited metal passes. In the determination of this time-temperature relation platinum to platinum-10 per cent rhodium thermocouples made from No. 40 B&S gauge wire were mounted in a 2 mm thermocouple tubing and inserted into holes drilled in the bottom face of the test plate, the

thermocouples being located so as to be at various distances from the deposited metal. A movie camera was used for each thermocouple to record simultaneously the transient readings of a millivolt meter and a stop watch as the bead weld was made on the top face of the test plate. Readings of the temperature of the weld deposit were also made using an optical pyrometer. The plate was sectioned after deposition of the weld metal to determine the location of the thermocouples with respect to the weld deposit. The beads were also sectioned for macro-examination.

8. After preliminary thermal runs, it was found that the amount of deposited metal with identical welding techniques was not equal. Hence, a series of bead welds were deposited using 145, 175, 205, 235 and 265 amperes current with a 25 volt arc and speed of travel of 6 inches per minute, with both the Cr-Ni and Grade EA electrodes. After plotting these data it is possible to establish equivalent welding techniques for both the Grade EA and 25% Cr - 20% Ni electrodes (see Plate 4).

9. Final data for the time-temperature relation were obtained using equivalent welding techniques for the two electrodes. The 25% Cr - 20% Ni bead weld was made using reversed polarity, 175 amperes, 25 volts, and 6 inches per minute travel. The Grade EA electrode bead weld was made using reversed polarity, 155 amperes, 25 volts, and 6 inches per minute.

DATA RECORDED DURING TEST

10. The time-temperature relation for identical welding techniques (175 amperes, 25 volts, 6 inches per minute travel, reversed polarity) is shown in Plates 1 and 2. Plate 3 illustrates the difference in size of beads obtained using identical welding technique with the above electrodes.

11. The relation of the area of the plate melted (as measured on macro-cross sections of the bead weld) to the welding current for Grade EA and 25% Cr - 20% Ni is shown in Plate 4. From these data it is possible to set up "equivalent" welding techniques which will produce an equivalent melting effect on the plate material.

12. The time-temperature relations for "equivalent" welding techniques are shown in Plate 5 and Plate 6. The 25% Cr - 20% Ni bead weld was made using reversed polarity 175 amperes, 25 volts, and 6 inches per minute travel. The Grade EA electrode bead weld was made using reversed polarity, 155 amperes, 25 volts, and 6 inches per minute.

13. The maximum temperature attained at increasing distance from the weld deposit in the STS plates welded with "equivalent" welding techniques is shown by Plate 7.

CONCLUSIONS AND RECOMMENDATIONS

(a) Facts Established

14. For the identical welding techniques used, Grade EA electrodes have a higher efficiency of deposition than 25% Cr - 20% Ni electrodes. The greater amount of weld metal deposited will tend to decrease the rate of cooling in the plate adjacent to the weld deposit for the Grade EA bead weld.

15. The thermal conditions in the plate contiguous to Grade EA and 25% Cr - 20% Ni weld metal, are identical if "equivalent" welding techniques are used.

(b) Discussion of Data

16. It is to be noted that in Plate 1 and Plate 2 with identical welding techniques the cooling rate is somewhat slower for the larger bead or the Grade EA electrode. With the Grade EA bead weld, after 20 seconds the plate temperature measures very nearly 250°C., while with the 25% Cr - 20% Ni bead weld the plate temperature is approximately 50°C. lower.

17. In order to establish "equivalent" welding techniques, a series of bead welds were deposited using Grade EA and 25% Cr - 20% Ni electrodes. Plate 4 shows the results of these tests. In all cases for any given current the area of the plate melted is greater for the EA electrode than it is for the 25% Cr - 20% Ni electrode. A horizontal line will intersect the curves at points indicating equivalent welding techniques; for example, a current of 175 amperes using the 25% Cr - 20% Ni electrode is equivalent to a current of 155 amperes using the Grade EA electrode.

18. Using equivalent welding techniques, Plate 5 and Plate 6 show no noticeable difference in the thermal effects in the plate area contiguous to the deposited bead welds. The consistency of the thermal effect is further brought out by the coincidence of the data presented in Plate 7.

SUMMARY AND CONCLUSIONS

19. In the present tests a comparison of the heating and cooling curves in the plate contiguous to a bead weld show with identical welding techniques a slower cooling of the plate with the bead weld deposited with an EA electrode than with a 25% Cr - 20% Ni electrode. This was due to the fact that a larger bead was deposited by the EA electrode. The heating cycles were equivalent.

20. A comparison of the heating and cooling curves in the plate contiguous to a bead weld with equivalent welding techniques melting equal amounts of plate metal show no difference in the heating and cooling cycles in the plate contiguous to bead welds deposited with Grade EA or 25% Cr - 20% Ni electrodes.

21. The difference in ballistic behavior of Grade EA and 25% Cr - 20% Ni welds deposited on STS plate is definitely not based on differences in thermal conditions. It is strongly suspected that the solution of this problem lies in a consideration of the rates of diffusion of the alloying constituents in the welding process. Further work will be necessary in order to give more definite conclusions.

Table 1

Analysis of Plate Material (STS)

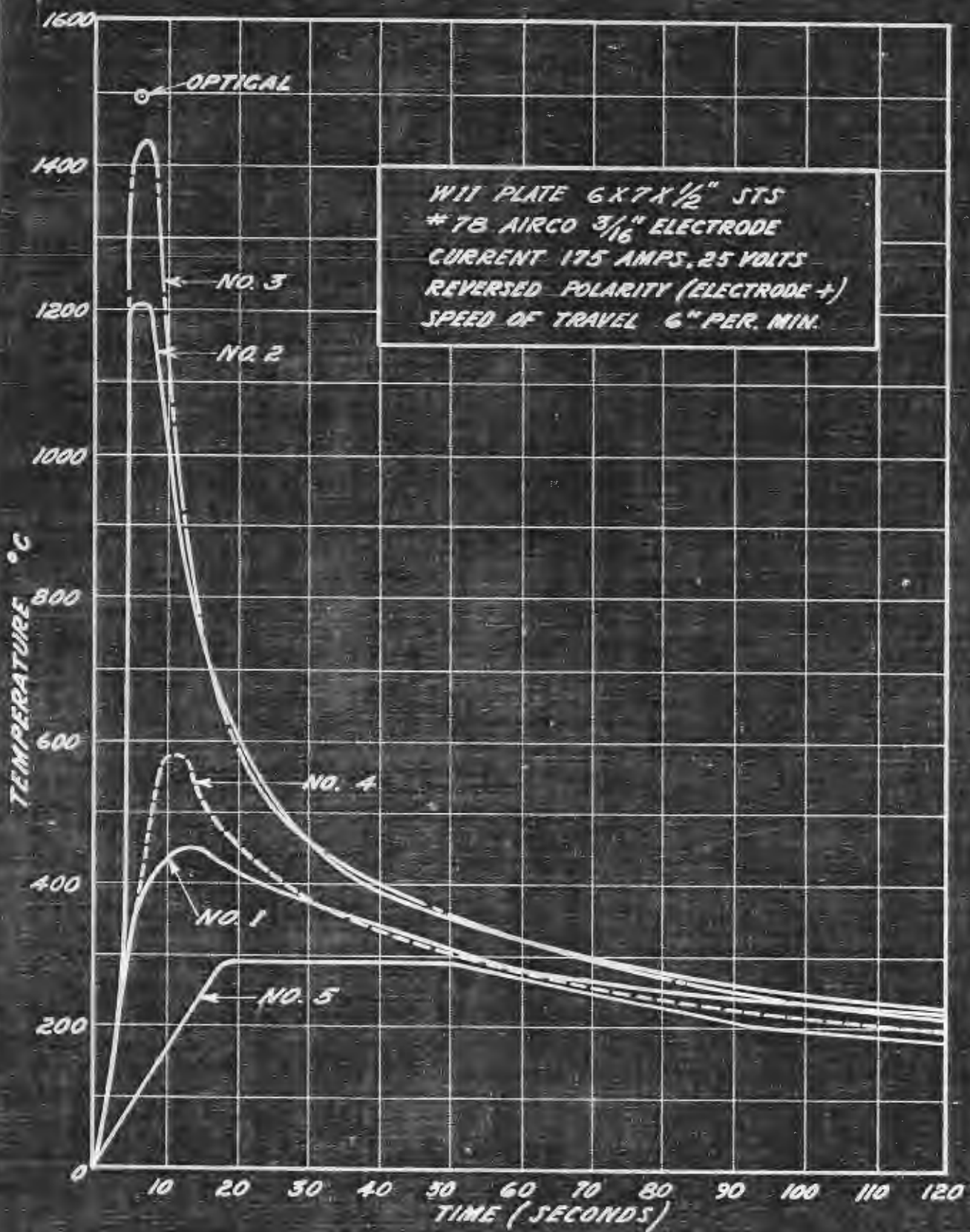
C	0.31 per cent
Mn	0.21 " "
Si	0.07 " "
Ni	3.22 " "
Cr	1.36 " "
P	0.010 " "
S	0.017 " "

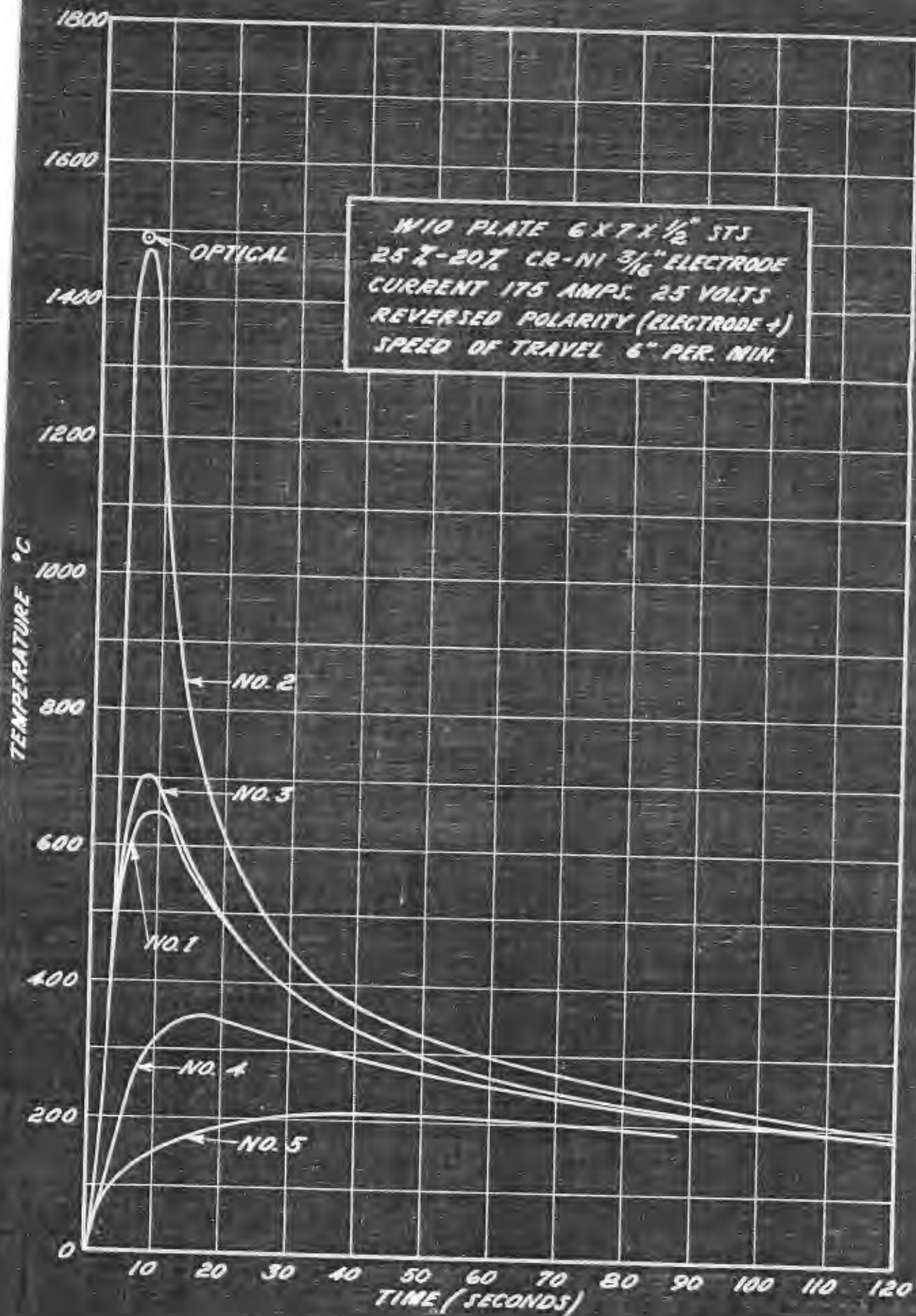
Analysis of 25% Cr - 20% Ni Electrode

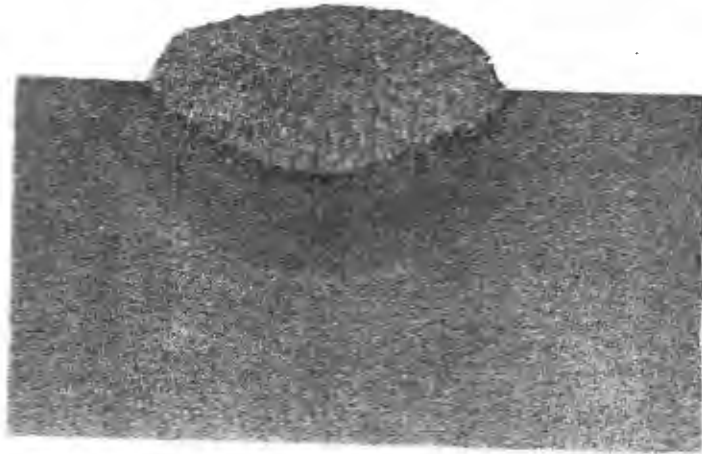
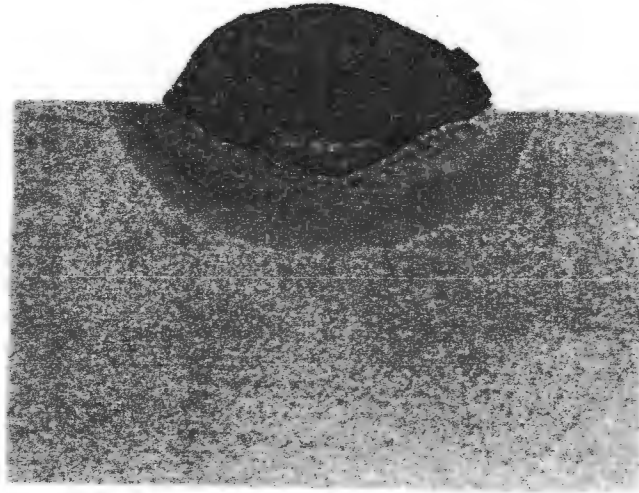
Cr	25.72 per cent
Ni	21.17 " "
C	.043 " "
Fe (by difference)	53.07 " "

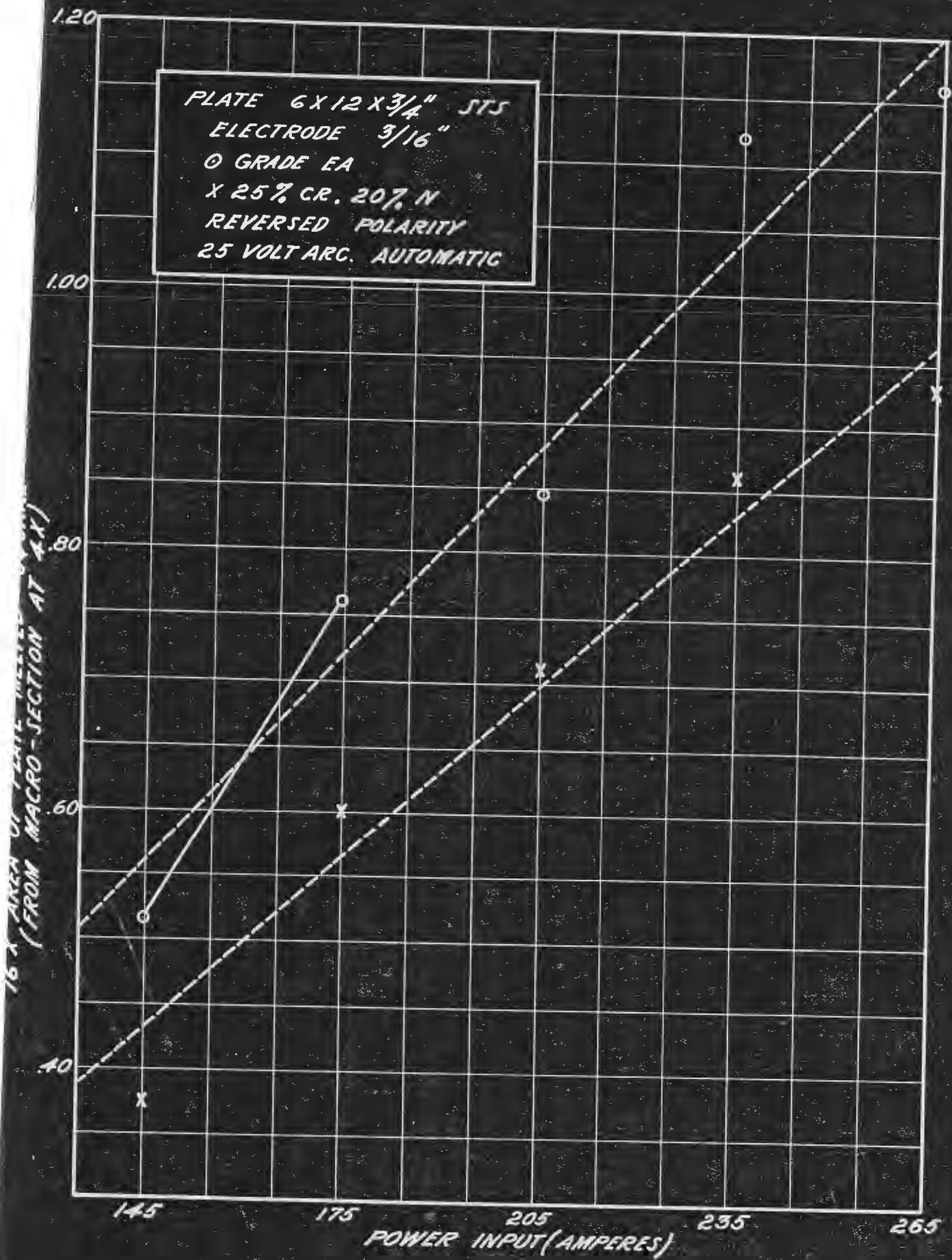
Analysis of Bead Weld Deposit (25% Cr - 20% Ni)

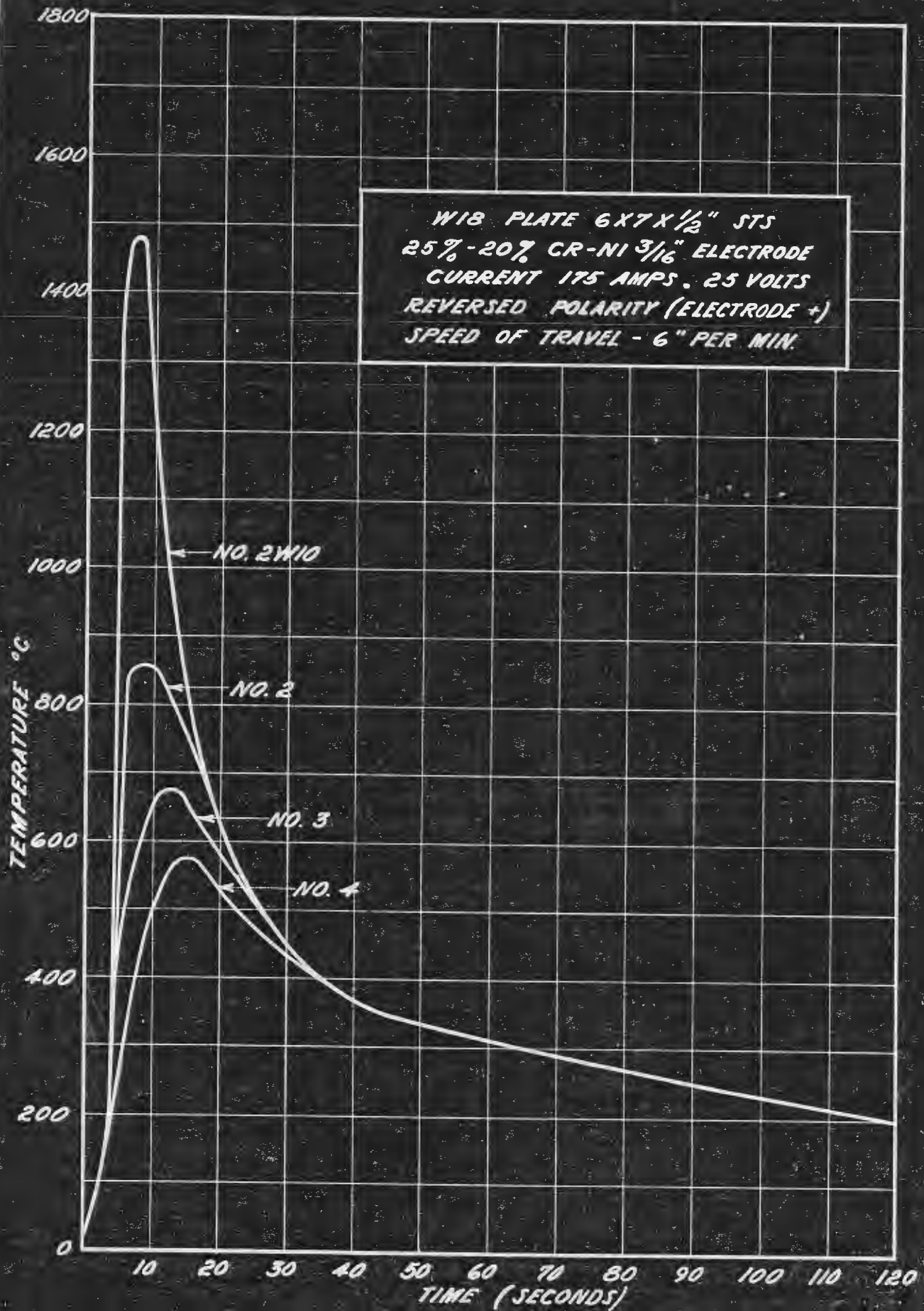
Cr	14.25 per cent
Ni	13.05 " "
C	.13 " "



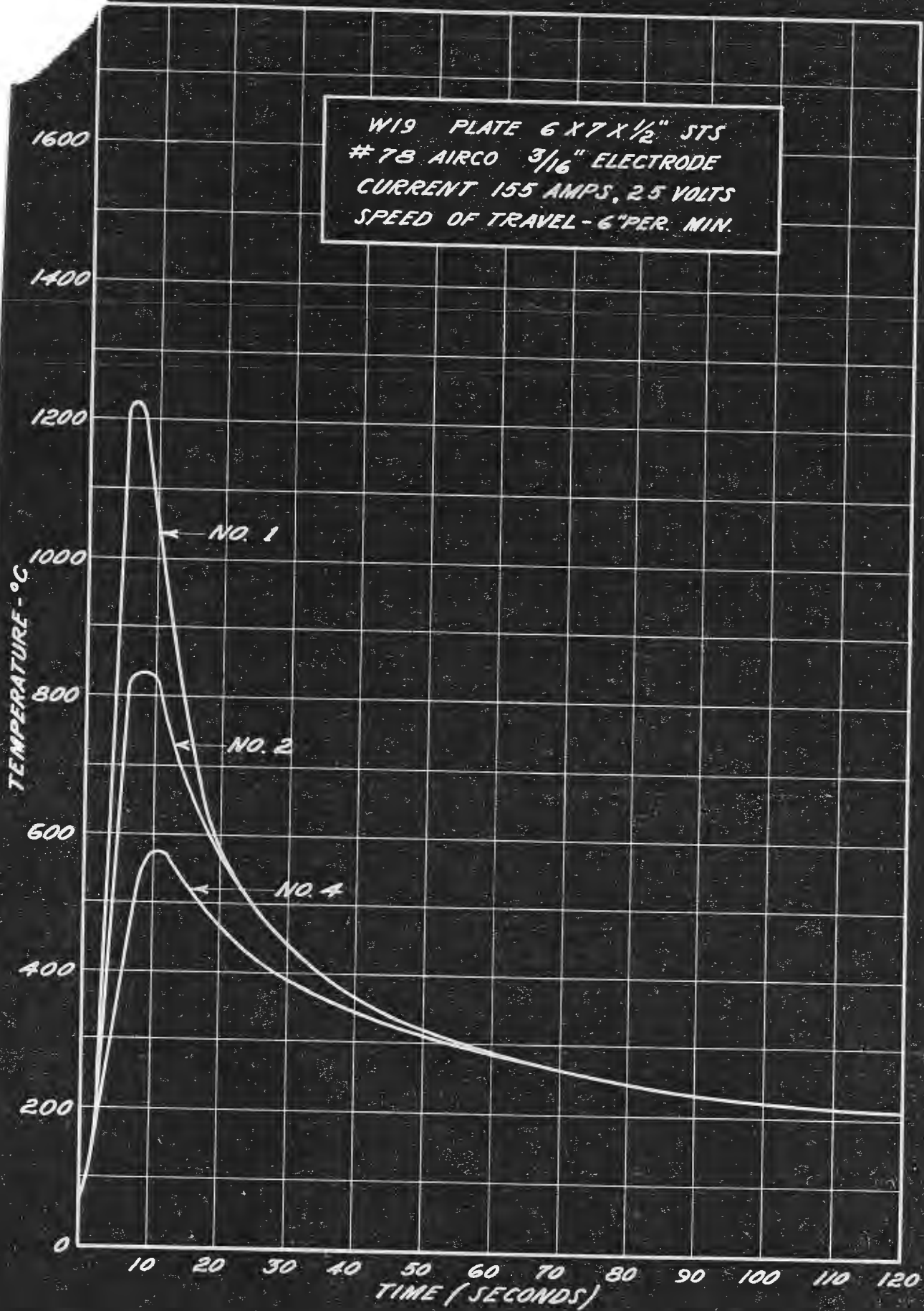


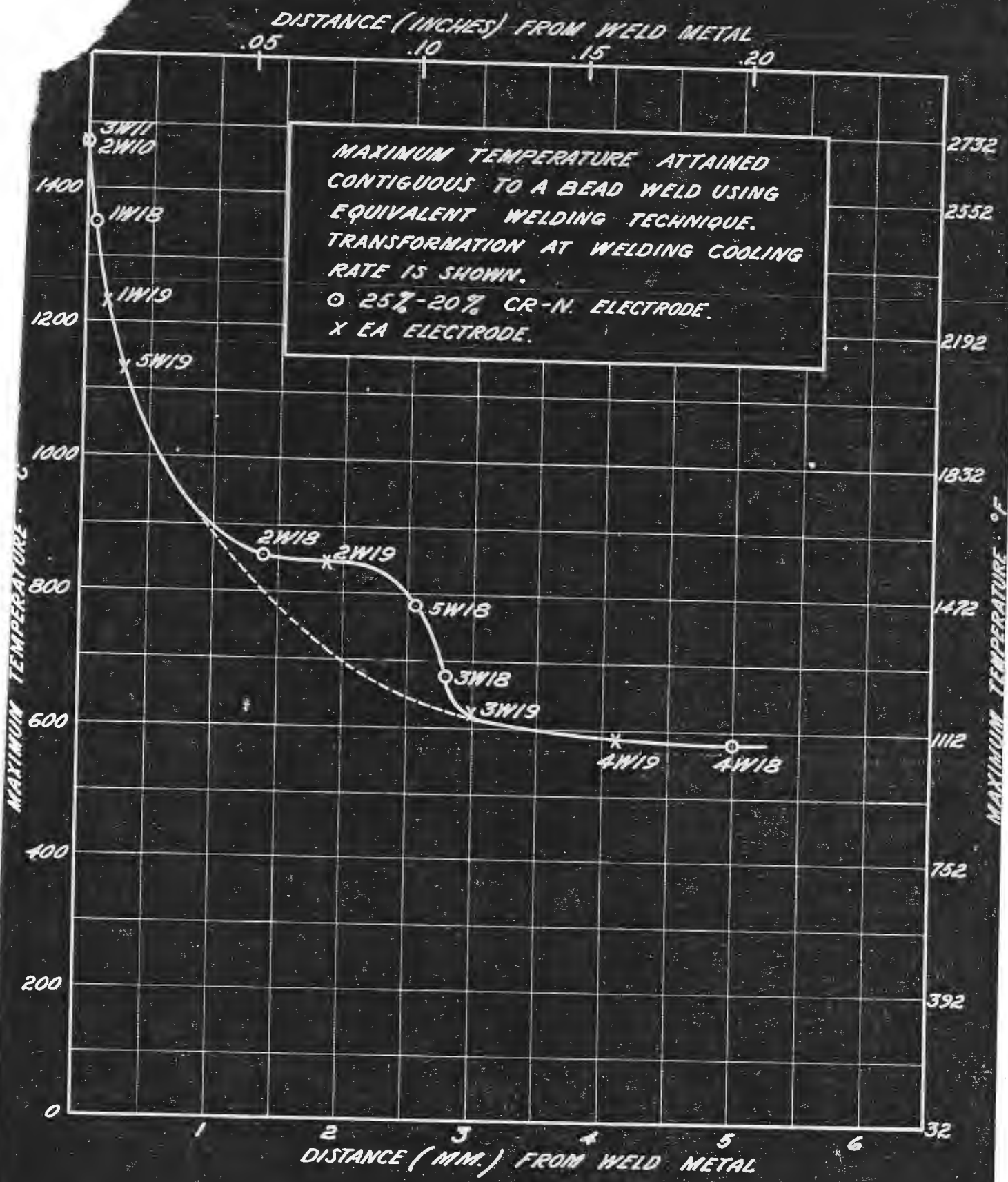






W19 PLATE 6 X 7 X 1/2" STS
78 AIRCO 3/16" ELECTRODE
CURRENT 155 AMPS, 25 VOLTS
SPEED OF TRAVEL - 6" PER. MIN.





16 X AREA OF PLATE MELTED - SQUARE INCHES
(FROM MACRO-SECTION AT A.A.)

PLATE 6 X 12 X 3/4" STS
ELECTRODE 3/16"
O GRADE EA
X 25% CR, 20% N
REVERSED POLARITY
25 VOLT ARC. AUTOMATIC

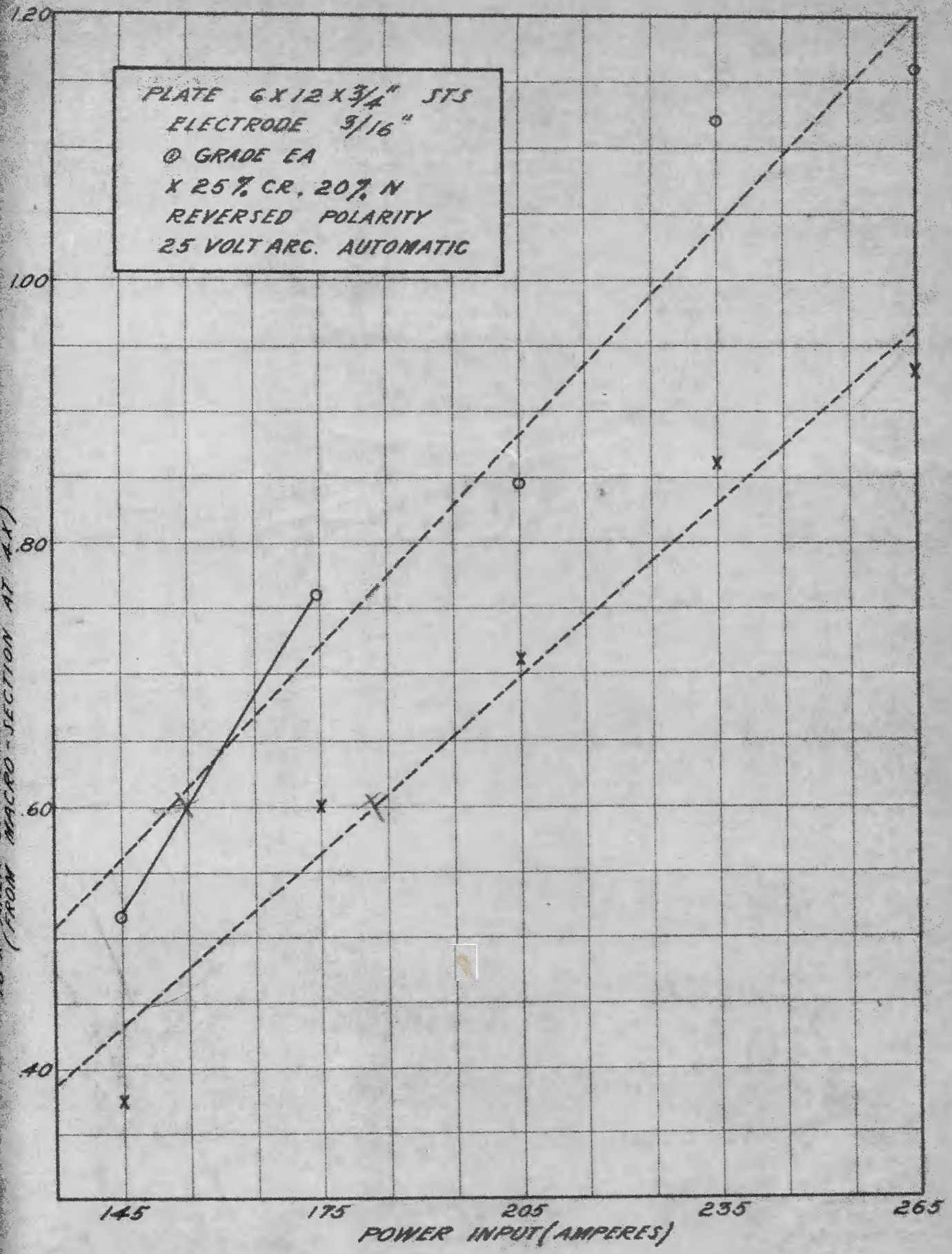


PLATE 4
1576