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LEHIGH UNIVERSITY INSTITUTE OF RESEARCH

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Jacques Brozzetti

Goran A. Alpsten

Lambert Tall

Fritz Engineering Laboratory
Department of Civil Engineering
Lehigh University
Bethlehem, Pennsylvania

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TABLE OF CONTENTS

ABSTRACT

A large number of medium-size to heavy test specimens were ordered for residual stress measurements in two research projects, "Welded Flame-Cut Columns", and "Residual Stresses in Thick Welded Plates". The plans for experimental studies in the two projects were coordinated so that a maximum of information could be obtained from a minimum number of specimens.

The manufacturing and fabrication conditions can be a major influence upon the magnitude and distribution of residual stresses in a welded plate or shape. Therefore, it is essential that the actual conditions during manufacture and fabrication of these test specimens are known and recorded.

The report summarizes all information collected during the manufacture and fabrication of the above-mentioned test specimens, starting from rolling of the component plates and up to the final welding. The information includes the geometry of the material before and after rolling, description of the rolling and cooling process, and procedures and data for the flame-cutting

and welding processes. Temperature measurements were made during cooling after rolling, flame-cutting and welding and heat input, that is, voltage and amperage in welding and speed of welding, was recorded for all weld passes.

The information contained in this report is intended as reference data which will be useful in the interpretation and study of the results obtained in the residual stress measurements and any other experiments to be carried out on this test material. The data should be of considerable interest also in a more general sense as examples of current manufacture and fabrication procedures employed in practice for medium-size to heavy welded shapes. Information is included for as-manufactured plates, (that is, universal-mill or flame-cut) welded plates with simulated weld beads, and finally, welded shapes, that is, several H-shapes and one box shape.

1. INTRODUCTION

This report is a description of the manufacture and fabrication procedures of several steel plates and shapes ordered by Fritz Engineering Laboratory, Lehigh University, from a major fabricator. The material will provide test specimens for an experimental study in Fritz Laboratory Projects 321 "Welded Columns and Flame-Cut Plates" and 337 "Residual Stresses in Thick Welded Plates". This material was needed for residual stress measurements and tensile specimen tests.

The plates ordered include universal-mill plates (UM) and flame-cut plates (FC). Some of the plates were welded together to form five structural shapes, listed in Table 1. For other plates center- and edge-welds were applied to simulate the conditions in the flange or web of the welded shape. Some plates were not welded at all to determine the effect of rolling and flame-cutting.

Figure 1 shows how the plates ordered were to be divided into plate components for the structural shapes (designated as either H or □), to be edge-welded (designated EW) to simulate the web of an H-shape or the plates of a box-shape, to be center welded (designated CW) to simulate the flanges of an H-shape, or to be left unwelded or as fabricated (designated AF).

It has been observed that the manufacture and fabrication procedures may be of a great influence on the magnitude and distribution of residual stresses in welded members.(1) In this connection, the complete manufacture and fabrication process of the test specimens studied, and relevant data was collected with the intention of correlating it to the experimental results.

It should be emphasized that the report is an account of the manufacture and fabrication of this particular order of material. However, in ordering the material it was specified that the test specimens should be made according to the normal procedures as used in current manufacturing and fabrication practice. The fabricator was given complete freedom in determining the fabrication details. Thus, it can be assumed that the data presented here would be typical of standard manufacturing and fabrication procedures.

The manufacture and fabrication procedure consisted of four stages. The first and second stages were rolling and partial flame-cutting. This part of the fabrication is covered in Section 2 of the report. The third and fourth stages are longitudinal and transverse flame-cutting and final welding. This is described in Section 3 of the report.

2. ROLLING PROCEDURE AND PARTIAL FLAME-CUTTING

2.1 Size of Plates Before and After Rolling

Tables 2a and b show the dimensions of the rolled plates as well as the heat number, the fabricator serial number, size of the ingot, and the final dimensions of the plate after partial flame-cutting to correspond with the sizes ordered.

Table 2a covers the plates rolled in the first rolling on May 1, 1968. This rolling was intended to furnish material for the entire order. However, it was necessary to reorder certain plates. These plates are designated in Table 2b. Thus, plate No. 12 (Fabricator No. 25478 W) had to be reordered. This plate was replaced by plate No. 16 (Fabricator No. 26856 W). Similarly, plates Nos. 3, 5, 6, 7, and 14 were reordered because they were rolled 2" wider. These plates have been substituted by plate Nos. 22, 19, 20, 21, and 23 respectively listed in Table 2b. The new series of plates, universal mill plates, were manufactured 2" smaller, all with as-rolled edges.

These changes resulted in plates taken from different heats with different chemical composition.

Table 3 summarizes the chemical composition and the mechanical properties of the different heats as given in the mill test report.

Plates Nos. 1 and 15, which correspond to the 24H1122 structural shape, were reordered from one heat to enable the correlation of UM and FC plates of the same heat in one structural shape. It was the original intention of the experimental program to have all the plates coming from the same heat, this was not possible.

2.2 Rolling Process

Figure 2 is a schematic diagram of the rolling process from the heating of the ingots to the cooling bed. The rolling process consists of two phases: the initial rolling and the final rolling.

The rolling process starts with the ingots being heated to a temperature of 2400°F in a furnace. The ingots were then passed through a first rolling stand, where they were reduced to approximately the required dimension. Figure 3 shows this phase of the rolling. Table 4 gives some data for the initial rolling.

The plates were then passed through a final rolling stand, to bring the plate dimensions very close to the required dimensions. Table 5 gives data for the final rolling. Since the initial and final rollings followed each other closely, it was not possible to get complete data on all the plates.

After the final rolling, the plates, in cherry red condition, were conveyed to the cooling bed. Figures 4 and 5 are a picture and a diagram of the position of the plates on the cooling bed. It can be easily seen that no particular arrangement had been attempted in placing the plates.

While it would have been ideal to take temperature measurements from the start of the rolling process, safety reasons made this impossible. Figure 6 is a graph of temperature vs. time after rolling. The first temperature measurements were taken quite a long time after start of rolling.

Temperature was measured using Tempelstik temperature crayons ranging from 100°F to 1450°F. Crayons were provided for this range at 50°F increments. It was not possible to measure the variation of temperature across the plate as, apparently, this variation at the time the temperature measurements were made was less than the 50°F increment.

Plates No. 1 and No. 4 (24x6 and 24x2, respectively) were measured for temperature quite comprehensively and the results are given in Fig. 6. Also included in Fig. 6 are the results for the fewer measurements on the other plates. It was specified that no straightening in any form should be used on the plates.

The final step performed at the plant was partial flame-cutting of the plates to correspond to the requested lengths.

The plates were then shipped to a fabricating shop for flame-cutting and welding. Section 3 of the report is concerned with this phase of the fabrication.

3. FLAME-CUTTING AND WELDING

3.1 Flame-Cutting

The plates to be flame-cut were rolled to sizes 2" wider than the requested width. One inch strips were flame-cut over the length of the plates. The flame-cutting of Plate No. 4 was observed and temperature measurements as well as other data were recorded.

The set-up for longitudinal flame-cutting was a standard burning machine with two torches to burn both edges simultaneously. Air burning tips (#3, style 263) were used with propane fuel at 316 psi and oxygen at 55 psi. The travel speed was set on the machine at approximately 10 ipm. For transverse cutting, the same data applies, except that only one torch was used. Figure 7 is a picture of the flame-cutting equipment. Figure 8 shows the relative position of the nozzle of the flame cutting machine and the points of measurement for plate No. 4. The temperature measurements were made by drawing lines on the plate surface using Tempelstik temperature crayons. This method is illustrated in Fig. 9. After the cutting torch had passed the gage section, the extent of melting of the lines were measured.

The data obtained is presented in Fig. 10 in the form of a temperature vs. distance from cutting torch-time curve. Transverse flame-cutting was also performed to divide the plates into the sections described in Fig. 1. The results of the measurements for some plates are given in Figs. 11 and 12. Measurements were made for the width of the flame-cut kerf for some plates. The values obtained were 0.29" for the 12x3½ plate, 0.14" for the 24x2 plate, and 0.25" for the 24x6 plate. The width of the flame-cut kerf gives an indication of the actual heat input used in the flame-cutting process.

Close inspection of the burned surfaces after transverse flame-cutting of the 24x6 plate H1122(FC), revealed small cracks at three sections along the plate. Generally, the cracks extended in planes parallel to the large surfaces of the plate.

3.2 Welding

The determination of the weld sizes to be used for the structural shapes was left to the discretion of the fabricator with the understanding that standard weld sizes be used. Data sheets No. 1 to No. 18 show the weld sizes and welding details used for the welded plates. The weld sizes of the center- and edge-welded plates were chosen to be the same as for the corresponding structural shape they simulate.

For those plates to be center-welded and edge-welded, grooves were prepared to contain the welds. The dimensions of the grooves are given on data sheets, No. 1 to No. 18. The H-shapes were welded with fillet welds without edge preparation. Grooves were prepared for the plates in the box-shape as shown on Data Sheet No. 18. No straightening, to obtain better fit, was allowed on the plates. Fit, tack, and seal welds were employed using arc welding with E7018 electrodes of 5/32" diameter. Figure 13 shows a seal weld being placed on the box shape.

The plates and the shapes were preheated with propane gas according to the AWS specifications.[2] The specification prescribes a minimum 150°F preheat for plates of thickness over 1½ inch to 2½ inclusive, and 225°F for plates over 2½" thick. An example of the preheating arrangement is given in Fig. 14 for the 24H1122 shape. The preheating was accomplished in two ways. One way was to use special fixed assemblies of about 5 nozzles from which propane gas flames heat the plates. The second method was to use a manually operated torch. It was observed that a more uniform temperature is obtained by the second method due to the mobility of the manual torch. In the first method, the area near the weld usually was hotter than the rest of the plate because the heat from the stationary nozzles was concentrated there. Figures 15 and 16 are pictures of the preheating using the two methods.

Figures 17 and 18 illustrate the welding process. The current, voltage, velocity of welding, and time of the welding have been recorded and can be found in Data Sheets No. 1 to No. 18. The current and voltage were kept as constant as possible and the velocity of welding was adjusted to obtain the proper size of the weld.

The velocity of feed of electrode depends on the current, voltage and velocity of welding. The feed of electrode has been calculated approximately after observing the rate of revolution of the feeding drum and the data below were determined for voltage of about 33 volts and current of about 410 amperes.

Velocity of welding in./min.	Velocity of feed of electrode in./min.
14	187 to 190
30	101 to 104

The center- and edge-welded plates have been welded using the same procedure as the shapes they simulate.

Temperature measurements have been made on the welded plates and the data are presented in Figs. 19 through 26. The method used for the measurements was similar to that used in temperature measurements during flame-cutting.

Much detail which has been omitted in the text can be found in the figures and data sheets.

4. SUMMARY

This report is a compilation of data taken during the fabrication and manufacture of thick plates and heavy shapes for the research projects "Welded Flame-Cut Columns", and "Residual Stresses in Thick Welded Plates".

First the rolling process has been followed, and some temperature measurements were recorded, in order to have information on the cooling temperature of plates of different sizes. The knowledge of this cooling temperature will give relevant information on the first stage of formation of residual stress.

Then the flame-cutting process was carried out and any information concerning this second heat input has been registered. Some temperature measurements were also conducted, and experimental results will be correlated with predictions given by the theory. From this second heat input, the influence and modification on the pattern and magnitude of residual stress will be deduced.

Finally the welding process was attended, and a particular care has been given to collecting information on this third heat input. A complete record on current, voltage, velocity of welding, number of passes used, was made. Special attention has been focused on details of fabrication during the welding process, where the highest amount of residual stresses are to be expected. In order to facilitate further correlation, neither welded plates and welded shapes have been straightened during the fabrication phases. This research requirement has been strictly observed in order to eliminate one variable factor. Also throughout the welding process, welding equipment, electrodes types, flux used, were kept identical for all plates and shapes. Whenever possible, it has been tried to keep constant the heat input and for this reason, the speed of welding, voltage, current, used in welding were kept as close as possible to certain limits. Any small changes inherent to fabrication procedure were recorded.

5. ACKNOWLEDGEMENTS

This report presents the results of studies made during the manufacture and fabrication of test specimens for an experimental investigation in two research projects, "Welded Flame-Cut Columns" and "Residual Stresses in Thick Welded Plates". This research is conducted at Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pennsylvania and is sponsored by the American Iron and Steel Institute, the Column Research Council, and the National Science Foundation.

All test specimens were manufactured and fabricated by the Bethlehem Steel Corporation. Sincere appreciation is expressed to this Corporation and to its personnel for advise and assistance in all phases of the design and fabrication of the specimens. The photographs taken at the plants were provided by the Bethlehem Steel Corporation.

The assistance of Angel L. Lazaro III and Negussie Tebedge in collecting test data is sincerely appreciated.

Thanks are also due Miss Joanne Mies for typing the report and John M. Gera for preparing the drawings.

TABLE I

DESCRIPTION OF WELDED SHAPES

Designation	Flange Size	Web Size	Length
12 H 210	12 x 2	9 x 1½	4'-5"
20 H 354	20 x 2	16 x 1½	6'-0"
24 H 428	24 x 2	20 x 1½	7'-0"
24 H 1122	24 x 2	20 x 2	8'-3"
24 ▯ 774	24 x 6	12 x 3½	7'-3"

TABLE 1 (continued)

DESCRIPTION OF PLAIN AND WELDED PLATES

Designation	Type	Reference Fabricator	Sizes in.	Length ft.
PL 9"x1½"	AM	H210(FC)W-1	9x1½	4'3½"
	CW	H210(FC)W-2	9x1½	4'2"
	EW	H210(FC)W-3	9x1½	4'2"
PL 12x2	AM	H210(FC)F-2	12x2	4'6½"
	CW	H210(FC)F-3	12x2	4'1"
	EW	H210(FC)F-4	12x2	4'1"
PL 12x2	AM	H210(FC)F-1	12x2	5'
PL 12x3½	AM	H1122(FC)W-1	12x3½	4'
	CW	H1122(FC)W-2	12x3½	4'
	EW	H1122(FC)W-3	12x3½	4'
PL 12x3½	AM	H1122(FC)W-4	12x3½	4'
PL 16x1½	AM	H354(FC)W-1	16x1½	6'7"
PL 20x1½	AM	H428(FC)W-1	20x1½	7'6"
PL 20x2	AM	H354(FC)F-1	20x2	6'7"
	CW	H354(FC)F-2	20x2	6'
	EW	H354(FC)F-3	20x2	6'
PL 24x2	AM	H428(FC)F-1	24x2	29'6½"
	CW	H428(FC)F-2	24x2	7'
	EW	H428(FC)F-3	24x2	7'
PL 24x2	AM	H428(UM)F-4	24x2	7'
	CW	H428(UM)F-5	24x2	7'

TABLE 1 (continued)

Designation	Type	Reference Fabricator	Size in.	Length
PL 24x3½	AM	H1122(UM)F-4	24x3½	7'
PL 24x6	AM	H1122(FC)F-1	24x6	7'
	CW	H1122(FC)F-2	24x6	7'
	EW	H1122(FC)F-3	24x6	7'
PL 24x6	AM	H1122(FC)F-5	24x6	7'

TABLE 2a

DIMENSIONS OF ROLLED PLATES

FRITZ LAB PLATE NO.	FABRICATOR PLATE NO.	SIZE OF INGOT (in.)	SIZE OF PLATES AFTER ROLLING AND PARTIAL FLAME-CUTTING Thickness (in.)	Width (in.)	Length (in.)	BREAKDOWN OF PLATE AS DELIVERED TO FRITZ LABORATORY	FINAL LENGTH	FINAL WIDTH	REMARKS
a) Heat No. 411 W 9731: May 1, 1968									
1	25472 W	31x50x74	6	26	36'-6"				REORDER
2	25473 W	26x42x75	2	26	36'-6"	2-FLG.-24H28	7'-0"	24"	
						PL-CW	7'-0"	24"	
						2-SIDE 24 □ 774	7'-3"	24"	
3					14'-6"				REORDER
4	25474 W	26x42x75	2	26	36'-6"	PL-EW	7'-0"	24"	
						PL-AF	29"-6"	24"	
5	25475 W	23x41x62	6	26	7'-3"				REORDER
6	25476 W	23x41x62	$3\frac{1}{2}$	26	7'-3"				REORDER
7					4'-3"				REORDER
8	25477 W	23x41x63	2	22	25'-0"	2-FLG.-20H354	7'-0"	20	
						PL-CW	6'-0"	20	
						PL-AF	6'-0"	20	
					21'-0"	Top 24 □ 774	7'-3"	20	
						Bottom 24 □ 774	7'-3"	20	
						PL-AF	6'-6"	20	
10	25478 W	23x41x63	$1\frac{1}{2}$	22	14'-6"	WEB 24H428	7'-0"	20	
						PL-AF	7'-6"	20	
					12'-6"	WEB 20H354	6'-0"	16	
						PL-AF	6'-6"	16	
					17'-0"				REORDER
13	25479 W	25x30x64	2	14	21'-6"	2-FLG.-12H210	4'-5"	12	
						PL-AF	3'-6"	12	
						PL-CW	4'-1"	12	
						PL-EW	4'-1"	12	
14					4'-3"				REORDER
15	25480 W	25x30x64	$3\frac{1}{2}$	14	20'-0"	WEB 24 H 1122			REORDER

TABLE 2b

FRITZ LAB PLATE NO.	FABRICATOR PLATE NO.	SIZE OF INGOT (IN)	SIZE OF PLATES AFTER ROLLING AND PARTIAL FLAME-CUTTING Thickness (in.)	Width (in.)	Length (in.)	BREAKDOWN OF PLATE AS DELIVERED TO FRITZ LABORATORY	FINAL LENGTH	FINAL WIDTH	REMARKS
b) Heat No. 479W0041									
16	26856 W	31x50x74	$1\frac{1}{2}$"	12	17'-$\frac{7}{8}$"	WEB 12H210	4'-5"	9	REPLACE PLATE NO. 12
						PL-AF	4'-2"	9	
						PL-EW	4'-2"	9	
						PL-CW	4'-2"	9	
c) Heat No. 477 W-3301									
17	26221 W		$3\frac{1}{2}$"	14"	24'-$\frac{3}{16}$"	WEB 24H1122	8'3"	12"	
						PL-AF	5'$5\frac{1}{2}$"	12"	
						PL-CW	5'3"	12"	
						PL-EW	5'3"	12"	
18	26222 W		6"	26"	41'-$\frac{7}{8}$"	2FLG. 24H1122	8'3"	24"	
						PL-CW	8'3"	24"	
						PL-EW	8'3"	24"	
						PL-AF	8'3"	24"	
19	26223 W		6"	24"	8'-4"	PL-AF	8'3"	24"	
20	26224 W		$3\frac{1}{2}$"	24"	8'-$\frac{15}{16}$"	PL-AF	8'0"	24"	
21	26225 W		$3\frac{1}{2}$"	12"	5'	PL-AF	5'1"	12"	
22	26226 W		2"	24"	16'-$\frac{15}{16}$"	PL-AF	8'1"	24"	
						PL-CW	8'0"	24"	
23	26227 W		2"	12"	5'-$\frac{7}{8}$"	PL-AF	5'0"	12"	

NOTE: Heat No. 477 W 3301 is the heat of plates reordered.

TABLE 3

CHEMICAL AND MECHANICAL PROPERTIES OF THE DIFFERENT HEATS

HEAT NUMBER	YIELD POINT (ksi)	TENSILE STRENGTH (ksi)	ELONG 2° %	C %	Mn %	P %	S %	Si %
411 W 9731	37.-44.4	65.5-71		.18	1.00	.012	.020	.25
479 W 0041	42	71		.20	1.00	.008	.019	
477 W 3301	40.-40.5-39	71.5	28.0	.19	1.06	.008	.023	.23

TABLE 4

INITIAL ROLLING

PLATE NUMBER	START OF ROLLING	END OF ROLLING	NUMBER OF PASSES
25472 W	9:14 a.m.	9:17 a.m.	21
25473 W	9:18	9:20	19
25474 W	9:20	9:22	19
25475 W	9:23	9:24	9
25476 W	9:25	9:26	9
25477 W	9:27	9:30	9
25478 W	9:30	9:32	10
25479 W			
25480			

TABLE 5

FINAL ROLLING

PLATE NUMBER	START OF ROLLING	END OF ROLLING	NUMBER OF PASSES
25472 W			
25473 W			
25474 W			
25475 W			
25476 W			
25477 W	9:30	9:32	8
25478 W	9:33	9:34	4
25479 W	9:35	9:36	6
25480 W	9:37	9:38	6

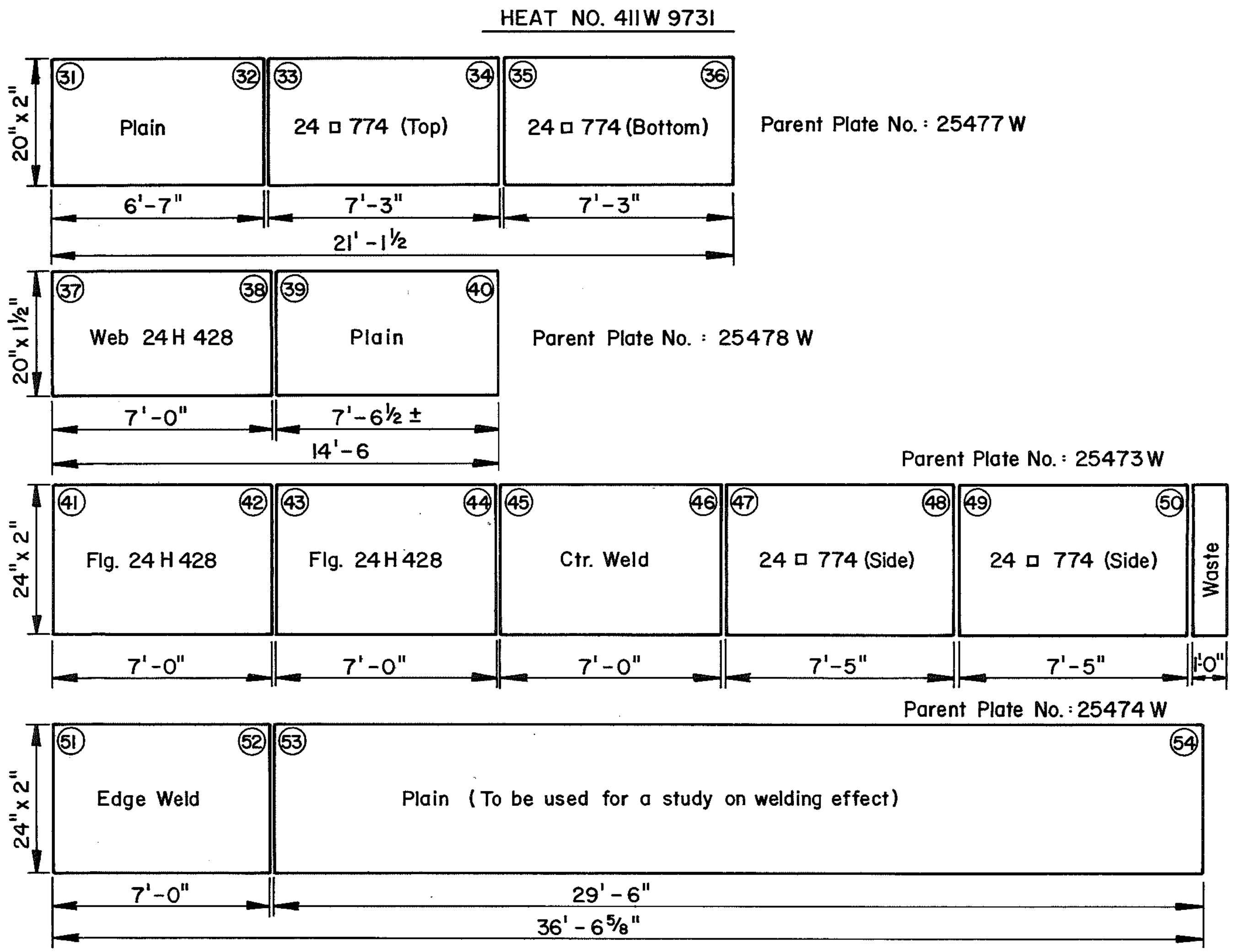


Fig. 1 Cutting Sketches for F.C. Plates.

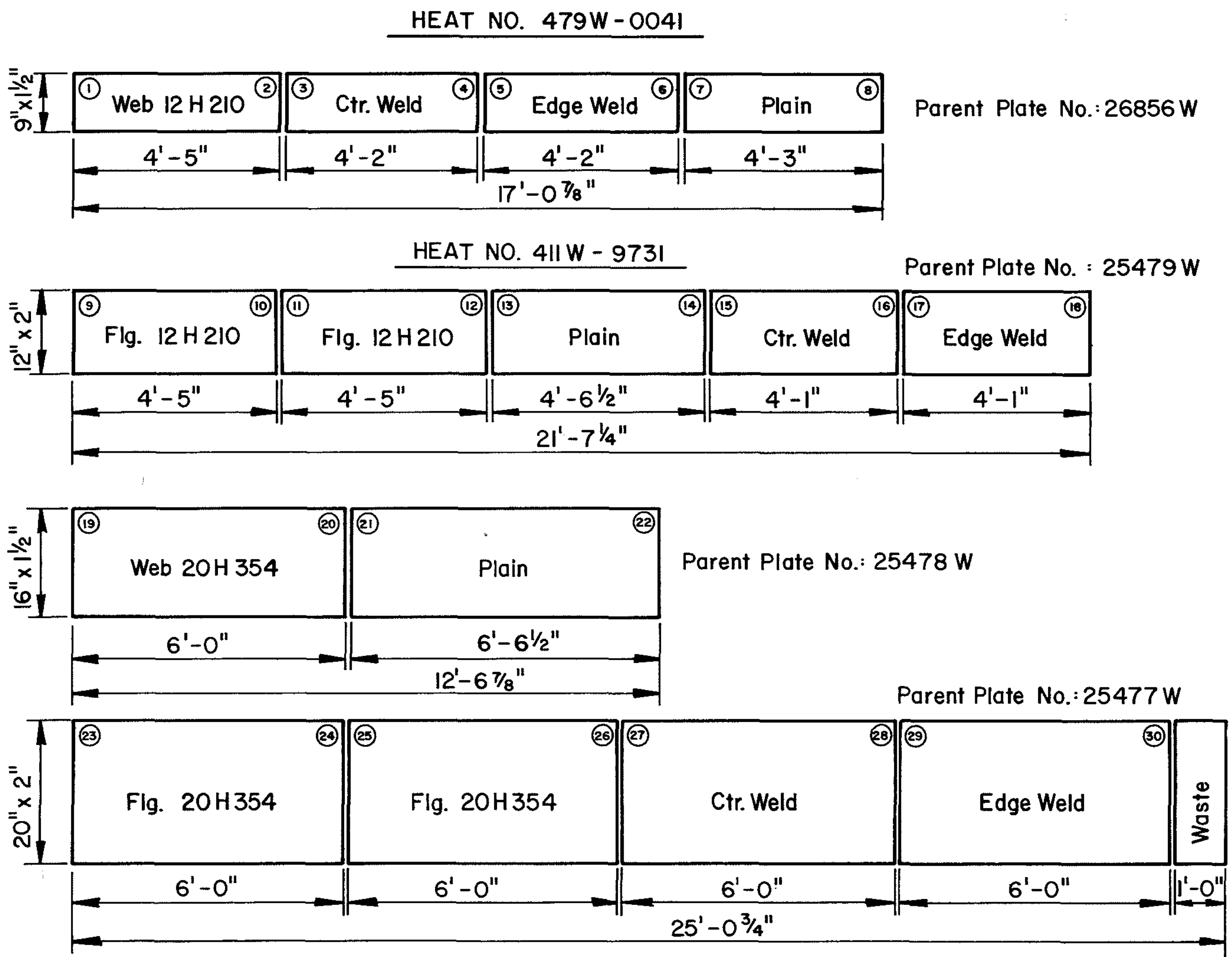


Fig. 1 Cutting Sketches for F.C. Plates (Continued).

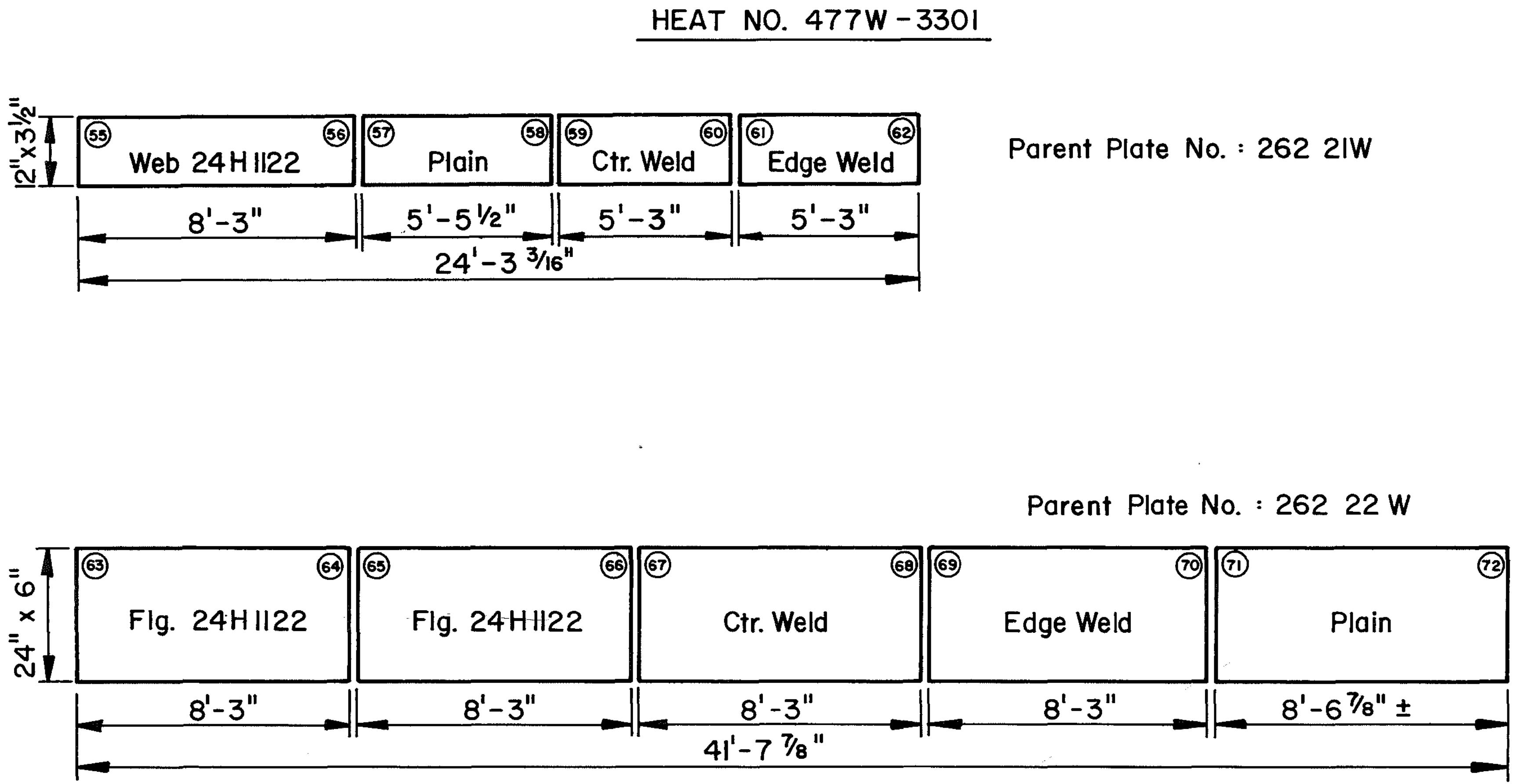


Fig. 1 Cutting Sketches for F.C. Plates (Continued).

HEAT NO. 477 W 3301

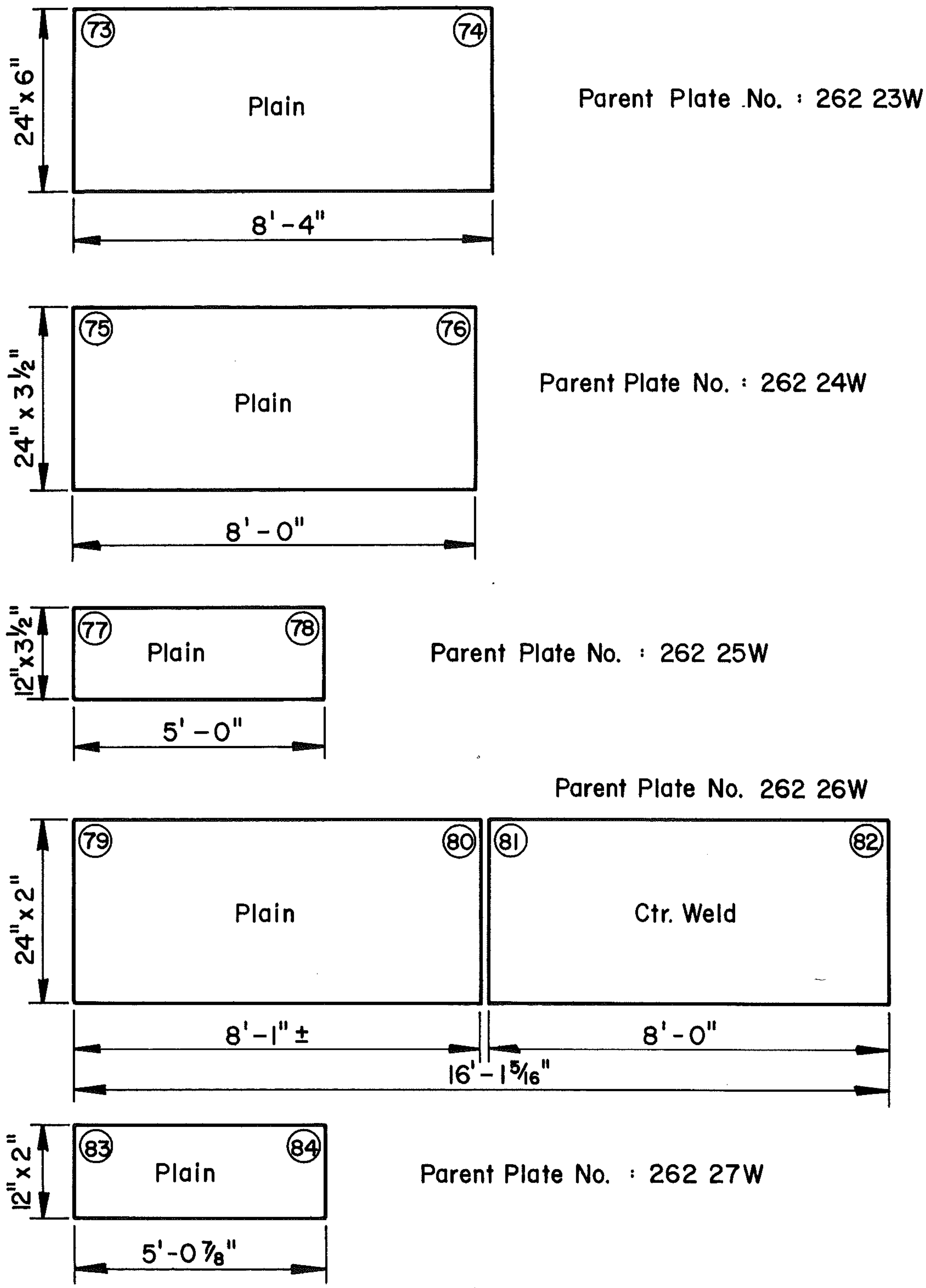


Fig. 1 Cutting Sketches for U.M. Plates (Continued).

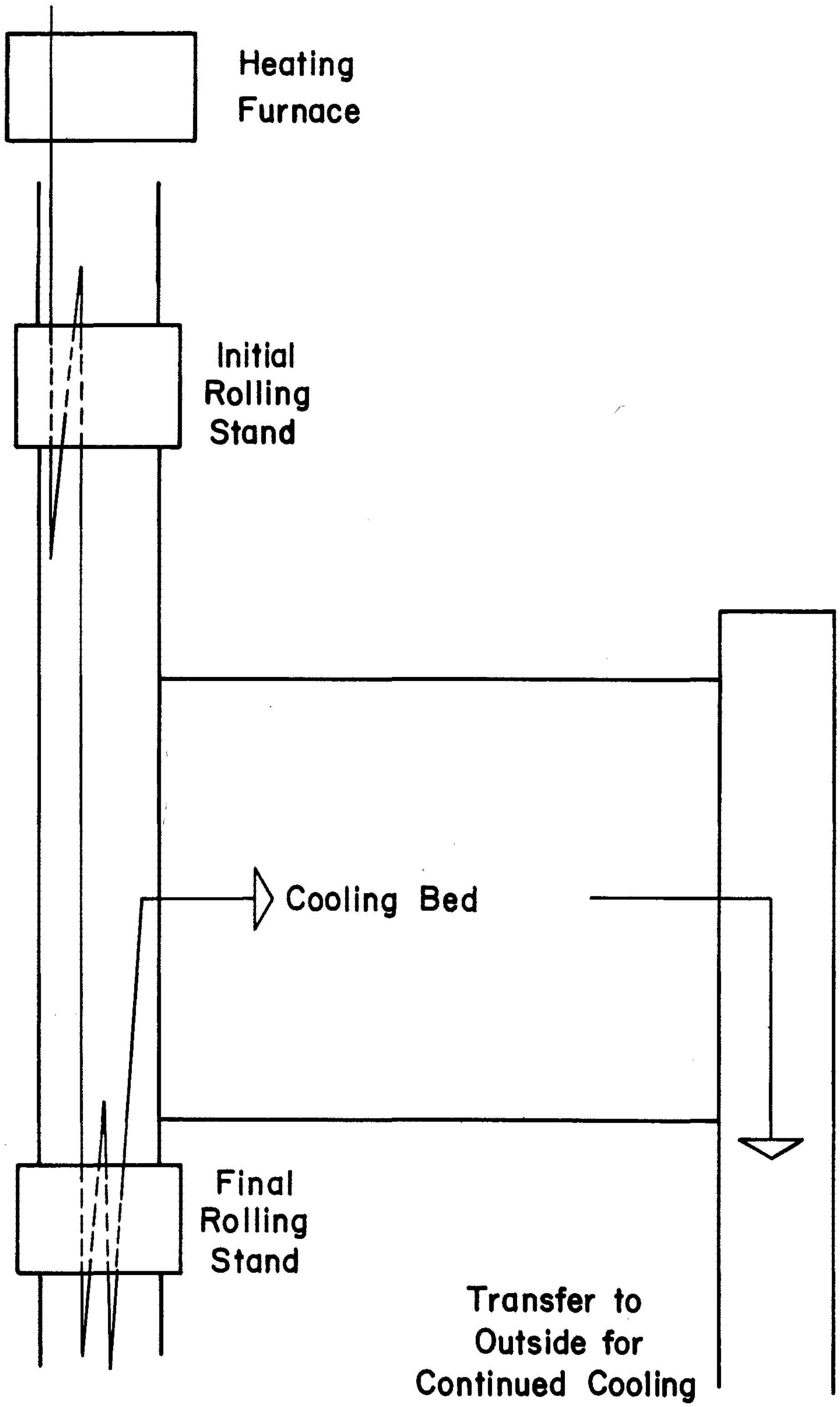


Fig. 2 Schematic Path for Rolling of Plates.

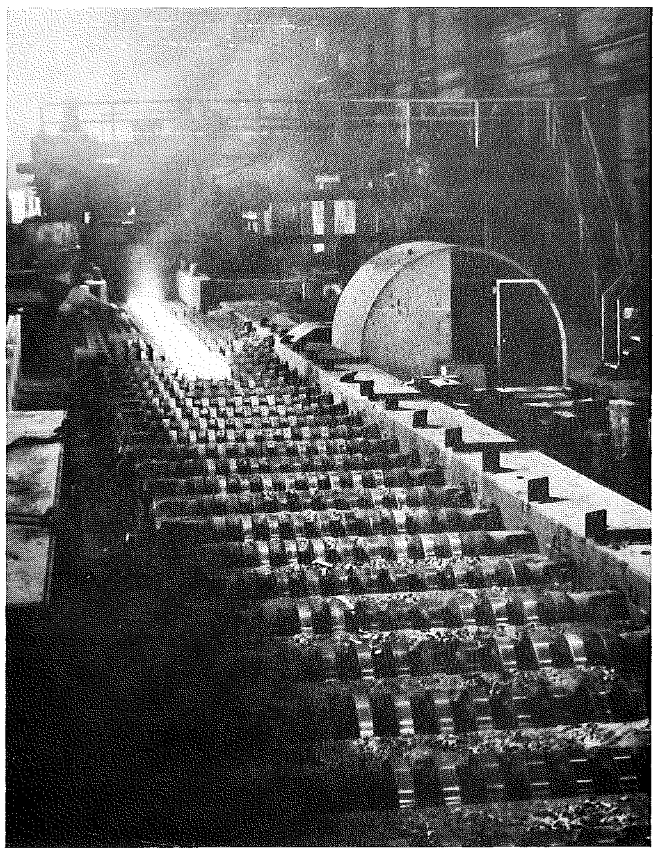


Fig. 3 Rolling Process of Plates.

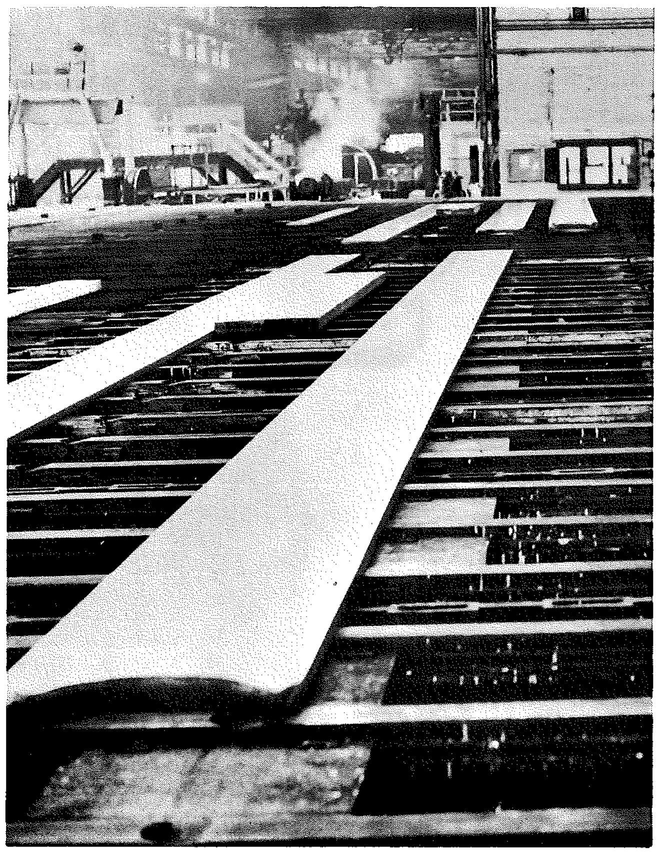


Fig. 4   Plates on Cooling Bed.

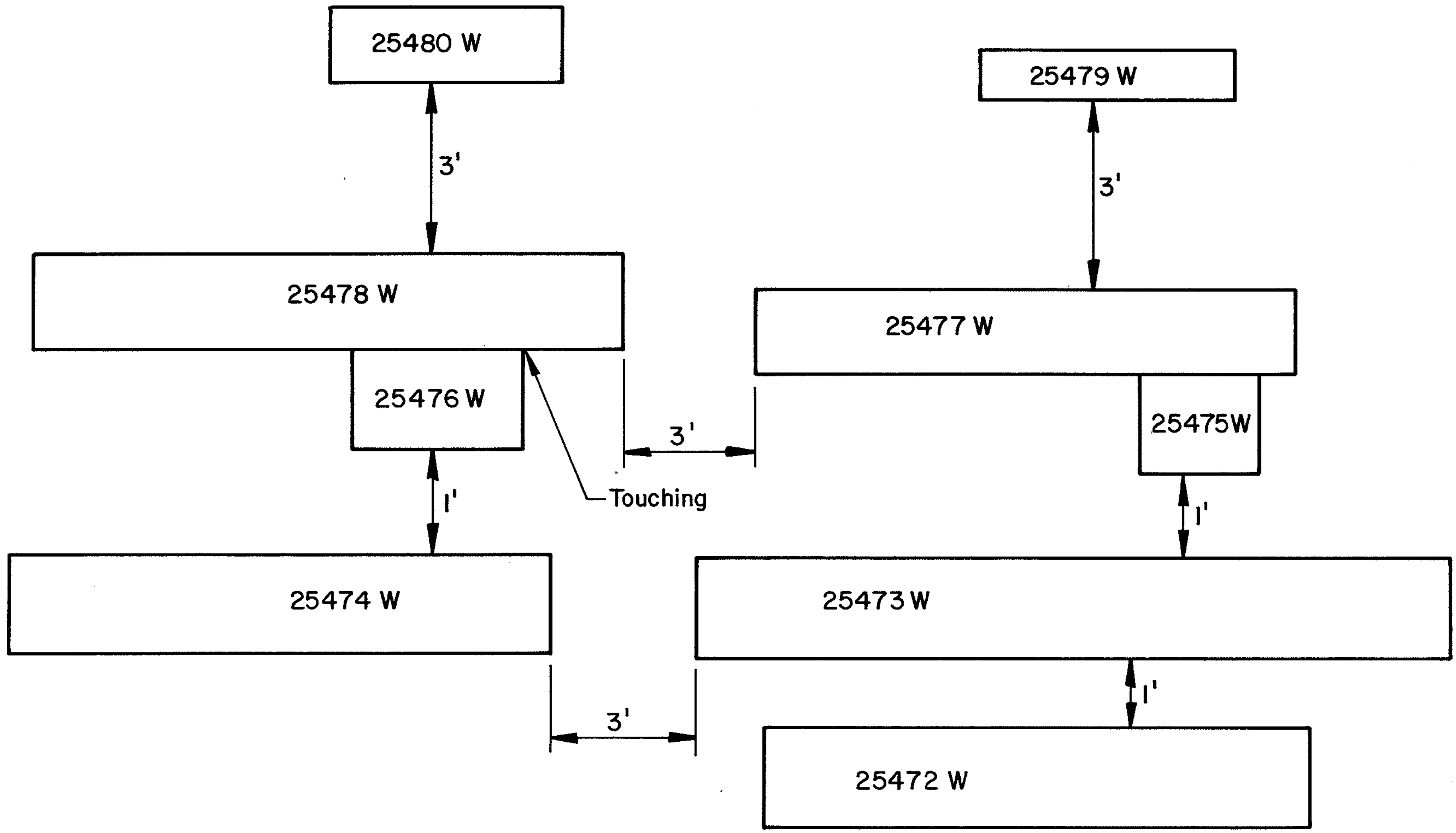


Fig. 5 Plate Arrangement on Cooling Bed.

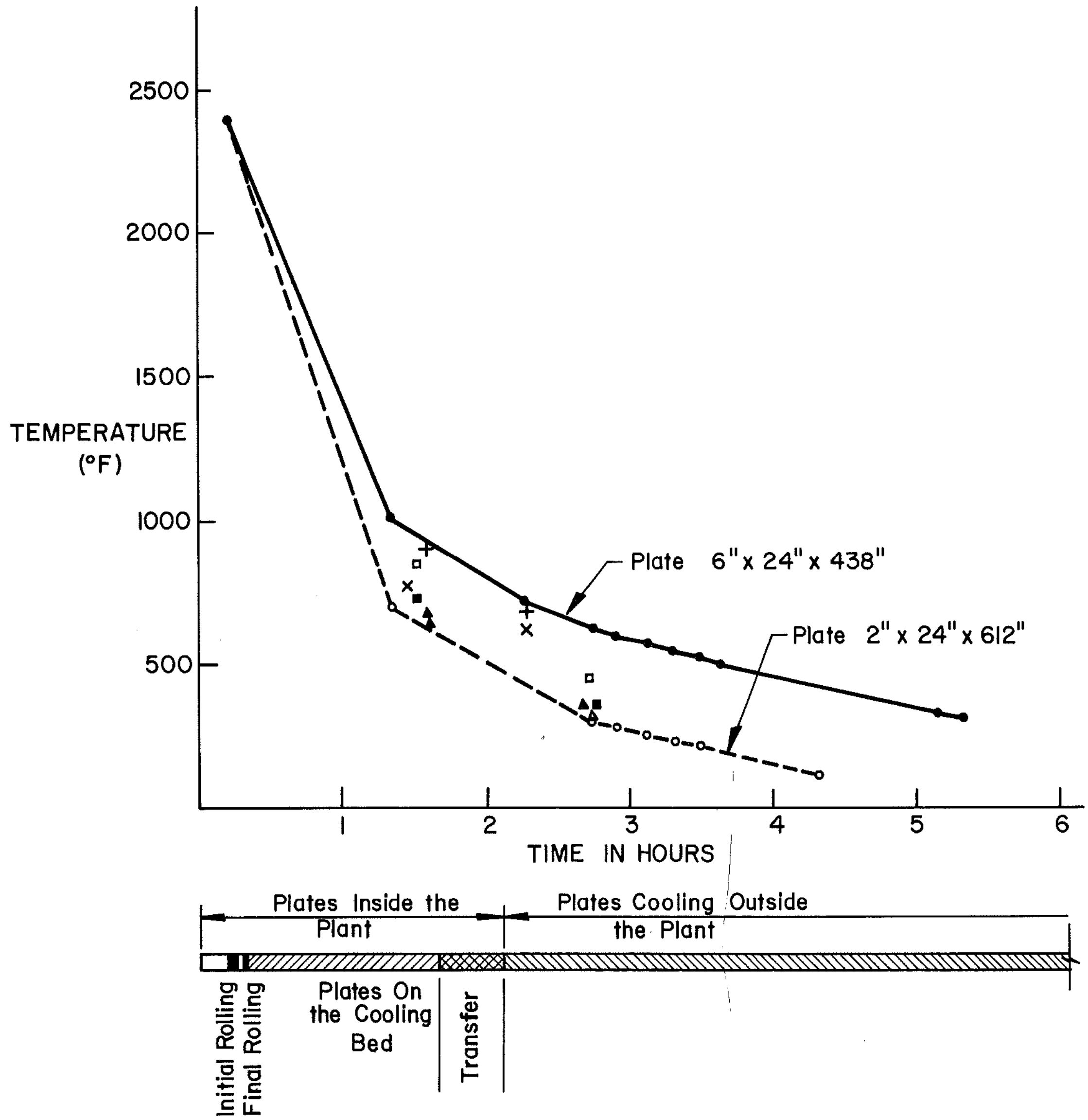


Fig. 6 Cooling Temperature for the Rolling Process.

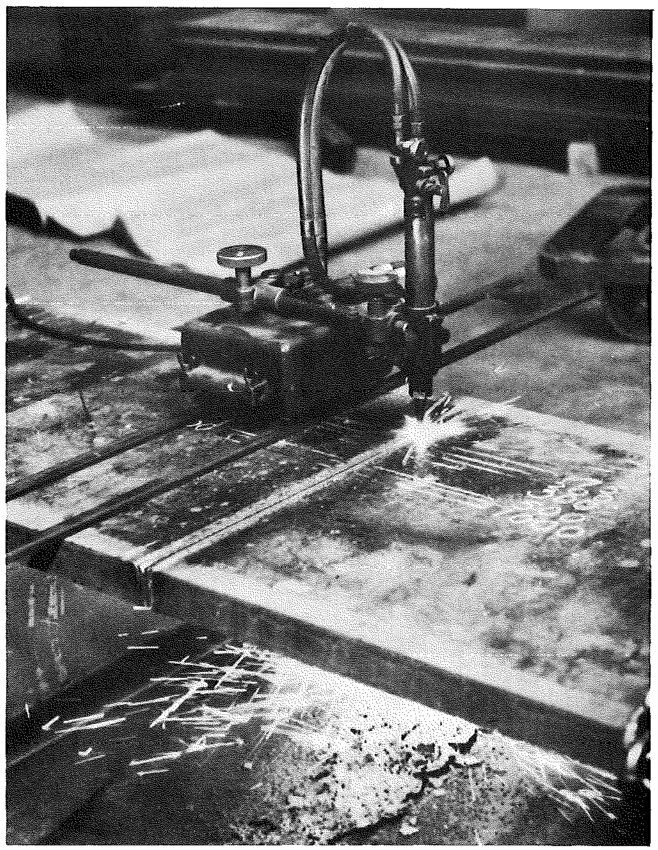
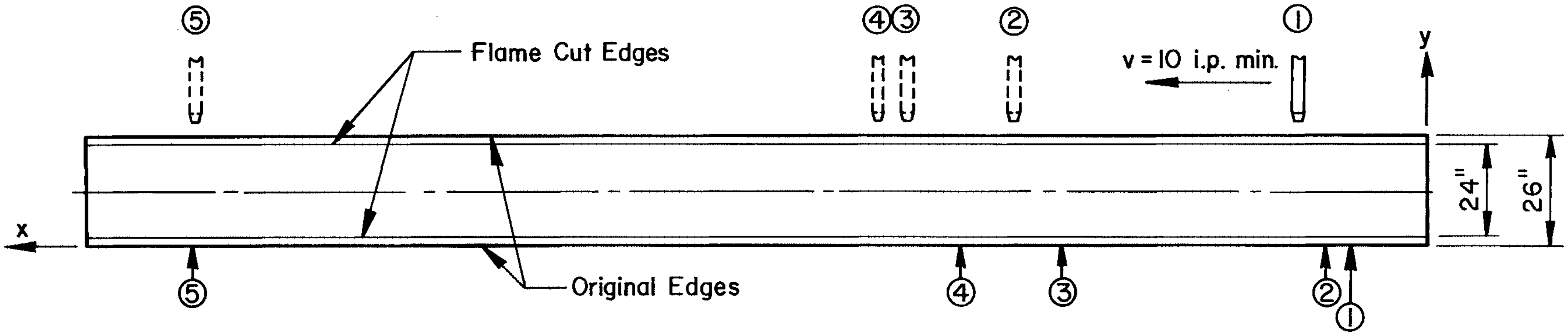


Fig. 7 Flame Cutting Process of a Plate 24" x 2".



Location Number	Time (Min.)	X Cordinate of Nozzle (in.)	Distance Between Section of Meas. and Nozzle (in.)
1	4:00	40	13
2	13:30	135	100
3	17:00	170	50
4	18:00	180	25
5	40:00	400	2

Symbols	
	Location of the Nozzle
	Location of Measurements

Fig. 8 Relative Position of Nozzle and Temperature Measurement Sections for Longitudinal Flame Cutting.

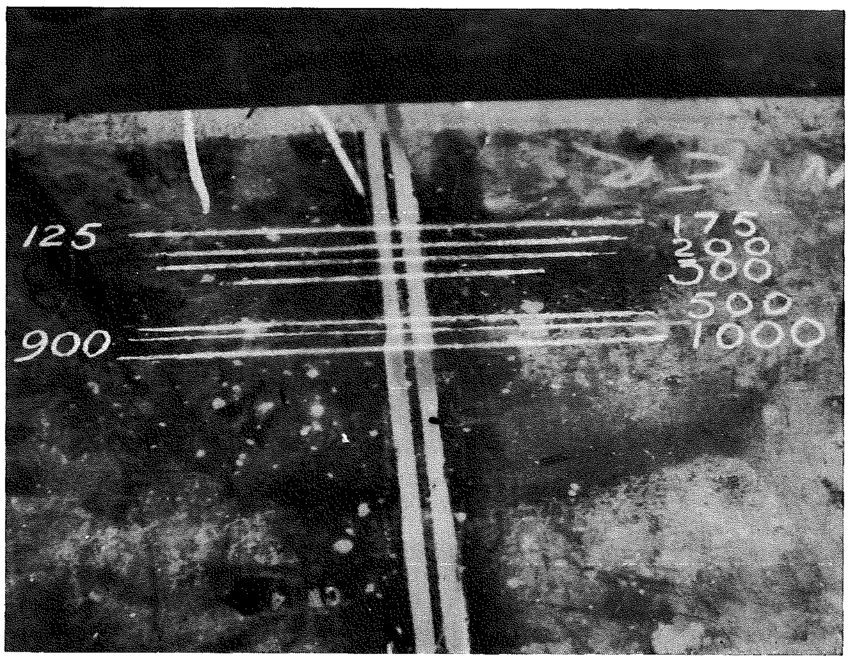


Fig. 9 Crayon Lines for Temperature Measurement.

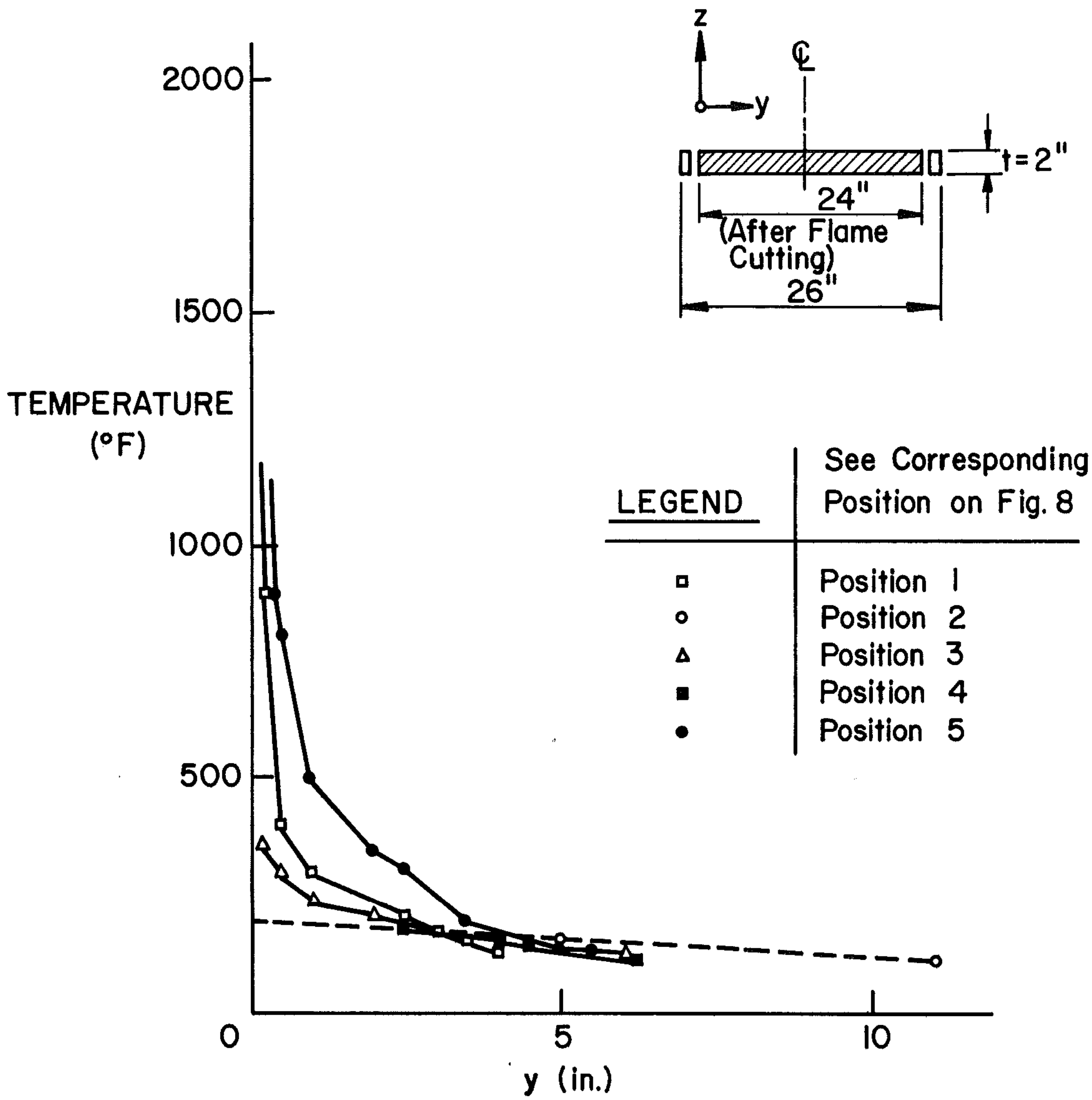


Fig. 10 Temperature Distribution Due to Flame Cutting of a Plate 24" x 2".

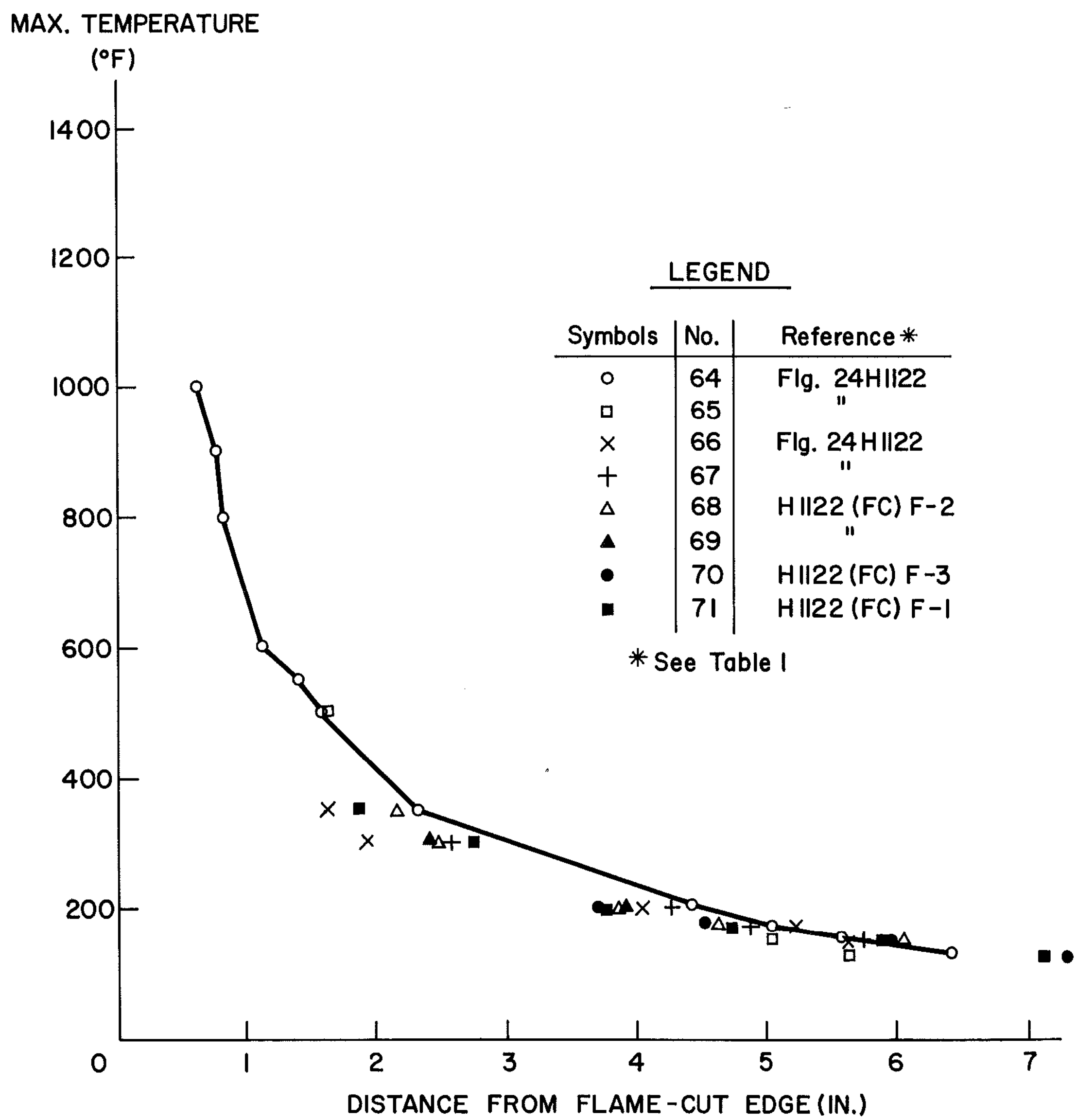


Fig. 11 Flame Cutting Temperature Measurement for Plates 24" x 6".

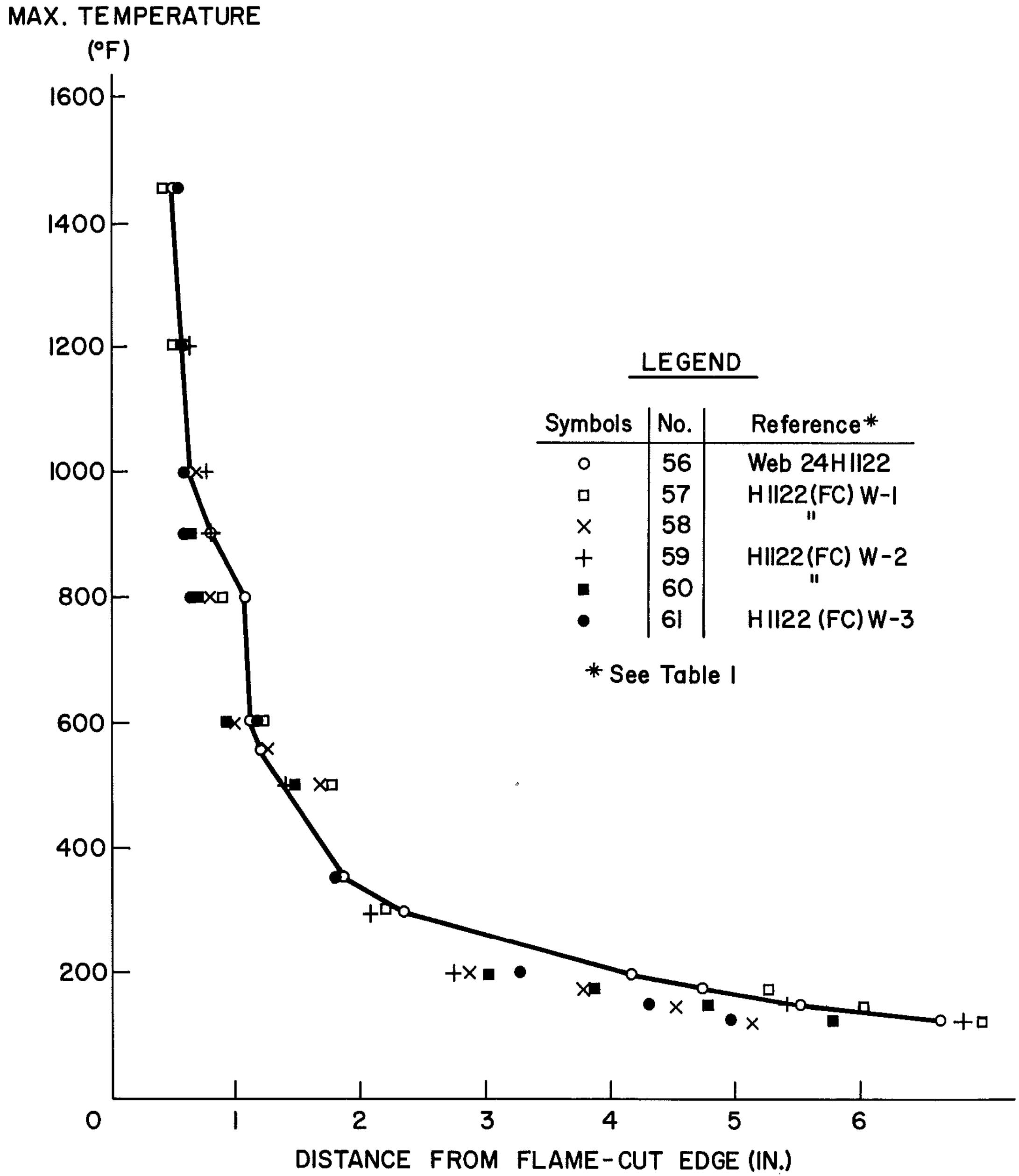


Fig. 12 Flame Cutting Temperature Measurement for Plates 24" x $3\frac{1}{2}$".

Fig. 13   Seal Weld Deposit on the Box Shape.

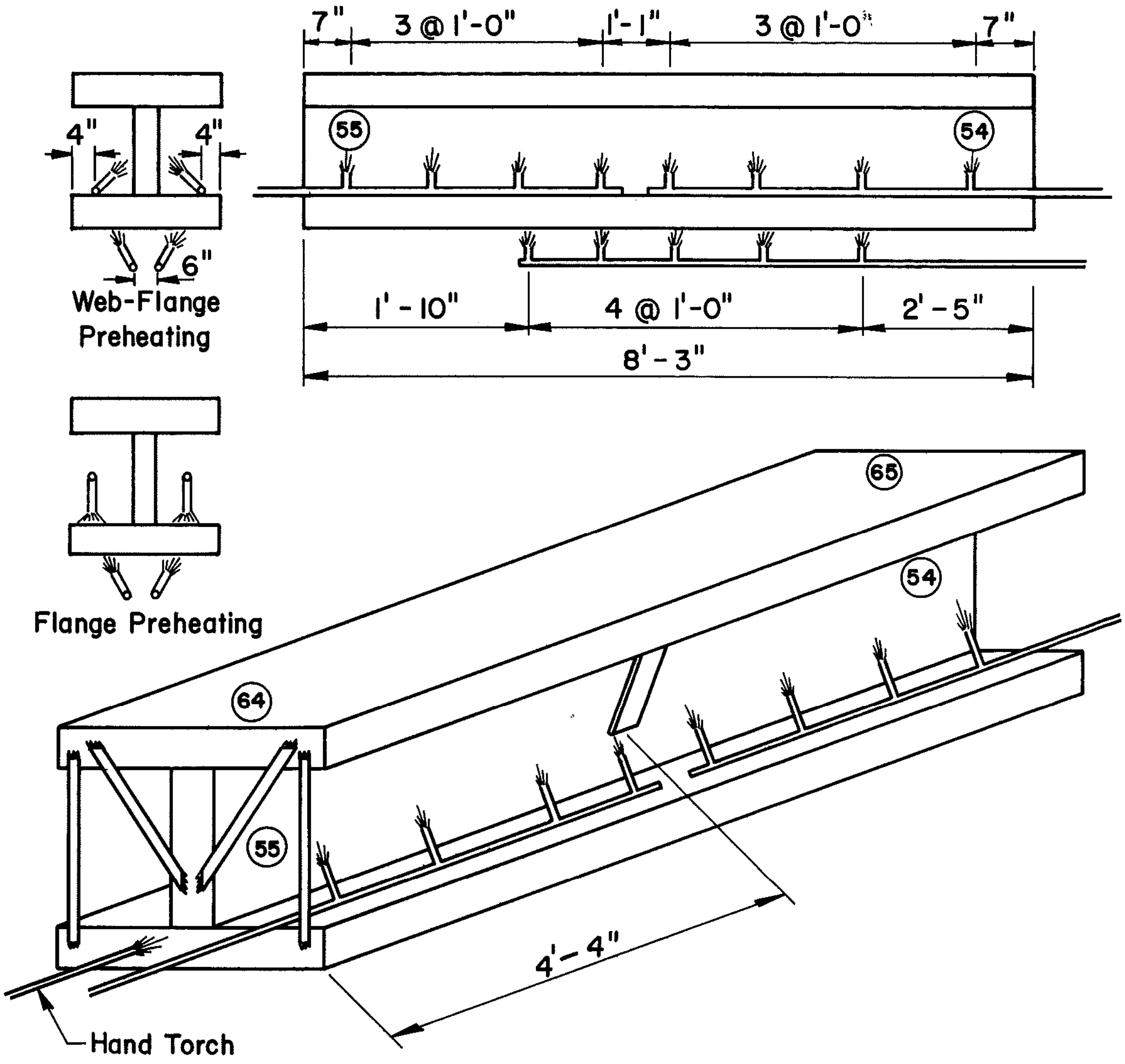


Fig. 14 Preheating Arrangement for the 24 H 1122.

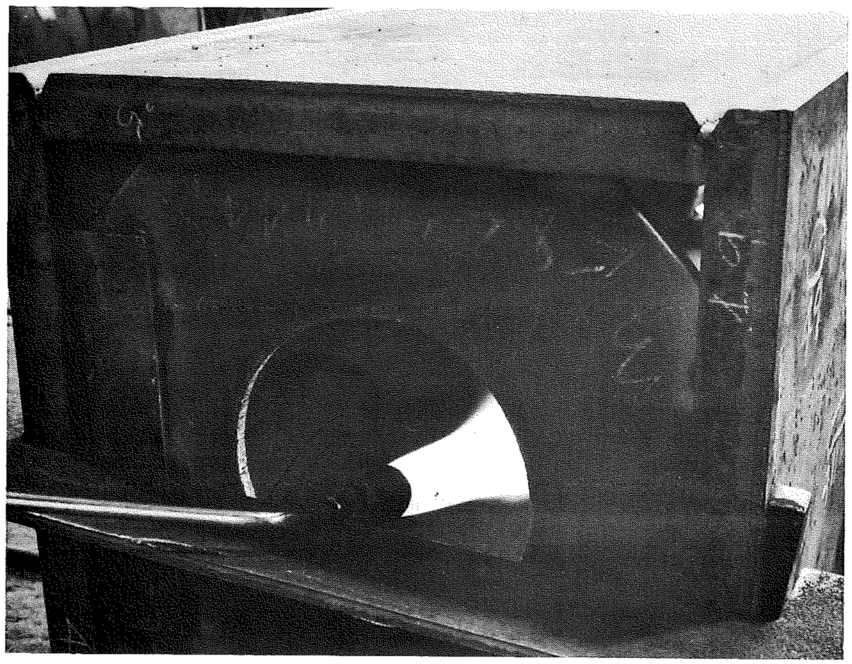


Fig. 15 Manual Preheating of the Box Shape.

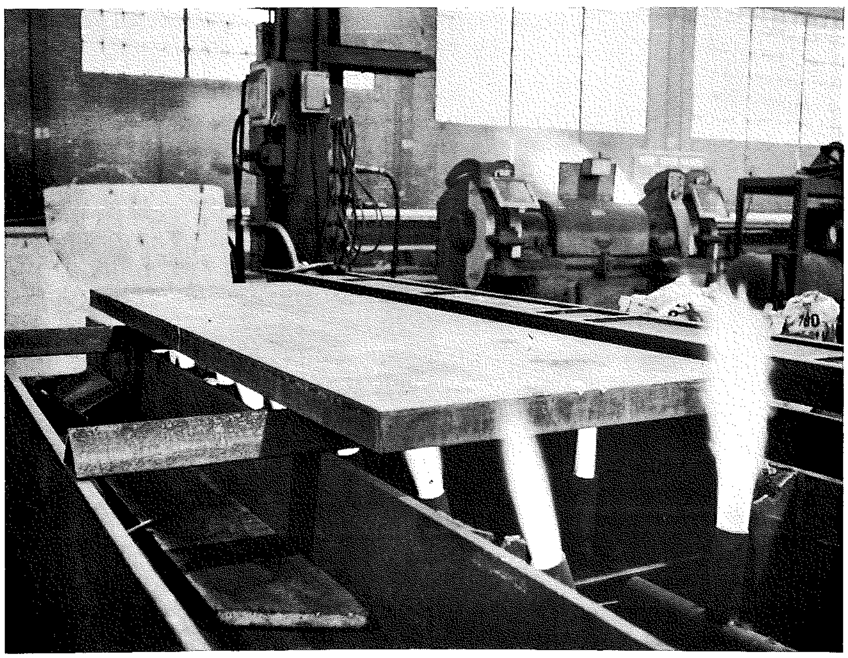


Fig. 16 Automatic Preheating of a Plate 24" x 2".

Fig. 17 Welding Process on a Plate 24" x 2".

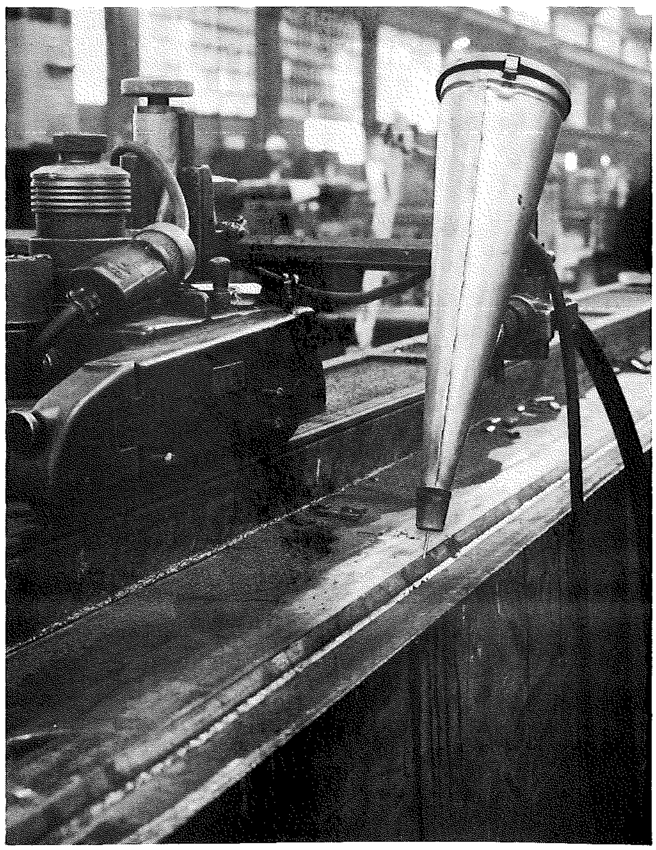


Fig. 18 Welding Process on the Box Shape 24 ☐ 774.

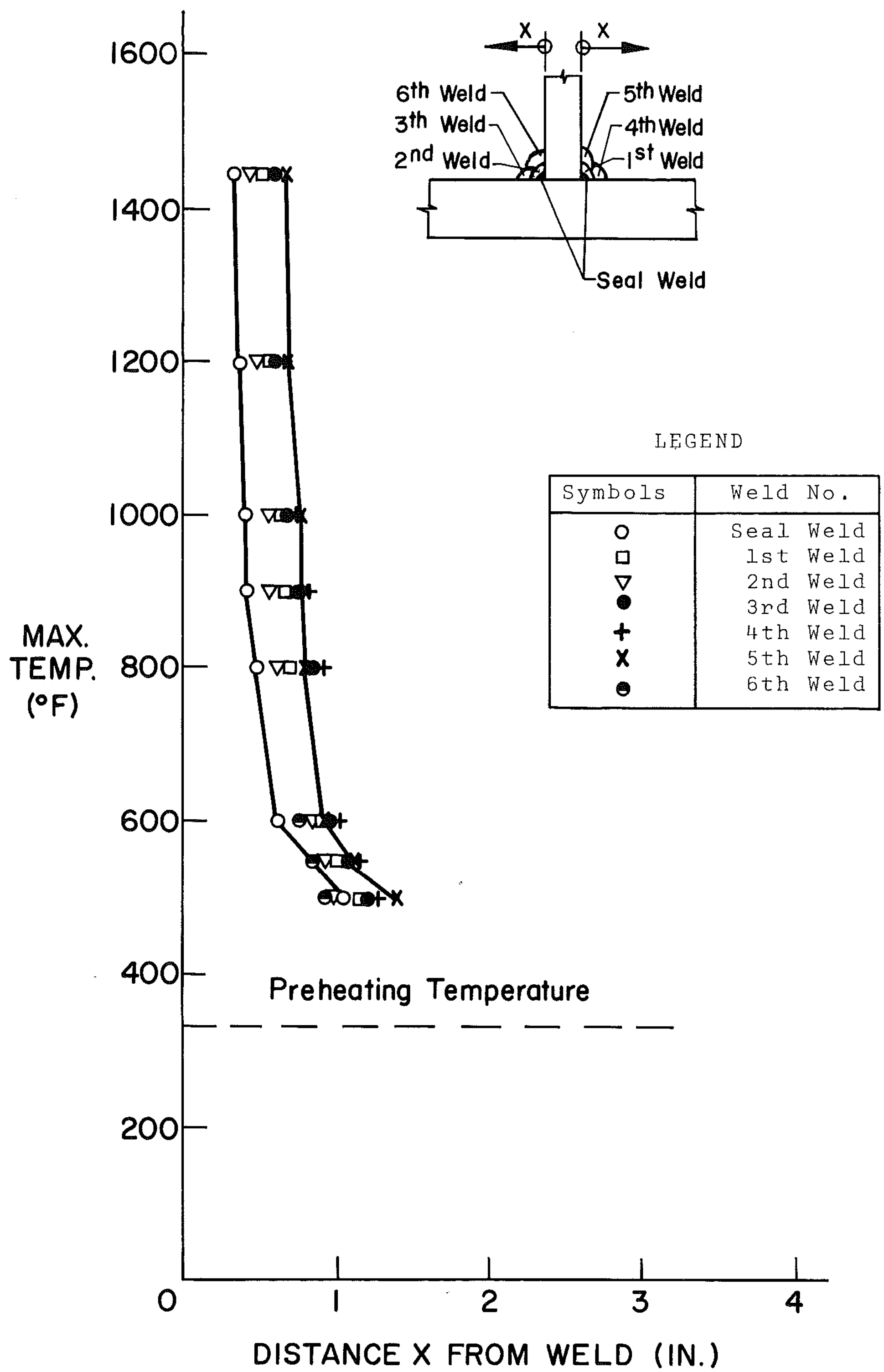


Fig. 19 Temperature Measurement on the Lower Flange of the 24 H 1122.

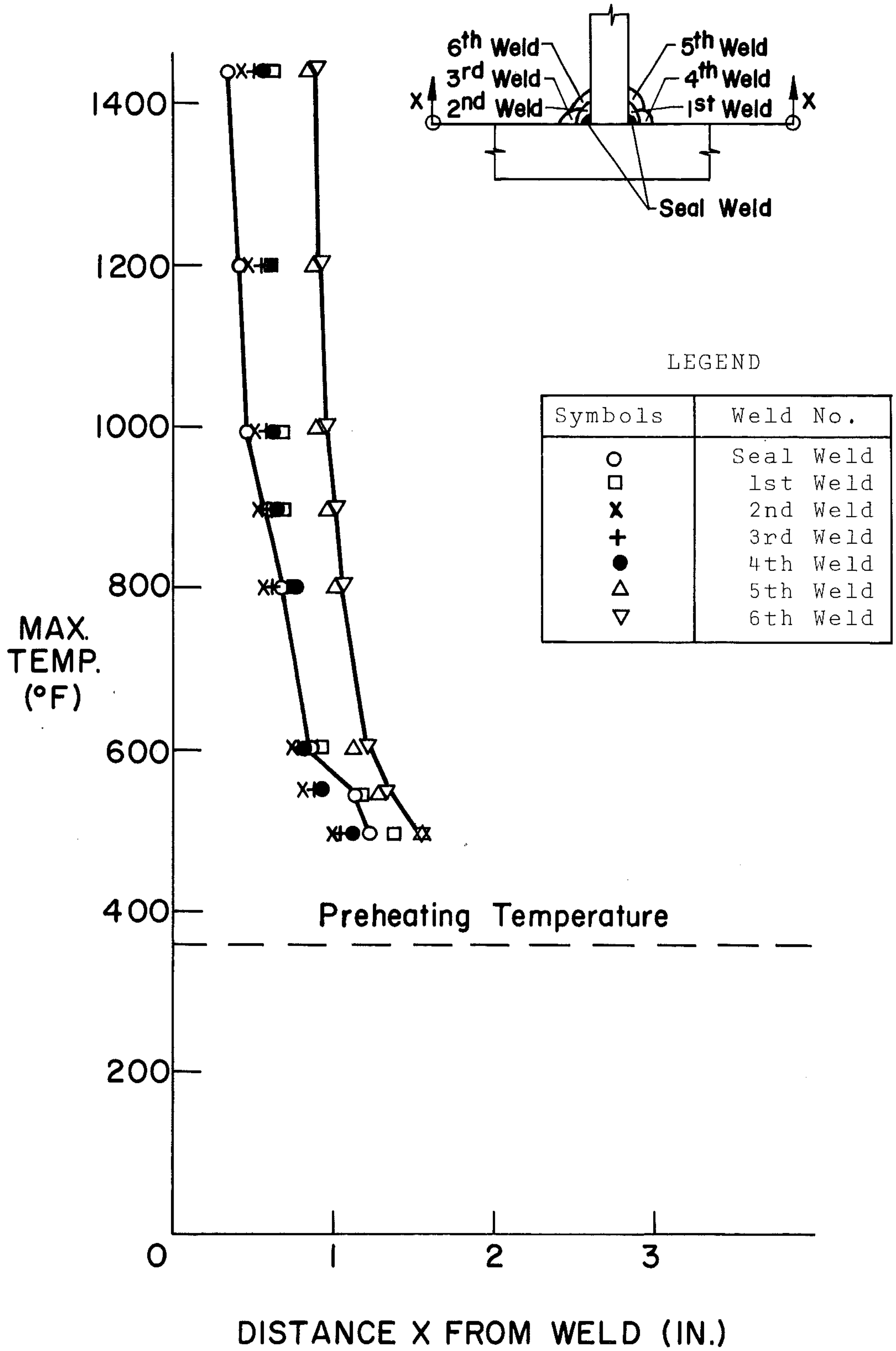


Fig. 20 Temperature Measurement on Web of the Lower Part of the 24 H 1122.

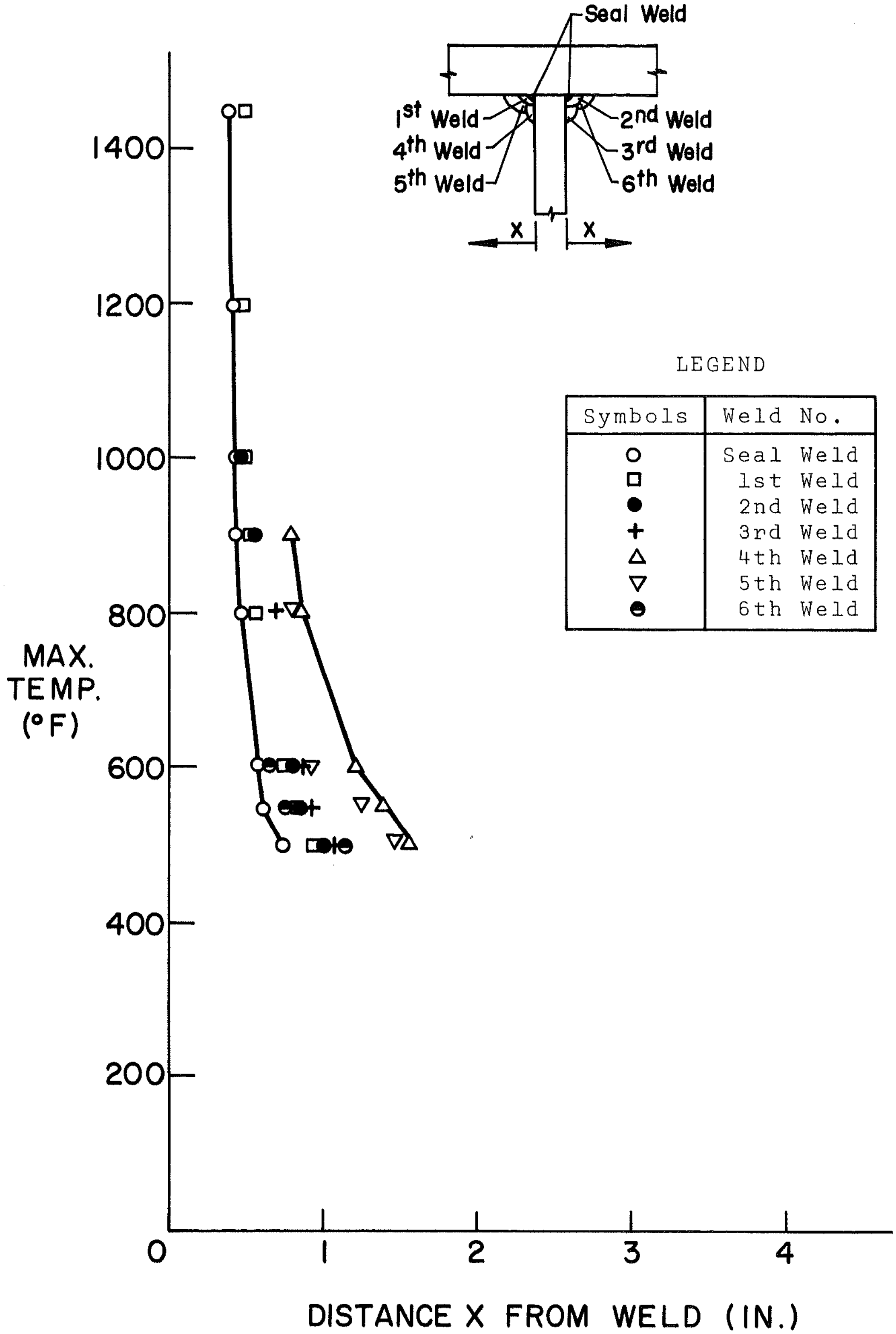


Fig. 21 Temperature Measurement on the Upper Flange of the 24 H 1122.

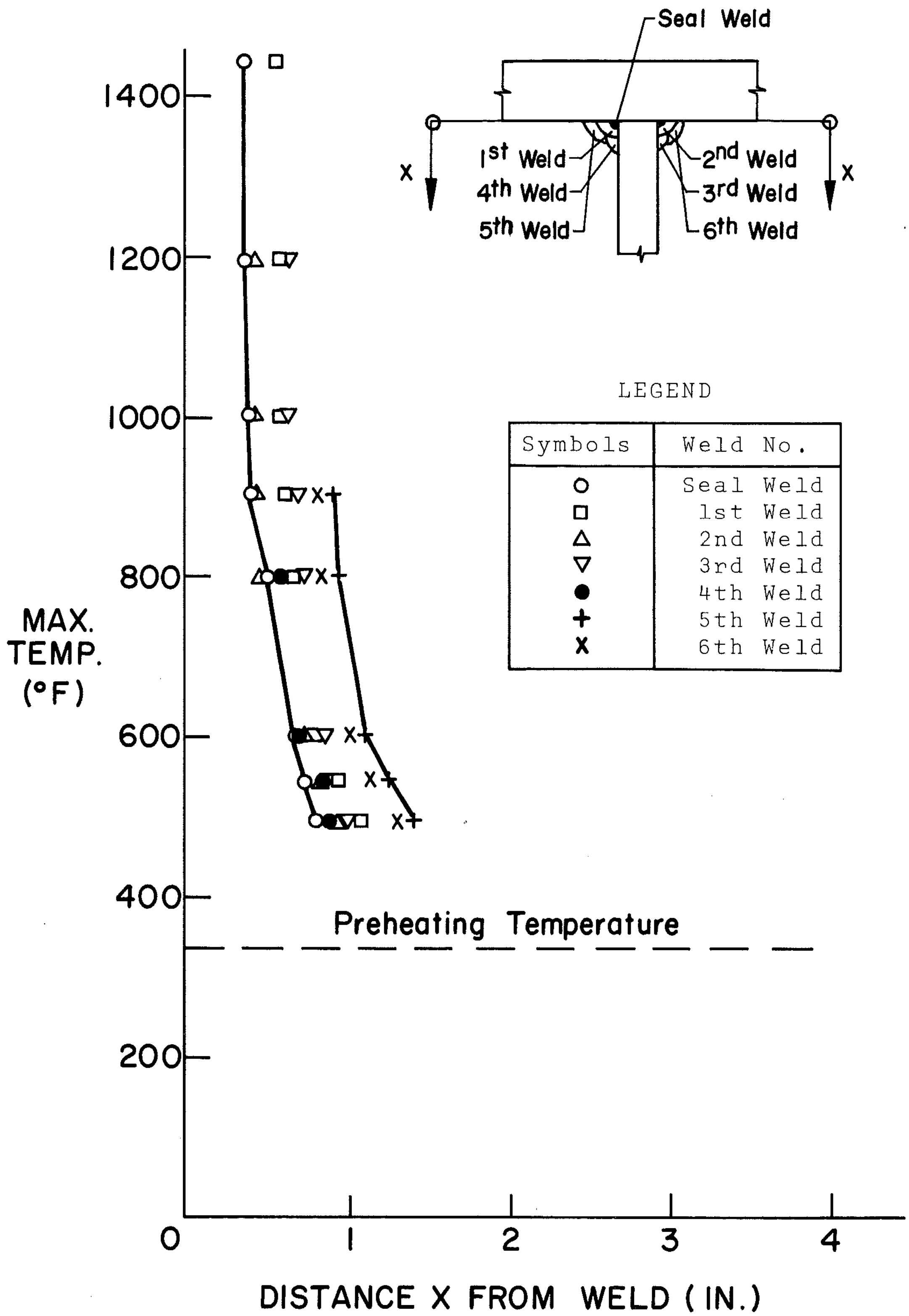


Fig. 22 Temperature Measurement on the Web at the Upper Part of the 24 H 1122.

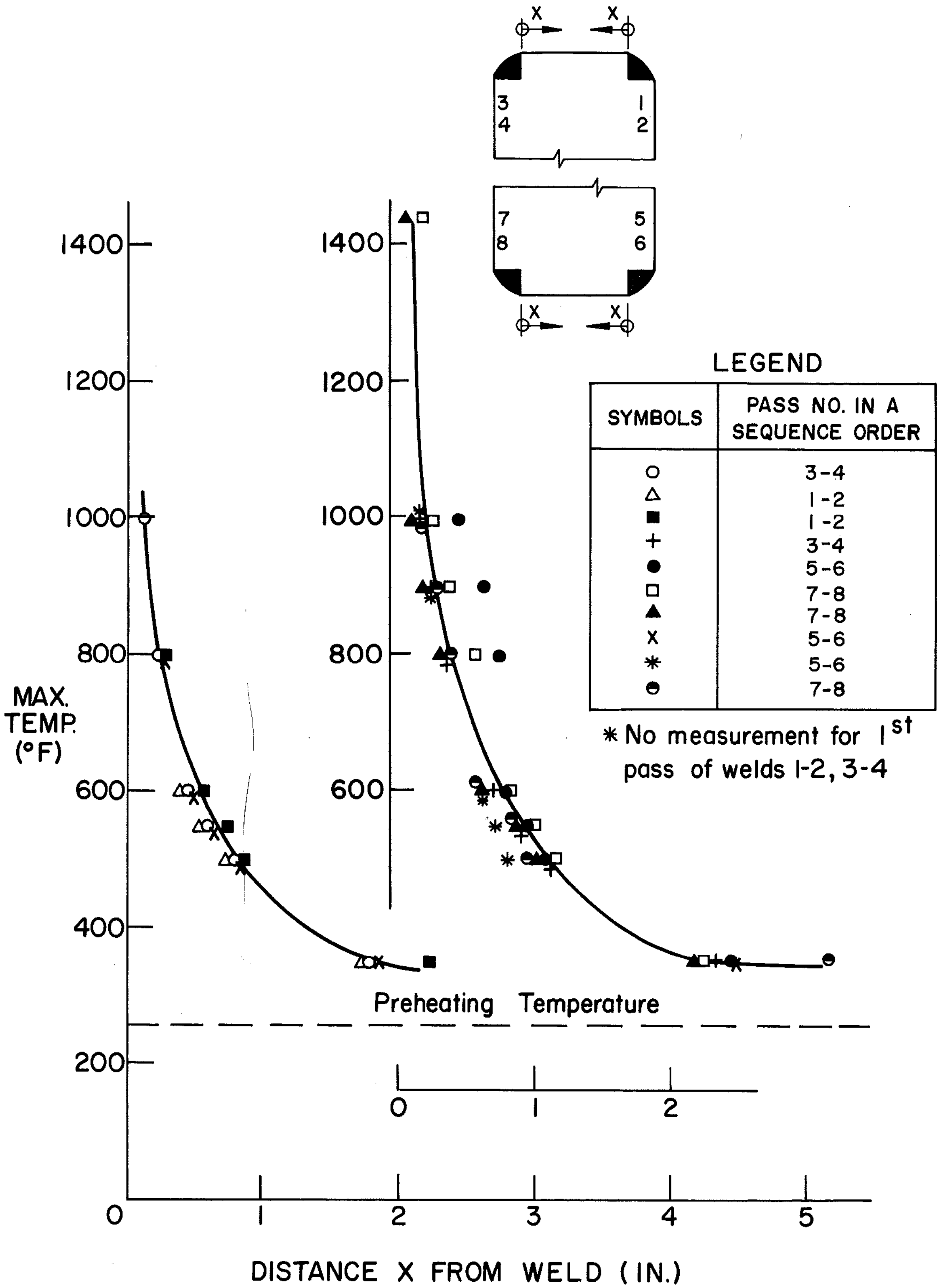


Fig. 23 Maximum Welding Temperature on Plate 24" x 6".

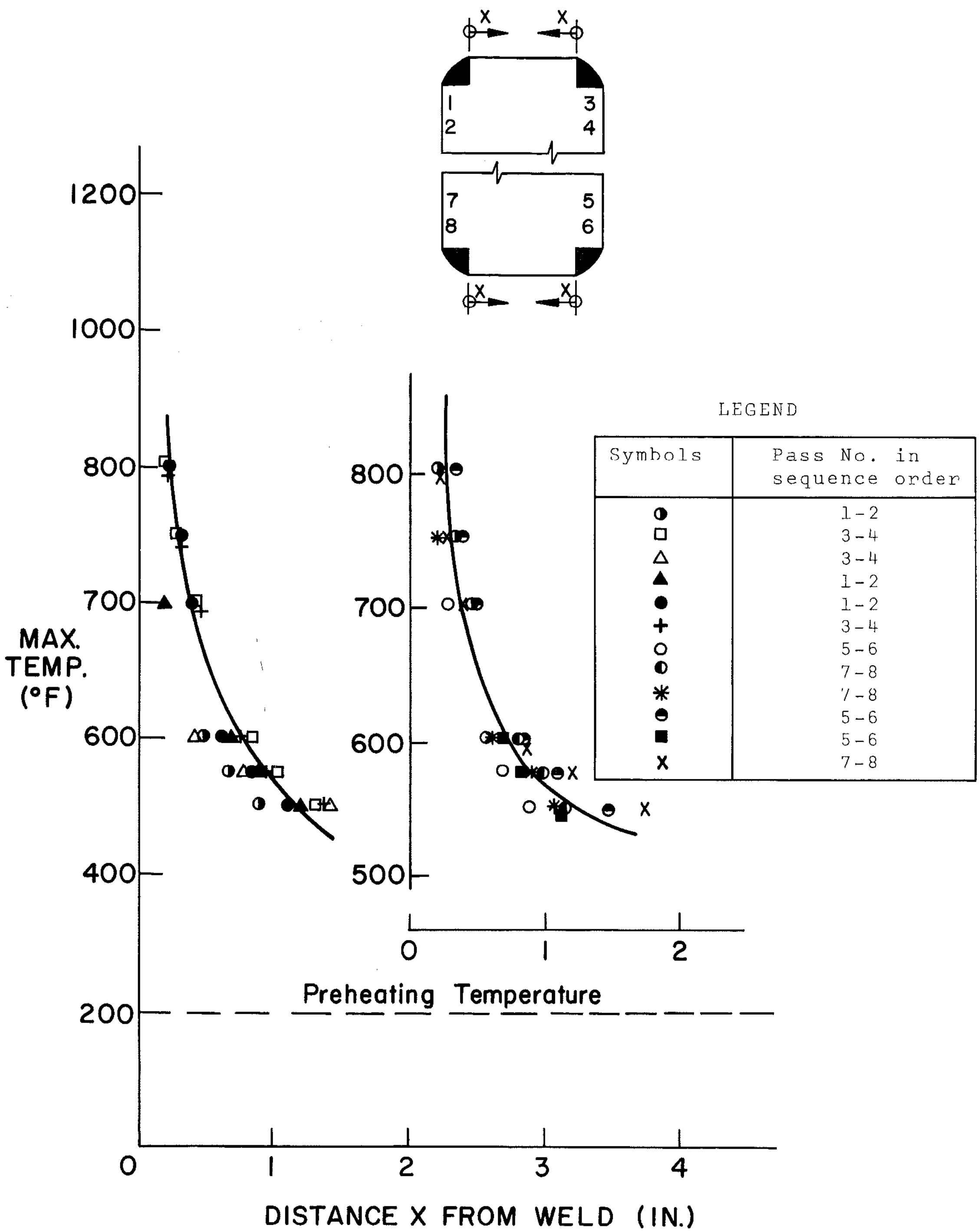


Fig. 24 Temperature Measurement on Plate 12" x $3\frac{1}{2}$" Edge Weld.

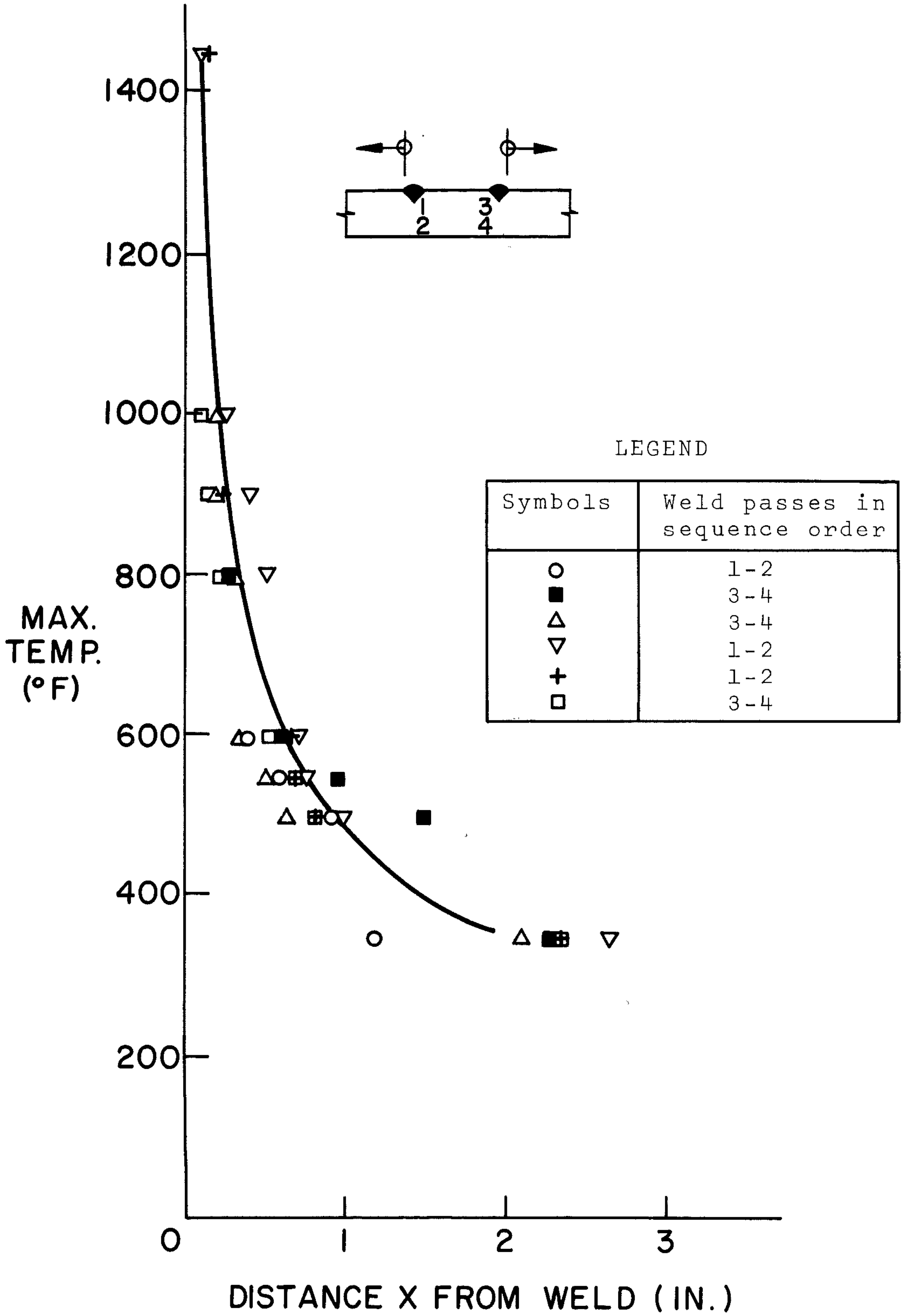


Fig. 25 Temperature Due to Welding, Plate 24" x 6" Center Weld.

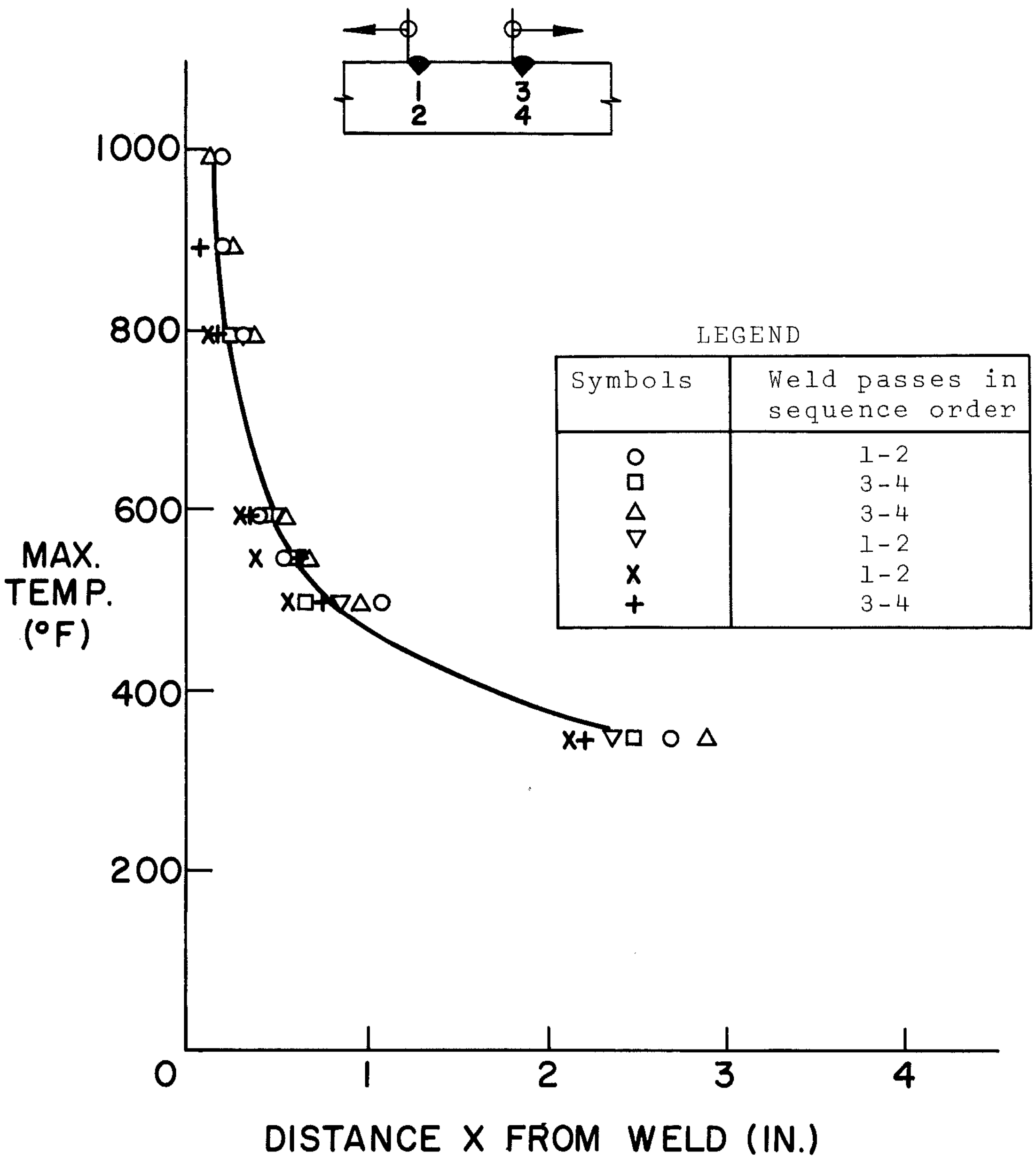


Fig. 26 Maximum Welding Temperature on Plate 12" x $3\frac{1}{2}$".

7. TABLE OF CONTENTS FOR DATA SHEETS

DATA SHEET NO.: 1

PLATE SIZE: 9" x 1½"

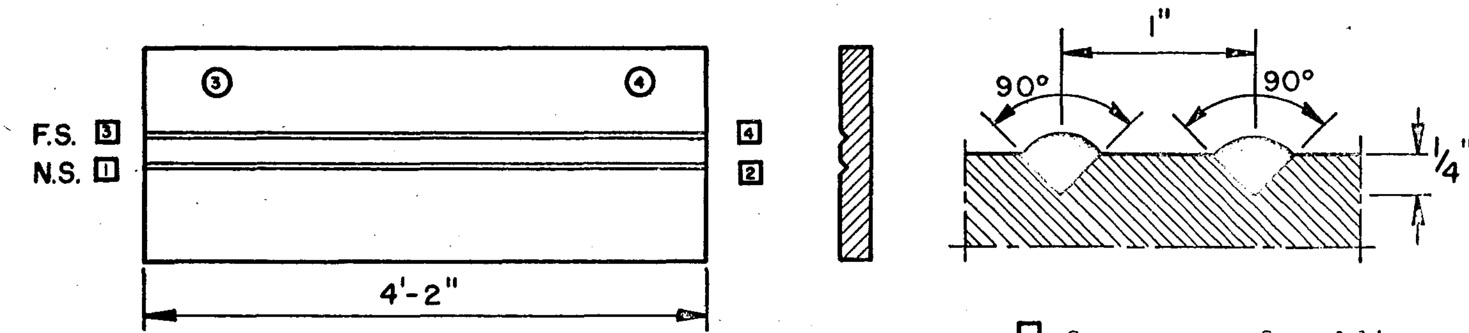
PARENT PLATE NO.: 26856W

HEAT NO.: 479 W 0041

CORRESPONDING SHAPE: 12 H 210

FABRICATOR REFERENCE NO.: H 210 (FC) W-2

STEEL: ASTM A36



□ Sequence of welding
○ Plate No.

DATA:

PASS NO.	3-4	1-2	1-2	3-4	
VOLTAGE (Volts)	33	32	35	35	
CURRENT (Amperes)	400	410	390	390	
STARTING TIME (sec.)	1:24	1:31:20	1:38:55	1:43:00	
STOPPING TIME (sec.)	1:27:40	1:33:35	1:40:40	1:44:45	
SPEED OF WELDING (in/min.)	13.7	22.2	28.6	28.6	

REMARKS:

Temperature of preheating non uniform 150°F<T<225°F lowest temperature recorded generally on the edges.

DATA SHEET NO.: 2

PLATE SIZE: 9" x 1½"

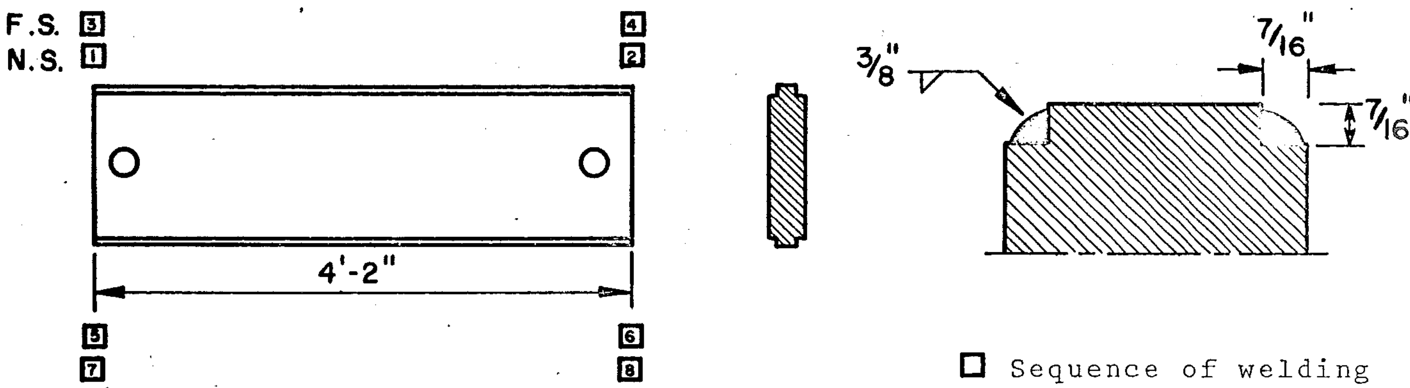
PARENT PLATE NO.: 26856 W

HEAT NO.: 479 W0041

CORRESPONDING SHAPE: 12 H 210

FABRICATOR REFERENCE NO.: H 210 (FC) W-3

STEEL: ASTM A36



□ Sequence of welding
○ Plate No.

DATA:

PASS NO.	1-2	3-4	3-4	1-2	5-6
VOLTAGE (Volts)	35	33	35	33	33
CURRENT (Amperes)	410	410	410	420	410
STARTING TIME (sec.)	4:01	4:16	4:24	4:35	5:28
STOPPING TIME (sec.)	4:05	4:19	4:26	4:37	5:31
SPEED OF WELDING (in/min.)	12.5	16.7	25.0	25.0	16.7

REMARKS:

Preheating temperature unequal $250°F < T < 300°F$
10 nozzles were used to preheat the plate.

DATA SHEET NO.: 2 (Continued)

PASS NO.	7-8	7-8	5-6		
VOLTAGE (Volts)	33	33	33		
CURRENT (Amperes)	420	430	430		
STARTING TIME (sec.)	5:39:10	5:47:20	5:57:50		
STOPPING TIME (sec.)	5:42:40	5:49:07	5:59:35		
SPEED OF WELDING (in/min.)	14.1	28.0	28.6		

DATA SHEET NO.: 3

PLATE SIZE: 12" x 2"

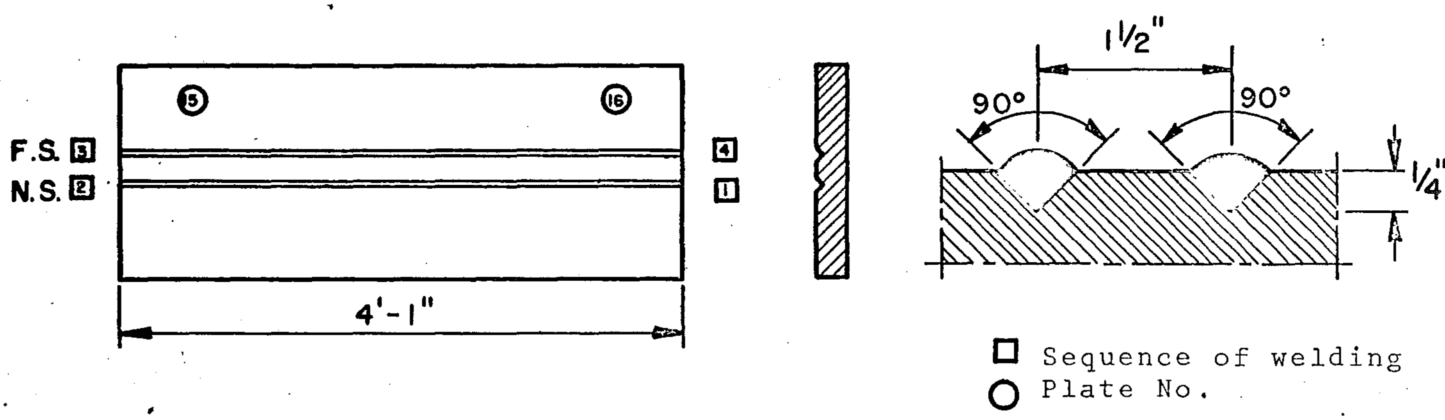
PARENT PLATE NO.: 25479W

HEAT NO.: 411 W 9731

CORRESPONDING SHAPE: 12 H 210

FABRICATOR REFERENCE NO.: H 210(FC) F-3

STEEL: ASTM A36



DATA:

PASS NO.	3-4	1-2	1-2	3-4	
VOLTAGE (Volts)	33	34	35	35	
CURRENT (Amperes)	400	410	390	390	
STARTING TIME (sec.)	1:53:50	1:59:15	2:04:15	2:08:10	
STOPPING TIME (sec.)	1:56:50	2:02:25	2:05:57	2:09:47	
SPEED OF WELDING (in/min.)	16.3	15.5	28.8	30.1	

REMARKS:

Temperature of preheating 175°F (manual preheating)

PLATE SIZE: 9½" x 1½"

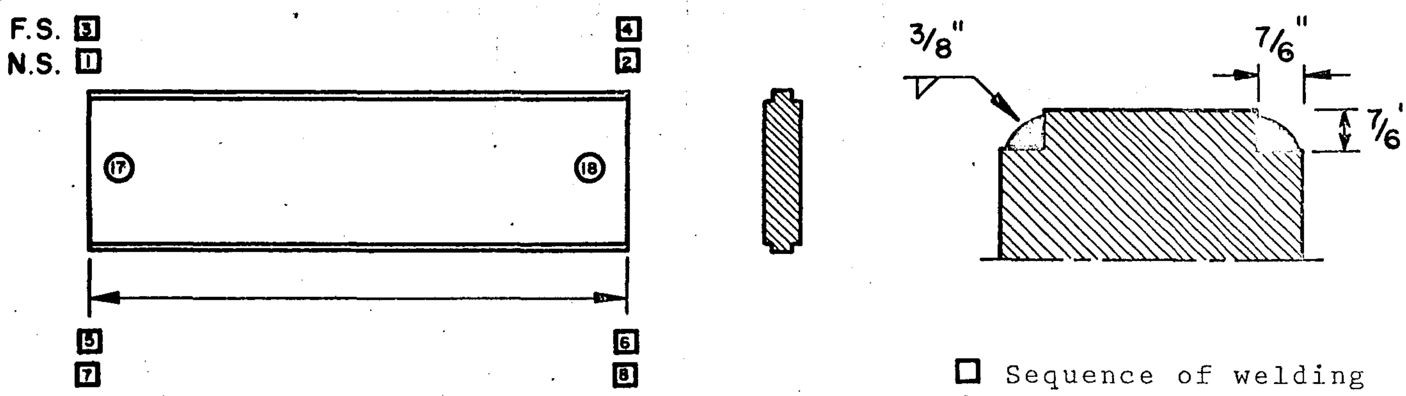
PARENT PLATE NO.: 26856W

HEAT NO.: 479 W 0041

CORRESPONDING SHAPE: 12H210

FABRICATOR REFERENCE NO.: H 210 (FC) F-4

STEEL: ASTM A36



□ Sequence of welding
○ Plate No.

DATA:

PASS NO.	3-4	1-2	1-2	3-4	5-6
VOLTAGE (Volts)	32	32	34	34	33
CURRENT (Amperes)	410	400	390	390	400
STARTING TIME (sec.)	9:30:13	9:50:08	9:55:21	10:15:34	11:05:29
STOPPING TIME (sec.)	9:33:43	9:53:40	9:57:01	10:17:15	11:08:39
SPEED OF WELDING (in/min.)	14.3	14.21	30.1	29.6	15.8

REMARKS:

DATA SHEET NO.: 4 (Continued)

PASS NO.	7-8	7-8	5-6		
VOLTAGE (Volts)	33	34	34		
CURRENT (Amperes)	410	380	380		
STARTING TIME (sec.)	11:10:21	11:15:12	11:35:08		
STOPPING TIME (sec.)	11:13:39	11:16:53	11:36:58		
SPEED OF WELDING (in/min.)	15.2	29.7	30.1		

DATA SHEET NO.: 5

SHAPE: 12 H 210

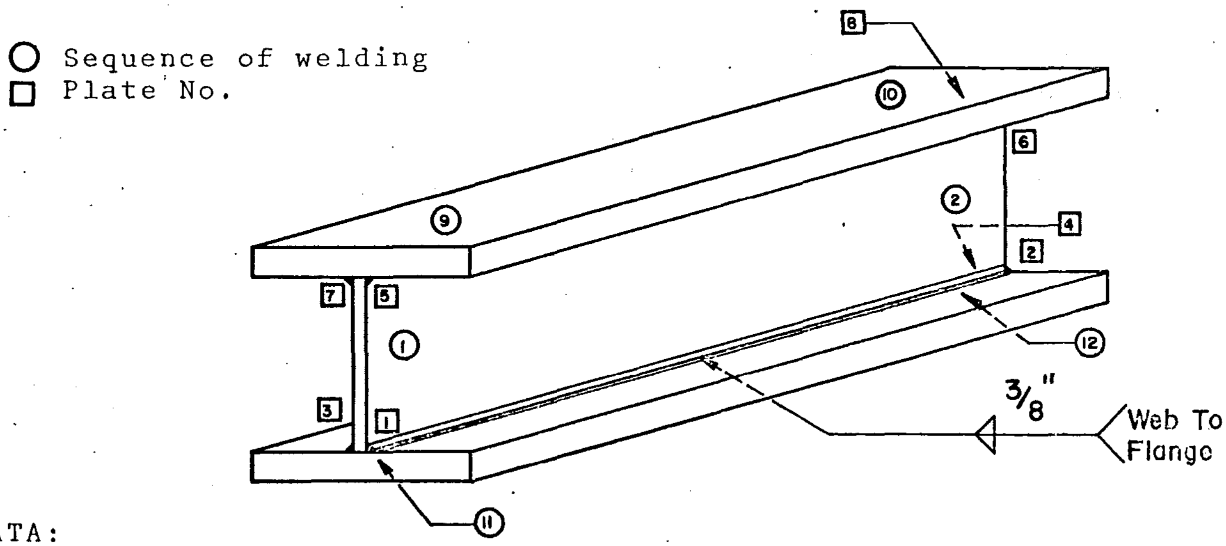
DIMENSIONS: FLANGES: 12 7/16"x2" WEB: $9\frac{1}{4}$" x $1\frac{1}{2}$"

LENGTH: 4'5"

PARENT PLATES NO.: FLANGES: 25479W WEB: 26856W

HEAT NO.: FLANGES: 411 W 9731 WEB: 479 W 0011

STEEL: ASTM A36



DATA:

PASS NO.	1-2	3-4	3-4	1-2	7-8
VOLTAGE (Volts)	32	32	33	33	33
CURRENT (Amperes)	410	390	390	390	420
STARTING TIME (sec.)	10:45	11:00	11:25	12:25	12:50
STOPPING TIME (sec.)					
SPEED OF WELDING (in/min.)	16	16	30	30	16

REMARKS:

Speed of welding has been obtained by recording the time over ten inches gage length in the center of the member.

DATA SHEET NO.: 5 (Continued)

PASS NO.	5-6	5-6	7-8		
VOLTAGE (Volts)	33	34	33		
CURRENT (Amperes)	420	400	420		
STARTING TIME (sec.)	1:25	1:40	2:40		
STOPPING TIME (sec.)					
SPEED OF WELDING (in/min.)	16	30	30		

DATA SHEET NO.: 6

PLATE SIZE: 12' x 3½"

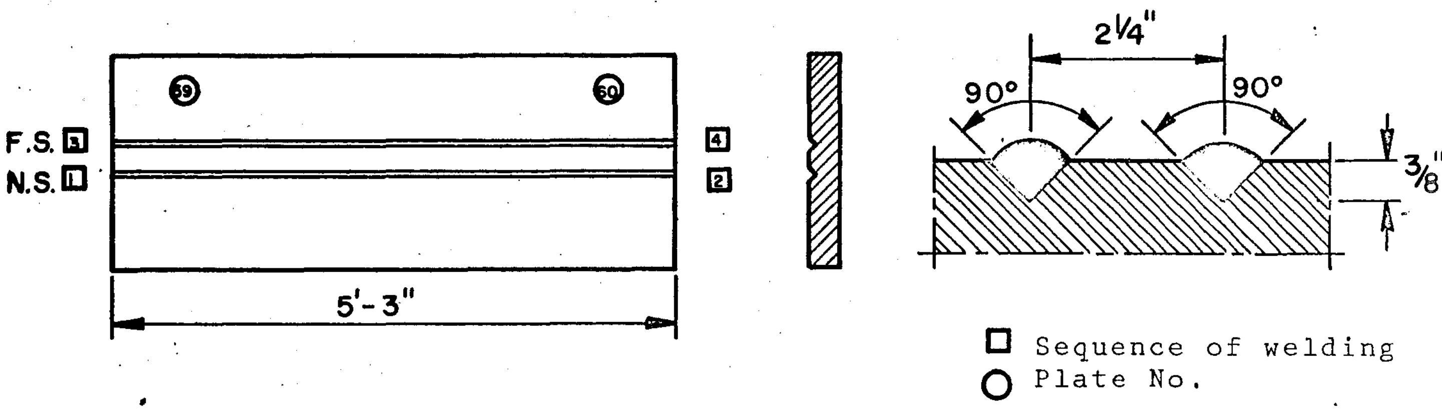
PARENT PLATE NO.: 26221W

HEAT NO.: 477 W 3301

CORRESPONDING SHAPE: 24 H 1122

FABRICATOR REFERENCE NO.: H 1122 (FC) W-2

STEEL: ASTM A36



DATA:

PASS NO.	1-2	3-4	3-4	1-2	1-2
VOLTAGE (Volts)	36	33	34	34	37
CURRENT (Amperes)	420	410	410	410	400
STARTING TIME (sec.)	3:25:00	3:32:00	3:45:40	3:53:19	4:34:45
STOPPING TIME (sec.)	3:28:50	3:35:40	3:49:20	3:58:21	4:39:56
SPEED OF WELDING (in/min.)	16.5	17.2	17.2	15.0	12.2

REMARKS:

DATA SHEET NO.: 6 (Continued)

PASS NO.	3-4				
VOLTAGE (Volts)	37				
CURRENT (Amperes)	400				
STARTING TIME (sec.)	4:45:45				
STOPPING TIME (sec.)	4:49:15				
SPEED OF WELDING (in/min.)	18.0				

DATA SHEET NO.: 7

PLATE SIZE: 12" x 3½"

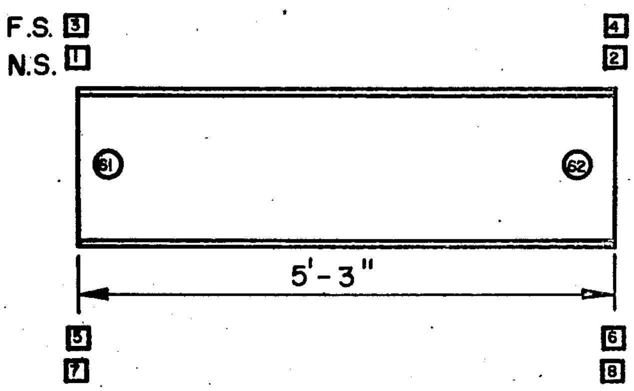
PARENT PLATE NO.: 26221W

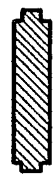
HEAT NO.: 477 W 3301

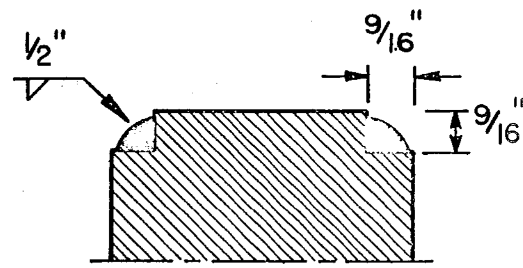
CORRESPONDING SHAPE: 24 H 1122

FABRICATOR REFERENCE NO.: H 1122 (FC) W-3

STEEL: ASTM A36







□ Sequence of welding
○ Plate No.

DATA:

PASS NO.	1-2	3-4	3-4	1-2	1-2
VOLTAGE (Volts)	33	34	34	34	34
CURRENT (Amperes)	410	410	410	410	410
STARTING TIME (sec.)	9:38:00	9:44:30	9:52:45	9:59:45	10:33:30
STOPPING TIME (sec.)	9:41:58	9:48:30	9:56:45	9:63:42	10:38:38
SPEED OF WELDING (in/min.)	15.9	15.8	15.8	16.0	12.3

REMARKS:

DATA SHEET NO.: 7 (Continued)

PASS NO.	3-4	5-6	7-8	7-8	5-6
VOLTAGE (Volts)	34	34	34	34	34
CURRENT (Amperes)	415j	420	410	415	415
STARTING TIME (sec.)	10:39:00	11:06:15	11:13:15	11:21:00	11:27:15
STOPPING TIME (sec.)	10:43:08	11:10:14	11:17:13	11:24:57	11:31:14
SPEED OF WELDING (in/min.)	15.3	15.7	15.7	16.0	16.0

PASS NO.	5-6	7-8			
VOLTAGE (Volts)	36	36			
CURRENT (Amperes)	410	415			
STARTING TIME (sec.)	11:33:00	11:40:30			
STOPPING TIME (sec.)	11:37:08	11:44:38			
SPEED OF WELDING (in./min.)	15.3	15.3			

DATA SHEET NO.: 8

PLATE SIZE: 24" x 6"

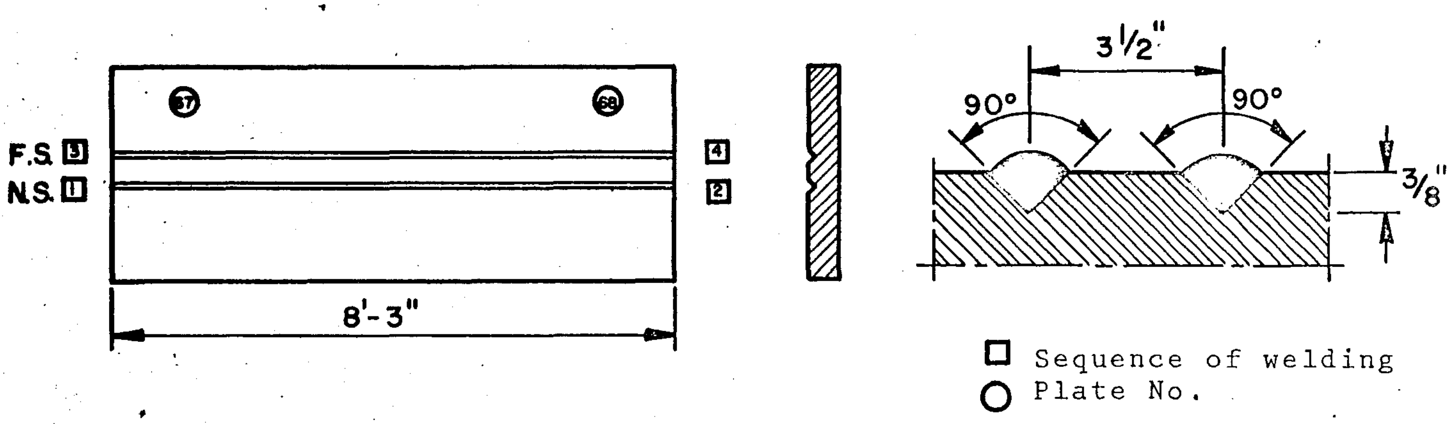
PARENT PLATE NO.: 26222W

HEAT NO.: 477 W 3301

CORRESPONDING SHAPE: 24 H 1122

FABRICATOR REFERENCE NO.: H 1122(FC) F-2

STEEL: ASTM A36



DATA:

PASS NO.	1-2	3-4	3-4	1-2	1-2
VOLTAGE (Volts)	33	34	33	32	35
CURRENT (Amperes)	415	415	410	420	420
STARTING TIME (sec.)	2:32:40	2:40:25	3:20:35	3:34:35	3:54:30
STOPPING TIME (sec.)	2:38:45	2:46:00	3:26:30	3:40:30	4:00:35
SPEED OF WELDING (in/min.)	16.3	17.7	16.7	16.7	19.5

REMARKS:

DATA SHEET NO.: 8 (Continued)

PASS NO.	3-4				
VOLTAGE (Volts)	36				
CURRENT (Amperes)	420				
STARTING TIME (sec.)	4:07:45				
STOPPING TIME (sec.)	4:14:07				
SPEED OF WELDING (in/min.)	15.6				

DATA SHEET NO.: 9

PLATE SIZE: 24" x 6"

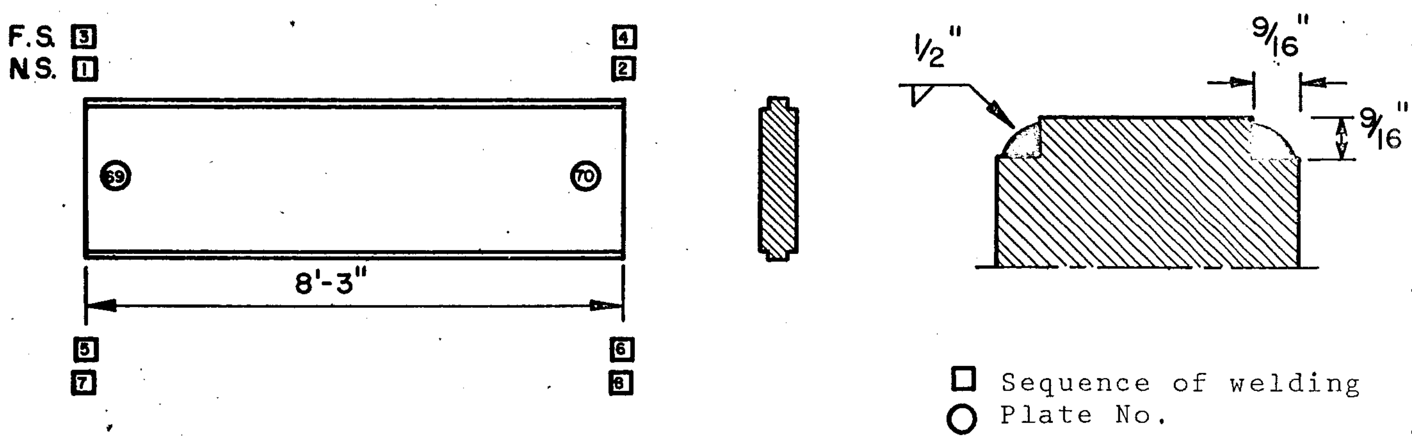
PARENT PLATE NO.: 26222W

HEAT NO.: 477 W 3301

CORRESPONDING SHAPE: 24 H 1122

FABRICATOR REFERENCE NO.: H 1122(FC) F-3

STEEL: ASTM A36



DATA:

PASS NO.	5-6	7-8	7-8	5-6	5-6
VOLTAGE (Volts)	34	34	34	34	36
CURRENT (Amperes)	400	400	420	410	410
STARTING TIME (sec.)	1:31:20	1:46:05	2:00:20	2:10:22	2:20:25
STOPPING TIME (sec.)	1:37:15	1:52:00	2:06:16	2:16:22	2:26:25
SPEED OF WELDING (in/min.)	16.7	16.7	17.1	16.5	16.0

REMARKS:

DATA SHEET NO.: 9 (Continued)

PASS NO.	7-8				
VOLTAGE (Volts)	37				
CURRENT (Amperes)	410				
STARTING TIME (sec.)	2:29:35				
STOPPING TIME (sec.)	2:25:44				
SPEED OF WELDING (in/min.)	16.1				

DATA SHEET NO.: 10

SHAPE: 24 H 1122

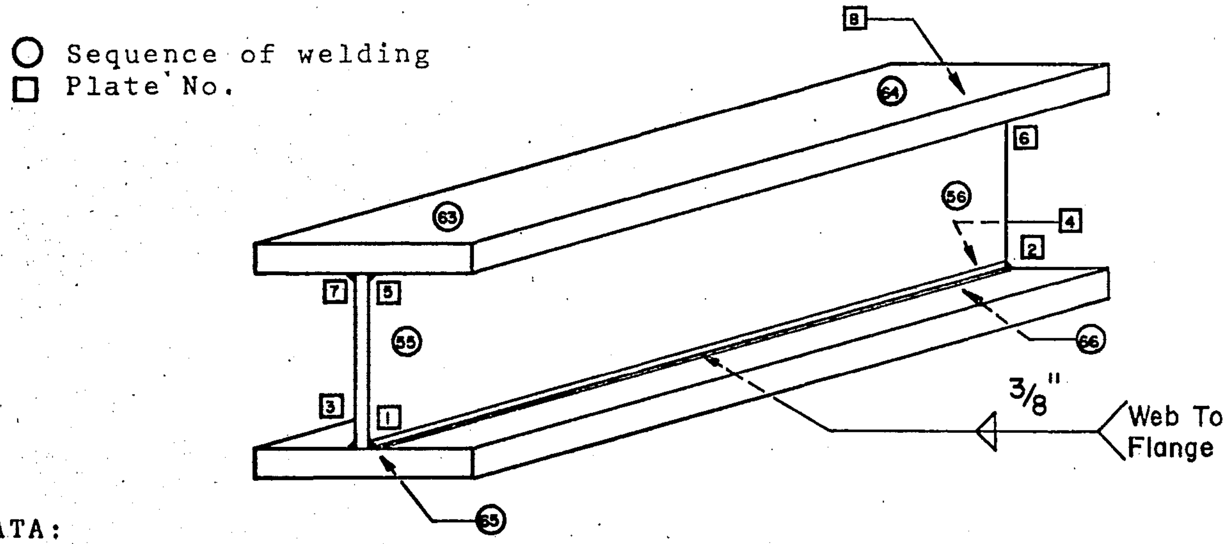
DIMENSIONS: FLANGES: 24" x 6" WEB: 12" x $3\frac{1}{2}$

LENGTH: 8'3"

PARENT PLATES NO.: FLANGES: 26222W WEB: 26221W

HEAT NO.: FLANGES: 477 W 3301 WEB: 477 W 3301

STEEL: ASTM A36



DATA:

PASS NO.	1-2	1-2	3-4	3-4	1-2
VOLTAGE (Volts)	34	33	33	34	33
CURRENT (Amperes)	430	410	420	410	420
STARTING TIME (sec.)	10:35:45	10:45:15	11:10:00 11:11:10	11:41:40	12:30:55
STOPPING TIME (sec.)			11:28:03 11:33:28	11:47:55	12:36:00
SPEED OF WELDING (in/min.)	22	16	16	16	16

REMARKS:

Speed of welding has been obtained by recording the time over ten inches gage length in the center of the member.

DATA SHEET NO.: 10 (Continued)

PASS NO.	1-2	3-4	5-6	5-6	7-8
VOLTAGE (Volts)	36	35	36	35	34
CURRENT (Amperes)	420	430	410	420	420
STARTING TIME (sec.)	12:41:50	1:06:20	1:14:40	1:23:40	3:45:10
STOPPING TIME (sec.)	12:47:20	1:13:35	1:18:00	1:29:00	
SPEED OF WELDING (in/min.)	15	15	22	16	16

PASS NO.	7-8	5-6	5-6	7-8	
VOLTAGE (Volts)	34	33	35	36	
CURRENT (Amperes)	410	400	420	400	
STARTING TIME (sec.)	3:56:10	4:22:00	4:36:15	4:51:50	
STOPPING TIME (sec.)					
SPEED OF WELDING (in./min.)	16	16	15	15	

DATA SHEET NO.: 11

PLATE SIZE: 20" x 2"

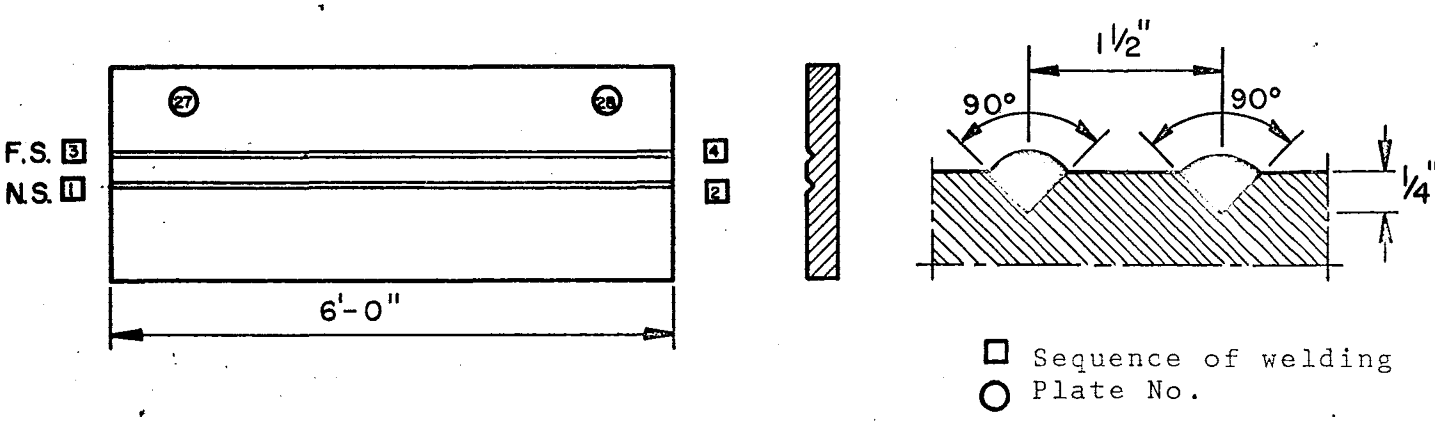
PARENT PLATE NO.: 25477W

HEAT NO.: 411 W 9731

CORRESPONDING SHAPE: 20 H 354

FABRICATOR REFERENCE NO.: H 354(FC) F-2

STEEL: ASTM A36



DATA:

PASS NO.	1-2	3-4	3-4	1-2	
VOLTAGE (Volts)	32	32	32	32	
CURRENT (Amperes)	420	420	440	440	
STARTING TIME (sec.)	7:15:00	7:25:00	7:35:12	7:40:22	
STOPPING TIME (sec.)	7:20:10	7:30:08	7:37:34	7:42:42	
SPEED OF WELDING (in/min.)	13.9	14.0	30.4	30.8	

REMARKS:

Preheating temperature equals 250°F near the welds, and 200°F at the edges, the nozzles were centrally located, 4 nozzles were used.

DATA SHEET NO.: 12

PLATE SIZE: 20" x 2"

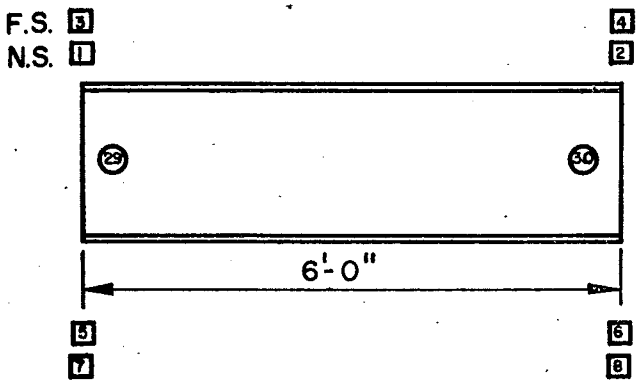
PARENT PLATE NO.: 25477W

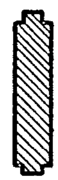
HEAT NO.: 411 W 9731

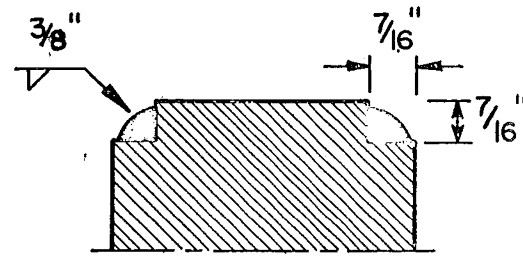
CORRESPONDING SHAPE: 20 H 354

FABRICATOR REFERENCE NO.: H 354(FC) F-3

STEEL: ASTM A36







☐ Sequence of welding
○ Plate No.

DATA:

PASS NO.	1-2	3-4	3-4	1-2	5-6
VOLTAGE (Volts)	32	32	32	34	34
CURRENT (Amperes)	410	410	410	390	410
STARTING TIME (sec.)	4:10:09	4:35:21	4:45:13	5:05:16	6:00:05
STOPPING TIME (sec.)	4:15:15	4:40:25	4:47:33	5:10:41	6:05:07
SPEED OF WELDING (in/min.)	14.1	14.2	21.6	13.3	14.3

REMARKS:

Preheating temperature = 300°F
Velocity of feed of electrode = 175 in/min, measured by observing how many times drum of electrodes rotates in 1 minute.

DATA SHEET NO.: 12 (Continued)

PASS NO.	7-8	7-8	5-6		
VOLTAGE (Volts)	32	32	32		
CURRENT (Amperes)	400	400	400		
STARTING TIME (sec.)	6:20:11	6:30:21	6:50:44		
STOPPING TIME (sec.)	6:25:20	6:33:41	6:53:09		
SPEED OF WELDING (in/min.)	14.0	21.6	32.0		

DATA SHEET NO.: 13

SHAPE: 20 H 354

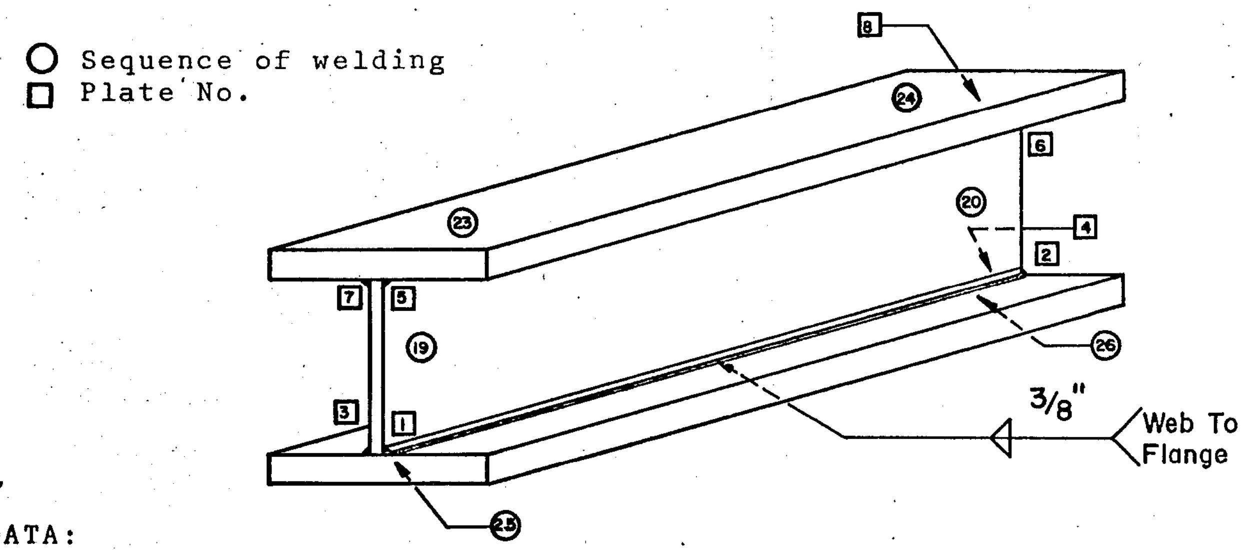
DIMENSIONS: FLANGES: 20 3/4" x 2" WEB: 16 3/4" x 1½"

LENGTH: 6'0"

PARENT PLATES NO.: FLANGES: 25477W WEB: 25478W

HEAT NO.: FLANGES: 411 W 9731 WEB: 411 W 9731

STEEL: ASTM A36



DATA:

PASS NO.	1-2	3-4	3-4	1-2	5-6
VOLTAGE (Volts)	32	32	34	34	32
CURRENT (Amperes)	410	410	400	400	410
STARTING TIME (sec.)					
STOPPING TIME (sec.)					
SPEED OF WELDING (in/min.)	14	14	30	30	14

REMARKS: Preheat temperature 150°F
One tack weld broke because of preheat was not uniform (lower part was heated up faster)
Speed of welding has been obtained by recording the time over ten inches gage length in the center of the member.

DATA SHEET NO.: 13 (Continued)

PASS NO.	6-7	6-7	5-6		
VOLTAGE (Volts)	32	34	34		
CURRENT (Amperes)	410	400	400		
STARTING TIME (sec.)					
STOPPING TIME (sec.)					
SPEED OF WELDING (in/min.)	14	30	30		

<u>DATA SHEET NO.:</u> 14

PLATE SIZE: 24" x 2"

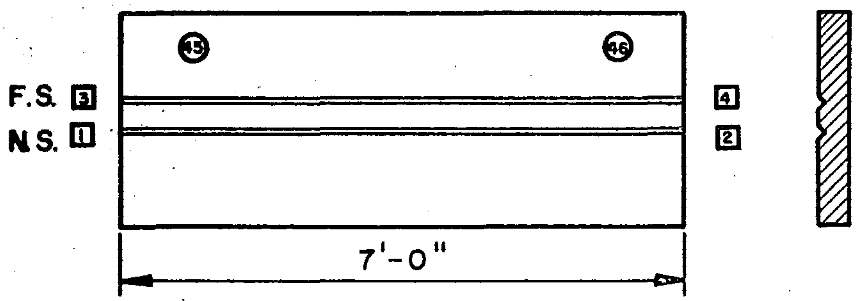
PARENT PLATE NO.: 25474W

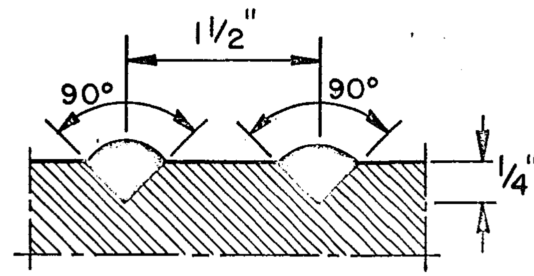
HEAT NO.: 411 W 9731

CORRESPONDING SHAPE: 24 H 428

FABRICATOR REFERENCE NO.: H 428(FC) F-2

STEEL: ASTM A36





□ Sequence of welding
○ Plate No.

DATA:

PASS NO.	3-4	1-2	1-2	3-4	
VOLTAGE (Volts)	33	33	33	33	
CURRENT (Amperes)	410	410	410	410	
STARTING TIME (sec.)	11:08:45	11:17:35	11:25:30	11:31:30	
STOPPING TIME (sec.)	11:13:25	11:22:10	11:28:15	11:34:10	
SPEED OF WELDING (in/min.)	18.0	18.3	30.6	31.4	

REMARKS:

Preheating temperature 200°F.

DATA SHEET NO.: 15

PLATE SIZE: 24" x 2" EW

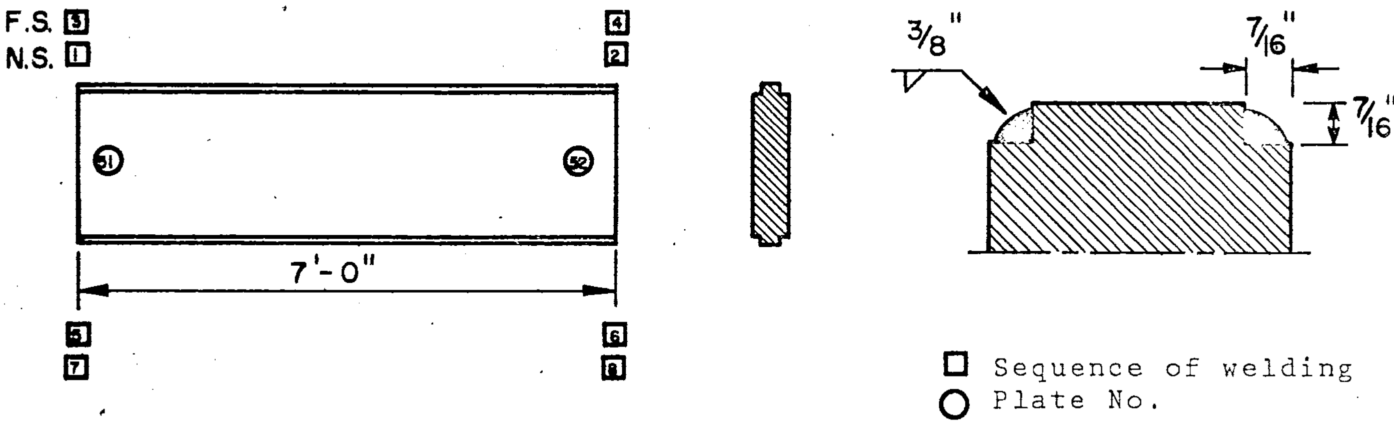
PARENT PLATE NO.: 25474W

HEAT NO.: 411 W 9731

CORRESPONDING SHAPE: 24 H 428

FABRICATOR REFERENCE NO.: H 428(FC) F-3

STEEL: ASTM A36



DATA:

PASS NO.	1-2	3-4	3-4	1-2	5-6
VOLTAGE (Volts)	35	35	35	34	34
CURRENT (Amperes)	400	390	400	410	400
STARTING TIME (sec.)	3:27:10	3:57:10	4:06:50	4:15:06	5:32:54
STOPPING TIME (sec.)	3:32:00	4:02:00	4:09:49	4:17:56	5:37:42
SPEED OF WELDING (in/min.)	17.4"	17.4"	28.2"	29.7"	17.5"

REMARKS:

Preheating: Constant temperature of 225°F.

DATA SHEET NO.: 15 (Continued)

PASS NO.	7-8	7-8	5-6		
VOLTAGE (Volts)	34	34	34		
CURRENT (Amperes)	410	430	410		
STARTING TIME (sec.)	5:44:24	5:52:36	6:24:06		
STOPPING TIME (sec.)	5:49:11	5:55:38	6:27:35		
SPEED OF WELDING (in/min.)	17.6	27.8	24.0		

DATA SHEET NO.: 16

PLATE SIZE: 24" x 2"

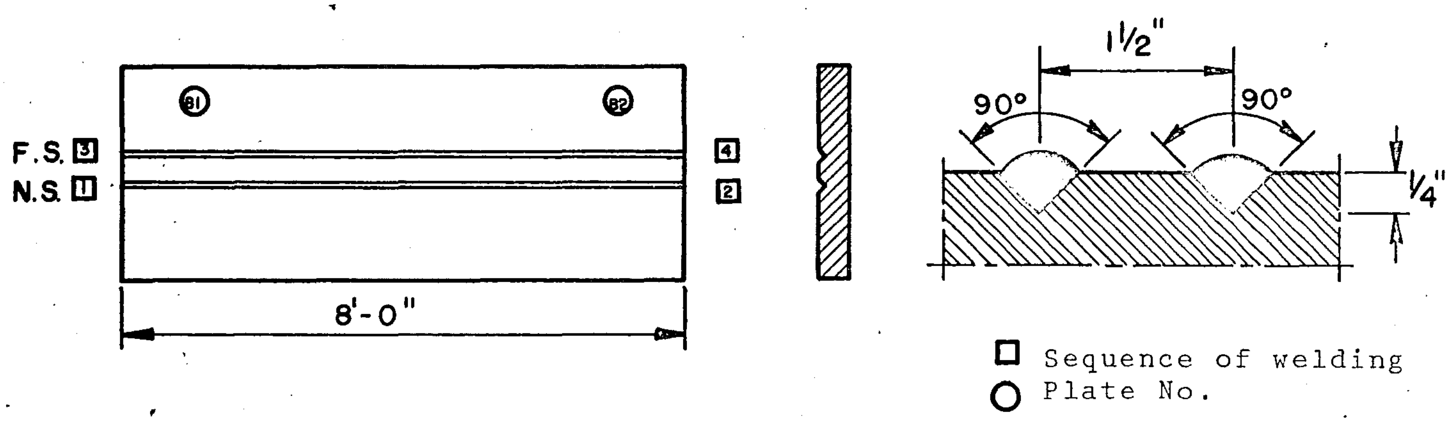
PARENT PLATE NO.: 26226W

HEAT NO.: 477 W 3301

CORRESPONDING SHAPE: 24 H 428

FABRICATOR REFERENCE NO.: H 428 (UM) F-5

STEEL: ASTM A36



DATA:

PASS NO.	1-2	3-4	3-4	1-2	
VOLTAGE (Volts)	34	34	36	36	
CURRENT (Amperes)	410	410	410	410	
STARTING TIME (sec.)					
STOPPING TIME (sec.)					
SPEED OF WELDING (in/min.)	15	15	18	18	

REMARKS:

Speed of welding obtained by measuring the time over ten inches gage length.

DATA SHEET NO.: 17

SHAPE: 24 H 428

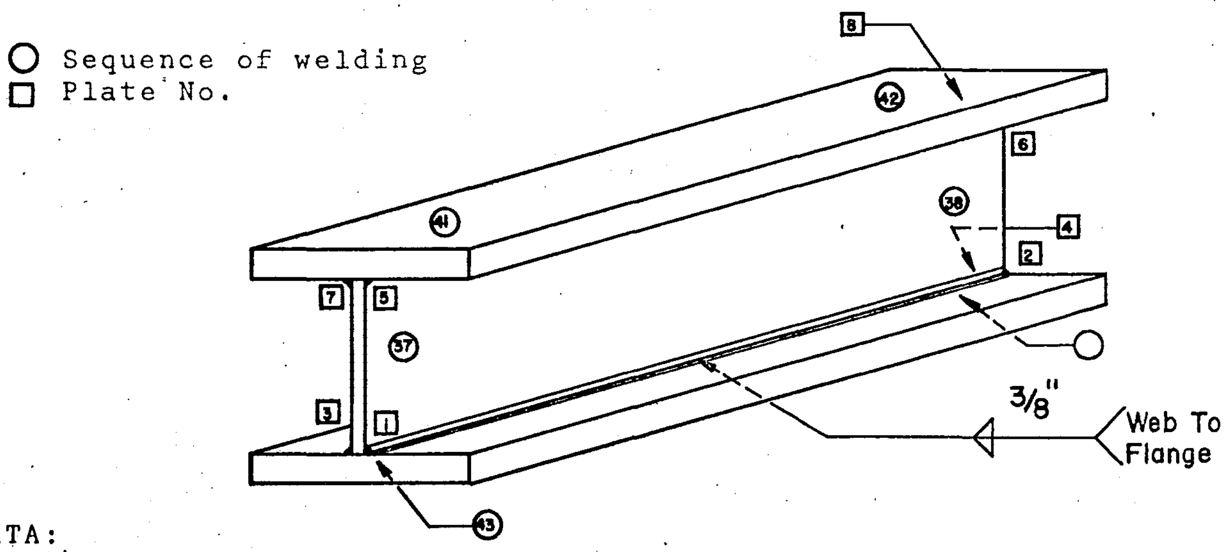
DIMENSIONS: FLANGES: 24" x 2" WEB: 20" x $1\frac{1}{2}$"

LENGTH: 7'0"

PARENT PLATES NO.: FLANGES: 25473W WEB: 25478W

HEAT NO.: FLANGES: 411 W 9731 WEB: 411 W 9731

STEEL: ASTM A36



DATA:

PASS NO.	3-4	1-2	1-2	3-4	5-6
VOLTAGE (Volts)	33	33	33	36	33
CURRENT (Amperes)	410	410	400	370	400
STARTING TIME (sec.)	9:50	10:20	10:30	10:49	11:24
STOPPING TIME (sec.)					
SPEED OF WELDING (in/min.)	16	16	30	30	16

REMARKS:

Shape has been preheated to a temperature greater than 225°F.

DATA SHEET NO.: 17 (Continued)

PASS NO.	7-8	7-8	5-6		
VOLTAGE (Volts)	32	34	34		
CURRENT (Amperes)	410	400	410		
STARTING TIME (sec.)	11:52:00				
STOPPING TIME (sec.)					
SPEED OF WELDING (in/min.)	16	30	30		

DATA SHEET NO.: 18

SHAPE: 24 □ 774

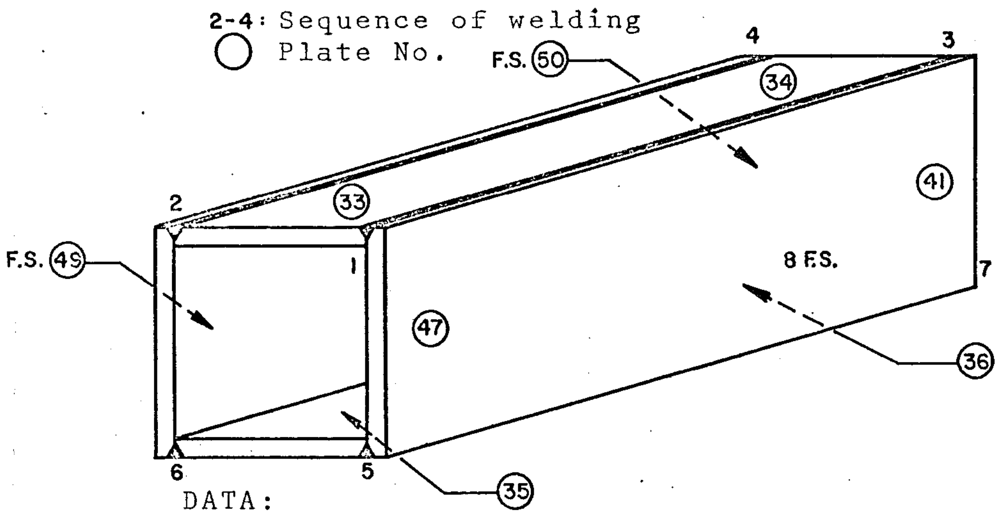
DIMENSIONS: FLANGES: 24" x 2" WEB: $20\frac{1}{4}$" x 2"

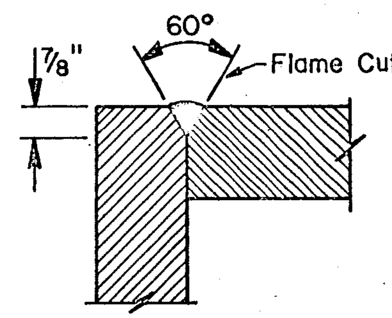
LENGTH: 7'3"

PARENT PLATES NO.: FLANGES: 25473W WEB: 25477W

HEAT NO.: FLANGES: 411 W 9731 WEB: 411 W 9731

STEEL: ASTM A36





ENLARGED DETAIL

DATA:

PASS NO.	1-3	2-4	2-4	1-3	1-3
VOLTAGE (Volts)	34	34	32	32	32
CURRENT (Amperes)	400	410	410	410	420
STARTING TIME (sec.)	1:09:55	1:41:40	2:00:23	2:11:47	2:23:26
STOPPING TIME (sec.)		1:45:08	2:04:26	2:16:02	2:27:22
SPEED OF WELDING (in/min.)		24".2"	21"	20"	21"

REMARKS: All grooves have been sealed with poor fit, (electrode 5/32" Ø E 7018).
Manual preheating gives unequal preheating around the bead (170°F).

PASS NO.	2-4	5-7	6-8	5-7	5-7
VOLTAGE (Volts)	32	31	32	34	33
CURRENT (Amperes)	420	410	410	410	400
STARTING TIME (sec.)	2:39:50	3:28:44	3:41:53	5:36:55	10:03:20
STOPPING TIME (sec.)	2:43:47	3:32:16	3:46	5:41:50	10:07:30
SPEED OF WELDING (in/min.)	21"	24"	20"	16½"	20"

PASS NO.	5-7	6-8	6-8	5-7	5-7
VOLTAGE (Volts)	33	34	34	33	33
CURRENT (Amperes)	410	410	410	410	410
STARTING TIME (sec.)	10:12:45	10:23:15	10:35:02	10:59:18	11:09:33
STOPPING TIME (sec.)	10:16:00	10:27:18	10:39:05	11:03:28	11:13:40
SPEED OF WELDING (in./min.)	26"	20 6/8"	20 6/8"	20"	20 3/8"

PASS NO.	6-8	6-8	5-7	5-7	6-8
VOLTAGE (Volts)	33	32	32	32	33
CURRENT (Amperes)	400	420	430	400	400
STARTING TIME (sec.)	11:27:25	3:49:07	3:59:34	4:18:25	4:26:00
STOPPING TIME (sec.)	11:27:30	3:53:26	4:03:47	4:24:05	4:30:53
SPEED OF WELDING (in./min.)	20 5/8"	19½"	20"	14 7/8"	17"

DATA SHEET NO.: 18 (Continued)

PASS NO.	6-8	6-8	5-7	5-7	6-8
VOLTAGE (Volts)	32	34	33	33	33
CURRENT (Amperes)	430	400	410	400	410
STARTING TIME (sec.)	4:34:55	4:46:20	5:22:10	5:29:29	11:33:34
STOPPING TIME (sec.)	4:38:37	4:50:23	5:26:26	5:34:15	11:37:38
SPEED OF WELDING (in/min.)	22 6/8"	21"	19"	17"	18.5

PASS NO.	1-3	1-3	2-4	2-4	1-3
VOLTAGE (Volts)	34	34	34	34	34
CURRENT (Amperes)	400	400	400	400	400
STARTING TIME (sec.)					
STOPPING TIME (sec.)					
SPEED OF WELDING (in./min.)	21"	20"	19"	20"	21"

PASS NO.	1-3	2-4	2-4	1-3	1-3
VOLTAGE (Volts)	34	33	33	34	34
CURRENT (Amperes)	400	410	400	390	410
STARTING TIME (sec.)	2:10	2:22:30	2:32	3:10	3:20
STOPPING TIME (sec.)	2:14	2:26	2:36		
SPEED OF WELDING (in./min.)	18.8	21.4	18.8		

DATA SHEET NO.: 18 (Continued)

PASS NO.	1-3	1-3	2-4	2-4	
VOLTAGE (Volts)	34	33	33	33	
CURRENT (Amperes)	410	410	420	420	
STARTING TIME (sec.)					
STOPPING TIME (sec.)					
SPEED OF WELDING (in/min.)	20"	20"	20"	20"	

8. REFERENCES

1. G. A. Alpsten, and L. Tall
   RESIDUAL STRESSES IN HEAVY WELDED SHAPES,
   Fritz Laboratory Report No. 337.12,
   January, 1969.

2. AWS SPECIFICATIONS, Code for Welding
   in Building Construction, 8th Edition,
   AWS DI 0.66 (1966).