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January 31, 1952

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ABSTRACT

Spot welds were made in 1/16-inch-thick Ames thorium sheet over a range of welding conditions. Various conditions produced satisfactory welds, but a 2-impulse cycle with postheat or current decay and variable pressure gave the best results. Ultimate loads of 1750 to 1850 pounds in tension shear were consistently attained with these conditions. No difficulty was encountered with cracking of the welds in 1/16-inch sheet. There was some indication that cracking might present a problem in welding thicker thorium sheet.

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INTRODUCTION

Spot welding of Ames thorium was investigated as part of the program on joining thorium, which was part of a broad research program to develop the technology of thorium. Tests were made to determine the proper welding conditions and the effects of varying welding time, pressure, and current pattern on the strength of spot welds in thorium sheet.

MATERIALS AND EQUIPMENT

The test program employed 1/16-inch-thick thorium sheet which was fabricated at Battelle from Ames ingot Number A-217. Analysis of this ingot is given in Table 1. After forging and hot rolling at 790 C to 1/8-inch sheet, the material was cold rolled to 1/16-inch thickness.

A few preliminary welding tests were made with hot-rolled 1/8-inch thorium sheet. No information on the composition of this material was available.

A 200-kva, 60-cycle, alternating-current, frequency-converter-type spot welder, shown in Figure 1, was used for all welding. The electrodes were Class 1 alloy with a 3-inch spherical radius.

EXPERIMENTAL WORK

Previously reported investigations on tungsten-arc welding of thorium (BMI-721) showed that Ames thorium was very likely to crack during welding operations. It was expected that spot welds in this material might also crack. This was partially confirmed by the few tests made on 1/8-inch-thick sheet(1). However, no cracking was observed in any of the welds made on 1/16-inch-thick sheet. While cracking might be more of a problem in spot welding thicker sheets, it is believed that the use of high forging pressure and postheat would eliminate it.

(1) Welded with 20,000 amperes, 2000 pounds constant pressure, and no postweld treatment.

TABLE 1. ANALYSIS OF AMES THORIUM INGOT NUMBER A-217[1]

Constituent	ppm
O_2	1300
C	1400
Al	100 to 1000
Be	225
Fe	200
Ni	121
Cu	10 to 120
S	< 100
N	80
Cr	72
Si	38
H_2	< 20
Mo	10
Mg	8
Mn	3
Pb	3
B	0.6
Cd	< 0.2

Sheets 1/16" x 1" x 2-1/2" were welded together with a 1-inch overlap, as shown in Figure 2. The sheets were wire brushed immediately before welding. This method of surface preparation proved satisfactory and good welds were obtained without any shielding from the air. The finished specimens were tested in tension-shear at a platen speed of approximately 0.02 inch per minute.

Welding conditions for Process A titanium of the same thickness were selected for the initial welds. These conditions were the only ones available for material similar to thorium. Series of tests were made in which all but one of the welding conditions were held constant.

Tension-shear loads as high as 2050 pounds were obtained at some conditions, but these were not deemed ideal since the electrodes stuck

(1) Marsh, L. L., and Keeler, J. R., "The Technology of Thorium", BMI-76, July 6, 1951.

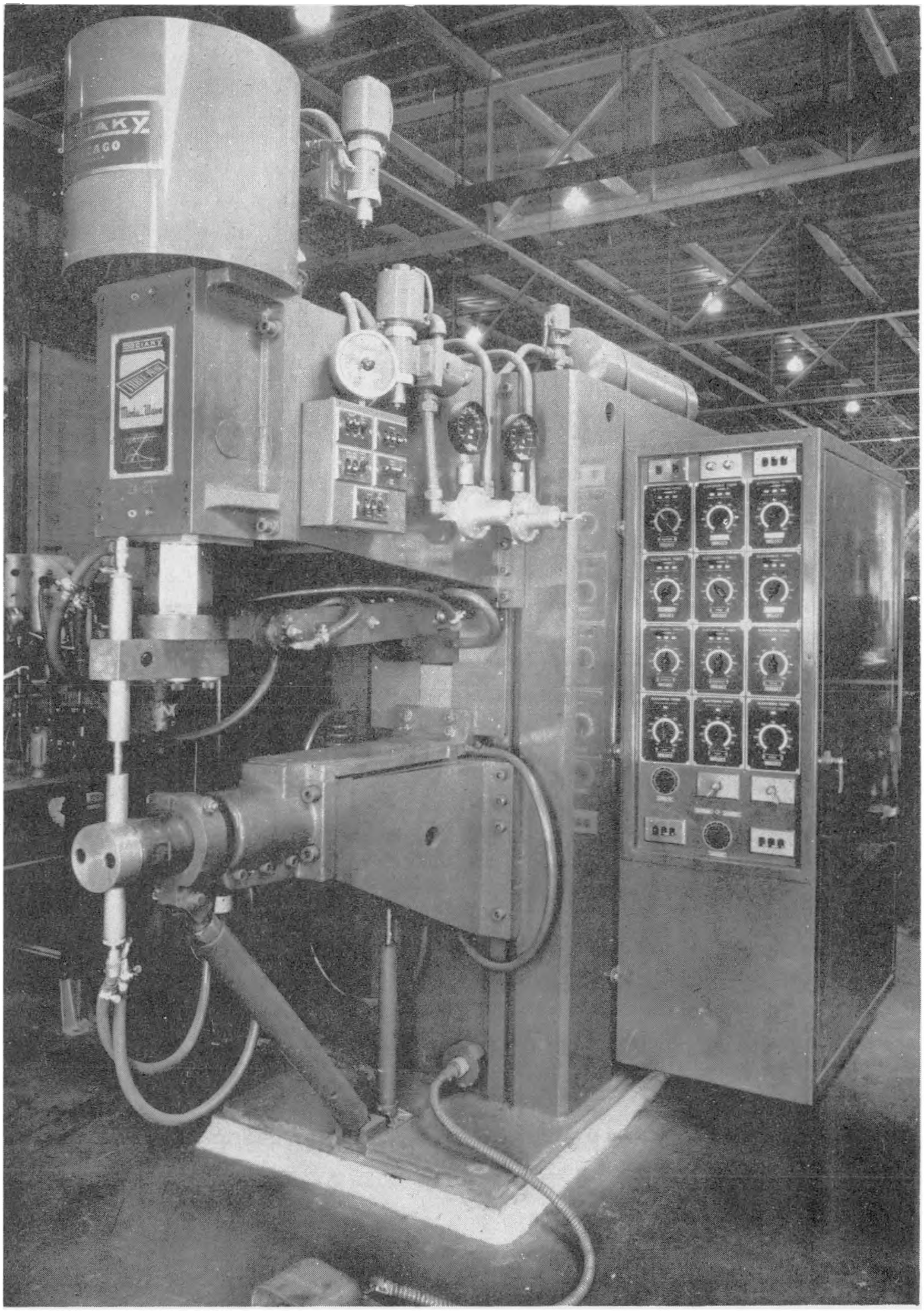

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FIGURE 1. 200-KVA SPOT WELDER

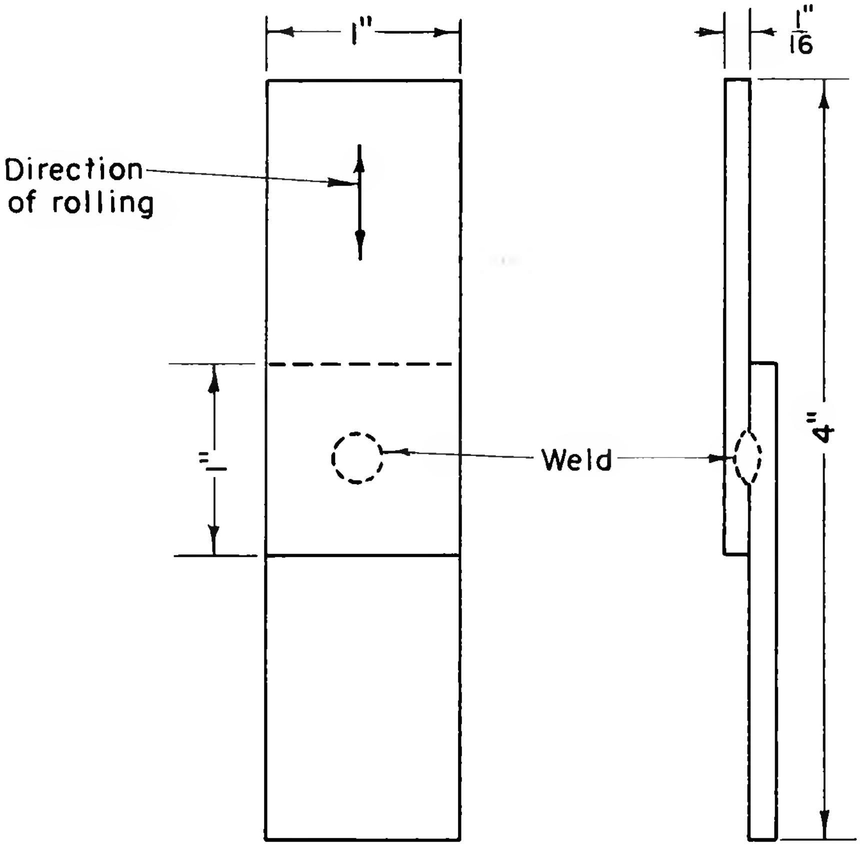

FIGURE 2. TENSION-SHEAR TEST SPECIMEN

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to the specimens. The final conditions selected are listed in Table 2, and are represented graphically in Figure 3. These conditions consistently gave ultimate loads between 1750 and 1850 pounds. Spot diameters in all tests were from 3 to 4 times the thickness of the sheet.

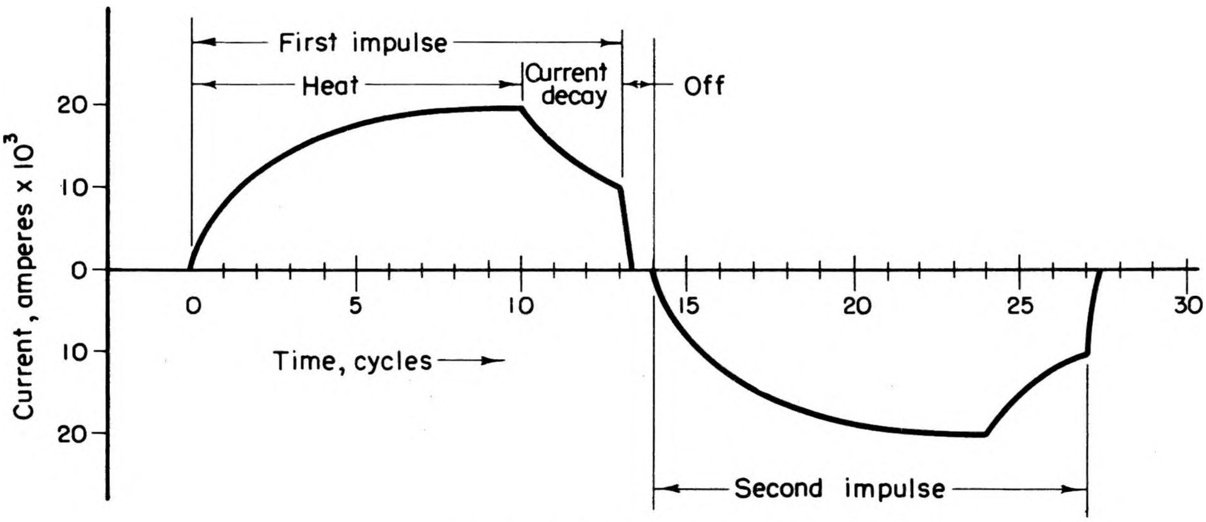
TABLE 2. WELDING CONDITIONS FOR 1/16-INCH-THICK AMES THORIUM

Pressure	
Welding force, pounds	- 1200
Forging force, pounds	- 2200
Weld	
Number of impulses	- 2
Heat time, cycles	- 10
Cool time, cycles	- 1
Current, amperes	- 20,000 (estimated)
Current Decay*	
Time, cycles	- 3
Current, amperes	- 10,000 (estimated)
Postheat*	
Number of impulses	- 3
Time, cycles	- 10
Current, amperes	- 10,000
Quench time, cycles	- 45

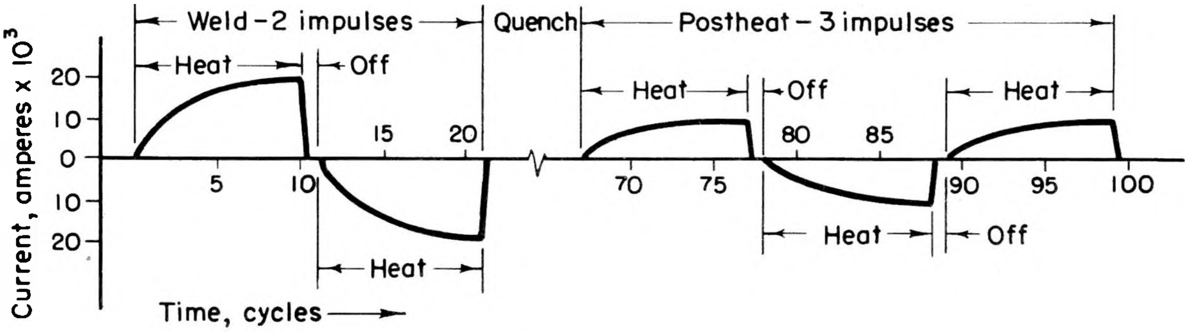
* Either current decay or postheat used, but not both.

Welding Variables

Pressure, heat input, and postheat were the only welding variables considered in this investigation. Discussion of the effect of each of these follows.



Weld With Current Decay



Weld With Postheat

FIGURE 3. SPOT-WELDING CYCLES FOR AMES THORIUM

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Pressure

Constant- and variable-pressure cycles both were used during the tests. Strength of the welds was not affected by changing from one pressure system to the other. Variable pressure was selected as being the best, since it was believed that it would be more effective in preventing cracking in thicker sheet.

Heat Input

The heat input to the weld can be changed by changing the current, the number of cycles, or the number of impulses. Increasing any one of these factors resulted in an increase in the ultimate strength. The practical limit for experimental work was two impulses of ten cycles (maximum number of cycles) each at 20, 000 amperes. Further increases in the current or the number of impulses caused the sheet to stick to the electrodes.

Postheat

Originally, postheat and current-decay cycles were tested because it was felt they might prevent cracking. Both cycles increased the ultimate strength approximately 100 pounds above the values of welds made with the same welding conditions but without any postheat cycle. For this reason, the postweld cycles were retained even after it became apparent that cracking was not a problem in welding 1/16-inch sheet.

Hardness Surveys

Vickers hardness surveys were made on transverse sections cut through the center of the welds. Changes in the welding conditions had no significant effect on the hardness readings. Figure 4 shows a hardness survey on a typical weld section.

Metallography

Metallographic examinations of transverse sections cut through the center of the welds showed no variation of structure with changes in the welding conditions. Figure 5 shows the microstructure of the fusion zone of a typical weld section. Carbide inclusions present in Ames thorium appear to collect along the fusion line of the spot welds.

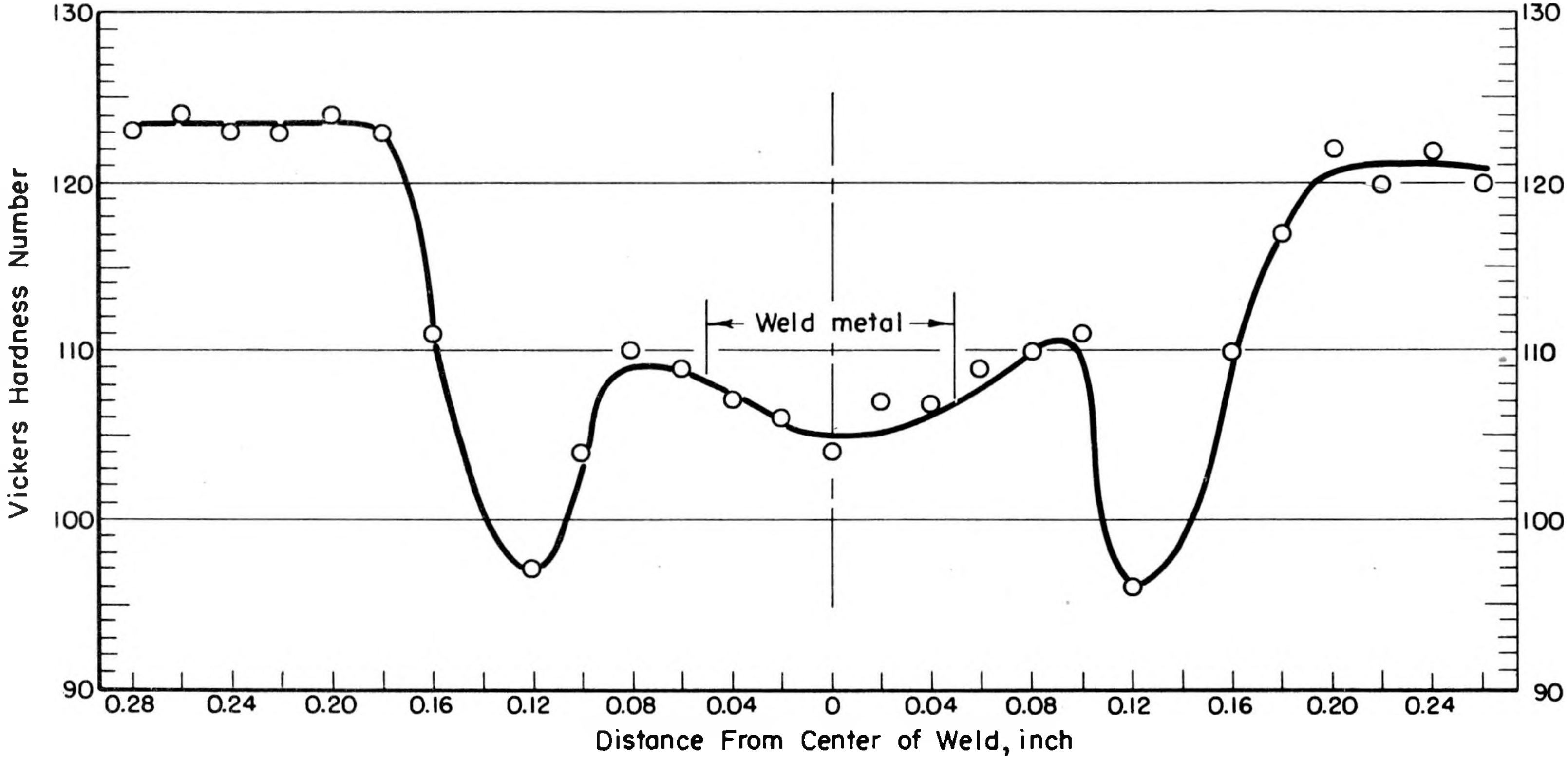

FIGURE 4. HARDNESS SURVEY ON AMES THORIUM SPOT WELD
(Welding conditions as given in Table 2, no postheat or current decay)

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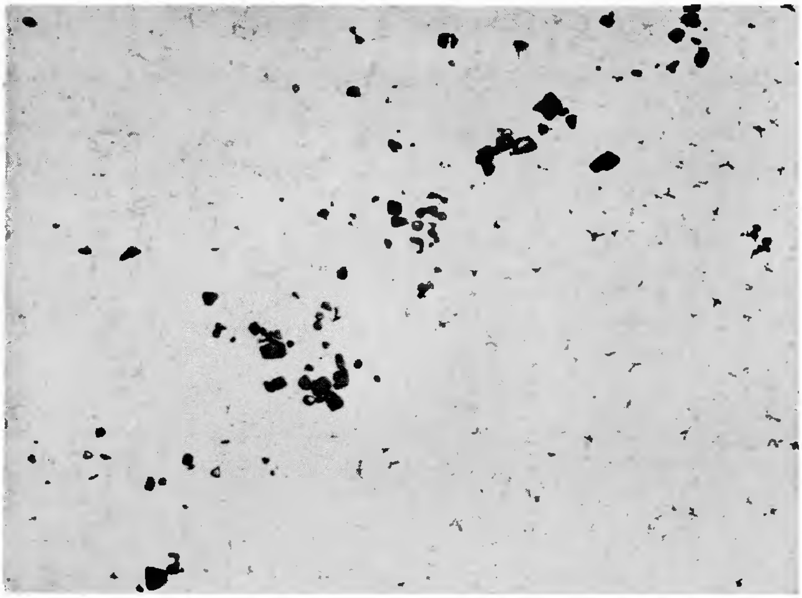
Heat-Affected Zone

Fusion Line



Weld Metal

250 X As Polished 83899

FIGURE 5. FUSION ZONE OF AMES THORIUM SPOT WELD

Welding Conditions As Given In Table 2, With Current Decay

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