DP - 185

Radiation Effects on Reactor Materials

AEC Research and Development Report

SHEARING IRRADIATED URANIUM PLATES

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W. S. Delicate, E. J. Osterman, and C. W. Zeh

Pile Engineering Division

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SHEARING IRRADIATED URANIUM PLATES

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Preliminary work on contamination by

W. T. Withers

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ABSTRACT

Natural uranium plates that were irradiated to 600 and 1500 MWD/T were cut under water by a guillotine-type shear. Irradiation reduced the force required for shearing to 50 per cent of that required for unirradiated uranium. Measurements were made of radioactivity released to treated and untreated water in which the cut sections were stored.

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

SHEARING IRRADIATED URANIUM PLATES

INTRODUCTION

This report describes experiments to determine the feasibility of cutting irradiated plates of natural uranium and to measure the amount of activity released when the cut sections are stored in water.

SUMMARY

Three aluminum clad plates of natural uranium that were irradiated to 600 and 1500 MWD/T were cut easily to short lengths with a guillotine-type shear. The maximum force required to cut an irradiated plate 0.180 inch thick by 3.1 inches wide was 18,000 pounds, which is less than half of the 41,000 pounds required for unirradiated material. Crumbling of the plate was reduced to an average of 1.4 grams of fragments per cut by employing a near-vertical shearing action rather than the scissors-type action of standard portable shears.

Approximately 100 microcuries of activity were released from one cut surface during a 24-hour storage period in 2.5 liters of water at 23°C. During an identical storage period in one per cent sodium dichromate solution, only half as much activity was released. About 0.17 microcurie of activity was released to 156 liters of air above the surface of the water and 0.02 microcurie of activity was released above the sodium dichromate solution.

SHEARING TESTS

THE URANIUM PLATES

Shearing tests were performed in the High Level Caves of the Savannah River Laboratory on three uranium plates that had been irradiated in the Materials Testing Reactor at Arco, Idaho and stored four to six months. The dimensions of the plates are shown in Figure 1.

The natural uranium cores were fabricated by rolling in the alpha phase at about 600°C.[1] The uranium was then beta transformed by heating in salt at 720°C for four minutes. Of the plates that were sheared, Plates Nos. 83 and 85 were beta transformed. Beta transformation of Plate No. 114 was omitted to test the behavior of the as-rolled core.

The plates were clad with about 0.022 inch of aluminum by mechanically pressing aluminum sheaths on nickel-plated cores at a pressure of 8,000 pounds per square inch for ten minutes at 510°C. The average strength of the bond between the cladding and the uranium ranged from 7,000 to 14,000 pounds per square inch.

EQUIPMENT ARRANGEMENT

The plates were sheared in a "Plexiglas" tank containing approximately 30 gallons of water at about 23°C. A schematic drawing of the equipment is shown in Figure 2 and a photograph in Figure 3. Pumps, gauges, and auxiliary equipment were located outside the cave. A standard hydraulic shear, Model S54-164E, built by the Manco Mfg. Co. was used with a modified shear blade as shown in Figure 4. In addition, a hydraulic cylinder was installed to hold the plate firmly in place. Cut pieces were caught by the fingers of a General Mills manipulator or dropped into a wire basket.

MAXIMUM FORCES REQUIRED TO SHEAR URANIUM PLATES

The maximum shearing force required to cut an irradiated uranium plate 0.180 inch thick and 3.1 inches wide was 18,000 pounds with the modified shear blade. This force of 18,000 pounds, which compared to 41,000 pounds for unirradiated uranium of the same size and metallurgical treatment, indicates that irradiation to high levels reduces the shear strength of uranium to less than one-half its unirradiated strength. The table on page 9 shows the forces required for various cuts.

In all cases, the uranium core of the irradiated plate broke under the pressure of the shear blade. The only evidence of true shearing action was the penetration of the blade in the aluminum cladding.

FRAGMENTATION OF THE URANIUM CORE

Sections of two plates that were cut with the modified shear blade are shown in Figures 5 and 6. The total weight of fragments from seven cuts on Plate No. 83 was 9.9 grams. These fragments are shown in Figure 7. After six cuts through Plate No. 114, 5.8 grams were found. With the scissors action obtained from the original shear blade, the cut pieces from Plate No. 85 as shown in Figure 8 produced 7.0 grams of fragments from three cuts. Pieces cut as short as 1.5 inches in length curled down, ripped through the aluminum sheath, and broke into large chunks as shown in Figure 9.

CONTAMINATION OF EQUIPMENT

The frame used to support the plates during cutting was contaminated to a radiation level of 1 r/hr at three inches. Before the shear was cleaned, an ionization chamber at an effective distance of three inches from the shear indicated a radiation level of 24 rep/hr. After the shear was cleaned, the radiation level was 30 mrep/hr.

A few fragments of uranium were scattered over a table in the cave where cut specimens were handled for inspection and photography; these fragments presented the major clean-up problem in the cave. The radiation level three inches from the fragments on the table top ranged from 400 mr/hr to more than 5 r/hr. No airborne activity was detected.

TESTS FOR ACTIVITY RELEASED BY CORROSION

EQUIPMENT ARRANGEMENT

The apparatus for measuring corrosion consisted of a four-liter round-bottom flask with three side arms; one arm was used for withdrawing liquid samples and the other two connected the flask to a recirculating gas loop. The gas loop consisted of a pump and rotameter, a filter to remove solid material, cold trap to freeze out entrained liquid, and a gas monitoring tube. The gas monitoring tube was a two-liter glass bulb into which two Geiger tubes were placed. For corrosion specimens from Plate No. 85, a Kanne Chamber was also used to measure activities.

ACTIVITY SAMPLING TECHNIQUES

Liquid samples were withdrawn from the storage flask daily, evaporated to dryness, and counted in calibrated counters for alpha, beta, and gamma activities. Since the liquid samples were evaporated to dryness before counting, the activity due to dissolved gases was not counted. Some of the samples were also analyzed for uranium.

ACTIVITY RELEASED TO LIQUIDS

In Experiment 1, two pieces of Plate No. 85, irradiated to 1500 MWD/T, were placed in disassembly basin water. In Experiment 2a, one piece of Plate No. 114 irradiated to 600 MWD/T was placed in tap water.

In Experiment 2b, one piece of Plate No. 114 was placed in a one per cent sodium dichromate solution. In Experiment 3a, two pieces of Plate No. 83 irradiated to 1500 MWD/T were placed in tap water and in Experiment 3b, two pieces were placed in a one per cent solution of sodium dichromate. The results are presented in Figure 10.

The curves, which represent the activity released to the water per cut surface as a function of time, for Experiments 2a and 3a were almost identical. This result suggests that (1) the dispersible fission product activity in the uranium had reached saturation somewhere below an irradiation of 600 MWD/T, as the cooling times of the plates were approximately the same; and (2) the amount of fission products released to the water depended upon the surface area exposed to water. In Experiment 1 the exposed surface area was much greater than in Experiments 2a and 3a and the activity released per cut surface was much larger.

A comparison of the uranium analyses and alpha counts in samples of the water showed that other alpha emitters were present in the water in addition to uranium.

ACTIVITY RELEASED TO THE AIR

In Figure 11 the airborne activities released in Experiments 1 and 2 are plotted as functions of time. The plot was based on the assumption of a one per cent counting efficiency and geometry, since no equipment was available to calibrate the gas monitoring tube. The difference between the amount of activity released in the two experiments may be the result of the difference in the exposed surface area, the difference in the exposure level, or a combination of both.

The activity released to the air was definitely gaseous. The filter, which would remove solid particles and entrained liquid, and the cold trap, which would remove condensable vapors, contained no activity. The nature of the airborne activity could not be firmly established. Samples of sufficient strength for pulse height analysis could not be obtained. In Experiment 1 the gas monitoring tube was isolated and the activity decay was followed for two weeks. A half life of 5.2 days was observed. The Kanne Chamber was also isolated and the decay of the activity was monitored for nine months. Activities with half lives ranging from 36 to 58 days were observed. There was no evidence of any short-lived activities.

ACTIVITY RELEASED IN SODIUM DICHROMATE SOLUTION

In one per cent sodium dichromate solution, the activity released to the liquid and to the gas was considerably less than that released from samples placed in water alone (see Figures 10 and 11). Over long storage periods the activity in the liquid decreased. This decrease in activity was accompanied by the formation of a dark precipitate of undetermined composition.

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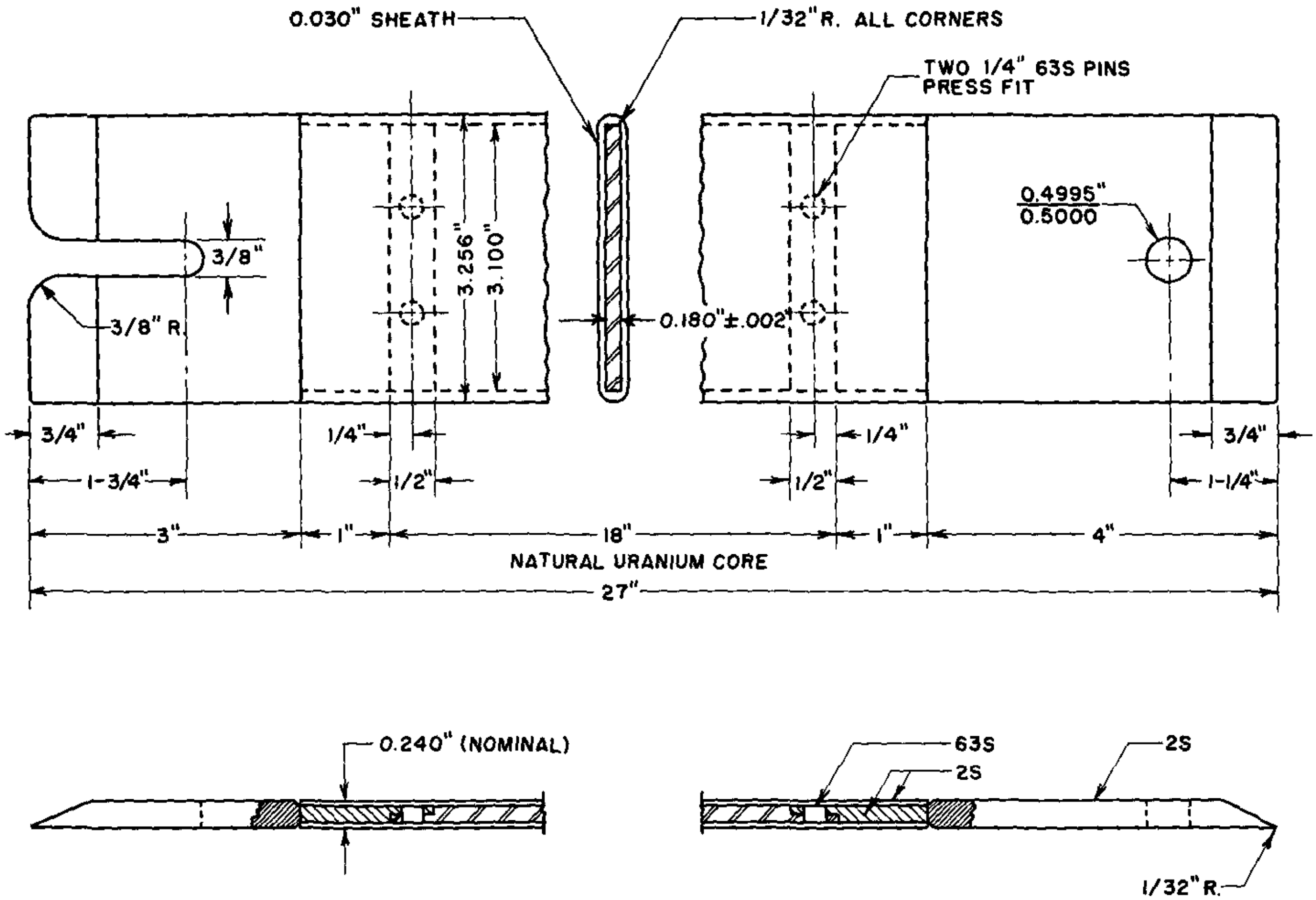
SHEARING TESTS OF URANIUM PLATES

Plate No.	How Fabricated	Irradiation Level MWD/T	Shearing Force Pounds	Grams of Fragments/Cut	No. of Cuts	Shear Blade	Length of Pieces Cut Off, in.
85	Alpha-Rolled Beta-Transformed	1500	4,000-6,000	2.3*	7	Original	1.5-7.25
83	Alpha-Rolled Beta-Transformed	1500	16,400-18,000	1.4	7	Modified	2-7.5
114	Alpha-Rolled	600	15,400-17,800	1	6	Modified	1.5-8
	Alpha-Rolled Beta-Transformed	Not Irradiated	11,000	Negligible	4	Original	2-3
	Alpha-Rolled Beta-Transformed	Not Irradiated	41,000	Negligible	4	Modified	2-3
2S Aluminum (end caps)		Not Irradiated	5,000	None	2	Original	3-3.5
2S Aluminum (end caps)		Irradiated	6,000	None	2	Original	3-3.5
2S Aluminum (end caps)		Not Irradiated	8,400	None	2	Modified	3-3.5
2S Aluminum (end caps)		Irradiated	9,000	None	2	Modified	3-3.5
Hot Rolled Steel (0.25 in. x 3.25 in.)	As-Rolled	Not Irradiated	10,000	None	6	Original	1-3
Hot Rolled Steel (0.25 in. x 3.25 in.)	As-Rolled	Not Irradiated	33,000	None	6	Modified	1-3

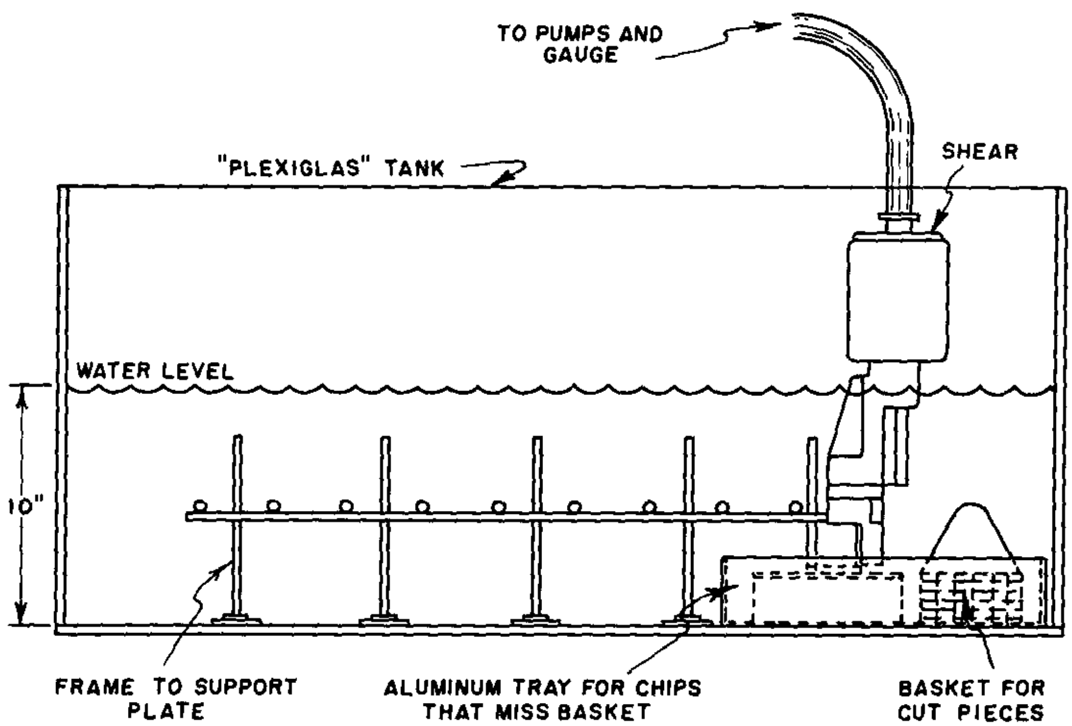
* Weight of fragments from first 3 cuts to shear long specimens. Subsequent 4 cuts broke short-length specimens into as many as four large pieces.

FIGURE 1



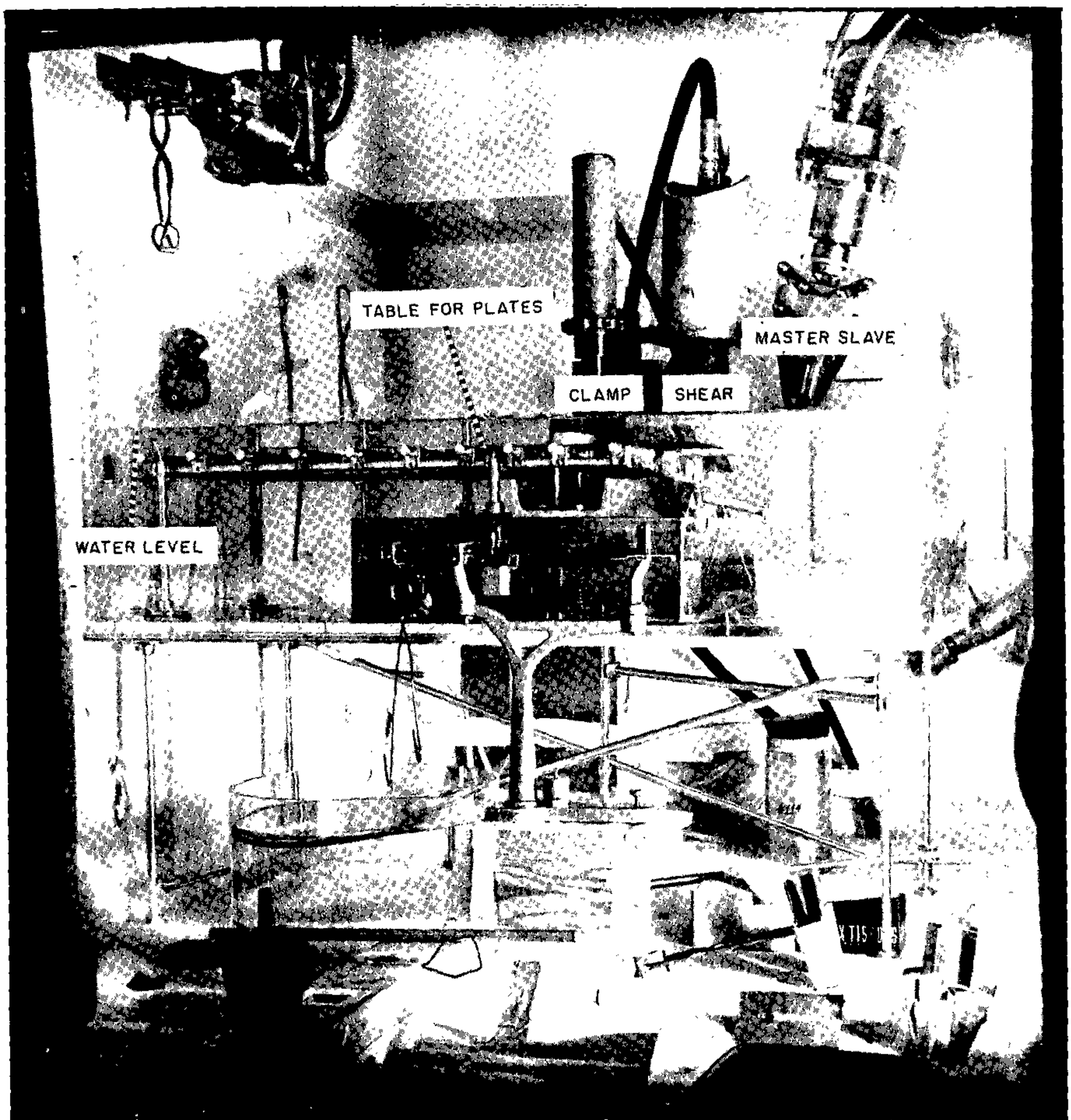
URANIUM PLATE ASSEMBLY

FIGURE 2



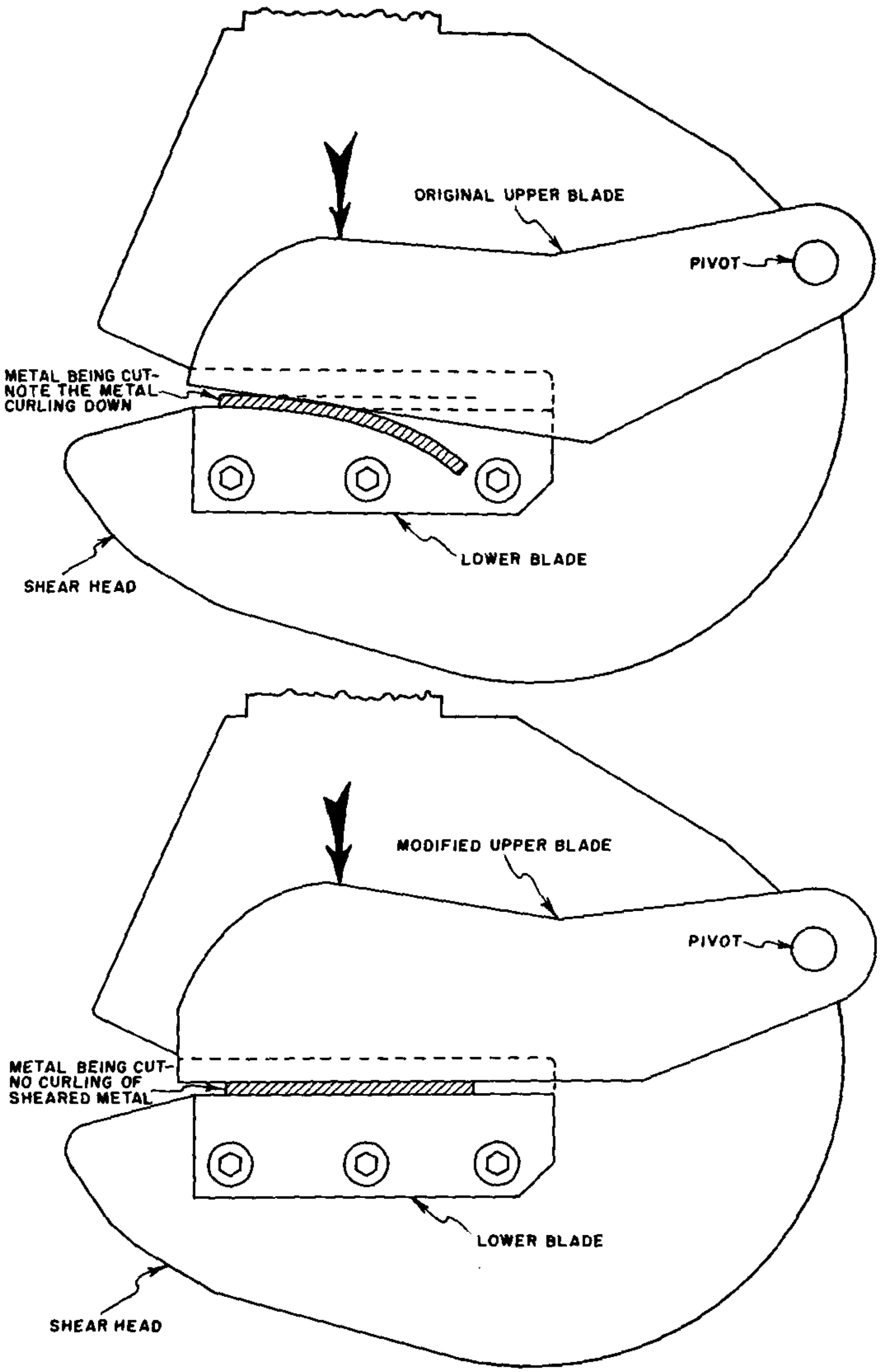
EQUIPMENT ARRANGEMENT INSIDE HIGH LEVEL CAVE

FIGURE 3



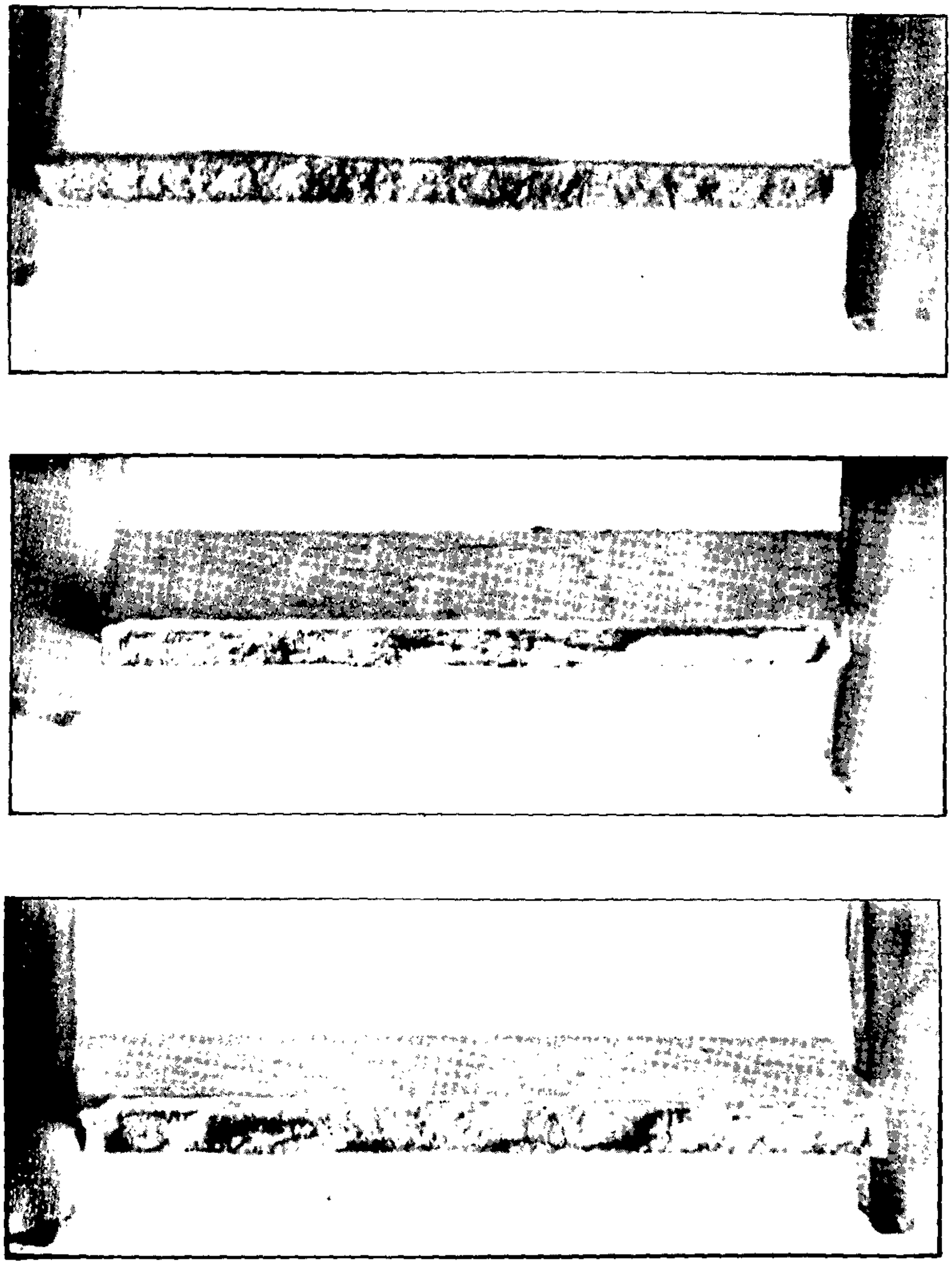
EQUIPMENT ARRANGEMENT

FIGURE 4



ORIGINAL AND MODIFIED SHEAR BLADES

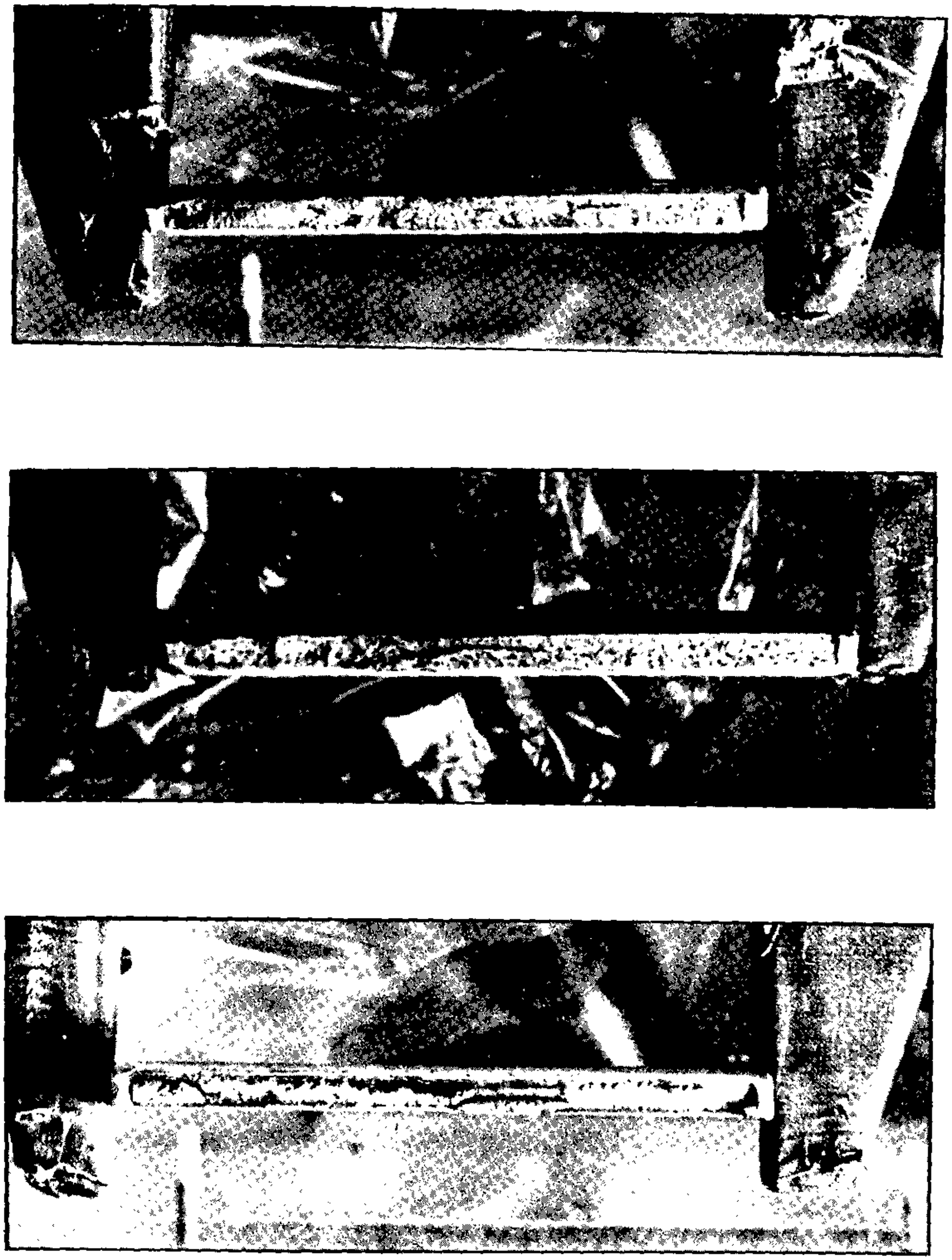
FIGURE 5



SECTIONS CUT FROM PLATE NO. 83

ALPHA-ROLLED, BETA-TRANSFORMED IRRADIATED TO 1500 MWD/T

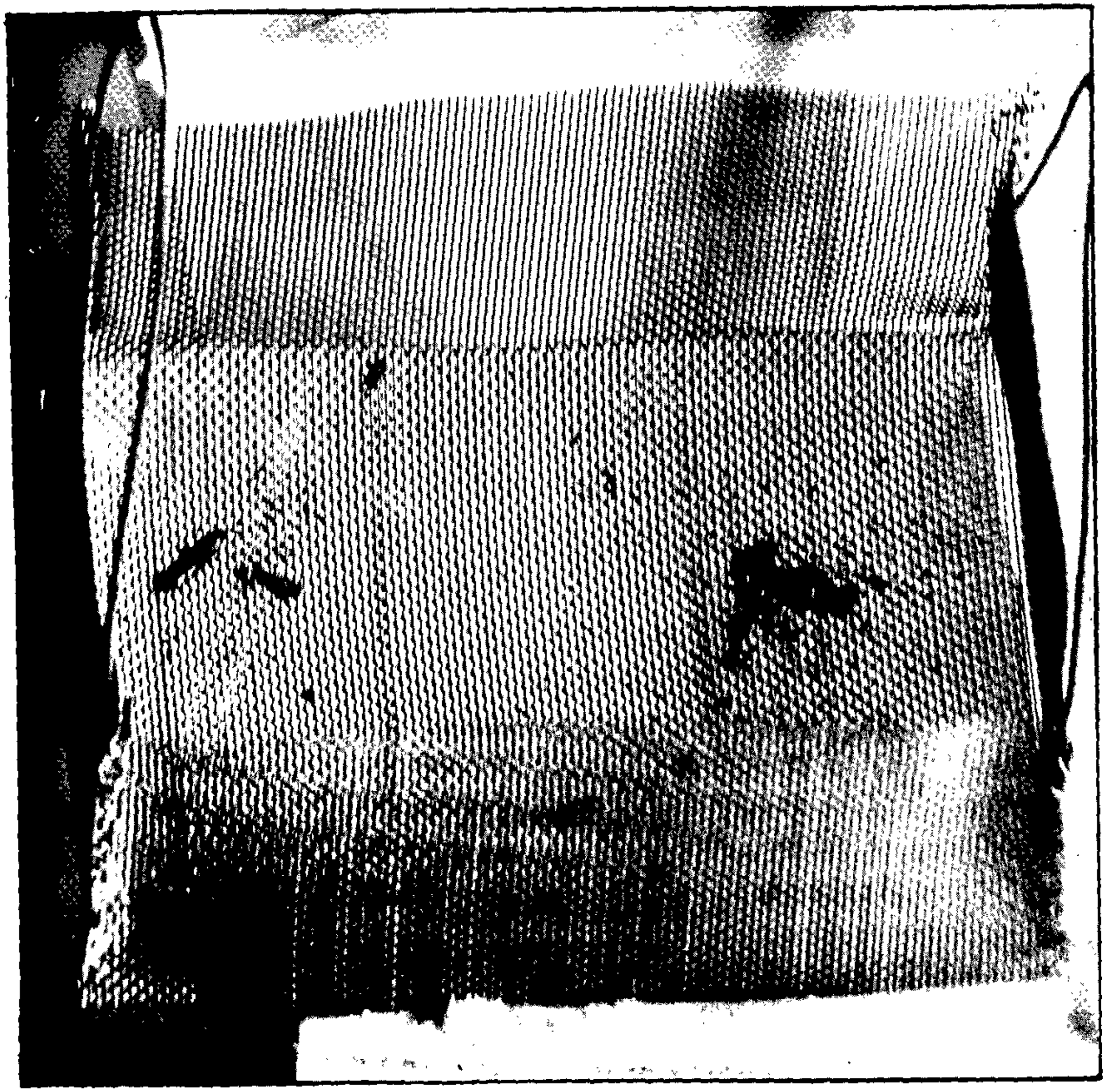
FIGURE 6



SECTIONS CUT FROM PLATE NO. 114

ALPHA-ROLLED IRRADIATED TO 600 MWD/T

FIGURE 7



FRAGMENTS FROM SEVEN CUTS-PLATE NO. 83

(TOTAL WEIGHT-9.9 GRAMS)

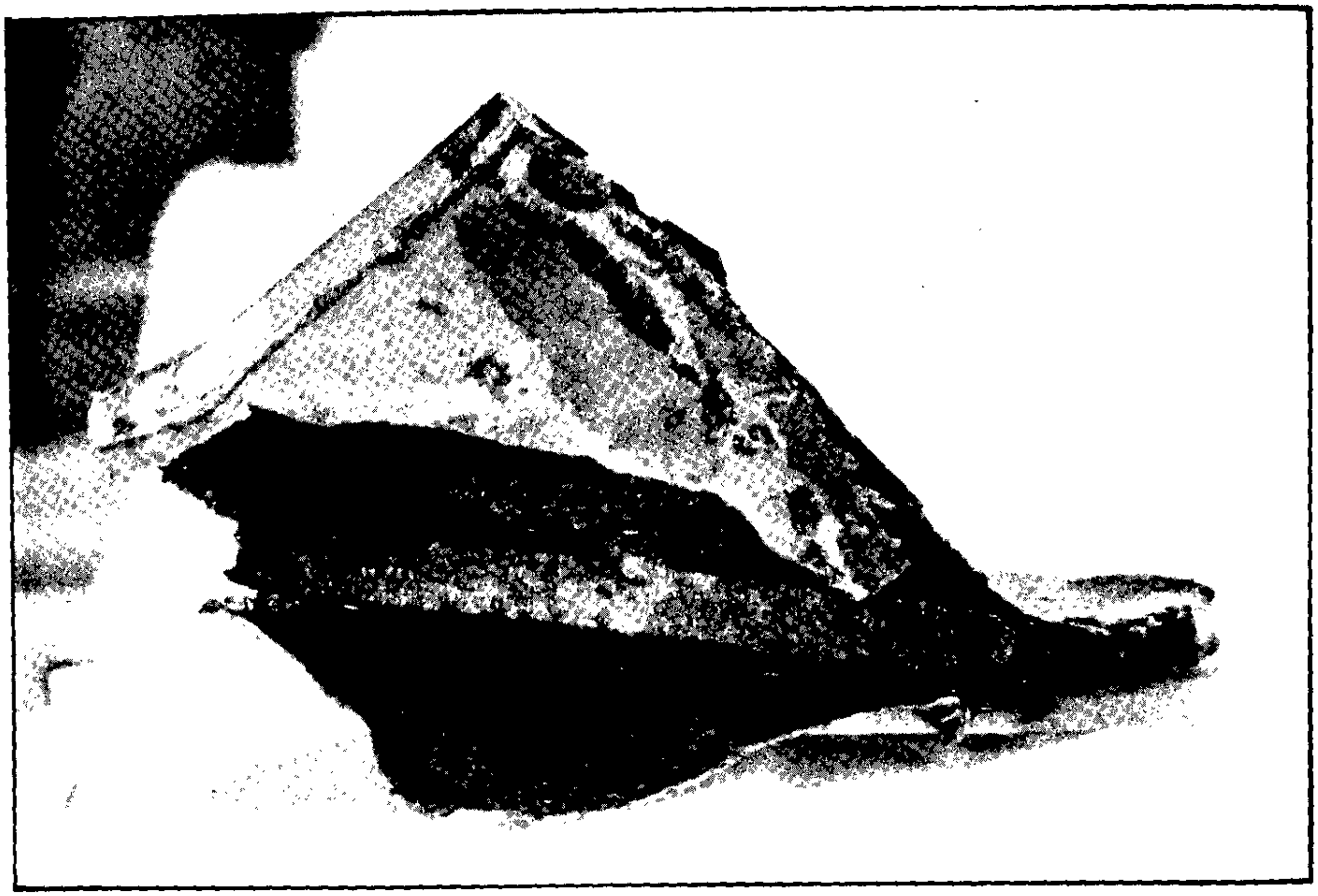
BOTTOM OF BASKET WAS COVERED
WITH WATERPROOF TAPE TO RETAIN SMALL FRAGMENTS

FIGURE 8

SECTIONS CUT FROM PLATE NO. 85

ALPHA-ROLLED, BETA-TRANSFORMED IRRADIATED TO 1500 MWD/T

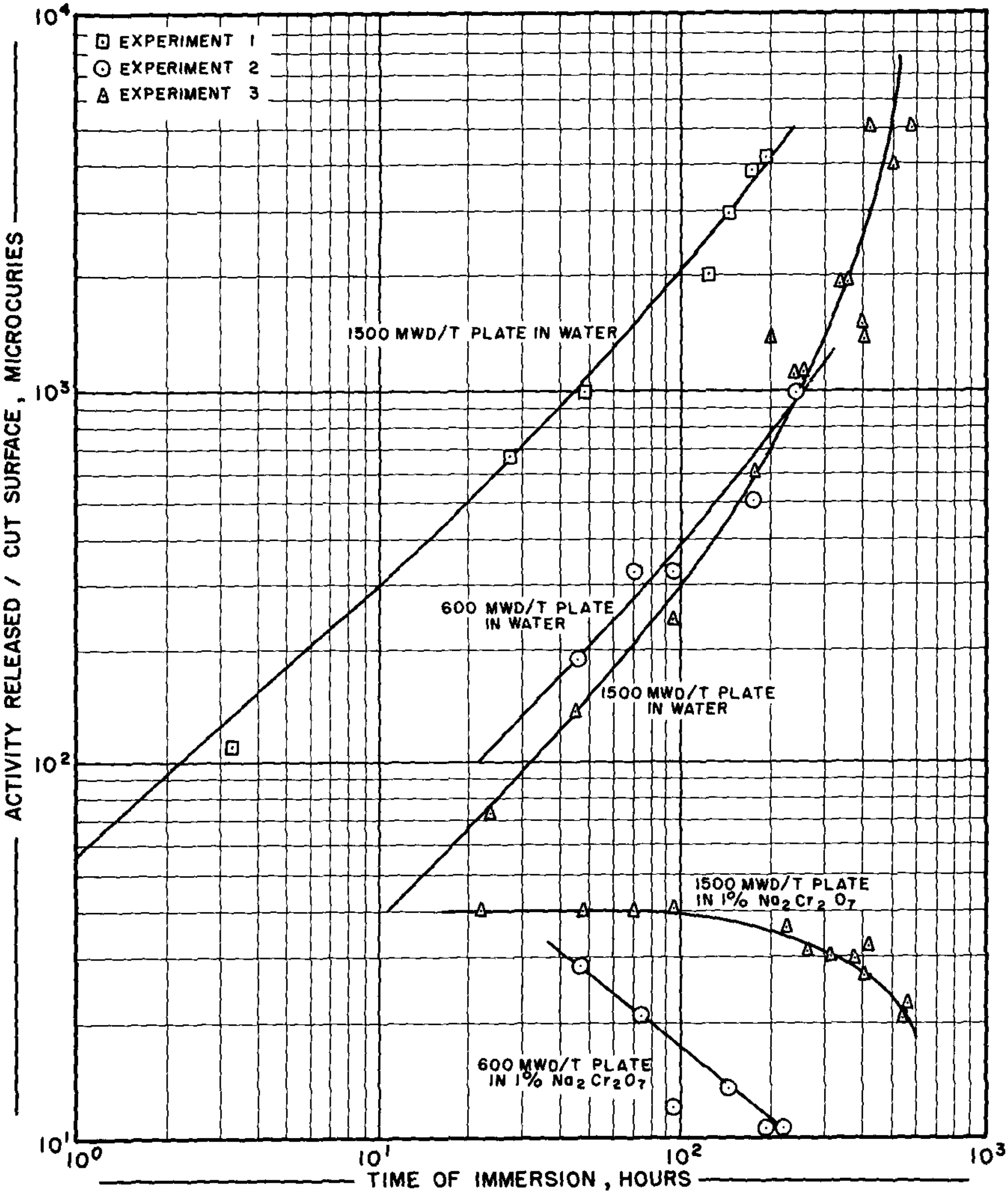
FIGURE 9



BROKEN SECTION OF PLATE NO. 85

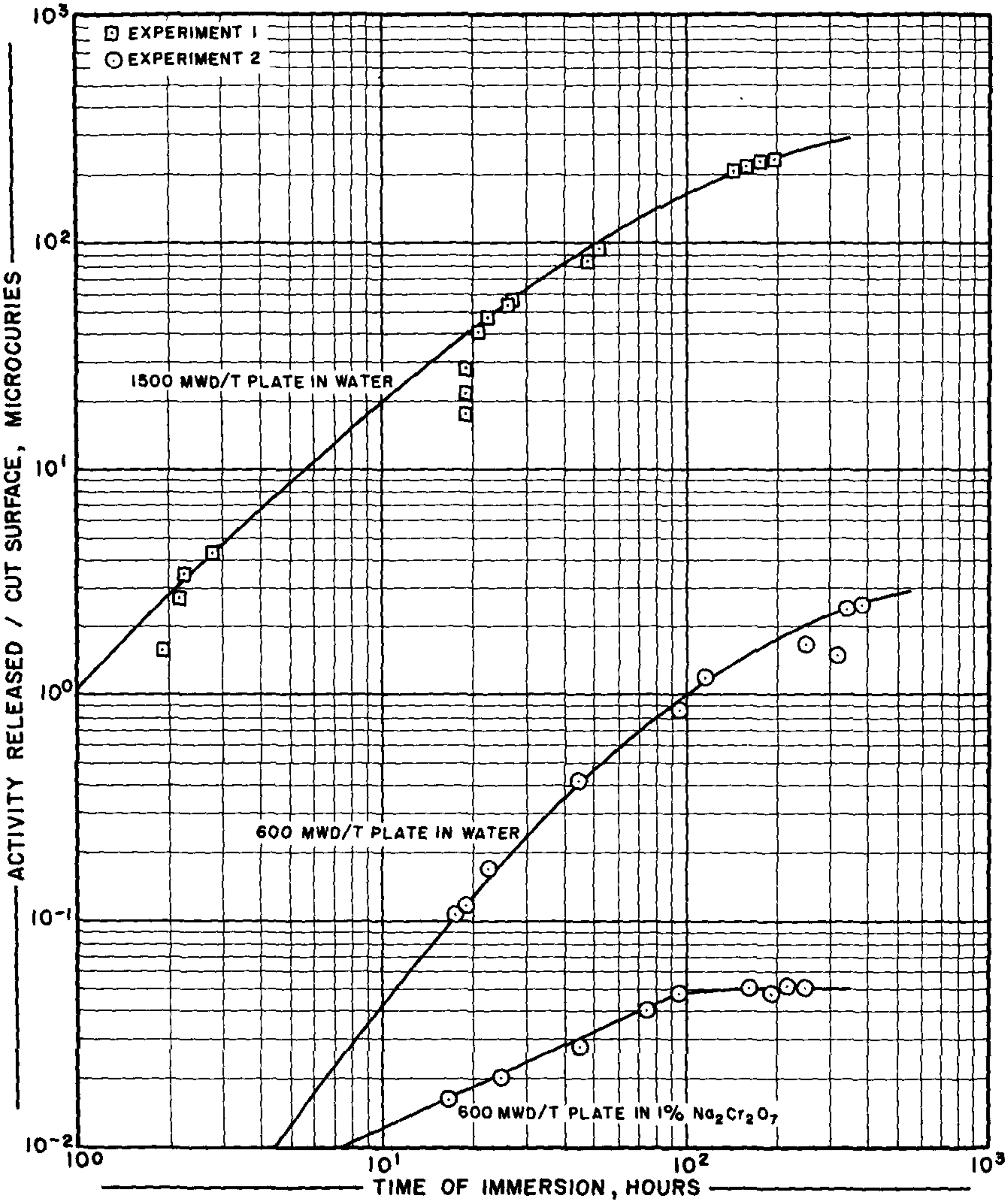
RESULTING FROM "CURLING ACTION" OF STANDARD SHEAR BLADE

FIGURE 10



ACTIVITY RELEASED TO LIQUID PER CUT SURFACE

FIGURE 11



ACTIVITY RELEASED TO AIR PER CUT SURFACE