Hydrostatic Bearing Runner Damage at the Spain 64-m-Diameter Antenna

J. Chapman
DSN Quality Assurance Section

K. Bartos
DSIF Engineering Section

On November 12, 1972 the rear pad of the 64-m-diameter antenna in Spain grounded upon a foreign object in the hydrostatic bearing runner oil trough. The rear pad and the runner were damaged. The antenna was being operated by the contractor, Collins Radio, Dallas, Texas, while conducting final analog pointing accuracy tests. This article describes the damage incurred by the three hydrostatic bearing pads and the runner surfaces and the methods of repair used by the contractor to return the antenna to testing status.

I. Introduction

The 64-m-diameter antenna rotates in azimuth on a hydrostatic bearing that consists of a 7-in.-thick steel runner of eleven segments, segments A through L less I (Fig. 1), and three pads spaced 120° apart through which high pressure oil is pumped to support or "float" the 5.5-million-lb antenna. The plan view of Fig. 1 shows a typical relative orientation of the antenna base triangle, pads, and runner segments. On November 12, 1972, the rear pad grounded upon a foreign object resulting in damage to the runner and the rear pad.

II. Damage to Runner

A. Major Damage

The major runner damage was confined to a 3-m length of runner segment K. As the antenna was being rotated clockwise, a foreign object became caught between the runner and the film height sensor (skateboard). As the antenna motion continued, the foreign object gouged the runner that in turn precipitated pad damage as the pad moved over the damaged runner area. Damage to both the pad and runner continued until the friction force equaled the antenna rotating force. The damage consisted of a gouge varying from zero depth at the start point to approximately 1 cm deep near the end of the gouge.

The width varied from 1 cm to 5 cm. Figure 2 shows the maximum point of clockwise rotation, the damaged film height sensor, and the edge of the pad acting as a machine tool for cutting metal from the runner surface. (It is noted that the antenna was moved counterclockwise about 30 cm while trying to pinpoint the reason for nonmotion immediately after the grounding occurred.)

Figure 3 shows the trailing edge of the pad, the starting point of the damage, and the typical film height sensors. Figures 4 and 5 show the characteristic print left by the foreign object on the runner at the starting point of damage and on the film height sensor.

B. Minor Damage

Nearly the entire runner showed minor damage in the form of single and multiple scratches caused by a foreign object, presumably the same object that precipitated the grounding. The scratches varied in depth and width—a maximum depth of 0.1 mm and a maximum width of 1.5 mm. The scratches also showed characteristic upset material on either side of the scratch due to Poisson's ratio effect on the order of 0.05 mm above the runner surface. The radii of the scratches near the outside of the runner (Fig. 1) can be directly attributed to the foreign object being lodged under the outside corner film height sensor assemblies of the left front and rear pads and under the film height sensor assembly corresponding to the grounding on segment K while the antenna was being rotated. These three height sensor assemblies showed the same characteristic imprint pattern (Fig. 5). The multiplicity of the scratches implies that the object was either long or that the object was in the trough during several antenna rotations. Figure 6 shows the maps of the scratches on each individual runner segments.

III. Damage of the Pads

A. Rear Pad

Rear pad damage was directly related and was a mirror image of the runner damage. Figure 7 shows the rear pad after removal. The other minor scratches are of the order of 0.07 mm in depth and correspond to the scratches that were made in the runner and then transferred to the pad, either by the upset material or small chips removed from the runner.

B. Front Pads

The front pads were removed to verify that no unknown major damage was hidden. As was expected only minor scratches existed, similar to those in Fig. 7 and of the order of magnitude of 0.05 mm deep and upset of 0.02 mm.

IV. Method of Repair

A. Runner Major Damage

The major damage of segment K was repaired by first removing all loose material. Dye penetrant was used to assure that no cracks or laminar material remained prior to welding. The gouge was filled to above the level of the runner surface with E7018 weld material placed as stringer beads with spacing techniques used to prevent heat distortion of the runner. The temperature of the work area was maintained between 20 and 30°C. After welding the repair area was ground, filed, and hand stoned to remove excess weld material. The area was carefully measured to assure that the original runner flatness of 0.07 mm was obtained. In fact the flatness was better than 0.025 mm. Four isolated instances, three related to the foreign object, required welding repair and finishing as above.

B. Runner Minor Damage

The entire runner surface was hand stoned to remove all upset material along the sides of individual and multiple scratches.

C. Rear Pad

The damaged areas on the rear pad were ground out and inspected using dye penetrant to assure that no cracks or laminar material remained before welding. The pad was then shipped to Bilbao, Spain, to be placed in an oven for preheat prior to weld repair.

The fabrication shop and oven of Talleres San Miguel, a Collins Radio subcontractor, was used to preheat the pad. The pad was preheated for 6 h to 315°C and welding by a certified welder was started. After one hour the preheat decreased to 260°C the minimum set prior to starting repair. The pad was returned to the oven and heated again for 12 h at an oven temperature of 480°C. When the pad was removed, the temperature was 425 to 460°C, as checked with temperature sensitive crayons. The welding was done using an E 8018 welding rod placed as stringer passes. Each pass was cleaned with a wire brush and the weld checked using the magnetic particle method. As in the runner repair, sufficient weld material was placed to be sure that the repair areas were above the plane of the pad surface. After welding the pad was returned to the oven and heat treated to 650°C for 20 h.

After cooling the pad surface was measured and found slightly warped, a peak-to-peak measurement of 0.25 mm. The pad surface was ground in 0.02-mm increments until flat. After machining the pad surface was phosphate coated in accordance with MIL-P-16232 D, Type Z, Class 2.

D. Front Pads

The raised material on either side of the minor scratches on both pads was removed with a hand stone. The pad faces were cleaned and the pads reassembled.

V. Reassembly of Hydrostatic Bearing

The rear pad was returned to the site after repair and all parts and cavities cleaned before reinstallation.

The runner surface was vacuumed and wiped clean with solvent to remove all foreign particles, and visually inspected before bolting down each access cover plate. The hydrostatic bearing oil was filtered before being returned to the oil trough and refiltered in the trough. All the film height recording devices were refurbished with new bearings and recalibrated. The antenna was rotated and returned to testing status on December 5, 1972.

VI. Conclusion

The repair was completed in an expeditious manner by the contractor, and operational tests and rotation checks have shown no deterioration in operation parameters.

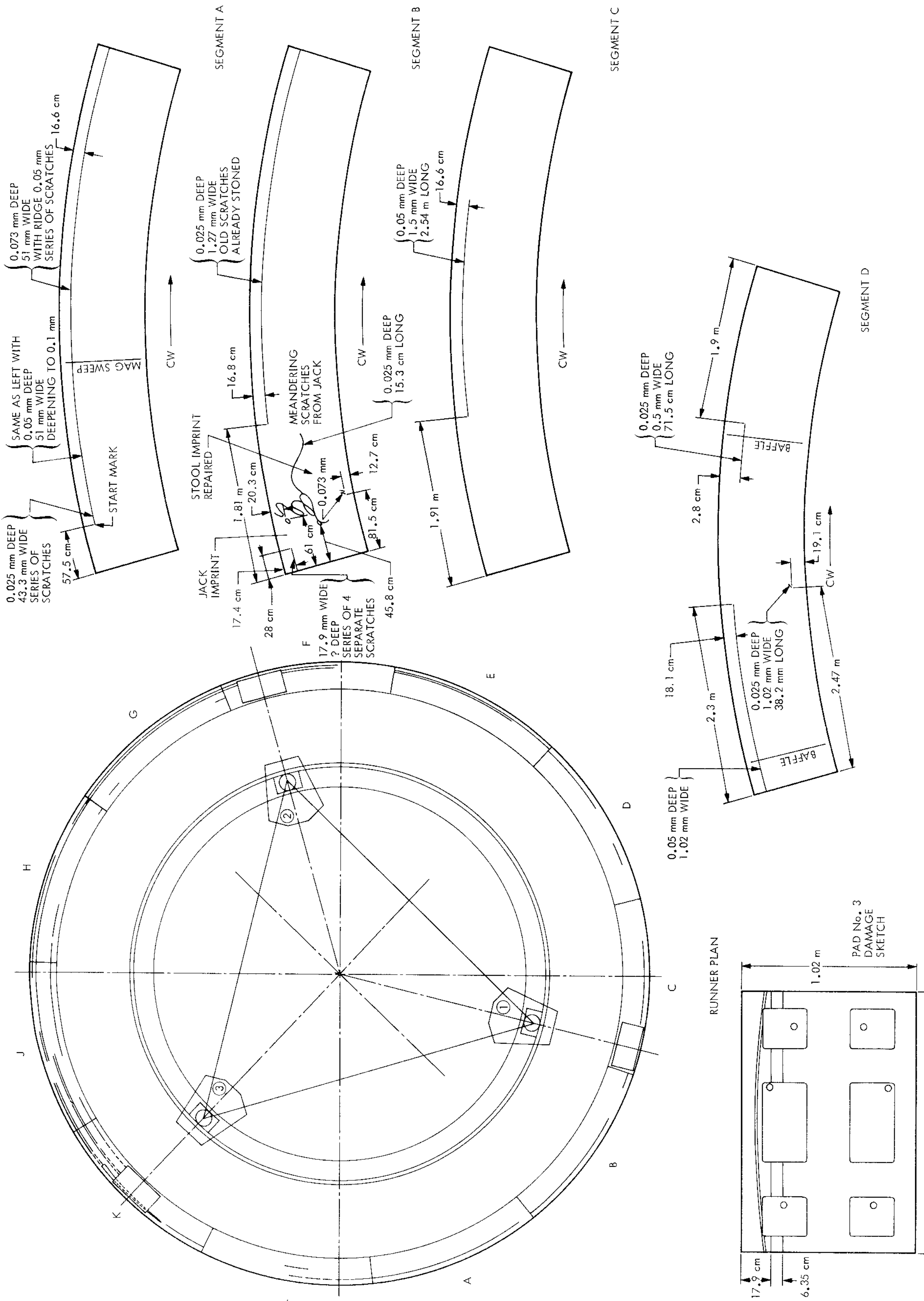

Fig. 1. Plan of Scratches

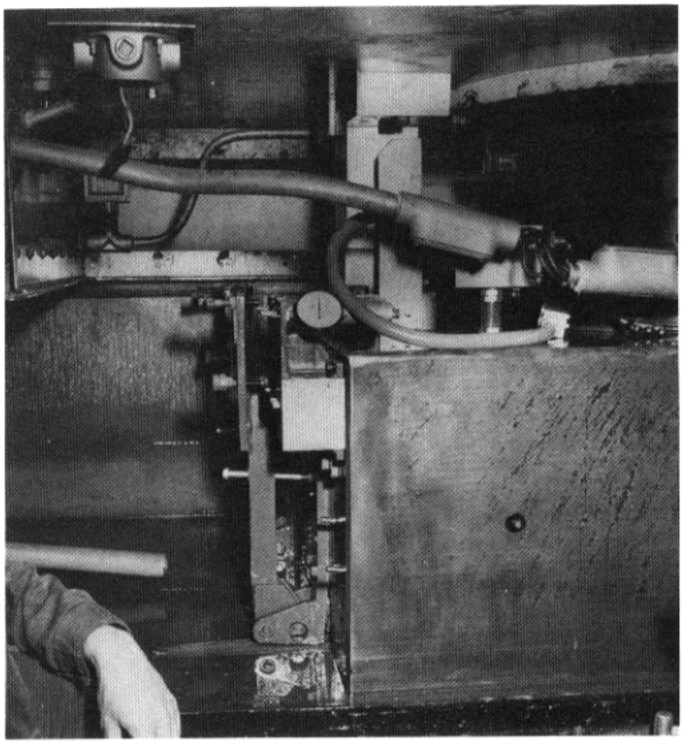

Fig. 2. Runner segment K

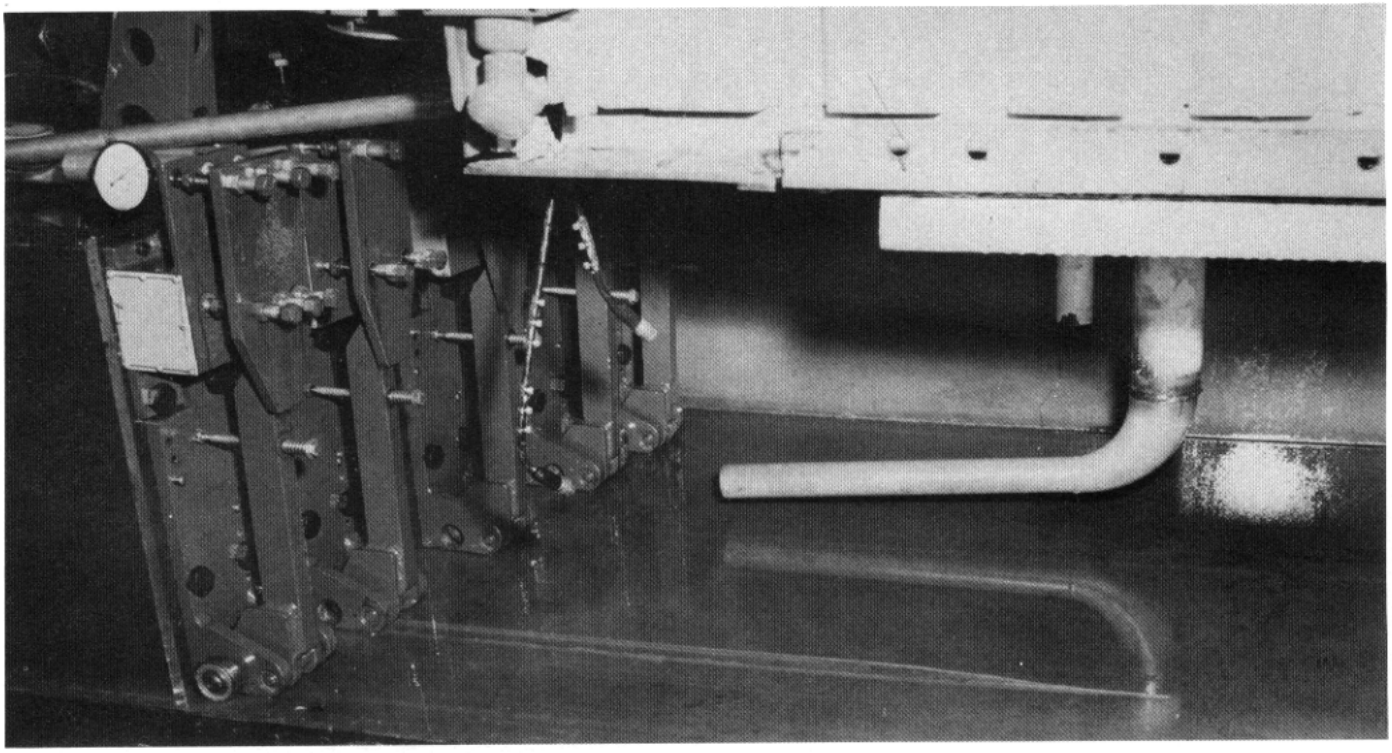

Fig. 3. Starting point of damage

Fig. 4. Damage print on runner

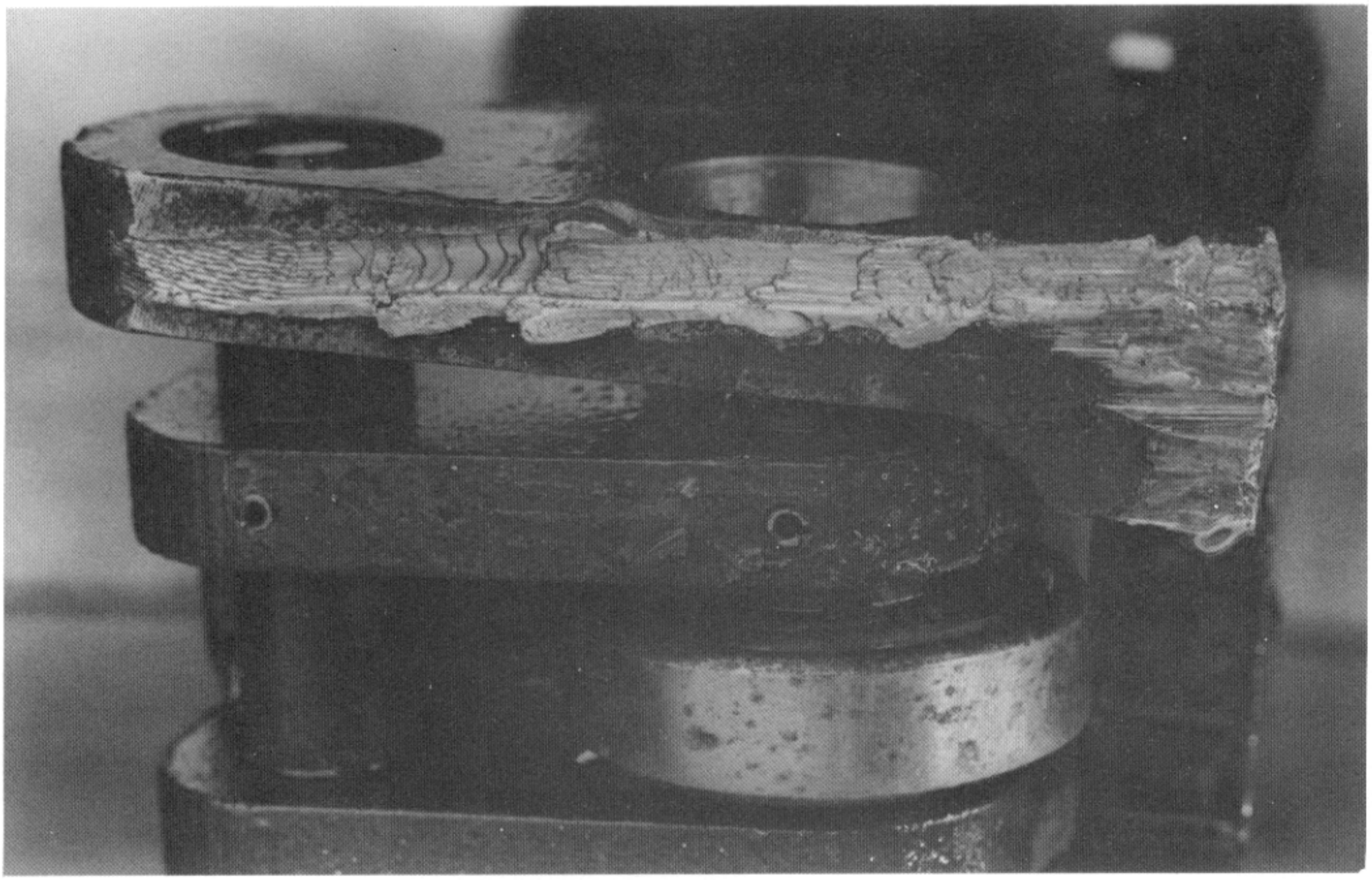

Fig. 5. Damage print on the film height sensor

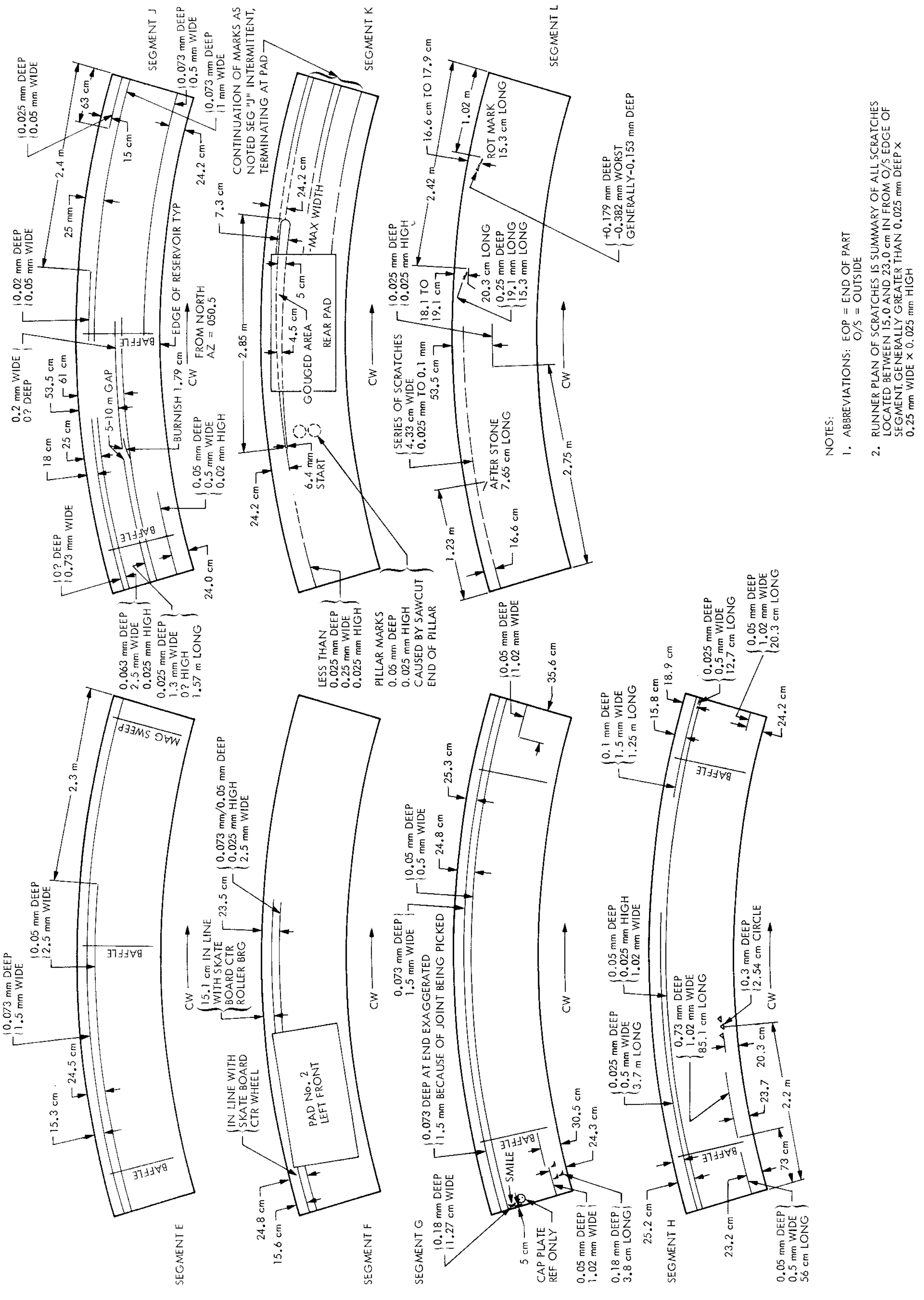

Fig. 6. Maps of individual segments

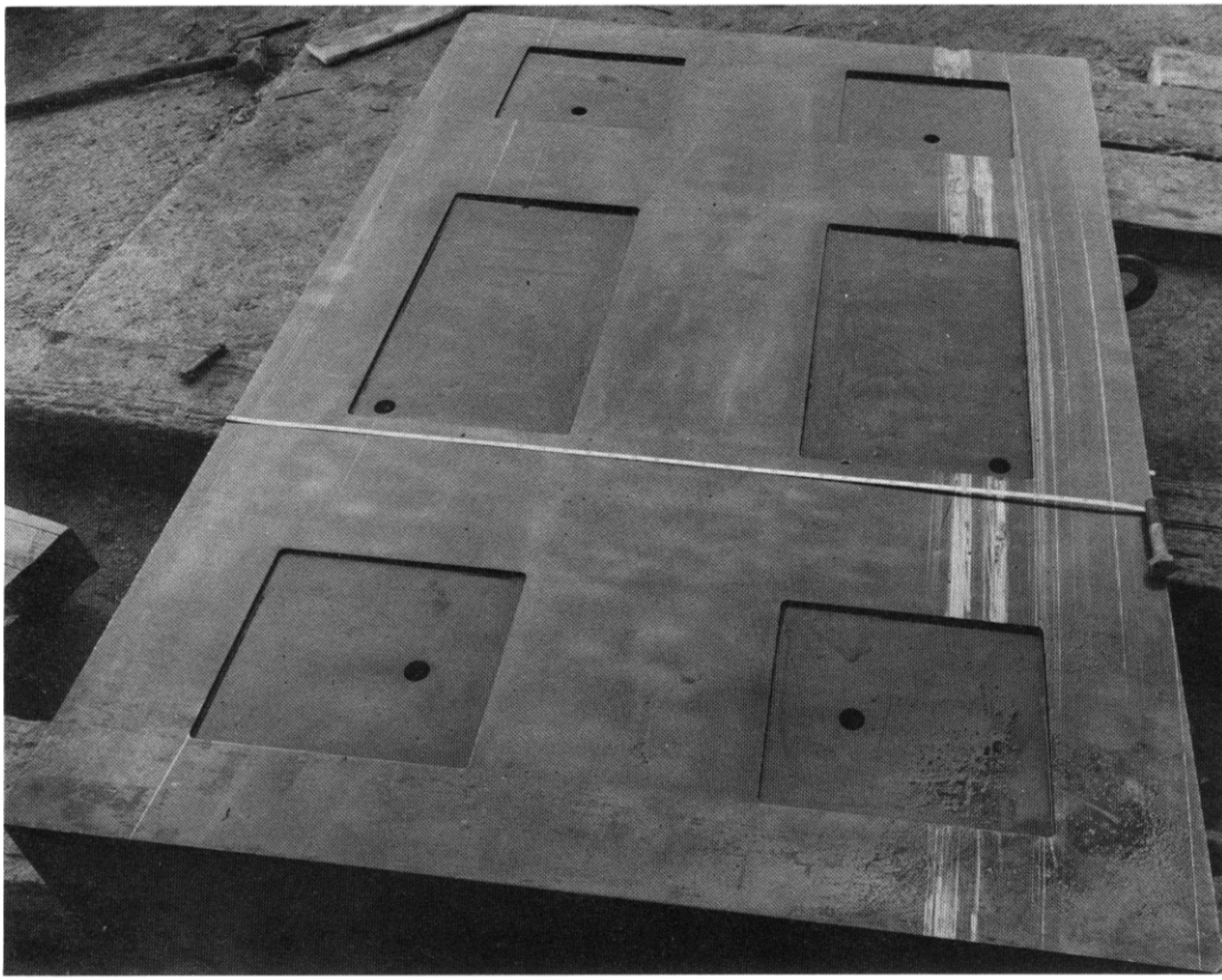

Fig. 7. Rear pad after removal