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A PROPOSED PROFILE DETECTOR FOR SLOW EXTERNAL BEAMS

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AGS DIVISION TECHNICAL NOTE

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Accurate, high resolution profiles of the slow external beam are required for proper design of the transport system as well as to check on the theory of resonant extraction.

To date, profiles in the beam have been measured with an array of 12 insulated targets, interrogated sequentially by an electronic switch.[1] Reasonable interrogation cycle times of 1 msec have been achieved. Problems arise with resolution, however, which is at least the effective width of one finger. Typically, the FWHM of the beam is spread across only 4 fingers causing a further decrease in resolution. Calibration or intercomparison of the electronics for each of the 12 signal channels is another source of error with this type of monitor.

Johnson and Thorndahl at CERN[2] have developed an ingenious profile monitor, the IBS. Electrons, from ionization of the residual gas by the circulating beam, are collected along swept equipotentials in an $\bar{E} \times \bar{B}$ field. Resolution of 1 mm in a sensitive width of 160 mm was reported for the prototype with an interrogation time of 100 μsec (1 μsec using an electron multiplier). The advantages of this device include a single channel of electronics and voltage-variable resolution. Unfortunately, the CERN device is completely unsuitable in the SEB since the beam current available to ionize the residual gas in the slow beam at the AGS is weaker than the CERN circulating beam by about 10^5. One solution would be to add thin windows so that the pressure of the contained gas could be increased to the region of 10^{-3} torr; higher pressure would probably cause difficulties with voltage breakdown and reduced electron mobility.

A better solution is to use essentially a two dimensional expanse of dense material, e.g., an insulated metal target, as a source of electrons, which will be collected by the crossed field "commutator" of Johnson and Thorndahl. One suitable candidate for the electron source is the fine metal and plastic screening used for wire spark chambers. The screening has a 2 mil diameter copper warp and nylon woof, 250 wires to the inch. With a suitable resistance established between adjacent wires the required horizontal electric field distribution can be generated at least as well as in the IBS. This material has an effective thickness of 20 μm. Budal's work on insulated targets[3] shows that this target, when inclined at an angle of 30^o to the beam axis, will emit 3 knock-on electrons per 100 incident protons. This may be contrasted with a yield of 1 electron per 10^6 protons for the CERN device, (assuming the residual gas is air at 10^{-6} torr, an active length of 10 cm, 30 eV/ion pair and dE/dX = 2.2 MeV/ g/cm^2). Thus the metal "target" produces 2×10^4 more electrons than the IBS of 10 cm active length, which practically compensates for the reduced proton current in the slow beam.

The principal disadvantage of the proposed monitor is the multiple coulomb scattering in the target. At an angle of 30^o to the beam the effective thickness becomes 40 μm, causing an rms scattering angle of roughly 30 μrad. If necessary, the target could readily be designed to swing clear of the beam when it is necessary to reduce scattering.

The characteristics of the three devices suitable for use in the slow beam are compared in the Table. The proton beam is taken as a uniform current of 10^{12} particles in 400 msec with momentum of 30 GeV/c. The IBS considered in this comparison has two mylar windows of 6 mil thickness and contains air at 10^{-3} torr. The active length is taken as 10 cm and a simple plate electron detector is assumed for both the IBS and the proposed device. The peak signal is calculated by assuming that 10% of the beam is within the resolving aperture. Sweep time for the "venetian blind" is limited by the associated commutation and digitizing electronics. This will be reduced to 10 μsec in the next model by using sample-and-hold circuits for each finger. For the swept field devices, the sweep time was taken as that time required to collect 10^4 electrons so that resolution is not limited by statistics.

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TABLE I

	"Venetian Blind" (Ref. 1)	IBS (Ref. 2) Adapted for SEB	Proposed Device
Sensitive Volume L (axial) x W (Hor) x H (Vert)	2.5cm x 1.9cm x 15cm	10cm x 15cm x 15cm	10cm x 15cm x 15c
Resolution	1.6 mm 8.5% of active width	voltage variable 1 mm typical 0.7% of active width	voltage variable 1 mm typical 0.7% of active width
Peak Signal	35 nA	.046 nA	1.2 nA
Sweep Time	600 μsec	3.5 μsec	0.14 μsec
Thickness in Beam Direction	2.5cm Al + 2.5cm Fe $t_{eff} = 26.8$ g/cm^2	3×10^{-2} cm Mylar $t_{eff} = 4.2 \times 10^{-2}$ g/cm^2	4×10^{-3} cm Cu $t_{eff} = 3.6 \times 10^{-[illegible]}$ g/cm^2
RMS Scattering Angle*	650 μrad	16 μrad	27 μrad

*Multiple coulomb scattering is assumed although in two cases the scatterer is much thinner than 1/10 the radiation length of the scattering material.

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2. C.D. Johnson and L. Thorndahl, "The CPS Gas Ionization Beam Scanner," IEEE Trans. on Nucl. Sci., 16, 909 (1969).

3. K. Budal, "Charge Transport From Targets in Porotn Beams as a Means of Monitoring," CERN 67-17, July 1967.

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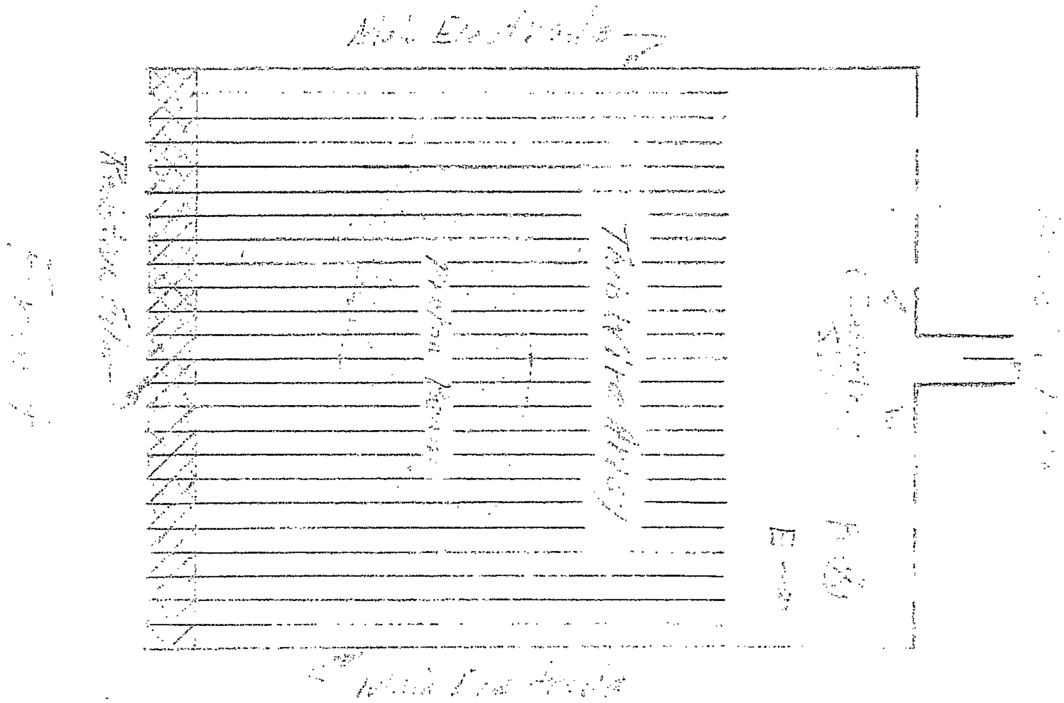

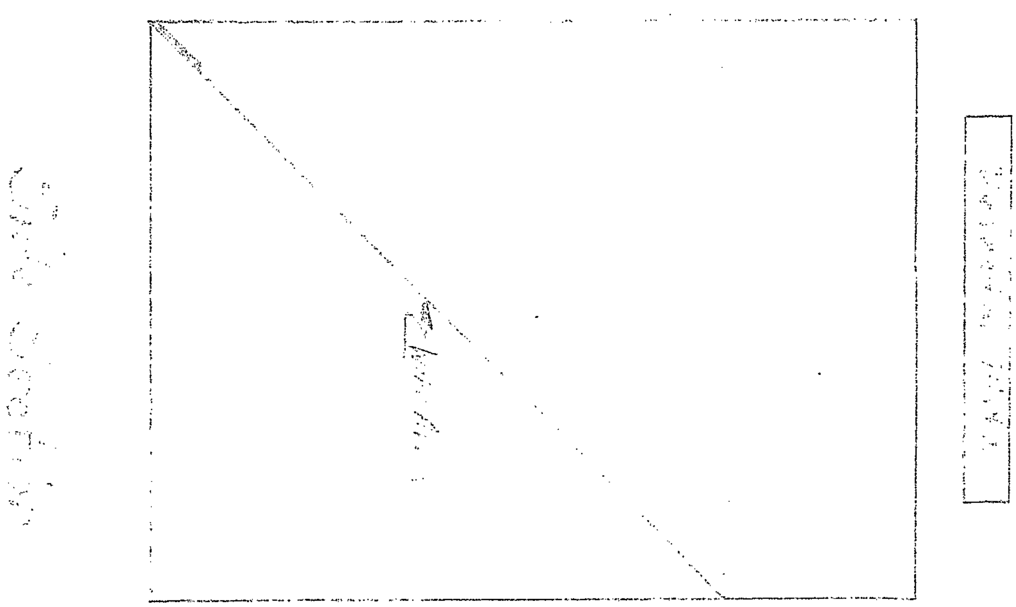

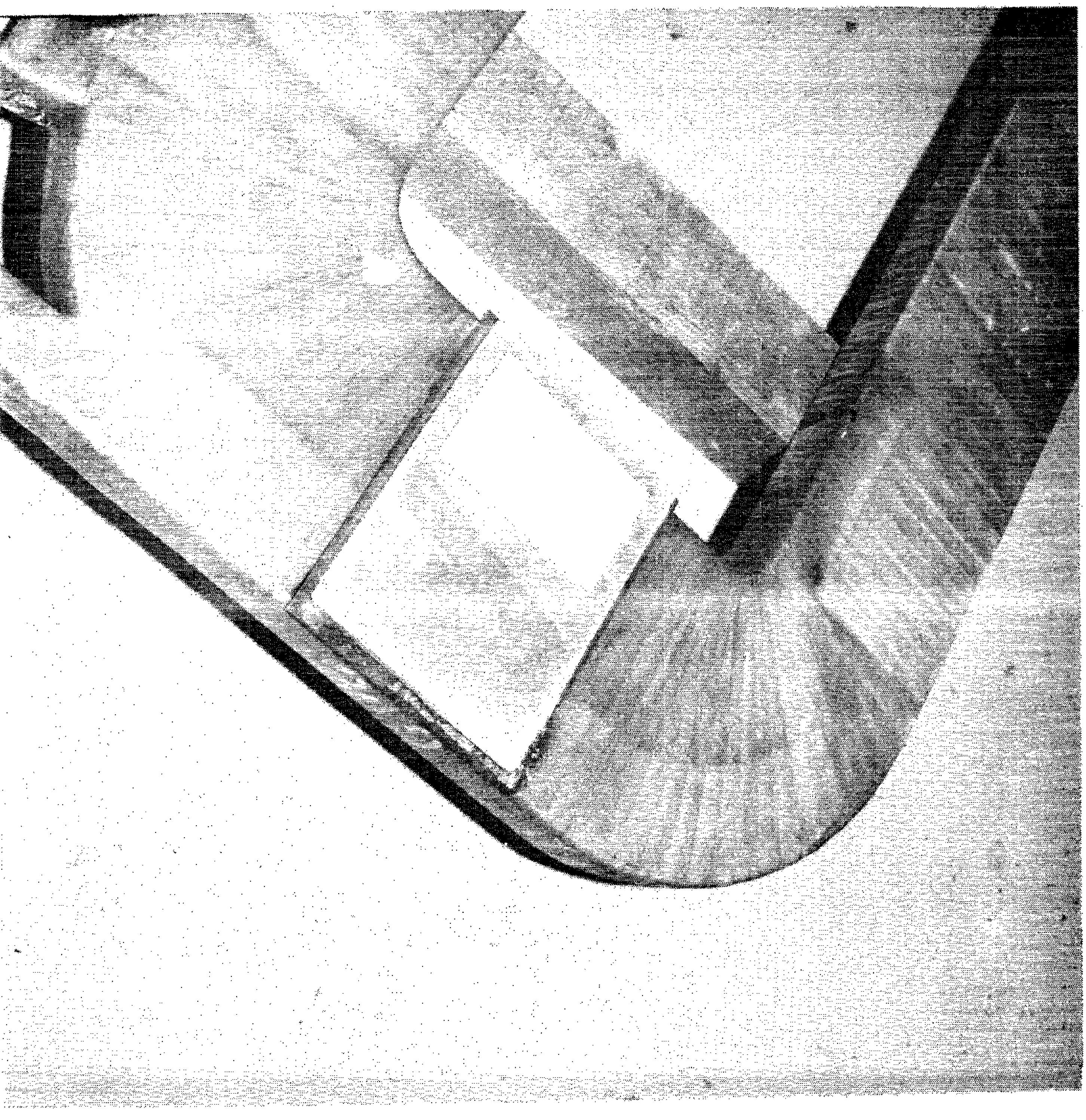

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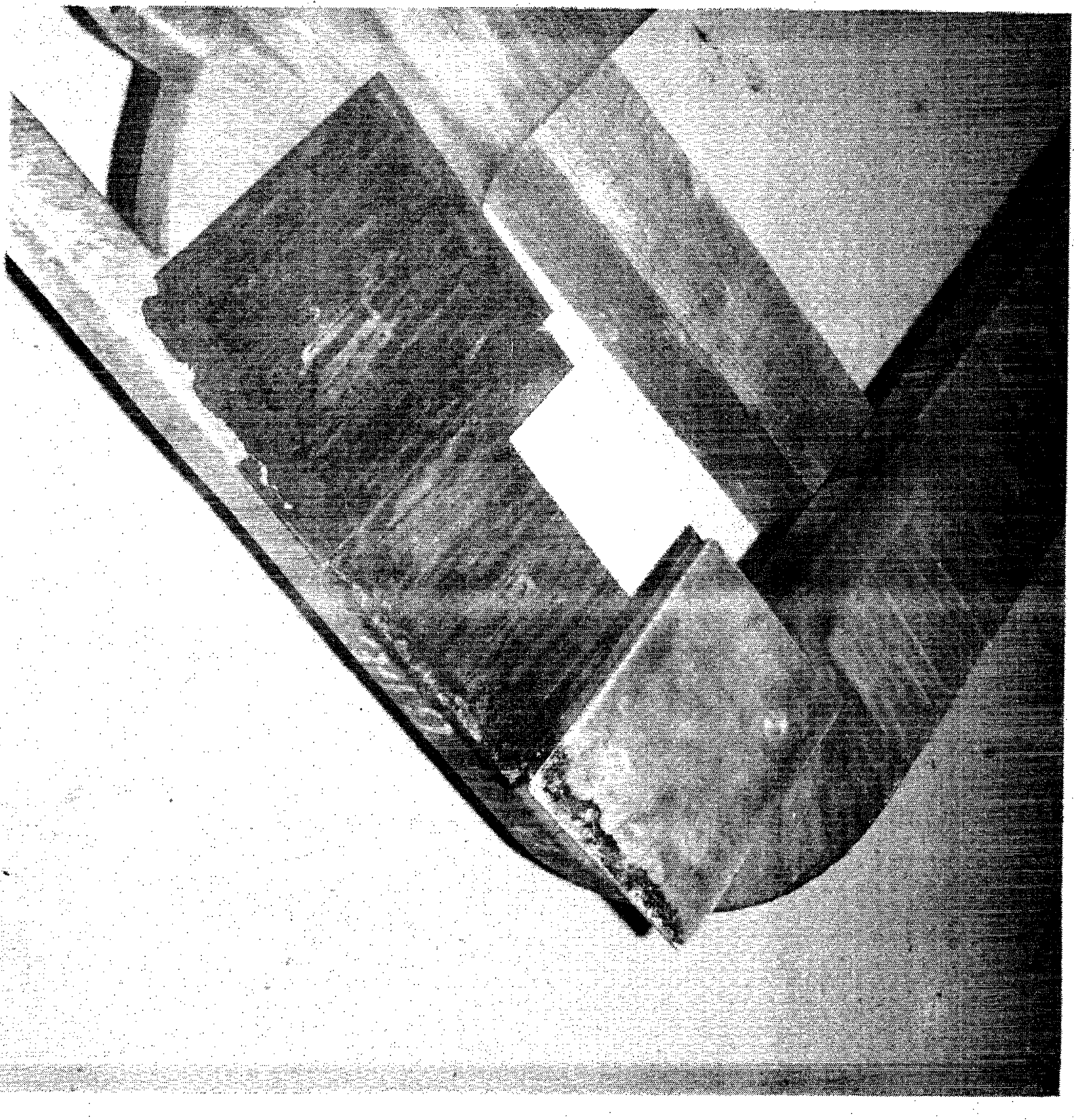
FIG 3



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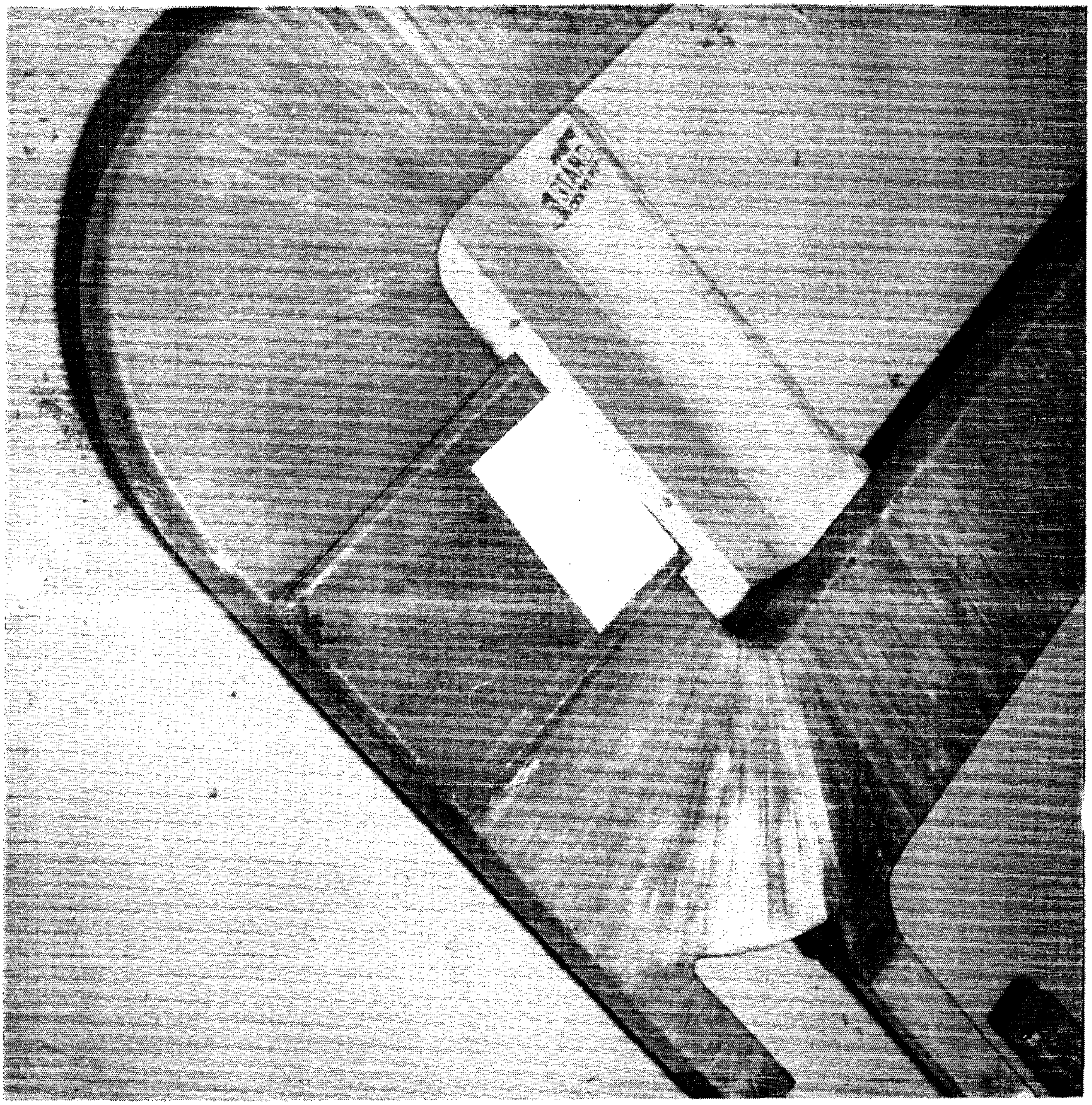
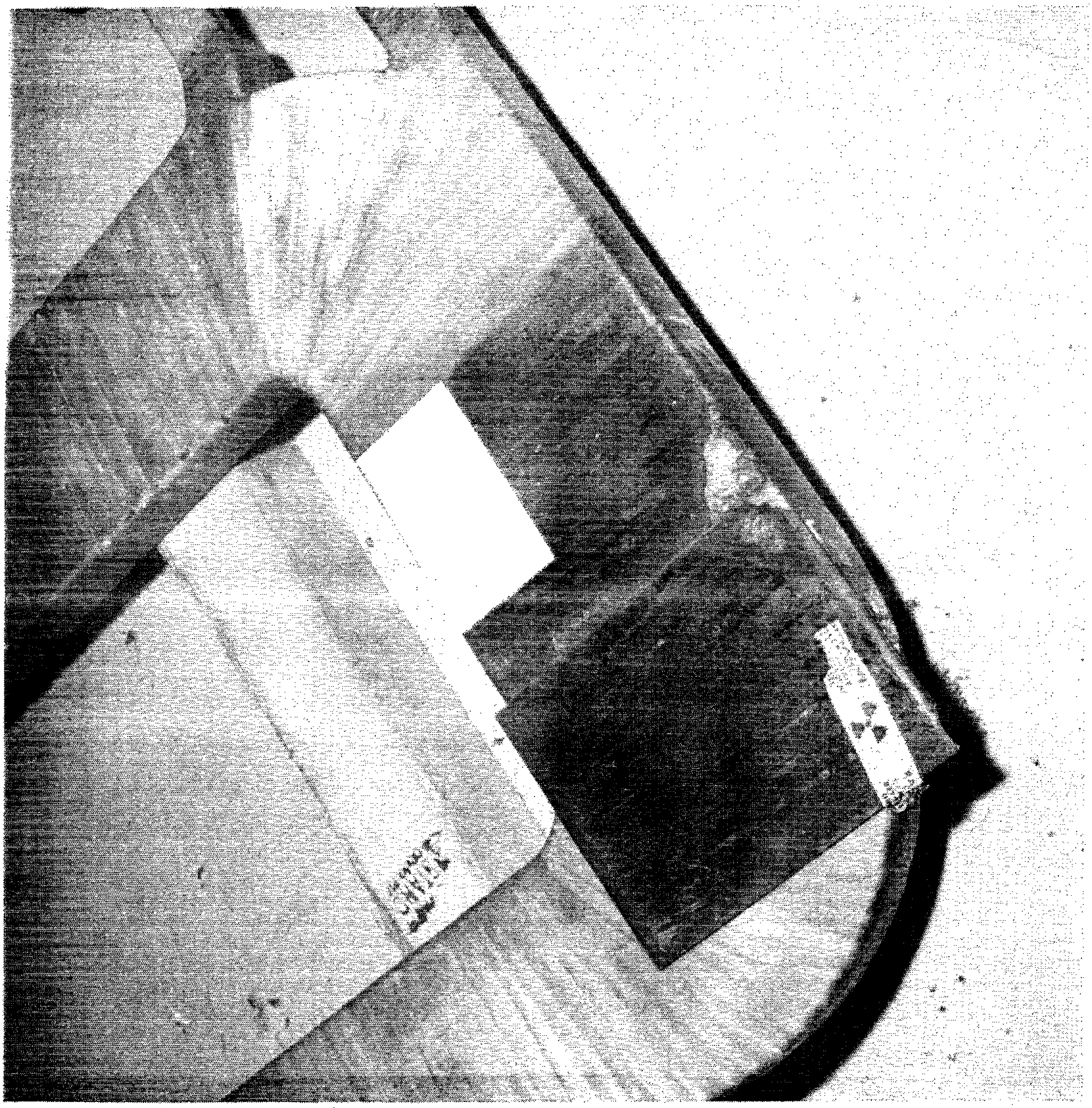


ASSEMBLED WITHOUT METAL PLATE (SEE FIG 2)

FIG 5



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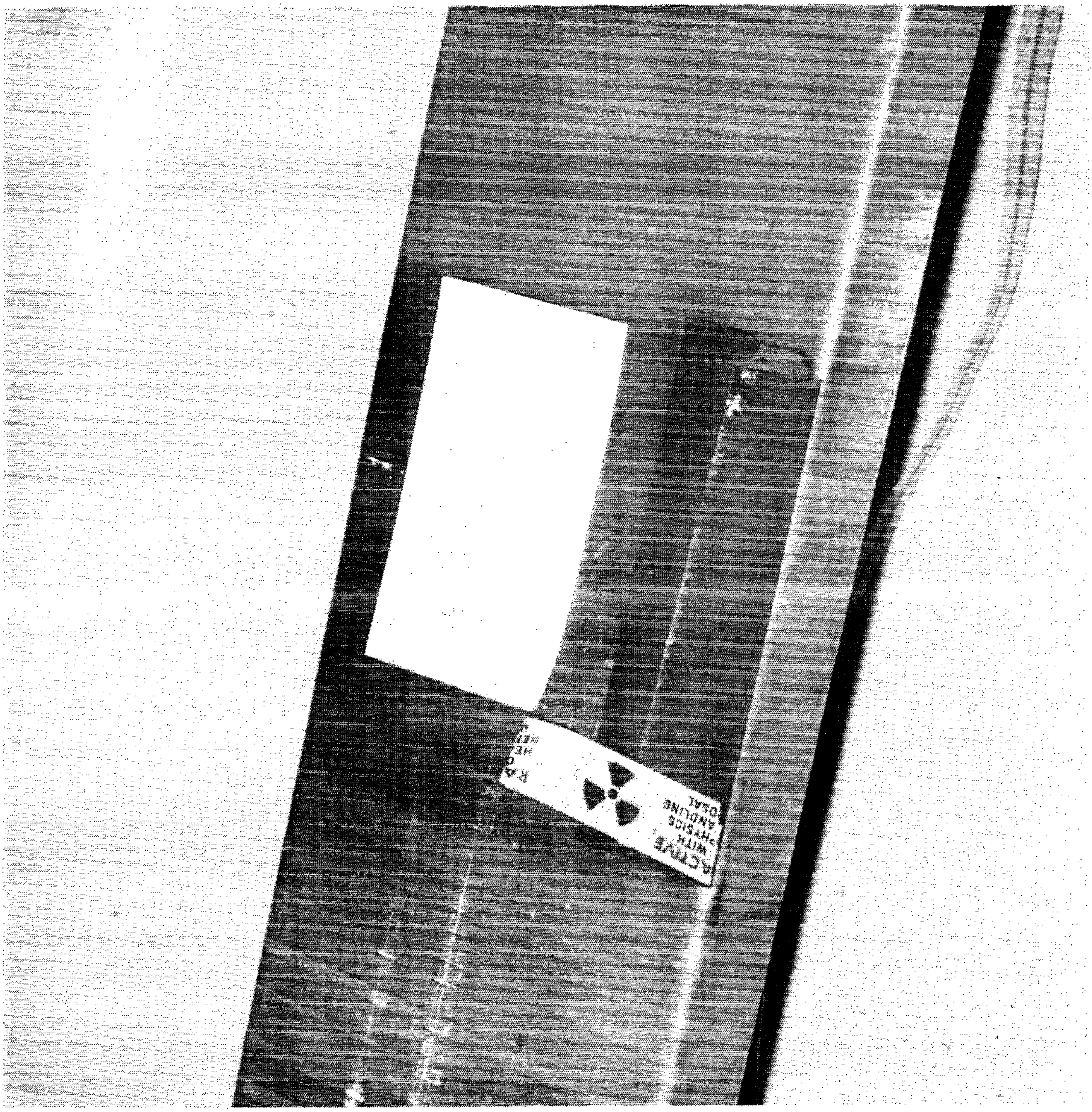

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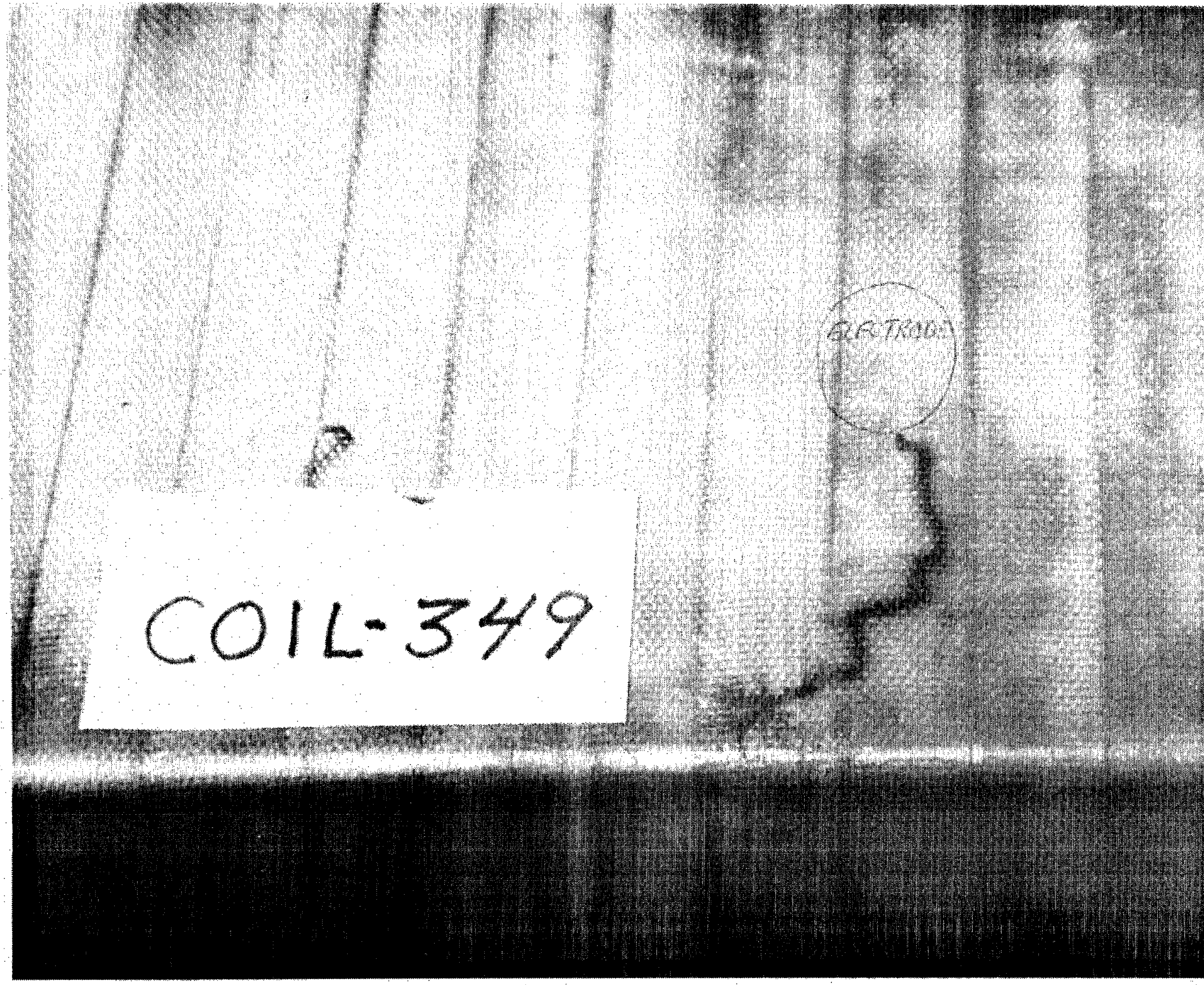
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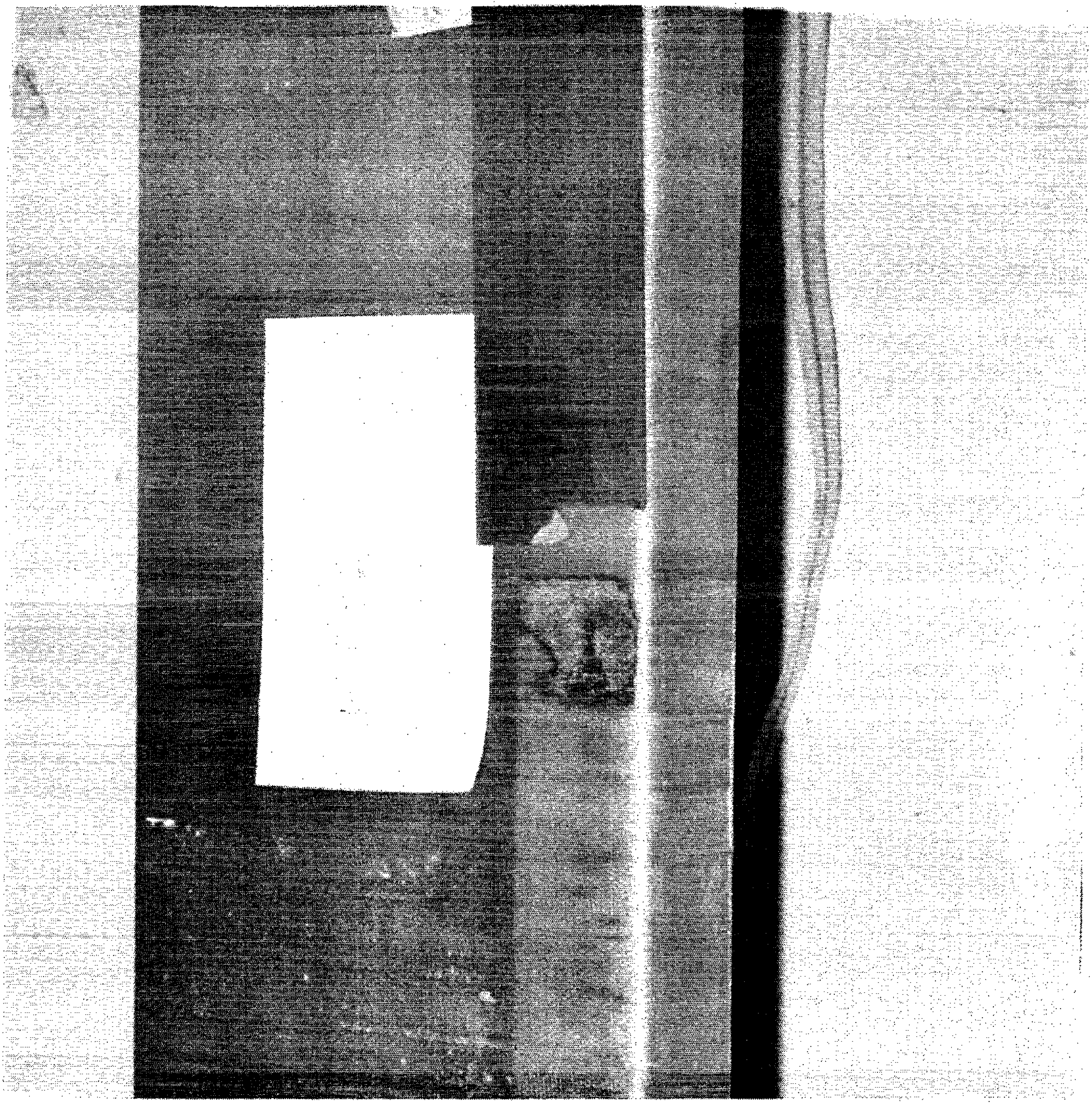

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