5.4 DETECTION OF CRACKS IN TRIGA FUEL RODS BY NEUTRON RADIOGRAPHY, W. A. Pochman, A. Zeilinger, H. Böck, (Atominstitut, Vienna, Austria)

During a routine inspection of 9 fresh fuel rods from General Atomic, stored in the fresh fuel storage facility for future use in the TRIGA Mark II reactor, Vienna, we discovered that two of the rods gave a noise, similar to that of a samba-shaker, when turned upside down. All other rods did not produce this specific noise, when handled similarly. To obtain the reason and the exact position of the obvious defects in the rods, neutron radiographic investigations were performed. An undefective rod (No. 7309) and one of the defective rods (No. 7307) were attached in a simple arrangement in front of a neutron radiographic casette (9 x 12 cm), containing an AGFA Osray T4 TA DW X-ray film and a granular neutron scintillator NE 426. The neutron radiographs were performed in the direct exposure front film technique. The optimum exposure time was found as six minutes, having an average thermal neutron flux of 6.10^5 $n/cm^{-2}s^{-1}$. The fuel rods attached to the film casette were arranged on a small waggon running on tracks right into the collimated neutron beam. The attachment was laid out in the manner, that the rods easily could be moved relative to the film-casette, in the aid of obtaining a total scan over the whole length of the pair of fuel rods.

The scan was started at the lower ends of the rods, respecting the 10 cm long graphite briquette, which was not radiographed, and having the rods held in such a position before radiographing, that any loose material must have assembled in the area round the opposite graphite briquette. A general assembly of a TRIGA fuel rod is shown in Fig.1.

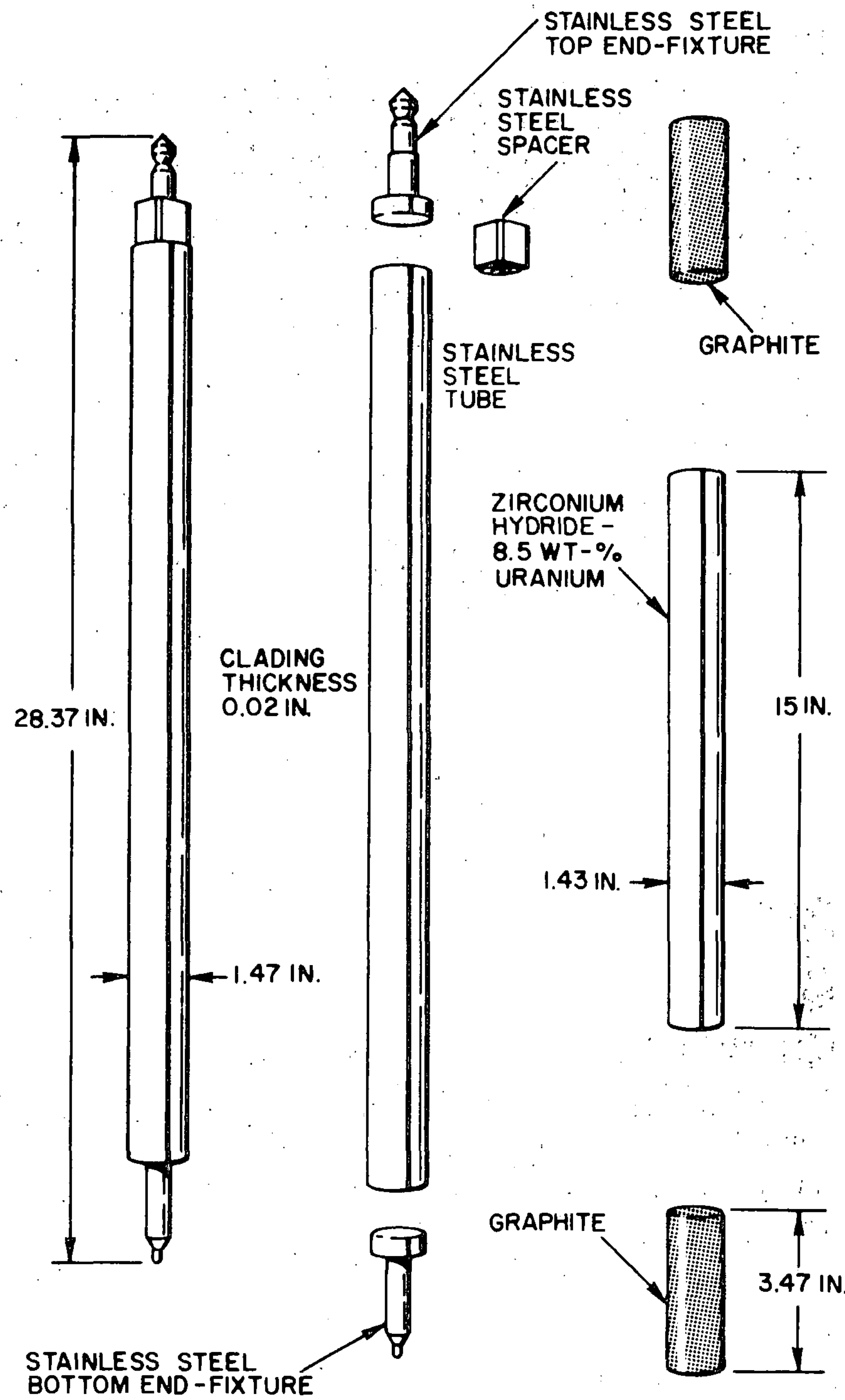
The first radiograph, obtained in the way just described, shows a crack in the enriched U-ZrH alloy of the upper fuel rod (No. 7307). The crack, clearly be seen on the radiographs (Fig.2, Fig.3), having a distance of about 9 cm from the end of the lower graphite briquette, seems to run totally through the fuel briquette, which was proofed by rolling the rod along its axis over 90° and making a further radiograph (Fig.4). Continuing the scan, a second crack much of the same size could be found 15 cm after the first one (Fig.5). After this no further crack or similar defect could be found (Fig.6 - Fig.9). Schematically the positions of the cracks are shown in Fig.10. In order to find the missing material, the area around the upper graphite briquette was radiographed (Fig.7). Because graphite has a much lower neutron cross-section than the U-ZrH alloy, the exposure time was reduced to 1.5 minutes, producing a better contrast on the radiographs (Fig.8, Fig.9). No significant sign of the presence of the fuel material dropped off the fuel briquette could be found. Therefore, it is estimated that either the material dropped off is too small to be detected, or that it is hidden elsewhere in the fuel rod and hence is not visible using the present method. Similar investigations were made with the second fuel rod (No. 7308) in combination with the same undefective rod (No. 7309), just having been used before. Three cracks have been found, the second and the third one, much of the same size as those in the other defect fuel rod. Only the first crack seems to be smaller than the others. The positions of the cracks in rod No. 7308 are shown in Fig.17, the radiographs in Fig.11 - Fig.16. In this specific case too the loose material could not be detected anywhere else.

The fuel rods, having been inserted several times into the thermal neutron beam, were however slightly activated. The gamma measurements performed, showed that the radiation level increased from 0.5 mrem/h to about 100 mrem/h after six minutes radiographing, the levels being measured on contact to the fuel rods. The gamma radiation level during radiographing went up from 1 mrem/h to 10 mrem/h, the neutron level from 10 mrem/h to 20 mrem/h, being measured at the experimentators place, which was not occupied during the total time of the radiographs by an experimentator. The various radiation levels are summarized in Table I. A few hours after the last radiograph was made the fuel rods produced the same gamma background as before the experiments.

It must be pointed out, that neutron radiographic investigations similar to that having just been described, could be performed with burned-up fuel rods too, but in that case the rods must be heavily shielded and the neutron radiographic transfer technique or the track etch technique have to be used. These methods are a bit more complicated to handle and have a worse visibility compared to the direct method.

Table I: Radiation levels

	Gamma	Neutron (thermal)
Radiation of 2 rods measured on contact, before radiographing, reactor off	0.5 - 1 mrem/h	----
Radiation at experim. place, before radiographing, reactor on	1 - 1.5 mrem/h	10 mrem/h
Radiation during radiographing	3 - 5 mrem/h	20 mrem/h
Radiation of 2 rods measured on contact immediately after radiographing, reactor off	100 mrem/h	----
Radiation at experim. place, immediately after radiographing, reactor on	20 mrem/h	10 mrem/h
Radiation of 2 rods measured on contact, a few hours after radiographing, reactor off	0.5 - 1 mrem/h	----



LC 40780A MIII 3B

Fig. 1

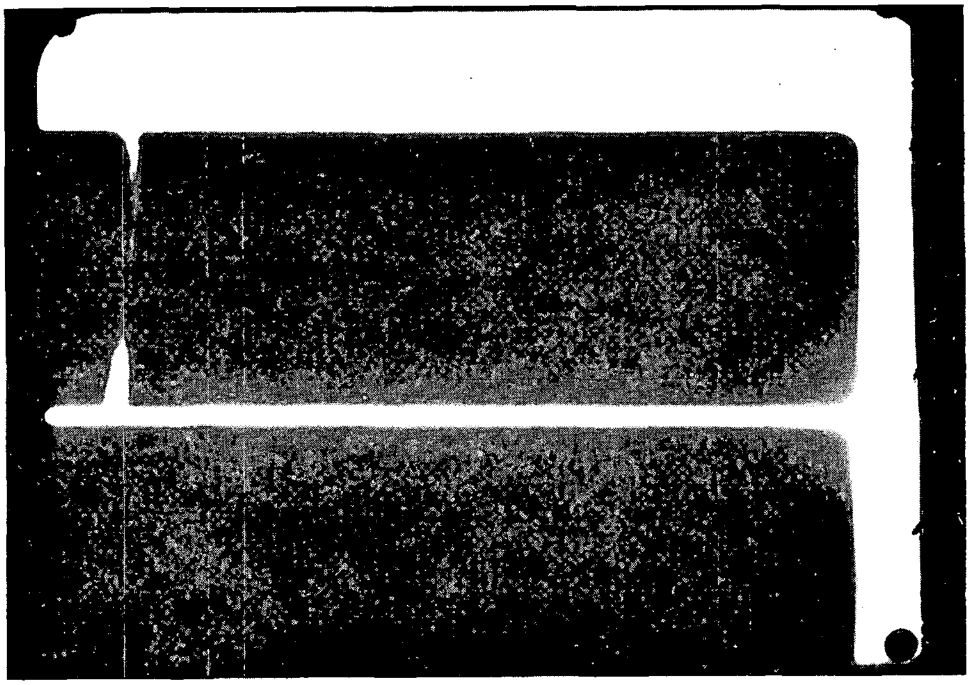


Fig.2

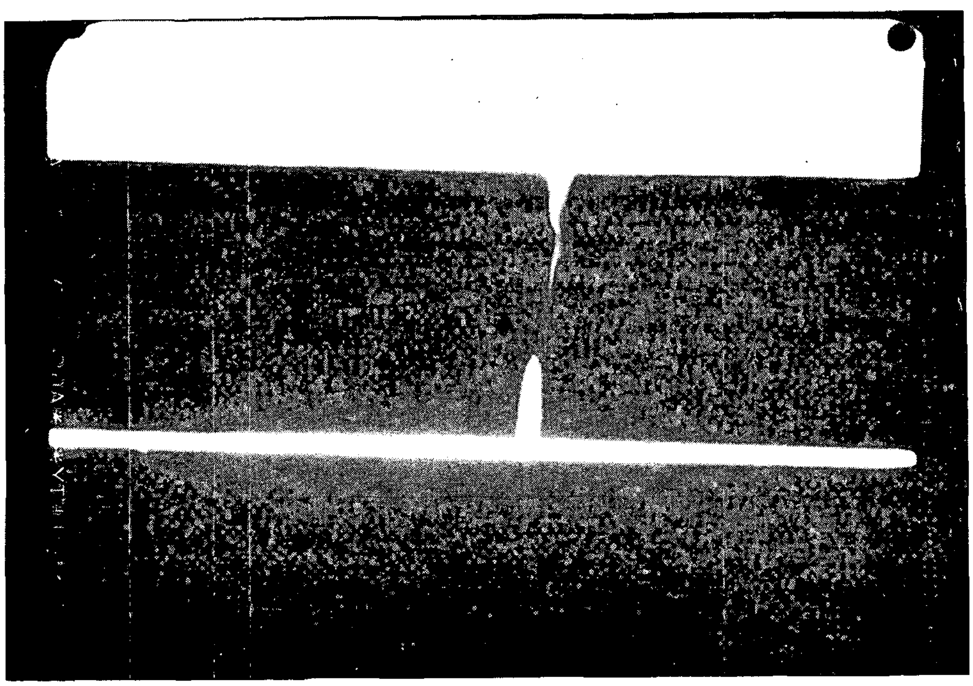


Fig.3

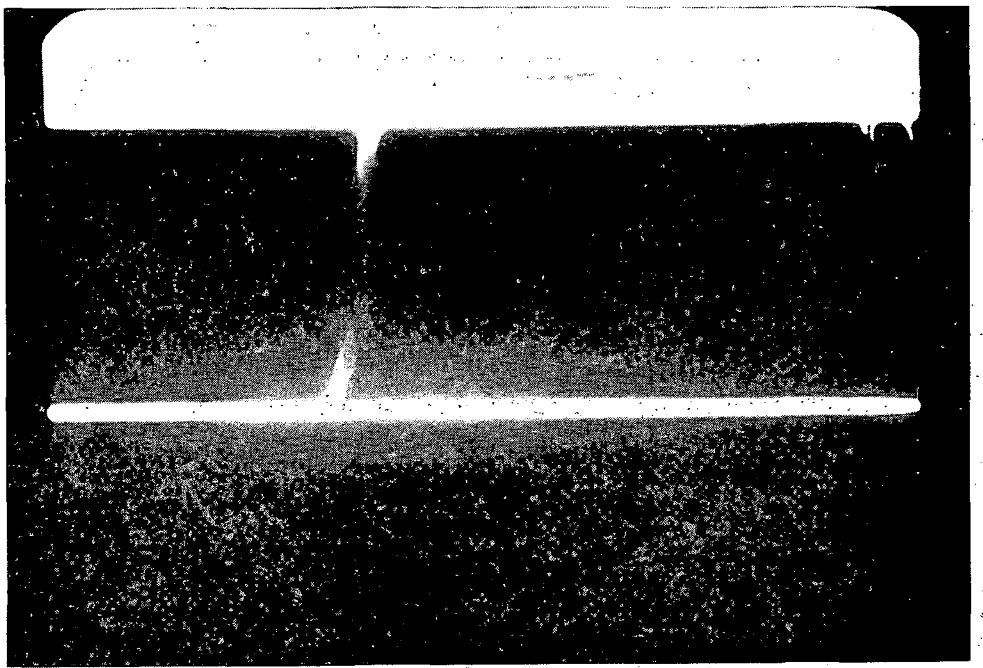


Fig.4

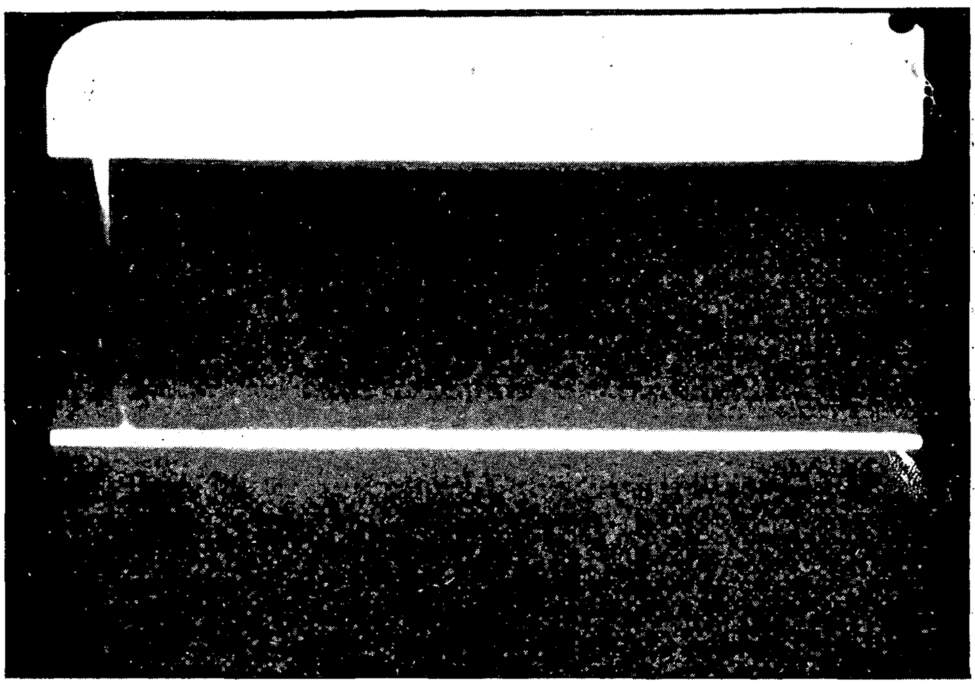


Fig.5

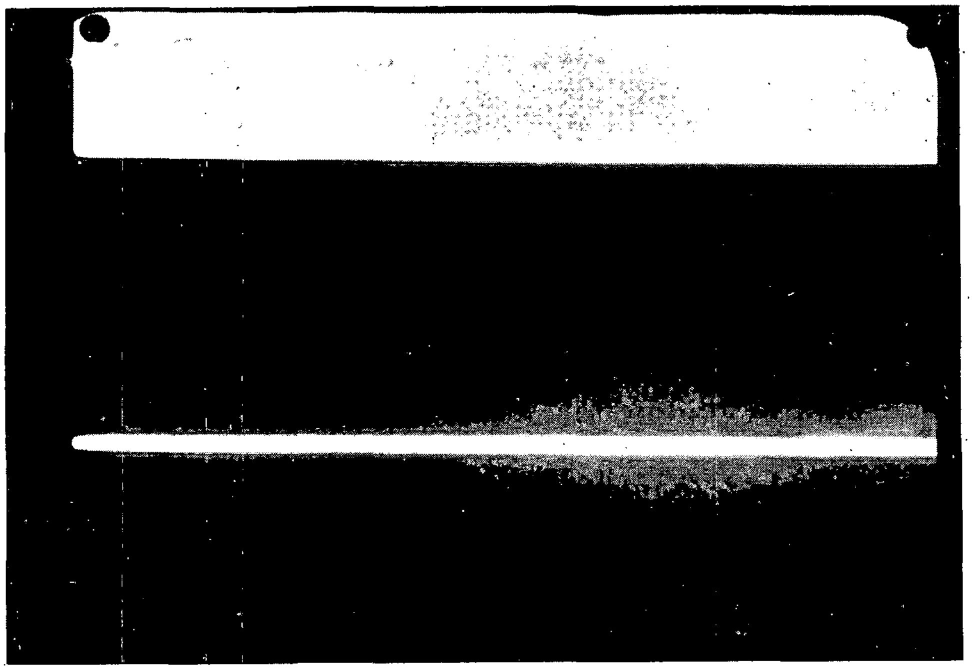


Fig.6

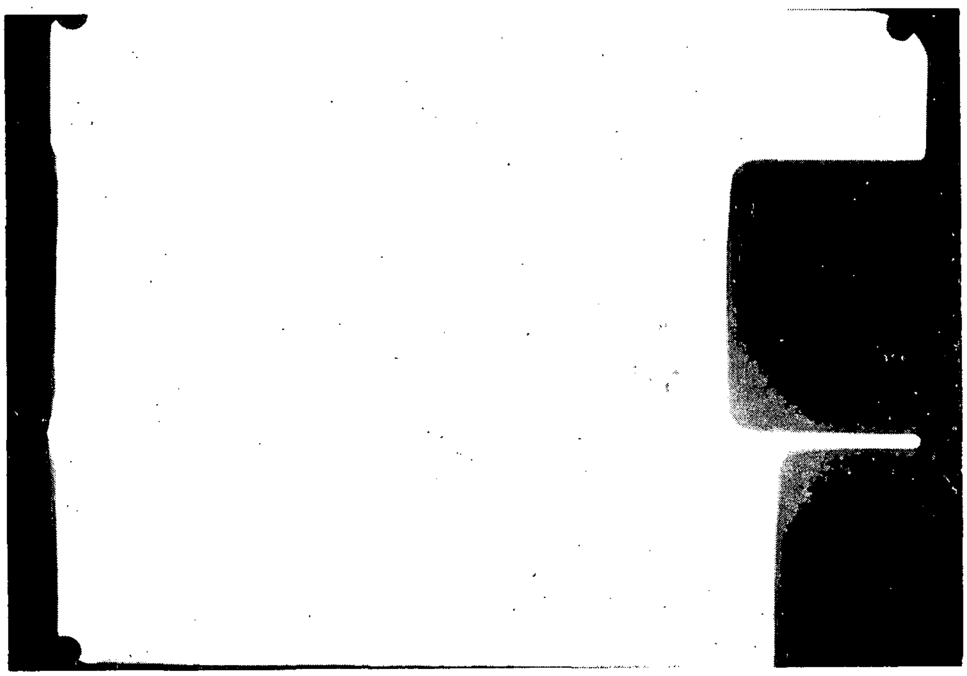


Fig.7

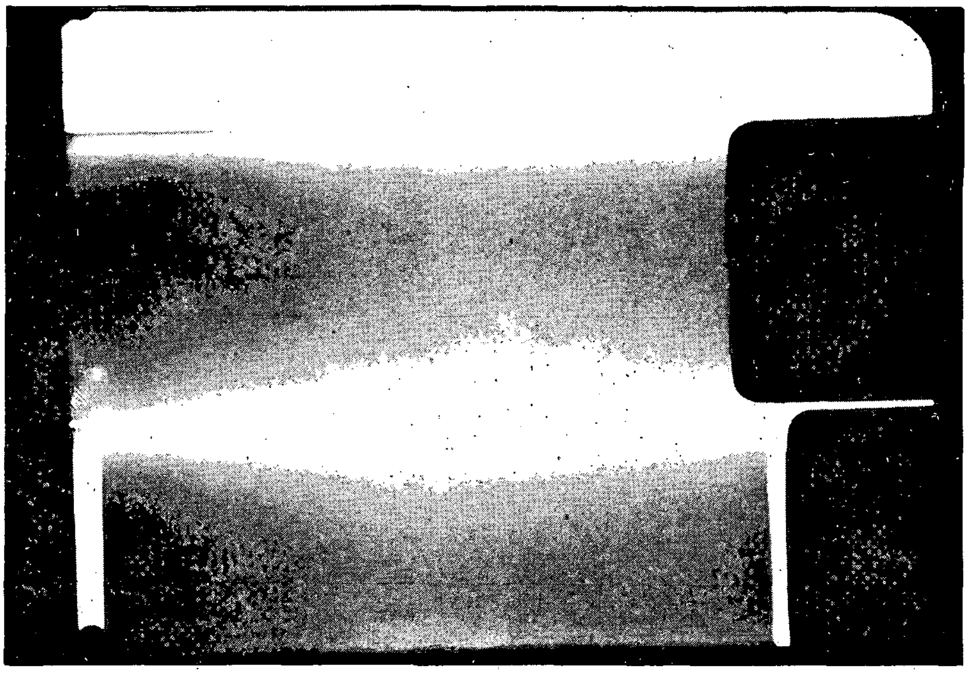


Fig.8

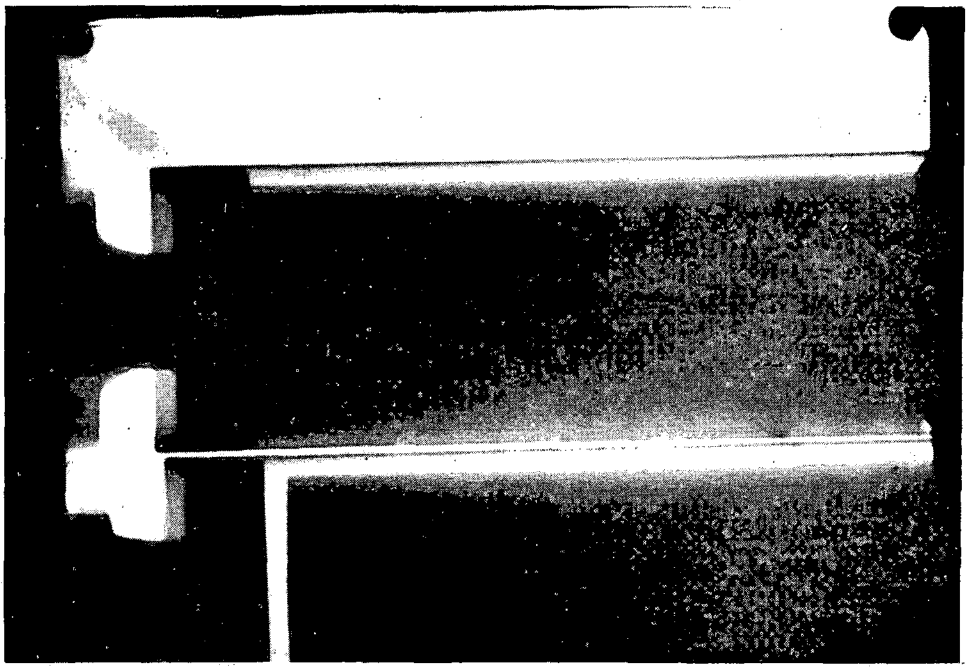


Fig.9

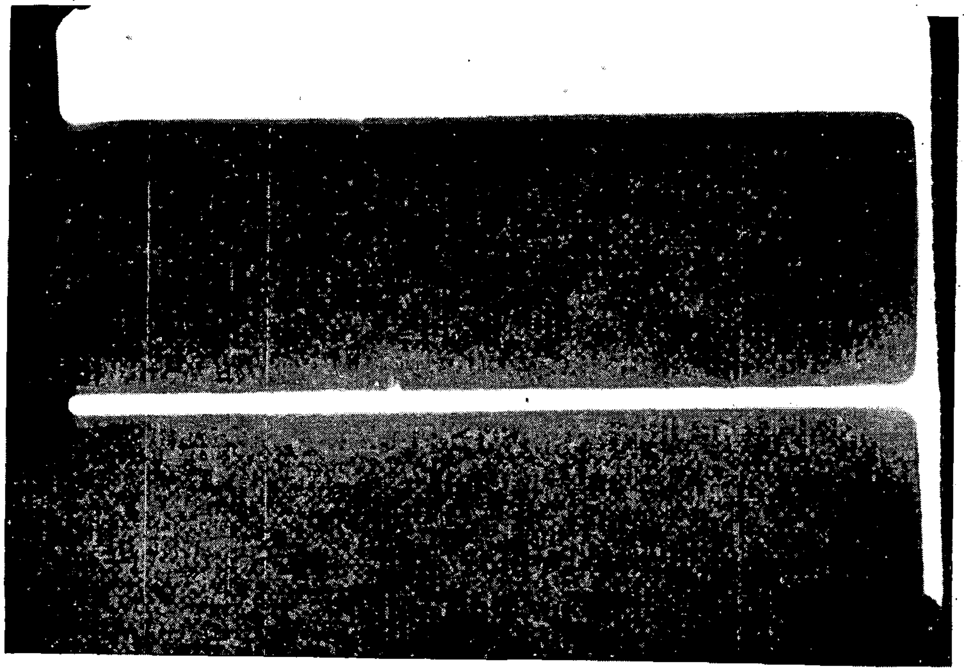


Fig.11

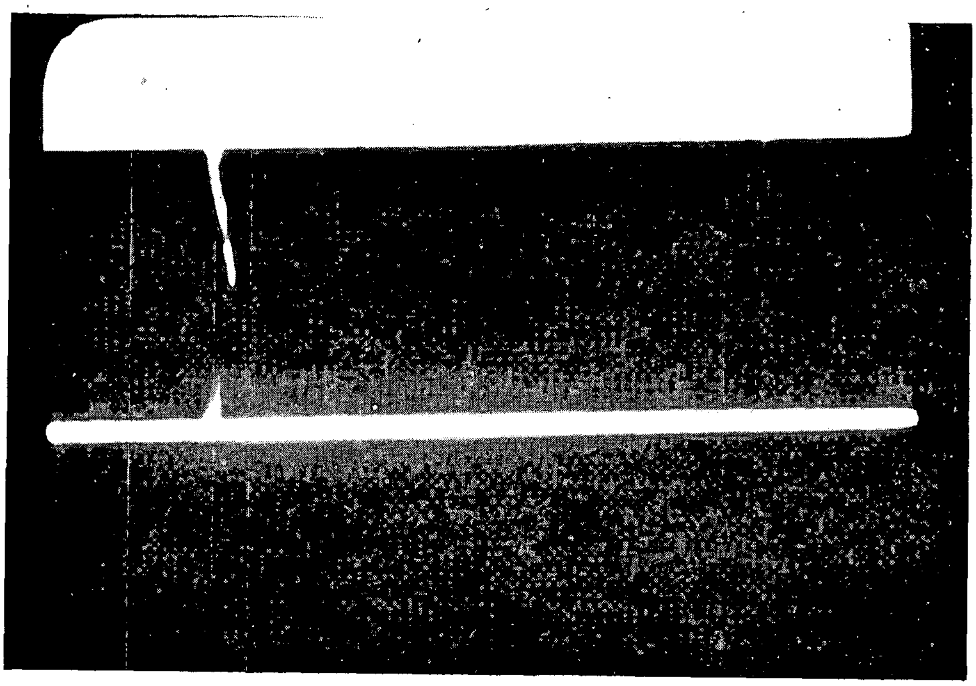


Fig.12

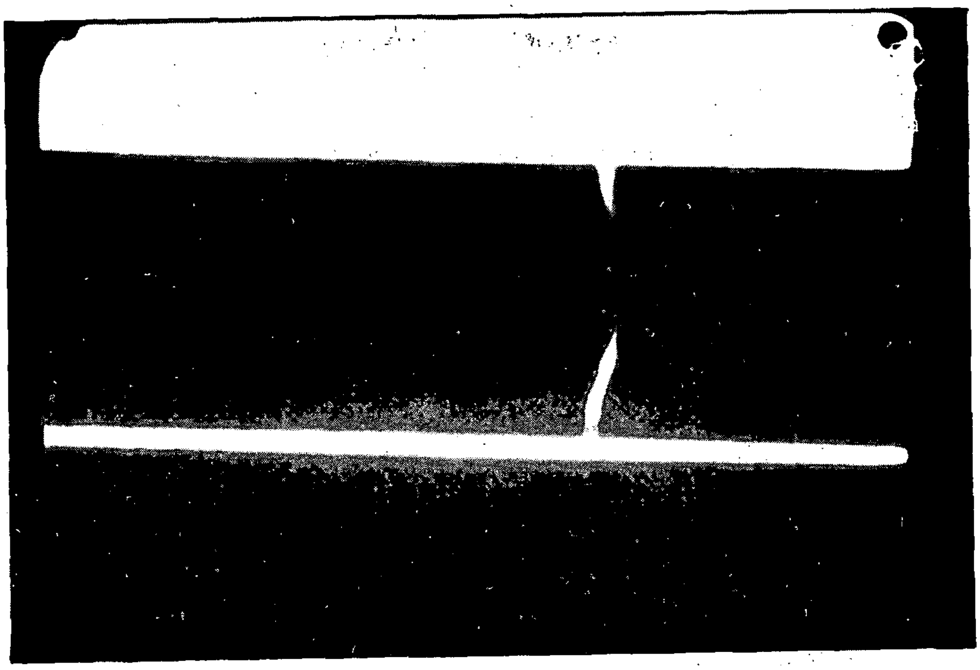


Fig.13

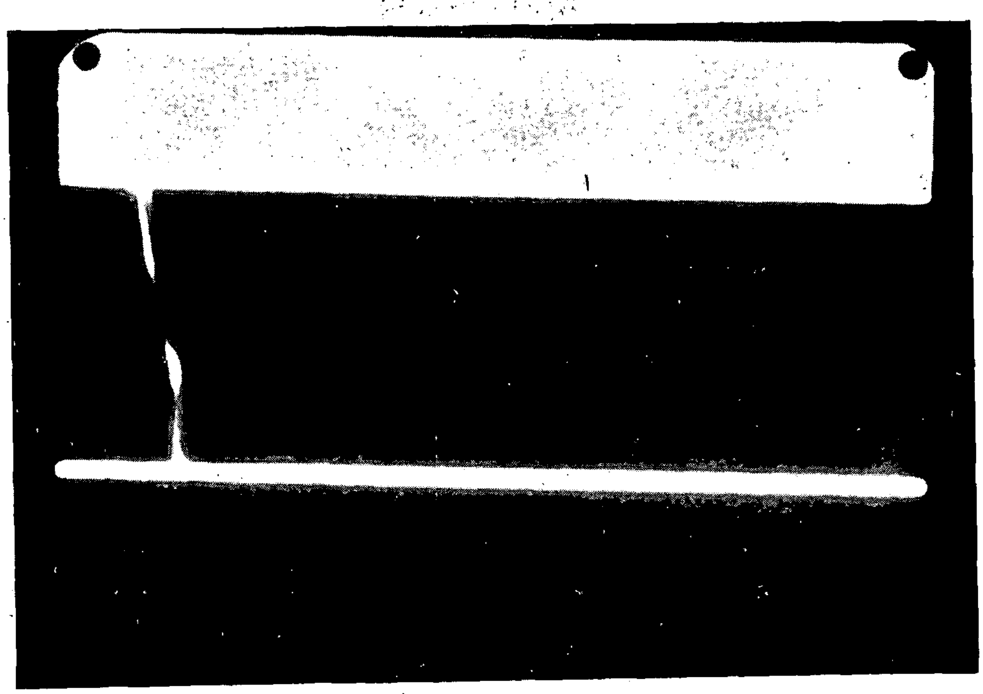


Fig.14

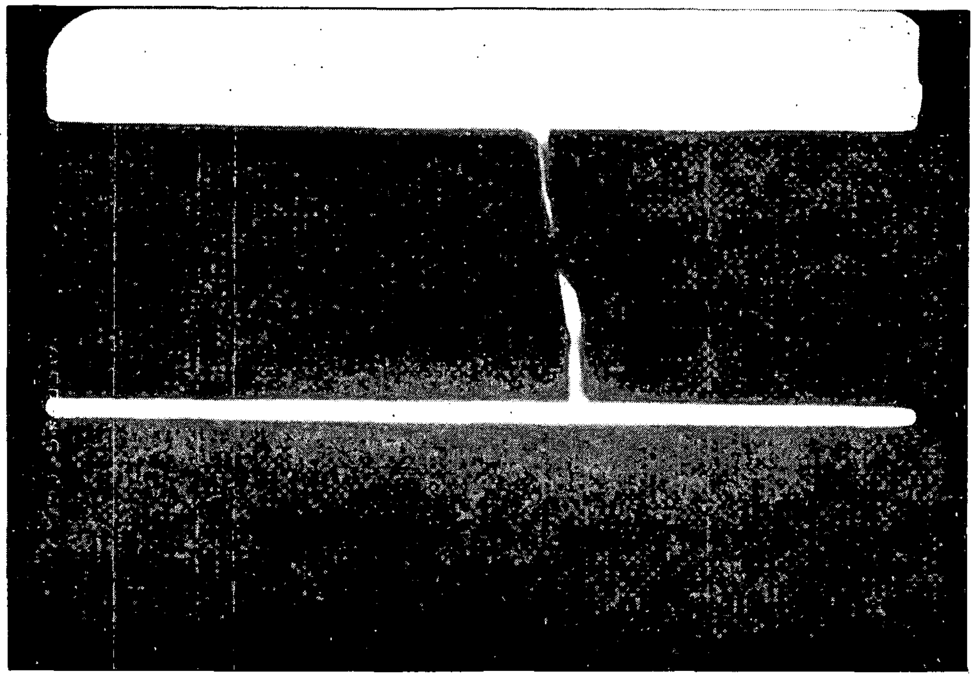


Fig.15

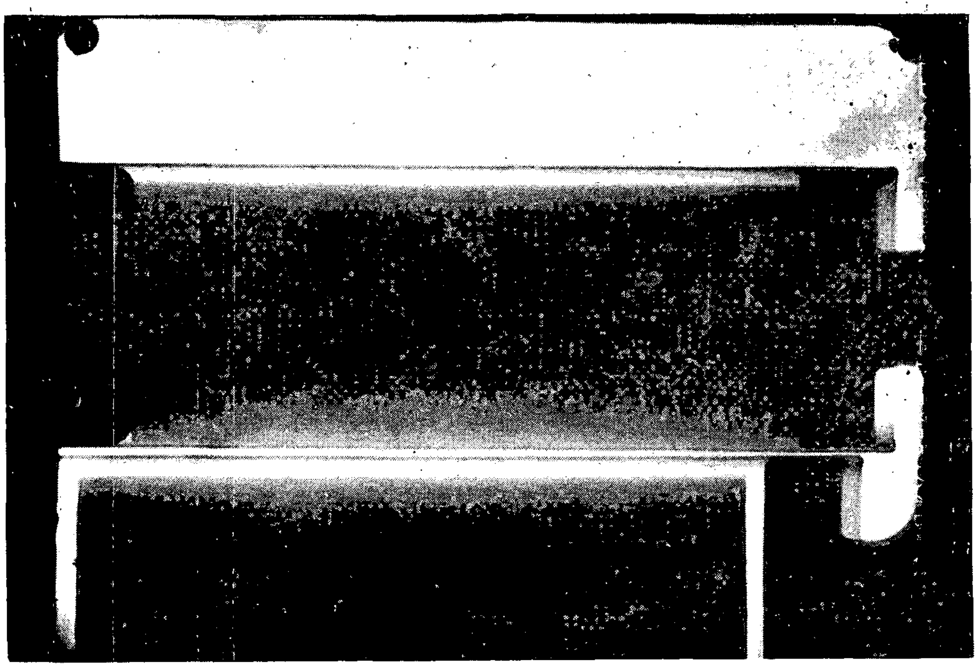


Fig.16

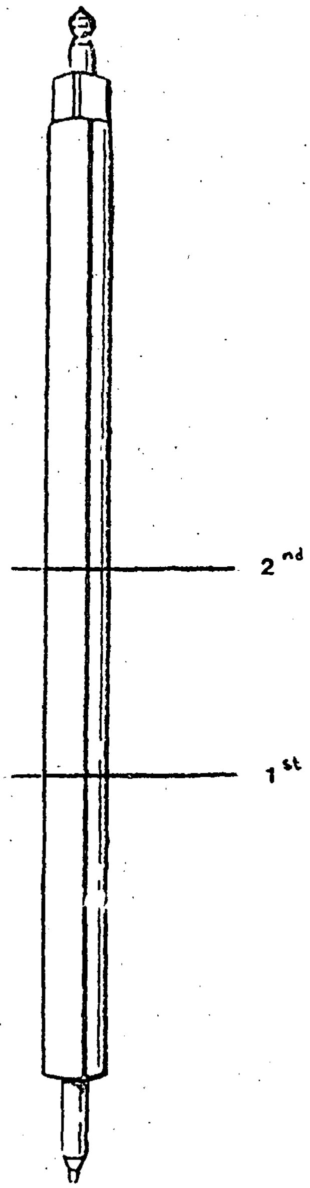


Fig.10

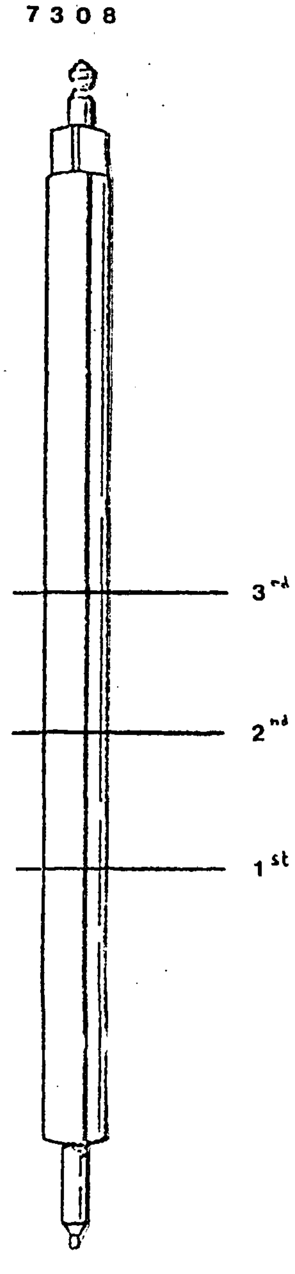


Fig.17