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DESCRIPTION OF MARKS OBSERVED ON CHANNEL H1.3/1

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1. INTRODUCTION

Channel H13/1 is part of the channel unit of the High Flux Reactor (HFR) characterized by the designation "average corrosion attack." It was dismantled so as to reveal the real corrosion state of the irradiated material.

The forward portion of the channel was preconditioned in a hot cell of the HFR and sent to the Kernforschungszentrum Karlsruhe (KfK)/ Germany where all the work required for the research was done.

2. DESCRIPTION OF CHANNEL H13

Made of the aluminum alloy AG3 NET, channel H13 [handwritten correction: H12] is placed horizontally in the reflecting can, 250 mm below the median plane of the core. It [handwritten correction: its axis] is oriented tangentially to a cercle whose center is the axis of the reflecting can. The distance between this axis and the forward end of the channel is 450 mm.

The total length of the channel is about 4.8 m with a length of about 1.60 m of the forward portion overhanging. Figure 1 gives the details of the construction of the channel end. The nose "a" is composed of a hemisphere (thickness 2 mm, interior diameter 100 mm) and of a conical end (length 30 mm, thickness 4 mm). The nose is connected to a conical ferrule (thickness 4 mm) by a circumferential weld. The conical ferrule, constructed from a rolled sheet, has a longitudinal weld.

At the time of manufacture, the weld beads of the forward portion were leveled, the exterior surface underwent passivation treatment.

The channel is submerged in the heavy water of the reflecting can and its interior is filled with helium.

The pH of the heavy water is between 5 and 5.5.

During the time the reactor is running, the temperature of the forward extermity of the channel can be estimated at about 70°C, the temperature of the rear portions at approximately 50°C.

Channel H13, in place since the beginning, was disassembled in October 1981, which corresponds to an irradiation for 2,257 equivalent days at full reactor power. The dose of thermal neutrons received by the forward extremity can be estimated at $1.7 \cdot 10^{23} n_{th}/cm^2$.

The portion of the channel for the tests was conditioned in the hot cell of the HFR so that a length of approximately 1.4 m from the forward end could be sent to KfK [Karlsruhe].

3. OBSERVATIONS

In order to compare the appearance of the channel covered with a layer of alumina to the appearance of the same channel after washing with demineralized water (without deposit), several series of photographs were placed in the hot cell. A first series (figures 2 - 10, figures 21 - 24) shows the channel in a position A that corresponds to that of the channel with respect to the television camera at the time of routine examinations. Position B (figures 11-15, figures 25-27) corresponds to a 120° rotation from A so that the zones visible on the figures are offset downwards. Position C (figures 16 - 20, figures 28-30) was obtained after another rotation, in the same direction, of approximately 120°.

3.1. The raw channel

The raw channel is covered with a thick deposit (figures 2 - 20) that exhibits a clean structuring. The weld beads (see figure 1) are scarcely perceptible (figures 2,3,4) on the portions located near the hemispherical bottom and become more distinct on the most distant portions (fiugre 7 - 10). Traces of rubbing due to handling are clearly apparent and produce marks of an great appearance. Generally, the deposit appears thicker on the hemisphere side (figure 2) that on the rear portion side (figure 10).

Despite the presence of the deposit, white dots with a rough appearance appear clearly on figures 2 to 6 with the greatest concentration on figure 4. The figures related to positions B and C exhibit the same appearance of the channel: thick deposit on the forward portions (B: figures 11-14/D: figures 16-19) with white dots that are difficult to identify as a function of the local appearance of the deposit that becomes thinner towards the rear part (B: figure 15/C: figure 20).

3.2. Washed channel

During the washing of the channel with sponges soaked with demineralized water, the deposit finally disappears, leaving the surface in a clear state, clearly revealing the weld beads and the white dots. The comparison of figures 21 to 24 (position A, washed) with figures 2 to 5 (position A, unwashed) shows the contribution of the deposit to the appearance of the unwashed channel. However, the majority of the white dots can be identified even on the unwashed channel.

The hemispherical bottom reveals a regular surface with a light grey satin appearance (figures 21, 25, 28 and 31) with several white dots having a rough structure and several fine small dots (figures 25, 31). The conical end, connected to the hemispherical bottom, is free of white dots or other traces of specific surfaces. The circumferential weld bead is also regular appearing without any particular sign, as well as the longitudinal weld bead on the conical ferrule.

The greatest concentration of visible white dots is on figures 22 and 23 in a zone approximately 20 to 40 mm from the nose of the channel (position A). This concentration greatly decreases as we more forward, backward and on a circumferential path towards the opposite side. The last visible white dots are on a zone 50 to 55 mm from the nose of the channel. The shape of the white "dots", as well as their relative magnitude, seems to be independent of the location of the dot on the channel.

4. METALLOGRAPHS

Figure 32 shows the location of the specimens that were used for the metallographs:

No. 1: white dot located in the hemispherical portion

No. 2: white dot located in the hemispherical portion near the conical end.

No. 3: white dot located in the conical ferrule. Zone with a high concentration of white dots.

No. 4: two white dots located on either side of the longitudinal weld.

The appearance of the corresponding white dots is given in figures 21 (numbers 1 and 2), 22 (no. 3), 23 (no. 4) and 31 (no. 1). The white dots are in the intersection of the horizontal and vertical lines designated by the specimen number.

4.1. Hemispherical bottom

Figure 33 shows a section through the white dot of specimen 1. The exterior portion of the channel (heavy water side) is at the top of the figure, the interior portion (helium side) at the bottom.

The thickness of the material, measured at the right and left edges, is 2.15 mm and decreases towards the bottom of the hollow portion to reach 1.55 mm [handwritten b 0.6]

The surface of the zone attacked has an irregular, often rounded shape. A portion of the material is completely separated from the base material. Generally, the material attacked has disappeared.

The detail of the separated portion of the base material reveals a principal crack whose two edges have almost the same shape (figure 34). To the left, this crack joins a caving attack zone with rounded and regular shapes. Another small crack, located to the left of the cave, detached the upper edge of the cave without the detached material having completely left it.

No trace of attack is visible on the interior portion (helium side) or the hemispherical bottom.

The white dot of specimen 2 [circled by hand] is located in the hemispherical bottom (local thickness 1.8 mm on the unattacked portions) near the conical end (local thickness 3.3 mm on the unattacked portions.)

The attacked zone is in a hollow in comparison to the unattacked zones, which decreases the thickness of the material to 1.2 mm. [handwritten and circled: 0.6]

The morphologies of specimens 1 and 2 look alike: local attack on approximately 5 mm with a thickness of 0.6 mm (figure 35). The surface attacked has an irregular shape, the detached portions form cracks with the base material whose edges have the same shape (figures 37 and 38).

On the other hand, the "cave" attack locations appear less clearly on specimen 2 than on the previous one. No attack on the helium side.

4.2. Conical ferrule

Specimen 3 is located in the conical ferrule 155 mm from the nose of the channel. The principal attack is constituted by a cave (figure 39) reducing the thickness of the wall from 4.25 mm to 3.6 mm [handwritten: 0.65]. Beside the principal cave, other small caves are being formed with the common characteristic of smooth surfaces with rounded shapes (figure 40) that do not retrace the grain boundaries (figures 41 and 42). As previously, the upper edges of the caves tend to separate from the base material (figure 39) by the formation of a network of cracks retracing the grain boundaries (figures 43 and 44). No trace of attack is visible on the helium side.

4.3. Longitudinal weld of the conical ferrule

Specimen 4 has two white dots located on either side of the longitudinal weld bead of the conical ferrule (figure 23). Figure 45 whose the metallograph of specimen 4 in a preparation that emphasizes the zones thermally affected by the welding. The attacked zones are shallow: 0.3 mm with rounded surfaces without detached portions.

The weld bead is free of attack. The zone thermally affected by the welding is not subjected to perferential attack. The interior side of the ferrule exhibits a small welding defect (root defect). No trace of attack is visible on the helium side.

5. <u>CONCLUSION</u>

The white dots visible on channel H13/1 are signs of a local corrosion. Metallographs made on four specimens reveal two types of corrosion:

I - in-depth caving corrosion

II - corrosion by the development of surface cracks.

Given the deeper corrosion of type I compared to that of type II and the simultaneous presence of the two types in the same zone, it can be assumed that the attack of type I affects the depths and the type II corrosion affects the extension of the zone corroded. It should be noted that the type I corrosion appears along, whereas the type II corrosion is always accompanied by type I corrosion. Despite the limited number of specimens it can be assumed that the type I corrosion leads to the development of type II corrosion. Later research planned for other channels should make it possible to determine the corrosion process of the white dots.

[signed] E. Bauer

LIST OF FIGURES

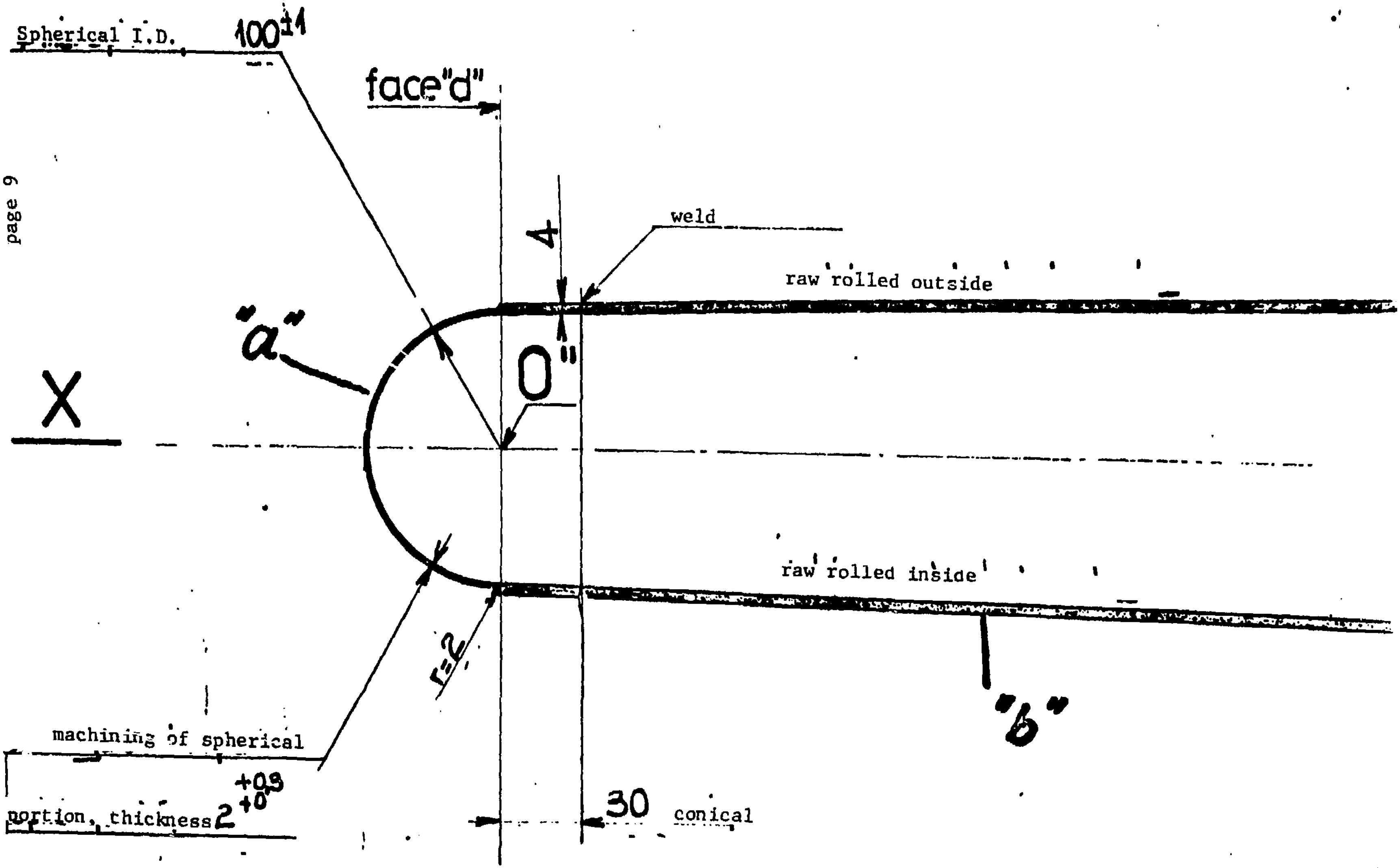
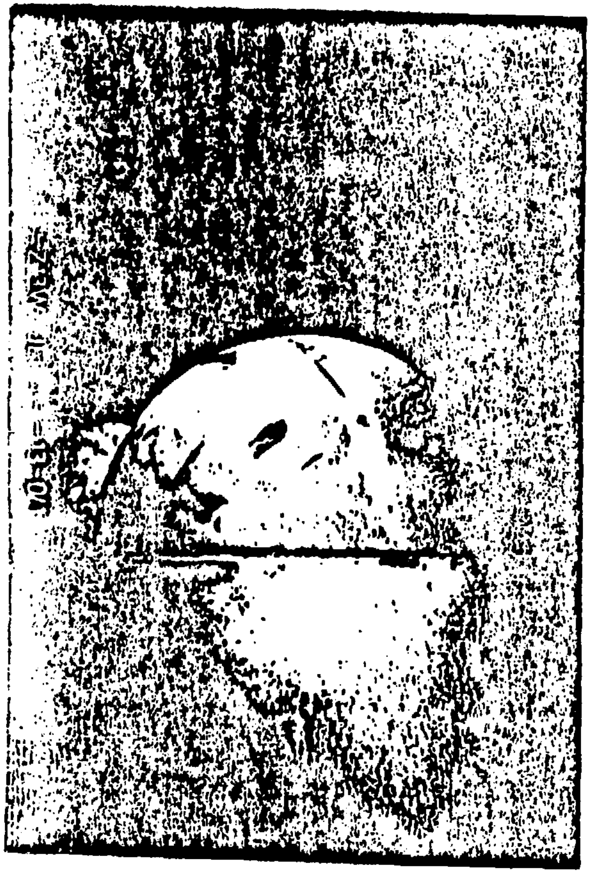


fig.1 - Channel H13/1 forward portion

AG3NET-RHF H13-1 Raw A1



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AG3NET-RHF H1311 Raw - A2

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AG3NET-RHF H13/1 Raw A3

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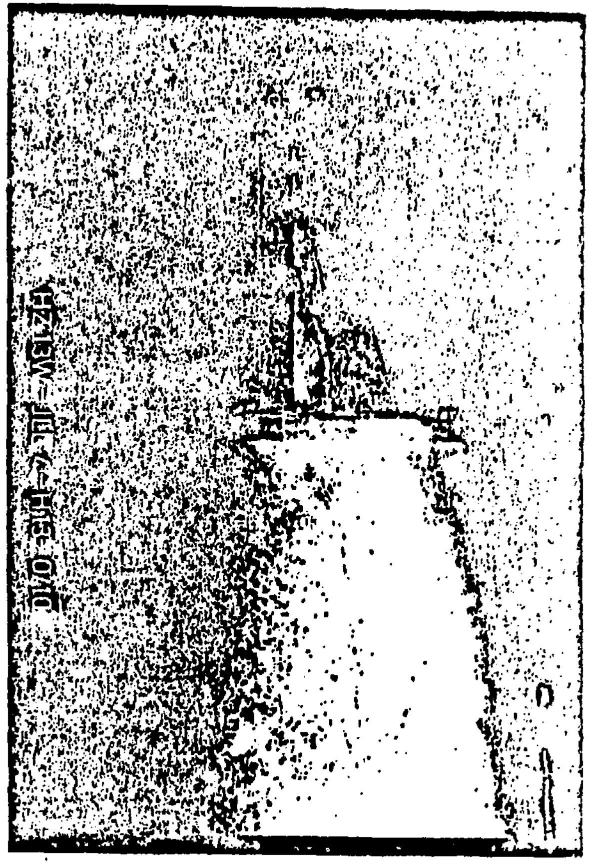

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AG3NET - RHF H13/1 Raw B1

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AG3NET - RHF H13/1 Raw - B2

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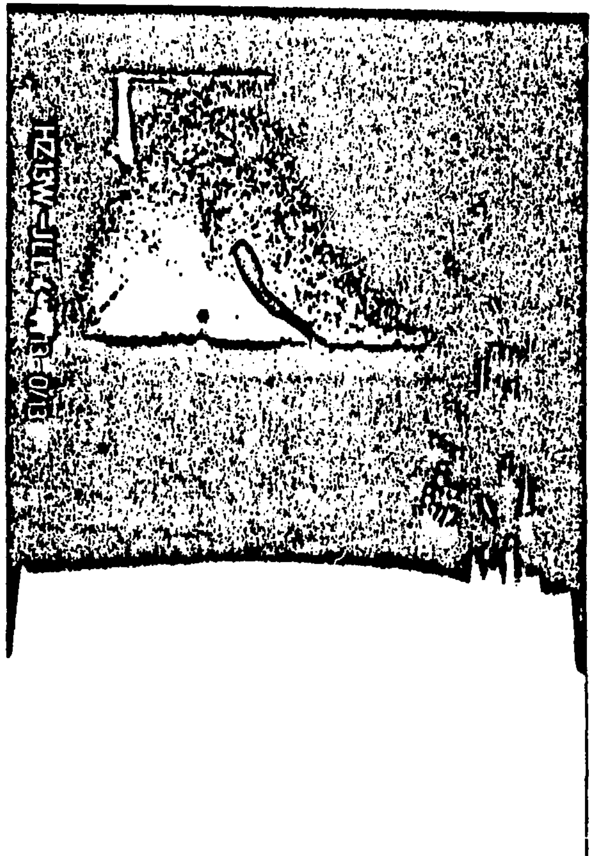

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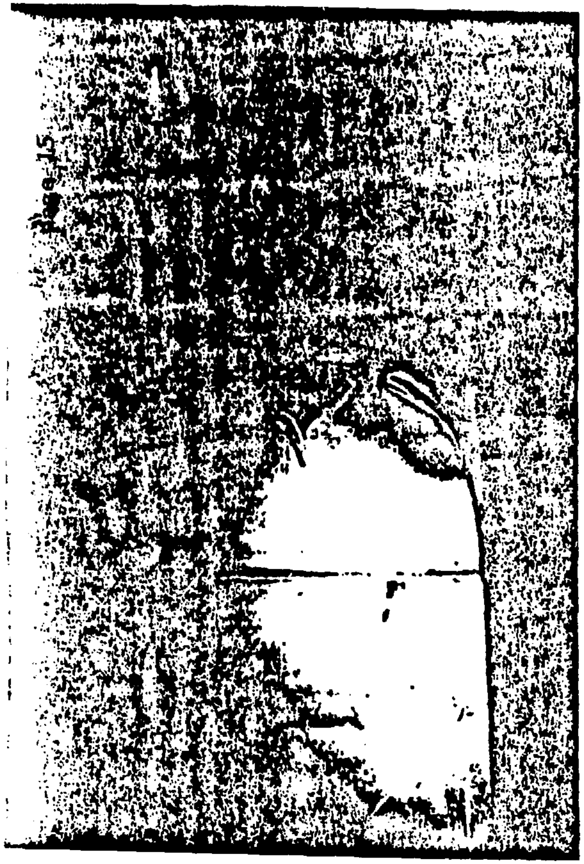
AG3NET - RHF H13/1 Raw C1



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AG3NET-RHF H13/1 Raw C2

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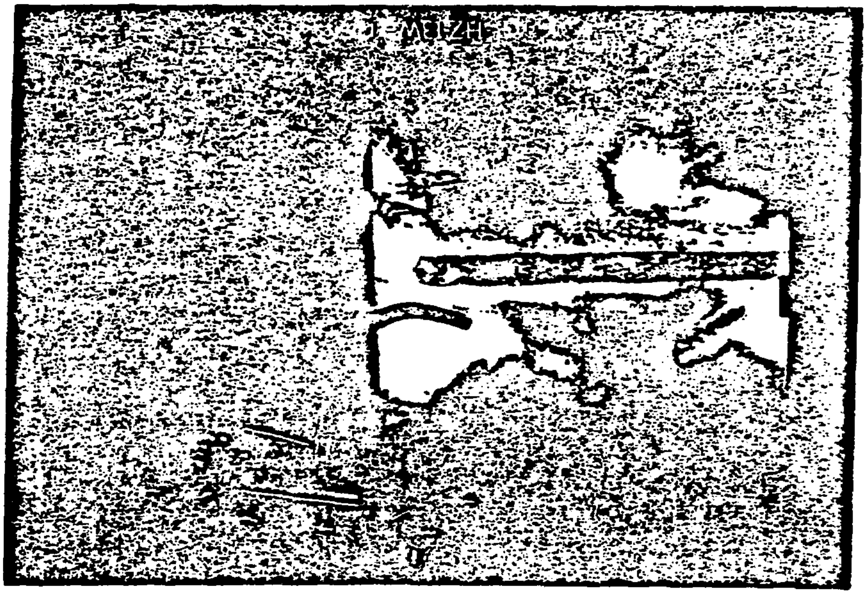
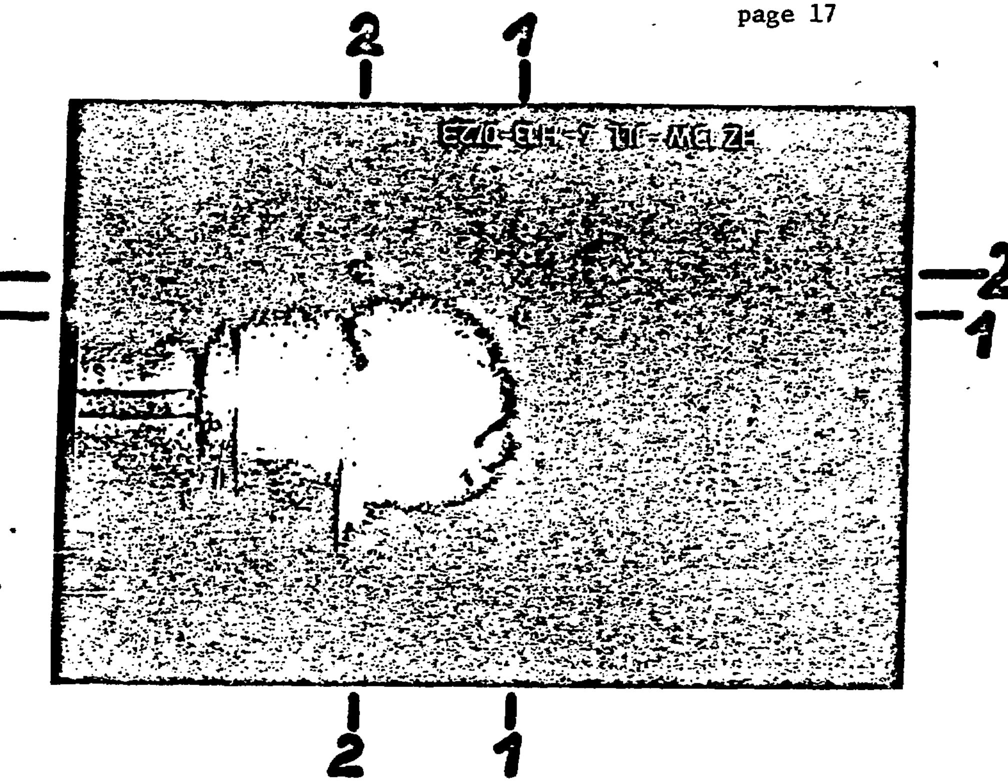


AG3NET-RHF H13/1 Washed A1



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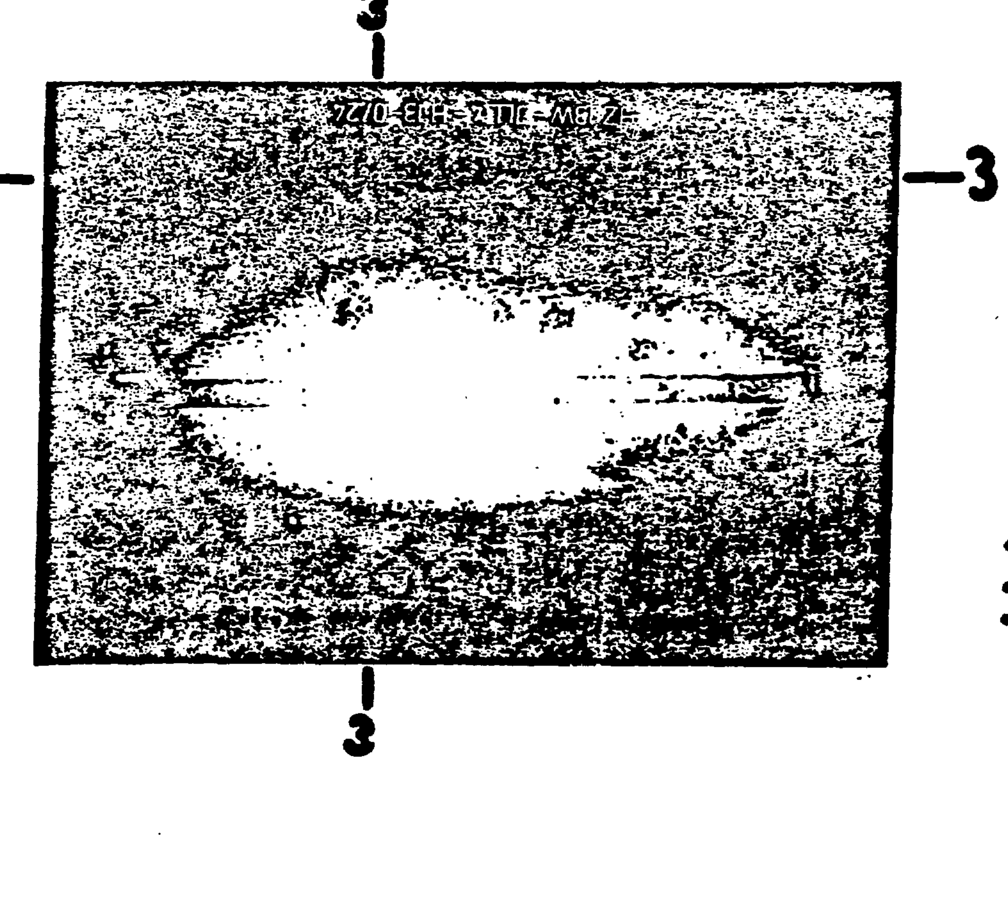

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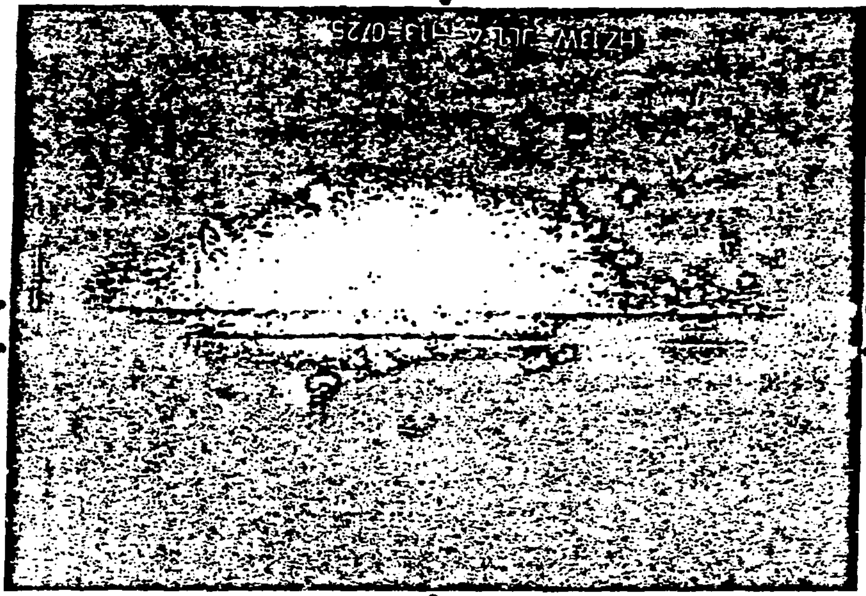

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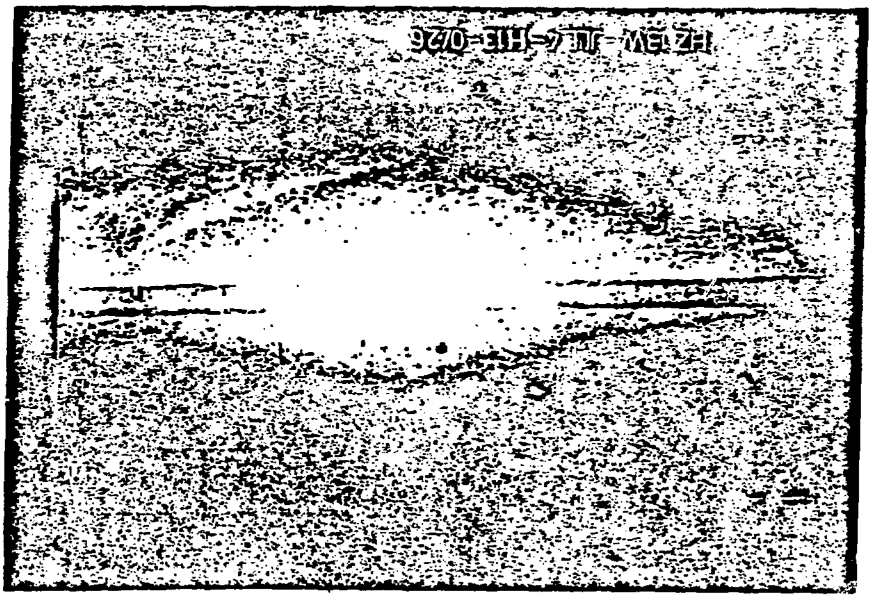

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AG3NET-RHF H13/1 Washed B1

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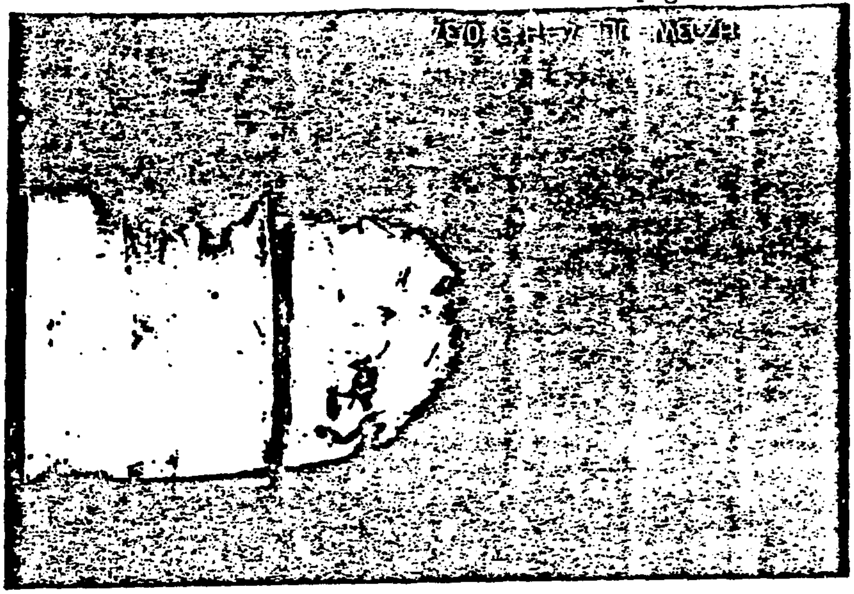

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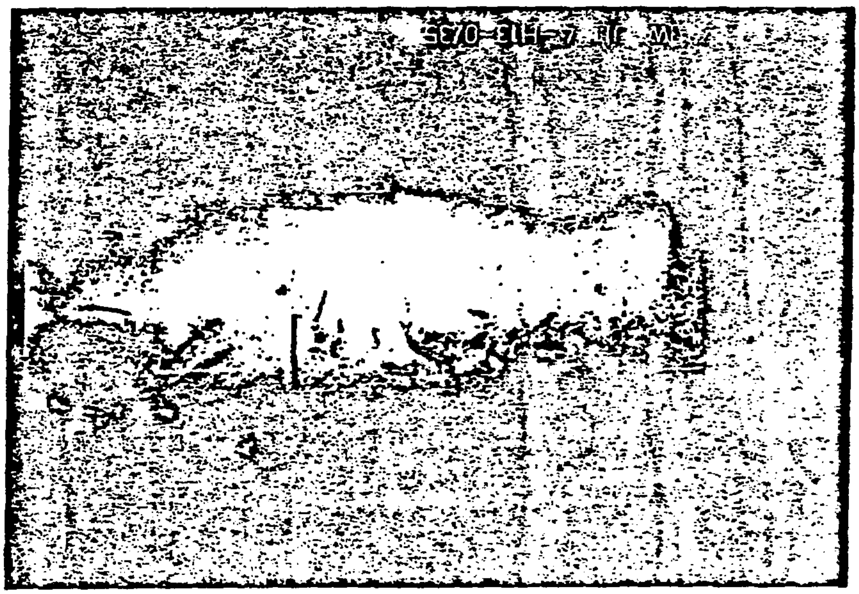

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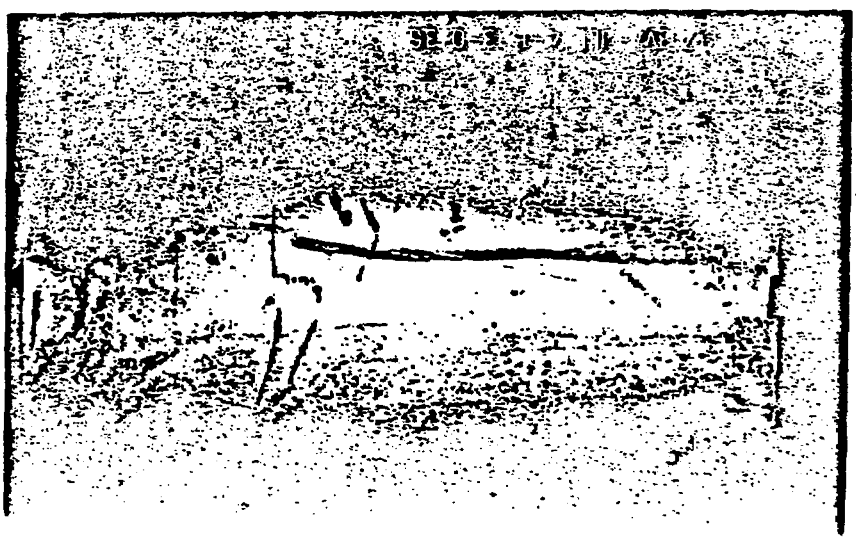
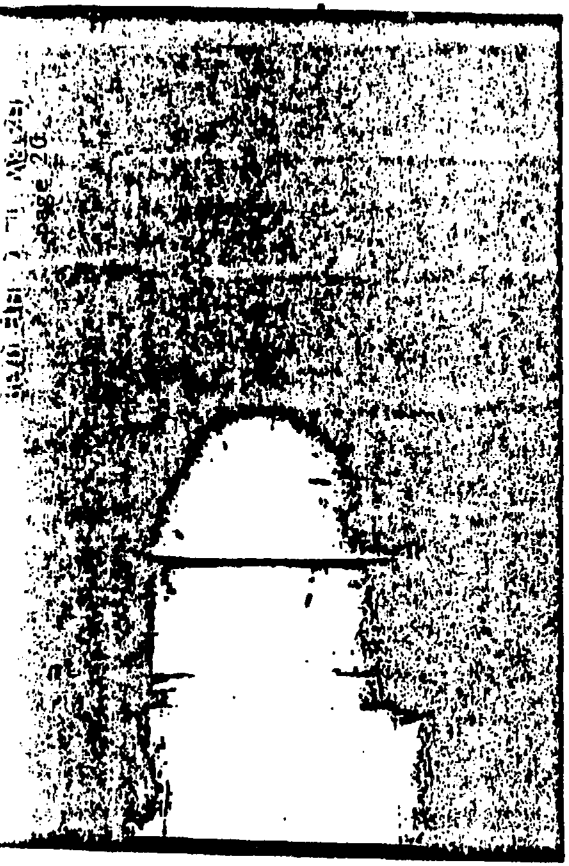


AG3NET-RHF H13/1 Washed C_1



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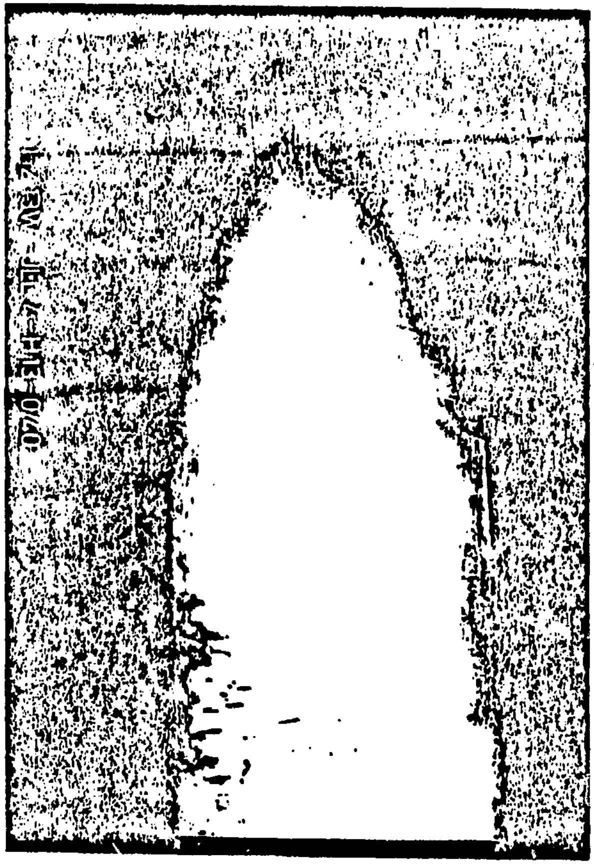

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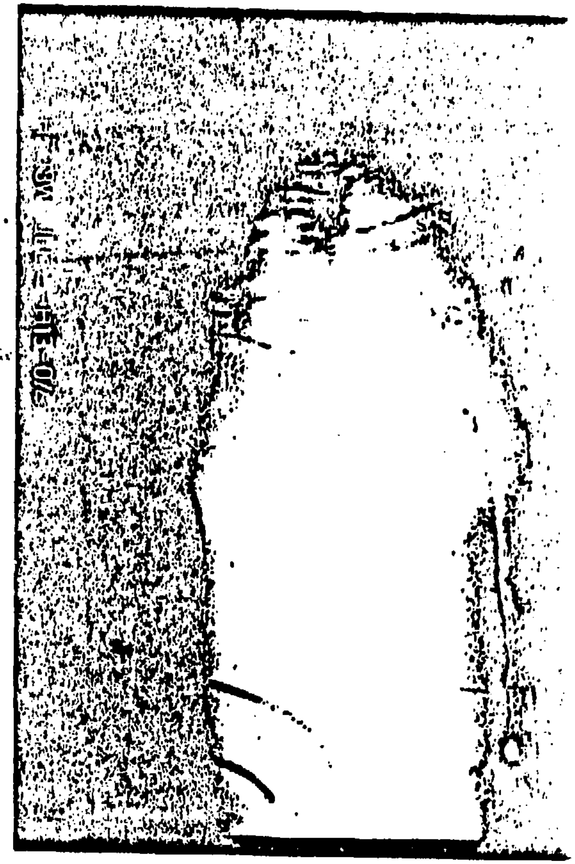

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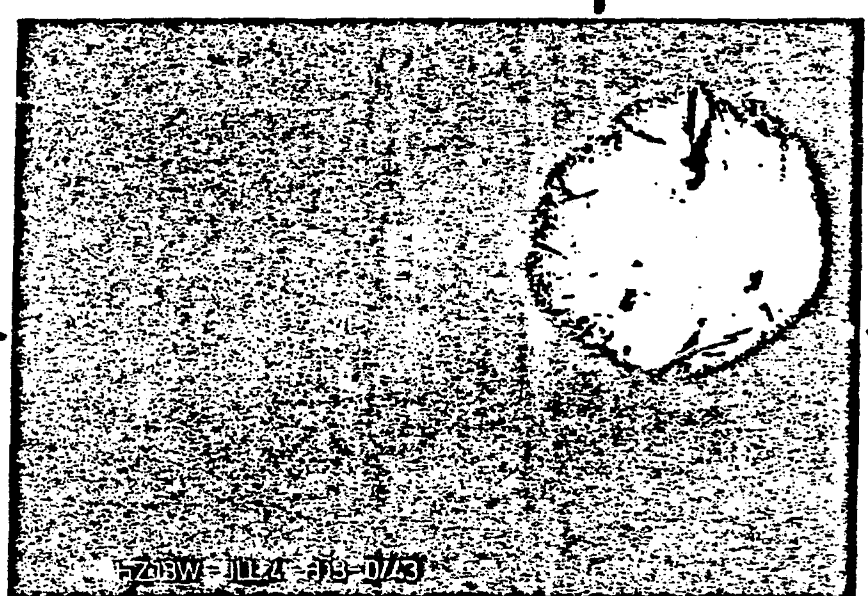
AG3NET-RHF H13/1 Washed Nez

1

1  1

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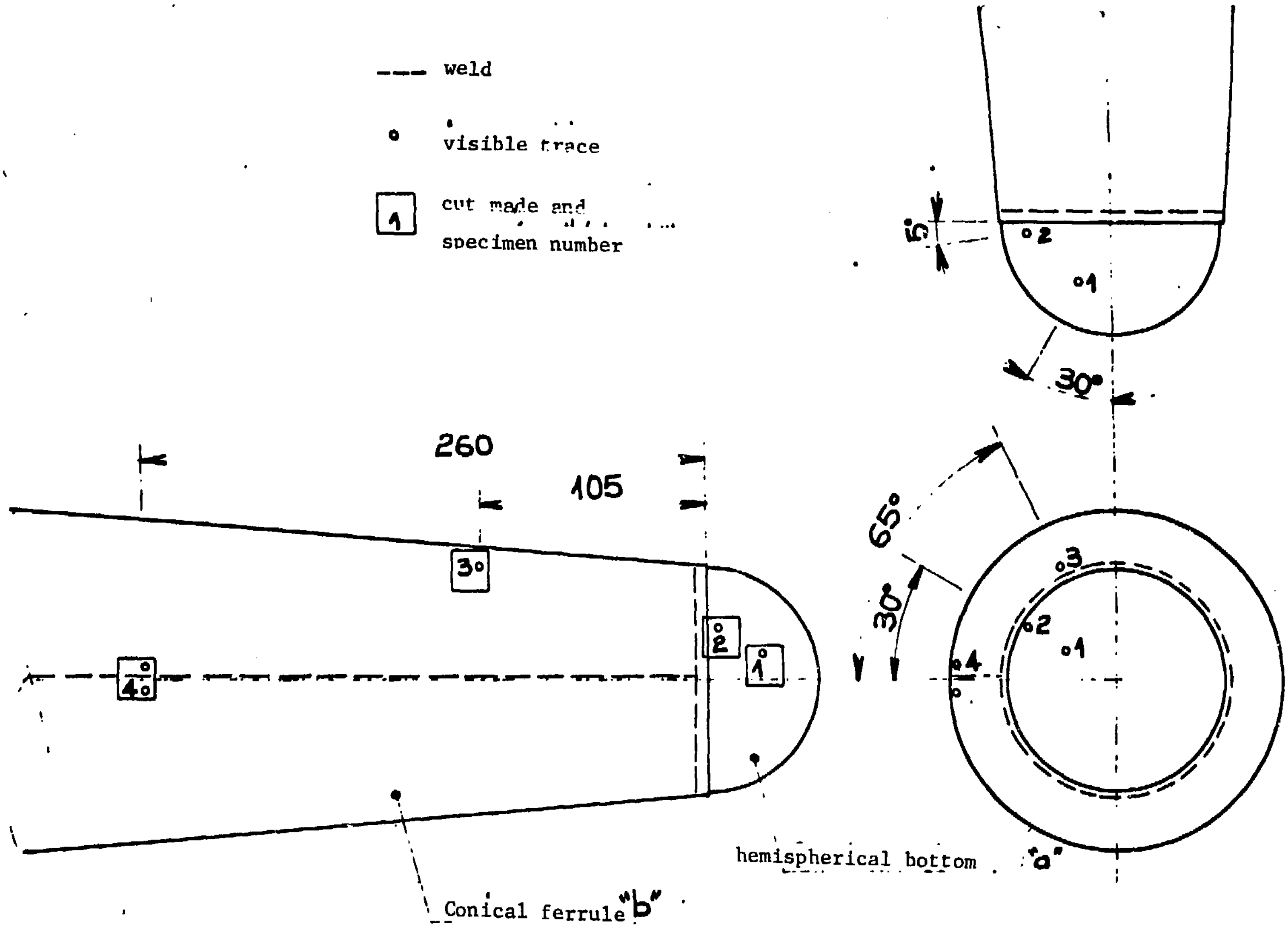
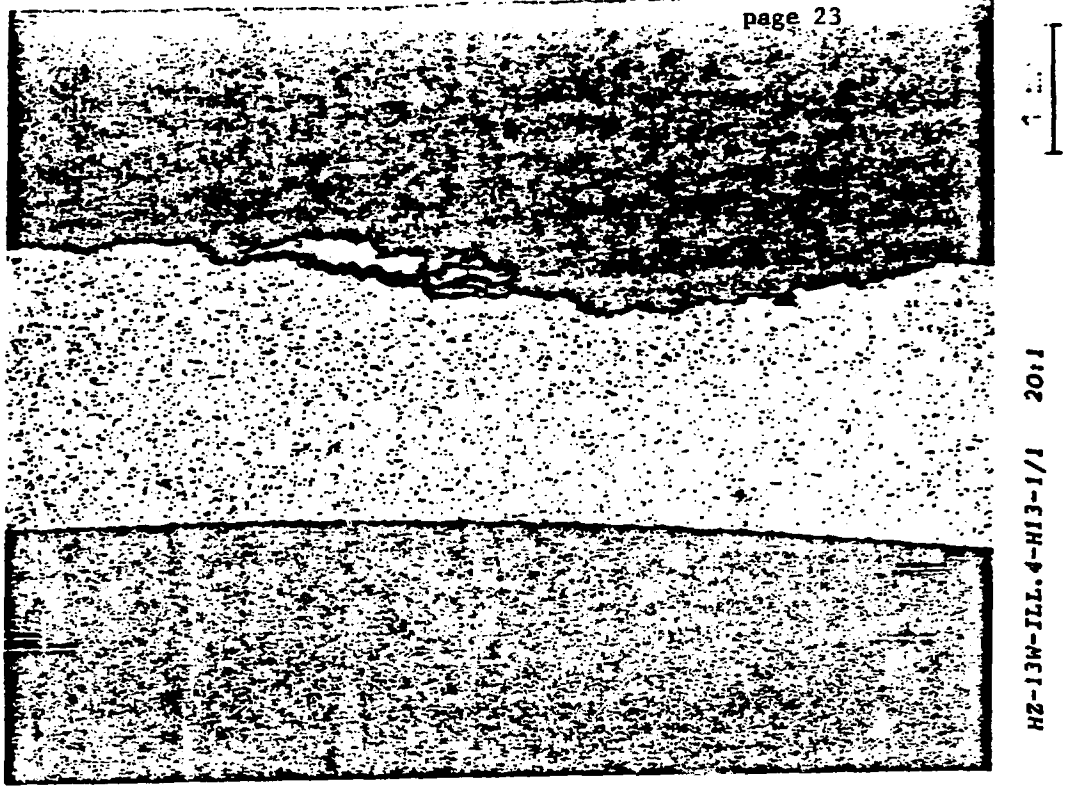


fig. 32 Location of metallograph specimens



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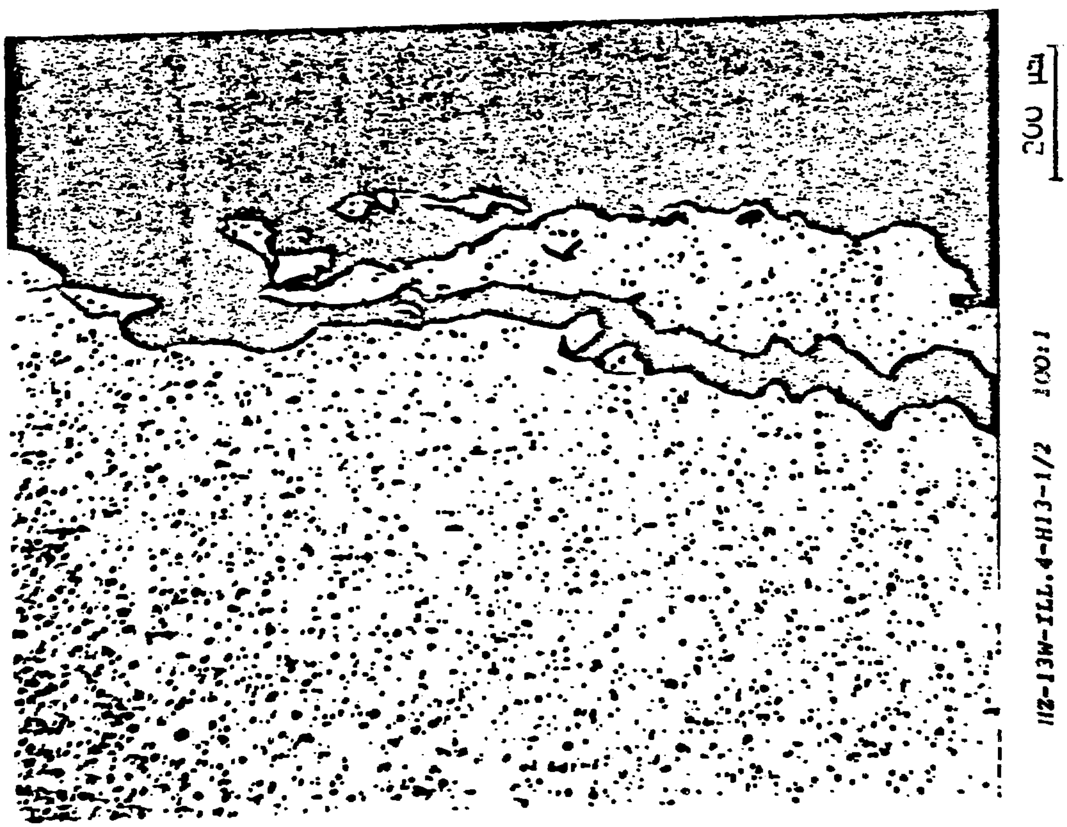
Hemispherical bottom



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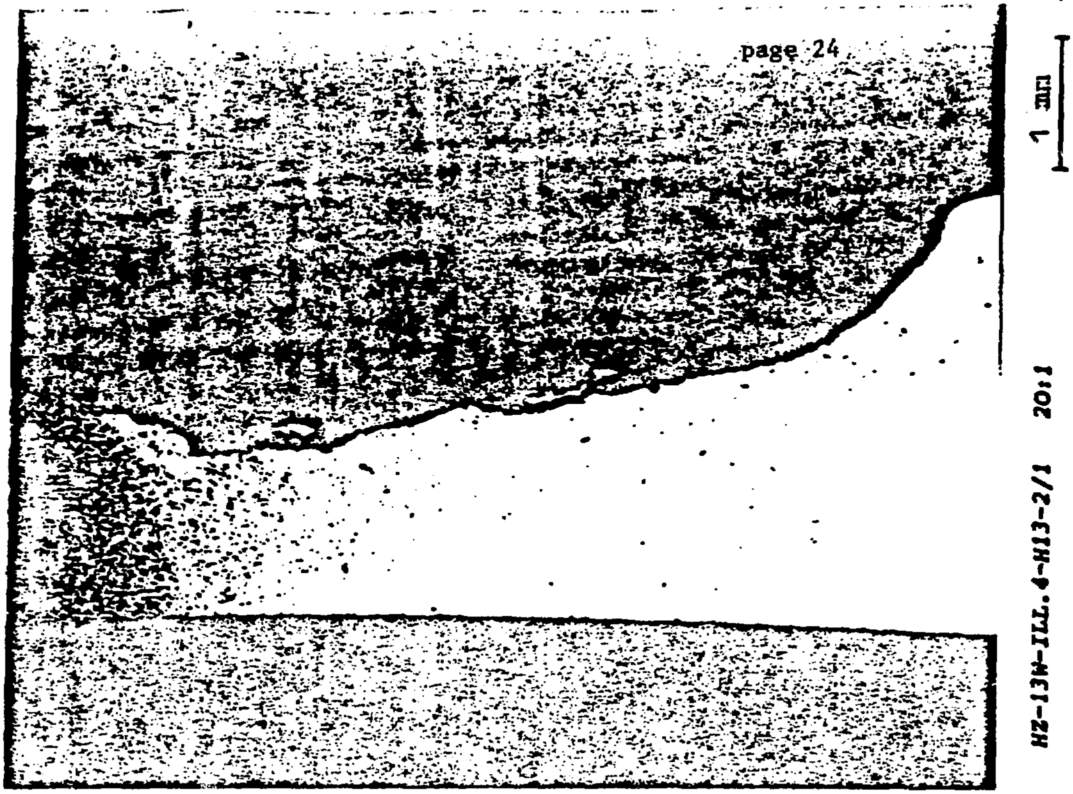

35

N° 2 - Hemispherical bottom

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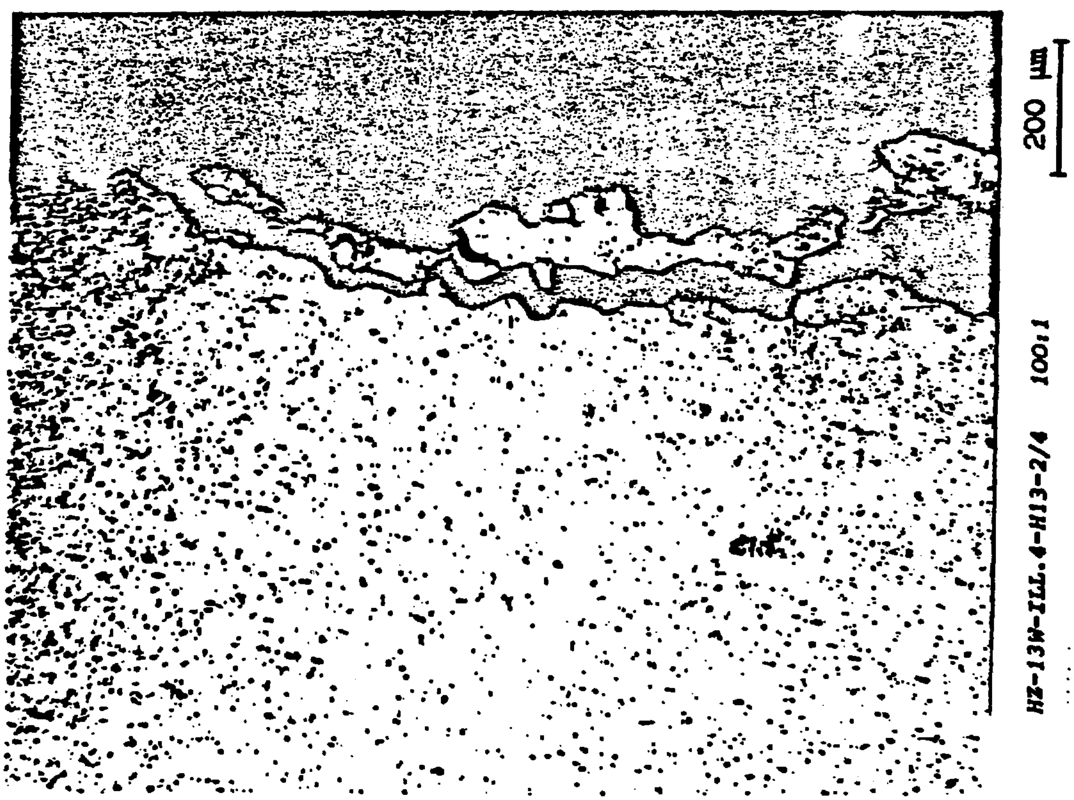
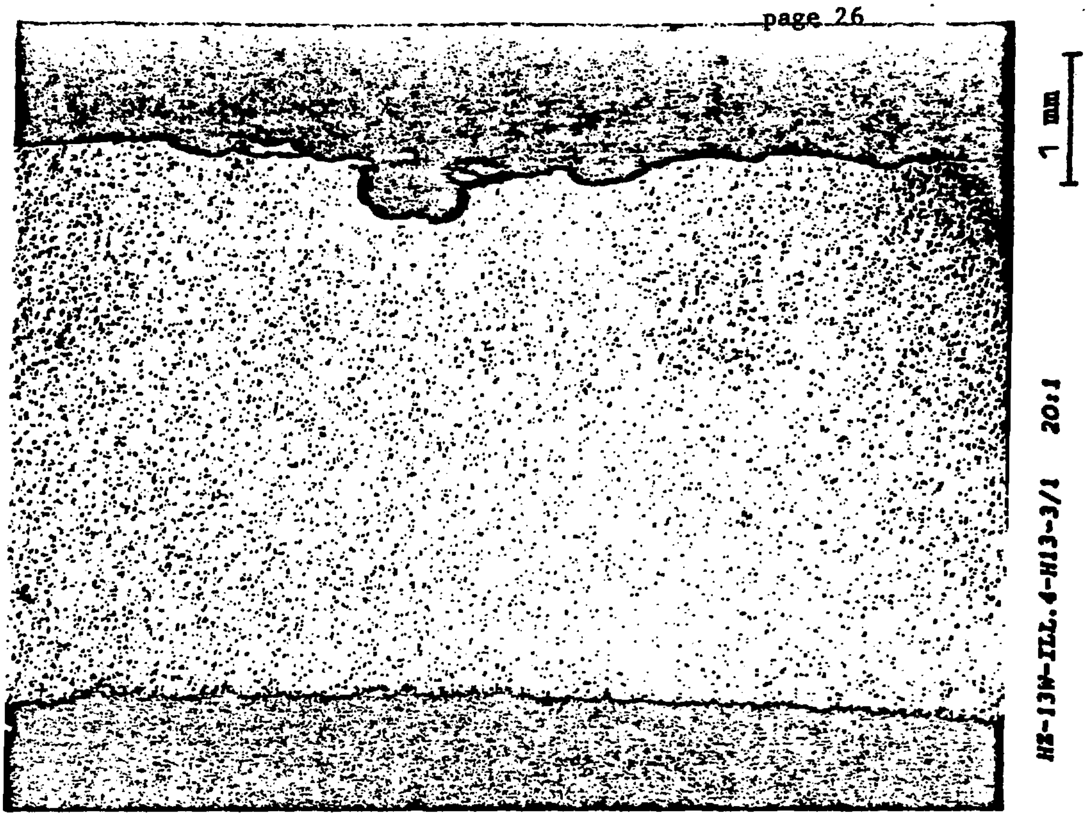
N° 2 - Hemispherical bottom - detail of central portion

38



N° 2 - Hemispherical bottom - detail right portion



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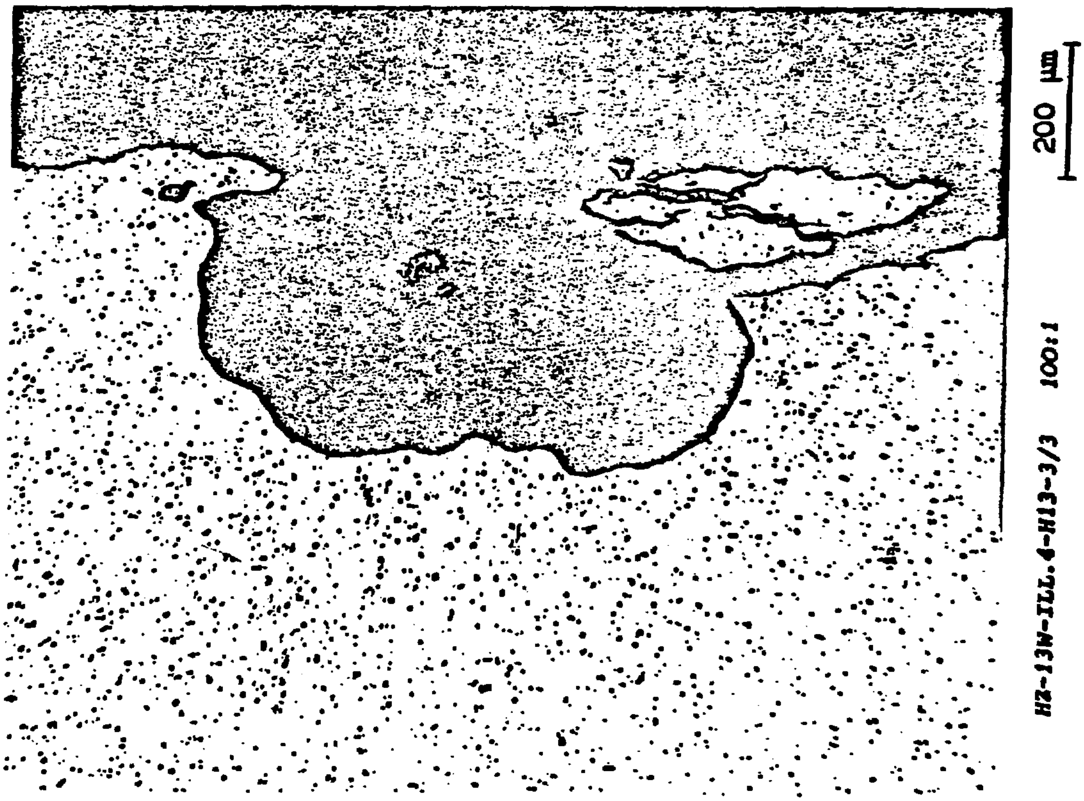
N° 3 - Conical Ferrule



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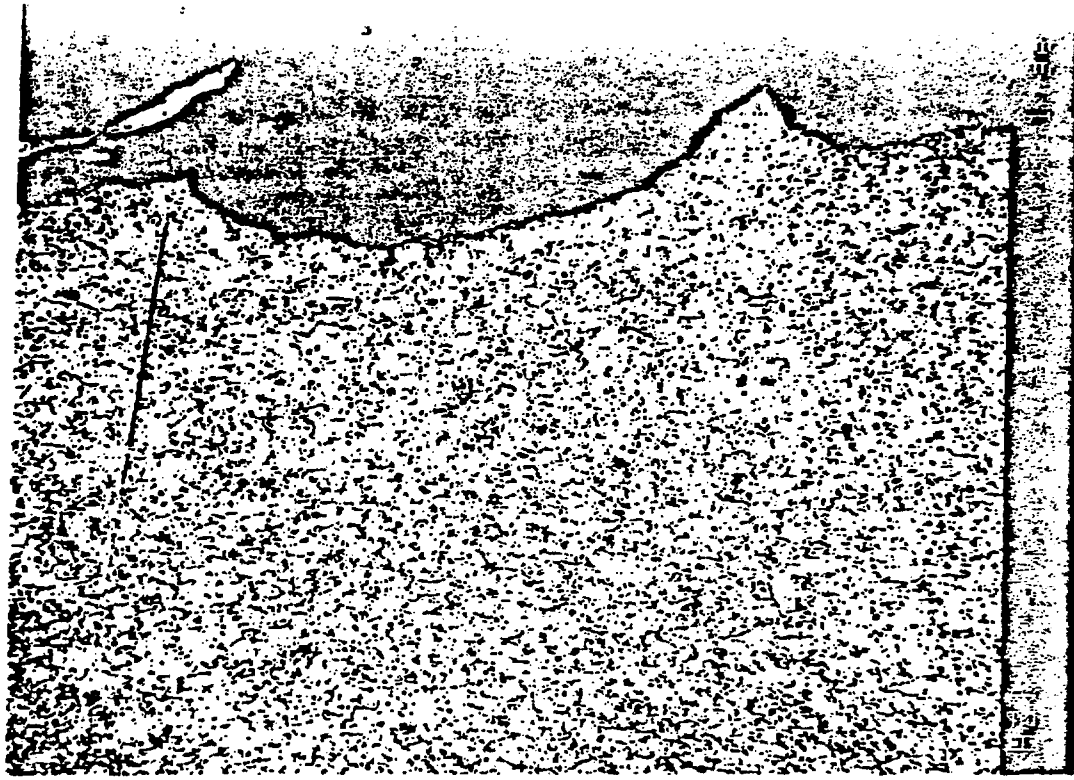

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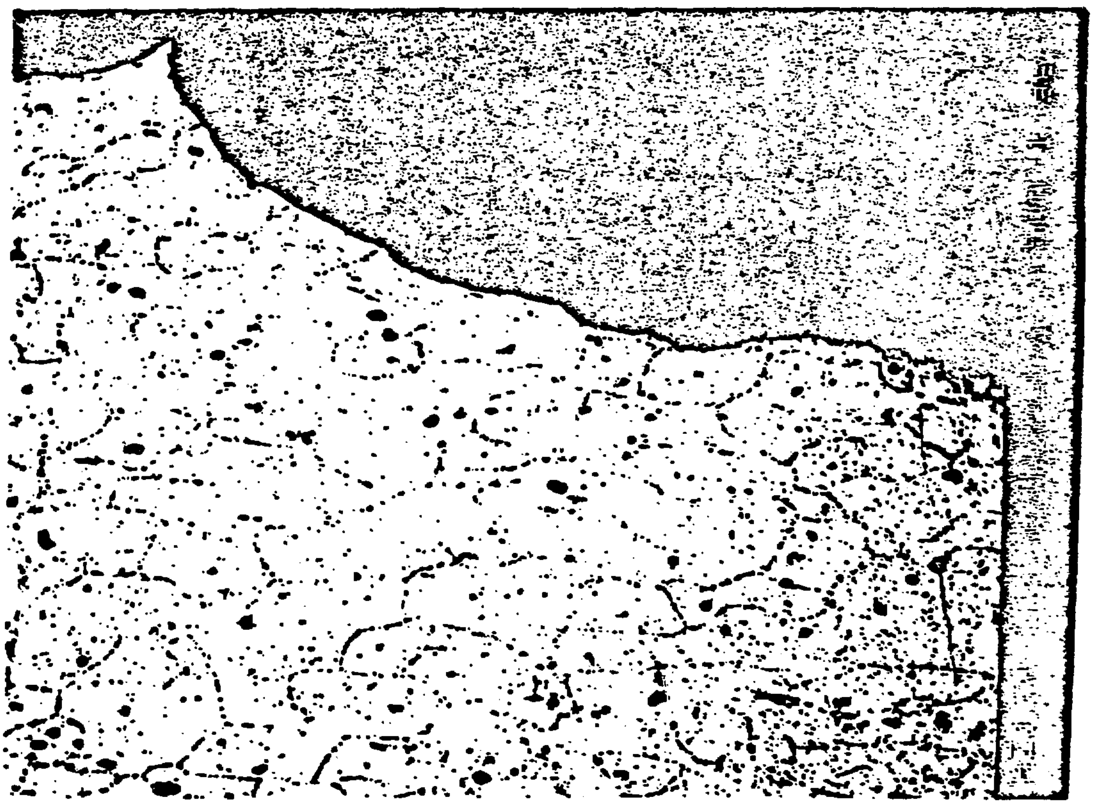
N° 3 - Conical ferrule - detail of a hollow with grains



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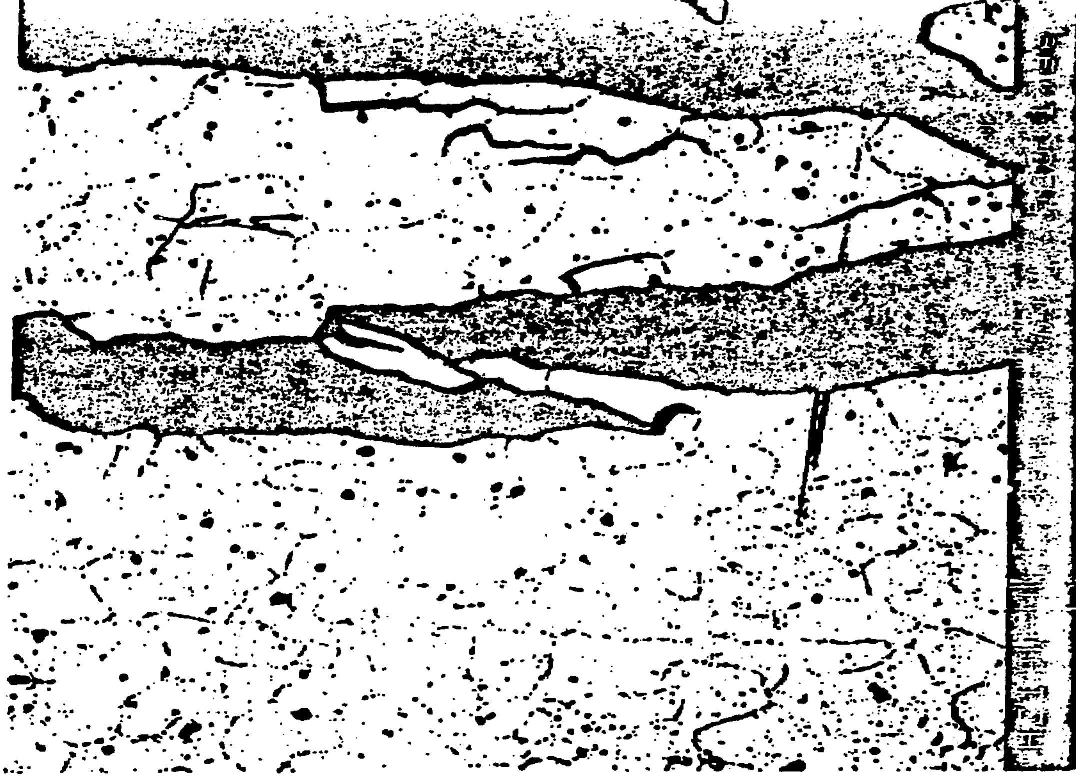

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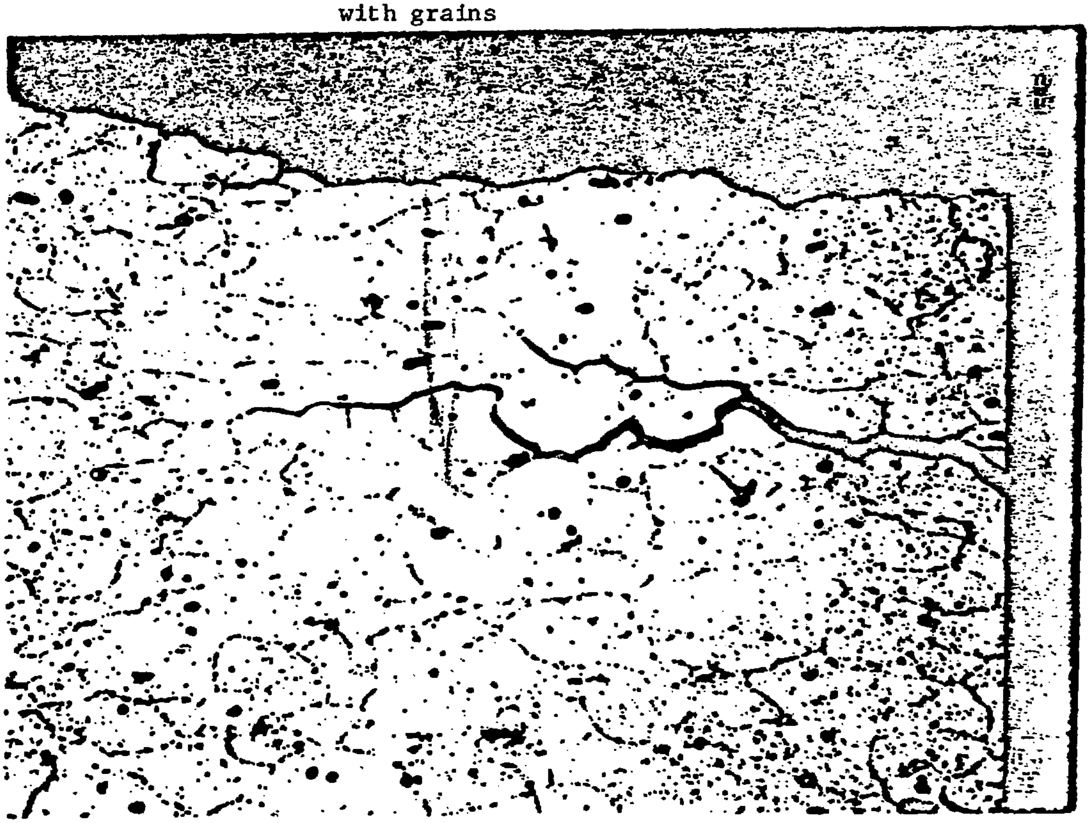
N° 3 - Conical ferrule - detail of a detached zone with grains



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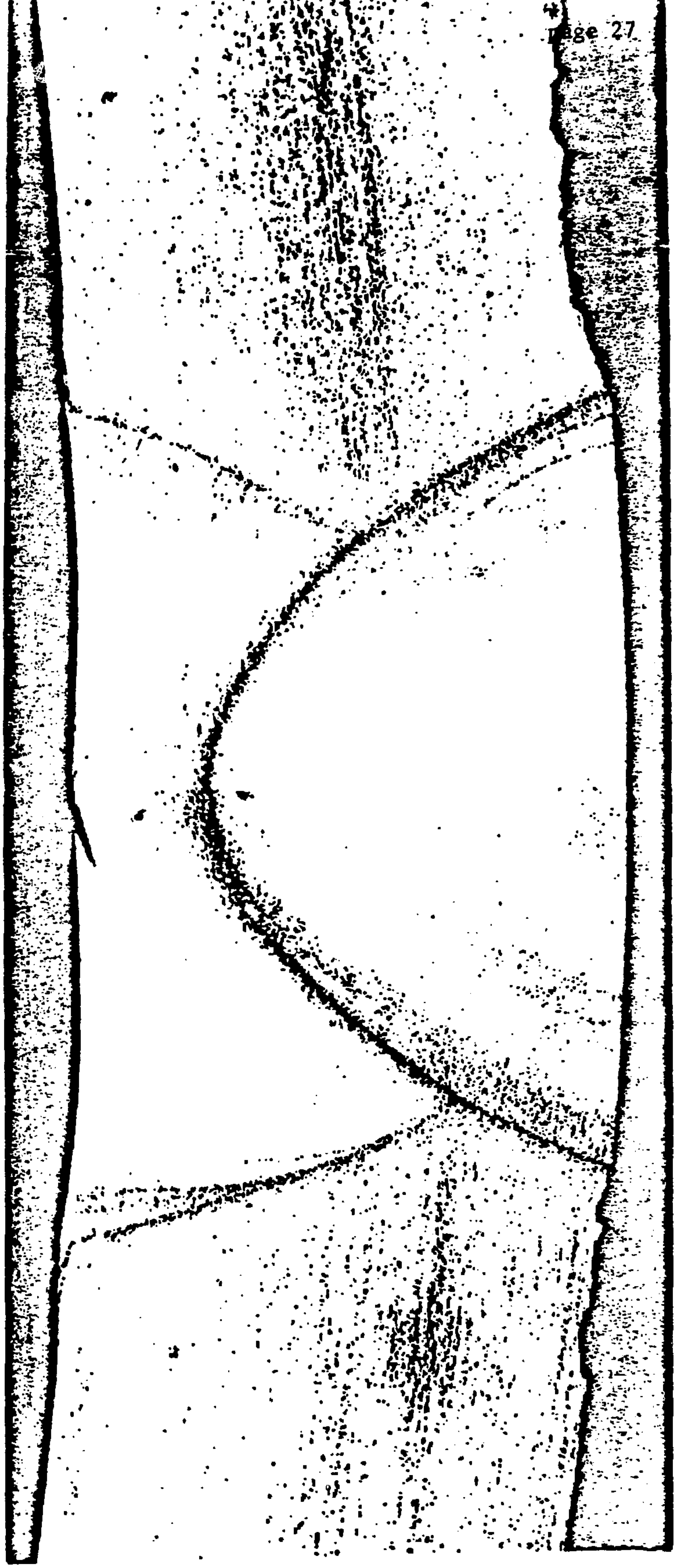
Conical ferrule - detail of a marked zone with grains



45

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1 mm

N° 4 - Longitudinal weld of the conical ferrule with heat-affected zones