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SHIP STRUCTURES LABORATORY

DELFT UNIVERSITY OF TECHNOLOGY

PLASTIC DEFORMATIONS AT NOTCHES IN WELDS OF MILD STEEL PLATES

Part II: NOTCHES IN TRANSVERSE WELDS

by

ir. J. J. W. NIBBERING

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§ 1. Introduction.

In mild steel structures the yield point of the welds is practically always appreciably higher than that of the steel. From this it is often concluded that the welds are "stronger" than the rest of the structure and consequently eventual fractures will show a preference for the latter.
This conclusion is especially when brittle fractures are concerned, a dangerous one; notch toughness and weld defects have more influence on the fracture behaviour than yield point.
Apart from this, welds in plates loaded in the direction of the welds have to deform in the same way as the plate-material. Only when welds are loaded perpendicular to the weld direction, eventual plastic deformations can start in the plate material before it does so in the welds.
There are reasons to suppose that the situation will not be much different when defects and cracks are present in the welds. For notches in longitudinal welds this has been demonstrated earlier. (S.S.L. report 129 - IIW doc. WG-2912-1-68).
In the present paper results of experiments with plates containing notches in transverse welds are given.

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§ 2. Notches in transverse welds.

Contrary to the situation of notches in longitudinally loaded welds, notches in transverse welds are "protected" from large deformations by a high yield point of the weld metal. This is explained in fig. 15.

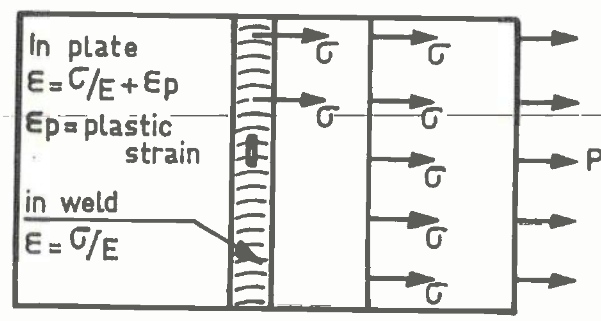
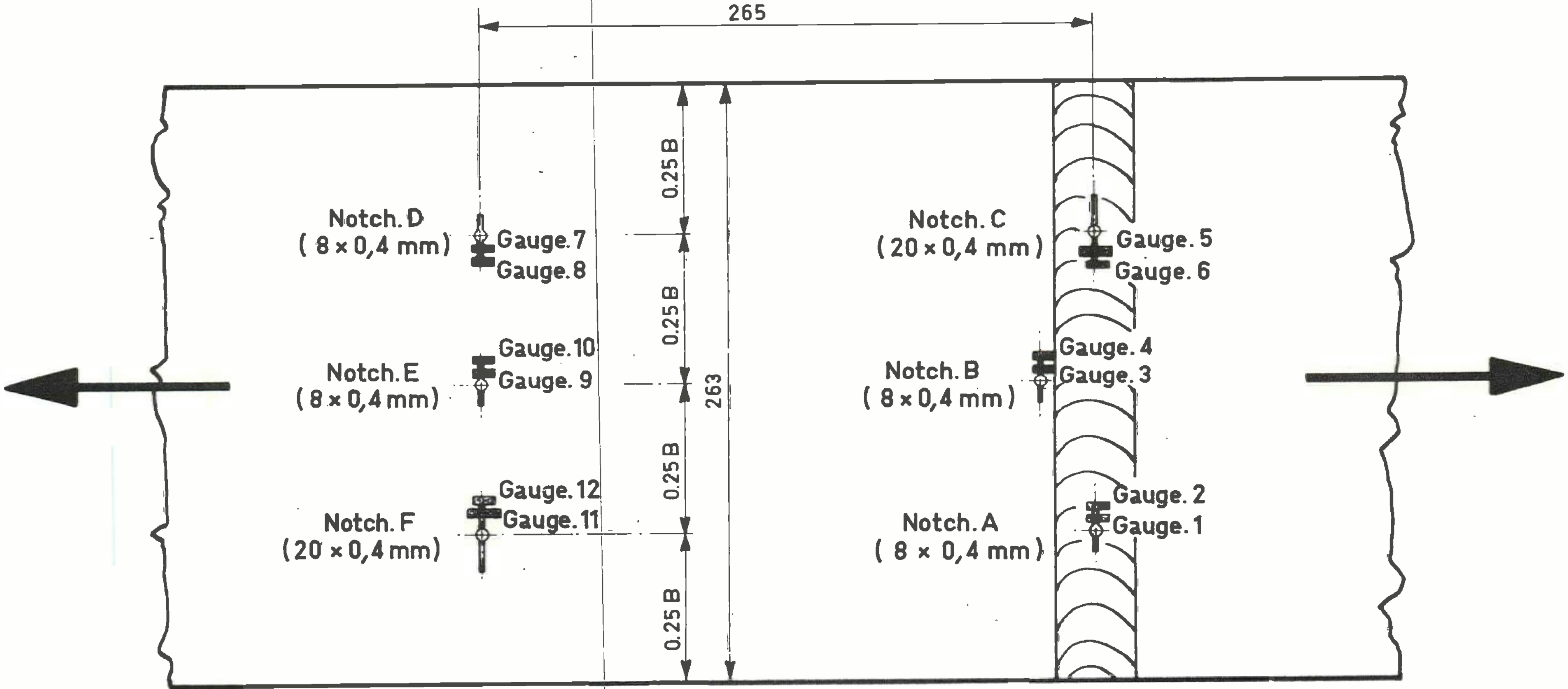


FIG. 15 $\sigma_y(\text{plate}) < \sigma < \sigma_y(\text{weld})$

It has been thought useful to set up an experiment for testing whether the hypothesis is universally true or not; the length of the notch for instance might have an appreciable influence. The specimen is shown in fig. 17. It contains 8 and 20 mm long notches in the plate, the H.A.Z. and the weld metal. Each notch is provided with two strain gauges, one "bridging" the notch and the other being placed in the plastic zone near the notch's root.
The length of most gauges was 3 mm. One side of the specimen had been sprayed with brittle lacquer in order to be able to make visual lüders lines and plastic zones. Fig. 22, 23 and 24 show the results of the strain gauge measurements. The thick drawn and dotted lines refer to the deformations in the weld metal or H.A.Z.; the thin lines to those

of the plate material.
In all cases, local as well as extensive yielding started first at the notches in the plate material and only at substantially higher loads in the weld metal and H.A.Z.
The length of the notches did not seem to have much influence on the relative behaviour of plate and weld; only at high stresses (fig. 20, σ_{net} = 31,50 kg/mm^2) a difference could be observed.
The brittle lacquer patterns confirmed in a very illustrative way the strain gauge results. Another demonstration of the behaviour of a transversely welded specimen is shown in fig. 21, presenting a longitudinal section of a test bar containing an X-weld. Originally weld and plate had the same thickness. From this test the effective yield point of the X-weld could be determined at 36 kg/mm^2 (for a pure weld-test bar it amounted to 44 kg/mm^2) for the plate σ_y was 27,3 kg/mm^2.



Length strain gauges 5 and 11 = 5mm.
Length rest of strain gauges = 3mm.

FIG. 17 TEST PIECE WITH NOTCHES AND STRAIN GAUGES.

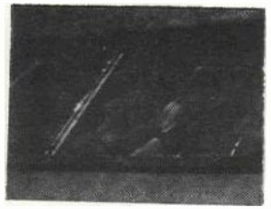


FIG. 18ᵃ

Brittle lacquer pattern at σ_{net} 26,70 kg/mm^2. In the plate extensive plastic deformation is present in the weld not any.

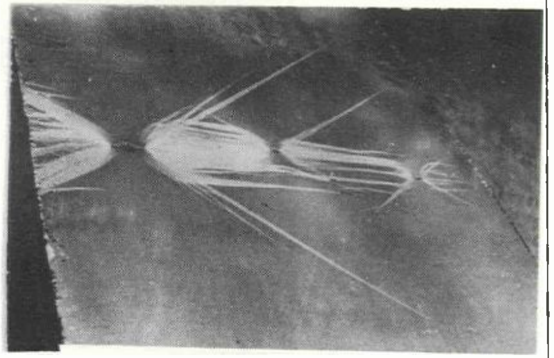


FIG. 18ᵇ

Detail of fig. 18ᵃ.

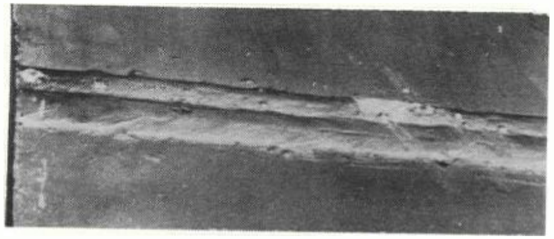


FIG. 18ᶜ

Detail of weld of fig. 18ᵃ ; Only in the H.A.Z. the brittle lacquer shows some tiny cracks.

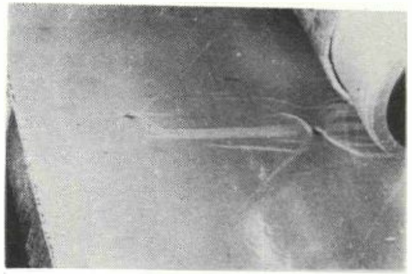


FIG. 19

Situation at the plate notches at at a net stress of 25,80 kg/mm^2.

FIG. 20

Situation at the weld and H.A.Z. at a net stress of 31,50 kg/mm^2. The weld itself is hardly deformed plastically. As the larger notch the plastic deformation is more extensive than at the smaller notch.

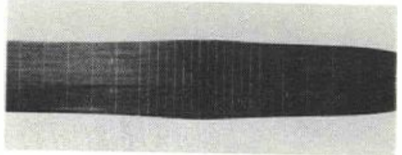
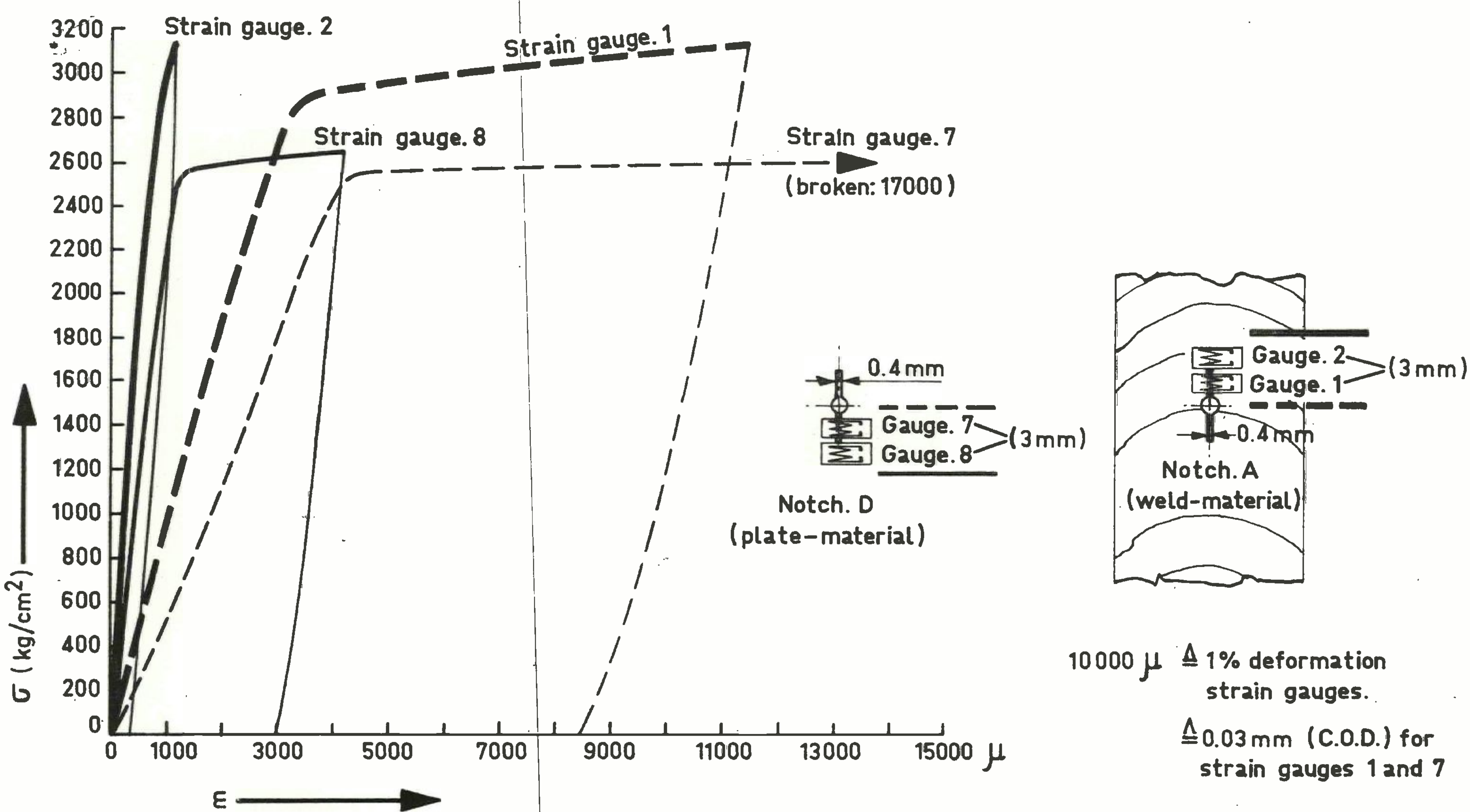


FIG. 21

Test piece with weld ; fracture occurred in plate material.

σ_v (weld) = 3600 kg/cm^2

σ_v (plate) = 2730 kg/cm^2



10 000 μ ≙ 1% deformation strain gauges.

≙ 0.03 mm (C.O.D.) for strain gauges 1 and 7

FIG. 22 COMPARISON BETWEEN NOTCHES A AND D.

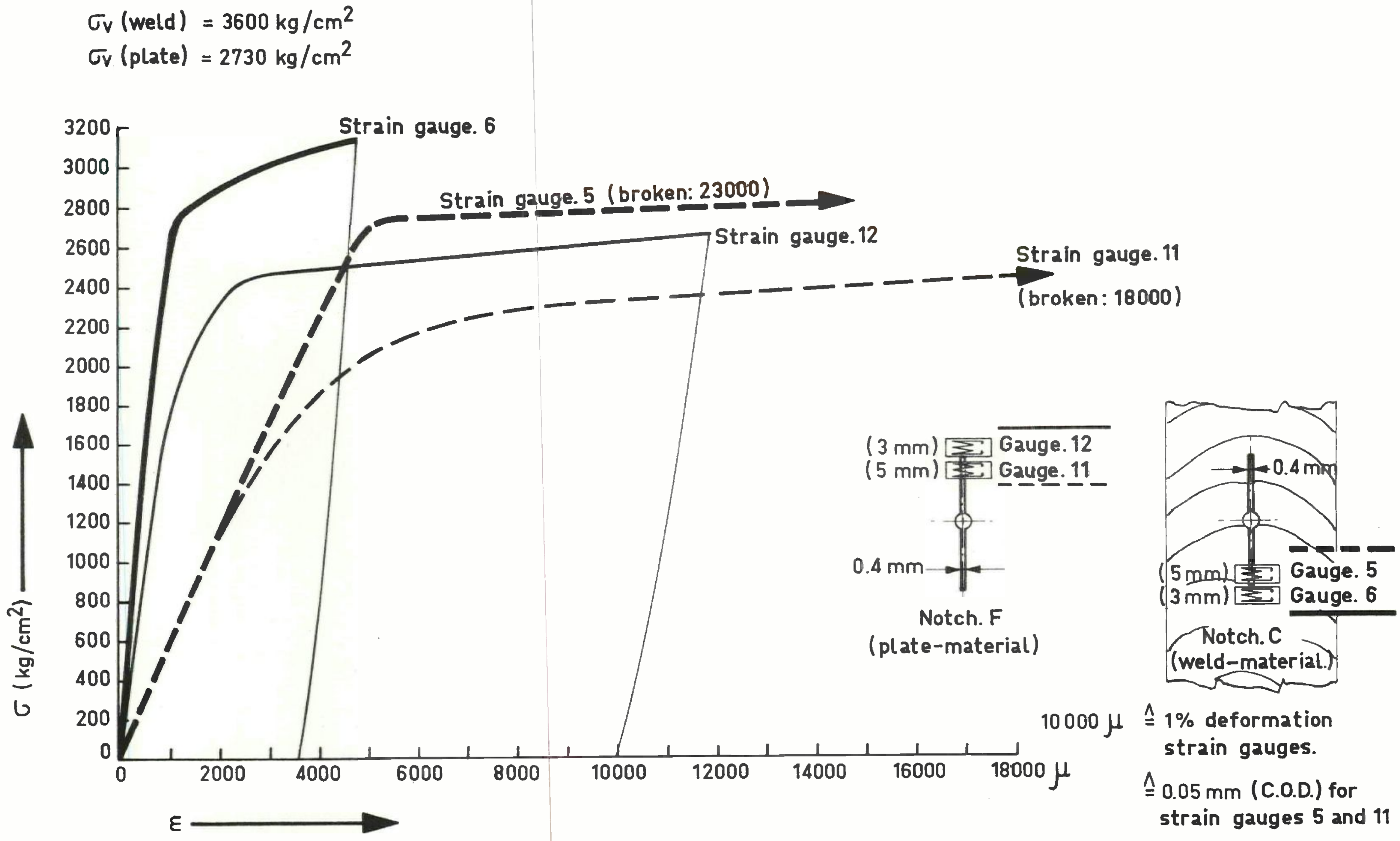


FIG. 23 COMPARISON BETWEEN NOTCHES C AND F.

(WAS 7546)

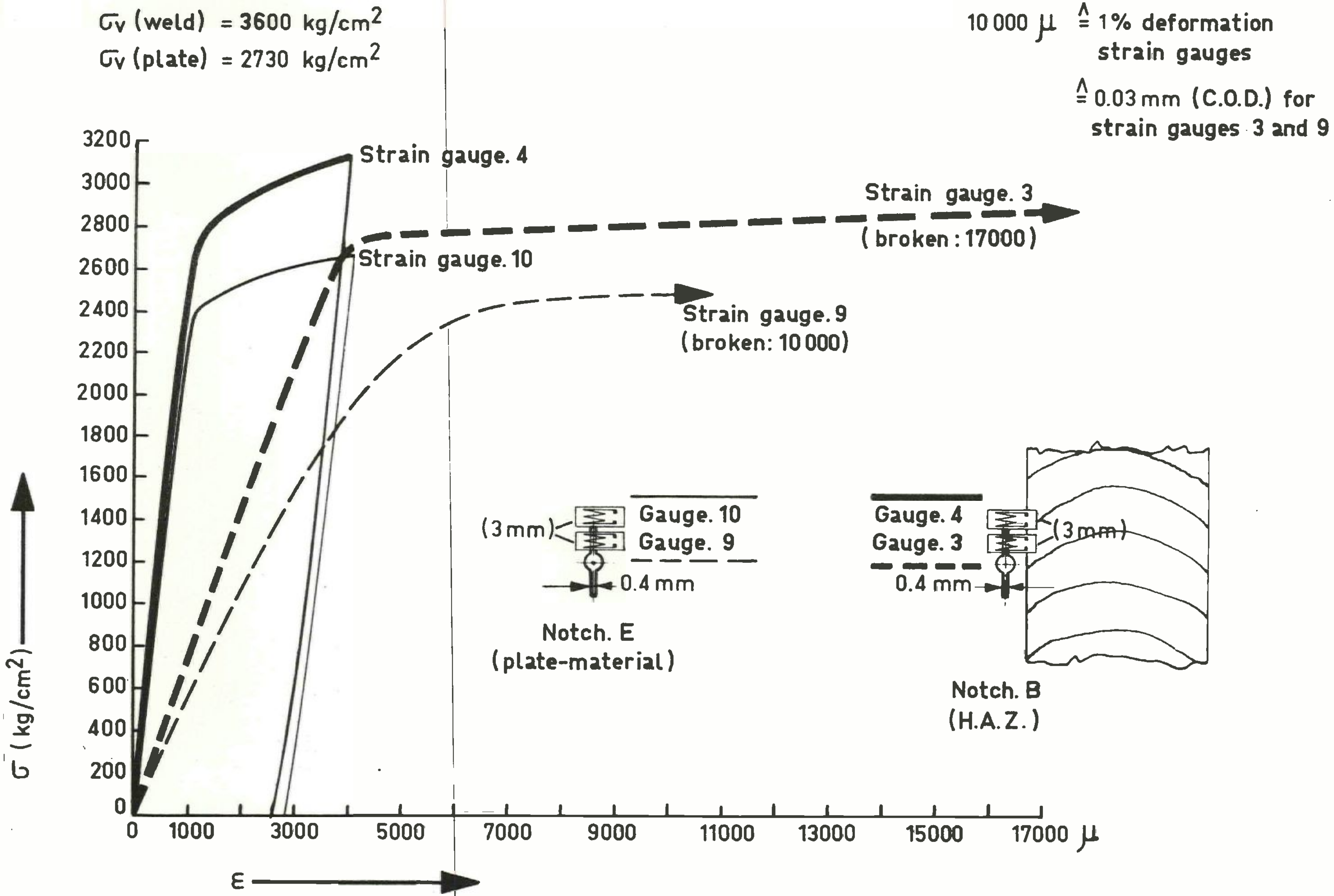


FIG. 24 COMPARISON BETWEEN NOTCHES B AND E