by linearly extrapolating the stress relation for the two preceding zones:

$$\sigma_{r_i}{}^{\mathrm{I}} = 2\sigma_{r_{i-1}} - \sigma_{r_{i-2}} \quad . \quad . \quad . \quad (17)$$

$\sigma_{t_i}{}^{\mathrm{I}}$ and $\sigma_{a_i}{}^{\mathrm{I}}$ being derived from two equations of the same type.

Calculation of the second approximation ($\sigma_{r_i}{}^{\mathrm{II}}$, $\sigma_{t_i}{}^{\mathrm{II}}$, $\sigma_{a_i}{}^{\mathrm{II}}$) is carried out according to Fig. 9, which gives the layout of a complete iteration. The steps in this iteration are as follows:

(1) The second approximation of σ_{r_i} is derived from equation (12).

(2) The value ϵ_{tv}, imposed for the strain ϵ_t by the condition of compatibility, is derived from equation (13); the value ϵ_{av}, imposed for the strain ϵ_a, is given by the stress field at the outer radius and does not depend on the zone considered.

(3) The strains ϵ_{tw} and ϵ_{aw}, corresponding to the stresses $\sigma_{r_i}{}^{\mathrm{II}}$, $\sigma_{t_i}{}^{\mathrm{I}}$, and $\sigma_{a_i}{}^{\mathrm{I}}$, are derived; in most cases these strains are not identical with the strains ϵ_{tv} and ϵ_{av}.

(4) The strains ϵ_{ta}, and ϵ_{aa}, corresponding to the stresses $\sigma_{r_i}{}^{\mathrm{II}}$, $\sigma_{t_i}{}^{\mathrm{I}}+\Delta\sigma$, and $\sigma_{a_i}{}^{\mathrm{I}}$ (where $\Delta\sigma$ is an arbitrary, though relatively small, increment) are derived.

(5) The strains ϵ_{tb}, and ϵ_{ab}, corresponding to the stresses $\sigma_{r_i}{}^{\mathrm{II}}$, $\sigma_{t_i}{}^{\mathrm{I}}$, and $\sigma_{a_i}{}^{\mathrm{I}}+\Delta\sigma$, are derived.

(6) The quantities α and β, defined by the following equations, are derived:

$$\alpha = \frac{(\epsilon_{tv}-\epsilon_{tw})(\epsilon_{ab}-\epsilon_{aw})-(\epsilon_{av}-\epsilon_{aw})(\epsilon_{tb}-\epsilon_{tw})}{(\epsilon_{ta}-\epsilon_{tw})(\epsilon_{ab}-\epsilon_{aw})-(\epsilon_{aa}-\epsilon_{aw})(\epsilon_{tb}-\epsilon_{tw})} \quad (18)$$

$$\beta = \frac{(\epsilon_{av}-\epsilon_{aw})(\epsilon_{ta}-\epsilon_{tw})-(\epsilon_{tv}-\epsilon_{tw})(\epsilon_{aa}-\epsilon_{aw})}{(\epsilon_{ta}-\epsilon_{tw})(\epsilon_{ab}-\epsilon_{aw})-(\epsilon_{aa}-\epsilon_{aw})(\epsilon_{tb}-\epsilon_{tw})} \quad (19)$$

(7) The second approximation of σ_{t_i} and σ_{a_i} is given by

$$\sigma_{t_i}{}^{\mathrm{II}} = \sigma_{t_i}{}^{\mathrm{I}}+\alpha\,\Delta\sigma; \qquad \sigma_{a_i}{}^{\mathrm{II}} = \sigma_{a_i}{}^{\mathrm{I}}+\beta\,\Delta\sigma \quad (20)$$

(8) The second approximation as a whole ($\sigma_{r_i}{}^{\mathrm{II}}$, $\sigma_{t_i}{}^{\mathrm{II}}$, $\sigma_{a_i}{}^{\mathrm{II}}$) is then compared with the first; if they differ, a further iteration is carried out starting from the second approximation, and so on,

Time required for the calculations

The calculation method set out above has been programmed for an IBM 1130 computer. The following example will give an indication of the time required: approximately 6 min were taken to carry out a complete calculation in which the cylinder wall was divided into 200 zones and the three stresses σ_{r_i}, σ_{t_i}, and σ_{a_i}, were printed for 20 points distributed over the thickness of the wall.

APPENDIX 2

REFERENCES

(1) DEFFET, L. and GELBGRAS, J. 'Le comportement des tubes à perois épaisses soumis à des pressions élevées', *Rev. Univ. Mines* (1953) **9**, 725.

(2) DEFFET, L. 'Les travaux de recherche sous pressions élevées', *C. r. XXXI^e Congrès Int. Chimie Ind.* 1959 **1**, 251.

(3) DEFFET, L. and LIALINE, L. 'L'influence de l'épaisseur des tubes sur leur comportement sous pression', *Acta tech., Belg.* 1959 **5**, 1.

(4) DEFFET, L. and GOUZOU, J. 'Study of the deformation and fracture of steel from the examination of the behaviour of thick-walled cylinders submitted to high pressures', Comm. Winter Annual Meeting A.S.M.E., New York 1968 (December).

(5) WEIBULL, W. 'A statistical theory of the strength of materials', *Handl. Ing. Vet. Akad.* 1939, 141.

(6) RICHARDS, C. W. 'Size effect in the tension test of mild steel', *Proc. Am. Soc. Test. Mater.* 1954 **54**, 995.

(7) RICHARDS, C. W. 'Effect of size on the yielding of mild steel beams', *Proc. Am. Soc. Test. Mater.* 1958 **58**, 955.

(8) GOUZOU, J. 'Le problème de la déformation plastique en traction monoaxée dans l'acier doux', Publication C.N.R.M. 1969 (May).

(9) GOUZOU, J., LEROY, V. and HABRAKEN, L. Comm. Colloque Franco-Belge sur les mécanismes de déformation et de rupture dans les matériaux cristallins et amorphes (Université Libre de Bruxelles, Institut des Matériaux, 1967 (December)).

(10) GOUZOU, J. 'Transition des microdéformations aux macrodéformations dans le fer et l'acier doux', *C. r. Acad. Sci.* 1967 **265**, 352.

(11) GOUZOU, J. and MAGNEE, A. 'Critère de plasticité et loi de déformation de l'acier doux', *C. r. Acad. Sci.* 1970 **271C**, 537.

(12) REE, T. and EYRING, H. In *Rheology, theory and application* 1958 vol. III, p. 83 (Academic Press, New York).

(13) LODE, W. 'Versuche über den Einfluss der Mittleren Hauptspannung auf das Fliessen der Metalle Eisen, Kupfer und Nickel', *Z. Phys.* 1926 **36**, 913.