For greater accuracy, when there is considerable initial plastic deformation, as in the present experimental work, it is necessary to start at zero time with the actual dimensions of the cylinder immediately after pressurization. The initial dimensions can be found by the method, based on torsion data, suggested by Manning [6] or later by Crossland [8], which is described in the following section. Hence, the shear stress at the outer surface for the first interval of time Δt is

$$\tau_1 = \frac{p}{n\left(K_{t=o}^{2/n} - 1\right)} \tag{16}$$

If it is assumed that any constant shear stress creep curve can be represented by an expression of the form of Eq. (7), then the increment of creep shear strain at the outer surface of the cylinder for a stress τ_1, acting for time, Δt is

$$\Delta\gamma_{b_1} = B\,\tau_1{}^n(\Delta t)^m \tag{17}$$

After this interval the new dimensions of the cylinder are calculated. Assuming $\Delta\gamma_{b_1}$ to be small (this can be assumed by making the time increment small enough) then the increment of circumferential strain at the outer surface is

$$\Delta\epsilon_{\theta_{b_1}} = \Delta\gamma_{b_1} \tag{18}$$

Also, for constancy of volume with zero axial creep, the relationship between the strain at the bore and the outer diameter is

$$\Delta\epsilon_{\theta_{a_1}} = K_{t=o}^2\,(\Delta\epsilon_{\theta_{b_1}}) \tag{19}$$

Therefore,

$$b_{t=\Delta t} = b_{t=o}\left(1 + \Delta\epsilon_{\theta_{b_1}}\right)$$

$$a_{t=\Delta t} = a_{t=o}\left[1 + K_{t=o}^2\,(\Delta\epsilon_{\theta_{b_1}})\right] \tag{20}$$

Hence,

$$K_{t=\Delta t} = \frac{(b)}{(a)}_{t=\Delta t} \tag{21}$$

This new value of diameter ratio gives the shear stress τ_2, which is considered constant for the next interval of time. To apply the strain-hardening theory, the time at which a creep test run at a shear stress of τ_2 attains a shear strain of $\Delta\gamma_{b_1}$ must now be evaluated from Eq. (7), and this is equal to $(\Delta\gamma_{b_1}/B\tau_2{}^n)^{\frac{1}{m}}$. The additional creep strain occurring over the next interval Δt is thus

$$\Delta\gamma_{b_2} = B\tau_2^n\left\{\left[\frac{(\Delta\gamma_{b_1})}{(B\tau_2{}^n)}\right]^{\frac{1}{m}} + \Delta t\right\}^m - \Delta\gamma_{b_1} \tag{22}$$

and the new dimensions are accordingly

$$b_{t=2\Delta t} = b_{\Delta t}\left(1 + \frac{\Delta\gamma_{b_2}}{2}\right)$$

$$a_{t=2\Delta t} = a_{\Delta t}\left[1 + K_{t=\Delta t}^2\left(\frac{\Delta\gamma_{b_2}}{2}\right)\right] \tag{23}$$

hence,

$$K_{t=2\Delta t} = \frac{(b)}{(a)}_{t=2\Delta t} \tag{24}$$

The shear stress τ_3 is then found and the time for a constant shear stress creep test at τ_3 to reach a total shear strain of

$$\Sigma(\Delta\gamma_b) = \Delta\gamma_{b_1} + \Delta\gamma_{b_2} \tag{25}$$

is calculated. The procedure can be continued in this manner for as long as desired. As the creep rate falls off the increment of time can be increased without loss of accuracy. The engineer's or nominal diametral strain at any time t is found simply by the relationship

$$\epsilon_{\theta_{b_t}} = \frac{b_t - b}{b} \tag{26}$$

where b refers to the original outer radius of the cylinder before it is pressurized.

CREEP OF THICK-WALLED CYLINDERS USING ISOCHRONOUS SHEAR STRESS-STRAIN CURVES

For the plastic deformation of metallic thick-walled cylinders at room temperature, where little if any creep takes place, Crossland [8] has suggested a method of predicting the pressure-expansion curve based on torsion data. This method, which is