swaging method of autofrettage, a conversion was made to an equivalent hydraulic pressure in psi acting on the rear face of the mandrel. A typical comparison of pressure–yield strength relations for the swaging and the conventional methods is graphically shown in Fig. 4 for a 2.8 wall-ratio cylinder with 2.5% bore enlargement. Some nonlinearity is indicated for the swaging method, whereas the conventional method shows linearity. The pressure required in the conventional process for complete yielding was computed from the empirical relation

$$P = 1.08\ \sigma_{ys} \log W \qquad (1)$$

It is also seen that the magnitude of the pressures required for swaging is much less than the conventional method for any given yield strength. For low yield strengths, the swaging force is almost constant. At higher yield strengths, the required pressure increases but remains much less than that for the conventional method.

Figure 5 shows a plot of hydraulic pressure as a function of wall ratio and compares the two methods for one typical yield-strength value. It is important to note that swaging and the conventional process pressures are dependent on percent bore enlargement for any given wall ratio. For comparison purposes, however, only that curve for the condition of complete yield through the wall for the conventional process is shown. This curve is given by eq (1). Again, the low-pressure advantage for the swage method is clearly indicated.

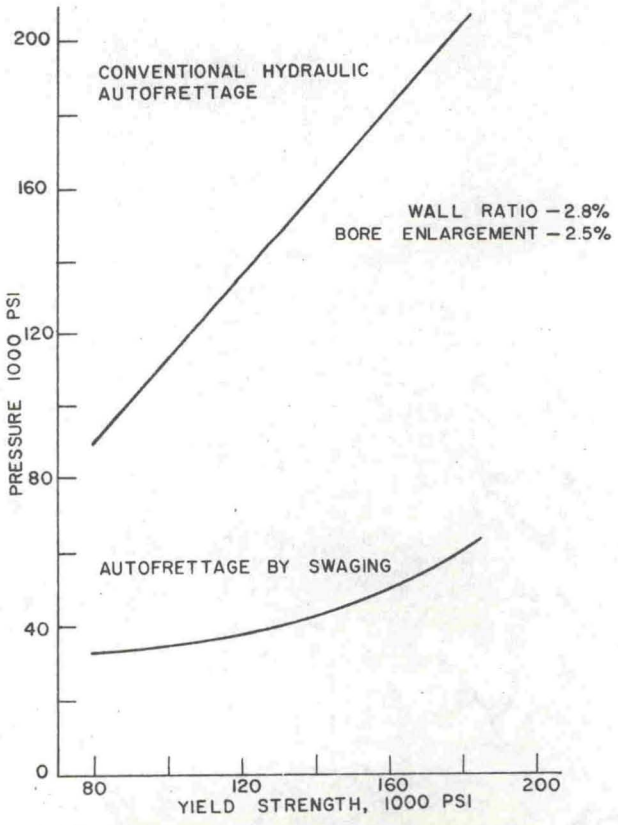

Fig. 4—Hydraulic pressure vs. yield strength

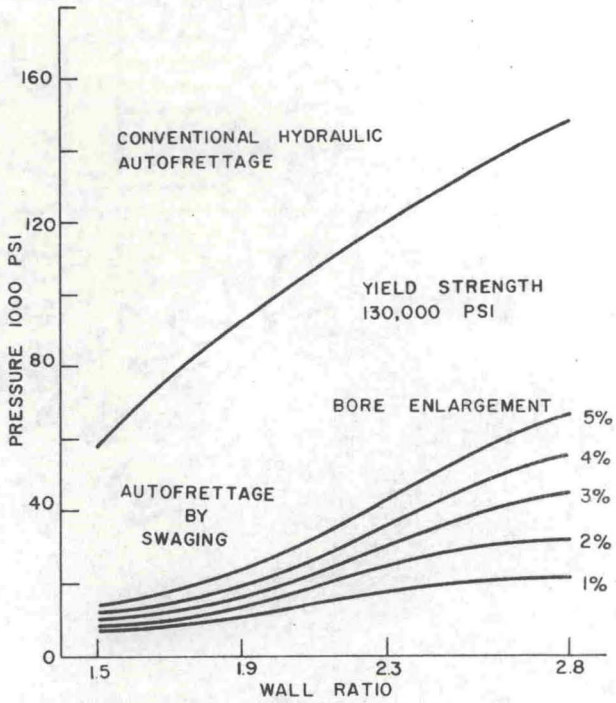

Fig. 5—Hydraulic pressure vs. wall ratio

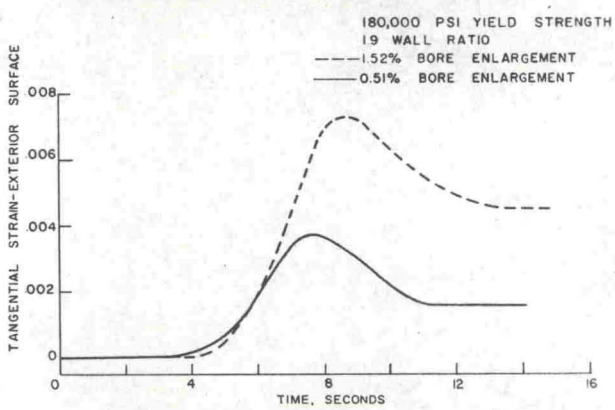

Fig. 6—Exterior surface strain during swaging

Elastic Recovery

Typical plots of tangential exterior-surface strains as a function of time at the mid-length section of the short specimens are shown in Fig. 6. Zero time on the graph corresponds to the entry of the mandrel into the bore. It is seen that the effects of the ends of the cylinders on the strain at the mid-point is negligible since the curves are horizontal at the beginning and end. This validated the assumption that the specimens were long enough to eliminate end effects on the induced residual stresses at mid-length section. This assumption was validated by this method for wall ratios of 1.5, 1.9 and 2.3 for bore enlargements ranging from 0.3 to 5.6% and for all yield strengths.

Figure 6 visibly demonstrates typical elastic recovery and residual strain which occur as the mandrel passes through the bore. The peak strain