and

$$S_m = \frac{k_n^2}{2(k_n^2 - 1)} \left[(p_{n-1} - p_n) + (q_{n-1} - q_n)\right], \text{ at } r = r_{n-1} \tag{10}$$

where

k_n = wall ratio of component n, $k_n = r_n/r_{n-1}$

p_n = pressure acting on component n at r_n where $p \neq 0$, psi

p_{n-1} = pressure acting on component n at r_{n-1} where $p \neq 0$, psi

q_n = residual interface pressure acting on component n at r_n where $p = 0$, psi

q_{n-1} = residual interface pressure acting on component n at r_{n-1} where $p = 0$, psi

r_n = outside radius of component n, inches

r_{n-1} = inside radius of component n, inches.

(Reference (1) gives the derivation of Equations (9) and (10)).

For large-diameter cylinders of large wall ratio (k_1), it has been found (in both theoretical and experimental studies at Battelle) that the minimum k_h, i.e., the optimum geometry, occurs when the side-bore diameter equals the bore diameter. This yet needs to be verified experimentally for smaller wall ratio liners for $k_1 \leq 6$. For $k_1 \geq 6$ it has also been found that $k_{hi} \approx k_{he}$. Thus, assuming $k_{hi} \cong k_{he} \equiv k_h$ and a maximum-tensile-stress fatigue criterion on the hoop stress for a side-bore liner, the pressure capability, p_{sb}, predicted for a side-bore container is

$$p_{sb} = p/k_h \tag{11}$$

where p is the pressure capability for a straight cylinder. If $k_h = 1.5$ and $p = 300,000$ psi, then $p_{sb} = 200,000$ psi.

The corners at the "tee-intersection" can also be rounded off at the points shown in Figure 1 to reduce the stress-concentration factor by a few percent, and thus increase p_{sb} somewhat.

To improve the pressure capacity of a side-bore container, it might be possible to provide some prestress to the liner material by similar techniques to those used in straight-bore containers. The possibilities offered by multi-ring construction are now considered.

Equation (11) would apply to a multi-ring, side-bore container only if the outer rings, which also must have side bores and corresponding stress concentrations, are not stressed too high. If it is necessary that the side-bore diameter of each ring must be equal to the bore diameter as was found for the optimum design of monoblock containers, then the side bore must be larger for each subsequent outer ring as shown in Figure 2. However, the stepwise increase in side-bore diameter results in less and less supporting material. Perhaps a better design would be to use a double set of shrink-rings that are separated longitudinally such as shown in Figure 3. This would avoid stress concentrations in the outer rings, but would result in less compressive stress at the bore of the liner than would be achieved if a continuous ring was shrunk

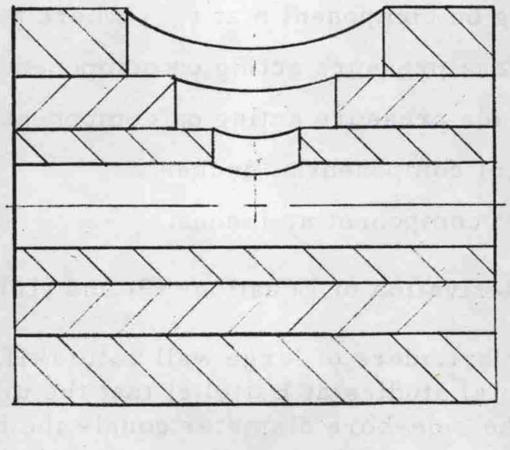

FIGURE 2. CROSS SECTION OF A SHRINK-FIT SIDE-BORE CONTAINER (WITH SIDE-BORE DIAMETERS EQUAL TO BORE DIAMETERS OF EACH RING)

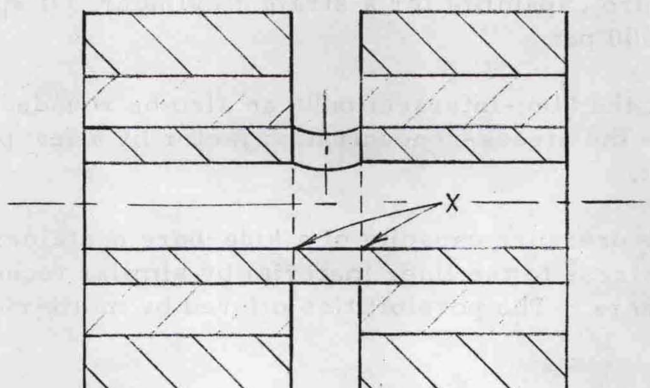

FIGURE 3. CROSS SECTION OF A SIDE-BORE CONTAINER WITH A DOUBLE SET OF SHRINK RINGS