On the basis of this design, three industrial companies have been asked to quote on the fabrication of the tooling. As soon as quotations have been received and the exact specification of the tooling has been ascertained, a more detailed design of the auxiliary tooling specifically required for the HYDRAW of wire will be prepared. This will include the wire spooling and paying-out arrangements. These will be based on preliminary model studies of techniques required to pay out axially from a large coil of fine wire. It is anticipated that most of this effort will be conducted in the next quarterly period.

Design of a Container for the HYDRAW of Titanium Tubing

A preliminary design assessment of a right-angle or side-bore container has been conducted because of the possibility of its use for the HYDRAW of titanium tubing.

A monoblock side-bore container is shown in Figure 1. (The term "side-bore" is used here to distinguish it from a "cross-bore" design in which one hole intersects the other in two places.) This design offers advantages to the hydrostatic extrusion process where the billet length plus the stem stroke results in an excessive length for a straight-bore container. If a side-bore container could be used, the required container length would be less and consequently the required working clearance of the press would be less.

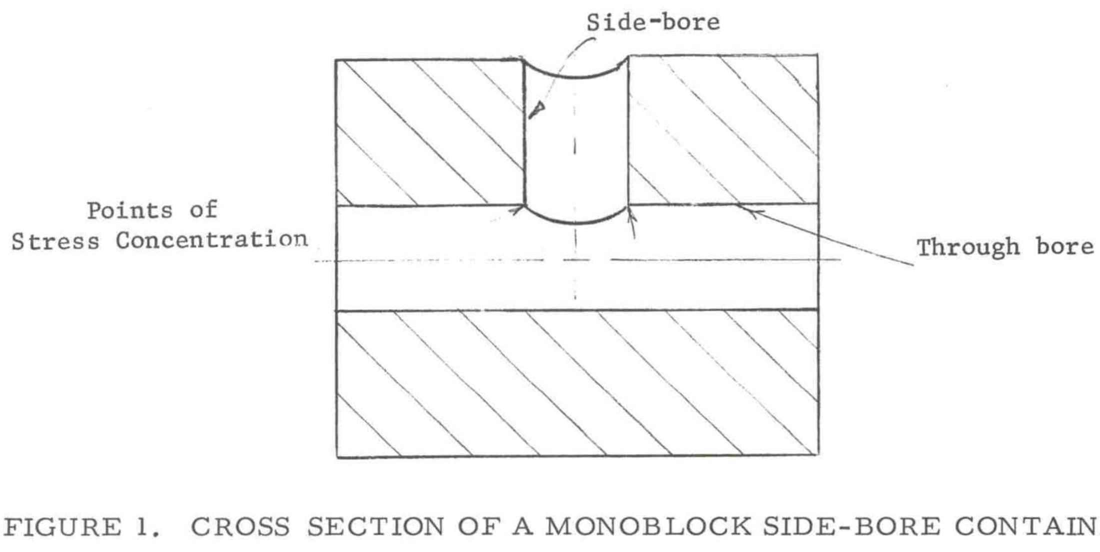

FIGURE 1. CROSS SECTION OF A MONOBLOCK SIDE-BORE CONTAINER

However, a side-bore container suffers from a stress concentration at the critical "tee-section" at points of intersection of the main bore and the side bore as shown in Figure 1. The stress-concentration factor, k_h, on the hoop stress results in a hoop stress of $(\sigma_\theta)_T$ at the tee-intersection of

$$(\sigma_\theta)_T = k_h \sigma_\theta \tag{2}$$

where σ_θ is the nominal hoop stress calculated for a straight cylinder.

The stress-concentration factor, k_h, can be expected to be different for internal pressure and external pressure loadings on the liner. The k_h for these two loadings are denoted as k_{hi} and k_{he} respectively.

In a straight-bore container, the maximum shear stress, S, at the bore is

$$S = \frac{\sigma_\theta - \sigma_r}{2} \quad . \tag{3}$$

At the tee-intersection of a side-bore container for the internal pressure condition, $\sigma_r = -p$, the shear stress is

$$S_T = \frac{k_{hi}\sigma_\theta + p}{2} \tag{4}$$

where p = fluid pressure.

Consequently, the stress-concentration factor, k_{si}, on the shear stress for the internal pressure condition is

$$k_{si} = \frac{S_T}{S} = \frac{k_{hi}\sigma_\theta + p}{\sigma_\theta + p} \quad , \tag{5}$$

whereas at the unloaded condition (residual stress condition with zero-bore pressure), the shear-stress concentration factor is

$$k_{se} = k_{he} \quad . \tag{6}$$

If the stress-concentration factors are known, then the semi-range and mean stresses for a pressure cycle can be calculated as follows:

$$(\sigma_\theta)_r = \frac{k_{hi}\,(\sigma_\theta)_{max} - k_{he}\,(\sigma_\theta)_{min}}{2}$$

$$(\sigma_\theta)_m = \frac{k_{hi}\,(\sigma_\theta)_{max} + k_{he}\,(\sigma_\theta)_{min}}{2} \tag{7a, b}$$

and

$$S_r = \frac{k_{si}\,S_{max} - k_{se}\,S_{min}}{2}$$

$$S_m = \frac{k_{si}\,S_{max} + k_{se}\,S_{min}}{2} \tag{8a, b}$$

where the stresses $(\sigma_\theta)_{max}$, $(\sigma_\theta)_{min}$, S_{max}, and S_{min} for a straight cylinder can be calculated using Equations (1a, b) and:

$$Sr = \frac{k_n^2}{2(k_n^2-1)}\,[\,p_{n-1} - p_n) - (q_{n-1} - q_n)],\ \text{at } r = r_{n-1} \tag{9}$$