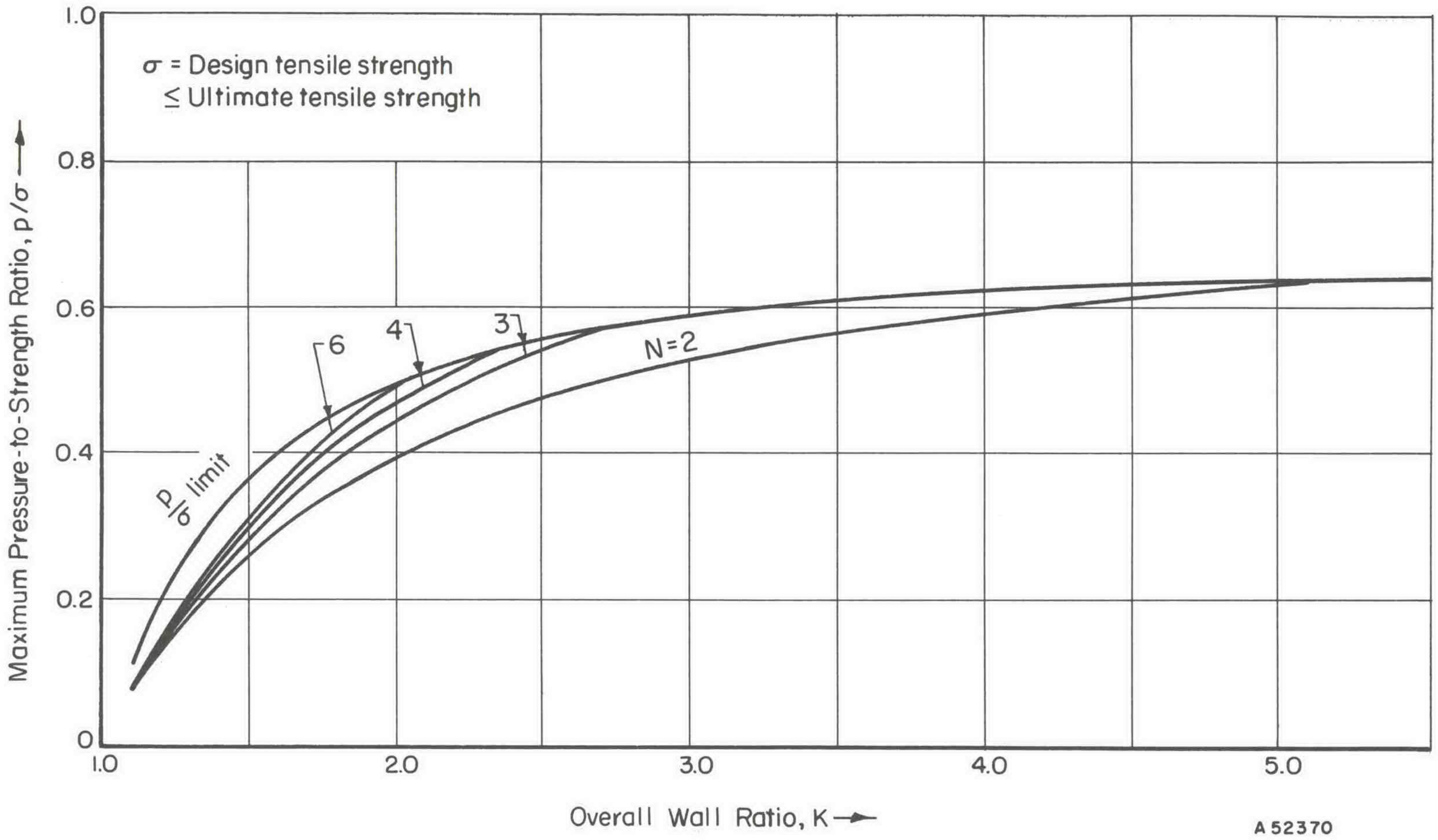

FIGURE 11. MAXIMUM PRESSURE-TO-STRENGTH RATIO, p/σ, IN MULTI-RING CONTAINER DESIGNED ON BASIS OF FATIGUE SHEAR STRENGTH

Each ring is assumed to be of the same ductile material.

In the formulation of the tensile fatigue criterion the parameter α has been defined by Equation (13a). Thus, from Equations (13a) and (46) it is found that

$$\frac{p}{\sigma_1} = 2\alpha_r \frac{K^2 - 1}{K^2 + 1}\ , \quad \sigma_1 \leqq \sigma_u \tag{47}$$

where σ_u is the ultimate tensile stress of the liner. The ratio p/σ_1 is plotted in Figure 12 for various K and α_r.

The fatigue data at room temperature of high-strength steels ($\sigma_u \leqq 300,000$ psi) listed previously in Tables 8, 9, and 10 are generally for $\alpha_r \leqq 0.5$ for lifetimes of 10^4 and greater. Hence, it is concluded that the maximum repeated pressure possible in a multi-ring container with a liner of $\sigma_u = 300,000$ psi is approximately 300,000 psi if appreciable fatigue life is required. This conclusion presupposes that the outer components can also be designed to withstand the required interface pressure and that sufficient precompression can be provided in the liner so that $\alpha_r = 0.5$ can be expected to give up to 10^4 cycles life. This is investigated next.

The stress range parameter α_r depends on the mean stress parameter α_m. The mean stress depends not only on the bore pressure p but on the interface pressures p_1 and q_1 between the liner and the second cylinder. The magnitudes of p_1 and q_1 that are possible depend upon the geometry and strength of the outer cylinders.

The outer rings are assumed to be all made of the same ductile material. Conducting a fatigue shear strength analysis of a multi-ring container having a pressure fluctuating between q_1 and p_1, we find from a method similar to that used in arriving at Equation (42) (using Equation (40) for n = 2, 3, ..., N-1), that in this case also the optimum design has

$$k_2 = k_3 = \ldots = k_n \tag{48}$$

Calculating the mean stress σ_m at the bore of the liner, equating $\alpha_m \sigma_1$ to σ_m from Equation (13b), substituting for q_1 from Equation (35), eliminating σ_1 by use of Equation (47), and solving for p_1, one finds

$$p_1 = \frac{p}{K^2 - 1}\left[\frac{K^2 - k_1^2}{k_1^2} + \frac{(K^2 + 1)}{4} \quad \frac{(k_1^2 - 1)}{k_1^2} \quad \frac{(\alpha_r - \alpha_m)}{\alpha_r}\right] \tag{49}$$

The other interface pressures p_n, $n \geq 2$ are again given by Equation (41). Eliminating the pressures p_1 and p_n, $n \geqq 2$ from Equations (49) and (41), and solving for the pressure-to-strength ratio p/σ, one gets

$$\frac{\;}{\sigma} = \frac{2(K^2 - 1)\,(k_n^2 - 1)\,(N-1)\,k_1^2\,\alpha_r}{k_n^2\left[5(K^2 - k_1^2) + (\alpha_r - \alpha_m)\,(K^2 + 1)\,(k_1^2 - 1)\right]} \tag{50}$$