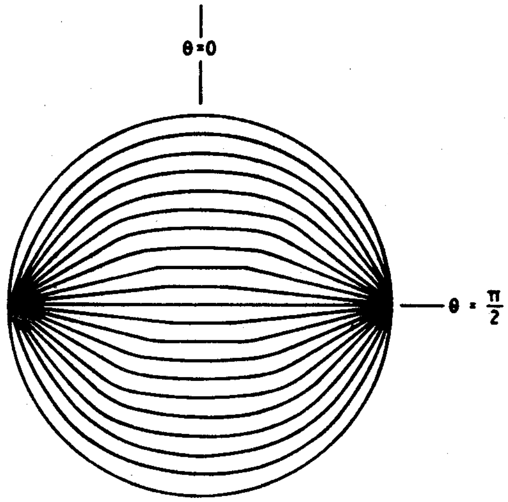

Fig. 3 Sections through the minimum drag spatular body with $\tau=0.5$. $C_D=0.0836$. $S/B=5.91$.

interest (i.e. $\tau \simeq 0.5$), the drag of the optimum spatular body is 15% less than the drag of the optimum axisymmetric body. Similar improvement in the drag is found for bodies with noncircular bases, and, in particular for elliptic bases, the drag is found to vary approximately in proportion to the ratio of the minor and major axes.

A disadvantage of spatular bodies is their large wetted area compared with axisymmetric bodies. For example, for the spatular body shown in Fig. 3, the wetted-area to base-area ratio (S/B) is 5.91. This can be compared with 4.8 for the optimum axisymmetric body and 4.12 for the cone with the same value of τ. The addition of a surface area constraint thus favors axisymmetric bodies. In Fig. 4 optimum bodies are considered with both a length ($\tau=0.5$) and a surface area constraint (S/B given). The most important feature of Fig. 4 is the small increase in the drag of spatular bodies for spatular bodies for values of S/B down to about 5. This wetted area decrease is achieved by the flattened region near the nose becoming slightly smaller and assuming a more rounded profile as illustrated in Fig. 2 and indicated in Fig. 4. For $S/B<5$ the drag is significantly above the free surface area minimum, and when S/B is 4.8 the minimum drag body can be either of two very different shapes, one axisymmetric and the other spatular. For $S/B<4.8$ the optimum bodies are axisymmetric.

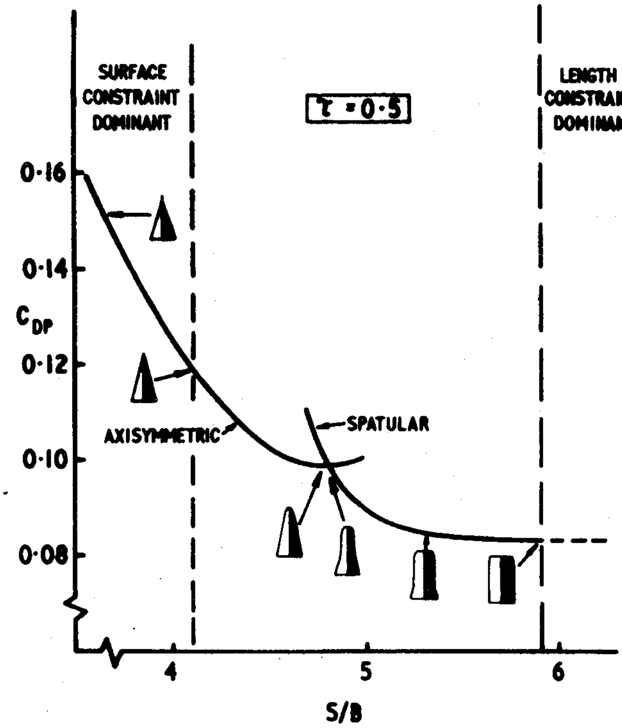

Fig. 4 Drag coefficients of optimum noses with $\tau=0.5$ and both length and surface area constraints.

To consider the effects of friction drag, it is taken as a first approximation to be proportional to the wetted area [i.e. $C_{DF}=C_F \times (S/B)$]. The optimum body of minimum total drag occurs at the point on the curve which has a gradient of $-C_F$. For practical values of skin friction spatular bodies are found to be optimum; for slender bodies ($\tau \leq 0.2$) or large skin friction the optimum bodies are axisymmetric.

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Notice: SI Units

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George W. Sutton
Editor-in-Chief