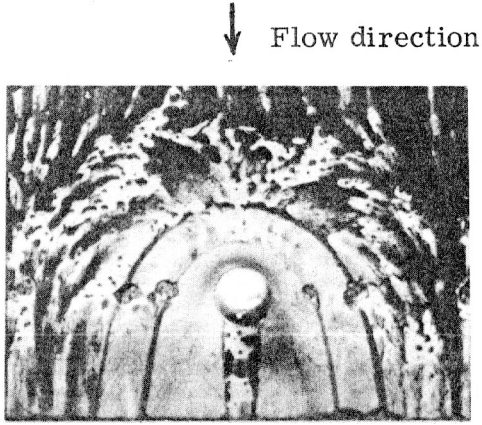
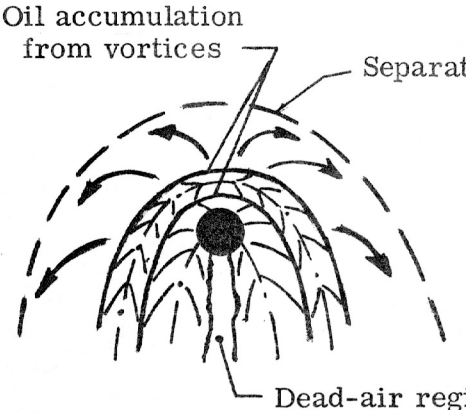
spheres are 0.238-cm diameter



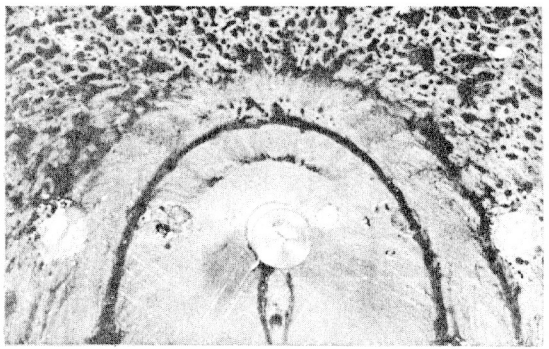


s=element spacing on CL.
w=max width of single element
k=element height
delta = bl thickness

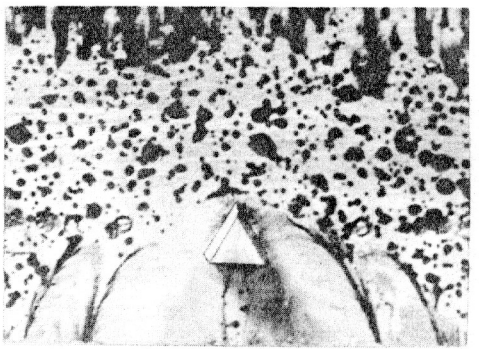
Minf=6.8, wedge model, M_e=M_l=5.5, k/delta = 2, detailed oil flow image. Basically similar for different roughness shapes

(a) Sphere.

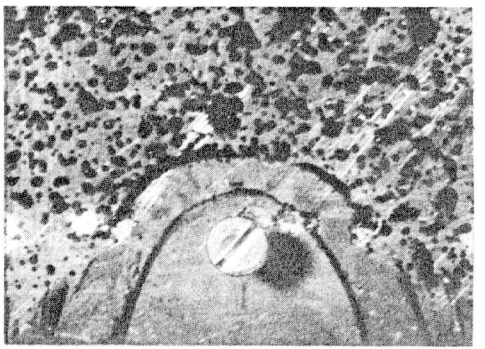
A.H. Whitehead, Jr., "Flowfield and drag characteristics of several boundary-layer tripping elements in hypersonic flow", NASA TN-D-5454, October 1969



(b) Cylinder.

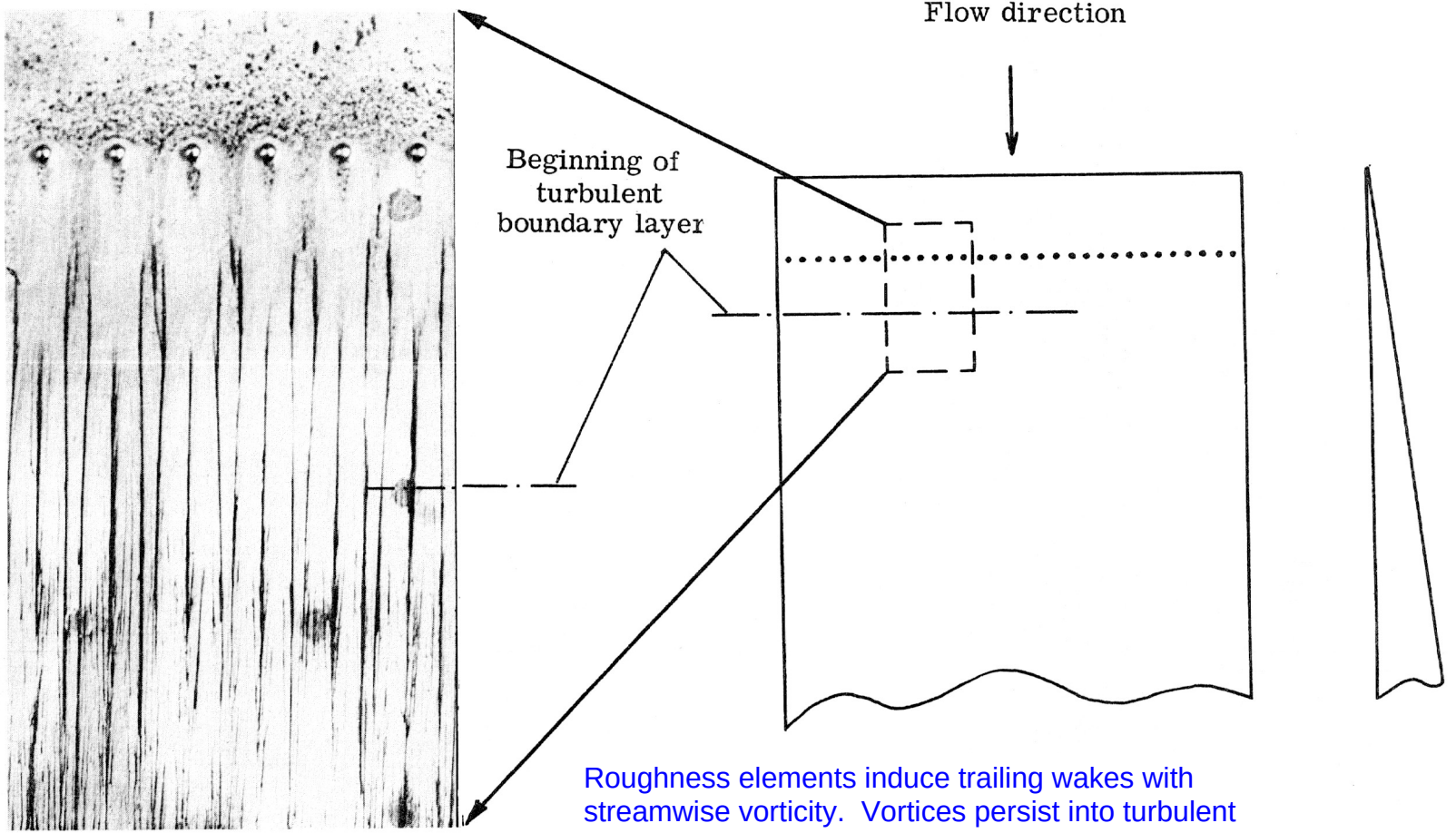


(c) Triangular prism.



(d) Pinhead.

Figure 4.- Flow behavior around elements. $M_l = 5.5$; $k/\delta = 2$; $s/w = 8$. L-69-5268



Roughness elements induce trailing wakes with streamwise vorticity. Vortices persist into turbulent region.

(a) Flat plate (ref. 12). $M_\infty = M_\ell = 6.0$; $k/\delta = 2$; $s/w = 4$.

L-69-5272

Figure 7.- Downstream influence of spherical elements.