However, this relation does not hold in each case. For instance, the static couple, $Wh \sin (\alpha \pm \theta)$, works against the thrust couple when the airship is in a climbing attitude and with it when the airship is in a descending one. The dynamic moment of the hull, on the other hand, assists the righting moment in case Nos. 4 and 5, but opposes it in case Nos. 3 and 6. Case Nos. 1 and 2 are unimportant as will be shown later. Obviously case Nos. 3 and 6 are the ones which must be considered when designing for stability.

b. The static righting moment is nearly a right-line function of the angle, θ. So for practical purposes is the upsetting moment. But whereas the righting moment is independent of the velocity, the upsetting moment varies as the square of the speed. Obviously as the speed increases a velocity will be reached where the upsetting moment just equals the righting moment. This is called the critical speed.

c. For an airship without control surfaces, neglecting for the moment propeller thrust and resistance, the critical speed would be reached when—

$$M_e = Wh \sin (\alpha \pm \theta).$$

By the formula of Doctor Munk:

$$M_e = (\text{Vol})\frac{\rho}{2}v^2(k_2 - k_1) \sin 2\theta$$

where k_2 and k_1 are constants to correct for the fact that masses of air are carried along with the hull in both transverse and longitudinal motion. Tables of values of k_2 and k_1 are given in National Advisory Committee for Aeronautics Report No. 184. From the Munk equation it appears that M_e varies directly as $\sin 2\theta$ and as the square of the speed. Combining the constant factors in the formula into one constant, M_c:

$$M_e = M_c \sin 2\theta v^2.$$

Hence the relation for critical speed without fins becomes—

$$M_c \sin 2\theta v_c^2 = Wh \sin (\alpha \pm \theta)$$

$$v_c = \sqrt{\frac{Wh \sin (\alpha \pm \theta)}{M_c \sin 2\theta}}$$

where v_c = critical speed.

This would give a very low critical speed. For an Italian military airship of the M type the critical speed without fins is 29 miles per hour.

d. Introducing the tail surfaces gives a much higher value of the critical speed. From the relations given in *a* above for case No. 3, the