1. At high altitudes the bodies will sublimate and sharp corners and protrusions will be removed or eroded.

2. Relatively volatile materials will leave the surface regions, making a porous shell of less volatile ice, *e.g.*, water. A process will begin where the more volatile matter slowly leaves the interior. The time required for the highly volatile matter to depart may be comparable to the time of descent, of the order of a few minutes.

3. At lower altitudes the outer shell will be subject to instantaneous melting and refreezing over areas which pass through the forward stagnation region.

4. Gas jets from the interior will help to keep the cometoid turning.

5. Radical recombinations and other sources of heat, such as chemical reactions, will contribute to the fast removal of the remaining internal volatile materials.

6. Internal gas temperatures may reach a few thousand degrees Kelvin. The gas will be in a continuous state of flux. It may be ejected at speeds ot 1 to 3 miles/sec., analogous to the observed ejection velocities of comets. A correction would have to be made in the atmosphere because of the high density of ambient gas.

7. Several different lift forces are discussed for the cometoid model which might keep a slow fireball aloft, or produce a "stationary" meteor for a short time.

8. It was suggested that cometoids may carry their own sources of phosphorescent light. The cold surfaces might glow when the temperatures reached certain critical values corresponding to the point where the frozen metastable species became mobile. The atoms would then radiate a characteristic light by dropping their excess energies. From laboratory experiments it is known that frozen metastable nitrogen can undergo a forbidden transition at 16° K. and radiate strongly in the blue-green. Attempts to measure spectra of slow, green fireballs have not been successful to the author's knowledge (Project Twinkle, U.S.A.F. Cambridge Research Centre) but if the nitrogen afterglow spectrum was observed it could be concluded that the internal temperatures were of the order of 16°–40° K.

The intensity of light emission depends on the rate at which the atoms reach the required temperature. This, in turn, depends on the erosion rate. A cometoid sublimating at the rate of 0·1 cm./sec. could be as bright as a 1700° K. tungsten lamp filament if 10% of the metastable nitrogen atoms radiate when dropping to the ground state.

APPENDIX A

If q is the average convected thermal influx/ft.^{2}/sec., over a sphere which is tumbling at random, then[19]

$$q = 0{\cdot}0145\, M^{3{\cdot}1}\, (p/a)^{\frac{1}{2}}\ \text{B.T.U. ft.}^{-2}\ \text{sec.}^{-1} \quad \ldots \quad \text{(A.1)}$$

where

M = Free stream Mach number
p = Ambient pressure, lb. ft.$^{-2}$
a = Radius of sphere, ft.

Equation (A.1) should be valid up to Mach 60 with an error of the order of $\pm 10\%$, and under continuum flow conditions. The conditions of compressibility and dissociation have been included. The equations relating to changes in radii and other characteristics of entry are given in another paper.[2]

APPENDIX B

The Great Siberian Cometoid

Early in the morning (0 hr. 16 min. 7 sec. world time) on 30 June, 1908, an immense object from outer space collided with the Earth. The explosive impact occurred in central Siberia at longitude 102° 0′ E. and latitude 60° 20′ N. in the Podkamennaya Tunguska river basin. The resulting devastation far exceeded that from any other known meteorite in recorded history and it has often been called the most remarkable astronomical event of the twentieth century.

Earthquakes were registered at Irkutsk, Chita and Kabansk in the U.S.S.R. and in microbarograms in England.[31]

Sound phenomena were heard at distances of up to 600 miles. At Kezhma, on the Angar river, a loud noise, similar to thunder, was heard immediately after the fireballs disappeared. The noise lasted for several minutes. This was followed by sounds similar to the firing of large cannon, which shook buildings. These detonations lasted for 2 min.

The large dust cloud associated with this event, which passed over England on 30 June, 1908 and 1 July, 1908, reflected enough light to enable harvesting throughout the night.[32,33]

However, the nature of the damage is indeed singular. No other large meteorite has ever been known to produce a vast mass of hot, high-speed gas. Furthermore, from the complete lack of meteorite fragments of any size, except possibly dust, the object could hardly have consisted of a large iron or stony meteorite of the type found in collections.

The fiery body, which rolled across the sky out of the southwest, fell in a swampy "taiga" (evergreen or coniferous forest) between Yenissei and Lena, about 400 miles north of the trans-Siberian railroad. This particular area, which abounds in swamps, lakes, rivers and mountains, is very difficult to penetrate. Also it was only scantily populated by uneducated Tungus (Mongoloid natives) who lived in the river basins. For these reasons and also because there were no scientists in the general vicinity, scientific researches were not undertaken until 19 years later, in 1927.

At that time Professor Leonid A. Kulik, of the U.S.S.R. Academy of Sciences, made three expeditions to the place of fall. Several attempts were made before the