up from behind the Earth and the angular velocity of the atmosphere would be in the right direction to make the drag stresses less severe.

VI. PHYSICAL PHENOMENA ACCOMPANYING COMETOID ENTRY INTO THE ATMOSPHERE

The entry of large bodies into the Earth's atmosphere can be analyzed[19] by present-day theory for speeds up to Mach 59 or about 10 miles/sec. This is more than 3 miles/sec. faster than the entry velocity of the slowest meteors and therefore of great value in this investigation.

With knowledge of the drag and heat transfer rate, the question of the survival time and sublimation rate of cometoids can be answered quantitatively. The basic equations along with many trajectories and sublimation rates, are presented in another paper.[2]

At this time we are interested in examining the processes taking place within a spherical cometoid which is rotating about an axis whose direction is changing randomly. The implications are that over a short period of time, the heat transferred per unit area will be approximately the same over any portion of the surface. Also this picture is in tune with assumptions made in arriving at the equation for heat influx (Equation (A.1); see Appendix A).

However, it is evident that if the object had been only approximately spherical prior to entry (*e.g.*, a cube), then the erosive action of the atmosphere would tend to make it spherical. For example, the corners might become turbulence centres, or stagnation points, and they would tend to become rounded. The edges would also be more susceptible to ablation than the flat sides.

This weathering action, combined with the added violence from radical recombinations, will tend to produce bodies of revolution, in general. In particular, depending on the initial configuration such shapes as spheres, discs, and cigars, etc., would be expected.

Returning now to the sphere, it is of interest to see what action may take place as it penetrates the Earth's upper atmosphere. Bodies which are captured by the Earth at speeds near the lowest possible limit will tend to have small entry angles with the local horizontal. Steep angles are not impossible but more improbable. The object which impacted in Siberia in 1908 may have had a steep entry angle. Because this fantastic event may have been caused by an ice meteorite of the type that we are considering, a separate section has been devoted to it.

With smaller entry angles, the net energy transferred by the time the speed has been reduced to Mach 0·5 may be considerably greater than for steeper angles, although the decelerations are more gentle. The crushing compressive stresses associated with steeper entry angles are more damaging, indirectly, than the thermal influx. That is to say, once the parent body is broken into numerous fragments, the real damage has been done, for then the heat influx affects each piece individually. Everything may then be quickly destroyed. For example, from Equation (A.1), if the fragments had the same speed as the parent body, the heat influx per unit area would be increased by $1/\sqrt{a}$, where a is the radius. Thus, a fragment with a radius of 1 in. decreases in radius ten times as fast as a parent body with a 100-in. radius. It follows that if a large cometoid can stay together through the high stress periods it will descend to low altitudes where it may produce unusual aerial phenomena and be classed as an unidentified flying object. Its speed may drop to a few miles/hr. or even to zero, while simultaneously it may be luminescent. The often heard comment that "it is going too slowly to be a meteor" is no longer justified since luminous ices in the atmosphere can be classified as meteors. Furthermore, it will be shown subsequently, that a small concentration of frozen metastable nitrogen atoms in an ice matrix, can indeed produce a brilliant light when the ice is ablating under the proper conditions.

1. Formation of Spheroidal Shapes by Ablation

A cometoid in general is a heterogeneous mixture. In space, the outer covering will contain only dust, and ices which have low vapour pressures such as water, resinous and wax-like materials. The internal parts will remain extremely cold and could contain materials which would be very volatile in the Earth's atmosphere, *e.g.*, methane or ethylene.

Upon entering the atmosphere at high altitude, a cometoid will lose its protective dust cover and start eroding and sublimating. A type of erosion caused by radical recombinations could continually produce groups of hot molecules. These molecules would be ejected at the corresponding thermal velocities. When recombinations occurred, neighbouring molecules could also be dislodged (sublimated) and lost to the ice matrix, but, fortunately, most of the recombination energy will go into the kinetic energy of ejected gas. The cometoid therefore need not be destroyed by its own internal energy. Also, the ejected vapour will act as a transpiration cooling agent, tending to cut the convected heat transfer by as much as 50%.

During this period when the pressure is inadequate to produce melting, the cometoid will undergo a preliminary shaping by the aforementioned ablation processes. Corners will be removed, sharp edges dulled and rounded, and the surface pitted.

Heterogeneous ices in the matrix will keep the entity turning. It is most improbable that the tangential components of the gas jets would be exactly balanced at all times. It does not matter whether the cometoid always turns in one direction or rocks back and forth, as long as it keeps exposing different parts of the surface to the stagnation region, the rounding and forming process will continue.

A macroscopic radical explosion, such as a chain reaction between many radicals, of course, can destroy the entity altogether. However, the heat transferred