instant the liquid touches the atmosphere (which would be relatively hot) it might expand to create a continuous pressure underneath. For example, a small quantity of liquid methane continually oozing out of the bottom would react violently when it touched the air, expanding and exerting pressure on the bottom. Less volatile liquids might also stream out.

The following incident (taken from the *San Diego Evening Tribune*) which occurred on 19 July, 1956, in Arkansas City, Kansas, seems to be an example of a cometoid:

> "The Kansas State Highway Patrol today said 'a ball of fire travelling east at a high rate of speed had been picked up by radar at the Hutchinson (Kan.) Naval Air Station.' City Editor, Brian Coyne, of the *Arkansas City Daily Traveler* said 'a brilliantly-lighted, tear-shaped object with prongs or streams of light spraying downward was sighted shortly after midnight. A second object was sighted around 1 a.m. The prongs or streams of bright light also were observed first as directed towards the Earth and then extending from the sides of the object.' He also described the head of the object as being green in color or 'bluish green.'"

Mr. Coyne was accompanied by a Trooper Dick Hadsall and city police from Arkansas City. Several such objects were observed.

A possible explanation for the bright blue-green colour will be offered in the next section.

VII. A POSSIBLE MECHANISM FOR INTENSE FIREBALL LIGHT

Until now it has been suggested that some cometoids, which enter the atmosphere under favourable conditions, will have fair chances of surviving the high drag and thermal stresses (which are apt to be encountered at altitudes of 30 or 40 miles). When the objects descend to altitudes of a few miles the velocities will reach terminal values (a few hundred miles/hr.). Light emission must therefore result from changes of state within the cometoid rather than from incandescence or excitation of the air. Otherwise jet planes, which sometimes travel at even higher speeds, would be luminous.

It is suggested that those cometoids which are fresh from the very cold sub-surface regions of comets may at times contain dormant metastable states which are capable of emitting light when sufficiently warmed. Since comets, in general, consist principally of unknown combinations of hydrogen, nitrogen, oxygen and carbon, the metastable materials would have to be formed from one or more of these elements.

There are several procedures that can be used in the laboratory in order to discover thermo-luminescent ices. One technique is to freeze the material at liquid helium temperatures in a vacuum. The resulting ice can then be bombarded with X-rays or electrons, etc., and sometimes decomposed into radicals or metastable atoms which may exist indefinitely at low temperatures. By allowing the resulting ice to warm up, radical recombinations may occur giving off heat. Also the metastable atoms may drop their excess energy by radiating. For the last three years a great deal of frozen radical research work has been going on, especially at the National Bureau of Standards. Hundreds of different materials have been studied which are composed entirely of elements known to be abundant in comets.

However, only a handful of ices have been found which phosphoresce significantly on warm-up. Only one is exceptional and this has been known for almost 40 years. This ice is frozen nitrogen, an element quite abundant in comets.

1. Luminescence of Solid Nitrogen

Many years ago Vegard[20] bombarded solid nitrogen, at liquid helium temperatures, with a stream of electrons (cathode rays) and obtained a brilliant green glow. It was also discovered that a blue-green phosphorescence remained for as long as 5 min. following excitation. Vegard believed that a typical auroral spectrum was emitted from solid nitrogen. Later, McLennan and Shrum[21] independently discovered the green luminescence from solid nitrogen and an additional phosphorescence from argon. The latter, however, never lasted for more than a few seconds. Their results can be summarized as follows:

(1) The spectrum of solid nitrogen, phosphorescing at the temperature of liquid hydrogen, consisted of the single wavelength 5231 Å., in approximate agreement with Vegard's 5230 Å.; and

(2) The spectrum of solid argon phosphorescing at the same low temperature consisted of a strong line at 4750 Å. and a weak line at 5300 Å. It was mentioned that nitrogen underwent a transition at 35·5° K. and changes from a transparent ice to a stable powdery form. The phosphorescent energy did not exist in the stable modification.

About 30 years after the pioneer work of Vegard and others, Broida and Pellum,[22] while freezing out the products of an electrodeless discharge through nitrogen gas, rediscovered the green glow. It came from the nitrogen ice on a cold wall at 4·2° K. Since it was known that atomic nitrogen could exist in concentrations up to several per cent. in travelling from the discharge region to the cold wall, they advanced the hypothesis that the green glow was associated with the presence of free nitrogen atoms in the solid matrix.

The emission spectra were also studied by Herzfeld and Broida,[23] who were able to explain many of the results by assuming that large numbers of nitrogen atoms, in various excited states, were deposited along with nitrogen molecules from the discharge. The latest laboratory work by Peyron and Broida[24] has yielded the most accurate data on the nitrogen warm-up and afterglows available at this time.

Their experimental procedure consisted of passing various gases through a needle valve into an electrodeless discharge (2450 Mc./sec.) at a pressure of 1000 microns. The discharge products were condensed on a Pyrex glass surface, maintained at 1·2° K. by pumping on liquid helium.