III. BACKGROUND

In 1803, the French Academy of Science was finally convinced, after years of resistance, that meteorites were extraterrestrial (not atmospheric). Biot made a detailed study of some stones that fell out of the sky at L'Aigle, in Normandy, and concluded to the academy's satisfaction that they did indeed fall from the surrounding space.

Prior to the eighteenth century, meteors were believed to be meteorological phenomena such as atmospheric manifestations. Consequently, learned people were not particularly prejudiced against slow moving objects, not knowing what caused them. Even stationary meteors were reported.

General acceptance of the new dogma that meteors were caused by solid, high-density materials such as pieces of stone or iron, made observations of slow or stationary meteors appear ridiculous. The reasoning ran something like this. It was known from Newton's law of gravitation that extraterrestrial objects enter the atmosphere with speeds of at least 6·9 miles/sec. Furthermore, it was observed that the majority of meteors travelled at speeds of 20 to 30 miles/sec. Also, except for dust particles and very special shapes, the atmosphere is not capable of slowing such dense objects down to speeds of a few hundred miles/hr. Finally, even if this did happen, they would be falling almost vertically at terminal velocities, and at these speeds the frictional heating would be inadequate to produce incandescence, or even luminous trails.

For these reasons and others, observations of slow moving bright fireballs have been seriously questioned and generally omitted from scientific journals, especially in recent years.

Many older observations can be found. For example, W. F. Denning[8] described a slow meteor which took at least 15 sec. to cross the sky.

One textbook, which was written in 1869 and used in colleges for some 50 years (the eighth edition was printed in 1920) still retained an interesting observation in the eighth edition.[9] The sighting occurred during the great Leonid meteor shower of 12 November, 1833, which is the most remarkable shower on record. At certain places the meteor density was of the order of 200,000 observable meteors/hr. from a single station.

During this shower certain bizarre objects, moving too slowly to be conventional meteors, were observed. To quote from p. 229 of White and Blackburn,[9] "An observer at Boston about 6.00 a.m. counted 650 shooting stars in a quarter of an hour. Large fireballs with luminous trains were also seen, some of which remained visible for several minutes. Even *stationary masses of luminous matter* are said to have been seen and one in particular is mentioned as having remained for some time in the zenith over the falls of Niagara, emitting radiant streams of light." Evidently, if this had occurred in the last decade, it would have been classified as an unidentified flying object (UFO). The nature of this luminous matter, apparently associated with the meteor shower, is of considerable interest. The question that arises then, is this: what kind of objects besides ordinary meteors might be present during a meteor shower?

IV. METEORS

The word *meteor* is derived from the Latin and Greek meaning "thing in the air." It is used here in reference to the light phenomena which occur when an extraterrestrial object falls into the atmosphere. It is now generally recognized that meteors result from two distinct classes of materials, meteorites and meteoroids. The *meteorites* are the hard, solid, high-density materials which occasionally hit the ground. The *meteoroids* as defined by Whipple have just the opposite characteristics, *i.e.*, they are fragile, porous materials that always seem to ablate high in the sky.[10] Almost all of the visual meteors which appear in the atmosphere each day (about 200 million) are caused by meteoroids, whereas meteorites are extremely rare.

This significant change in our concepts of ordinary meteors has occurred within the last few years. It was brought about by the Harvard Photographic Meteor Programme and substantiated in part by radar studies. According to Whipple,[11] the following deductions have been substantiated for the meteors photographed in their programme:

(1) Practically all are of cometary origin (meteoroids).
(2) Asteroidal meteors are very scarce if present at all.
(3) There are strong indications that the meteoroids have densities of the order of 0·05 g./cm.^{3} (about one-fourth the density of balsa wood).
(4) They appear to be extremely fragile.
(5) Meteoroids which have a common origin from a known comet tend statistically to be more alike with respect to fragility, composition, density, luminous and ionizing efficiency.

Therefore, with few exceptions, meteors are caused by extremely fragile, porous objects which probably originate from comets. In some instances meteor streams have been definitely connected with comets. For example, there are four permanent annual cometary showers (Lyrids, Aquarids of May, Orionids and the Leonids). Some evidence suggests that the Orionids and Aquarids of May are the same current encountered twice at different points along the Earth's orbit, *i.e.*, the maxima occur at times of closest approach of the Earth to the orbit of Halley's comet. There are also several temporary streams known to be associated with short period comets. For example, the Draconids of June follow the orbit of Pons-Winnecke. Finally there are many sporadic meteors which have not been tied in with any known stream or comet.

However, neither meteorites nor meteoroids, as ordinarily conceived, can possibly produce the characteristics of the slow fireballs. It is logical therefore to look for another possible component in the meteor