0088 'The fireship of Bay Chaleur', in **Science**, 19.10.06 [Hallet]

0089 Meaden, Dr G T, **The Circles Effect and its mysteries**, 1989 (excerpt)

0090 'Sur les incendies qui paraissent dus à des chutes d'aérolithes' in **Comptes rendus** vol 16, pp206-8, 1843 [Hallet]

0091 Keul, Dr Alexander, & Schwarzenbacher, Kurt, **Phenomenological & psychological analysis of 150 Austrian ball lightning cases** : part of paper presented at Tokyo Ball Lightning Conference 1988

0092 'Fireballs in the family', letter in **Fate**, 03.53

0093 Ohtsuki, Prof. Y H, **Balls of fire observed in Japan** (two selected cases by way of example)

0094 chapter on 'Fireballs' from the english-language translation of Flammarion, Camille, **Les phénomènes de la foudre**, ca 1890. [Skinner : in addition, M. Hallet sent the original French text, but because so many of our subscribers find english easier, I have supplied that version. I will be glad to send the French text on request.]

0095 Barry, J Dale, 'Laboratory Ball Lightning' in **Journal of Atmospheric & Terrestrial Physics**, vol 30 pp.313-317, 1968 [Hallet]

0096 'Luminous phenomena accompanying earthquakes' in **Nature** 25.07.31, p.155 [Hallet]

0097 excerpts from Curtis Fuller's monthly column 'I see by the papers' in **Fate**, issue 35, 02.53 [Bord]

0098 Note on Planté's artificial ball lightning, in **Ciel et terre** (Bruxelles) 1884-85 [Hallet]

0099 Mitchell, John, 'Observations on Ignis Fatuus', in **American Journal of Science & Arts** vol xvi no 2, 07.1829 [Hallet]

0100 newsclip from **The Sun**, Auckland NZ, 16.02.88 [Bott]

THE FIRE-SHIP OF BAY CHALEUR.

In his 'Notes on the Natural History and Physiography of New Brunswick' (*Bull. Nat. Hist. Soc. New Brunswick,* xxiv, Vol. V., 1905) Professor W. F. Ganong has a short paper, 'On the Fact Basis of the Fire (or Phantom) Ship of Bay Chaleur.' After an examination of all the evidence it appears to the author plain (1) that a physical light is frequently seen over the waters of Bay Chaleur and its vicinity; (2) that it occurs at all seasons, or at least in winter and summer; (3) that it usually precedes a storm; (4) "that its usual form is roughly hemispherical with the flat side to the water, and that at times it simply glows without much change of form, but that at other times it rises into slender moving columns, giving rise to an appearance capable of interpretation as the flaming rigging of a ship, its vibrating and dancing movements increasing the illusion." This is doubtless a manifestation of *St. Elmo's Fire,* but the compiler of these notes is not aware of any reports of similar phenomena, of such frequency in one locality, and of such considerable development. Professor Ganong cites the case of some lights reported around Tremadoc Bay in Wales, but notes that they in all probability had only a subjective basis. Lights of unexplained origin, the author notes, were reported as common off the Welsh coast two hundred years ago, and mention is made of St. Elmo's Fire observed at Anticosti. The phenomenon described by Professor Ganong is an interesting one, well worthy of careful study.

'Science' 19 Oct. 1906

[Marc Hallet]

LUMINOUS BALL NEAR WESTBURY

I interviewed the witness on 13 January 1989. His frightening experience happened a year before, on the night of 22-23 January 1988. A C.B. enthusiast he often spent the night on the high ground adjoining the White Horse for the purpose of long-distance transmissions. The weather was clear and frosty. Around 1 a.m. while operating the radio the equipment suddenly went dead as if a fuse had blown. Having no spare fuse, his reaction was to start the car in order to return home – but the ignition was unaccountably dead. Some fifteen seconds having passed since the interruption began, he became aware of an external humming noise which he likened to the hum one can hear near electric power lines. He then became aware of a glow developing about him which, like the hum, came from *above* his vehicle. The light rapidly intensified and illuminated brilliantly an area some ten metres or more in diameter. Then after a total of ten seconds since the light was noticed, it 'went out' which it did by diffusing away, as if 'evaporating'. The main volume of the light was white but towards the edges it was a 'dull orange'. Terrified he tried the ignition again, and it worked!, upon which he left at once for home.

The *Daily Weather Summary* charts of the Meteorological Office, together with my weather diary notes showed that after rain had stopped at 09 on 22nd January sunny periods developed in a north-westerly airstream. A clear evening followed as a ridge of high pressure crossed the region. The wind was light at midnight, westerly or near calm, which suggested well-stratified stable moist air. But the next weather front was approaching and the wind started backing and began to pick up again. We surmise that in the westerly airflow the plasma vortex developed overhead possibly in a trailing-vortex system where turbulence at a point along a line of separation upset a smoother stable flow. This could have provoked vortex 'breakdown' and led to the radio-frequency plasma whose total recorded lifetime in the neighbourhood of the vehicle was 25 seconds. Note that the undoubted plasma never reached the ground (so no circle would have been made) but its other observed properties of light, sound and radio-frequency energy were indisputably accompanied by a 'hovering' and a 'dissolution into thin air' as related in the two preceding letters.

Slow-moving or hovering lights of obscure origin which definitely have no military connection are not uncommon on or close to the Westbury-Bratton-Tinhead Hills. We know of several, the latest of which happened on the top ridge of Tinhead Hill, at 21 hours in late November or early December 1988.

6.6 CAR STOP EVENT BY COLLOWAY CLUMP

I am often asked about the circles 'that never were', those non-events which one would expect now and then because the circle-making agent missed the field of crops. These must occur in their thousands for every one that hits a sufficiently mature crop as to leave an indelible impression. Some of the vortices that miss fields of crops hit houses (as reviewed in Section 2.5), some hit people (Section 2.3), and some hit roads or motor vehicles.

This next incident happened on the Westbury road a little north of Warminster at the Colloway Clump bend before the last turning back to Upton Scudamore for a driver going south. The date was 7 September 1965 and the time between 19 and 1930 GMT. Being twilight and not yet dark, any luminosity was too weak to be noticed[49].

It was while travelling in top gear at 45 m.p.h. that the engine of Major Hill's car cut out. As it came to a halt the car shuddered 'under the down-beating pressure of aerial vibrations. For a time the Major felt a rolling motion beneath him as the whole bodywork swayed . . . his headlights flickered, lacking power. The convulsions of the car subsided enough for him to jump out . . . However, he was immediately conscious of air vibrations of a violent character which surrounded and beat down on him, and heard a sinister whining and crackling . . . (He said) "It was on a par with the sounds of high-powered refrigeration units or deep-freeze equipment, but far away above that level, magnified many times. After less than three minutes everything was back to normal. I pressed the starter button, and the car purred away perfectly, just as if it had never been halted at all". He further affirmed that the decisive peculiarity of his experience was that there was "a definite impression of something pressing down on me with force. It was distinctly uncanny".

Using the *Daily Weather Summary* I found that the regional geostrophic flow that evening was south-westerly. After the light winds of a ridge of high pressure, the wind had picked up as a south-westerly. A sharp hill was close by on the east and south-east (Colloway and Arn Hill), so the vortex could have formed immediately to the windward of these slopes if the local wind was south-west (or in the lee if the local wind was south-east). In another incident which happened before dawn in almost the same spot one month earlier the vortex plasma struck in a clear lee situation, the wind being east-south-east to east. This is what is described next.

6.7 TRUCK HIT SPINNING 'BALL OF LIGHT'

The time was 0336 GMT on 10 August 1965 as the southbound truck went round the bend by Colloway Clump and met a ball of crimson light which got struck while braking[50].

'. . . the orb virtually fastened on to his windscreen without shattering the glass . . . The truck ended up by the wire fencing on the offside, just short of the triangle of grass beside the signpost to the village of Upton Scudamore . . . Only then did the crimson body of the thing spin away. The bright circle detached itself and soared aloft. The driver said: "It was so huge; much larger than my truck. I would say it measured a good thirty to forty feet across at the base (say 9-12 metres).

bol - 0089 excerpt from Meaden, 'The Circles Effect and its Mysteries' (1989)

MÉTÉOROLOGIE. — *Sur des incendies qui paraissent dus à des chutes d'aérolithes.* (Extrait d'une Lettre de M. le JUGE DE PAIX DE MONTIERENDER à M. *Arago.*)

« Depuis quatre ou cinq mois, de trop nombreux incendies désolent nos contrées, et toutes les recherches et les investigations de l'autorité, quoique des plus actives et des plus scrupuleuses pour découvrir les causes de ces tristes événements, sont jusqu'à ce jour restées sans résultat.

» Est-ce la malveillance, est-ce la négligence ou l'imprudence qu'il faut accuser? Voilà les questions que chacun se fait sans pouvoir les résoudre.

» Il est remarquable que souvent deux incendies ont éclaté presqu'en même temps, c'est-à-dire à quelques heures l'un de l'autre, et à une distance assez rapprochée et telle que si ce n'est dans le même endroit, c'est au plus à 5 ou 10 kilomètres.

» Il n'est pas moins remarquable qu'aucun de ces sinistres n'a pris naissance dans la partie des habitations où il y a des foyers et où l'on porte habituellement du feu ou de la lumière; c'est au contraire dans des granges, des écuries, des remises ou autres bâtiments séparés et souvent éloignés du principal corps habité, et toujours dans les combles, que le feu a pris.

» Dès le principe, ces circonstances toutes particulières ont naturellement porté à attribuer ces malheurs à la malveillance; mais la non-découverte d'aucun coupable dans des cas aussi multipliés a nécessairement fait changer d'opinion et rejeter les causes tantôt sur la négligence, tantôt sur l'imprudence. Ceci est-il mieux fondé? c'est douteux. Et en effet, en présence de sinistres se renouvelant à chaque instant, et lorsque chacun tremble d'être victime à son tour, est-on négligent ou imprudent? Non certainement, et la police atteste d'ailleurs des soins et de la vigilance apportés de toutes parts pour prévenir de si terribles accidents.

» Cependant ils ne sont pas moins fréquents aujourd'hui que précédemment, et il y a évidemment une cause: ne pourrait-elle pas résulter des phénomènes assez singuliers qui ont été signalés ici, et que je vais avoir l'honneur de vous faire connaître.

» 1°. A Montierender, le 18 novembre dernier, à 11 heures du soir, une jeune fille, entrant dans sa chambre ayant jour sur un jardin clos, vit une forte lueur passer et frapper les vîtres de sa fenêtre; elle pensa que quelqu'un traversait le jardin portant un fallot ou une chandelle allumée, et étant allée ouvrir cette fenêtre, elle ne vit plus rien ni n'entendit personne. Le lendemain 12, à 2 heures après midi, le grenier de cette chambre et ceux de quatre maisons voisines étaient enflammés avant qu'aucun secours eût pu être porté.

» 2°. A Boulancourt, distant de Montierender de 1 myriamètre, le 10 novembre, à 9 heures du soir, on aperçut une grande flamme s'échapper de la toiture d'une grange, bien séparée de la ferme; on eut peur d'abord, puis on prit cette flamme pour une étoile filante et on ne s'en occupa pas davantage; mais le 12, entre 11 heures et minuit, cette grange était en feu dans toute l'étendue de son faîte, avant même qu'on eût pu s'en apercevoir.

» 3°. A Montierender, dans les premiers jours de décembre, entre 5 et 6 heures du matin, on vit, allant de l'ouest à l'est, un globe lumineux jetant une si grande lumière, que plusieurs personnes sortirent de leurs maisons, persuadées que ces maisons étaient en feu, et elles entendirent d'assez forts petillements au passage de ce phénomène.

» Les personnes de Montierender crurent voir ce globe peu élevé au-dessus des maisons, et se jeter dans une prairie à peu de distance entre le pays et la forêt; et des individus se trouvant sur les routes et dans la campagne, rapportèrent avoir vu ce globe au delà de Montierender et descendre sur la forêt.

» 4°. Enfin, le 8 du présent mois, entre 8 et 9 heures du soir, à Montierender on vit un pareil globe qu'on s'imagina sortir d'une cheminée à l'ouest du pays et marcher aussi à l'est. Arrivé au-dessus du cimetière, ce globe, qui cette fois ne produisait aucun petillement, se divisa en trois parties dont l'une descendit sur le cimetière, tandis que les deux autres se perdaient derrière les maisons; on fut sur-le-champ examiner l'endroit du cimetière où la première partie semblait être tombée, et on n'y remarqua absolument rien.

» Le lendemain, 9, à 8 heures du soir, à 5 kilomètres et à l'ouest de Montierender, un incendie éclatait dans une grange et la réduisait en cendres, ainsi que les bâtiments qui y tenaient; les fermiers ne s'aperçurent du désastre que lorsque la grange était totalement enveloppée par les flammes, et que déjà les combles de la maison fermière étaient atteints.

» Voilà, monsieur, quatre circonstances qui vous paraîtront peut-être mériter l'attention de la science; c'est dans ce but que j'ai l'honneur de vous les signaler. L'Académie seule est compétente pour reconnaître si ces phénomènes atmosphériques peuvent ou non occasionner les malheurs qui nous frappent. »

Comptes Rendus vol 16 (1843) pp 206-208

[Marc Hallet]

bol - 0091

PHENOMENOLOGICAL AND PSYCHOLOGICAL ANALYSIS OF 150 AUSTRIAN BALL LIGHTNING REPORTS

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This paper will cover five main topics:
1) Basic information about Austria and the Ball Lightning (BL) project
2) Short illustrative examples of Austrian BL cases
3) Ideas and method of the 1988 BL evaluation
4) Results of the 1988 BL evaluation - phenomenology and psychological effects
5) Comparison with other studies and suggestions for future BL research

Basic information about Austria and the Ball Lightning (BL) project

Austria is a neutral state in Central Europe between the west and east bloc. Austria has 7.5 million inhabitants on a territory smaller than Florida (USA) or about the size of Hokkaido (Japan). Two thirds of the territory are made up by sparsely populated, high mountains (the Austrian Alps), the remaining one third by densely populated plains and valleys (Figure 1a, 1b). Austria has a moderate climate with prevailing western winds bringing in rain from the Atlantic Ocean. Thunderstorms have a frequency between 15 and 30 days per year, with a maximum area in southeastern Austria (Figure 2).

BL was and still is a subject of folklore in Austria: The "babbling ball" telling the future to good people or the "skopniak", a mischievous fiery dwarf, are old forms (Figure 3). Modern Austrian folklore links any unusual damage or unexplained thunderstorm effect with BL. This dramatized, false picture of BL is spread by the local police and press.

Scientific attention for BL in Austria developed 30 years after Arago (1838): Von Haidinger (1868 a,b,c) and a private natural history society collected and published first reports. 13 of them are quoted in the famous book by Brand (1923). Other BL articles came from Prohaska (1900, 1901, 1903), Trapp (1949), Neunteufl (1951), Pühringer (1965, 1967), Zapletal (1970) and Charlier (1966, 1972-1973). They were mostly descriptive and speculative - "mixed pickles" without systematic attempts.

When in contact with Pühringer in my Vienna days as a meteorology student, I started with BL field investigations (Keul, 1977), made press calls-for-reports and published a simple statistical analysis of 65 Austrian case histories (Keul, 1980, 1981). Ten more press calls in 1981 and 1982 helped to double the number of cases. Prof.Ohtsuki's letter in 1987 was the "spark" that set off a new, computer-based evaluation of 150 reports.

Short illustrative examples of Austrian BL cases

I will give you a few field-investigated examples of Austrian BL cases in a short, narrative form:

-Summer 1971, Vienna city area: A worker looked out of the window during a thunderstorm with rain. He saw a bright globe falling down into the lane, splitting into three identical balls upon impact. Two rolled on in the lane, but the third one passed through a metal garden fence and disappeared in the garden. No damage was done to the fence.

-Spring 1972, Graz city: A pensioned teacher watched TV on a damp, rainy evening. Three other persons in the yard of the same house observed a bluish, hazy ball flying a "wavy" trajectory to the open window of the teacher's flat, where it exploded with a loud bang. A tickling, "electrified" sensation was present in- and outdoors some time after the incident.

-Summer 1976, Graz city: Lightning struck the house of a family, damaging telephone and electrical appliances. Seconds after the clash, a bright, yellow ball "two times a cherry" jumped down the staircase step by step "like a rubber ball", disappearing soundlessly. At the first floor where it originated, a wall damage in the form of a hole was detected.

-Summer 1979, open countryside in southeastern Austria: A farmer saw a blinding ball of light in the evening, near a local power line. When phoning the power company, we heard that the 60 kilovolt line had been interrupted at the time of the observation due to a short-circuit (forming an arc). This explained the report.

-Summer 1979, Vienna city: A pensioned electrician was at home in his flat during a violent thunderstorm with hail and floods. Suddenly, his pet poodle fled in panic under a chair, when a yellow-red, transparent globe appeared near the gas stove and moved towards the observer, ending up with a "deafening bang" and bright rays. No damage and no odor was noticed.

Ideas and method of the 1988 BL evaluation

The main shortcoming of present BL research is the lack of a good working definition for the phenomenon under study. Revers, a late psychology teacher of mine, always emphasized: "**What** do you want to study?" As long as it is unclear, what **is** BL and what **is not** BL, theoretical confusion with hypotheses from afterimages to black holes, and a polarization of researchers between "believers" and "non-believers" is quite natural. Circular definitions like "during thunderstorm.. luminous.. globular" (Barry, 1980, p.33) or "elusive globe which appears in thunderstorms" (Singer, 1980, p.332) do not help very much. When even these redundant pieces of information - round and thunderstorm-association - do not hold in a fair amount of cases (Ohtsuki, 1987), we are approaching the unfortunate UFO "definition", where anything inexplicable automatically becomes a member of this "dustbin category". Reports of St.Elmo's Fire, corona discharges, bright meteors, short-circuit arcs, will-o-the-wisps, earthquake lights, glow-worms and fireworks are **not** excluded by an open BL definition.

Our evaluation idea was not to use a narrow BL definition and throw out aberrant cases, but to take the risk of including marginal phenomena like St.Elmo's Fire seen as a ball, and then to cluster cases according to their phenomenology to see what is the Austrian "core phenomenon" and what is a "borderline case".

Until 1988, we had collected 250 raw reports. 45 were excluded from this evaluation because they were explainable lightning or high tension effects like the one in the previous case example. 55 more were excluded because of insufficient information, for instance short old press reports. 150 case histories remained. Of these, 16 have been field-investigated personally, 110 observers were interviewed on the phone or sent a questionnaire after their first reports, and 24 written reports were not directly investigated by us.

The coding was done by the authors (who cross-checked each other) and used a total of 28 qualitative and 14 quantitative variables. The observer variables were sex, age, profession, reported eyesight, reported reaction, and number of witnesses. The situation and environment variables were date, local time, location pixel, sea level, distance, observer geography and the weather. The phenomenon variables were number of objects, duration, object geography, height, motion, object relation (between object and other things), shape, size, outline, color, brightness, odor, sound, sparks, tail, residue, rotation, size variation, formation and disappearance.

The final data field was evaluated at the computing center of the natural sciences faculty at Salzburg University using the BMDP statistical software package, program version 1987.

Results of the 1988 BL evaluation - phenomenology and psychological effects

The results of our evaluation were the following (Table 1):

The witnesses showed the same sex distribution as the Austrian population. The mean reporting age was much higher than the mean observation age. This seems to be a natural selection effect - when asked to report, chances for old people to have seen BL during their lifetime are higher, so the reporter population is over-aged, but the sighter population is fairly normal. The number of reporting academics was higher than in the general population, the self-reported eyesight seemed to be better than on the Austrian average. Every second case had a single observer, but there were up to ten witnesses in some events.

Five years (1950, 1963, 1972, 1976 and 1977) showed more cases than the rest. There was a distinct summer peak coinciding with the Austrian thunderstorm maximum (July). The-time-of-day peak again overlaps the frequency-of-lightning-discharges maximum (3:30 - 4:30 P.M. Central European Time). For the sources of the meteorological statistics, see Keul (1981). Most cases came from Vienna and Styria (the southeastern Federal Province), where the population maximum (Vienna) and the thunderstorm maximum (Styria) are located (Figure 4). Report frequency falls off with rising sea level, but there still are cases at heights of 3000 meters and more. The great majority of events happened within settlements and the objects were observed from indoors, which is not unusual under thunderstorm conditions. Every second object was as near as five meters or less to the observer, and 75% moved within a 100 meter radius. BL is closely linked with thunderstorms in Austria (72%), but not so close with precipitation (mostly rain). A near lightning stroke was mentioned in about 40% of the reports. Sometimes, static electricity was present.

The objects were nearly always single phenomena with up to ten seconds duration. 80% were seen inside settlements, two thirds of them outdoors, one third happened indoors. Ground level was the typical height, and the characteristic motion was horizontal or downwards. Some showed a hopping or vibrating secondary motion. Every second object had physical contact, i.e. touched a bad conductor (like the floor, walls) when moving, one third was related to good conductors (electric cables, water), the rest floated freely. BL is a correct term in Austria - objects are always round to oval. The diameter distribution has a mean of 30 centimeters, but every second object is smaller than 20 centimeters. The outline is sharp in most cases. The red-orange-yellow sector is the predominant color, but there are also clusters of blue-violet and white objects. The overall brightness is not blinding and steady. "Special effects" noticed in some cases are odors, simultaneous sound, sparks, a tail, rotation and size variations. Formation of BL is quite frequently seen (25%). About 40% of the objects ended with a terminal explosion, usually a loud bang, but nearly the same number disappeared without sound. "Residue" reported after BL events could be identified as normal lightning damage in most cases, but there were also cases of BL starting a fire or scorching things.

The overall phenomenology is not significantly different from the picture obtained by the first evaluation done in 1980 (Keul, 1980, 1981). As an expansion of our files from 65 to 150 cases has not upset the patterns, we assume that 100 or 200 additional cases from Austria would not be too different, either. The "core phenomenon" of BL in Central Europe seems to be stable enough to use a working definition for it.

So far, we have only looked at isolated variables and their distributions - an elementaristic approach. It neglects the natural links between variables. To detect more structures, we used a block clustering program for categorial data (BMDP3M) for nine variables: Sea level, thunderstorm, precipitation, lightning stroke, duration, primary motion, object relation, diameter and color. In a successful block clustering, the total number of block counts should be a high proportion of the total number of categorial data values. In our case, it was only 58%.

As a more promising way of evaluation, we tried a correlation analysis. 20 variables (13 qualitative and 7 quantitative) were used in BMDP4F for two-way frequency tables, Spearman rank correlation coefficients and the equivalent t-test values. We computed a total of 200 correlations and obtained 16 Spearman rank correlation coefficients with highly significant t-test values (according to the alpha-adjustment for 200 correlations, the 1%-level is still significant, here). In this computer run, "delta", the difference between observation and reporting age of the witness, was correlated with all salient BL variables to see whether older and older cases show a drift in reported phenomenology as suspected by Charman (1979, p.281-282). The program detected two correlations (delta and number of persons, delta and emotional reactions), one nonsense, one psychological, but no drift of phenomenal details. The "tree" of significant correlations shows a positive one between diameter and distance, a negative one between distance and reported emotional reaction, and so on (Table 2). Interpreting the non-trivial correlations, we notice:

- Reported diameter increases with reported distance (I)
- Reported fear reactions decrease with distance and elapsed time between observation and report (II)

Weaker correlations are:

- The number of persons increases with elapsed time and sea level (nonsense correlation?)
- Reported diameters are bigger without lightning strokes
- Secondary motion (i.e. hopping) decreases with reported diameters
- Objects associated with good conductors are thunderstorm-bound
- Primary motion increases with reported duration

Of the two strongest results, II is easily understood. Fear correlates negatively with distance, and the reason why fear reactions are less reported with increasing time distance between event and report was called "repression" (of unwelcome emotions) by Sigmund Freud.

Effect I is not so simple (Figure 5). There is no physical reason why more distant objects should be systematically bigger. As Altschuler (1969, p.730-731) has already mentioned in his summary on BL, a positive distance-diameter correlation would either mean that more distant objects are overestimated because of a lack of reference objects (which is unlikely), or that distant objects would have to be bigger to attract attention and smaller ones pass unnoticed (which is more plausible). Irradiation (greater subjective size of bright objects) is dependent on object brightness and the adaptation level of the eye, so it cannot explain the distance effect. As the median distance object-observer is two meters indoors and 55 meters outdoors (Altschuler: 3 versus 30 meters; 1969, p.730), and the median BL diameter is 12 centimeters (mean: 23 cm) indoors and 25 centimeters (mean: 30 cm) outdoors, I suggest for the future to separate "BL I" (indoors or less/equal 10 meters distance) and "BL II" (outdoors or more than 10 meters distant), or two categories of a better definition, instead of mixing the two distance categories beyond statistical recognition.

The weaker correlations look like genuine physical information at first sight, but need to be confirmed by other studies to be meaningful.

I will sketch you six special evaluations that were made to answer questions which came up in course of the general evaluation:

Do BL events really happen at random? An approximation of the Binomial distribution -the Poisson distribution- can be used for the statistical representation of stochastic, rare events. Misprints per page of a given book, or deadly accidents per year and given mile of a highway are poisson-distributed, if random. Austrian lightning stroke frequency per square kilometer is about three per year. Together with the estimated BL frequency of 0.3% of all lightning strokes (Barry, 1979, p.308), this gives a maximum observation probability of one every 10 years. Counting the number of BL events per year and given Austrian pixel, we got values that are correctly approximated by a Poisson distribution except for the observed values of two pixels (Table 3a). The Vienna and Styria pixel produced series of BL reports falling out of a Poisson distribution. We conclude that BL observations happen in a random way except when population density and/or thunderstorm frequency is high. Also, the number of indirect lightning-strokes via the grid in densely populated areas is considerably higher (Gugenbauer, 1988), and causes additional BL.

How good are BL duration estimates? It is problematic to calculate a simple arithmetic mean of BL observation duration values. First, the observation may cover the total duration of the BL phenomenon, or only a part of it. Second, not all observers have the same expertise to estimate the subjective duration of the event. It is known from experimental psychology (e.g.Funke, 1988) that reconstruction of an event ("re-living" it in the mind) gives more realistic duration estimates than simple guessing. In the Austrian file, we have all types of complete or incomplete observations (Figure 6). There are cases where the witness just tried to guess the duration, and field-investigated cases where a duration reconstruction was done. Evaluating 109 Austrian cases, I noticed that although it is not possible to interpret the results in a strictly quantitative way because the visible path of BL is different from case to case, there is a trend of reconstructed durations to be shorter than guessed ones, and of the standard deviations to be smaller (Table 3b). Although anxiety and unpleasantness seem to lengthen duration estimates (Fraisse, 1984, p.23-25), there was no significant correlation between reported emotional reaction and duration estimates. Interpretation is difficult, here - Funke (1988) detected high interindividual differences, but Drake (1974) found a good matching of witness duration data on fireballs with instrumental data. In any case, I suggest that a duration reconstruction is done with the witness at the location of his observation whenever possible to obtain more realistic subjective time data. In case you are still not convinced that a very short emotionally strong event may be blown up to a minute when guessing, just go and visit your dentist.

After all, are BL reports highly subjective, imaginary stories? In our file of 150 reports, 19 events were multiple reporter cases (Table 4a): Eight people had reported two BL events each, one person even three events. This offered a chance to find out whether two reports of one observer are very similar (as should be the case when the observation is highly stereotype and subjective) or rather dissimilar. Four reporters (A to D) had seen two events in different locations, four reporters (E to H) had their two (respective three) encounters at the same location. Looking at 18 phenomenon variables, I counted the number of different variables from case to case. A location effect was apparent, but not really strong. What was more interesting: Eight of the nine variables that were different in three cases or more, were central phenomenon variables. Of course, it is not possible to deduce whether varying descriptions of identical phenomena or correct descriptions of varying phenomena were given, but it should be noticed that multiple observers have no pronounced BL stereotype.

Are Austrian BL cases without thunderstorms different? Case reports violating the inofficial BL definition are rare in our Austrian files. Only nine events were counted. Most of them also mentioned no lightning stroke (7), no precipitation (6), and no electrostatic phenomena (5). Durations, distance, diameter and color of the objects scatter considerably. No "typical non-thunderstorm BL" is noticed, but it looks rather like a residual category.

Is it possible to link Austrian BL with St.Elmo's Fire? According to Elster and Geitel (c.f.Gockel, 1925, p.79-97), who observed St.Elmo's Fire at the Sonnblick mountaintop observatory in the Austrian Alps, the electrostatic discharge phenomenon is always associated with precipitation, but not always with thunderstorms. A faint sizzling sound is heard, and when daylight is weak, or particularly at night, red, blue and/or white light effects are noticeable. The phenomenon happens as a brush discharge on protruding objects. To check our BL data set for a link with St.Elmo's Fire, I scanned the variables precipitation, object relation, color (red, blue, white) and simultaneous sound (Table 4b): Of the 32 cases where at least two of the four St.Elmo-parameters coincided, 24 or 75% had reported precipitation. Nine precipitation cases reported white objects, seven reported red objects, four reported blue or violet objects. If we take into account that this combination includes 21 or about half of all 44 white, red and blue objects in our Austrian data file, it does not look like a mere coincidence. The borderline between the two phenomena seems to be fuzzy. A similar evaluation should be done for BL and short-circuit phenomena (electric arcs).

Is BL more frequent or more rare on mountaintops? We received two old reports of BL from a (retired) meteorological observer who had worked at the Mt.Sonnblick weather station (3105 meters, Austria's highest observatory) for 34 years. As Prof.Berger, Zürich, had based his anti-BL-article (1973) on the fact that he did never witness or photograph BL during many years of lightning observations on Mt.San Salvatore near Lugano, Switzerland, I thought it would be of interest to investigate BL on mountaintops a little further.

I phoned seven more meteorological observatories on mountaintops (Mt.Schöckl, Feuerkogel, Patscherkofel, Zugspitze, Wendelstein and Hohenpeißenberg) in Austria and Southern Germany, ranging from under 1000 to nearly 3000 meters above sea level and asked the weather observer whether he or a colleague had ever seen BL. The result was negative for all stations - even senior weather observers working for 30 to 40 years on the mountaintops had not witnessed BL. Only a retired weather observer from Southern Germany had seen BL, not on the mountain, but at home in his village. Since only four (2.7%) of our 150 cases happened on mountaintops, this form of BL seems to be a phenomenon with almost zero probability in Central Europe. Therefore, Prof.Berger's reasoning that BL could not exist because he did never see it on his mountaintop, is erroneous.

bol-0092

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FIREBALLS IN THE FAMILY

ONE evening in 1901 when my husband was 10 years old and living in the country with his grandparents, there was a severe lightning storm such as happens in the summer months. He and his grandparents were seated in the living room, reading, when all at once a fireball about 12 inches in diameter rolled out of the telephone and across the room, set fire to the lace curtains and disappeared.

Another more recent experience of his was in 1938 when he was at work in an auto repair shop. There was an electrical storm in the afternoon and as it abated he and another man came and stood in the doorway. As they looked outside, they saw a large fireball about 20 inches in diameter. It rolled from the top of the courthouse steeple, down the side of the courthouse and onto some telephone wires, rolling along the wires sometimes on top and sometimes underneath. When it came to the pole nearest my husband it rolled down the pole and out into the street and exploded with enough force to knock my husband and the other man to the floor. However, they were uninjured.

My own experience occurred one summer afternoon when I visited the dentist for a tooth extraction. A sudden electrical storm appeared and when the dentist finished and I got out of the chair, a large fireball about 36 inches in diameter rolled out of the X-ray machine. It rolled slowly past me and two other people, passing through two rooms, two doors and and on out into the street, where it disappeared without exploding. — *E. J. Church, Rushville, Ind.*

[Janet Bord]

bol-0093

Ball of Fires observed in Japan

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We have organized "Japanese Information Center of Ball Lightning (Fire Ball)" in 1986. For three years we could obtain 2200 cases including 6 photographs and two video tapes. According to the eyewitness data, we make computer graphic images with the background of the video scene of observed points. Followings are typical reports obtained by such manners.

[two specimen cases are included : the reproduction of Prof. Ohtsuki's photographs is of course less than adequate.....]

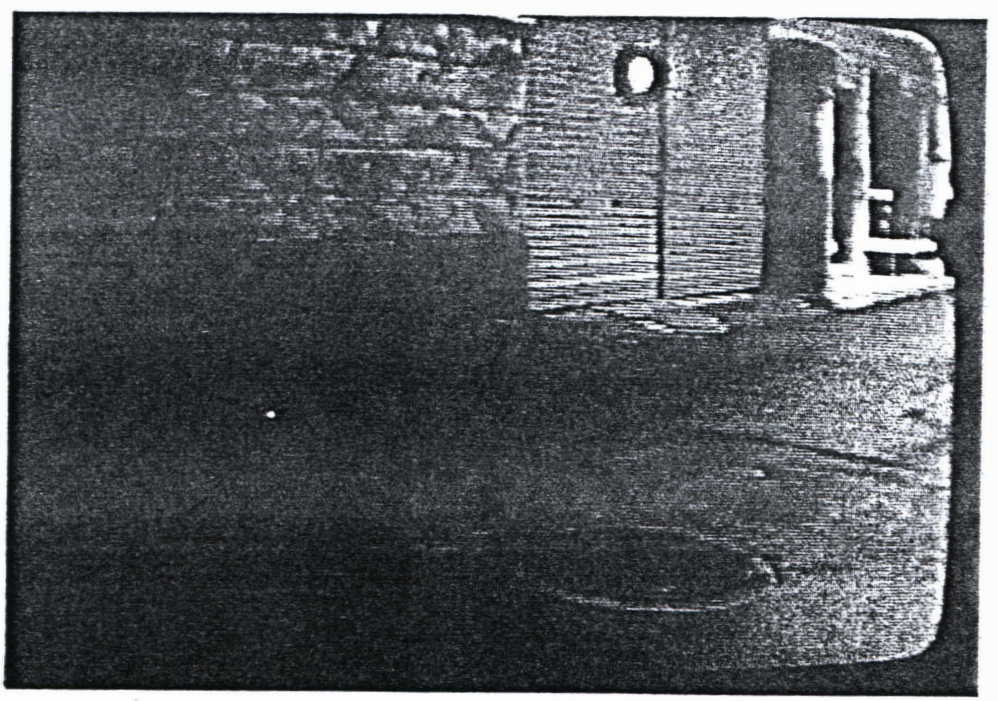
2

Mr. T.T. (Tokyo) (? years old)

At 9:20 - 9:23 p.m. on July 21th 1987 the weather was cloudy. When I was on my way back home and I turned a corner, I saw a lighting matter floating 1 m above the road. I neared it, but it went away from me. I ran after it for 1 min, but I could not cut down the distance. It broke and disappeared at the one side of the road as if a balloon had bursted.

The shape of the lighting matter was sphere with a small tail. The color of its center was orange and red, and its tail was blue. The diameter was 25 - 30 cm.

2-1



7

Mr. K. WADA (MAEBASHI, 43 years old)

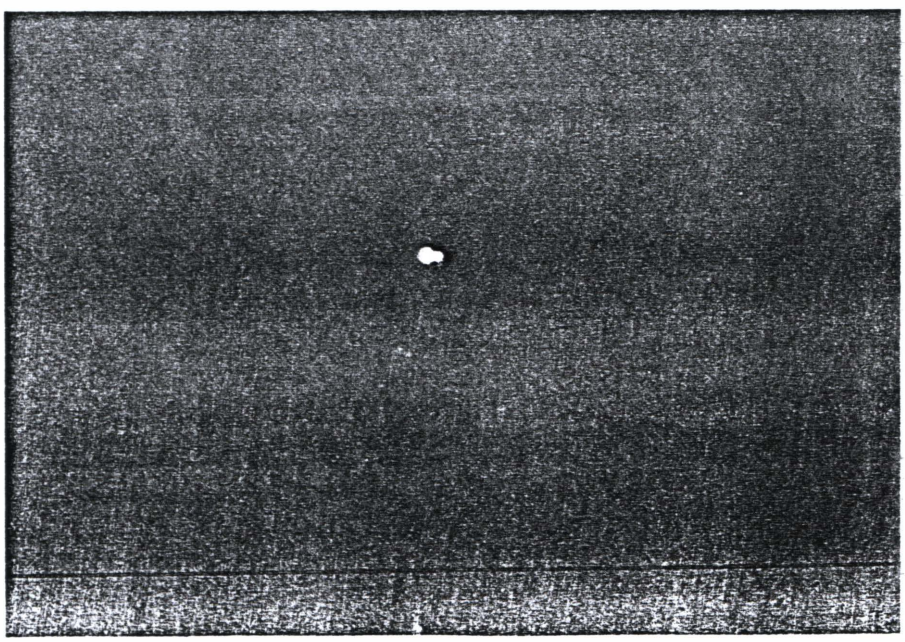
On 30th August 1987 my wife and I went to Kirigamine highland (Nagano pref.) to take photographs of the view of dawn. The weather was fine without any cloud. Stars were twinkling.

At 4:20 - 5:00 a.m. we walked on a path from a hut for about 20 minutes. When we turned around to see the hut, suddenly an orange color light began to shine in the west sky. The light became brighter and brighter, and reached the strongest brightness. After 10 seconds, the light became weaker and weaker, turned white color and disappeared.

In a minute it appeared in the white color. It became brighter and brighter, turned to orange color and reached the strongest brightness. It lasted for 10 - 20 seconds. The light became weaker and weaker, and disappeared.

My wife told me that there was another light in the righthand side, and I saw the light there. She told me that it appeared many times, but I could see it once. Moreover she told me it also changed the color, but I did not see such a phenomenon.

7



bol 0094

CHAPTER IV

FIREBALLS

HERE we penetrate into what is, perhaps, the most mysterious, and certainly the least understood domain of thunder and lightning.

Among all the electrical phenomena to be observed in the atmosphere, there is nothing stranger than those fireballs of which we have already spoken, and which in form and size recall the electric lights in our Paris boulevards. Curious the contrast between electricity tamed and civilized and electricity running wild! Between the arc lights fulfilling their peaceful and useful function as substitutes for the sun, and these dread engines of destruction sowing death and havoc!

It is not long since the existence of these fireballs has been acknowledged by scientists as an actual fact. Until quite recent times they were regarded as the figment of excited imaginations, and wise men smiled at the wild stories of their ravages. Their reality has now been established, however, beyond the possibility of doubt.

excerpt from Flammarion, Les phénomènes de la foudre (no date, circa 1890) — english-language translation. not earlier than 1906)

In shape they are not always quite spherical, though this is their normal appearance; and although their contours are usually clearly defined, they are sometimes encircled by a kind of luminous vapour, such as we often see encircling the moon. Sometimes they are furnished with a red flame like a fuse that has been lit. Sometimes their course is simply that of a falling star. Sometimes they leave behind them a luminous trail which remains visible long after they themselves have disappeared. They have been described as looking like a crouching kitten, an iron bar, a large orange—so harmless apparently, that you were tempted to put out your hand to catch it. There is record of one being seen as large as a millstone.

One remarkable thing about them is the slowness with which they move, and which sometimes enables their course to be watched for several minutes. In our first chapter we gave several instances of the occurrence of fireballs. Let us look at some more. Here is one taken from Arago's learned treatise upon thunder. The record is from the pen of Batti, a marine painter in the service of the Empress of Austria and resident at Milan.

"In the month of June, 1841, I was staying at the Hôtel de l'Agnello in a room on the second floor, overlooking the Corso dei Servi. It was about six in the afternoon. The rain was coming down in torrents, and

the darkest rooms were lit up by the lightning flashes better than our rooms generally are by gas. Thunder broke out every now and again with appalling violence. The windows of the houses were closed, and the streets were deserted, for, as I have said, there was a steady downpour, and the main road was turned into a torrent. I was sitting quietly smoking, and looking out at the rain, which an occasional ray of sunlight set flashing like threads of gold, when I suddenly heard voices in the street calling out 'Guarda, guarda!'—'Look, look!' and at the same moment a clatter of hob-nailed boots. After half an hour of absolute silence, this noise attracted my attention. I ran to the window, and looking to the right, in the direction of the clamour, I saw a fireball making its way down the middle of the road on a level with my window, in a noticeably oblique direction, not horizontally. Eight or ten persons, continuing to call out 'Guarda, guarda!' kept pace with it, walking down the street, stepping out quickly. The meteor passed my window, and I had to turn to the left to see what would be the end of its caprice. After a moment, fearing to lose sight of it behind some houses which jutted out beyond my hotel, I went quickly downstairs and into the street, and was in time to see it again and to join those who were following its course. It was still going slowly, but it was now higher up, and was still ascending—so

much so that after a few minutes it hit the cross upon the clock tower of the Chiesa dei Servi and disappeared. Its disappearance was accompanied by a dull report like that of a big cannon twenty miles away when the wind carries the sound.

"To give an idea of the size and colour of this globe of fire, I can only compare it to the appearance of the moon as one may see it sometimes rising above the Alps on a clear night in winter, and as I myself have seen it at Innsbrück—that is to say, of a reddish yellow, with patches on it almost of red. The difference was that you could not see the contours of the meteor distinctly as you could the moon, and that it seemed to be enveloped in a luminous atmosphere of indefinite extent."

This fireball was an innocuous one. We may take next, by way of contrast, the case of one which wreaked terrible damage and loss of life.

On July 27, 1789, at about three o'clock in the afternoon, a fireball of about the size of a cannon-ball, fell in a great hall at Feltri (Marche Trevisane) in which six hundred people were seated, wounded seventy and killed ten, putting out all the lights.

On July 11, 1809, about eleven o'clock in the morning, a fireball penetrated into the church of Chateauneuf-les-Moustiers (Basses-Alpes) just as the bell was ringing and a large congregation had taken

their seats. Nine persons were killed on the spot and eighty-two others were wounded. All the dogs that had got into the church were killed. A woman who was in a hut on a neighbouring hill saw three fireballs descend that day, and made sure they would reduce the village to ashes.

Müsschenbroek recounts the following incident which took place at Solingen in 1711. M. Pyl, the Pastor at Duytsbourg, was preaching one Sunday, when in the middle of a storm a fireball fell into the church through the clock tower and exploded. The sanctuary was set on fire and became thick with smoke. Three persons were killed and more than a hundred were wounded.

From the *Bulletin* of the Société Astronomique de France the following narrative contributed to it by Mlle. de Soubbotine, a member of this society, has been taken :—

"A terrible storm broke out at Ouralsk on May 22, 1901. It was a *fête* day and the streets were thronged with people. Towards five in the afternoon some young men and girls, twenty-one in all, had taken refuge in the vestibule of a house, and a girl of seventeen, Mlle. K., had sat down on the threshold, her back turned towards the street. Suddenly there was a violent clap of thunder, and in front of the door there appeared a dazzlingly brilliant ball of fire,

gradually descending towards where they were all grouped. After touching Mlle. K.'s head, who bowed down at once, the fireball fell on the ground in the middle of the party, made a circuit of it, then forcing its way into the room of the master of the house, whose boots it touched and singed, it wreaked havoc with the apartment, broke through the wall into a stove in the adjoining room, smashed the stove-pipe, and carried it off with such violence that it was dashed against the opposite wall, and went out through the broken window.

"After the first feeling of fright, this is what transpired. The door near which Mlle. K. was seated had been thrown back into the court, and in the ceiling there were two holes of about 18 centimetres each.

"The young girl, still seated with her head bowed down, looked as though she were asleep. Some of the people were walking in the courtyard, having seen and heard nothing, and the others were all lying in the vestibule in a dead faint. Mlle. K. was dead. The fireball had struck her on the nape of her neck and had proceeded down her back and left hip, leaving a black mark all along. There was a sore on one hand, with some blood on it, and one of her shoes was torn completely off, and there was a small hole in one of the stockings.

"All the victims became deaf."

On September 10, 1845, at about two in the afternoon, in the course of a violent storm, a fireball came down the chimney into a room in a house in the village of Salagnac (Creuse). A child and three women who were in the room suffered no harm from it. Then it rolled into the middle of the kitchen, and passed near the feet of a young peasant who was standing in it. After which it went into an adjoining room, and disappeared without leaving any trace. The women tried to persuade the man to go in and see whether he could not stamp it out, but he had once allowed himself to be electrified in Paris, and thought it prudent to refrain. In a little stable hard by, it was found afterwards that the fireball had killed a pig. It had gone through the straw without setting fire to it.

On July 12, 1872, a new form of fireball made its appearance in the Commune of Hécourt (Oise). It was of the size of an egg, and it was seen burning upon a bed. Efforts were made in vain to extinguish it, and presently the entire house, together with the neighbouring dwellings and barns, became a prey to the flames.

On October 9, 1885, at 8.25 p.m., during a violent storm, a globe of fire of the size of a small apple was seen coming into a ground-floor room in a house at

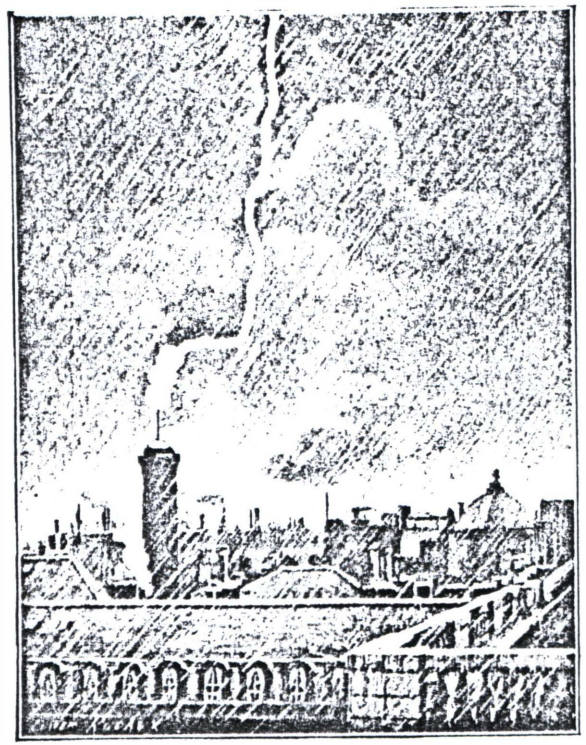
Constantinople through an open window, the family being at table in this room at the time. It first played round a gas-jet, then, moving towards the table, it passed between two guests, went round a lamp hanging over the centre of the table, and then precipitated itself into the street, where it exploded with an appalling crash, but without having caused any damage or hurt anybody. Not far from the scene of this phenomenon there are a number of buildings provided with lightning conductors. The fireball left no trace of smell behind it.

Here is another curious narrative of a fireball.

A party of five women took refuge during a storm in the entrance to a house in order to escape from the rain and the lightning.

They had scarcely gained the doorway when there was a tremendous thunderclap which sent them flying backwards—and two girls who had joined them—knocked senseless by lightning in the form of a fireball. One of the girls remained unconscious for a long time; all the others were more or less seriously injured, but all recovered. The strangest circumstance in connection with this affair, however, still remains to be told.

On the same side of the street as the passage, in a neighbouring house, nine or ten yards away, in a ground-floor room of which the door was shut, a young



SINGULAR CASE OF THREE FIREBALLS OBSERVED IN PARIS ON JUNE 10, 1905, BY M. H. RUDAUX.

They were seen to descend in this way upon the lightning conductor above the Palais Royal electric-power station. This engraving, after a sketch made at the time by M. Rudaux, appeared in *La Science Illustrée*, for August, 1905.

[*Page* 61.

woman was working at a sewing-machine. At the moment of the thunderclap, she experienced a violent shock throughout her whole body, and a fierce burning sensation in the hollow of her back. It was found afterwards that between the shoulder-blades and also on her leg, she had been badly scorched, but the wounds quickly healed. Now, in the room of this victim, no trace was to be found of the passing of the fireball, neither on the ceiling, nor on the floor, nor on the walls. There was absolutely nothing to show how the electric fluid could have made its way in from the spot in which the fireball had exploded in the neighbouring house, separated from it by two thick walls.

Mysterious, is it not? The fireball seems to dwindle out of sight. In some cases, it seems to reduce itself into vapour in order to pass from one place to another.

With animals these fireballs seem deadlier and more merciless than with human beings.

Thus, on February 16, 1866, a thunderstorm descended upon a farm in the Commune of Chapelle-Largeau (Deux-Sèvres), and the circumstances attending its explosion are too remarkable to be overlooked. After a tremendous thunderclap, a young man who was standing near the farm saw an immense fireball touch the ground at his feet, but it did him no damage,

but passed, still harmlessly, through a room in the farmhouse in which there were nine persons. The only effect it produced was the flaring up of some matches upon the chimney-piece.

It proceeded towards the stables, which were divided into two compartments. In one there were two cows and two oxen: the first cow, to the right of the entrance, was killed, the second was uninjured; the first ox was killed, the second was uninjured.

The same effect was found to have been produced in the other compartment, in which there were four cows; the first and the third were killed, the second and fourth were spared: the odd numbers taken and the even numbers left.

Similar freaks have been recorded in connection with piles of plates struck by lightning—holes being found in alternate plates. How are these things to be explained?

The following story is very extraordinary, though it does not help to clear up the mystery of lightning's strange ways:—

On August 24, 1895, about ten in the morning, in the midst of a storm of wind and rain, several persons saw descending to the ground a whitish-coloured globe of about an inch and a half in diameter, which, on touching the ground, split into two smaller globes. These rose at once to the height of the chimneys on the

houses close by, and disappeared. One went down a chimney, crossed a room in which were a man and a child, without harming them, and went through the floor, perforating a brick with a clean round hole of about the size of a franc. Under this room there was a sheep-fold. The shepherd's son, seated at the doorway, suddenly saw a bright light shining over the flock of sheep, while the lambs were jumping about in alarm. When he went up to them, he was startled to discover that five sheep had been killed. They bore no trace of burning, or of wound of any kind, but about their lips was a sort of foam, slightly pink in colour.

In the adjoining house, the second fireball had also gone down a chimney, and had exploded in the kitchen, causing great damage.

In 1890, a young farmer was working on a plot of ground, two or three miles from Montfort-l'Amaury. A storm breaking out, he stood up against his horses to take refuge from the rain; moving away a few yards in order to get his whip, there was seen, when he returned, a ball of fire almost touching the ear of one of his horses. A moment later it exploded with a deafening noise. The two horses fell—one of them unable to get up again. The farmer himself was dashed to pieces.

On other occasions the meteor is hardly more devastating than the ordinary bomb.

On April 21, at Lanxade, near Bergerac, a storm

had been raging already for some hours, when suddenly —simultaneously with a small thunderclap—a ball of fire, of the size of the opening of a sack of corn, fell slowly on one of the banks of the Dordogne, spoiling some fruit trees, and then crossing the river, it raised a waterspout several yards high as it went.

It disappeared finally on the other side of a field of corn.

On November 12, 1887, a very curious instance of a fireball was noticed on the Atlantic.

It was at midnight, near Cape Race. An enormous fireball was seen to rise slowly out of the sea to the height of sixteen or seventeen metres. It travelled against the wind, and came quite near the vessel from which it was being watched. Then it turned towards the south-east and disappeared. The apparition lasted about five minutes.

In July, 1902, in the course of a violent storm, and immediately after a loud peal of thunder, a fireball of about the size of a toy balloon was seen to make its appearance suddenly in the Rue Veron at Montmartre. After moving along, just above the ground, in front of a wine-merchant's shop, it exploded like a bomb, most fortunately without hurting any one, or doing any damage.

The little village of Candes, situated by the confluence of the Vienne and the Loire, was the scene of

the appearance of a fireball in June, 1897. Three persons were sitting in the verandah of a house during a storm, when they suddenly saw a fireball travelling past them through the air for a distance of thirty yards or so. Then it exploded with a loud noise, striking sparks from the ironworks of the verandah. At the same moment, the servants saw another fireball cross a garden at the other side of the house, and drop into a small pond. A gardener was knocked over, but not hurt.

On March 6, 1894, M. Dandois, professor of surgery at the University of Louvain, went to the neighbouring town of Linden, by railway, to see a patient. On his return, on foot, the sky suddenly so darkened over, that he made for the nearest dwelling-place, avoiding, as he did so, the telegraph poles along the road. Suddenly a ball of fire came against him and threw him over a ditch into a field, where he lay unconscious.

A quarter of an hour later, having regained his senses and finding himself undamaged save for a numbness in one arm and one leg, the doctor set out again, congratulating himself on the fact that his umbrella had acted as a sort of portable lightning conductor, for the steels were all twisted, and showed signs of having borne the brunt of the fray. Had the handle been of steel also, the electric current would

have run down it into his hand, doubtless, and killed him.

On another occasion a fireball fell upon the door of a house, pushed it violently open, and made its way into the kitchen.

At the sight of this strange visitor, the cook bolted from the room. A sempstress, who was at work near the window, received a small burn on her forehead, of about the size of half a franc, with a slight weal a couple of inches long—like the tail of a comet.

After bursting, the fireball made its way up the chimney, from which it removed a mass of soot, smelling somewhat of sulphur.

Here is an instance more curious still—

A violent storm was raging near Marseilles, when seven persons, seated together in the ground-floor drawing-room of a country house, saw a fireball as big as a plate appear in their midst.

It directed its course towards a young girl of eighteen, who, frightened out of her life, had fallen on her knees. Touching her shoes, it rebounded to the ceiling, then came down to her feet again, and so on two or three times, with mysterious regularity, the girl experiencing, it seems, no other sensation than that of a slight cramp in her legs. Eventually the fireball made its exit from the room through a keyhole!

The girl could not get up at once after it had gone. For a fortnight or so she could not walk without assistance, and it was two years before she got over a liability to sudden weakness in her legs, causing her suddenly to fall.

It is strange to reflect that these diminutive fireballs, produced by the actual atmosphere we breathe, are less understood by us than that enormous globe which we call the sun, and to which is due the flowering of the entire life of our planet. If we are still in doubt as to the nature of the sun's spots, at least we have been able to analyse its own elements. And we know its dimensions, its weight, its distance from us, its rate of rotation, etc., etc.

Yet these electric spheres that make their escape from the clouds in times of storm, baffle our investigations altogether.

According to records which seem authentic, fireballs have been seen actually to come into existence upon the surface of a ceiling, at the mouth of a well, and upon the flagstones of a church.

In 1713, at the chateau of Fosdinaro, in the neighbourhood of Massa Carrara, in the course of a storm and heavy downpour of rain, there was seen to appear suddenly upon the ground a very vivid flame, white and blue in colour. It seemed to flare fiercely, but did not move apparently from the one spot, and after growing

quickly in volume it suddenly disappeared. Simultaneously with its going, one of the observers felt a curious sort of tickling behind his shoulder, moving upwards; several bits of plaster from the ceiling under which he stood fell upon his head, and there was a sudden crash quite unlike an ordinary thunderclap.

In 1750, on the 2nd of July, at about three in the afternoon, the Abbé Richard happened to be in the church of St. Michel at Dijon during a storm. "Suddenly," he tells us, "I saw between two pillars of the nave a bright red flame floating in the air about three feet above the floor. Presently it rose to a height of twelve or fifteen feet, increasing in volume. Then, after having moved some yards to one side, while still rising diagonally to the height almost of the woodwork of the organ, it disappeared at last with an explosion like the report of a cannon."

On July 21, 1745, a violent storm broke out in Boulogne, and the tower of a convent was struck by a fireball. It was of great size, and was seen to emerge from one of the sewers of the town and to move along the surface of the road until it hit against this tower, of which a part subsided. No one was hurt. A nun affirmed that some years before she had seen just such another fireball emerge from the same spot and precipitate itself with a crash against the summit of the tower without doing any damage.

In the middle of a violent storm, Dr. Gardons saw several fireballs flying in different directions, not far from the ground, making a crackling sort of noise. One of them was seen by witnesses to come out of an excavation full of stagnant water. They killed one man, several animals, and did much damage to the trees and houses in the vicinity.

In February, 1767, at Presbourg, a blue, conical flame escaped suddenly with a detonating noise from a brasier, breaking it to pieces, and scattering the glowing cinders all around. It then went twisting about the room, burnt the face and hands of a child, escaped partly through the window, partly through the door, broke into a thousand pieces a second brasier in another room, and disappeared finally up a chimney, carrying up with it and discharging from the chimney-top into the street several hams which had been hung under the chimney-piece. For several days afterwards the atmosphere of the house retained a smell of sulphur.

In some cases, fireballs have been seen to come down from the sky apparently, and then, after almost reaching but not actually touching the ground, to ascend again. Thus on a hot day in summer 1837, M. Hapoule, a landed proprietor in the department of the Moselle, standing in front of the entrance to his stables under the shelter of a porch during a storm,

saw a fireball about the size of an orange moving in the direction of a dung-heap not far from him. But instead of going right into it, it stopped about a yard off, and changing its route, it went off at an angle, keeping the same level for some distance, when it suddenly seemed to change its mind again, and rose perpendicularly till it disappeared in the clouds.

These sudden changes, as we have seen, are strangely characteristic of the habits of fireballs.

The Garde Champêtre of the village of Lalande de Libourne (Gironde) was traversing the country one evening about half-past ten, engaged in organizing a *garde de surveillance*, when he suddenly found himself surrounded by a bright and penetrating light. Astonished, he looked behind him, and saw a fireball, just broken loose from a cloud, descending quickly to the ground.

The light vanished presently, but he made his way towards where the fireball seemed to be falling. When he had gone about two hundred yards, he saw another brilliant light breaking out from the top of a tree and spreading itself into a sheaf of rays, every point of which seemed to emit electric sparks.

At the end of a quarter of an hour the light became weaker, and then disappeared. The tree was afterwards cut down, and it was found that the lightning had gone down the centre to a distance of three yards, and had

then passed down outside to the soil, leaving trace of a semi-circular route; and finally, after rising again on the opposite side of the tree to a height of four yards, tearing off two narrow strips of bark, had disappeared. At the foot of the tree a small hole, about an inch and a quarter in diameter, retained a certain degree of warmth for an hour and a half afterwards.

Fireballs often keep within the frontiers of cloud-land. They may be seen passing sometimes from one cloud to another in the high regions of the atmosphere.

On September 22, 1813, at seven in the evening, M. Louis Ordinaire saw a fireball leave a cloud at the zenith—the sky being very much lowering at the time—and go towards another. It was of a reddish-yellow and extremely brilliant, lighting up the ground with a bright radiance.

He was able to follow its movements for at least a minute, and then saw it disappear into the second cloud. There was an explosion followed by a dull sound like the firing off of a cannon in the distance.

After a violent storm which broke out near Wakefield on March 1, 1774, there remained only two clouds in the sky, just above the horizon. Balls of fire were observed gliding from the higher of the two into the lower, like falling stars.

In high mountainous districts—in the Alps, for instance—you may often look down from above upon

a storm. It is fascinating thus to watch the grandiose spectacle of the elements at war. Here from the pen of Pere Lozeran du Fesch is a striking picture of such a scene—

"It was on the 2nd of September, 1716, about three o'clock in the afternoon. A traveller was making his way down towards Vic from the summit of Cantal, accompanied by a guide.

"The weather was calm and very warm, but down below, about the middle of the mountain, a vast sea of mist stretched out in wavelike clouds.

"These clouds were furrowed continually by lightning flashes, some going quite straight, some zigzag, some taking the shape of fireballs. When the two men came near this region of clouds, the mist grew so thick they could hardly see the bridles of their horses.

"The air became gradually more cold and the darkness more dense as they proceeded downwards. Now they were in the midst of the fireballs flying in every direction all round them, revolving as they went, reddish in colour, like saffron lit up.

"They were of all sizes—some quite small on their first appearance, seeming to grow immensely in volume in a few moments. Drops of rain fell when they passed. Up to this point the sight had been curious but not terrifying, but suddenly now, one of these fireballs, about two feet in diameter, burst open near

the traveller and emitted streams of a bright and beautiful light in every direction, and there was a dull report followed by a tremendous crash. The two men were much shaken and the air all round them seemed polluted. After a minute or two, however, all trace of the explosion had been dissipated, and they proceeded on their way."

On January 6, 1850, near Merlan, about six in the afternoon, a fireball burst above the heads of two men, enveloping them in a bluish light, without hurting them or even damaging their clothes, but giving them a momentary thrill as from an electric battery. It left no traces of any kind, not even a smell.

Mr. G. M. Ryan records an instance which he witnessed at Karachi in Scinde. While in his drawing-room one day with two friends who were taking refuge from a storm, he rose from his chair and went to the door to open it, the windows as well as the door being shut at the time. Returning, he saw in the air and between his friends, a ball of fire of about the size of a full moon. At the same time there was a terrible clap of thunder. Two of the spectators were slightly wounded; one felt a sharp pain on the left side of the face, the other, a sensation in one arm with a feeling as if his hair were burning. There was a strong smell of sulphur. In the next room there were two rifles in a

case; one was intact but the other was broken, and there was a hole in the wall at the point where the muzzle leant against it, and there were two holes in the same wall a story higher.

On Sunday, August 19, 1900, several people were assembled in a room in the château of the Baron de France at Maintenay (Pas-de-Calais), when there was a violent storm raging over the country.

Suddenly there appeared in the midst of the eleven people who were there, a globe of blue fire about the size of an infant's head, which quietly crossed the room, touching four people on its way. None of them were injured. An awful explosion was heard at the moment when the electric ball disappeared through an open door in front of the great staircase.

On August 3, 1809, a fireball struck the house of a Mr. David Sutton, not far from Newcastle-on-Tyne. Eight people were having tea in the drawing-room when a violent clap of thunder knocked down the chimney.

Immediately after they saw on the ground, at the door opposite the fireplace, the brilliant visitor which announced itself in the sonorous voice of Jupiter the thunderer. It remained discreetly at the entrance of the room, no doubt waiting for the sign to advance. No one making a move, it came into the middle of the

room, and there burst with a crash, throwing out fiery grains like aeroliths.

The spectacle must have been magnificent—but, we must acknowledge, rather disquieting.

On September 27, 1772, at Besançon, a voluminous fireball crossed over a corn-shop and the ward of a hospital full of nurses and children. This time again the lightning was merciful—it spared nurses and children, and went and drowned itself in the Doubs.

Nearly thirty years before, in July, 1744, it showed the same regard for an honest German peasant woman. She was occupied in the kitchen superintending the family meal, when, after a terrible clap of thunder, she saw a fireball the size of a fist come down the chimney, pass between her feet without hurting her, and continue on its course without burning or even upsetting the spinning-wheel and other objects on the floor.

Much frightened, the young woman tried to escape; she threw herself towards the door and opened it, when the fireball at once followed her, played about her feet, went into the next room, which opened out-of-doors, crossed it, and through the door into the yard.

It went round the yard, entered a barn by an open door, climbed the wall opposite, and reaching the edge of the roof, burst with such a terrific noise that the

peasant woman fainted. The barn at once took fire and was reduced to cinders.

Towards the middle of the last century, March 3, 1835, the steeple of Crailsheim was set on fire by lightning. The guardian's daughter, aged twenty years, was at this moment in her room and had her back turned to the window, when her young brother saw a fireball enter by the window-sill and descend on to his sister's back, giving her a sudden shock all over her body. The young girl then saw at her feet a quantity of small flames, which went towards the kitchen, the door of which had been opened, and set fire to a pile of mossy wood. There was no further damage than this attempt at incendiarism, which was easily extinguished.

Occasionally a fireball seems to take a malignant pleasure in hurling itself like a fury against lightning conductors; but instead of quietly impaling itself like the linear lightning, and breathing its last sigh in a prolonged roar, it struggles, and comes forth victorious from this curious contest.

There are many cases of fireballs playing about the lightning conductors without being caught.

In 1777, a fireball shot from the clouds on to the point of the lightning conductor on the Observatory of Padua. The conductor, which consisted of an iron chain, was broken at its junction with the stem. However, it sent on the discharge.

Some years later, in 1792, a huge ball of lightning struck one of the two conductors on the house of M. Haller at Villiers la Garenne. This conductor was much injured by the audacious assailant, and so was the framework of the house; the keen fluid had damaged the metallic gutters.

At this point I must add that lightning conductors are of recent creation. Nor would it be surprising if there were defective ones which could not assure an efficient protection.

However, much later, on December 20, 1845, the same phenomenon was observed at the château of Bortyvon, near Vire. There, again, the fireball, ignoring the danger to which it was exposing itself, flung itself on a lightning conductor placed in the centre of the château. It was spared, but the château suffered greatly. The electric ball descended from both sides of the metallic stem, causing a great deal of damage along its path. On touching the ground it expanded, and many persons affirm that they saw what was like a huge cask of fire rolling along the ground.

In truth, ball lightning seems in a certain measure to escape the influence of lightning conductors.

On September 4, 1903, towards ten o'clock in the evening, M. Laurence Rotch, director of the Observatory of Blue Hill (U.S.), happening to be in

Paris, made the following curious observation from the Rond-point of the Champs Elysées.

Looking in the direction of the Eiffel Tower, he saw the summit of the edifice struck by white lightning coming from the zenith. At the same moment a fire-ball, less dazzling than the lightning, slowly descended from the summit to the second platform. It appeared to be about one yard in diameter, and to be situated in the middle of the tower, taking less than two seconds to cover a distance of about 100 yards. Then it disappeared. The next day the observer ascertained, on visiting the tower, that it had actually been struck by lightning twice on the previous day.

It is to be noted that the meteor did not follow the conductor; but, after all, is not the whole tower itself the most powerful conductor imaginable? Would not the enormous masses of iron used in its construction neutralize the attraction of the thin metallic rods, effectual for the protection of ordinary buildings, but incapable, one would think, of competing with the attractive force of this immense metallic framework?

Here are some cases where globular lightning has struck bells or telegraph wires, which it has followed with docility.

Several times it has been seen poised like a bird on a telegraph wire near a railway-station, and has then quietly disappeared.

THE EIFFEL TOWER AS A COLOSSAL LIGHTNING CONDUCTOR.

Photograph taken June 3, 1902, at 9.20 p.m., by M. G. Loppé. Published in the *Bulletin de la Société Astronomique de France* (May, 1905). [*Page* 82.

We see that it is not absolutely inimical to points, nor to metals, but it prefers its independence, and he must get up early who would catch it in a snare.

It is an anarchist—it acknowledges no rule.

But we must confess that if spheroidal lightning seems particularly capricious, it is because we are still ignorant of the laws which guide it. Our ignorance alone is the cause of the mystery.

We try to discover the enigma in the silence of the laboratories, where physicians question science without ceasing; we try to reproduce fireballs artificially, but the problem is complicated, and its solution presents enormous difficulties.

Hypotheses are not wanting. Some years ago, M. Stéphane Leduc recorded an interesting experiment, producing a moving globular spark.

When two very fine and highly polished metallic points, each in affinity with one of the poles of an electro-static machine, rest perpendicularly on the sensitive face of a gelatine bromide of silver photographic plate, which is placed on a metallic leaf, the two points being 5 to 10 centimetres the one from the other, an effluvium is produced round the positive point, while at the negative point a luminous globule is formed.

When this globule has reached a sufficient size, you can see it detach itself from the point, which

ceases to be luminous, begin to move forward slowly on the plate, make a few curves, and then set off for the positive point; when it reaches this, the effluvium is extinguished, all luminous phenomenon ceases, and the machine acts as if its two poles were united by a conductor.

The speed with which the luminous globe moves is very slight. It takes from one to four minutes to cover a distance of 5 to 6 centimetres. Sometimes, before reaching the positive point, the globe bursts into two or more luminous globules, which individually continue their journey towards the positive point.

On developing the plate, you will find traced on it the route followed by the globule, the point of explosion, the routes resulting from the division, the effluvium round the positive point. Also, if you stop the experiment before the arrival of the globule at the positive point, the photograph will only give the route to that point.

The globule makes its course the conductor. If during its journey you were to throw powder on the plate—sulphur, for example—the course it followed will be marked by a line of little aigrettes, looking like a luminous rosary.

Of all the known electric phenomena, this is the most analogous with globular lightning.

But the really complicated part of the question

is when ball lightning loses part of its fluidity and becomes a semi-solid body, as in the following instance:—

On April 24, 1887, a storm burst over Mortrée (Orne), and the lightning literally chopped the telegraph wire on the route to Argentan for a distance of 150 yards. The pieces were so calcinated that they might have been under the fire of a forge; some of the longer ones were bent and their sections welded together. The lightning entered by the door of a stable in the form of a fireball, and came near a person who was preparing to milk a cow; then it *passed between the legs of the animal*, and disappeared without causing any damage. The terrified cow raised itself on its hind legs with frantic bellowing, and its master ran away, frightened out of his wits, but there was no harm done.

The inexplicable phenomenon was that at the precise moment when the lightning crossed the stable, a great quantity of incandescent stones fell before a neighbouring house. "Some of these fragments, of the size of nuts," wrote the Minister of Post and Telegraphs at the Academy, "are of a not very thick material, of a greyish-white, and easily broken by the fingers, giving forth a characteristic odour of sulphur. The others, which are smaller, are exactly like coke.

"It would perhaps be useful to say here, that during this storm the thunderclaps were not preceded by the ordinary muttering, they burst quickly like the discharge of musketry, and succeeded one another at short intervals. Hail fell in abundance, and the temperature was very low."

It is only by a semblance of disbelief that one can get the peasants to tell us the stories of what they pretend to have seen of the fall of aeroliths during storms. They have christened the uranoliths "thunderstones."

These substances have evidently no relation to uranoliths, but they prove none the less that ponderable matter may accompany the fall of lightning.

Here are two more examples—

In the month of August, 1885, a storm burst over Sotteville (Seine-Inférieure); lightning furrowed the sky, the thunder muttered, and the rain fell in torrents. Suddenly, in the Rue Pierre Corneille, several small balls, about the size of a common pea, were seen to fall; these burned on touching the ground, sending out a little violet flame. People counted more than twenty, and one of the spectators, on putting her foot on one of them, produced a fresh flame. They left no trace on the ground.

On August 25, 1880, in Paris, during a rather

violent storm, in broad daylight, M. A. Trécul, of the Institute, saw a very brilliant voluminous body, yellowish-white, and rather long in shape, being apparently 35 to 40 centimetres in length, by about 25 in width, with slightly conical ends.

This body was only visible for a few seconds; it seemed to disappear and re-enter a cloud, but in departing—and this is the chief point—it dropped a little substance, which fell vertically like a heavy body under the sole influence of gravity. It left a trail of light behind it, at the edges of which could be seen sparks, or rather red globules, because their light did not flash. Near the falling substance the luminous trail was almost vertical, while in the further part it was sinuous. The small substance divided in falling, and the light went out soon after, when it was on the point of reaching the tops of the houses. When it was disappearing, and at the moment of the division, no noise was heard, although the cloud was not far away.

This fact incontestably proves the presence of ponderable matter in clouds, which is not violently projected by an explosion in the bolis, nor accompanied by a noisy electric discharge.

We are still far from understanding the interesting problem of the formation and nature of ball lightning. Instead of denying it, men of science ought to study it, because it is certainly one of the most remarkable of the curiosities of atmospheric electricity.

bol - 0095

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Laboratory ball lightning

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Abstract—A mechanism for the formation of ball lightning is discussed. It is suggested that the presence of a low density of simple hydrocarbons in the atmosphere, coupled with an atmospheric electrical discharge, may be sufficient to form the phenomenon. A simple calculation establishes a theoretical diameter of approximately 6–130 cm. A laboratory experiment is described in which a ball of fire was formed. The phenomenon appeared to possess many properties of natural ball lightning, including existence for a finite time without an external energy source.

1. Introduction

Ball lightning is generally considered an atmospheric electrical phenomenon, commonly observed during thunderstorm activity. It is reported to be a self-contained, highly-luminous, mobile, globular mass that appears to behave independently of external forces. It possesses certain characteristics of motion, illumination, structure, and decay that distinguish it from other natural atmospheric electrical phenomena such as St. Elmo's Fire.

A recent study (Barry, 1967) indicates that ball lightning is most commonly spherical or oval shaped, with a diameter less than 35 cm. It is predominantly red or red-yellow with a burning structure, is initially observed with a descending motion, and often becomes motionless after a short time. The phenomenon has a lifetime of a few seconds or less and decays either silently or noisily. It has been estimated from observations that natural ball lightning may have an energy density as great as 2·5 kJ/cm^3 (Goodlet, 1937). If the color of ball lightning is indicative of its thermal properties and Wien's Law is applicable, then it may have an internal temperature of 4000°C–5000°C. Even though ball lightning is commonly observed during thunderstorms, there have been many observations during other stresses of nature such as earthquakes, tornadoes, and volcanic eruptions (Cadenat, 1890; Terada, 1931). A common characteristic of the natural disturbances during which ball lightning is observed is the presence of strong electric fields (Anderson, 1965; Muller-Hildebrand, 1963).

2. Ball Lightning Origin

Many explanations of ball lightning origin have been suggested. These range from considering ball lightning to be a result of a combustion process (Hildebrand-Hildebrandson, 1885), a focused electromagnetic wave resonance (Kapitsa, 1955; Marchant, 1930), or a locally contained plasma (Finkelstein and Rubinstein, 1964). The combustion explanation was investigated experimentally by others (Nauer, 1953; Plante, 1877). Our work is a specific expansion of these earlier experimental efforts.

We suggest that at least two conditions may be necessary for the formation of natural ball lightning in the atmosphere. First, some type of atmospheric electric discharge must be present to provide the energy of formation. Second, the development of the phenomenon depends upon the presence of natural hydrocarbons (CH_4, C_3H_8, etc.) in proximity to the atmospheric discharge. It must be emphasized that this hydrocarbon density is assumed to be low, less than that necessary for combustion.

In order to develop this explanation of the formation mechanism, two experimental observations are utilized. First, an electrical discharge within a simple hydrocarbon atmosphere causes more complex hydrocarbons to form (PONNAMPERUMA and WOELLER, 1964). Second, within an ionized aerosol atmosphere, complex polymolecular chains are formed which tend to clump together in small regions (CAWOOD and PATTERSON, 1931). Therefore in a hydrocarbon atmosphere in which an electrical discharge occurs with subsequent ionization, small regions of more complex hydrocarbons at an increased density will form.

Using these basic facts, we can develop a logical extension which may apply to natural ball lightning formation in the atmosphere. Consider a large volume of the atmosphere with a simple hydrocarbon density less than that necessary to support combustion but greater than that of the normal atmosphere. (Such conditions exist, for example, near areas where methane from decomposing organic matter escapes into the atmosphere.) If a thunderstorm develops in the vicinity of the hydrocarbon region, the hydrocarbons may become ionized, and at least one small region of more complex hydrocarbons with an increased density may form. If an electric discharge then occurs near this small region, combustion could be supported if the hydrocarbon density were sufficient. If all these conditions are fulfilled, a small local burning center would form.

The burning center would appear as an illuminated globe, with a red or red-yellow color. A finite lifetime would be expected since burning would continue as long as the hydrocarbon density in the small local region is sufficient to support the combustion process. Two decay modes are obvious: a silent decay if the hydrocarbon density falls below that necessary for combustion, and a noisy decay if the hydrocarbon-air mixture becomes explosive. The illuminated globe would possess motion if influenced by electric fields or air currents, or would appear immobile if uninfluenced. It would also possess motion if the burning center progressively burned from one hydrocarbon concentration to another (if more than one were formed), or appear immobile if it were continually supplied with fuel by the surrounding hydrocarbonated atmosphere.

Dimensional boundaries for the burning center can be derived by assuming the normal spherical flame energy relation (LEWIS and VON ELBE, 1961)

$$E = \frac{d^3(T_b - T_a)cp\pi}{6}$$

where E is the energy, d is the ball diameter, c is the specific heat of hydrocarbon mixture, p is the mixture density, T_a is the initial mixture temperature, and T_b is the final temperature. Assuming our formation mechanism with an initial CH_4 density

less than that necessary for ordinary combustion, a resulting more complex hydrocarbon density just great enough to support combustion within a small volume (for example, C_3H_8 at 3 per cent), an energy of 10^2 to 10^6 J, a specific heat of 0·28 cal./g°C, a density of $0{\cdot}2 \times 10^{-3}$ g/cm^3, and a final temperature of 4000°C, then a ball of fire with diameter between approximately 6 and 130 cm is predicted.

The properties of this hypothetical ball lightning agree quite well with those of the natural phenomenon not only in color, shape, and lifetime, but also in decay modes, motion and size.

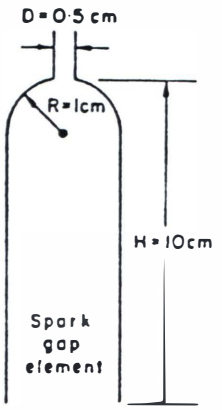
3. The Experiment

Experiments were conducted in an attempt to form laboratory ball lightning in the manner discussed. We enclosed a large volume of the atmosphere at NTP. A specific amount of a hydrocarbon was introduced into the enclosed volume and a single, high voltage d.c. discharge triggered across a spark gap within the enclosure.

The experimental enclosure consisted of a six-sided, transparent plexiglass chamber of interior dimensions 50·2 cm × 50·2 cm × 100·4 cm and a wall thickness of 0·62 cm. The high voltage cables and tubing to introduce the hydrocarbon gas entered the chamber through sealable holes in one side. Propane was used as the initial hydrocarbon gas. After each trial, the enclosure was emptied to reduce the possibility of contamination of the succeeding trial. The gas was introduced by a standard liquid displacement method and completely mixed with the enclosed atmosphere by use of a small brushless fan mounted within the chamber. The spark gap was formed by two copper electrodes placed 25 cm above the base of the chamber and along its center vertical axis. Various electrode dimensions, shapes, and separation distances were tested. It was found that the general configuration illustrated in Fig. 1 with a gap of 0·5 cm, gave the most satisfactory results.

The high voltage discharge was obtained from a capacitor bank rated at 5 mf, 25 kV. The capacitors were charged using a laboratory-built high voltage power supply, rated at 10 kV. The capacitors were oil emersion type and rated for instantaneous discharge. The discharge circuit is shown in Fig. 1. The discharge spark was mechanically triggered and the discharge time was about 1 msec. The discharge energy was about 250 J, neglecting the small impedance dissipations in the discharge circuit.

The process began by introducing 5·0 per cent propane (referenced to the enclosed volume), mixing, and then triggering the discharge. The process was repeated, each time reducing the amount of gas introduced by 0·2 per cent. As expected, normal combustion phenomena were observed at the beginning of the series of trials. As the hydrocarbon volume percentage decreased to less than that necessary for ordinary combustion (about 2·8 per cent), no phenomena were observed. But in the range 1·4 to 1·8 per cent of gas, a small yellow-green ball of fire formed. It was brightly luminous, had a diameter of a few centimeters, exhibited rapid random motion about the chamber, and decayed silently. Most interestingly, the ball of fire (interpreted here as a laboratory ball lightning) had a life-time of about 2 sec, and most importantly, the lifetime of the phenomenon extended long after energy ceased to be injected into it.



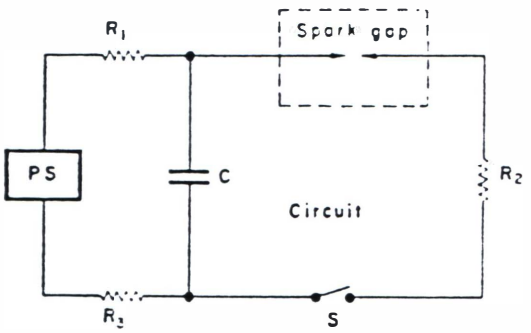


Fig. 1.

4. CONCLUSIONS

It appears that a phenomenon which closely resembles natural ball lightning may be formed in the laboratory. Other phenomena have been produced in the laboratory which also resemble natural ball lightning. These include discharge phenomena such as those formed in focused electromagnetic wave experiments (BABAT, 1947), or those formed with a plasma torch. It is significant to note that these discharge phenomena cannot be easily maintained at atmospheric pressure nor will they continue to exist after the input energy ceases. The most important aspects of our laboratory phenomenon are that it was formed at atmospheric pressure, it exhibited properties of appearance, motion, and lifetime resembling those of the natural ball lightning, it existed for a significant time without an external energy source, and was formed in a manner which could occur naturally.

It is apparent that the ball lightning formation mechanism discussed cannot account for all instances of ball lightning appearance. The naturally occurring volume abundance of CH_4 in the atmosphere is only about 10^{-4} per cent (RATCLIFFE, 1960). If the atmosphere were the only source for a 1 per cent volume concentration of CH_4 in about 10^5 cm^3 (the laboratory volume), it would be necessary for the

clumping process to operate effectively over a spherical volume with a radius of about 100 m. If the natural abundance of CH_4 were greater than 10^{-4} per cent within a smaller region, then the clumping process would not need to be so radially extensive. This implies that the process would be more probable near those atmospheric regions of increased hydrocarbon content, for instance, above a marsh or natural gas seepage area.

It is certainly possible that several phenomena, with similar appearances but different source mechanisms, are all identified as ball lightning. For instance, the terms kugelblitz, boules de feu, ball of fire, and others have been used interchangeably with reference to ball lightning phenomena. The laboratory phenomenon described here may be just one type of ball lightning.

This constitutes the preliminary report on the experimental phase of our study. Work stressing a spectroscopic and three dimensional photographic study of the experimental ball lightning is planned.

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(Transmis par : Marc HALLET)

bol - 0096

Luminous Phenomena accompanying Earthquakes. —There can be little doubt that the destructive Idu (Japan) earthquake of Nov. 26, 1930, was closely associated with the lights seen shortly before, and for at least an hour after, the earthquake. They were observed by Mr. K. Musya, who collected records from about 1500 observers on both sides of the Idu peninsula, in the valley of the Sagami river, and on the shores of Tokyo Bay and the Boso peninsula (*Earthq. Res. Inst. Bull.*, vol. 9, pp. 177-215; 1931). The lights were very strong—in one place brighter than moonlight. They were usually described as bluish in colour, but sometimes as reddish yellow, yellow, or reddish blue. In shape, they resembled the rays of the rising sun, search-lights, and fireballs. The duration of each light was longer than that of lightning, and some careful observers report that the same light continued more than a minute. The directions in which they were seen pointed usually, but not always, to the epicentral region of the earthquake.

[M. Hallet]

bol-0097

Curtis Fuller,
in his column
'I see by the papers'
in FATE vol 35
Feb. 1953

A PROBLEM FOR PHYSICISTS

I WOULD like to pose a problem to scientists — the problem of will-o'-the-wisps. Whenever a mysterious floating light is seen close to the ground which behaves in a certain manner, scientists dismiss it airily with the explanation, "Why, that is nothing more than a will-o'-the-wisp!"

That of course is supposed to explain everything! Gentlemen, what is a will-o'-the-wisp?

I looked it up in my own dictionary, the new Random House American College Dictionary, and it referred me to a subject titled *ignis fatuus.*

I looked up *ignis fatuus,* and find it means "foolish fire." There is also a further explanation: "A flitting phosphorescent light, seen at night, chiefly over marshy ground, and *supposed* to be due to spontaneous combustion of gas from decomposed organic matter."

My Columbia encyclopedia has another explanation: "The light is a mass of phosphorescent gas, and may be blown about by air currents. The weird and mysterious lights have given rise to superstitions."

This all seemed so vague and uncertain that I questioned a physicist of my acquaintance, member of the Chicago Physics Club, who has made a number of remarkable independent discoveries in the physical sciences.

LIKE so many other scientists, he had assumed that the term "will-o'-the-wisp" explained the mysterious lights so often seen at night. But when he thought about it for three minutes, both of the above explanations seemed to be quite ridiculous to him. He scratched his head and said flatly that maybe somebody should do some investigating.

For example, the two above explanations contradict each other. One is that the will-o'-the-wisp is spontaneous combustion. That means a fire. The other is that it is a mass of phosphorescent gas. That means cold light; no fire.

Furthermore, anyone who knows anything about the behavior of gases knows that a small compact mass of gas simply does not stay in a small compact mass when it is blown about. For exam-

ple, the Random House dictionary says flatly that a gas is "a substance possessing perfect molecular mobility and the *property of indefinite expansion.*"

It seems, therefore, that it would be impossible for any closely-knit mass of gas to stay together for any length of time — whether it was spontaneously burning or merely being blown about with its own phosphorescent glow.

I myself have seen fox-fire in the woods (it is not in the dictionary — at least under that name), and have played with it at night. It is simply rotting wood which glows because of the activity of certain bacteria. I have picked it up, I have smelled it, I have handled it, I have even frightened the devil out of a friend by affixing two pieces of it onto the wall of a dark tent about as far apart as a wildcat's eyes. So I know it exists and I know that it is an entirely different thing than a will-o'-the-wisp.

YOU ASK THEM

I WOULD like to ask any physicist you care to name whether he has ever seen a will-o'-the-wisp. Has he ever chased one, caught one, smelled one, touched one?

Is it warm or cold? Is it burning by combustion or is it glowing by phosphorescence?

I think this is an important problem and I am unwilling to see it sloughed aside so easily. It does not satisfy me to see these floating lights "explained" as will-o'-the-wisps. Giving a name to something does not explain it.

RELATED TO SAUCERS?

I SUPPOSE I could go on and on pointing out the parallels between attitudes toward will-o'-the-wisps and other unknown or misunderstood phenomena. I will spare you that — at least for the time being.

But I believe that some of the effort that is going into "saucer" investigations might be directed to investigating will-o'-the-wisps. Maybe the two things will even turn out to be related. Of course a good many scientists still deny that "saucers" exist, though not so many as a few years ago. There aren't any, however, who deny that will-o'-the-wisps exist. They're just "fool's fire" — that's all. Which is as good an explanation as any other I've heard.

BALLS OF FIRE

I GOT onto this subject because of a clipping from the Toronto *Globe & Mail* of September 5 which tells about six OPP officers who spent most of one night chas-

ing a mysterious light along the north shore of Lake Simcoe. What was it? Will-o'-the-wisp, of course.

But to many of the old-timers of the Brechin district it was that and more. Mrs. J. B. Running of Harshaw Avenue, Toronto, explained that 50 years ago or so the mystery light was an accepted phenomenon. "Only they didn't make so much fuss about it then as they do now," said Mrs. Running. "But then, they saw it so often they became used to it."

One of the light's favorite pranks was to appear on the Grand Trunk Railway tracks and stop trains. When the crew climbed down to find out the trouble, the light, which gave a reddish glow much like a lantern, disappeared completely into the swamp.

Mrs. Running recalled a game warden named Henry Thompson who chased the light several times as it went ahead of him down a trail to his cabin beside the lake. He used to laugh about it until one morning he came into the Brechin Hotel white-faced and shaking. Seems he had waked up during the night to hear a loud buzzing outside his cabin window. His dog was running around looking for a place to hide and his cat was climbing the wall. Right outside the window was "a ball of fire — as big as a football."

Will-o'-the-wisp, of course. Whatever that is.

SAUCERS AND IONIZATION

WE HAVE a little more information on the theory that "flying saucers" are really ionized areas in the air. We have already pointed out that Army engineers at Fort Belvoir Laboratory have "manufactured" artificial saucers by means of electric discharges in a partial vacuum which created weird mobile shapes of ionized gas capable of moving at high speed, reflecting radar signals, giving off multi-colored light, and either vanishing or appearing suddenly.

The difficulty with this theory, as we have also pointed out, is that it is purely a laboratory phenomenon and that the conditions that would bring it about could practically never occur in nature. The problem is not the ionization — that takes place constantly in the air — but the maintenance of an area of partial vacuum. That is pretty hard to swallow.

Nevertheless, it is suggested that the saucers are ionized areas in the air which follow electrical and magnetic patterns originating from the high ionization powers of radioactive materials, thunderstorms, radiation from the sun, or even the slow disintegration of natural ores. The latter explanations are offered to explain the sightings of these phenomena before the days of atomic energy plants.

[Janet Bord]

bol - 0098

Planté's 'artificial ball lightning' experiments.

Correspondance.

La foudre en boule.

Walcourt, 6 avril 1884.

Votre numéro du 1er avril 1884 contient, dans un article : « Les orages », d'après l'*English Mechanic*, ce qui suit : « Quant au curieux phénomène connu sous le nom de foudre globulaire on ne peut en dire grand'chose, aucune expérience n'est parvenue à le reproduire artificiellement et en outre aucun observateur exercé n'a été mis à même de l'étudier ».

Permettez-moi de faire observer que, contrairement à cette assertion, M. Gaston Planté s'est occupé des éclairs en boule et qu'il est parvenu à reproduire artificiellement, dans son laboratoire, de petits globes lumineux comparables à la foudre en boule. Il s'est servi d'une batterie de 20 piles secondaires accouplées en tension : si, en faisant plonger l'un des pôles de l'accumulateur dans un vase d'eau, on approche le pôle opposé de la surface du liquide, on voit se former une boule lumineuse animée d'un mouvement giratoire, qui disparaît après une forte étincelle à l'autre pôle.

M. Planté pense qu'un effet analogue doit se produire dans les grands orages, quand l'électricité se trouve en très forte tension et de plus quand l'atmosphère est traversée par une pluie abondante permettant la formation de sphéroïdes de vapeur d'eau électrisée. Le tonnerre en boule serait donc, d'après M. Planté, de la vapeur d'eau et de l'air raréfié formant une petite masse puissamment chargée d'électricité, et rendant brusquement ce travail emmagasiné.

L. BAYET,
ingénieur.

[Ces expériences de M. G. Planté sont en effet rapportées dans les *Recherches sur l'électricité* (Paris, 1879; in-8°) du même physicien, pages 141 à 154 ; l'analogie des effets observés avec les phénomènes de foudre globulaire est exposée dans le chap. 1er de la IVe partie du livre.]

Note de la Rédaction.

Ciel et Terre (Bruxelles)
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ART. V.—*Observations on Ignis Fatuus; by* Rev. JOHN MITCHELL.

THOSE luminous appearances, which are popularly called "Will-o'the-wisp" and "Jack-a-lantern," have been alike the object of vulgar superstition and philosophical curiosity; and notwithstanding all attempts to apprehend and subject them to examination, they are not much more the subjects of knowledge now than they were centuries ago. They are still but an ignis fatuus to the philosopher, and a thing of mystery to the credulous.

I was myself, formerly, familiar with these appearances; they were of frequent occurrence near my father's residence, owing, probably, to the proximity of extensive wet grounds, over which they are usually seen. The house stood upon a ridge, which sloped down on three sides to the beautiful meadows which form the margin of the Connecticut, and of its tributary creeks, and which, owing to their own luxuriance and the deposits of the vernal freshets, are covered with rich and constantly decaying vegetable matter. From the circumstance, also, that we had no neighbors in the direction of these grounds, a light could not be seen over them without attracting our notice. I mention this by way of suggesting, that probably the ignis fatuus, in consequence of its not being always distinguished from the lights of surrounding houses, and therefore exciting no curiosity, is oftener seen than it is supposed to be.

These mysterious luminaries used often to be seen by the fishermen; who plied their nets by night as well as by day. They commonly reported that they saw them a little above the surface of the meadow, dancing up and down, or gliding quietly along in a horizontal line. Sometimes two, or even three, would be seen together, skipping and dancing or sailing away in concert, as if rejoicing in their mutual companionship. I might entertain you with abundance of fabulous accounts of them—the offspring of imaginations tinctured with superstition, and of minds credulous from a natural love of the marvellous. Fables, however, are of little value for the purposes of science: if the following account of some of the phenomena of the ignis fatuus, shall, with the observations of others, contribute towards a true theory of its nature, you will think them worthy of a place in your Journal.

A friend of mine, returning from abroad late in the evening, had to cross a strip of marsh. As he approached the causeway, he noticed a light towards the opposite end, which he supposed to be a lantern in the hand of some person whom he was about to meet. It proved, however, to be a solitary flame, a few inches above the marsh, at the distance of a few feet from the edge of the causeway. He stopped some time to look at it; and was strongly tempted, notwithstanding the miriness of the place, to get nearer to it, for the purpose of closer examination. It was evidently a vapor, [phosphuretted hydrogen?] issuing from the mud, and becoming ignited, or at least luminous, in contact with the air. It exhibited a flickering appearance, like that of a candle expiring in its socket; alternately burning with a large flame and then sinking to a small taper; and occasionally, for a moment, becoming quite extinct. It constantly appeared over the same spot.

With the phenomena exhibited in this instance, I have been accustomed to compare those exhibited in other instances, whether observed by myself or others; and generally, making due allowance for the illusion of the senses and the credulity of the imagination in a dark and misty night, (for it is on such nights that they usually appear,) I have found these phenomena sufficient for the explanation of all the fantastic tricks which are reported of these phantoms.

They are supposed to be endowed with a locomotive power. They appear to recede from the spectator, or to advance towards him. But this may be explained without locomotion—by their variation in respect to quantity of flame. As the light dwindles away, it will seem to move from you, and with a velocity proportioned to the rapidity of its diminution. Again as it grows larger, it will appear to approach you. If it expires, by several flickerings or flashes, it will seem to skip from you, and when it reappears you will easily imagine that it has assumed a new position. This reasoning accounts for their apparent motion, either to or from the spectator; and I never could ascertain that they moved in any other direction, that is, in a line oblique or perpendicular to that in which they first appeared. In one instance, indeed, I thought this was the fact, and what struck me as more singular, the light appeared to move, with great rapidity, directly against a very strong wind. But after looking some time, I reflected that I had not changed the direction of my eye at all, whereas if the apparent motion had been real, I ought to have turned half round. The deception was occasioned by the motion of the wind itself—as a stake standing in a rapid stream will appear to move against the current.

It is a common notion that the ignis fatuus cannot be approached, but will move off as rapidly as you advance. This characteristic is mentioned in the Edinburgh Encyclopœdia. It is doubtless a mistake. Persons attempting to approach them, have been deceived perhaps as to their distance, and finding them farther off than they imagined, have proceeded a little way and given over, under the impression that pursuit was vain. An acquaintance of mine, a plain man, told me he actually stole up close to one, and caught it in his hat, as he thought;—"and what was it?" I asked. "It was'nt nothin."* On looking into his hat for the "shining jelly," it

* In the colloquial double negative of the common people of New England.—*Ed.*

had wholly disappeared. His motions had dissipated the vapor, or perhaps his foot had closed the orifice from which it issued. To this instance another may be added. A young man and woman, walking home from an evening visit, approached a light which they took for a lantern carried by some neighbor, but which on actually passing it, they found to be borne by no visible being; and taking themselves to flight, burst into the nearest house, with such precipitation as to overturn the furniture, and impart no small share of their fright to the family.

The circumstance that these lights usually appear over marshy grounds, explains another popular notion respecting them; namely, that they possess the power of beguiling persons into swamps and fens. To this superstition Parnell alludes in his Fairy Tale, in which he makes Will-o'the-wisp one of his dancing fairies;

> "Then Will who bears the wispy fire,
> To trail the swains among the mire," &c.

In a misty night, they are easily mistaken for the light of a neighboring house, and the deceived traveller, directing his course towards it, meets with fences, ditches, and other obstacles, and by perseverance, lands at length, quite bewildered, in the swamp itself. By this time, he perceives that the false lamp is only a mischievous jack-a-lantern. An adventure of this kind I remember to have occurred in my own neighborhood. A man left his neighbor's house late in the evening, and at daylight had not reached his own, a quarter of a mile distant; at which his family being concerned, a number of persons went out to search for him. We found him near a swamp, with soiled clothes and a thoughtful countenance, reclining by a fence. The account he gave was, that he had been led into the swamp by a jack-a-lantern. His story was no doubt true, and yet had little of the marvellous in it. The night being dark, and the man's senses a little disordered withal, by a glass too much of his neighbor's cherry, on approaching his house, he saw a light, and not suspecting that it was not upon his own mantel, made towards it. A bush or a bog, might have led to the same place, if he had happened to take it for his chimney top.

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From : Marc HALLET

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Freak TV fireball knocks boy over

A FIREBALL threw a teenager backwards yesterday after a lightning bolt hit a transformer and travelled 100 metres to a television.

Scott Addis, 13, was sitting in front of the television when the fireball erupted from the set.

"There was this big wham sound and the TV exploded outwards," Scott, of Whitney St, Avondale, said last night.

"I remember a yellow flash for about a second and then feeling a big thump in my chest. Next thing I was thrown back."

Lightning hit a transformer in Whitney St at 4.30pm sending a fireball into the house through power lines. The impact cut electricity to houses nearby.

Scott's mother Jenny Addis said: "We just heard this huge wham noise."

Shocked

She left the kitchen to find Scott lying several feet back from the set, with his hair standing on end.

Hospital staff later checked his heart with an ECG, but he was fine, Mrs Addis said.

Although his sister Misty, 11, had been sitting next to her brother, she had not been affected at all.

A neighbour alerted fire services when he saw the bolt strike the power transformer.

"It was spectacular," he said. "There was this huge flame when the lightning struck

"You could smell the smoke in the air. The bolt just seemed to jump across the street."

BLASTED . . . Scott Addis with mother Jenny

Picture: Anthony Phelps

'The Sun'. Auckland (NZ) 16.2.1988 [Murray Bott]