Atmospherical phenomena.

ATMOSPHERICAL PHENOMENA

METEORS.

From look to look, contagious through the croud,
The panic runs, and into wondrous shapes
Th' appearance throws: armies in meet array,
Thronged with aerial spears and steeds of fire;
Till the long lines of full-extended war
In bleeding fight commixt, the sanguine flood
Rolls a broad slaughter o'er the plains of heaven.
As thus they scan the visionary scene,
On all sides swells the superstitious din,
Incontinent; and busy frenzy talks
Of blood and battle; cities overturned,
And late at night in swallowing earthquake sunk,
Or hideous wrapt in fierce ascending flame;
Of sallow famine, inundation, storm;
Of pestilence, and every great distress;
Empires subversed, when ruling fate has struck
Th' unalterable hour: ev'n nature's self
Is deemed to totter on the brink of time.
Not so the man of philosophic eye,
And inspect sage; the waving brightness he
Curious surveys, inquisitive to know
The causes, and materials, yet unfixed,
Of this appearance beautiful and new.

THOMSON.

THE nature of these splendid phenomena of the heavens cannot be so well elucidated as by an extract from the travels of M. M. Humboldt and Bonpland to the equinoctial regions of the New Continent. The sublime wonders described by the former of these travellers were witnessed by them at Cumana, a city of South America, and capital of the province of that name.

"The night of the 11th of November, 1799, was cool and extremely beautiful. Toward the morning, from half after two, the most extraordinary luminous meteors were seen towards the east. M. Bonpland, who had risen to enjoy the freshness of the air in the gallery, perceived them first. Thousands of bolides, (fire-balls,) and falling stars, succeeded each other during four hours. Their direction was very regular, from north to south. They filled a space in the sky extending from the true east 30° toward the

north and south. In an amplitude of 60° the meteors were seen to rise above the horizon at east-north-east, and at east to describe arcs more or less extended, falling toward the south, after having followed the direction of the meridian. Some of them attained a height of 40°; and all exceeded 25° or 30°. There was very little wind in the low regions of the atmosphere, and this blew from the east. No trace of clouds was to be seen. M. Bonpland relates, that from the beginning of the phenomenon, there was not a space in the firmament equal in extent to three diameters of the moon, which was not filled at every instant with bolides and falling stars. The first were fewer in number, but as they were seen of different sizes, it was impossible to fix the limit between these two classes of phenomena. All these meteors left luminous traces from five to ten degrees in length, as often happens in the equinoctial regions. The phosphorescence of these traces, or luminous bands, lasted seven or eight seconds. Many of the falling stars had a very distinct nucleus, as large as the disc of Jupiter, from which darted sparks of vivid light. The bolides seemed to burst as by explosion; but the largest, those from 1° to 1° 15′ in diameter, disappeared without scintillation, leaving behind them phosphorescent bands *(trabes)* exceeding in breadth fifteen or twenty minutes, or sixtieth parts of a degree. The light of these meteors was white, and not reddish, which must be attributed, no doubt, to the absence of vapours, and the extreme transparency of the air. For the same reason, under the tropics, the stars of the first magnitude have, at their rising, a light evidently whiter than in Europe.

"Almost all the inhabitants of Cumana were witnesses of this phenomenon, and did not behold these bolides with indifference; the oldest among them remembered, that the great earthquakes of 1766 were preceded by similar phenomena. The fishermen in the suburbs asserted, that the *fire-work* had begun at one o'clock; and that, as they returned from fishing in the Gulf, they had already perceived very small falling stars toward the east. They affirmed at the same time, that igneous meteors were extremely rare on those coasts after two in the morning.

"The phenomenon ceased by degrees after four o'clock, and the bolides and falling stars became less frequent;

but we still distinguished some toward the north-east, by their whitish light, and the rapidity of their movement, a quarter of an hour after sun-rise. This circumstance will appear less extraordinary, when I state that in full day-light, in 1788, the interior of the houses in the town of Popayan was brightly illuminated by an aërolite of immense magnitude. It passed over the town when the sun was shining clearly, about one o'clock. M. Bonpland and myself, during our second residence at Cumana, after having observed on the 26th of September, 1800, the immersion of the first satellite of Jupiter, succeeded in seeing the planet distinctly with the naked eye, eighteen minutes after the disc of the sun had appeared in the horizon. There was a very slight vapour in the east, but Jupiter appeared on an azure sky. These facts prove the extreme purity and transparency of the atmosphere under the torrid zone. The *mass* of diffused light is so much less, as the vapours are more perfectly dissolved. The same cause that weakens the diffusion of the solar light, diminishes the extinction of that which emanates either from a bolis, Jupiter, or the moon, seen on the second day after her conjunction.

"The researches of M. Chladni having singularly fixed the attention of the scientific world upon the bolides and falling stars at my departure from Europe, we did not neglect, during the course of our journey from Caracas to the Rio Negro, to enquire every where, whether the meteors of the 12th of November had been perceived. In a savage country, where the greater number of the inhabitants sleep out in the air, so extraordinary a phenomenon could not fail to be remarked, except when concealed by clouds from the eye of observation. The Capuchin missionary at San Fernando de Apura, a village situate amid the savannahs of the province of Varinas; and the Franciscan monks stationed near the cataracts of the Oroonoko, and at Maroa, on the banks of the Rio Negro; had seen numberless falling stars and bolides illumine the vault of heaven. Maroa is south-west of Cumana, at one hundred and seventy-four leagues distance. All these observers compared the phenomenon to a beautiful fire-work, which had lasted from three till six in the morning. Some of the monks had marked the day upon their ritual; others had noted it by the nearest festivals of the church. Unfor-

tunately, none of them could recollect the direction of the meteors, or their apparent height. From the position of the mountains and thick forests which surround the missions of the cataracts and the little village of Maroa, I presume that the bolides were still visible at 20° above the horizon. On my arrival at the southern extremity of Spanish Guiana, at the little fort of San Carlos, I found a party of Portugueze, who had gone up the Rio Negro from the Mission of St. Joseph of the Marivitains, and who assured me, that in that part of Brazil, the phenomenon had been perceived, at least as far as San Gabriel das Cachoeiras, consequently as far as the equator itself.

" I was powerfully struck at the immense height which these bolides must have attained, to have been visible at the same time at Cumana, and on the frontiers of Brazil, in a line of two hundred and thirty leagues in length. But what was my astonishment, when at my return to Europe, I learnt, that the same phenomenon had been perceived on an extent of the globe of 64° of latitude, and 91° of longitude; at the equator, in South America, at Labrador, and in Germany! I found accidentally during my passage from Philadelphia to Bordeaux, in the memoirs of the Pennsylvanian Society, the corresponding observations of Mr. Ellicott (lat 30° 42′); and, upon my return from Naples to Berlin, I read the account of the Moravian Missionaries among the Eskimoes, in the library of Gottingen. Several philosophers had already discussed at this period the coincidence of the observations in the north with those at Cumana, which M. Bonpland and I had published in 1800.

" The following is a succinct enumeration of facts: 1st, the fiery meteors were seen in the east, and the east-north-east, to 40° of elevation, from 2 h. to 6 h. at Cumana (lat. 10° 27′ 52″, long. 66° 30′); at Porto Cabello (lat. 10° 6′ 52″, long. 67° 5′); and on the frontiers of Brazil, near the equator, in the longitude of 70° west of the meridian of Paris. 2d, In French Guiana (lat. 4° 56′, long. 54° 35′), the northern part of the sky was seen all on fire. Innumerable falling stars traversed the heavens during an hour and a half, and diffused so vivid a light, that those meteors might be compared to the blazing sheaves shot out from a fire-work. 3d, Mr. Ellicott, astronomer to the United States, having

terminated his trigonometric operations for the rectification of the limits on the Ohio, being, on the 12th of November, in the Gulf of Florida, in the latitude of 25°, and longitude 81° 50′, saw, in all parts of the sky, 'as many meteors as stars, moving in all directions: some appeared to fall perpendicularly; and it was expected every minute that they would drop into the vessel.' The same phenomenon was perceived upon the American continent as far as the latitude of 30° 42′. 4th, In Labrador, at Nain (lat. 56° 55′), and Hoffenthal (lat. 58° 4′); in Greenland, at Lichtenau (lat. 61° 5′), and at New Herrenhut (lat. 64° 14′, long. 52° 20′); the Eskimoes were frightened at the enormous quantity of bolides which fell during twilight toward all points of the firmament, some of them being a foot broad. 5th, In Germany, M. Zeissing, vicar of Itterstadt near Weimar (lat. 50° 59′, long. 9° 1′ east), perceived, on the 12th of November, between the hours of six and seven in the morning, when it was half after two at Cumana, some falling stars, which shed a very white light. Soon after, toward the south and south-west, luminous rays appeared from four to six feet long; they were reddish, and resembled the luminous track of a sky-rocket. During the morning twilight, between the hours of seven and eight, the south-west part of the sky was seen, from time to time, strongly illuminated by white lightning, which ran in serpentine lines along the horizon. At night the cold increased, and the barometer rose.

"The distance from Weimar to the Rio Negro, is 1800 sea leagues; and from Rio Negro to Herrenhut in Greenland, 1300 leagues. Admitting that the same fiery meteors were seen at points so distant from each other, we must also admit, that their height was at least 411 leagues. Near Weimar, the appearance like sky-rockets was seen in the south, and south-east; at Cumana, in the east, and in the east-north-east. We may therefore conclude, that numberless aërolites must have fallen into the sea, between Africa and South-America, to the west of the Cape-Verde Islands. But, since the direction of the bolides was not the same at Labrador and at Cumana, why were they not perceived in the latter place towards the north, as at Cayenne? I am inclined to think, that the Chayma Indians of Cumana did not see the same bolides as the Portugueze in Brazil, and the

missionaries in Labrador; but, at the same time, it cannot be doubted, and this fact appears to me very remarkable, that in the New World, between the meridians of 46° and 82°, between the equator and 64° north, at the same hour, an immense number of bolides and falling stars were perceived; and that those meteors had every where the same brilliancy, throughout a space of 921,000 square leagues.

"The scientific men who have lately made such laborious researches on falling stars and their parallaxes, consider them, as meteors belonging to the farthest limits of our atmosphere, between the region of the Aurora Borealis and that of the lightest clouds. Some have been seen, which had not more than 14,000 toises, or about five leagues of elevation. The highest do not appear to exceed thirty leagues. They are often more than a hundred feet in diameter; and their swiftness is such, that they dart, in a few seconds, over a space of two leagues. Some of these have been measured, the direction of which was almost perpendicularly upward, or forming an angle of 50° with the vertical line. This extremely remarkable circumstance has led to the conclusion, that falling stars are not aërolites, which, after having hovered about a long time in space, take fire on entering accidentally into our atmosphere, and fall toward the earth.

"Whatever may be the origin of these luminous meteors, it is difficult to conceive any instantaneous inflammation taking place in a region, where there is less air than in the vacuum of our air-pumps; and where (at 25,000 toises high) the mercury in the barometer would not rise to 0·012 of a line. We have ascertained the uniform mixture of atmospheric air to 0·003 nearly, only to an elevation of 3000 toises: consequently, not beyond the last stratum of fleecy clouds. It might be admitted, that, in the first revolutions of the globe, gaseous substances, which yet remain unknown to us, may have risen toward that region, through which the falling stars pass: but accurate experiments, made upon mixtures of gases which have not the same specific gravity, prove, that we cannot admit a superior stratum of the atmosphere entirely different from the inferior strata. Gaseous substances mix and penetrate each other with the least motion; and a uniformity of their mixture would have taken place in the lapse of ages, unless we suppose in them the effects of a repulsive action unexampled in those

substances which we can subject to our observations. Farther, if we admit the existence of a particular aërial fluid in the inaccessible regions of luminous meteors, falling stars, bolides, and the Aurora Borealis, how can we conceive why the whole stratum of those fluids does not at once take fire, but that the gaseous emanations, like the clouds, occupy only limited spaces? How can we suppose an electrical explosion without some vapours collected together, capable of containing unequal charges of electricity, in air, the mean temperature of which is, perhaps, 25° below the freezing point of the centigrade thermometer, and the rarefaction of which is so considerable, that the compression of the electrical shock could scarcely disengage any heat? These difficulties would, in great part, be removed, if the direction of the motion of falling stars allowed us to consider them as bodies with a solid nucleus, as cosmic phenomena (belonging to space beyond the limits of our atmosphere) and not as telluric phenomena (belonging to our planet only).

"Supposing that the meteors of Cumana were only at the usual height at which falling stars in general move, the same meteors were seen above the horizon in places more than 310 leagues distant from each other. Now, what an extraordinary disposition to incandescence must have reigned on the 12th of November, in the higher regions of the atmosphere, to have furnished, during four hours, myriads of bolides and falling stars, visible at the equator, in Greenland, and in Germany.

"Mr. Benzenberg judiciously observes, that the same cause, which renders the phenomenon more frequent, has also an influence on the largeness of the meteors, and the intensity of their light. In Europe, the nights when there are the greatest number of falling stars, are those in which very bright ones are mixed with very small ones. The periodicalness of the phenomenon augments the interest which it excites. There are months, in which M. Brandes has reckoned in our temperate zone, only sixty or eighty falling stars in one night; and in other months their number has risen to two thousand. Whenever one is observed, which has the diameter of Sirius or of Jupiter, we are sure of seeing so brilliant a meteor succeeded by a great number of smaller meteors. If the falling stars be very frequent during one night, it is very probable that this frequency

will continue during several weeks. It would seem that, in the higher regions of the atmosphere, near that extreme limit where the centrifugal force is balanced by gravity, there exists, at regular periods, a particular disposition for the production of bolides, falling stars, and the Aurora Borealis. Does the periodicalness of this great phenomenon depend upon the state of the atmosphere? or upon something which this atmosphere receives from without, while the earth advances in the ecliptic? Of all this we are still ignorant as men were in the days of Anaxagoras.

"With respect to the falling stars themselves, it appears to me, from my own experience, that they are more frequent in the equinoctial regions than in the temperate zone; more frequent over the continents, and near certain coasts, than in the middle of the ocean. Do the radiation of the surface of the globe, and the electric charge of the lower regions of the atmosphere, which varies according to the nature of the soil, and the positions of the continents and seas, exert their influence as far as those heights, where eternal winter reigns? The total absence even of the smallest clouds, at certain seasons, or above some barren plains destitute of vegetation, seems to prove, that this influence can be felt at least as far as five or six thousand toises high. A phenomenon analogous to that of the 12th of November, was observed thirty years before, on the table-land of the Andes, in a country studded with volcanoes. At the city of Quito, there was seen, in one part of the sky, above the volcano of Gayambo, so great a number of falling stars, that the mountain was thought to be in flames. This singular sight lasted more than an hour. The people assembled in the plain of Exico, where a magnificent view presents itself of the highest summits of the Cordilleras. A procession was already on the point of setting out from the Convent of St. Francis, when it was perceived, that the blaze on the horizon was caused by fiery meteors, which ran along the skies in all directions, at the altitude of twelve or thirteen degrees."

The bolides, or fire-balls, and falling stars, so striking an example of which is given above, are of all sizes, from a small shooting star of the fifth magnitude, to a cone or cylinder of two or three miles in diameter. They differ in consistency as much as in dimensions, and in colour as much as in either. Occasionally, they are a subtile, lumi-

nous, and pellucid vapour ; and sometimes a compact ball, or globe, as though the materials of which they are formed, were more condensed and concentrated. Not unfrequently they have been found to consist of both, and consequently to assume a comet-like appearance, with a nucleus or compact substance in the centre, or towards the centre, and a long, thin, pellucid, or luminous main, or tail, sweeping on each side. They are sometimes of a pale white light; at others, of a deep igneous crimson ; and, occasionally, irridescent and vibratory. The rarer meteors appear frequently to vanish on a sudden, as though abruptly dissolved or extinguished in the atmospheric medium, their flight being accompanied by a hissing sound, and their disappearance by an explosion. The most compact of them, or the nuclei of those which are rarer, have often descended to the surface of the earth, and with a force sufficient to bury them many feet under the soil ; generally exhibiting marks of imperfect fusion and considerable heat. The substance is, in these cases, for the greater part metallic ; but the ore of which they consist is not any where to be found, in the same constituent proportions, in the bowels of the earth. Under this form the projected masses are denominated aërolites, or meteoric stones.

It may not be uninteresting to preface a succinct account of the most surprising of these meteors, by a brief notice of the hypotheses which have been imagined concerning them ; however justly the learned Humboldt may have concluded, in the words of the extract given above, that we are still " as ignorant on this subject as men were in the days of Anaxagoras." Sir J. Pringle contended, with other philosophers, that they are revolving bodies, or a kind of terrestrial planets. Doctor Halley conjectured them to consist of combustible vapours, accumulated and formed into concrete bodies on the outskirts, or extreme regions of the atmosphere, and to be suddenly set on fire by some unknown cause ; an opinion which, with little difference, has been since entertained by Sir W. Hamilton and Doctor King. Doctor Blagdon regarded them altogether as electrical phenomena. M. Izarn believed them to consist of volcanic materials, propelled into the atmosphere in the course of explosions of great violence. M. Chladni supposed them to be formed of substances existing exteriorly to the asmosphere

of the earth, and other planets, which have never incorporated with them, and are found loose in the vast ocean of space, being there combined and inflamed by causes unknown to us. Lastly, the most favourite hypothesis is, that the whole, or, at least, the more compact division of these meteors, are made up of materials thrown from immense volcanoes in the moon. This hypothesis, which was started by M. Olbers, in 1795, has been since very plausibly supported by the celebrated Laplace, but does not apply to the smaller and less substantial meteors, named shooting stars. Hence these philosophers derive the latter phenomena from some other cause, as electricity, or terrestrial exhalations; and observe, in support of the distinction they find it necessary to make, that shooting stars must be of a different nature from fire-balls, since they sometimes appear to ascend as well as to fall. This observation has been especially dwelt on by MM. Chladni and Benzenburg, both of them favourably noticed, as accurate observers, by Humboldt.

On the 21st of March, 1676, two hours after sunset, an extraordinary meteor was seen to pass over Italy. At Bononia, its greatest altitude in the south-south-east was 38°; and at Sienna, 58° towards the north-north-east. In its course, which was from east-north-east to west-south-west, it passed over the Adriatic sea, as if coming from Dalmatia. It crossed all Italy, being nearly vertical to Rimini and Savigniano, on the one side, and to Leghorn on the other: its perpendicular altitude was at least thirty-eight miles. At all the places near its course it was heard to make a hissing noise as it passed, like that of artificial fire-works. In passing over Leghorn, it gave a very loud report, like that of a cannon; immediately after which another sort of sound was heard, like the rattling of a deeply-loaded waggon passing over the stones, which continued for several seconds. The professor of mathematics at Bononia calculated the apparent velocity of this surprising meteor at not less than one hundred and sixty miles in a minute of time, which is above ten times as swift as the diurnal rotation of the earth under the equinoctial, and not many times less than that with which the annual motion of the earth about the sun is performed. It there appeared larger than the moon in one diameter, and above half as large again in the other;

which, with the given distance of the eye, made its real smaller diameter above half a mile, and the larger one in proportion. It is, therefore, not surprising, that so great a body, passing with such an amazing velocity through the air, however rarified it may be in its upper regions, should occasion so loud a hissing noise as to be heard at such a distance. It finally went off to sea towards Corsica.

Two luminous meteors of great magnitude were observed at Leipsic within the space of six years. On the 22d of May, 1680, about three in the morning, the first of these was seen, to the great terror of the spectators, descending in the north, and leaving behind it a long white streak where it had passed. As the same phenomenon was witnessed in the north-north-east at Haarburg, and also at Hamburgh, Lubec, and Stralsund, all of which places are about a hundred and fifty English miles from Leipsic, it was concluded that this meteor was exceedingly high above the earth. The second meteor was still more terrific. On the 9th of July, 1686, at half past one in the morning, a fire-ball with a tail was observed in 8½ degrees of Aquarius, and 4 degrees north, which continued nearly stationary for seven or eight minutes, with a diameter nearly equal to half the moon's diameter. At first, its light was so great that the spectators could see to read by it; after which it gradually disappeared. This phenomenon was observed at the same time in several other places, more especially at Schlaitza, a town distant from Dantzic forty English miles towards the south, its altitude being about 6° above the southern horizon. At Leipsic it was estimated to be distant not more than sixty English miles, and to be about twenty-four miles perpendicular above the horizon, so that it was at least thirty miles high in the air.

A very extraordinary meteor, which the common people called a flaming sword, was first seen at Leeds, in Yorkshire, on the 18th of May, 1710, at a quarter after ten at night. Its direction was from south to north: it was broad at one end, and small at the other; and was described by the spectators as resembling a trumpet, moving with the broad end foremost. The light was so sudden and bright, that they were startled at seeing their own shadows, when neither sun nor moon shone upon them. This meteor was, in its course, seen, not only in Yorkshire and Lancashire,

but also in the counties of Nottingham and Derby, notwithstanding which, each of those who observed it, although so many miles distant from each other, fancied it fell within a few yards of him. In disappearing, it presented bright sparklings at the small end.

A blazing meteor was, on the 19th of March, 1719, seen in every part of England. In the metropolis, about a quarter after eight at night, a sudden powerful light was perceived in the west, far exceeding that of the moon, which then shone very bright. The long stream it gave out appeared to be branched about the middle; and the meteor, in its course, turned pear-fashioned, or tapering upwards. At the lower end it came at length to be larger and spherical, although not so large as the full moon. Its colour was whitish, with an eye of blue of a most vivid dazzling lustre, which seemed in brightness very nearly to resemble, if not to surpass, that of the body of the sun in a clear day. This brightness obliged the spectator to turn his eyes several times from it, as well when it was a stream, as when it was pear-fashioned and a globe. It seemed to move, in about half a minute or less, about the length of twenty degrees, and to disappear about as much above the horizon. Where it had passed, it left behind a track of a cloudy or faint reddish yellow colour, such as red-hot iron or glowing coals have: this continued more than a minute, seemed to sparkle, and kept its place without falling. This track was interrupted, or had a chasm towards its upper end, at about two-thirds of its length. Not any explosion was heard; but the place where the globe of light had been, continued for some time after it was extinct, of the same reddish yellow colour with the stream, and at first sparks seemed to issue from it, such as proceed from red hot iron beat out on an anvil.

It was agreed by all the spectators in the capital, that the splendour of this meteor was little inferior to that of the sun. Within doors the candles did not give out any light; and in the streets, not only all the stars disappeared, but the moon, then nine days old, and high near the meridian, the sky being very clear, was so far effaced as scarcely to be seen: it did not even cast a shade, where the beams of the meteor were intercepted by the houses; so that, for a few seconds of time, there was in every respect a resemblance of perfect day.

The perpendicular height of this surprising meteor was estimated at 64 geometrical miles; and it was computed to have run about 300 of these miles in a minute. It was seen, not only in every part of Great Britain and Ireland, but likewise in Holland, in the hither parts of Germany, in France, and in Spain, nearly at the same instant of time. The accounts from Devonshire, Cornwall, and the neighbouring counties, were unanimous in describing the wonderful noise which followed its explosion. It resembled the report of a large cannon, or rather of a broadside, at some distance, which was soon followed by a rattling noise, as if many small-arms had been promiscuously discharged. This tremendous sound was attended by an uncommon tremour of the air; and every where in those counties, not only the windows and doors of the houses were sensibly shaken, but, according to several of the reports, even the houses themselves, beyond the usual effect of cannon, however near.

On the 11th of December, 1741, at seven minutes past one in the afternoon, a globe of fire, somewhat larger than the horizontal full moon, and as bright as the moon appears at any time while the sun is above the horizon, was seen at Peckham, in Surry, in a south-south-east direction, moving towards the east with a continued equable motion, and leaving behind it a narrow streak of light, whiter than the globe itself, throughout its whole course. Towards the end it appeared less than at the beginning of its motion; and within three or four seconds suddenly vanished. Its apparent velocity was nearly equal to half the medium velocity of the ordinary meteors called falling or shooting stars; and its elevation, throughout the whole of its course, about twenty degrees above the horizon.

On the 18th of August, 1783, an uncommon meteor was seen in several parts of Great Britain, as well as on the continent. Its general appearance was that of a luminous ball, which, rising in the north-north-east, nearly of a globular form, became elliptical, and gradually assumed a tail as it ascended. In a certain part of its course it underwent a remarkable change, which might be compared to bursting, and which, it ought to be observed, has been since frequently noticed in the passage of the aërolites, or meteoric stones, particular mention of which will be made hereafter. After this it no

longer proceeded as an entire mass, but was apparently divided into a great number, or cluster of balls, some larger than the others, and all carrying a tail, or leaving a train behind. Under this form, it continued its course with a nearly equable motion, dropping, or casting off sparks, and yielding a prodigious light, which illumined all objects to a surprising degree; until, having passed the east, and verging considerably to the southward, it gradually distended, and was at length lost to the sight. The time of its appearance was 9h. 16min. P. M. mean time of the meridian of London, and it continued visible about half a minute.

This beautiful meteor having been seen in Shetland, and in the northern parts of Scotland, ascending from the north, and rising like the planet Mars, little doubt was entertained of its course having commenced beyond the farthest extremity of this island, somewhere over the northern ocean. Having proceeded over Essex, and the Straits of Dover, it probably entered the continent not far from Dunkirk, where, as well as at Calais and Ostend, it was thought to be vertical. Still holding on its course to the southward, it was seen at Brussels, at Paris, and at Nuits in Burgundy; insomuch that there was sufficient proof of its having traversed thirteen or fourteen degrees of latitude, describing a track of at least one thousand miles over the surface of the earth;—a length of course far exceeding the extent of what had been then ascertained of any similar phenomenon.

During the passage of this meteor over Brussels, the moon appeared quite red, but soon recovered its natural light. The results of several observations give it an elevation of more than fifty miles above the surface of the earth, in a region where the air is at least thirty thousand times rarer than here below. Notwithstanding this great elevation, the fact of a report having been heard some time after it disappeared, rests on the testimony of too many witnesses to be controverted. It was compared to the falling of some heavy body in a room above stairs, or to the discharge of one or more large cannon at a distance: this report was loudest in Lincolnshire, and the adjacent counties, and also in the eastern parts of Kent.

Supposing the transverse diameter of this meteor to have subtended an angle of 30 minutes when it passed over the zenith, and that it was fifty miles high, it must have been

almost half a mile across. The tail sometimes appeared ten or twelve times longer than the body; but most of this was train, and the real elongation behind seems seldom to have exceeded twice or thrice its transverse diameter; it consequently was between one and two miles in length. Now, if the cubical contents be considered, for it appeared equally round and full in all directions, such an enormous mass must afford just matter of astonishment, when the extreme velocity with which it moved is considered. This velocity, agreeably to the observations of Sir W. Herschel and several other astronomers, could not have been less than 20 miles in a second, exceeding that of sound above ninety times, and approaching toward that of the earth in her annual orbit. At such a rate, it must have passed over the whole island of Great Britain in less than half a minute, and would, in the space of less than seven minutes, have traversed the whole diameter of the earth!

On the 4th of October of the above year, 1783, two meteors were seen in England. The first, at three in the morning, on account of the early hour, was witnessed by but few spectators, who represented it as rising from the north to a small altitude, and then becoming stationary with a vibratory motion, and an illumination like day-light: it vanished in a few moments, leaving a train behind. This sort of tremulous appearance has been noticed in other meteors, as well as their continuing stationary for some time, either before they begin to shoot, or after their course is ended. The second of these meteors appeared at forty-three minutes past six in the evening, and was much smaller, and also of much shorter duration, than the one seen in August. It was first observed to the north, like a stream of fire, similar to that of the common shooting stars, but large; and having proceeded some distance under this form, suddenly burst out into that intensely bright blueish light, peculiar to such meteors, which may be most aptly compared to the blue lights of India, or to some of the largest electrical sparks. The illumination was very great; and on that part of its course where it had been so bright, a dusky red streak or train was left, which remained visible about a minute, and was thought by some gradually to change its form. Except this train, the meteor had not any tail, but was nearly of a round body, or, perhaps, some-

what elliptical. After moving not less than ten degrees in this bright state, it became suddenly extinct, without any appearance of bursting or explosion.

AËROLITES.

THESE phenomena, otherwise entitled meteoric stones, have been ascertained, by recent observations, to be connected with the BOLIDES, or fire-balls, described above. Scoriaceous masses have frequently been either actually seen to fall at the time of the disappearance of the latter, or have been found soon after on the surface of the earth. Most of the stones which have fallen from the atmosphere have been preceded by the appearance of luminous bodies, or meteors. These meteors burst with an explosion, and then the shower of stones falls to the earth. Sometimes the stones continue luminous till they sink into the earth; but most commonly their luminousness disappears at the time of their explosion. These meteors move in a direction nearly horizontal, and seem to approach the earth before they explode.

The stony bodies, when found immediately after their descent, are always hot. They commonly bury themselves some depth under ground. Their size differs, from fragments of a very inconsiderable weight, to masses of several tons. They usually approach the spherical form, and are always covered with a black crust; in many cases they smell strongly of sulphur. The black crust consists chiefly of oxide of iron; and from several accurate analyses of these stones, the following important inferences have been drawn: that not any other bodies have as yet been discovered on our globe which contain the same ingredients; and that they have made us acquainted with a species of pyrites not formerly known, nor any where else to be found.

The ancients were not unacquainted with these meteoric stones, a shower of which is reported by Livy to have fallen at Rome under the Consulate of Tullus Hostilius, and another under that of C. Martius and M. Torquatus. Pliny relates that a shower of iron (for thus he designates these stones) fell in Lucania, a year before the defeat of Crassus: and likewise speaks of a very large stone which fell near

the river Negos, in Thrace. In the chronicle of Count Marcellin, there is an account of three immensely large stones having fallen in Thrace, in the year 452 before the Christian era. To proceed to more modern, and well authenticated instances of the fall of aërolites.

On the 7th of November, 1492, a little before noon, a dreadful thunder-clap was heard at Ensisheim, in Alsace, instantly after which a child saw a huge stone fall on a field newly sown with wheat. On searching, it was found to have penetrated the earth about three feet, and weighed 260lbs. making its size equal to a cube of thirteen inches the side. All the contemporary writers agree in the reality of this phenomenon, observing that, if such a stone had before existed in a ploughed land, it must have been known to the proprietor.

The celebrated astronomer Gassendi relates an instance of an aërolitic descent of which he was himself an eye-witness. On the 27th of November, 1627, the sky being clear, he saw a burning stone fall on Mont Vaisir, in the south-east extremity of France, near Nice. While in the air, it seemed to be about four feet in diameter; was inclosed in a luminous circle of colours like a rainbow; and in its fall produced a sound like the discharge of cannon. It weighed 59lbs. was very hard, of a dull metallic colour, and had a specific gravity considerably greater than that of marble.

In the year 1672, two stones fell near Verona, in Italy, the one weighing 300, the other 200lbs. This phenomenon was witnessed in the evening, by three or four hundred persons. The stones fell, with a violent explosion, in a sloping direction, and in calm weather. They appeared to burn, and ploughed up the ground.

Paul Lucas, the traveller, relates that when he was at Larissa, a town of Greece, near the gulf of Salonica, a stone weighing 72lbs. fell in the vicinity. It was observed to come from the northward, with a loud hissing noise, and seemed to be enveloped in a small cloud, which exploded when the stone fell. It looked like iron dross, and smelt of sulphur.

In September 1753, several stones fell in the province of Bresse, to the west of Geneva: one in particular fell at Pont-de-Vesle, and another at Liponas, places nine miles distant from each other. The sky was clear,

and the weather warm. A loud noise, and a hissing sound, were heard at those two places, and for several miles round, on the fall of these stones, which exactly resembled each other, were of a darkish dull colour, very ponderous, and manifesting on their surface that they had suffered a violent degree of heat. The largest weighed about 20lbs. and penetrated about six inches into the ploughed ground; a circumstance which renders it highly improbable that they could have existed there before the explosion. This phenomenon has been described by the astronomer Delalande, whose strict enquiries on the spot enabled him to testify the truth of the circumstances he relates.

In the year 1768, three stones were presented to the French Academy of Sciences, which had fallen in different parts of France; one at Lucé, in the Maine; another at Aire, in Artois; and the third in Cotentin. They were all externally of the same identical appearance; and on the former of them a particular report was drawn up by Messrs. Fougeraux, Cadet, and Lavoisier. This report states, that on the 18th of September, 1768, between four and five in the afternoon, there was seen, near the above village of Lucé, a cloud in which a short explosion took place, followed by a hissing noise, but without any flame. The same sound was heard by several persons about ten miles from Lucé; and, on looking up, they perceived an opaque body describe a curve in the air, and fall on a piece of green turf near the high road. They immediately ran to the spot, where they found a kind of stone, half buried in the earth, extremely hot, and weighing about 7½lbs.

In the particular instance now to be cited, very distinct traces were left to show the progress of aërolites through the air. During the explosion of a meteor near Bordeaux, on the 20th of August, 1789, a stone in diameter about fifteen inches, fell through the roof of a cottage, and killed a herdsman and some cattle. Part of this stone is now in the Greville Museum, and part in the Museum of Bordeaux.

On the 24th of July, 1790, between nine and ten at night, a shower of stones fell near Agen, in Guienne, near the south-west angle of France. First a luminous ball of fire was seen, traversing the atmosphere with great rapidity, and leaving behind it a train of light which lasted about fifty

seconds; soon after tnis a loud explosion was heard, and sparks were seen to fly off in all directions. This was soon after followed by the fall of stones, over a considerable extent of ground, and at various distances from each other. These were all alike in appearance, but of many different sizes, the greater number weighing about two ounces, but many a vast deal more. Some fell with a hissing noise, and entered the ground; but the smaller ones remained on the surface. The only damage done by this shower of stones was, that they broke the tiles of several houses, in falling on which they had not the sound of hard and compact substances, but of a matter in a soft half-melted state. Such as fell on straws adhered to them, and could not be readily separated;—a manifest proof that they were in a state of fusion.

On the 18th of December, 1795, several persons, near the house of Captain Topham, in Yorkshire, heard a loud noise in the air, followed by a hissing sound, and soon after felt a shock, as if a heavy body had fallen to the ground at a little distance from them. In reality, one of them saw a huge stone fall to the earth, at the distance of eight or nine yards from the place where he stood. When he first observed it, it was seven or eight yards above the ground; and in its fall it threw up the mould on every side, burying itself twenty one inches in the earth. This stone, on being dug up, was found to weigh 56lbs.

On the 17th of March, 1798, a body, burning with an intense light, passed over the vicinity of Ville Franche, on the Saone, near Lyons, accompanied by a hissing sound, and leaving behind a luminous track. This phenomenon exploded with a great noise, about twelve hundred feet from the ground, and one of the splinters, still luminous, having been observed to fall in a neighbouring vineyard, was traced. It was about a foot in diameter, and had penetrated twenty inches into the ground.

On the 4th of July, 1803, a ball of fire struck a public house at East Norton, in Oxfordshire. The chimney was thrown down, the roof partly torn off, the windows shattered to atoms, and the dairy, &c. converted into a heap of rubbish. It was of considerable magnitude, and, on coming in contact with the house, exploded with great noise, and a very oppressive sulphureous smell. Several fragments of

stones were found on the spot, having a surface of a dark colour, and varnished as if in a state of fusion, with numerous globules of a whitish metal, combining sulphur and nickel. The indentures on these surfaces render it probable that the ball was soft when it descended; and it was obviously in a state of fusion, as the grass, &c. were burnt where the fragments fell. The motion of this fire-ball, while in the air, was very rapid, and apparently parallel to the horizon.

The latest remarkable fall of aërolites in Europe, of which there is a distinct account, was in the vicinity of Laigle in Normandy, early in the afternoon of the 26th of April, 1812. A fiery globe of a very brilliant splendour, which moved in the air with great rapidity, was followed in a few seconds by a violent explosion, which lasted five or six minutes, and was heard to the extent of more than thirty leagues in every direction. Three or four reports, like those of a cannon, were followed by a discharge resembling a fire of musketry, after which a dreadful rumbling was heard, like the beating of a drum. The air was calm, and the sky serene, with the exception of a few clouds, such as are frequently observed. The noise proceeded from a small cloud of a rectangular form, the largest side being in a direction from east to west. It appeared motionless all the time the phenomenon lasted; but the vapour of which it was composed was projected momentarily from the different sides by the effect of the successive explosions. This cloud was about half a league to the north-north-east of the town of Laigle, and was at so great an elevation, that the inhabitants of two hamlets, a league distant from each other, saw it at the same time over their heads. In the whole canton over which this cloud hovered, a hissing noise, like that of a stone discharged from a sling, was heard; and a multitude of meteoric stones were seen to fall at the same time.

The district in which they fell forms an elliptical extent of about two leagues and a half in length, and nearly one in breadth; the greatest dimension being in a direction from south-east to north-west, forming a declination of about 22°. This direction, which the meteor must have followed, is exactly that of the magnetic meridian; which is a remarkable result. The number of these stones was reckoned to

exceed three thousand; and the largest of them weighed nearly 20lbs. They were friable some days after their fall, and smelt strongly of sulphur. They subsequently acquired the degree of hardness common to these stones.

While, in Europe, these phenomena thus strongly confirmed the long-exploded idea of the vulgar, that many of the luminous meteors observed in the atmosphere, are masses of ignited matter, an account of one of precisely the same description was received from the East Indies. On the 19th of December, 1798, at eight in the evening, a large fire-ball, or luminous meteor, was seen at Benares, and at several places in its vicinity. It was attended by a loud rumbling noise; and, about the same time, the inhabitants of Krakhut, fourteen miles from Benares, saw the light, heard what resembled a loud thunder-clap, and, immediately after, the noise of heavy bodies falling around them. Next morning the mould in the fields was found to have been turned up in many spots; and unusual stones of various sizes, but of the same substances, were picked out of the moist soil, generally from a depth of six inches. One stone fell through the roof of a hut, and buried itself in the earthen floor.

From these multiplied evidences it is proved that, in various parts of the world, luminous meteors have been seen moving through the air with surprising rapidity, in a direction more or less oblique, accompanied with a noise, commonly like the whizzing of cannon balls, followed by explosion, and the fall of hard, stony, or semi-metallic masses in a heated state. The constant whizzing sound; the fact of stones being found, similar to each other, but unlike all others in the vicinity, at the spots towards which the luminous body, or its fragments had been seen to move; the scattering or ploughing up of the soil at those spots, always in proportion to the size of the stones; the concussion of the neighbouring ground at the same time; and, especially, the impinging of the stones on bodies somewhat above the earth, or lying loose on its surface, are circumstances perfectly well authenticated in these reports; proving that such meteors are usually inflamed hard masses, descending rapidly through the air to the earth.

AURORA BOREALIS, AND AURORA AUSTRALIS.

THESE splendid meteors are generally considered as the result of a combination of the two powers of magnetism and electricity. When the *light*, or *aurora*, appears chiefly in the north part of the heavens, it is called the AURORA BOREALIS, or NORTHERN LIGHTS; and when chiefly in the south part, the AURORA AUSTRALIS, or SOUTHERN LIGHTS. Where the corruscation is more than ordinarily bright and streaming, which, however, seldom occurs in the north, it is denominated LUMEN BOREALE; and where these streams have assumed a decided curvature, like that of the rainbow, they are distinguished by the name of LUMINOUS ARCHES.

The aurora is chiefly visible in the winter season, and in cold weather It is usually of a reddish colour, inclining to yellow, and sends out frequent coruscations of pale light, which seem to rise from the horizon in a pyramidal, undulating form, shooting with great velocity up to the zenith. This meteor never appears near the equator; but of late years has frequently been seen toward the south pole.

The aurora borealis has appeared at some periods more frequently than at others. This phenomenon was so rare in England, or so little regarded, that its appearance was not recorded in our annals between a remarkable one observed on the 14th of November, 1554, and a very brilliant one on the 6th of March, 1716, and the two succeeding nights, but which was much strongest on the first night. Hence it may be inferred, that the state of either the air or earth, or perhaps of both, is not at all times fitted for its production.

The extent of these appearances is surprisingly great. The very brilliant one referred to above was visible from the west of Ireland to the confines of Russia, and the east of Poland, extending over, at the least, thirty degrees of longitude, and, from about the fiftieth degree of latitude, over almost all the northern part of Europe. In every place, it exhibited, at the same time, the same wonderful features. The elevation of these lights is equally surprising: an aurora borealis which appeared on the 16th of

December, 1737, was ascertained, by a mean of thirty computations, to have an average height from the earth of 175 leagues, equal to 464 English miles.

Captain Cook, in his first voyage round the world, observes that these coruscations are frequently visible in southern latitudes. On the 16th of September, 1770, he witnessed an appearance of this kind about ten at night, consisting of a dull, reddish light, and extending about twenty degrees above the horizon. Its extent was very different at different times, but it was never less than eight or ten points of the compass. Rays of light, of a brighter colour, passed through and without it; and these rays vanished and were renewed nearly in the same time as those in the aurora borealis, but had little or no vibration. Its body bore S.S.E. from the ship, and continued, without any diminution of its brightness, till twelve o'clock, when the observers retired. The ship was at this time within the tropic of capricorn.

On the 17th of February, 1773, during his second voyage, Captain Cook speaks of a beautiful phenomenon which was observed in the heavens. "It consisted of "long colours of a clear white light, shooting up from "the horizon to the eastward, almost to the zenith, and "spreading gradually over the whole southern parts of "the sky. These columns even sometimes bent sideways "at their upper extremity; and, although in most respects "similar to the northern lights (the *aurora borealis* of "our hemisphere) yet differed from them in being always "of a whitish colour; whereas ours assume various tints, "especially those of a fiery and purple hue. The stars "were sometimes hidden by, and sometimes faintly to "be seen through the substance of these southern lights, "*aurora australis*. The sky was generally clear when "they appeared, and the air sharp and cold, the mercury "in the thermometer standing at the freezing point; the "ship being then in 58 degrees south." On six different nights of the following month (March) the same phenomenon was observed.

LUMEN BOREALE, OR STREAMING LIGHTS.

On the 8th of October, 1726, uncommon streams of light were exhibited in every part of the heavens, about eight

o'clock in the evening. They were seen throughout England, as well as in the southern parts of Europe. They were mostly pointed, and of different lengths, assuming the appearance of flaming spires or pyramids; some again were truncated, and reached but half way; while others had their points reaching up to the zenith, or near it, where they formed a sort of canopy, or thin cloud, sometimes red, sometimes brownish, sometimes blazing as if on fire, and sometimes emitting streams all around it. This canopy was manifestly formed by the matter carried up by the streaming on all parts of the horizon. It sometimes seemed to ascend with a force, as if impelled by the impetus of some explosive agent below; and this forcible ascent of the streaming matter gave a motion to the canopy, and sometimes a gyration, like that of a whirlwind. This was manifestly caused by the streams striking the outer part of the canopy; but if they struck the canopy in the centre, all was then confusion. The vapours between the spires, or pyramids, were of a blood-red colour, which gave those parts of the atmosphere the appearance of blazing lances, and bloody-coloured pillars. There was also a strange commotion among the streams, as if some large cloud or other body was moving behind and disturbing them. In the northern and southern parts the streams were perpendicular to the horizon; but in the intermediate points they seemed to decline more or less in one way or the other; or rather to incline towards the meridian. Several persons declared that, in the time of the streaming, they heard a hissing, and in some places a crackling noise, like what is reported to be often heard in earthquakes.

At Naples, on the 16th of December, 1737, early in the evening, a light was observed in the north, as if the air was on fire, and flashing. Its intenseness gradually increasing, about seven o'clock it spread to the westward. Its greatest height was about 65 degrees. Its extremities were unequally jagged and scattered, and followed the course of the westerly wind; so that for a few hours it spread considerably wider, yet without ever reaching the zenith. About eight o'clock, a very regular arch, of a parabolic figure, was seen to rise gently, to two degrees of rectangular elevation, and to twenty degrees of horizontal amplitude. At ten the intenseness of the colour

disappeared; and by midnight not any traces of this phenomenon were left. It was seen throughout Italy, as the subsequent accounts will show.

At Padua, on the appearance of this extraordinary meteor, the air was calm, and the barometer remarkably high. At five in the afternoon a blackish zone, with its upper limb of a sky-colour, appeared near the horizon; and above this zone was another, very luminous, resembling the dawn pretty far advanced. The highest zone was of a red fiery colour. A little after six o'clock, the upper parts of these zones emitted an abundance of red streamings, or rays; their vivid colour being occasionally intermixed with whitish and darkish spots. In a few seconds after, there issued from the west, a red and very bright column, which ascended to the third part of the heavens, and which, a little after became curved like a rainbow. At half past eight, almost instantaneously, the bright zone, from eight degrees west to fifty degrees east, became more vivid, and rose higher; and above this appeared a new large one, of a red fiery colour, with several successive streamings tending upward, and exceeding sixty degrees of altitude; the western part having assumed the form of a thin cloud. At midnight these splendid lights disappeared entirely.

At Bononia, this surprising meteor spread to such an extent as to occupy about one hundred and forty degrees of the heavens. Its light was so vivid that houses could be distinguished, at eight in the evening, at a very considerable distance; and these were so reddened, that many persons thought there was a fire in the neighbourhood. At that time the aurora formed itself into a concave arch towards the horizon; and in half an hour, at its eastern limit, a pyramid was displayed, of a more intense colour towards the north, from the centre of which there shot up vertically a streak of light, between a white and a yellow colour. A very dark narrow cloud crossed the whole phenomenon, and went to terminate in the pyramid. At the upper part, a very considerable tract of the heavens was enlightened by a very vivid red light, which was interrupted by several streaks or columns of a bright yellowish light. These streamings shot up vertically, and parallel to each other, the narrow cloud seeming to serve them as a basis. Under the cloud there issued forth two tails of a whitish light,

hanging downward on a basis of a weak red, and seeming to kindle and dart the light downward. A white streak, which passed across these two tails, and extended from one end of the phenomenon to the other, in a position almost parallel to the above-mentioned cloud, gave a splendid effect to the whole. This surprising meteor disappeared a little after nine o'clock; but an abundance of falling stars were afterwards seen in the south.

Similar observations were made at Rome; but in Great Britain, where this phenomenon was likewise seen, different appearances were displayed. At Edinburgh, at six in the evening, the sky appeared to be in flames. An arch of red light reached from the west, over the zenith, to the east, its northern border being tinged with a colour approaching to blue. This aurora did not first form in the north, as usually happens, and after forming an arch there, rise toward the zenith; neither did the light shiver, and spread itself, by sudden jerks, over the hemisphere, as is common; but gradually and gently stole along the face of the heavens, till it had covered the whole hemisphere: this alarmed the vulgar, and was indeed a strange sight. At Rosehill, in Sussex, it appeared as a strong and very steady light, nearly of the colour of red ochre. It did not dart or flash, but kept a steady course against the wind, which blew fresh from the south-west. It began in the north-north-west, in form of a pillar of light, at a quarter past six in the evening: in about ten minutes a fourth part of it divided from the rest, and never joined again. In ten minutes more it described an arch, but did not join at top; and at seven o'clock it formed a bow, disappearing soon after. It was lightest and reddest at the horizon, and gave as much light as a full moon.

LUMINOUS ARCHES.

In the month of March, 1774, a very beautiful luminous arch was seen at Buxton. It was white, inclining to yellow; and its breadth in the crown was apparently equal to that of the rainbow. As it approached the horizon, each leg of the arch became gradually broader. It was stationary and free from any sensible coruscations. Its direction was from north-east to south-west; and its

elevated part, not far from the zenith. This phenomenon lasted about half an hour.

The grandest spectacle of this kind which appears to have been seen in Great Britain, was observed at Leeds, in Yorkshire, on the 12th of April, 1783, between the hours of nine and ten at night. A broad arch of a bright pale yellow, and having an apparent breadth of about fifteen degrees, arose in the heavens, and passed considerably south of the zenith. Such was its varied density, that it appeared to consist of small columns of light, having a sensible motion. After about ten minutes innumerable bright coruscations shot out at right angles from its northern edge, elongating themselves more and more till they had nearly reached the northern horizon. As they descended, their extremities were tipped with an elegant crimson, such as is produced by the electric spark in an exhausted tube. After some time this beautiful northern light ceased to shoot, and, forming a range of bright yellow clouds, which extended horizontally about the fourth of a circle, its greatest portion, which darted from this arch towards the north, as well as the cloud-like and more stationary aurora, became so dense as to hide the stars from view. The moon was eleven days old, and shone brightly during this scene, but did not eclipse the splendour of these coruscations. The wind was in the north, a little inclined to the east.

A similar phenomenon was observed at Leeds on the 26th of the same month. From a mass, or broad column of light in the west, issued three luminous arches, each of which made a different angle with the horizon. They had not been viewed many minutes when they were rendered invisible by a general blaze of aurora borealis, which possessed the space just before occupied by these arches.

IGNES FATUI, OR MOCK-FIRES.

These meteors, denominated by the vulgar *Will-with-a-wisp*, and *Jack-with-a-lanthorn*; and, at sea, or on the coast, *Mariners' lights*, or *St. Helmo's fires*, are now considered as real exhalations from the earth, produced by gas, vapour, or some other attenuated substance, emanating from vegetable, animal, or mineral materials, and combined with the matter of light or heat, or both. Instead

of being dense or solid, they are uniformly rare and subtile; and, instead of originating in the loftiest regions of the atmosphere, or beyond its range, are generated for the greater part in low marshy plains or valleys. To the fearful and superstitious they are a source of as much terror as the nobler and sublimer meteors which have just been contemplated; and it is probable that they have occasionally been the source of real and extensive damage, when in a state of actual combustion; and that they have still more frequently seduced a timid and benighted traveller into dangerous bogs and quagmires.

In ITALY, in the BOLOGNESE TERRITORY, they are so frequent, in the morassy grounds, that they are to be seen every night, some of them affording as much light as a kindled torch, and others not being larger than the flame of a candle, but all of them so luminous as to shed a lustre on the surrounding objects. They are constantly in motion, but this motion is various and uncertain. They sometimes rise, and at other times sink, occasionally disappearing of a sudden, and appearing again in an instant in some other place. They usually hover about six feet from the ground, differing both in figure and size, and spreading out and contracting themselves alternately. Sometimes they break to appearance into two parts, soon after uniting again in one body; and at intervals float like waves, letting fall portions of ignited matter, like sparks from a fire. They are more frequently observed in winter than in summer, and cast the strongest light in rainy and moist weather. They are most friendly to the banks of brooks and rivers, and to morasses; but are likewise seen on elevated grounds, where they are, however, of a comparatively diminutive size.

In the month of March, 1728, a traveller being in a mountainous road, about ten miles south of BONONIA, perceived, as he approached the river RIOVERDE, between eight and nine in the evening, a light shining very brightly on some stones which lay on the banks. It was elevated about two feet above them; its figure describing a parallelopid, more than a foot in length, and about six inches high, its longest side lying parallel to the horizon. Its light was so strong that he could distinguish by it very plainly a part of a neighbouring hedge, and the water in the river. On a near approach, it changed from

a bright red to a yellowish colour; and on drawing still nearer became pale; but when the observer reached the spot, it vanished. On his stepping back, he not only saw it again, but found that the farther he receded, the stronger and more luminous it became. This light was afterwards seen several times, both in Spring and Autumn, precisely at the same spot, and preserving the same shape.

On the 12th of December, 1776, several very remarkable *ignes fatui* were observed on the road to Bromsgrove, five miles from Birmingham, a little before daylight. A great many of these lights were playing in an adjacent field, in different directions; from some of which there suddenly sprang up bright branches of light, something resembling the explosion of a rocket, filled with many brilliant stars, if, in the case of the latter, the discharge be supposed to be upward, or vertical, instead of taking the usual direction. The hedge, and the trees on each side, were strongly illuminated. This appearance continued a few seconds only, when the *ignes fatui* played as before. The spectator was not sufficiently near to observe whether the apparent explosions were attended with any report.

In the month of December, 1693, between the 24th and 30th, a fiery exhalation, without doubt generated in the same way with the meteors described above, set fire to sixteen ricks of hay, and two barns filled with corn and hay, at the village of Hartech, in Pembrokeshire. It had frequently been seen before, proceeding from the sea, and in these instances lasted for a fortnight or three weeks. It not only fired the hay, but poisoned the grass, for the extent of a mile, so as to induce a distemper among the cattle. It was a weak blue flame, easily extinguished, and did not in the least burn any of the men who interposed their endeavours to save the hay, although they ventured, not only close to it, but sometimes into it. All the damage sustained happened constantly in the night.

Belonging to this class of meteors is the DRACO VOLANS, a fiery exhalation, frequent in marshy and cold countries. It is most common in summer: and, although principally seen playing near the banks of rivers, or in boggy places, still it sometimes mounts up to a considerable height in the air, to the no small terror of the amazed beholders. Its

appearance is that of an oblong, sometimes roundish, fiery body, with a long tail. It is entirely harmless, frequently sticking to the hands and clothes of the spectators, without doing them the least injury.

SPECTRE OF THE BROKEN.

THIS is one of those curious and interesting atmospherical phenomena, or deceptions, which proceed from one common cause, an irregularity in the tenuity of the atmospheric fluid. This fluid is commonly of an homogeneous, or equable tenuity, and consequently suffers the rays of the sun to penetrate it without any obstruction or change; but is at times irregular, and composed of parts or bodies of a denser medium than its general texture and constitution. Under these circumstances, the fluent ray, if it do not enter the denser medium in a direct or perpendicular line, will be either reflected, or refracted, or both; and the object surveyed through it, will assume a new, and, not unfrequently, a grotesque or highly magnified appearance.

The SPECTRE OF THE BROKEN is an aërial figure which is sometimes seen among the Hartz mountains in Hanover. This phenomenon has been witnessed by various travellers, and, among them, by M. Haue, from whose relation the following particulars are extracted. "Having ascended "the Broken (mountain) for the thirtieth time, I was at "length so fortunate as to have the pleasure of seeing this "phenomenon. The sun rose about four o'clock, and the "atmosphere being quite serene towards the east, its rays "could pass without any obstruction over the Heinrichshöhe "mountain. In the south-west, however, towards the moun-"tain Achtermannshöhe, a brisk west wind carried before it "thin transparent vapours. About a quarter past four I looked "round, to see whether the atmosphere would permit me "to have a free prospect to the south-west, when I ob-"served, at a very great distance towards the Achtermann-"shöhe, a human figure of a monstrous size! A violent "gust of wind having almost carried away my hat, I "clapped my hand to it; and in moving my arm towards "my head, the colossal figure did the same.

"The pleasure which I felt at this discovery can hardly "be described; for I had already walked many a weary

"step in the hope of seeing this shadowy image, without "being able to gratify my curiosity. I immediately made "another movement, by bending my body, and the co- "lossal figure before me repeated it. I was desirous of "doing the same thing once more, but my colossus had "vanished. I remained in the same position, waiting to "see whether it would return; and in a few minutes it "again made its appearance on the Achtermannshöhe. I "then called the landlord of the neighbouring inn, and "having both taken the position which I had taken alone, "we looked towards the Achtermannshöhe, but did not "perceive any thing. We had not, however, stood long, "when two such colossal figures were formed over the "above eminence, which repeated their compliments by "bending their bodies as we did, after which they vanished. "We retained our position, kept our eyes fixed on the "spot, and in a little time the two figures again stood be- "fore us, and were joined by a third." [that of a traveller who then came up and joined the party.] "Every move- "ment made by us, these figures imitated; but with this "difference, that the phenomenon was sometimes weak "and faint, sometimes strong and well defined."

In Clarke's "Survey of the Lakes," a phenomenon similar to that of the Spectre of the Broken, is recorded to have been observed in the years 1743, and 1744, on Souter Fell, a mountain in Cumberland. It excited much conversation and alarm at the time, and exposed to great ridicule those who asserted they had witnessed it. It is, however, too well attested not to deserve a short notice here, and may be referred to the same causes by which the above aërial images on the Broken mountain were produced. The relation is as follows.

Souter Fell is a mountain about half a mile in height, inclosed on the north and west sides by precipitous rocks, but somewhat more open on the east, and easier of access. At Wilton Hall, within half a mile of this mountain, on a summer's evening, in the year 1743, a farmer and his servant, sitting at the door, saw the figure of a man with a dog, pursuing some horses along Souter Fell side, a place so steep that a horse could scarcely travel on it. They appeared to run at an amazing pace, till they got out of sight at the lower end of the Fell. On the following morning

the farmer and his servant ascended the steep side of the mountain, in full expectation that they should find the man lying dead, being persuaded that the swiftness with which he ran must have killed him; and imagined also that they should pick up some of the shoes which they thought the horses must have lost, in galloping at so furious a rate. They were, however, disappointed, as not the least vestige of either man or horses appeared, not so much as the mark of a horse's hoof on the turf.

On the 23d of June of the following year, 1744, about half past seven in the evening, the same servant, then residing at Blakehills, at an equal distance from the mountain, being in a field in front of the farm-house, saw a troop of horsemen riding on Souter-Fell side, in pretty close ranks, and at a brisk pace. Having observed them for some time, he called out his young master, who, before the spot was pointed out to him, discovered the aërial troopers; and this phenomenon was shortly after witnessed by the whole of the family. The visionary horsemen appeared to come from the lowest part of Souter Fell, and were visible at a place called Knott: they then moved in regular troops along the side of the Fell, till they came opposite to Blakehills, when they went over the mountain. They thus described a kind of curvilinear path, and their first, as well as their last appearance, was bounded by the foot of the mountain. Their pace was that of a regular swift walk; and they were seen for upwards of two hours, when darkness intervened. Several troops were seen in succession, and frequently the last, or last but one in the troop, would quit his position, gallop to the front, and then observe the same pace with the others. The same change was visible to all the spectators; and the sight of this phenomenon was not confined to Blakehills, but was witnessed by the inhabitants of the cottages within a mile. It was attested before a magistrate by the two above-cited individuals in the month of July, 1785. Twenty-six persons are said in the attestation to have witnessed the march of these aërial travellers.

It should be remarked that these appearances were observed on the eve of the rebellion, when troops of horsemen might be privately exercising; and as the imitative powers of the Spectre of the Broken demonstrate that the

actions of human beings are sometimes pictured in the clouds, it seems highly probable, on a consideration of all the circumstances of this latter phenomenon on Souter Fell, that certain thin vapours must have hovered round the summit of the mountain when the appearances were observed. It is also probable that these vapours may have been impressed with the shadowy forms which seemed to "imitate humanity," by a particular operation of the sun's rays, united with some singular, but unknown, refractive combinations then taking place in the atmosphere.

THE MIRAGE.

This very curious phenomenon, which was remarked by M. Monge, one of the French savants belonging to the Institute of Cairo, in the hot and sandy desert between Alexandria and that city, is described by him as resulting from an inverted image of the cerulean sky intermixed with the ground scenery, the neighbouring villages appearing to be surrounded with the most beautiful sheeting of water, and to exist, like islands, in its liquid expanse, tantalizing the eye by an unfaithful representation of what the thirsty traveller earnestly desires.

Doctor Clarke, in his interesting travels, introduces the following animated description of this phenomenon. "Here [at the village of Utko] we procured asses for our party, and, setting out for Rosetta, began to re-cross the desert, appearing like an ocean of sand, but flatter and firmer as to its surface, than before. The Arabs, uttering their harsh guttural language, ran chattering by the side of our asses; until some of them calling out '*Raschid!*' we perceived its domes and turrets, apparently upon the opposite side of an immense lake or sea, that covered all the intervening space between us and the city. Not having in my own mind, at the time, any doubt as to the certainty of its being water, and seeing the tall minarets and buildings of Rosetta, with all its groves of dates and sycamores, as perfectly reflected by it as by a mirror, insomuch that even the minutest detail of the architecture, and of the trees, might have been thence delineated, I applied to the Arabs to be informed in what manner we were to pass the water. Our interpreter although a Greek, and therefore likely to have been

informed of such a phenomenon, was as fully convinced as any of us that we were drawing near to the water's edge, and became indignant, when the Arabs maintained, that within an hour we should reach Rosetta, by crossing the sands in the direct line we then pursued, and that there was no water. 'What,' said he, giving way to his impatience, 'do you suppose me an idiot, to be persuaded contrary to the evidence of my senses?' The Arabs, smiling, soon pacified him, and completely astonished the whole party, by desiring us to look back at the desert we had already passed, where we beheld a precisely similar appearance. It was, in fact, *the mirage*, a prodigy to which every one of us were then strangers, although it afterwards became more familiar. Yet upon no future occasion did we ever behold this extraordinary illusion so marvellously displayed. The view of it afforded us ideas of the horrible despondency to which travellers must sometimes be exposed, who, in traversing the interminable desert, destitute of water, and perishing with thirst, have sometimes this deceitful prospect before their eyes."

This appearance is often seen, when the sun shines, upon the extensive flat sand on the shores of the Bristol channel, in Somersetshire, and probably on the sea-shore in other parts of England; the cause is, we believe, the evaporation of water.

FATA MORGANA.

As when a shepherd of the hebrid isles
Placed far amid the melancholy main,
(Whether it be lone fancy him beguiles,
Or that aërial beings sometimes deign
To stand, embodied, to our senses plain)
Sees on the naked hill, or valley low,
The whilst in ocean Phœbus dips his wain,
A vast assembly moving to and fro;
Then all at once in air dissolves the wondrous show.

THOMSON.

THESE optical appearances of figures in the sea and air, in the Faro of Messina, are the great delight of the populace, who, whenever the vision is displayed, run about the streets shouting for joy, and calling on every

one to partake of the glorious sight. To produce this pleasing deception, many circumstances must concur which are not known to exist in any other situation. The spectator must stand with his back to the east, in some elevated place behind the city, that he may command a view of the whole bay, beyond which the mountains of Messina rise like a wall, and darken the back-ground of the picture. The winds must be hushed, the surface quite smoothed, the tide at its height, and the waters pressed up by currents to a great elevation in the middle of the channel. All these events coinciding, as soon as the sun surmounts the eastern hills behind Reggio, (on the Calabrian coast, opposite) and rises high enough to form an angle of forty-five degrees on the water before the city, every object, existing or moving at Reggio, will be repeated a thousand-fold in this marine looking-glass, which, by its tremulous motion, is, as it were, cut into facets. Each image will pass rapidly off in succession, as the day advances, and the stream carries down the wave on which it appeared. Thus the parts of this moving picture will vanish in the twinkling of an eye. Sometimes the air is at that time so impregnated with vapours, and undisturbed by winds, as to reflect objects in a kind of aërial screen, rising about thirty feet above the level of the sea. In cloudy, heavy weather, they are drawn on the surface of the water, bordered with fine prismatic colours.

Swinburne, in his travels, cites Father Angelucci as having been the first to describe this phenomenon accurately. His relation is as follows. "On the 15th of August, 1643, "as I stood at my window, I was surprised with a most "wonderful and delectable vision. The sea which washes "the Sicilian shore swelled up, and became, for twelve "miles in length, like a chain of dark mountains; while "the waters near our Calabrian coast grew quite smooth, "and in an instant appeared as one polished mirror, "reclining against the aforesaid ridge. On this glass was "depicted, in *chiar-oscura*, a string of several thou-"sands of pilasters, all equal in altitude, distance, and "degree of light and shade. In a moment they lost half "their height, and bent into arcades, like Roman aqueducts. "A long cornice was next formed on the top, and above it "rose castles innumerable, all perfectly alike. These

soon split into towers, which were shortly after lost in "colonnades, then in windows, and at last ended in pines, "cypresses, and other trees, even and similar. This was "the Fata Morgana, which, for twenty-six years, I had "thought a mere fable."

ATMOSPHERICAL REFRACTION.

A SURPRISING instance of atmospherical refraction occurred at Hastings on the 26th of July, 1798. W. Latham, Esq. F. R. S. sitting in his dining room, situated on the parade, close to the sea shore, and nearly fronting the south, about five in the afternoon, had his attention suddenly drawn by a great number of people running down to the sea side. On enquiring the reason, he was informed that the coast of France was plainly to be distinguished with the naked eye. On going down to the shore, he was surprised to find that, even without the assistance of a telescope, he could very plainly see the cliffs on the opposite coast; which, at the nearest part, are between forty and fifty miles distant, and are not to be discerned, from that low situation, by the aid of the best glasses. They appeared to be only a few miles off, and seemed to extend for some leagues along the coast. Pursuing his walk along the shore to the eastward, close to the water's edge, and conversing on the subject with the sailors and fishermen, they could not, at first, be persuaded of the reality of the appearance; but soon became so thoroughly convinced, by the cliffs gradually appearing more elevated, and approaching nearer, as it were, that they pointed out, and named to him the different places they had been accustomed to visit, such as, the Bay, the Old Head or Man, the Windmill, &c. at Boulogne; together with St. Vallery, and other places on the coast of Picardy. This they afterwards confirmed, when they viewed them, thus refracted, through their telescopes, observing that the above places appeared as near as if they had been sailing, at a small distance, into the harbours.

From the eastern cliff, which is of a very considerable height, a most beautiful scene presented itself to Mr. Latham's view, for there he could at once see Dungeness, Dover Cliffs, and the French coast, all along from Calais,

Boulogne, &c. to St. Vallery; and, as some of the fisher men affirmed, as far to the westward even as Dieppe. By the telescope, the French fishing boats were plainly to be seen at anchor, and the different colours of the land on the heights, with the buildings, were perfectly discernible. This curious phenomenon continued in the highest splendour till half past eight o'clock, notwithstanding a black cloud for some time totally obscured the face of the sun, and then vanished gradually. So remarkable an instance of atmospherical refraction had not been before witnessed by the oldest inhabitant of Hastings. It was likewise observed at Winchelsea, and other places along the coast. The day was remarkably hot, without a breath of wind stirring.

PARHELIA, OR MOCK SUNS.

On the 5th of February, 1674, near Marienberg in Prussia, the sky being every where serene, the sun, which was still some degrees above the horizon, was seen to lance out very long and reddish rays, forty or fifty degrees towards the zenith, notwithstanding it shone with great lustre. Beneath this planet, towards the horizon, there hung a somewhat dilute small cloud, at the inferior part of which there appeared a mock sun, of the same apparent size with the true sun, and of a somewhat red colour. Soon after, the true sun descending gradually to the horizon, towards the said cloud, the spurious sun beneath it grew clearer and clearer, insomuch that the reddish colour in this apparent solar disc vanished, and put on the genuine solar light, in proportion as it was approximated by the genuine disc of the sun. The latter, at length, passed into the lower counterfeit sun, and thus remained alone. This phenomenon was considered the more extraordinary, as it was perpendicular under the sun, instead of being at its side, as parhelia usually are; not to mention the colour, so different from that which is usual in mock suns, nor the great length of the tail, cast up by the genuine sun, of a far more vivid and splendid light than parhelia use to exhibit. This appearance was soon followed by an exceedingly intense frost, which lasted till the 25th of March, the whole bay being frozen up from the town of Dantzic to Hela in the Baltic Sea.

On the 28th of August, 1698, about eight o'clock in the morning, there was seen, at Sudbury, in Suffolk, the appearance of three suns, which were then extremely brilliant. Beneath a dark, watery cloud, in the east, and nearly at its centre, the true sun shone with such strong beams, that the spectators could not look at it; and on each side were the reflections. Much of the firmament was elsewhere of an azure colour. The circles were not coloured like the rainbow, but white; and there was also, at the same time, higher in the firmament, and towards the south, at a considerable distance from the other phenomena, the form of a half moon, but apparently of double the size, with the horns turned upward. This appearance was within of a fiery red colour, imitating that of the rainbow. These phenomena faded gradually, after having continued about two hours.

Two mock suns, an arc of a rainbow inverted, and a halo, were seen at Lyndon, in the county of Rutland, on the 22d of October, 1721, at eleven in the morning. There had been an aurora borealis the preceding night, with the wind at west-south-west. The two parhelia, or mock suns, were bright and distinct, and in the usual places, namely, in the two intersections of a strong and large portion of a halo, with an imaginary circle parallel to the horizon, passing through the true sun. Each parhelion had its tail of a white colour, and in direct opposition to the true sun; that towards the east being 20 degrees or 25 degrees long, and that towards the west 10° or 12°, both narrowest at the remote ends. The mock suns were evidently red towards the sun, but pale or whitish at the opposite sides, as was the halo also. Still higher in the heavens, was an arc of a curiously inverted rainbow, about the middle of the distance between the top of the halo and the vertex. This arc was as distinct in its colours as the common rainbow, and of the same breadth. The red colour was on the convex, and the blue on the concave of the arc, which seemed to be about 90° in length, its centre being in or near the vertex. On the top of the halo was a kind of inverted bright arc. This phenomenon was seen on the following day, and, again, on the 26th. On the 11th of the preceding month, September, a very splendid and remarkable aurora borealis, presenting truly unaccountable motions and re-

movals, was witnessed in Rutlandshire, in Northamptonshire, and at Bath.

LUNAR RAINBOW

This very rare phenomenon was witnessed at Glapwell Hall, in Derbyshire, on the 25th of December, 1710, about eight in the evening, with a remarkable and very unusual display of colours. The moon had passed her full about twenty-four hours, and the evening had been rainy; but the clouds were dispersed, and the moon then shone pretty clear. This iris lunaris had all the colours of the solar iris, exceedingly beautiful and distinct, only faint in comparison with those which are seen in the day; as must necessarily have been the case, both from the different beams by which it was occasioned, and the disposition of the medium. What most surprised the observer was the largeness of the arc, which was not so much less than that of the sun, as the different dimensions of their bodies, and their respective distances from the earth, seemed to require; but the entireness and beauty of its colours furnished a charming spectacle.

CONCENTRIC RAINBOWS.

This extraordinary phenomenon, which is seen at sun-rise on the Cordilleras of the Andes, in South America, was first witnessed by Ulloa and his companions in the wild heaths of Pambamarca, and is thus described by him. "At day-break the whole of the mountain was enveloped "in dense clouds, which at sun-rise were dissipated, leaving "behind them vapours of so extreme a tenuity as not to "be distinguishable to the sight. At the side opposite to "that where the sun rose on the mountain, and at the dis-"tance of about sixty yards from the spot where we were "standing, the image of each of us was seen represented, "as if in a mirror, three concentric rainbows, the last, or "most exterior colours of one of which touched the first "of the following one, being centered on the head. "Without the whole of them, and at an inconsiderable "distance, was seen a fourth arc purely white. They "were all perpendicular to the horizon; and in proportion "as any one of us moved from one side to the other, he

" was accompanied by the phenomenon, which preserved " the same order and disposition. What was, however, " most remarkable, was this, that although six or seven " persons were thus standing close together, each of us " saw the phenomenon as it regarded himself, but did not " perceive it in the others. This, adds Bouguer, is a kind " of apotheosis, in which each of the spectators, seeing " his head adorned with a glory formed of three or four " concentric crowns of a very vivid colour, each of them " presenting varieties similar to those of the first rainbow, " tranquilly enjoys the sensible pleasure of reflecting that " the brilliant garland he cannot discover in the others, is " destined for himself alone."

A similar phenomenon is described by Mr. Hagarth, F. R. S. as having been seen by him on the 13th of February, 1780. His relation is as follows. " In ascending, " at Rhealt, the mountain which forms the eastern boun- " dary of the vale of Clwyd (in Denbighshire) I observed " a rare and curious phenomenon. In the road above me, " I was struck with the peculiar appearance of a very " white shining cloud, which lay remarkably close to the " ground. The sun was near setting, but shone extremely " bright: I walked up to the cloud, and my shadow was " projected into it, its superior part being surrounded, at " some distance, by a circle of various colours, whose " centre appeared to be near the situation of the eye, and " whose circumference extended to the shoulders. This " circle was complete, except what the shadow of my " body intercepted. It exhibited the most vivid colours, " the red being outermost, all of them appearing in the " same order and proportion as they are presented to the " view by the rainbow. It resembled very exactly what " in pictures is termed A GLORY, surrounding the heads " of saints: not indeed that it exhibited the luminous ra- " diance which is painted close to the head, but an arch " of concentric colours placed separately and distinctly from " it. As I walked forward, this glory approached or re- " tired, just as the inequality of the ground shortened or " lengthened my shadow. The cloud being sometimes in a " small valley below me, sometimes on the same level, " or on higher ground, the variation of the shadow and " glory became extremely striking and singular. To add

" to the beauty of the scene, there appeared, at a con-
" siderable distance, to the right and left, the arches of a
" white shining bow. These arches were in the form of,
" and broader than a rainbow; but were not completely
" joined into a semicircle above, on account of the shallow-
" ness of the cloud."

THUNDER AND LIGHTNING.

The thunder of his power who can understand?

JOB.

Loud thunder, livid flames, and Stygian night,
Compounded horrors, all the deep affright.

BLACKMORE.

To conceive justly of the nature of thunder and lightning, we have only to view the effects of a common electrical machine, and its apparatus, in an apartment. These experiments mimic the great, wonderful, and terrific phenomena of nature. The stream, or spark, from the machine to the hand, represents the shaft of lightning from the clouds to the earth; and the snapping noise of the diminutive spark corresponds with the explosion produced by the shaft of lightning which we call thunder. In what manner the clouds become electrified, and, in short, what is the nature of electricity itself, our present range of experiments so little qualify us to determine, that a century will perhaps elapse before a philosophical precision can be attained. At present we only know for certain that the electrical power displays itself merely on the surfaces of bodies; and whether it is a fluid *per se*, a vacuum restoring itself, or whatever its nature may be, the state of experimental knowledge does not enable us to determine.

The obvious analogy between lightning and electricity had long been suspected, and was placed beyond a doubt by Doctor Franklin, who was the first to conceive the practicability of drawing down lightning from the clouds. Having found, by previous experiments, that the electric fluid is attracted by points, he apprehended that lightning might likewise possess the same quality; although the effects of the latter would in that case surpass those of the former in an astonishing degree. Flashes of lightning, he likewise observed, are generally seen crooked and waving in the air; and the electric spark drawn from an irregular body at some distance, when it is drawn by an irregular

body, or through a space in which the best conductors are disposed in an irregular manner, always exhibits the same appearance.

Lightning strikes the highest and most pointed objects in its way, in preference to others, as high hills, trees, spires, masts, &c.; and all pointed conductors receive and throw off the electric fluid more readily than those which are terminated by flat surfaces. Lightning is observed to take the best and readiest conductor; and this is also the case with electricity, in the discharge of the Leyden phial; whence Doctor Franklin inferred that, in a thunder-storm, it would be safer for a person to have his clothes wet than dry. Lightning burns, dissolves metals, rends some particular bodies, such as the roots and branches of trees, strikes persons with blindness, destroys animal life, deprives magnets of their virtue, and reverses their poles; and these are the well known properties of electricity.

Lightning not only gives polarity to the magnetic needle, but to all bodies which have any portion of iron in them, as brick, &c.; and, by observing which way the poles of these bodies lie, the direction in which the stroke has passed may be known with the utmost certainty.

In order to demonstrate, by actual experiment, the identity of the electric fluid with the matter of lightning, Doctor Franklin contrived to bring lightning from the heavens by means of an electrical kite, which he raised on the approach of a thunder storm; and, with the electricity thus obtained, charged phials, kindled spirits, and performed all other electrical experiments, as they are usually exhibited by an excited globe or tube. This happened in 1752, a month after the French electricians, pursuing the method which he had proposed, had verified the same theory; but without any knowledge on his part of what they had done. On the following year, he further discovered that the air is sometimes electrified positively, and sometimes negatively; and that, in the course of one thunder-storm, the clouds change from positive to negative electricity several times. He was not long in perceiving that this important discovery was capable of being applied to practical use; and proposed a method, which he soon accomplished, of securing buildings from being damaged by lightning, by means of conductors, the use of which is now universally known.

From a number of judicious experiments made by him, Signor Beccaria concludes that the clouds serve as conductors to convey the electric fluid from those parts of the earth which are overloaded with it, to those where it is exhausted. The same cause by which a cloud is first raised, from vapours dispersed in the atmosphere, draws to it those which are already formed, and still continues to form new ones, till the whole collected mass extends so far as to reach a part of the earth where there is a deficiency of the electric fluid, and where the electric matter will discharge itself on the earth. A channel of communication being thus produced, a fresh supply of electric matter is raised from the overloaded part, which continues to be conveyed by the medium of the clouds, till the equilibrium of the fluid is restored between the two places of the earth. He further observes that as the wind constantly blows from the place where the thunder cloud proceeds, the sudden accumulation of such a prodigious quantity of vapours must displace the air, and repel it on all sides. Indeed, many observations of the descent of lightning confirm his theory of the mode of its ascent; for it often throws before it the parts of conducting bodies, and distributes them along the resisting medium through which it must force its passage; and on this principle the longest flashes of lightning seem to be produced, by its forcing in its way part of the vapours in the air. One of the chief reasons why the report of these flashes is so much protracted, is the vast length of the vacuum made by the passage of the electric matter; for although the air collapses the moment after it has passed, and the vibration, on which the sound depends, commences at the same moment, still, when the flash is directed towards the person who hears the report, the vibrations excited at the nearer end of the track will reach his ear much sooner than those from the remote end, and the sound will, without any echo or repercussion, continue till all the vibrations have successively reached him. The rattling noise of the thunder, which makes it seem as if it passed through arches, or were variously broken, is probably owing to the sound being excited among clouds hanging over one another, and the agitated air passing irregularly between them.

Among other precautions pointed out by Doctor Franklin, he recommends to those who happen to be in the fields, at

the time of a thunder storm, to place themselves within a few yards of a tree, but not quite near it. Signor Beccaria, however, cautions persons not to depend on a higher, or, in all cases, a better conductor than their own body; since, according to his repeated observations, the lightning by no means descends in one undivided track, but bodies of various kinds conduct their share of it at the same time, in proportion to their quantity and conducting power. The late Earl Stanhope, in his principles of Electricity, observes that damage may be done by lightning, not only by the main stroke and lateral explosion, but likewise by what he calls THE RETURNING STROKE; that is, by the sudden violent return of that part of the natural share of electricity of any conducting body, or any combination of conducting bodies, which had been gradually expelled from such body or bodies respectively, by the superinduced elastic electrical pressure of a thunder-cloud's electrical atmospheres.

Among the awful phenomena of nature, none have excited more terror than thunder and lightning. It is recorded of several of the profligate Roman emperors, who had procured themselves to be deified, that when they heard the thunder, they tremblingly concealed themselves, acknowledging a divine power greater than their own—*a Jupiter thundering in the heavens!*

REMARKABLE THUNDER STORMS.

A FEW instances in which the effects of these storms have been particularly characterised, will be both interesting and instructive.

That fermented liquors are apt to be soured and spoiled by thunder, is a fact well known; but that dried substances should be so acted on, is a still more remarkable phenomenon, and not so easy of explanation. It happened, however, some years ago, that in the immense granaries of DANTZIC, the repositories of the corn, of Polish growth, intended for exportation, the wheat and rye, which were before dry and sweet, were, by the effect of a violent thunder-storm in the night, rendered clammy and stinking, insomuch that it required several weeks to sweeten them and render them fit for shipping.

The effects of a thunder-storm on a house and its furniture, at NEW FORGE, Ireland, on the 9th of August

1707, were very singular. It was observed that the day was throughout close, hot, and sultry, with scarcely any wind, until towards the evening, when a breeze came on with mizzling rain, which lasted about an hour. As the air darkened after sun-set, several faint flashes of lightning were seen, and thunder claps heard, as at a distance; but between ten and eleven o'clock they became, in their approach, very violent and terrible, progressively increasing in their intensity, and coming on with more frequency, until towards midnight. A flash of lightning, and clap of thunder, louder and more dreadful than all the rest, came simultaneously, and shook and inflamed the whole house. The mistress being sensible at that instant of a strong sulphureous smell in her chamber, and feeling a thick gross dust fall on her hands and face as she lay in bed, concluded that part of her house to have been thrown down by the thunder, or set on fire by the lightning. The family being called up, and candles lighted, both the bed chamber, and the kitchen beneath it, were found to be filled with smoke and dust. A looking-glass in the chamber had been broken with such violence, that not a piece of it was to be found of the size of half a crown: several of the pieces were stuck in the chamber door, which was of oak, as well as on the other side of the room. The edges and corners of some of the pieces of broken glass were tinged of a light flame colour, as if they had been heated by the fire.

On the following morning it was found that the cornice of the chimney next the bed-chamber had been struck off, and a breach twenty inches in breadth, made in the wall. At this part there was seen on the wall a smutted scar or trace, as if left by the smoke of a candle, which pointed downward to another part of the wall, where a similar breach was made. Within the chamber, the boards on the back of a large hair trunk, filled with linen, were forced in: two thirds of the linen were pierced or cut through, the cut appearing of a quadrangular figure. Several pieces of muslin and wearing apparel, which lay on the trunk, were dispersed about the room, not in any way singed or scorched, notwithstanding the hair on the back of the trunk, where the breach was made, was singed. In the kitchen, a cat was found dead, with its legs extended as in a moving pos-

ture, without any other sign of being hurt, except that the fur was singed a little about the rump.

In the parish of SAMFORD-COURTNEY, near Oakhampton, in Devon, on the 7th of October, 1811, about three in the afternoon, a sudden darkness came on. Several persons being in the church-porch, a great fire ball fell among them, and threw them down in various directions, but without any one being hurt. The ringers in the belfry declared that they never knew the bells go so heavy, and were obliged to desist ringing. Looking down from the belfry into the church, they perceived four fire balls, which suddenly burst, and the church was filled with fire and smoke. One of the congregation received a blow in the neck, which caused him to bleed both at nose and mouth. He observed the fire and smoke to ascend to the tower, where a large beam, on which one of the bells was hung, was broken, and the gudgeon breaking, the bell fell to the floor. One of the pinnacles of the tower, next the town, was carried away, and several of the stones were found near a barn door, at a considerable distance from the church.

On the 15th of December, 1754, a vast body of lightning fell on the great hulk at Plymouth. It burst out a mile or two to the westward of the hulk, and rushed towards it with incredible velocity. A portion of the derrick (a part of the apparatus which serves to hoist in and fix the masts of the men of war) was cut out, of a diameter of at least eighteen inches, and about fifteen feet in length: this particular piece was in three or four places girt with iron hoops, about two inches broad, and half an inch thick, which were completely cut in two by the lightning, as if done by the nicest hand and instrument. The lightning was immediately succeeded by a dreadful peal of thunder, and that by a most violent shower of hail, the hail-stones being as large as nutmegs, and for the greater part of the same size and shape.

Among the many fatal accidents by lightning which have befallen ships, the following is a remarkable instance. In the year 1746, a Dutch ship lay in the road of Batavia, and was preparing to depart for Bengal. The afternoon was calm, and towards evening the sails were loosed, to take advantage of the wind which then constantly blows from the land. A black cloud gathered over the hills, and was

brought by the wind towards the ship, which it had no sooner reached, than a clap of thunder burst from it, and the lightning set fire to the main-top-sail: this being very dry, burned with great fury; and thus the rigging and mast were set on fire. An attempt was immediately made to cut away the mast, but this was prevented by the falling of the burnt rigging from the head of the mast. By degrees the fire communicated to the other masts, and obliged the crew to desert the ship, the hull of which afterwards took fire, and, burning down to the powder magazine, the upper part was blown into the air, and the lower part sunk at the place where the ship was at anchor.

In crossing the Atlantic, in the month of November, 1749, the crew of an English ship observed a large ball of blue fire rolling on the water. It came down on them so fast, that before they could raise the main tack, they observed the ball to rise almost perpendicularly, and within a few yards of the main chains: it went off with an explosion as if hundreds of cannon had been fired off simultaneously, and left behind it a great smell of brimstone. The main-top-mast was shattered into a thousand pieces, and spikes driven out of the main-mast which stuck in the main-deck. Five seamen were knocked down, and one of them greatly burnt, by the explosion. The fire ball was of the apparent size of a large millstone, and came from the north-east

The ingenious and indefatigable Professor Richman lost his life on the 6th of August, 1753, as he was observing, with M. Sokolow, engraver to the Royal Academy of St. Petersburgh, the effects of electricity on his gnomon, during a thunder-storm. It was ascertained that the lightning was more particularly directed into the professor's apartment, by the means of his electrical apparatus, for M. Sokolow distinctly saw a globe of blue fire, as large as his clenched hand, jump from the rod of the right gnomon, towards the forehead of Professor Richman, who at that instant was about a foot distant from the rod, observing the electrical index. The globe of fire which struck the Professor, was attended with a report as loud as that of a pistol. The nearest metal wire was broken in pieces, and its fragments thrown on M. Sokolow's clothes, on which burnt marks of their dimensions were left. Half of the glass vessel was broken off, and the metallic filings it con-

tained thrown about the room. Hence it is plain that the force of the lightning was collected on the right rod, which touched the filings of metal in the glass vessel. On examining the effects of the lightning in the Professor's chamber, the door-case was found split half through, and the door torn off, and thrown into the chamber. The lightning therefore seems to have continued its course along the chain conducted under the ceiling of the apartment.

In a Latin treatise, published by M. Lomonosow, member of the Royal Academy of Sciences of St. Petersburgh, several curious particulars are mentioned relative to this melancholy catastrophe. At the time of his death, Professor Richman had in his left coat-pocket seventy silver coins, called rubles, which were not in the least altered by the accident which befel him. His clock, which stood in the corner of the next room, between an open window and the door, was stopped; and the ashes from the hearth thrown about the apartment. Many persons without doors declared that they actually saw the lightning shoot from the cloud to the Professor's apparatus at the top of his house. The author, in speaking of the phenomena of electricity, observes that he once saw, during a storm of thunder and lightning, brushes of electrical fire, with a hissing noise, communicate between the iron rod of his apparatus and the side of his window, and that these were three feet in length, and a foot in breadth.

HAIL STORMS.

On the 17th of July, 1666, a violent storm of hail fell on the coasts of Norfolk and Suffolk. At North Yarmouth the hail-stones were comparatively small; but at Snapebridge one was taken up which measured a foot in circumference; at Seckford Hall, one which measured nine inches; and at Melton, one measuring eight inches. At Friston Hall, one of these hail-stones being put into a balance, weighed two ounces and a half. At Aldborough, it was affirmed that several of them were as large as turkies' eggs. A carter had his head broken by them through a stiff felt hat: in some places it bled, and in others tumours arose: the horses were so pelted that they hurried away

his cart beyond all command. The hail-stones were white, smooth without, and shining within.

On the 25th of May, 1686, the city of Lille, in Flanders, was visited by a tremendous hail storm. The hail-stones weighed from a quarter of a pound to a pound weight, and even more. One among the rest was observed to contain in the centre a dark brown matter, and being thrown into the fire, gave a very loud report. Others were transparent, and melted instantly before the fire. This storm passed over the city and citadel, leaving not a whole glass in the windows on the windward side. The trees were broken, and some beaten down, and partridges and hares killed in abundance.

In 1697, a horrid black cloud, attended with frequent lightnings and thunder, coming with a south-west wind out of Carnarvonshire, and passing near Snowdon, was the precursor of a most tremendous hail storm. In the part of Denbighshire bordering on the sea, all the windows on the weather side were broken by the hail-stones discharged from this cloud, and the poultry and lambs, together with a large mastiff, killed. In the north part of Flintshire several persons had their heads broken, and were grievously bruized in their limbs. The main body of this hail-storm fell on Lancashire, in a right line from Ormskirk to Blackburn, on the borders of Yorkshire. The breadth of the cloud was about two miles, within which compass it did incredible damage, killing all descriptions of fowl and small creatures, and scarcely leaving a whole pane of glass in any of the windows where it passed. What was still worse, it ploughed up the earth, and cut off the blade of the green corn, so as utterly to destroy it, the hail-stones burying themselves in the ground. These hail-stones, some of which weighed five ounces, were of different forms, some round, others semi-spherical; some smooth, others embossed and crenulated, like the foot of a drinking glass, the ice being very transparent and hard; but a snowy kernel was in the midst of most of them, if not of all. The force of their fall showed that they descended from a great height. What was thought to be most extraordinary in this phenomenon was, that the vapour which disposed the aqueous parts thus to congeal, should have continued undispersed for so long a tract as upwards of sixty miles, and should,

during this extensive passage, have occasioned so extraordinary a coagulation and congelation of the watery clouds, as to increase the hail-stones to so vast a bulk in so short a space as that of their fall.

On the 4th of May, 1767, at Hitchin, in Hertfordshire, after a violent thunder-storm, a black cloud suddenly arose in the south-west, about two o'clock in the afternoon, the wind then blowing strongly in the east, and was almost instantly followed by a shower of hail, several of the hail-stones which fell measuring from seven or eight to thirteen or fourteen inches in diameter. The extremity of the storm fell near Offley, where a young man was killed, and one of his eyes beaten out of his head, his body being in every part covered with bruizes. Another person, nearer to Offley, escaped with his life, but was much bruised. At a nobleman's seat in the vicinity, seven thousand squares of glass were broken, and great damage was done to all the neighbouring houses. The large hail-stones fell in such immense quantities, that they tore up the ground, and split many large oaks and other trees, cutting down extensive fields of rye, and destroying several hundred acres of wheat, barley, &c. Their figures were various, some being oval, others round, others pointed, and others again flat.

HURRICANES.

The ruin and desolation accompanying a hurricane can scarcely be described. Like fire, its resistless force rapidly consumes every thing in its track. It is generally preceded by an awful stillness of the elements, and a closeness and mistiness in the atmosphere, which make the sun appear red, and the stars of more than an ordinary magnitude. But a dreadful reverse succeeding, the sky is suddenly overcast and wild; the sea rises at once from a profound calm into mountains; the wind rages and roars like the noise of cannon; the rain descends in a deluge; a dismal obscurity envelopes the earth with darkness; and the superior regions appear rent with lightning and thunder. The earth, on these occasions, often does, and always seems to tremble, while terror and consternation distract all nature: birds are carried from the woods into the ocean; and those whose element is the sea, fly for refuge on land. The affrighted

animals in the fields assemble together, and are almost suffocated by the impetuosity of the wind, in searching for shelter, which, when found, serves them only for destruction. The roofs of houses are carried to vast distances from their walls, which are beaten to the ground, burying their inmates beneath them. Large trees are torn up by the roots, and huge branches shivered off, and driven through the air in every direction, with immense velocity. Every tree and shrub that withstands the shock, is stripped of its boughs and foliage. Plants and grass are laid flat to the earth. Luxuriant spring is in a moment changed to dreary winter This direful tragedy ended, when it happens in a town, the devastation is surveyed with accumulated horror: the harbour is covered with wrecks of boats and vessels; and the shore has not a vestige of its former state remaining. Mounds of rubbish and rafters in one place; heaps of earth and trunks of trees in another; deep gullies from torrents of water; and the dead and dying bodies of men, women, and children, half buried, and scattered about, where streets but a few hours before were, present to the miserable survivors a shocking conclusion of a spectacle to be followed by famine, and, when accompanied by an earthquake, by mortal diseases.

Such is the true and terrific picture of a hurricane in the West Indies, as drawn by Doctor Mosely, in his treatise on tropical diseases!

On the Indian coast hurricanes are both frequent and disastrous. On the 2d of October, 1746, the French squadron, commanded by Le Bourdonnai, being at anchor in Madras roads, a hurricane came on which in a few hours destroyed nearly the whole of the fleet, together with twenty other ships belonging to different nations. One of the French ships foundered in an instant, and only six of the crew were saved. On the 30th of December, 1760, during the siege of Pondicherry, a tremendous hurricane drove on shore, and wrecked, three British ships belonging to the besieging squadron: the crews were saved. On the 20th of October of the following year, 1761, the British fleet, then lying in Madras roads, had to encounter a violent hurricane. The men of war put to sea, and were thus providentially saved; but all the vessels which still lay at anchor were lost, and scarcely a soul on board saved. On the 29th of October,

1768, another hurricane was, on the coast of Coromandel, fatal to the Chatham Indiaman, which neglected to put to sea.

In the West Indies, the late tremendous hurricane of the 21st of October, 1817, was particularly severe at the Island of St. Lucie. All the vessels in the port were entirely lost. The Government-house was blown down, and all within its walls, comprising the Governor, his lady and child, his staff, secretaries, servants, &c. amounting to about thirty persons, buried in its ruins: not one survived the dreadful accident; and, still more horrid to relate, the barracks of the officers and soldiers were demolished, and all within them (about two hundred persons) lost. All the estates on the island were reduced to a heap of ashes. At Dominica, nearly the whole of the town was inundated, with an immense destruction of property.

In Great Britain, a dreadful hurricane, commonly called the great storm, set in at ten at night, on the 26th of November, 1703, and raged violently until seven the next morning. It extended its ravages to every part of the kingdom. In the capital, upwards of two thousand stacks of chimnies were blown down. The lead on the tops of several churches was rolled up like skins of parchment. Many houses were levelled with the ground, and, by the fall of the ruins, 21 persons were killed, and more than 200 wounded. The ships in the Thames broke from their moorings: four hundred wherries were lost, and many barges sunk, with a great loss of lives. At sea the destruction was still greater: twelve ships of war, with upwards of eighteen hundred men on board, were totally lost, together with many merchantmen.

THE MONSOONS.

The setting in of the Monsoon, or tropical sea wind, in the East Indies, is thus described by Forbes in his Oriental Memoirs. The scene was at Baroche, where the British army was encamped. "The shades of evening approached as we reached the ground, and just as the encampment was completed, the atmosphere grew suddenly dark, the heat became oppressive, and an usual stillness presaged the immediate setting in of the monsoon. The whole appearance of nature resembled those solemn preludes to earthquakes and hurricanes in the West Indies, from which the

east in general is providentially free. We are allowed very little time for conjecture; in a few minutes the heavy clouds burst over us.

"I had witnessed seventeen monsoons in India, but this exceeded them all in its awful appearance and dreadful effects. Encamped in a low situation, on the borders of a lake formed to collect the surrounding water, we found ourselves in a few hours in a liquid plain. The tent-pins giving way, in a loose soil, the tents fell down, and left the whole army exposed to the contending elements. It requires a lively imagination to conceive the situation of an hundred thousand human beings of every description, with more than two hundred thousand elephants, camels, horses, and oxen, suddenly overwhelmed by this dreadful storm, in a strange country, without any knowledge of high or low ground; the whole being covered by an immense lake, and surrounded by thick darkness, which prevented our distinguishing a single object, except such as the vivid glare of lightning displayed in horrible forms. No language can describe the wreck of a large encampment thus instantaneously destroyed, and covered with water; amid the cries of old men and helpless women, terrified by the piercing shrieks of their expiring children, unable to afford them relief. During this dreadful night more than two hundred persons and three thousand cattle perished, and the morning dawn exhibited a shocking spectacle."

The south-west monsoon generally sets in very early in certain parts of India. "At Anjengo," observes the above author, "it commences with great severity, and presents an awful spectacle; the inclement weather continues, with more or less violence, from May to October: during that period, the tempestuous ocean rolls from a black horizon, literally of 'darkness visible,' a series of floating mountains heaving under hoary summits, until they approach the shore, when their stupendous accumulations flow in successive surges, and break upon the beach; every ninth wave is observed to be generally more tremendous than the rest, and threatens to overwhelm the settlement. The noise of these billows equals that of the loudest cannon, and, with the thunder and lightning, so frequent in the rainy season, is truly awful. During the tedious monsoon I passed at Anjengo, I often stood upon the trembling sand-bank,

to contemplate the solemn scene, and derive a comfort from that sublime and omnipotent decree, 'Hitherto shalt thou come, but no further; and here shall thy proud waves be stayed!'"

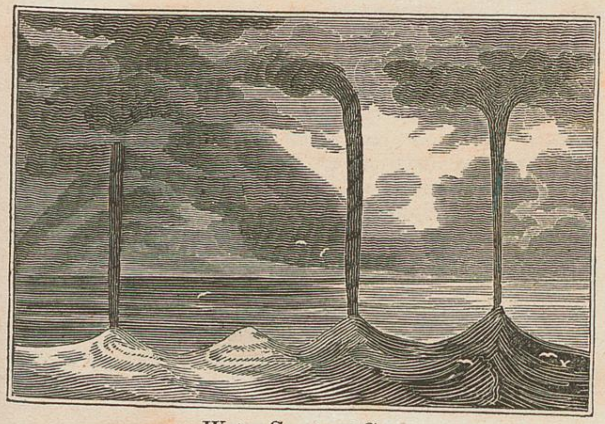
WHIRLWINDS AND WATERSPOUTS.

——————the dreadful spout
Which shipmen do the hurricano call
Constring'd in mass by the almighty sun.
SHAKSPEARE (*Troilus and Cressida.*)

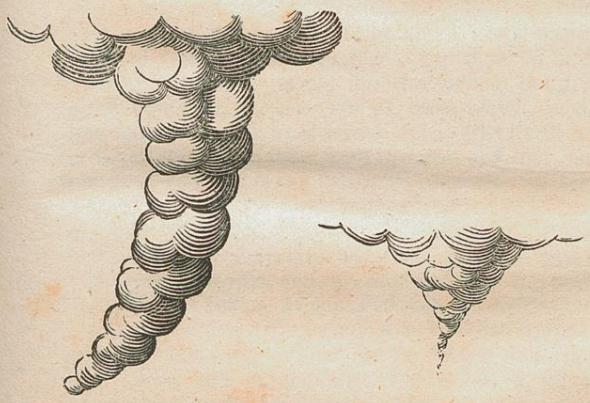
In number 302 of the Monthly Magazine, Sir Richard Phillips, in describing a water-spout observed by him, points out the connexion between those phenomena, and offers a very philosophical explanation of the formation of the latter

"It happened to him," he observes, "on the 27th of June, 1817, about seven in the evening, to witness the formation, operation, and extinction of what is called a water-spout; His attention was drawn to a sudden hurricane which nearly tore up the shrubs and vegetables in the western gardens, and filled the air with leaves and small collections of the recently-cut grass. Very dark clouds had collected over the adjoining country, and some stormy rain, accompanied by several strokes of lightning, followed this hurricane of wind. The violence lasted a few minutes, and the writer being drawn to an eastern balcony, it was evident that a whirlwind agitated the variety of substances which had been raised into the air. The storm proceeded from west to east, that is, from Hampstead over Kentish-Town towards Holloway. In about five minutes, in the direction of the latter place, a magnificent projection was visible from the clouds, like what is represented by *Fig.* 1 in the plate. It descended two-thirds of the distance from the clouds towards the earth, and evidently consisted of parts of clouds descending in a vortex, violently agitated like smoke from the chimney of a furnace recently supplied with fuel. It then shortened, and appeared to be drawn up towards the stratum of clouds, and presently it assumed the appearance represented by *Fig.* 2.

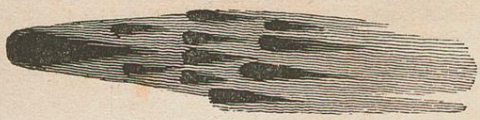
It finally drew itself into the cloud; but a small cone, or projecting thread, of varying size and length, continued for ten minutes. At the time, and for half an hour after, a



Water Spouts at Sea.



Water Spout on Land.—Fig. 2. *Water Spout.—Fig.* 1.



Flight of Meteoric Stones.

severe storm of rain was visibly falling from the mass of clouds connected with it, the extent being exactly defined by the breadth of Holloway, Highgate, and Hornsey. About two hours after, on walking from Kentish-Town towards Holloway, it was found that one of the heaviest torrents of rain remembered by the inhabitants had fallen around the foot of Highgate-hill; and some persons having seen the projecting cloud, an absolute belief existed that a water-spout had burst at the crossing of the new and old roads. On proceeding towards London, various accounts agreeing with the superstition or pre-conceived notions of the bye-standers, were given; but, in the farm-yard at the three-mile stone, it appeared that some hay-makers were stacking hay from a waggon which stood between two ricks, and that the same whirlwind which passed over Kentish Town, had passed over the loaded waggon with an impetus sufficient to carry it above twenty yards from its station, and to put the men upon it, and on the rick, in fear of their lives. Passing the road, it carried with it a stream of hay, and, nearly unroofing a shed on the other side, filled the air to a great height with fragments of hay, leaves and boughs of trees, which resembled a vast flight of birds The family of the writer beheld the descending cloud, or water-spout, pass over, and they saw its train, which, at the time, they took to be a flight of birds. They afterwards beheld the descending cloud draw itself upward, and they, and other witnesses, describe it as a vast mass of smoke working about in agitation; to them it was nearly vertical in a northern direction; and to persons a quarter of a mile north, it was nearly vertical in a southern direction; and all agree that it drew itself up without rain, and was followed near the earth by the train of light bodies. It appeared also, on various testimony, to let itself down in a gradual and hesitating manner, beginning with a sort of knob in the cloud, and then descending lower, and curling and twisting about, till it shortened, and gradually drew itself into the cloud."

The inferences which Sir Richard draws from what he saw and heard, are as follow: "That the phenomenon called a water-spout is a mere collection of clouds, of the same rarity as the mass whence they are drawn. That the descent is a mechanical effect of a whirlwind, which creating a vacuum, or high degree of rarefaction, extending between

the clouds and the earth, the clouds descend in it by their gravity, or by the pressure of the surrounding clouds or air.—That the convolutions of the descending mass, and the sensible whirlwind felt at the earth, as well as the appearance of the commencement, increase, and decrease, of the mass, all demonstrate the whirl of the air to be the mechanical cause.—That the same vortex, whirl, or eddy, of the air, which occasions the clouds to descend, occasions the loose bodies on the earth to ascend.—That, if in this case the lower surface had been water, the same mechanical power would have raised a body of foam, vapour, and water, towards the clouds.—That, as soon as the vortex or whirl exhausts or dissipates itself, the phenomena terminate by the fall to the lower surface of the light bodies or water, and by the ascent of the cloud.—That when water constitutes the light body of the lower surface, it is probable that the aqueous vapour of the cloud, by coalescing with it, may occasion the clouds to condense, and fall at that point, as through a syphon.—That if the descending cloud be highly electrified, and the vortex pass over a conducting body, as a church steeple, it is probable it may be condensed by an electrical concussion, and fall at that spot — discharging whatever has been taken up from the lower surface, and producing the strange phenomena of showers of frogs, fish, &c—And, lastly, it appears certain, that the action of the air on the mass of clouds, pressing towards the mouth of the vortex as to a funnel (which, in this case, it exactly represented,) occasioned such a condensation as to augment the simultaneous fall of rain to a prodigy."

In the month of July, 1800, a water-spout was seen rapidly to approach a ship navigating between the Lipari Islands. It had the appearance of a viscid fluid, tapering in its descent, and proceeding from the cloud to join the sea. It moved at the rate of about two miles an hour, with a loud sound of rain, passing the stern of the ship, and wetting the after part of the mainsail. It was thence concluded that water-spouts are not continuous columns of water, as has been confirmed by subsequent observations.

In November, 1801, about twenty miles from Trieste, in the Adriatic sea, a water-spout was seen eight miles to the southward: round its lower extremity was a mist, twelve feet high, nearly of the form of an Ionian capital, with

very large volutes, the spout resting obliquely on its crown At some distance from this spout, the sea began to be agitated, and a mist rose to the height of about four feet: a projection then descended from the black cloud which was impending, and met the ascending mist about twenty feet above the sea, the last ten yards of the distance being described with great rapidity. A cloud of a light colour appeared to ascend in this cloud like quicksilver in a glass tube. The first spout then snapped at about one third of its height, the inferior part subsiding gradually, and the superior curling upward.

Several other projections from the cloud, appeared with corresponding agitations of the water below, but not always in spouts vertically under them: seven spouts in all were formed; and two other projections re-absorbed. Some of the spouts were not only oblique, but curved, the ascending cloud moving most rapidly in those which were vertical. They lasted from three to five minutes, and their dissipation was not attended by any fall of rain. For some days before the weather had been very rainy, with a S. E. wind; but not any rain had fallen on the day of observation.*

The corresponding phenomena of whirlwinds have been occasionally productive of much mischief, as the following brief narratives will show. On the 30th of October, 1669, about six in the evening, the wind being then westwardly, a formidable whirlwind, scarcely of the breadth of sixty yards, and which spent itself in about seven minutes, arose at Ashly, in Northamptonshire. Its first assault was on a milk-maid, whose pail and hat were taken from off her head, and the former carried many scores of yards from her, where it lay undiscovered for some days. It next stormed a farm-yard, where it blew a waggon body off the axle-trees, breaking in pieces the latter, and the wheels, three of which, thus shattered, were blown over a wall. Another waggon, which did not, like the former, lie across the passage of the wind, was driven with great speed against the side of the farm house. A branch of an ash-tree, so large that two stout men could scarcely lift it, was blown

* In the plate representing the two figures of a water-spout, the passage of a cluster of aërolites, or meteoric stones, through the air, is likewise described; and to that subject the reader's attention is directed in viewing the plate.

over a house without damaging it, although torn from a tree 100 yards distant. A slate was carried nearly 200 yards, and forced against a window, the iron bar of which it bent. Several houses were stripped; and in one instance, this powerful gust, or stream of air, forced open a door, breaking the latch; whence it passed through the entry, and, forcing open the dairy door, overturned the milk pans, and blew out three panes of glass. It next ascended to the chambers, and blew out nine other panes. Lastly, it blew a gate-post, fixed two feet and a half in the ground, out of the earth, and carried it many yards into the fields.

On the 30th of October, 1731, at one in the morning, a very sudden and terrific whirlwind, having a breadth of two hundred yards, was experienced at Cerne-Abbas, in Dorsetshire. From the south-west side of the town, it passed to the north-east, crossing the centre, and unroofing the houses in its progress. It rooted up trees, broke others in the middle, of at least a foot square, and carried the tops a considerable distance. A sign-post, five feet by four, was broken off six feet in the pole, and carried across a street forty feet in breadth, over a house opposite. The pinnacles and battlements of one side of the church-tower were thrown down, and the leads and timber of the north aisle broken in by their fall. A short time before the air was remarkably calm. It was estimated that this sudden and terrible gust did not last more than two minutes.

About the middle of August, 1741, at ten in the morning, several peasants being on a heath near Holkham in Norfolk, perceived, about a quarter of a mile from them, a wind like a whirlwind approach them gradually, in a straight line from east to west. It passed through the field where they were ploughing, and tore up the stubble and grass in the ploughed ground, for two miles in length, to the breadth of thirty yards. In reaching an enclosure at the top of a rising ground, it appeared like a great flash or ball of fire, emitting smoke, and accompanied by a noise similar to that of carts passing over a stony ground. Both before and after the wind passed, there was a strong smell of sulphur; and the noise was heard long after the smoke had been perceived. This fiery whirlwind moved so slowly forward, that it was nearly ten minutes in proceeding from the enclosure to a farm house in the vicinity, where it did much mischief.

SOUNDS AND ECHOES.

SOUND is propagated successively from the sounding body to the places which are nearest to it, then to those more distant, &c. Every observer knows that when a gun is fired at a considerable distance from him, he perceives the flash a certain time before he hears the report; and the same thing is true with respect to the stroke of a hammer, or of a hatchet, the fall of a stone, or, in short, any visible action which produces a sound or sounds. In general, sound travels through the air at the rate of 1142 feet in a second, or about thirteen miles in a minute. This is the case with all kinds of sounds, the softest whisper flying as fast as the loudest thunder. Sound, like light, after it has been reflected from several places, may be collected into one point as a focus, where it will be more audible than in any other part; and on this principle WHISPERING GALLERIES are constructed.

The particulars relative to the celebrated whispering gallery in the Dome of St. Paul's Church, London, will be comprehended in the description of that noble edifice.

AN ECHO is the reflection of sound striking against a surface adapted to the purpose, as the side of a house, a brick wall, hill, &c. and returning back again to the ear, at distinct intervals of time. If a person stand about sixty-five or seventy feet from such a surface, and perpendicular to it, and speak, the sound will strike against the wall, and be reflected back, so that, he will hear it as it goes to the wall, and again on its return. If a bell situated in the same way be struck, and an observer stand between the bell and the reflecting surface, he will hear the sound going to the wall, and also on its return. Lastly, if the sound strike the wall obliquely, it will go off obliquely, so that a person who stands in a direct line between the bell and the wall will not hear the echo.

According to the greater or less distance from the speaker, a reflecting object will return the echo of several, or of fewer syllables; for all the syllables must be uttered before the echo of the first syllable reaches the ear, to prevent the confusion which would otherwise ensue. In a moderate way of speaking, about three and a half syllables are

pronounced in one second, or seven syllables in two seconds: therefore, when an echo repeats seven syllables, the reflecting object is 1142 feet distant; for sound travels at the rate of 1142 feet per second, and the distance from the speaker to the reflecting object, and again from the latter to the former, is twice 1142 feet. When the echo returns fourteen syllables, the reflecting object must be 2284 feet distant, and so on.

The most remarkable Echo recorded, is at the palace of a nobleman, within two miles of Milan, in Italy. The building is of some length in front, and has two wings jetting forward; so that it wants only one side of an oblong figure. About one hundred paces before the mansion, a small brook glides gently; and over this brook is a bridge forming a communication between the mansion and the garden. A pistol having been fired at this spot, fifty-six reiterations of the report were heard. The first twenty were distinct; but in proportion as the sound died away, and was answered at a greater distance, the repetitions were so doubled that they could scarcely be counted, the principal sound appearing to be saluted in its passage by reports on either side at the same time. A pistol of a larger calibre having been afterwards discharged, and consequently with a louder report, sixty distinct reiterations were counted.

From this example it follows, that the farther the reflecting surface is, the greater number of syllables the echo will repeat; but that the sound will be enfeebled nearly in the same proportion, until at length the syllables cannot be distinctly heard. On the other hand, when the reflecting object is too near, the repetition of the sound reaches the ear, whilst the perception of the original sound still continues, in which case an indistinct resounding is heard, as may be observed in empty rooms, passages, &c. In such places, several reflections from the walls to the hearer, as also from one wall to the other, and then to the hearer, clash with each other, and increase the indistinction