and is crossed by a county-road bridge, built in the same manner as those already described: the road was slightly diverted, in order to make the bridge square.

The whole work, which was completed in the summer of 1847, has been executed under the superintendence of Mr. W. Loftie Stoney, at the cost of £3,300.

The Paper is illustrated by a series of diagrams, from which Plates 9 to 16 are compiled.

Mr. BATEMAN recapitulated the general features of the Bann Reservoirs, and detailed the advantages that had resulted to the mill-owners, and the consequent increase of value of the property in the district, from the system of impounding the surplus water, to be used at times when, but for such assistance, there would be a scarcity. He directed attention to the self-acting balance flood-gates, not on account of any novelty in the principle, but because he thought there were many positions where they might be advantageously employed. The work, generally, was very plainly, but substantially executed, and at a very small cost.

Mr. HOMERSHAM inquired, whether the Lough Island Reavy Reservoir had, at all times, been found sufficiently large to collect and yield, for regular use, the water flowing off the land in very wet seasons, and during the greatest floods; or if any large quantity of water occasionally ran to waste. It was important to ascertain the amount of storage required for a certain extent of land draining into a reservoir. The Lough Island Reavy Reservoir was equal to a storage of 82,000 cubic feet per acre; and was the largest, in relation to the drainage-ground, he had ever known.

Mr. BATEMAN was not quite aware of all these circumstances; as since the completion of the works, he had not been frequently there. The capacity of the Lough Island Reavy Reservoir was 287,000,000 cubic feet, and the drainage ground was 3,300 acres. The case of this reservoir was not analogous to that of reservoirs for the supply of towns, nor to those constructed for the purpose of regulating mill-streams, occupied by mills immediately below the site of the reservoir. The mills, for the benefit of which the Lough Island Reavy Reservoir was mainly constructed, were at distances of fifteen miles to twenty miles. For six, or eight months during each year, at least, there was an abundant supply of water from other sources; and as during that period the reservoir was required to be large enough to contain all the water flowing into it,

it was obvious, that it must be larger than one from which a daily supply was regularly withdrawn for the use of the mills.

Mr. GLYNN had paid more attention to the drainage of land and to getting rid of the water, than to storing it for ultimate use. He was quite aware, that no general rule could be laid down, as to the amount of rain that could be collected; but he thought, that not more than one-third should be relied upon. The question was entirely one of locality, as to the amount of rain that fell, the quantity running off the ground, and the evaporation. He had found, that in the fen districts, not more than one-third was collected in the drains. During a period of six years, the largest quantity of rain which had fallen in one single year, in Deeping Fen near Spalding, was 34·32 inches, and the smallest was 18·1 inches. In Swaffham Fen near Cambridge, the largest quantity was 23·31 inches, and the least 14·98 inches; whereas at Kendal, the largest quantity that had fallen in one year, during a period of ten years, was 65·12 inches, and the smallest 45·73 inches, the greater part of which ran off the ground and could, of course, be collected. Mr. Glynn laid on the table the Meteorological and Magnetical Observations made in Russia during the year 1841, and directed the attention of Members to the instruments used, and to the mode of taking the observations.

Mr. BATEMAN replied to questions from Members, that during the period of the execution of works, rain-gauges were placed in various parts of the Mourne Mountains, and from them it appeared, that the ordinary amount of rain falling was from 60 inches to 70 inches per annum. The absolute quantity collected in the reservoirs, was from 48 inches to 50 inches. The result of observations made in the Longdendale district, and the adjacent hills, whence the city of Manchester was to be supplied with water, showed the average quantity of rain, falling in 1847, to be 55·50 inches, of which there flowed off the ground, as ascertained by measurement of the streams, 49·50 inches. It was however, probable, that more rain fell than was registered. In the adjacent Swineshaw Valley 49·33 inches of rain fell, and the quantity flowing off the ground was 37 inches. The rain-gauges were placed in situations varying from 500 feet, to 1,800 feet in elevation; the highest point of the hills being about 2,000 feet above the level of the sea.

Mr. HAWKSLEY said, that in the Rivington district, whence the town of Liverpool was to be supplied with water, the rain, in 1847, was 56·50 inches, and the loss by evaporation and absorption was 22 per cent., or 13 inches, leaving about 43 inches to 44 inches

flowing off the ground. The points of observation varied from 450 feet to 1,500 feet, which was the greatest elevation of the hills, above the level of the sea. The average rain-fall would probably prove to be about 50 inches, and the quantity collected about 36 inches.

Mr. HOMERSHAM said, he could not agree with Mr. Bateman, that the depth of rain falling on the land, or the flow of water off the land in this district, were so great as had been just represented. He had carefully and repeatedly examined the Longdendale district for the last fifteen, or sixteen months, and he had two funnel rain-gauges fixed near the ground in that locality, one at 1,000 feet, and another at 1,500 feet of elevation above the level of the sea; the former showed a rain-fall of only 33 inches in depth. During the past year, for such months as could be compared, the gauge on the hill, at the elevation of 1,500 feet, showed month for month, less rain fallen, than the gauge at the lower elevation; but owing to the latter gauge having been damaged, the returns for every month in the year were incomplete. In several other situations,—at the Combs Reservoir, near Chapel-le-Frith, 720 feet above the level of the sea, and Combs Ridge 1,670 feet high,—at Todd's Brook Reservoir 620 feet, and Brinks 1,500 feet high,—at the Bosley Reservoir 720 feet, and Bosley Minns 1,260 feet high,—the results obtained from funnel rain-gauges showed a less amount of rain falling on the tops of the hills, than lower down. Now according to the evidence given by Mr. Bateman on this subject at Manchester, and before a recent Parliamentary Committee, all Mr. Bateman's rain-gauge returns showed, that more rain fell on the tops of the hills than at the base: this result was contrary to the recorded experience of every meteorological writer with whose works Mr. Homersham was acquainted, and was contrary to the results of his own experiments. He believed Mr. Bateman to have been misled, owing to the faulty construction of the rain-gauges used by him. In each of his gauges was a staff $\frac{1}{4}$ of an inch in diameter; now in many of them Mr. Homersham had seen the staff standing 16 inches above the top, the gauge being only 7 inches in diameter. Experiments made by Mr. Homersham, and recently published, showed that from the drifting character of the rain falling on the tops of hills, a large quantity of water was arrested by the exposed surface of the staff, and ran down it into the gauge. The staff-gauges erected by Mr. Homersham showed, that at the tops of hills, a larger quantity of drifting rain was arrested than at the bottom; whereas the funnel-gauges without staves, used by Mr. Homersham, showed exactly the reverse, a greater quantity of rain

being indicated by such gauges at the bottom of the hill, than by those at the top.*

Mr. MURRAY alluded to the experiments made by Professor Phillips, at York, which proved the necessity of placing the gauges in proper positions, in order to ascertain accurately the quantity of rain falling. The result obtained by him, showed, that a rain-gauge placed on the ground, collected a much larger quantity of water, than one placed on the top of the Museum, and a still larger quantity than another placed on the top of York Minster. From observations made in 1834 and 1835, the ratio was found to be, 100 on the ground, 76 on the Museum, and 52 on the Minster.

Mr. BATEMAN explained, that the staff alluded to by Mr. Homersham, had, in some cases, been allowed to rise above the top of the gauge, and would, no doubt, be liable to some slight objection on that account. In the results, however, which he had just given, the staff had been fastened down, during the first half of the year, so that it could not rise at all, and during the latter half of the year, it had been entirely removed; being merely inserted at the time of taking an observation. The returns were, therefore, free from the objection made by Mr. Homersham; and they showed, that in high land, the quantity of rain increased as the altitude, up to an elevation of about 2,000 feet, except under peculiar local circumstances. Mr. Homersham had recently been engaged in drawing comparisons between the fall on high land and on low land. For this purpose he had taken the returns from a gauge placed on the ground at Rochdale, at the foot of the hills, and from another placed on the top of a house at Blackstone Edge, which was on the summit of the hills; and he found under such circumstances, that the rain appeared to be greatest at the foot of the hill. There appeared to be two other cases near Chapel-le-Frith, among Mr. Homersham's observations, which gave similar results. These, however, Mr. Bateman contended, were the exceptions to a general rule; the fact of more rain falling upon high land than upon low land, was distinctly proved by his own observations, by those made in the neighbourhood of Bolton-le-Moors, by those published by Dr. Dalton, (although the gauges had unfortunately been placed on the tops of houses,) and recently, by the extensive and very valuable researches of Mr. Miller of Whitehaven, from whose Report, dated 11th of March, 1848, Mr. Bateman read the following extracts:—

* *Vide* "Report on the Supply of Surplus Water to Manchester, Salford, and Stockport." London, 1848.

"In the last Report I observed, 'It would be premature, from the scanty data before me, to draw any conclusion as to the gradation in the quantity of rain, at these great elevations above the sea. But it seems probable, that in mountainous districts, the amount of rain increases from the valley upwards, to an altitude of about 2,000 feet, where it reaches a maximum; and that above this elevation, the quantity rapidly decreases.' The Table for 1846 exhibited the rain-fall of the summer months only, but the additional returns of 1847, obtained in every variety of season, confirm the above deductions in every essential particular, so that we may fairly assume the combined results to be indicative of a physical law, so far, at least, as relates to the particular locality in question. Thus in twenty-one months,—

			Inches.
The Valley . .	160	feet above the sea, has received	170·55
Stye Head . . .	1,290	,, ,,	185·74
Seatollar . . .	1,334	,, ,,	*180·23
Sparkling Tarn .	1,900	,, ,,	207·91
Great Gabel . .	2,925	,, ,,	136·98
Sca Fell . . .	3,166	,, ,,	128·15

"An apparent exception to this law occurs in the gauge stationed at Burnt Rigg, about midway between the top of Stye Head and the vale of Wastdale, and which, in 1847, has received about one-eighth, or 12½ per cent. less rain than the valley.

"This is the only one of the gauges situated on the slope of a mountain: it is on the windward side, and I imagine, that in such a position, eddies, or counter-currents, are produced in windy weather, which cause a less quantity of water to be deposited in the instrument, than is due to the elevation. We know, that all sloping roofs, from the same cause, materially diminish the receipts of rain-gauges.

"It will be observed, that the amount of water received by the Seatollar gauge, is invariably less than the deposit in the adjacent vale of Seathwaite, and the deficiency is pretty equable in every month of the year.

"I am unable to give any satisfactory reason for this anomaly, or to account for the very great excess of rain in this valley, over all others in the lake districts. As the gauge on Seatollar is two, or three miles distant, in a direct line, from the others, the near approach of its receipts to those of the Stye Head gauge, both about the same elevation, is rather remarkable. In 1846, the Seatollar exceeded the Stye gauge in quantity, which it should do if the assumed height be correct.

* "The height of Seatollar Common has not been accurately ascertained."

"By referring to the Table for the summer months, we find, that between the 1st of May and the 31st of October, the gauge at 1,290 feet has obtained nearly 12 per cent. more rain than the valley; at 1,334 feet, 9½ per cent. more; at 1,900 feet, 29 per cent. more; at 2,928 feet, 7½ per cent. less; and at 3,100 feet, 13½ per cent. less than the valley. In the winter months, (November to April inclusive,) the gauge at 1,290 feet has received 4½ per cent. more than the valley, at 1,334 feet, the same quantity as the valley; at 1,900 feet, 11¼ per cent. more; at 2,928 feet, 38½ per cent. less; and at 3,100 feet, 42½ per cent. less than the valley.

"The difference in the proportion to the valley, between the winter and summer half-year, as shown by the Tables, is rather startling.

"When much snow falls, no doubt a considerable portion is lost to the gauge, either by its being blown out of the funnel, or by the aperture getting choked up. But I do not think, that this cause alone, is at all adequate to account for the great comparative deficiency in the winter season; for there was very little snow on the mountain tops, during the winter of 1846-7, less, I am told by one of the oldest inhabitants of the Fell dales, than he almost ever remembers. At Whitehaven, we had no snow worth naming, except on the night of the 23rd of December, when it lay to the depth of nearly an inch on the ground; but disappeared in the course of the ensuing morning.

"The late Mr. Crosthwaite of Keswick, by means of marks on the side of Skiddaw, and with the assistance of a telescope at his residence, made two, or three, daily observations on the height of clouds for several years, and it is clearly shown by his Tables, that the clouds are lowest in the three first and the three last months of the year. Moreover, Dr. Dalton affirms, that the clouds are seldom a mile high, (or little more than one and a half times the height of Sca Fell,) in our climate, in winter. Now the Doctor here probably alludes to, or at least includes, the most elevated clouds, such as the cirri, and some varieties of the cirrostratus. But there can be no doubt, that between the months of November and March, the under surface of the nimbus, or rain-cloud, (the lowest, except the stratus,) is far below the tops of our highest mountains, and I have reason to believe, not unfrequently, its upper surface also: when this is the case, the gauges on Sca Fell, Gabel, &c., will receive no rain at all, when it is descending abundantly in the valleys beneath. The lowness of the rain-cloud at this season, is, I apprehend, the principal cause of the small quantity of rain, in proportion to the valley, during the winter, as compared with the summer months. . . .

" A little consideration will greatly lessen our surprise at the enormous quantity of water deposited in the hilly districts of Cumberland and Westmoreland, and at the consequent unequal distribution of rain in the climate of Great Britain. To those unacquainted with these localities, it may be briefly stated, that the Lake District valleys radiate from a series of mountains of slate and primitive rock, having the Gabel, 2,928 feet in height, as a nucleus, or central point; and in the immediate vicinity of which are Sca Fell and Pillar, of the respective elevations of 3,166 and 2,893 feet, and Great End, Bowfell, and Glaramara, not much inferior in altitude. These mountains are distant only about thirteen, or fifteen miles, in a direct line, from the Irish Channel, and as no hills intervene, they are, consequently, fully exposed to our wet and prevailing winds, which are the south-west. The warm south-westerly current arrives at the coast loaded with moisture, obtained in its transit across the Atlantic :—now, our experiments justify us in concluding, that this current has its maximum density at about 2,000 feet above the sea level; hence, it will travel onward until it is obstructed by land of sufficient elevation to precipitate its vapour; and retaining a portion of the velocity of the lower parallel of latitude whence it was originally set in motion, it rapidly traverses the short space of level country, and with little diminution of its weight, or volume; but on reaching the mountains, it meets with a temperature many degrees lower than the point at which it can continue in a state of vapour; sudden condensation consequently ensues, in the form of vast torrents of rain, which, in some instances, must descend almost in a continuous sheet, as when 9, or 10 inches are precipitated in forty-eight hours. When we reflect, that a warm moist current, perhaps only 3°, or 4° above the point of saturation, in coming in contact with the mountain ridge, probably meets with a stratum of air 10°, or 15° lower than its own inherent temperature, we shall cease to marvel that such quantities as 4, 5, or even 6 inches of water should be deposited in these localities, in the course of a few hours. The mountains are, in fact, huge natural condensers, destined to force from the atmosphere, the mighty volumes of water requisite for the supply of our lakes and rivers."

Mr. HOMERSHAM did not contend, that a less amount of rain fell in hilly districts than on plains; he knew, that the greatest quantity of rain did fall in hilly, or mountainous districts; but his own experiments showed, and all meteorological writers agreed, that in such localities, less rain fell on the tops of hills, than lower down. The district of country, in which Mr. Hawksley had made his experiments, was to the west of Manchester, about

twelve miles, or sixteen miles distant from the sea, and it was the first high land to intercept the clouds, as they came from the ocean charged with vapour; now the Longdendale district, referred to by Mr. Bateman, was considerably to the east of Manchester, and about fifty miles distant from the sea. He contended, therefore, that no analogy existed in the amount of the rain-fall, between the two districts. The same might be said of the experiments of Mr. Miller, of Whitehaven: they were conducted among the high lands of Cumberland, at from twelve miles to eighteen miles from the sea, and within the influence of a cluster of mountains, each more than 3,000 feet in height; the greatest distance between any two of them not being more than twelve miles. These mountains were bounded to the north, west, and south, by the sea, and immediately to the east by very large lakes. Experiments conducted in such a district bore no analogy to the Longdendale district; but even Mr. Miller's experiments showed that, upon the whole, less rain fell on the tops of the hills, than at their base, and any apparent exception to this rule, arose from experiments made on comparatively low hills, in the immediate vicinity of very much higher land.

The practical question of the supply of water that could be actually obtained for domestic use from the Longdendale district, could only be solved, by ascertaining, in that immediate locality, the amount of water yielded, in a dry year, from a reservoir of a given content, fed from a given area of land.

Mr. WALKER remarked, with reference to the alleged discrepancy in the results of Mr. Bateman's experiments, that as all his gauges had graduated staves in them, and they had been placed in low, as well as in high situations, the general comparative results would not be vitiated, even if an undue quantity of drifting rain had been intercepted, by that portion of the staff, that rose above the level of the funnel. He did not think the extent of surface exposed by a staff, $\frac{3}{4}$ of an inch in diameter, could intercept enough rain to account for the difference between the results recorded by Mr. Bateman and those produced by Mr. Homersham.

Mr. POLE mentioned a fact which might bear upon the subject of the quantity of rain falling in the same locality at different levels. The district he referred to was the western, or Malabar coast of India, which was exposed, from June to September, to the south-west monsoon. The Deccan, or high land of the interior of the peninsula, was terminated on the west, by a range of precipitous cliffs, called the Ghauts, varying from 2,000 feet to 4,000 feet in height, between which and the sea, there was a flat tract of land, called the Konkun, only slightly elevated above the sea level.

Now at Bombay, and in the low district generally, the fall of rain during the monsoon, (which was, in fact, the annual fall,) was from 70 inches to 80 inches; whereas upon the range of Ghauts it was much more, the quantity there increasing according to the elevation. For example, at Mahabuleshwar, or Malcolm Peth, a sanitary station established some years ago by Sir John Malcolm, at an elevation of 3,700 feet above the sea, the fall of rain was about 240 inches, or more than three times as great as in the lower districts; so great, in fact, as to amount to a deluge, and to render the place uninhabitable during the monsoon. At Khandalla, another point in the same range of hills, but only 1,700 feet high, the fall of rain was about a mean between the two extremes just mentioned. The differences here were so wide as to admit of no dispute as to the accuracy of the rain-gauges. From the peculiar nature of the weather in these localities, it might be a question, whether they could be fairly placed on a parallel with districts in Europe; but the facts were extraordinary, and deserved to be recorded.

Sir CHARLES MALCOLM confirmed Mr. Pole's statements, adding, that the maximum fall of rain in the districts referred to, was at a level of about 4,000 feet, and that above that elevation it appeared to decrease; thus demonstrating the existence of a law analogous to that given by Mr. Bateman, as the result of Mr. Miller's experiments upon the lakes in the north of England.

Mr. HOMERSHAM said, the results published by Colonel Sabine, as to the amount of rain among the hills at St. Helena,* proved less rain to have fallen on the tops of the hills, than lower down; and Dr. Dalton, as well as all other meteorological writers, had demonstrated the fact by direct experiments.

Mr. HAWKSLEY, in reply to further inquiries, stated, that on the lands whence the water for the supply of Liverpool was to be obtained, and which comprised the elevated range of hills in the vicinity of Rivington Pike, six gauges, manufactured by Troughton and Simms, had been erected. The funnels were 10 inches in diameter, and the readings were given from a scale attached to a glass tube. In the year 1847 the fall of rain, as ascertained from the average of all the gauge instruments, was about 56·50 inches, varying from about 49 inches on the low ground, to 61 inches on the high ground. According to present observations it appeared, that the greatest

* *Vide* "Observations made at the Magnetical and Meteorological Observatory of St. Helena, 1841, by Captain Lefroy, Director of the Observatory at St. Helena." Published by order of Her Majesty's Government, 1847.

amount of rain fell, in that district, at an elevation of about 1,000 feet above the sea. It was probable, that this altitude corresponded, very nearly, with the mean height of the densest portion of the rain-cloud. The loss from evaporation had been ascertained to be from 20 to 25 per cent., the inclination of the ground being very rapid, with little table-land, and the surface consisting chiefly of a thin vegetable covering, reposing on a stratum of yellow clay, overlying the millstone-grit formation.

Mr. Hawksley did not consider it safe to rely upon proportions obtained from previous observations, in determining the amount of water which might be collected into reservoirs; it was better to ascertain the actual number of inches evaporated. He had found that, whilst on the Lancashire hills more than two-thirds of the mean quantity of rain could be collected, on the Lincolnshire wolds it would *not* be possible to collect even *one-third*. In both districts the evaporation amounted to 12 inches, or 14 inches, and this result corresponded, very nearly, with Mr. Dickenson's observations in Hertfordshire.* When, however, the fall of rain was less than the mean amount, the evaporation was also less, for the obvious reason, that during the prolonged period of drought, no water was present for the atmosphere to act upon. Under this condition, grasses and plants depending for their nourishment upon the superficies of the land, withered, and in some instances, ceased even to live.

The Liverpool water-shed had a westerly aspect; it was situated twenty miles from the Irish Channel, and commenced at an elevation of 500 feet above the sea, afterwards attaining, in some places, an altitude of about 1,800 feet. Now it was worthy of remark, that whilst on the Cumberland mountains, there was an average annual precipitation of 100 inches, or 120 inches, and on the Liverpool water-shed of, at least, 50 inches, on the east side of the kingdom, the average was not more than 22 inches, and in the midland counties it was under 30 inches. A fall of rain of even less than 15 inches had been known to occur in the fen districts of Lincolnshire.

With respect to the dispute amongst meteorologists, as to whether most rain fell at the bottom, or the top of a hill, Mr. Hawksley had no doubt, that in attempting to generalise on this subject, both parties had fallen into an error. The greatest fall, 'cæteris paribus,' would take place at the mean height of the rain-cloud; but locally-produced currents would necessarily exercise an influence on the result. If the hills were low, or only moderately high, the

* *Vide* Minutes of Proceedings Inst, C.E., 1843, vol. ii., p. 159.

amount of rain would generally increase, from the foot to the summit; if they were very high, so as to pierce and pass through the clouds, less rain would fall on the summit, than at some distance down the declivity; but the exact point must depend on the climate, the temperature, and other circumstances. The problem did not, therefore, admit of a general solution.

Mr. BATEMAN was happy to find, that scarcely any difference existed between his observations and those made by Mr. Hawksley. The average of Mr. Hawksley's returns, for 1847, was 56·50 inches, whilst Mr. Bateman's was 55·50 inches. The returns of several gauges in the Longdendale district for 1847 were:—

	Inches.
At 500 feet above the sea. . .	46·6
„ 800 „ „ . . .	50·5
„ 1,700 „ „ . . .	52·1
„ 1,700 „ „ . . .	56·5
„ 1,800 „ „ . . .	62·1

By a careful examination of the water flowing off the ground, Mr. Bateman was convinced, that had there been gauges placed on the highest part of the hills, the amount of rain falling would have been shown to be still greater.

Mr. HOMERSHAM was not convinced by these returns; on the contrary, he contended, that the amount of rain falling decreased with the altitude, that all writers on meteorology, except Mr. Miller, agreed on this point, and his own observations confirmed it. He had two gauges in the district whence Mr. Bateman's returns were made, and they showed only 33 inches of rain.

Mr. BATEMAN concluded, that in this case there must be some great error, as these returns of 33 inches of rainfall, were from a district from which it was clearly shown, that 49·50 inches had actually flowed off the ground. This was ascertained, by every stream being measured daily,—some regularly once a-day, some twice a-day, at the same hours,—and the river into which all the streams flowed, being measured three times a-day. The measurement of one stream, corroborated the accuracy of the observations upon the others, and they all agreed in giving nearly the same quantity flowing off the ground. The general result might be a little above, or below the truth; but it was a close approximation.

Mr. BIDDER said, he had not made any direct observations upon the district in question; but from the general results, he believed the opinion advocated by Mr. Homersham to be incorrect.

Mr. HOMERSHAM said, that from April 1844 to April 1845, the

reservoir of the Ashton Water Works collected all the water flowing off its drainage ground of 378 acres; and by accurate experiment this was proved to be only equal to a depth of 15·50 inches over its surface. The reservoir was within four miles of the Longdendale district, and its drainage-ground was about 800 feet above the level of the sea: this proved that much less water flowed off the ground, than Mr. Bateman's experiments seemed to indicate. He considered, that two, or three measurements of a mountain-stream per day, as practised by Mr. Bateman, would not give a true indication of the quantity of water flowing off the land, owing to the irregularity in the quantities flowing down such streams in a very short space of time: a flood would sometimes only last for one hour, or two hours, and a measurement taken at such a period would vitiate the whole results.

Mr. BEARDMORE said, that he must protest against Mr. Homersham's conclusions, as contrary to the general opinion of Engineers, and to Mr. Beardmore's own experience. Colonel Sabine's experiments were, doubtless, capable of some explanation, as it was improbable, that the results obtained by so eminent an authority, as to the amount of rain falling in hilly districts, should be contrary to facts familiarly known to every Engineer who was engaged in forming reservoirs for storing water. He had examined the amount of rain-fall on various parts of the Pentland Hills, and had made the most minute experiments on the proportion flowing off the ground. The results were, briefly, that whilst the mean rain-fall in Edinburgh, at about 200 feet above the level of the sea, for the years 1844, 1845, and 1846, was about 30 inches at the Glencorse Reservoir, in the Pentland Hills, distant only nine miles from the sea, and about 700 feet above its level, the mean rain-fall, for the same period, was 37·4 inches, and at Carlops, similarly situated but 900 feet above the sea, the fall was 49·16 inches. Numerous gauges which had been strictly kept, in the Glencorse district of the Pentlands, during December, January, February, and March 1846–47, indicated similar results. That period happened to be singularly propitious for experiments, as it was drier by 66 per cent. than any previous winter season for at least sixteen years. The results gave, for a district about 1,000 feet above the sea, and immediately adjacent to Glencorse Reservoir, 51 inches of rain.

The strongest proofs, however, were given by gauging every drop of water that fell into the reservoir, which was kept under diurnal observation for that purpose. It thus appeared, that during the four winter months above named, rather more water

was actually delivered into the reservoir, than was indicated by the rain-gauge kept at the same level; the registered fall being 4·35 inches, whilst the water gauged was 4·53 inches; a result fully borne out by the upland gauges, which gave about 5·5 inches, for the same period. That as much water was available at any given point, as was indicated by the rain-gauge at the same place, was proved by other gaugings taken at a different point in the same district; all the results showed, that the rain-fall was greater on the higher slopes. As to the method of gauging by a notch-board, however accurate it might be in ordinary cases, it was manifest, that, during heavy floods, a large amount of water must pass off without due observation, from the velocity which the whole mass of water acquired, and which rendered the ordinary formula useless. As the greater proportion of rain passed off in a state of flood, when the error would much reduce the real quantity, it was fair to conclude, that more water really passed off than was ordinarily supposed; and his experiments, at various times, seemed to establish the fact.

He did not think, that any fixed rule could be laid down, as to the amount of storage-room required in proportion to the area of drainage ground. This must be greatly influenced by the amount of rain-fall, the contour and declivity of the ground, and above all, by its nature;—flat peat districts, offering the utmost contrast to precipitous rocky hills, where the water descended to the lower valleys immediately after storms. Again, in large districts, the time during which the stored water would be required for the supply of mills, would evidently vary, and where, as in the case of the Bann Reservoirs, the periodical occurrence of a drought was to be provided against, a large amount of storage-room was of the utmost possible advantage.

Mr. HOMERSHAM said, the practical question resolved itself into this: what quantity of water had been regularly yielded for consumption throughout a year, by a reservoir of a given capacity, fed from a given area of drainage-ground? The example he had quoted of the Ashton Water-works Reservoir was a practical case, and he contended, that such were the only sure guides to be depended upon.

Mr. WALKER observed, that the principle of large impounding reservoirs ought to apply to all large towns; for the rain stored in a wet season, might then supply the deficiencies of one, or two succeeding dry seasons.

Mr. HOMERSHAM remarked, that the amount calculated upon by Engineers was based upon the hypothesis, that two-thirds of the fall of rain flowed off the ground.

Mr. HAWKSLEY said, that Mr. Homersham misconceived what Engineers really did understand upon that subject; that which was the rule for the west coast of England would not apply to the east coast, where the rain-fall was only 22 inches, or 24 inches, and where, occasionally, only 14 inches of rain had fallen. He instanced a case, in which, out of a fall of 23 inches of rain, 15 inches had been evaporated, or absorbed; thus showing a loss of two-thirds with respect to store reservoirs; where one on the wettest part of the west coast, of a capacity equal to a supply of ninety days, would be sufficient, another, on the east coast, would require to be of dimensions equal to a supply for one hundred and eighty days, or more.

Mr. MCCLEERY, through the Secretary, said, that, according to Townsend, the fall of the Lower Bann was 39 feet 3 inches, to the height of ordinary spring-tides, when the Lough Neagh was at its lowest.

	Ft.	In.
At Salmon Leap . . .	4	7
At Loughang . . .	1	3
At the Vow . . .	2	11
At Movannahed . . .	12	0
At Pertna	18	6

The map in the Bog Reports gave the fall at Pertna as only 16 feet 6 inches; but this was, probably, a misprint. Mr. Townsend stated the highest water-flood to be 46 feet 3 inches above the sea,—a difference of 7 feet,—which the greatest rise of Lough Neagh had never exceeded. On the same authority, the distance from the Bar of Toome to the Salmon Leap was twenty-four and a-half Irish, or about thirty-one statute miles: the area of Lough Neagh was 97,272½ acres, and that of Loughby 25,551 acres. Lieutenant Graves made a survey of Lough Neagh by order of the Admiralty, and in his chart it was stated, that the fall of the Lower Bann, when at summer level, to low-water mark in spring-tides, was 48 feet, and that in winter, the lake rose from 6 feet 7 inches to 8 feet.

Mr. BATEMAN, through the Secretary, said, that the extraordinary discrepancy which appeared to exist between the observations of Mr. Homersham, and those of other persons, had led him to examine the nature of the rain-gauge used by Mr. Homersham, when the cause of the anomaly was at once apparent. The gauge was a mere evaporating vessel, as the whole apparatus was placed above the ground, and the rain, which was collected within a funnel 9 inches in diamater, was conveyed by a short pipe at the bottom,

into an open glass bottle, or receiver, of about the same diameter as the funnel. The surface of the water not being covered by a float, was in contact with the external air, and was, therefore, liable, in a great degree, if not entirely, to be affected in the same manner as the surface of an open pond. Evaporation from a water surface varied from between 20 inches and 30 inches to 50 inches per annum, the evaporation rapidly increasing with an increase of elevation. The quantity of water measured in Mr. Homersham's gauge, was the mere residuum, after evaporation had carried off as much as possible. The case was analogous to that of a common tea-kettle. The metal funnel and glass receiver formed the kettle: the dry rarified air of an elevated district, the currents of dry wind and the solar heat, performed the offices of the fire: the open funnel and communicating pipe acted as the lid and spout of the kettle, through which the water, converted into steam, regularly escaped.

Mr. Homersham adduced three instances of observations made with these funnel-gauges — at Woodhead, in Longdendale, — at Todd's Brook,—and at Combs. At Woodhead the rain appeared to be 33 inches in a district, from which, as already stated, 49·50 inches had actually flowed off the ground. Now adding to the 33 inches the amount due to evaporation at an elevation of 1,000 feet, the difference was at once accounted for. Supposing the real evaporation from water, at this height, to be 40 inches, half might fairly be taken as the amount evaporated from the water within the gauge, (as it was to some extent covered, although not excluded from the air), which would thus give a total rain-fall of 53 inches. Of the two gauges of Mr. Bateman, the nearest to Woodhead, which was three miles distant, showed, at an elevation of 800 feet, 50·50 inches, whilst the other, which was two miles and a-half distant, and at an elevation of 1,800 feet, showed 62·10 inches.

At Todd's Brook, the rain at the foot of the hill and on the top, appeared to have been ascertained by similar gauges. Corrected by the probable amount due to evaporation, the returns would stand thus:—

	Water measured. Inches.	Evaporation. Inches.	Total Rain-fall. Inches.
At Todd's Brook Reservoir, 620 feet above sea,	38·39	+ 10 for evap.	= 48·39
At the top of the hill, 1,500 feet „	29·50	+ 20 „	= 49·50

At Combs Reservoir the rain at the foot of the hill was ascertained by a staff-gauge, which Mr. Homersham contended, showed more rain than fell, but which he, nevertheless, compared with a funnel-gauge at the top. Allowing for the evaporation of the funnel-gauge, the returns would be:—

			Total Rain. Inches.
Combs Reservoir,	720 feet above sea	. . . . .	51·30
„ Ridge,	1,670 „	35·85 in. + 20 in. for evaporation	= 55·85

An occasional instance of less rain occurring on high land than on low land, like the one alluded to by Mr. Miller of Whitehaven, might, certainly, be met with; but the great weight of evidence was in favour of the conclusion, that up to a certain height within the region of the clouds, the rain was greater in proportion to the greater elevation of the ground. It was no less certain and curious, that in a direct line upwards, the greatest fall was upon the ground; —that there was less rain upon the top of a house than at the bottom, and still less upon the top of a church. This fact had misled many meteorologists into the belief, that the same rule applied to increased elevation of land.

If one of Mr. Homersham's funnel-gauges were placed in an exposed situation on Epping Forest, where the amount of rain was less than the evaporation from water, and visited at the end of a year, in the months of August, or September, Mr. Bateman had no doubt it would be found entirely empty.

Mather's Elastic Metallic Piston.

After the Meeting, Messrs. W. and C. Mather exhibited and described their Elastic Metallic Piston.

The main feature of this piston consisted in the combination of two helical coils, one placed within the other; the internal one giving the elastic power vertically and horizonally, the external case transmitting that power to the cylinder, and receiving the wear and tear against it. The essential elements of a good metallic piston, viz., horizontal and vertical elasticity, were thus secured in the formation of a perfect elastic metallic packing.

The great superiority of this improvement, was its simplicity; it only consisting of two pieces of metal, having vertical and horizontal elasticity in due and proper proportions, in simple combination, the horizontal elasticity keeping the packing steam-tight against the cylinder, and the vertical elasticity keeping it steam-tight between the top and bottom plates of the piston-block, thus allowing no space for the steam to escape in any direction. Another advantage was to be found in the mildness of the elastic pressure, which was generated by the circumference, and not by the diameter; thus creating but little friction, and consequently economising power and the wear and tear of the piston and cylinder. The internal helical