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XLI. *An Account of some Thunder-storms and extraordinary Electrical Phenomena that occurred in the neighbourhood of Manchester on Tuesday the 16th of July 1850.* By PETER CLARE, F.R.A.S., Vice-President of the Literary and Philosophical Society of Manchester*.

[With a Plate.]

ON the 16th of July in the present year several severe storms of thunder, lightning, hail and rain, attended with fatal results, occurred in the southern part of Lancashire and northern part of Cheshire, which were succeeded by some very extraordinary electrical appearances, such as I do not remember to have previously noticed, although I have been an attentive observer of electrical discharges in the atmosphere for more than half a century.

These storms, with one exception (which occurred in Derbyshire), appear to have originated in different localities, within a range of fifty miles from north to south, and forty miles from east to west; extending from the river Ribble below Preston in the north to the neighbourhood of Nantwich in the south, and from the course of the river Irwell near Bury in the east, to North Meols in the west.

For several days previous to that on which the storms occurred, the weather had been generally very fine, the barometer varying only from 30·15 inches to 30 inches, giving a mean for the three preceding days of 30·07 inches. The thermometer for the same period, at eight o'clock in the morning, varied from 65 to 67 degrees of Fahrenheit; at two o'clock P.M., from 77 to 79 degrees; and at ten o'clock in the evening, from 65 to 69 degrees, giving a mean for the four days of 70·33 degrees; whilst during the same period the wind near the earth blew from the north, or north-north-east, and the clouds during the whole time moved from east to west.

On the morning of the 16th, previous to the commencement of the storms, the weather was very fine at Manchester, with some thin clouds floating in the atmosphere; but as the day advanced the clouds became more dense, although the pressure of the air did not vary more than the one-hundredth part of an inch from eight o'clock in the morning until ten o'clock in the evening. About two o'clock in the afternoon some dark clouds had formed in the north and east, and afterwards extended towards the west; at four o'clock those in the north-west had become much more dense and dark, and one or two distant peals of thunder were heard in that direction, but with-

* Communicated by the Author; having been read to the Literary and Philosophical Society, October 1, 1850.

out the usual signs of an approaching storm. It appears, however, that about this time a violent storm of thunder and lightning had commenced in the neighbourhood of Bolton, twelve miles north-north-west of Manchester, accompanied with very heavy rain and large hail-stones, and continued for nearly two hours, extending westward, and to the west-south-west and north-west, for many miles; it also extended five or six miles to the east, as far as Bury, a distance of nine miles north of Manchester; but the rain and hail were not quite in such profusion as at Bolton, or to the north-west of it, nevertheless a boy and horse were killed by the lightning about a mile and a half beyond and to the north of Bury: the boy was about ten years of age, and riding on a horse with milk cans attached to it; and when they got to Littlewood Cross they were struck by the electric fluid, and both boy and horse killed on the spot. During the storm a house near Union Square, Bury, was also struck by the lightning, but not much damaged.

At six o'clock the rain ceased at Bolton for nearly an hour, after which the thunder, lightning and rain recommenced to the west, north-west, and east of the town, and continued for some time. The damage done within the borough of Bolton was much less than might have been expected, considering the severity of the storm; yet there were not less than seven houses and mills struck with the lightning; but the damage actually done was not to any great extent, as the fires which it occasioned were soon subdued. The effects of the storm were however more appalling in a west and north-westerly direction, to a distance of several miles, where the rain descended in torrents, causing the water to rush down the hills with immense force, covering whole meadows, carrying abundance of hay with it, and overflowing the banks of rivers to a considerable extent, by which one of the trains was stopped at the Horwich station on the Bolton and Preston Railway for about twenty minutes.

In the district below the Rivington Hills the water advanced so unexpectedly, so rapidly, and with such impetuosity, as to remove whole bales of cotton from the mills, and also pieces of cloth from the print-works, to a considerable distance. Other casualties also occurred, comprising the following, some of which are of a melancholy character.

At Horwich the flood rose to such a height, that the water burst through the windows of the cotton mill of William Bennett, jun., at Wilderswood, doing damage to the amount of several hundred pounds; other mills in the same neighbourhood also sustained considerable injury from the flood. At

Adlington, a colt belonging to Ralph Shaw was drowned by the flood. At Blackrod, Joseph France, aged forty years, was engaged with another man in sinking a shaft at a colliery, when the water rushed so suddenly into it that he could not be got out and was drowned.

At Burnden the head gearing of a chain belonging to a coal-pit of Mr. Scowcroft's was struck by the lightning and damaged; and in the same neighbourhood, a chimney-piece in the house of Thomas Braughton was struck and shattered.

At West Houghton, a large stack of hay belonging to Thomas Woods was set on fire, but soon extinguished.

At Adlington, the electric fluid entered a house where a woman and her five children were sitting, and after breaking a looking-glass that hung over her head, and destroying the chimney ornaments, it left the house without injuring any of the inmates.

At Horwich, the electric fluid entered the house of Mr. Welsh, broke a large mirror and sundry other articles, and struck a boy twelve years of age, who afterwards lay in a precarious state for some time.

At Dobhill, to the west of Bolton, a cow belonging to Peter Boardman was killed in a field by the lightning.

At Lostock, Ralph Shaw had a foal killed in a field from the same cause.

James Lathom, also of Lostock, had a three-years old colt and a horse both killed by the lightning.

At Belmont, a cow belonging to Benjamin Helme was killed by the lightning on the road near to the church.

At Hindley, a valuable cow belonging to John Battersby, of Castle Hill, was killed whilst grazing in a field with nine others.

At Horrocks Fold Farm, two girls, named Alice Makinson of Preston, and Ellen Longworth of Horwich, were sitting in the kitchen with four other persons, when the electric fluid came down the outside of the chimney, through the roof and the floor, and struck Alice Makinson dead on the spot: the fluid hit her on the shoulder, and passing down her body tore the sole from one of her clogs in its resistless progress. There were no appearances on the body of the other girl, Ellen Longworth, of having been struck by lightning, but she was taken out of the kitchen in a state of insensibility; and though she revived a little, and was restored to consciousness, she only lingered until five o'clock the next morning, when she died.

These instances of the destructive violence of the storm occurred chiefly to the north-west and west of Bolton, between

that town and Wigan, in which direction it seems to have progressed; for a little before five o'clock distant thunder was heard towards the east and south-east of Wigan, and about six another storm arose to the north of the last-named town, which spread or extended southward, so as to unite with that approaching from the east; and when they united, the rain began to descend in torrents, having more the appearance of the descent of a water-spout than of a shower of rain: the thunder and lightning were terrific; but I have not been able to ascertain whether there was any loss of life in this immediate neighbourhood, although it is reported that a person was killed at Wigan.

At St. Helens, which is six or eight miles to the south-west of Wigan, John Rigby, a coal miner, aged forty-six years, was looking out of an upstairs window of his house during the thunder-storm, about seven o'clock in the evening, when he was struck by the electric fluid and killed on the spot: there was a mark on his breast, and the shoe on his right foot was torn to pieces. Several persons in the same house were knocked down, but all of them recovered.

Robert Gore, a farm-labourer, of Marsh-side in North Meols, aged twenty years, was driving his master's cart home between six and seven o'clock the same evening, when the mare took fright at the noise of the thunder and ran away; the man and a little boy were riding in the cart at the time: when the master's son came up with them, he found the mare and cart on the ground, and Gore lying by the side of the cart quite dead: the horse and boy escaped.

Evan Rimmer, a farm-servant, aged eighteen years, was taking shelter with four others in a stable or shed adjoining William Wright's farm in Moss Lane, North Meols, when the building was struck by the electric fluid about seven o'clock the same evening during the thunder-storm, and they were all knocked down. Rimmer was killed; the others were put to bed and recovered.

In the country between St. Helens and North Meols, a distance of about twenty miles in a north-westerly direction, several persons sustained injury by the lightning; but excepting the three above mentioned, no fatal cases occurred. At Ormskirck, a woman who was sewing was struck blind by a flash of lightning, but recovered her sight in a few days.

From North Meols the storm passed northward towards the river Ribble and Lytham, but it does not appear that any damage was done there by the lightning.

At about eight o'clock the same evening the town of Warrington, which is situated several miles to the south of the

direction in which the storm above described had raged, was also visited by a violent storm of thunder and lightning; the lightning was intensely vivid, and the peals of thunder followed each other in rapid succession: several accidents occurred, but no fatal cases are recorded. At Sankey, a little to the north-west of Warrington, a stack of hay was set on fire by the lightning, and a large quantity burnt before the flames were extinguished. A flat sailing on the canal was also set on fire by the same cause, but the damage done was not extensive. This storm appears to have been limited to a comparatively small district.

About six o'clock the same evening a storm of thunder and lightning accompanied with heavy rain commenced about ten miles to the west of Warrington, and proceeded in a south-easterly direction. After crossing the river Mersey near Runcorn and Weston Point, it passed up the valley of the river Weaver towards Northwich, a town situated ten miles south of Warrington. At Anderton, about a mile short of the town, the lightning struck a stack of hay and set it on fire, but the torrents of rain soon extinguished it. At Witton to the east, and Leftwich to the south, and both immediately adjoining Northwich, it appears as if a discharge of electricity had struck three places at one and the same time; viz. a cottage near the toll-bar in Witton was struck, but not much damaged; a church in Leftwich was also struck, and a quantity of stone broken and forced off the gable-end by the lightning, which passed from thence to a gutter and down a metal spout to the ground; the third was a poplar-tree in Leftwich, which was shivered at the top and down the trunk to the ground. In about an hour afterwards the spire of Davenham Church, situated two miles to the south, was also struck by the lightning; it first came in contact with a wind-vane at the top of the spire, after which it passed down a copper rod about two inches diameter inserted through the solid stone-work for several yards, with a screw and nut at the bottom to hold the masonry together; and when it got to the lower end of the metal, left it and made a large hole in the spire about two yards long and one foot wide; it then proceeded along the masonry to the bottom of the spire, where it made another large opening in the stone-work, from whence it immediately entered the tower; here an iron pipe or smoke-flue on the outside of the tower served as a conductor for the lightning, which was conveyed without injury to the building as far as the metal went; but where it terminated, towards the bottom of the tower, some damage was done to the stone-work before the lightning entered the ground.

Later in the evening a cow belonging to the Rev. Mr. France of Davenham was killed in Bostock Park, about two miles further south; and soon afterwards a barn at Winsford, about a mile and a half to the west of Bostock, was struck by the lightning but not much damaged; and a little later in the evening a cow was killed at Minshull, a few miles south of Winsford.

The storm extended some distance further to the south and west, visiting in its progress Holmes Chapel, Over, Nantwich, &c.

The electrical state of the atmosphere during the progress of these storms must have been very much disturbed, as manifested by the frequency and intensity of the electrical discharges; whilst the torrents of rain that fell for some time were probably caused by the currents of air in the higher part of the atmosphere being much agitated, and moving in various directions, thereby allowing them to mix freely, and large clouds to be rapidly generated.

With the limited knowledge we have of the operation of those causes which produce thunder-storms, the following view may not be undeserving a little consideration.

If we suppose that the quantity or intensity of the electric fluid connected or combined with each particle or atom of water is not the same when the atom is in a liquid as it is when in an æriform state, but, like heat, abounds more when the atoms are in a state of vapour than when they are in a liquid state, and which view some experiments appear to support; then, whenever a quantity of vapour is suddenly condensed in the atmosphere, the water, whether in the state of a liquid mass or in innumerable drops, would probably give out electricity, or under favourable circumstances become positively electrified; by this hypothesis we may account for most, if not all, the phænomena that occur in thunder-storms.

For if the currents of warm and cold air in the atmosphere are in a very disturbed state, moving in opposite or various directions, and both nearly saturated with vapour, and if under such circumstances they become mixed, a portion of the vapour in the warm air will be condensed and form clouds: the clouds would be electrified with an intensity proportioned to their density, magnitude, rapidity with which they were formed, and the hygrometric state of the air between them and the earth; and if sufficiently electrified, would remain in masses separated from each other: this appearance is often observed in the vicinity of an electrified cloud, or previous to a thunder-storm. And further, as clouds are generally of different magnitudes and densities, the electrical power of

those most intensely charged will cause the electricity of the sides, or portions of other clouds nearest to them, to be electrified in a different state, according to the well-known laws of electrical induction: and as the larger clouds increase in density or electrical intensity, they will discharge portions of their electricity to the smaller and less intensely charged clouds; these again may discharge themselves to more remote clouds that are still more slightly charged, and thus a succession of flashes of lightning and peals of thunder may occur for some time. But if the general state of the atmosphere below the clouds be very damp, the superabundant electricity would be quietly conveyed to the earth without producing any electrical appearances whatever.

In those regions of the atmosphere where clouds float or are formed at a considerable elevation, and where the air is much more rare than near the surface of the earth, the resistance to the passage of electricity through it is much less than near the ground, and consequently the discharges from cloud to cloud will be more frequent and to greater distances than from the clouds to the earth.

If the clouds are rapidly formed and discharge their electricity frequently to the earth, it is probable that a very large amount of rain will ensue; for during the time they are charged, the small particles of water of which they are composed will be repelled from each other by the diverging power of their electricity; whilst the moment a discharge takes place, especially if it be to the earth, the electricity which kept the particles from uniting together being removed, the drops of water will immediately unite in immense quantities, and, falling to the earth, will suddenly increase the shower, not only in quantity but in the size of the drops, as is frequently noticed by attentive observers. As the different strata of air continue to mix, the clouds increase and again become charged with electricity, the drops again diverge by repulsion, and the rain ceases to fall as copiously as it did soon after the discharge of electricity to the earth; in this manner we may account for the occasional change during a thunder-storm, from an immense profusion to a moderate fall of rain, and *vice versâ*.

In a thunder-storm prevailing over a considerable extent of country, and with the clouds at a great elevation, the discharges of electricity may pass several miles through the air from one cloud to another; in such cases an observer may have considerable difficulty to ascertain in what portion of the sky the lightning has prevailed; but our late eminent president, Dr. Dalton, has elegantly described, at page 203 of the second edition of his Meteorology, how the difficulty can be explained.

The electrical state of the atmosphere must have been greatly disturbed for a much wider district than has been described ; but though we have no account of a thunder-storm having occurred on the 16th of July between Bury and the Derbyshire Hills, yet beyond them there was a severe storm ; for Mr. Ransome, F.R.C.S., informs me he was travelling on that day between Matlock and Buxton, and whilst on the railway, before arriving at Rowsley, they experienced a violent storm of thunder, lightning and rain, about five o'clock ; but on arriving at Buxton he did not hear that the storm had visited that neighbourhood.

In the country between Buxton and Holmes Chapel in Cheshire, a distance of twenty-five miles from east to west, and with some lofty hills to the west of Buxton, there was not any severe storm of thunder and lightning on that day ; but some sheet lightning and distant thunder were noticed over a considerable extent of that country in the course of the evening, with a little rain about sixteen or eighteen miles to the west of Buxton.

The storms herein described have no extraordinary features, except their violence and the melancholy casualties that accompanied them ; but they exhibit a case of electrical disturbance deserving notice in connexion with, or immediately preceding the very extraordinary appearances that occurred in the course of the same evening.

As the evening advanced, the sheet lightning became more frequent and vivid at Manchester ; and before nine o'clock the clouds in the south-south-west and west had become very dark, whilst those towards the south and south-east were not near so dense, and were separated into masses, with open spaces between them ; these spaces became very plainly visible when the sheet lightning occurred, which about this period was very frequent, and accompanied with distant thunder.

From a quarter before until half-past nine some very extraordinary appearances of lightning were observed, such as I never before witnessed ; several flashes seeming to be almost continuous, or repeated at such short intervals as were scarcely appreciable, whilst at other times the light actually continued for a considerable portion of a second.

The bright coruscations of the electric fluid, which on ordinary occasions pass between one cloud and another, or between a cloud and the earth, in a tortuous or zigzag line, on this occasion presented a great variety of forms and ramifications towards the south and south-south-west, similar to the accompanying sketches, and at an elevation of from fourteen to twenty degrees above the horizon (see Plate I.) ; sometimes

Fig 1.

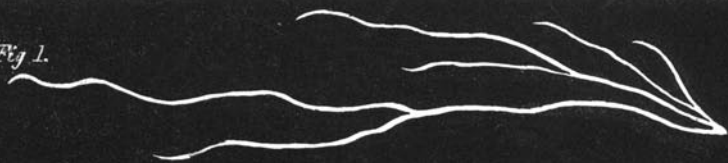


Fig 2.



Fig 3.



Fig 4.



Fig 5.

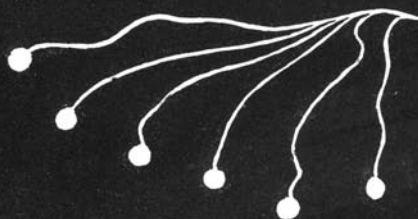


Fig 6.

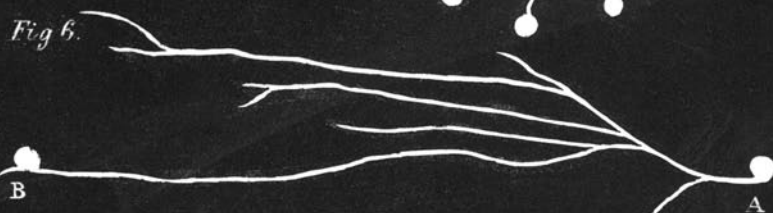


Fig 7.



they appeared branched like the roots of a tree, and occasionally with bright balls at the termination of all or some of the branches. These coruscations of light commenced about the south-west by south, and in all cases proceeded from west to east, or from right to left, passing through a horizontal space of from eight to fourteen degrees; and at times the motion of the electric fluid appeared to be so slow, that its progress could be easily observed.

On three or four occasions, immediately after a ray or narrow line of light had passed through a horizontal space of ten or twelve degrees, a luminous ball of considerable size, more than twice the diameter of Venus when at her greatest brilliancy, suddenly appeared, and moved along in the same direction as the ray of light had passed, with a progressive motion from right to left, as from A to B in figs. 2 and 6, and occupied at least the tenth of a second in its progress. The other appearances were of a similar character to what are given in the different figures, and their motion varied from a horizontal to a vertical direction, as much as the position of the figures represented in the sketches.

Some of the coruscations of the electric fluid terminated with a bright ball at the extremity of each branch, as in fig. 5; whilst at other times bright balls were seen at only two or three branches, as at fig. 7. In all cases these luminous appearances seemed to commence from a point where the clouds were not dense or dark, and to proceed through the air to their termination without entering or being obscured by a cloud.

These, or similar phænomena, were observed by Mr. Ransome and his son at Fairfield, near Buxton, in a westerly direction, about eight o'clock; but with this difference, that the branches appeared to pass from left to right, whilst those I witnessed passed from right to left; similar appearances were seen by Mr. Chrimes to the north of the zenith, about a mile beyond Wilmslow in Cheshire, who also observed that the branches passed from left to right, beginning in the west and moving towards the north-east; and in some cases they were so near the ground, that when they disappeared he thought they were in contact with the hedges.

Edward Brooke, Esq., of Marsden House, about five miles to the east of Stockport, with some friends who were on a visit to him, also observed these remarkable coruscations, which he says proceeded from left to right, similar to those observed near Buxton and Wilmslow; and Colonel Stott, who was of the party, and who had been several years resident in the East Indies, declared he had very frequently noticed the dis-

play of lightning in that part of the world, but never saw anything like the coruscations that appeared that evening.

Mrs. Clayton, of Adlington in Cheshire, whose residence is situated three or four miles to the south of Marsden House, also observed these brilliant coruscations, and likewise says they appeared to proceed from left to right, or in a direction contrary to the drawings in the Plate.

Mr. Alderman Shuttleworth informs me that his sister-in-law observed these remarkable coruscations of lightning in the neighbourhood of Bolton, which, being twelve miles to the north-north-west of Manchester, gives a much wider extent of country in which they were observed than the previous accounts have stated. In the extract of a letter from her which he has sent, she says, "I was at Bolton on the 16th of July, and witnessed an awful storm of thunder and lightning * * * about eight a servant who was watching at an upper window came to say that she saw rings of fire in the sky. There was a large black cloud in the south-west; behind it the heavens appeared to open, throwing forth sometimes showers of brilliant sparks or of balls of fire, sometimes circles of flame, sometimes fiery serpents, and at others forked lightning of unusual breadth, the clouds always edged with beautiful sheet lightning."

Mr. Joule, F.R.S., has published a highly interesting account in the *Philosophical Magazine* for August, of these remarkable phænomena as observed by him. He says, some of the coruscations passed across the zenith; and from the time that elapsed between seeing them and hearing the thunder, he considers their general elevation to have been about three miles and a half: he likewise observed that the branches moved from right to left, similar to what I saw, as shown in the accompanying figures. His residence is about a mile and a quarter to the west-north-west of mine. He has given a sketch in the *Magazine* of the appearance observed by him, which terminated in more numerous branches than those I noticed; but though I did not observe any branches so much fimbriated at the end as he has represented, yet Mrs. Clayton, to whom I showed his account, said she saw some branches very much like the figure accompanying his paper, but with curves at the ends bent more inwards than in his figure.

With regard to the identity of these luminous appearances seen by different individuals, and the apparent difference in the direction of their motion, as stated by the observers at Buxton, Marsden House, Adlington and Wilmslow, compared with the account given by the observers at Manchester and its vicinity, it may be remarked that Marsden House is

to the south of east, Buxton and Adlington to the south-east, and Wilmslow nearly south of Manchester. Now if we suppose these coruscations to have moved from south-west to north-east, and some of them at no great elevation above the earth or distance from Manchester, they would appear to move from right to left at that town or its vicinity; but if the same were observed at Marsden House, Adlington or Wilmslow, they would appear to move in an opposite direction with regard to the spectator, or from left to right, although in both cases their motion would actually commence in the south-west and be continued towards the north-east.

Considering the distance of Buxton from Manchester, it is not likely that the same coruscations would be seen at both places; nor would those observed near Buxton be identical with those seen near Marsden House, Adlington or Wilmslow, on account of the lofty hills intervening, and the low elevation of the electrical discharges seen at the latter place; it is therefore probable that these discharges of the electric fluid were not confined to a very limited space, but prevailed in the atmosphere over a considerable district of country, and at a very moderate elevation; but there is not sufficient evidence to enable us to determine either their height, or to what extent they prevailed.

Mr. Chrimes states that he did not hear any sound as if it proceeded from the coruscations of light which he observed in the neighbourhood of Wilmslow; although at the same time he heard distant thunder in the west, but not any sound in the north or north-east, although that was the direction in which the lights were observed to pass and disappear. And as all parties agree that these brilliant ramifications did not proceed with the usual velocity of lightning, is it not probable that their motion was not sufficiently rapid to cause such a violent concussion in the air as to produce sound?

There were no very dense clouds where the coruscations appeared; but in the same direction the sky was mostly obscured with clouds of different heights, some of which, as well as various strata of the air, were probably in different states of electrification, whereby the electric fluid might be induced to pass from clouds positively electrified to those in a negative state, or to a stratum of air negatively electrified. In the passage of electricity from a body positively electrified, it frequently becomes divided into various branches, especially as it approaches the negative body: this is often illustrated in the progress of electrical discharges from the clouds to the earth, when they are observed to be divided into several branches as they approach the ground. Similar appearances

are often noticed in strong electrical discharges with a powerful machine, especially where the electric fluid has to be diffused on or amongst imperfect conductors.

Probably these or similar phænomena are not uncommon in the torrid zone, where it is said the coruscations of lightning are frequently seen in the sky when there are no clouds; but as similar appearances are rarely, if ever, observed in this neighbourhood, I have been induced to draw up the foregoing account in the hope that if similar phænomena have been noticed, some description of them may be given by other writers.

Manchester, September 30, 1850.

XLII. *Essay on the Theory of Attraction.* By JOHN KIN-
NERSLEY SMYTHIES, *Barrister-at-Law of the Middle Temple.*

To the Editors of the Philosophical Magazine and Journal.

3 Oakley Square, London,
October 14, 1850.

GENTLEMEN,

I ADMIT that my essay noticed in your last Number contains a serious error. I now perceive that wherever ϕ (the function of the distance, according to which the attractive force varies) occurs in an equation, the term involving it is multiplied by a function of the distances and angles, which is zero for all positions of the bodies, so that ϕ may have any value consistently with the equations containing it. The correction of this error requires that sections 11, and 13-18 inclusive, and some short references to them, should be cancelled: the remainder will be free from this error.

Till I read your notice, I supposed that my equation between the ten mutual distances of five points in space was new; and having since referred to Carnot's memoir, I find that the labour I spent on the solution of that problem is not wholly lost, since my demonstration is much shorter and less laborious for the reader than Carnot's. When all, in which I have been anticipated or have erred, shall have been deducted from my essay, I venture to express my hope that something new and true will still remain. By the publication of this short statement in your Magazine you will much oblige, Gentlemen,

Your obedient Servant,
J. K. SMYTHIES.