MESSRS. WATERLOW AND SONS, of 66, London Wall, announce that the invention of an entirely new method of producing a number of copies of the same manuscript without the use of ink, by a very simple process which they term printing by electricity, and to which we have already referred, may now be seen in operation on their premises.

WE have received a circular from the Secretary of the Philadelphia Philosophical Association, containing a statement of its leading principles, and an outline of the method pursued in carrying them out. These principles are stated to be :—1, That force is persistent; 2, That all knowledge is relative; 3, That philosophy is the synthesis of the doctrines and methods of science; 4, The critical attitude of philosophy is not destructive, but constructive; not sceptical, but dogmatic; not negative, but positive. The Association appears to have been established in November 1871, and proposes to select a number of suitable papers, or parts of papers, for publication in a Quarterly Journal.

A CORRESPONDENT at Brighton describes a solar phenomenon visible on the afternoon of April 8, at 5.35 P.M. The sun being just within the upper part of a mass of light clouds, through which it shone with a white glare, there appeared a distinct belt of colours, in order and apparent width exactly like those of an ordinary rainbow, but apparently flattened above. Half a minute afterwards a second belt appeared, equally bright, and with no interval between the two. At the same time a fainter belt appeared to the right, but not forming a part of the same circle as the others. The three were visible together, but did not last above a minute. After the unusual appearance was first noticed, the sky above was tolerably clear, with a few light upper clouds. After the prismatic lines had faded, there was that diffused white glare round the sun which is commonly said to betoken windy weather.

THERE is now every prospect that the getting of coal by machinery will be more generally adopted than hitherto. At present it has only been adopted at a few places, but a new machine, patented by Messrs. Gillott and Copley, has just been tested at the Wharncliffe Silkstone Colliery, near Barnsley, in the presence of a number of mining engineers from various parts of the kingdom, and with most satisfactory results. In 136 minutes a bank of coal, 58 yards long and four feet eight inches thick, was cut to a depth of three feet one inch. The quantity of coal so cut would be about 80 tons in the time stated. In connection with coal machinery a hydraulic coal breaker, patented by Mr. Clubb, of London, has just been very successfully tested at the Oaks Colliery, Barnsley.

AN Indian paper prints the following interesting account of a fight between a hyæna and a man :—"About five days ago a party of six natives coming towards Deyra through the Mohun Pass, were attacked by a hyæna; it made straight at one of them, and flew at his throat. The poor devil stretched out his hands to keep off his assailant, on which the hyæna bit them severely; his companions, instead of coming to his aid, took refuge in some adjoining trees; the man, finding himself thus deserted and his hands in a mutilated state, pluckily turned on his enemy, and seized his nose with his teeth, roaring out in the best way he could for assistance. By this means he secured the animal, and his companions, taking courage, came down from their secure position, and belaboured the beast to death with sticks. I saw the unfortunate man at the dispensary, where he had gone to have his wounds dressed, and was shown the head of his enemy having his teeth marks on the nose. I believe this is almost an unprecedented instance in the annals of natural history, as a hyæna is well known as a most cowardly brute, never venturing to attack man, but preying chiefly on dogs, carrion, and young children."

ANNUAL ADDRESS TO THE GEOLOGICAL SOCIETY OF LONDON, FEB. 16, 1872

BY J. PRESTWICH, F.R.S., PRESIDENT

(*Continued from page* 433.)

Our Coal-measures and our Coal-supply

WHILE the presence of water has determined the early settlement of population, the existence of coal has given rise to exceptional local growths of that population, quite irrespective of the original cause of settlement. The existence of coal has created new wants, developed vast energies, enormous resources, and has established great industries dependent upon it for their maintenance and prosperity. Natural causes, unceasing and ever renewing in their action, maintain our supplies of water in a condition of constant and unfailing operation. They are physical and geological agents, equally in force in the past as in the future of the earth's history. Not so with coal, which is a store of the past, and of which we can look for no renewal. Our Coal Measures, great as they are, have defined limits, whereas our wants seem to have no bounds. With the increasing magnitude of the latter our fears of the extent of the former have increased, and have given rise to much speculation and much discussion. At first the estimates of the duration of our coal-fields were little more than guesses; but the subject has of late years been treated in a systematic manner, and in all its various bearings, in the able works of Hull, Jevons, and Warington Smyth. To obtain more precise data on these important questions, the Royal Commission of 1866 was appointed, with your President-elect, the Duke of Argyll, at its head. On the practical and economical questions different members of the Commission and separate committees have made valuable reports. I wish on this occasion merely to direct your attention to some of the more special geological bearings of the questions discussed in one of the committees, of which the lamented Sir Roderick Murchison was chairman, the object being "to inquire into the probability of finding coal under the Permian, New Red Sandstone, and other superincumbent strata."

On the evidence laid before this committee regarding England north of the Bristol coal-field, Prof. Ramsay was deputed to report, while the south of England was relegated to myself. The one district embraces all the unproved older secondary tracts between the different well-known coal-fields of the central and northern portions of England. The other district takes in that occupied by the later Secondary and the Tertiary strata, already the subject of a valuable paper in our Journal for 1856, by Mr. Godwin-Austen. The excellent mapping of our coal-districts by the Geological Survey, and their accurate sections through the several coal-fields, furnished Prof. Ramsay with data which have enabled him to prolong these sections across the intervening tracts with a degree of certainty which gives them very great value. He has presented us with 32 such sections, which, when published, will, with the text already before the public, show how great has been the task, and how successfully it has been accomplished.

The area of the exposed coal-measures of England may be estimated at about 2,840 square miles. To these Mr. Hull had added 932 square miles of coal-measures overspread by newer formations. The investigations of Prof. Ramsay lead him now to conclude that this latter total of unproved coal-measures may be increased to 2,988, to which may be added 153 miles of the Bristol coal-field, making a total of 3,141 square miles of Coal-measures under the Permian, New Red, and Triassic strata of central and northern England, or of 301 square miles more than the area of all our exposed coal-fields. This branch of the inquiry embraces curious questions of variations in the mass of the coal-measures, in the thickness of the strata, and in the number and persistence of the coal-seams. The extent and magnitude of the faults bounding so many of our coal-fields, is also a point of great difficulty, especially when it is complicated by denudations of pre-Permian and of pre-Triassic age; and in this intricate inquiry it must be borne in mind that it is only a question of superposition and faulting, but one also of removal and replacement, involving a number of important geological problems. Especially is it necessary to distinguish steep old-surface and submarine valley denudations from faults.

The other inquiry relating to the possible range of the coal-measures under the Jurassic, Cretaceous, and Tertiary strata of the south-east of England, involves questions of a much more hypothetical character, and can, in the absence of positive in-

formation, only be treated on purely abstract geological reasoning. Still it is one essentially within the range of inquiry, and the collateral geological data we possess are sufficient to guide and direct those inquiries. There are two primary points to be determined:—First, how much of the area under investigation remained dry land during the Carboniferous period, and was therefore never covered by Coal-strata. Secondly, supposing the Coal-strata to have spread over a portion of that area, how much of them escaped subsequent denudation? With regard to the first question it is comparatively easy, where the Palæozoic rocks now form the surface, to determine the antiquity of that surface, but where the old rocks are covered by great masses of other strata it becomes very difficult to determine the original conditions. Mr. Godwin-Austen has ingeniously sought to establish the position of the old coast-lines of the Carboniferous and other periods, the area of the old coal-growth, and the great features of the ancient physical geography of this period in Western Europe. I have given more especial attention to relations of the Secondary and Palæozoic formations to one another and to those points which depend upon physical conditions connected with the nature and age of old disturbances and denudations, the direction and position of the great anticlinal and synclinal lines, to the correlation of certain strata, and the dimensions of the overlying strata.

The great lines of disturbance traversing Central and North-eastern England are subsequent to the Carboniferous period, and the many detached coal-basins separated by the Penine chain and the Derbyshire hills, together with the Mountain Limestone forming those ranges, are held to be portions of one great Carboniferous formation, which, in its entirety, spread from the south of Scotland to central England, and, as we shall observe presently, probably still farther south. This great Carboniferous deposit was originally bounded on the north either by the uplands of the Scottish-border counties, or, possibly, by the Grampians; on the west by the high lands of Cumberland and Wales; while on the south we find no old exposed land-surfaces of older Palæozoic age until we reach Brittany and Central France. With respect to the deposits going on during the Carboniferous period in this area, Professor Phillips was the first to show that the lower Carboniferous series puts on, as it trends north from Derbyshire, more sedimentary conditions—that the Mountain Limestone there begins to show traces of the proximity to land, which increase rapidly in proceeding northwards,—beds of shale and sandstone and subordinate beds of coal gradually setting in in the limestone series, and increasing in importance as they approach the older border land. In the same way the approach to an old barrier-land on the south and west is supposed by Professor Ramsay to be indicated in the overlying Coal Measures by the increase in number and thickness of the beds of sandstone in the south of the Staffordshire and Shropshre coal-field, and Mr. Hull connects that old land with the Cambrian and Silurian rocks of Leicestershire.

If such were the case, the question arises, did this form a barrier which cut off the Carboniferous deposits from extending over the south of England, or was it only a partial barrier which in no way prevented the extension southward of the Carboniferous rocks?

It has been supposed that during the Carboniferous period a spur from the Silurian district of Wales extended eastward from Herefordshire into central England, dividing the coal-fields of Shropshire and Staffordshire from those of Gloucestershire; and that against this old Silurian tract the Coal Measures of South Staffordshire die out. If carried farther eastward it would limit the southern prolongation of the Coal Measures of Leicestershire, and then pass under the Oolites of Northamptonshire and the Cretaceous series of Norfolk; and so great an expansion has been given it southward, that it would equally exclude the Coal Measures from the area of the south-east of England. We have, however, no sufficient evidence of the continuous extension of these old rocks eastward of Staffordshire. Palæozoic rocks show, it is true, in Leicestershire; but there the Coal Measures wrap round them, and the older rocks seem merely to be an island in their midst. At those spots in the southern counties where they have been proved underground, I imagine they were raised by disturbances of a later date than the Coal Measures, and did not form part of the land surface of the Carboniferous period. As just mentioned, the older Carboniferous rocks show deeper-sea conditions as they trend from north to south, and the same deep-sea conditions existing in Derbyshire are found to prevail in the Mountain Limestone of Belgium, while, at the same time, similar slight indications of distant land, in the presence of intercalated shales and imperfect coal, reappear and increase westward in their range into the district of the Boulonnais, in France. There is nothing to show but that the spur of old land stretching eastward from Herefordshire was merely a promontory ending in Warwickshire, and round which the Carboniferous sea passed and extended southward uninterruptedly to Belgium and the north of France, and westward to Somersetshire and South of Wales, spreading over all this wide area first the Mountain Limestone and then, in due order, the Coal Measures. Of the existence of these formations over the south-western and south eastern portions of this area we have proof in Wales, Somersetshire, and Belgium. The intermediate area is covered by Jurassic, Cretaceous, and Tertiary formations, which hide from us the older rocks whose position it is our object to determine.

Just as with the disturbance which at a later period caused the Mountain Limestone of the Penine chain to break through the great expanse of Coal Measures originally spread over the central and northern counties of England, and brought up to the surface the disturbed and disjointed coal-strata, of which, after subsequent denudation, we have the isolated portions remaining in the existing coal-fields, so was the area of Southern England traversed by the earlier axis of Palæozoic rocks of the Ardennes and Mendips, bringing up the Coal Measures in like manner along their northern flanks in separate basins and troughs, some of which are uncovered by newer strata, while other basins not exposed on the surface may still possibly exist beneath the newer strata of the south-east of England. They have in fact been proved to exist under considerable portions of those newer strata of north-western France and of Belgium, and under some of the older Secondary strata in the south-west of England.

The probable continuation of this great range of Palæozoic rocks from the Rhine to South Wales, passing underground in the south of England, was shadowed out by Buckland and Conybeare in 1826, commented on by Dufresnoy and Elie de Beaumont in 1841, by M. Meugy in 1851, and more fully investigated and discussed by Mr. Godwin-Austen in 1855. These views having been controverted, the subject was fully discussed by the Commission, and again in the separate report drawn up by myself.

All geologists are agreed upon the age of this great east-and-west axis of disturbance. It took place after deposition of the Coal Measures, and before the deposition of the Permian strata. Its effects, all through its range, are singularly alike. It was not so much a great mountain-elevation, as a crumpling up and contortion of the strata for a breadth of many miles, and along a length of above eight hundred miles. The Silurian and Devonian rocks are thrown up by it into a number of narrow anticlinals, and the flanking coal-strata are tilted, turned back on themselves, squeezed and contorted in the most remarkable manner,—the same type of disturbance being apparent whether in Westphalia, Belgium, France, Somerset, or Pembroke. These great flexures have also resulted in throwing the Coal Measures into deep narrow troughs, having a length of many miles and a width of but very few.

In France, these disturbed old strata are covered transgressively by Jurassic, Cretaceous, and Tertiary strata, and in Somerset by Permian, Liassic, and Jurassic strata; they sink beneath the Oolites at Frome, and reappear in Belgium from beneath the Cretaceous strata. What becomes of them in the intermediate area? It is not to be supposed that a line of disturbance of such great magnitude could have been intermittent. The coal-trough has, in fact, been followed from near Charleroi, where it passes under the Cretaceous and Tertiary strata, to Mons, Valenciennes, and Bethune, a distance of eighty-six miles. Along the whole of this line, the Chalk and overlying beds extend, with a thickness varying from 500 to 900 feet around Mons, decreasing to from 250 to 300 near Valenciennes, and increasing again towards Bethune. At Guines the Chalk was found to be 670 feet thick, and at Calais 762 feet. On the other side, the coal-trough of Somerset passes eastward under the older Secondary rocks, which in their turn pass under the Cretaceous and Tertiary strata of Wiltshire; but no attempt has been made to follow Coal Measures beyond a distance of six miles from their outcrop, where the overlying strata have been found to attain a thickness of about 450 feet.

The original supposition that the Secondary strata maintained, in the main, their regular sequence, and, to a certain extent, their thickness over large areas has long been proved to be erroneous;

but we were hardly prepared until lately to learn how rapid the variation in their thickness is. Mr. Hull has now shown that the Great and Inferior Oolites thin out from a thickness of 792 feet in Gloucestershire to 205 feet in Oxfordshire, and the Lias and Trias from 1090 feet to 400 (?) feet; while in like manner the Trias decreases from 5600 feet in Lancashire and Cheshire, to 2000 in Staffordshire, and 600 feet in Warwickshire. We also know that on the northern flank of the Mendips, the Trias, Lias, and Oolites tail off, although their dimensions in Gloucestershire are so considerable. It would appear that all the Secondary rocks, except those of the Cretaceous series, show a distinct thinning-out in their range southward, which is doubtless due to the existence of an old pre-Triassic land on the south—such as would have been formed by the prolongation of the Palæozoic rocks of the Ardennes and Mendips through the south of England. It has been urged, on the other hand, that this thinning-out is a proof of the existence of a still older land in that area; but as the argument is based on the evidence of rocks of post-Carboniferous age, it is clear that, whether the land were of Cambrian and Silurian, or of Devonian and Carboniferous age, the result, as affecting the Secondary rocks, would be the same.

This thinning-out of the Secondary strata has now been proved not to be merely hypothetical. At three points, on or near the presumed line of the old underground range, the Tertiary and Cretaceous strata have been traversed in well-sections, and Palæozoic rocks found to underlie them at once, without the intervention of any Triassic, Liassic, or Oolitic strata. Thus at London the presence of red and grey Sandstones, apparently of Palæozoic age, has been proved under the Chalk at a depth of 1,114 feet. Again, at Harwich and at Calais, strata of early Carboniferous age have been found also immediately under the Chalk, at depths respectively of 1026 and 1032 feet. There is therefore reason to believe that the underground ridge of the Mendips and the Ardennes passes in a line from Frome through North Wiltshire, Berkshire, Middlesex, North-east Kent, and between Calais and Boulogne, at a depth beneath the Secondary strata of not more than from 1000 to 1500 feet, while the coal-troughs, which may flank this range on the north would, judging from the analogy of the structure and relations of the same rocks at Mons and Valenciennes, be met with at depths very little, if at all, greater.

To the north of this area it is probable that the thickness of the overlying rocks is greater; but we have no means of knowing exactly. In Northamptonshire the Great and Inferior Oolites and the Lias have been found not to exceed together 880 feet, at which depth the New Red Sandstone was reached; but its thickness was not proved beyond 87 feet; while at Rugby, the Lias was found to be about 905 feet thick, below which 136 feet of beds of New Red Sandstone were passed through. Looking at the proved thinning out from north to south of the New Red and Permian strata, there is no reason to suppose that they would be found of any very great thickness in the southern counties. Even immediately to the south of the known coal-fields of the Midland counties, the trials for coal have not yet proved any very great thickness of these rocks. It would seem, in fact, that the extensive tracts of Chalk, Oolites, and Trias, forming the substrata of our Midland and Southern counties, constitute but a comparatively shallow crust filling up the plains and valleys of Palæozoic rocks, the great framework of which stretches apparently at but a moderate depth under our feet, and of which the highest ridges only, such as those of the Ardennes and Mendips, now rise above ground.

It is clear, therefore, that in any search for coal, the relation of the Secondary and the Palæozoic groups of rocks to one another being perfectly independent, the latter must be considered entirely on their own internal evidence, and apart from the bearing of the newer rocks covering them and forming the present surface, except possibly in a few cases where old lines of disturbance have proved points of least resistance, and yielded again, as suggested by Mr. Godwin-Austen, to later movements, which have equally affected the overlying formations.

It may be asked if any correlation can be established between the coal-measures of Bristol and South Wales and those of France and Belgium. So far as the identity of any particular bed of coal or of rock, it is impossible, and we should not expect it; for the variation in all the beds of any coal-basin is well known to be so great and rapid, that in the different parts of the same basin it is often difficult, and sometimes impossible, to establish any correlation; while in adjacent basins, such as those of Wales and Bristol, or of Hainaut and Liége, such attempts have, with few exceptions, hitherto utterly failed. There are, however, more general features which serve to show, at all events, some relationship. The great dividing mass of from 2,000 to 3,000 feet of rock called Pennant exists in both the Welsh and Bristol coal-field; and the total mass of coal-measures is not very different, it being 10,000 to 11,000 feet in the one, and from 8,000 to 9,000 in the other, and there being in Wales 76, and in Somerset 55 workable seams of coal. In the Hainaut (or Mons and Charleroi) basin, the Measures are 9,400 feet thick, with 110 seams of coal; in the Liége basin 7,600 feet, with 85 seams; and in Westphalia 7,200 feet, with 117 seams. On the other hand, none of our central or northern coal-basins, with the exception of the Lancashire field, exceed half this thickness, and more generally are nearer one fourth. Further, the marked difference which exists between the northern coals and those of Wales and Somerset, the preponderance of caking-coals in the north, and of anthracite, steam, and smiths' coal in the south, equally exists between our northern coals and those of Belgium, which latter show, on the other hand, close affinities with those of Wales and Bristol. I am informed by two experienced Belgian coal-mining engineers and good geologists, who have twice visited our coal-districts, that the only coals they found like those of Belgium were the coals of South Wales and Radstock—there was the same form of cleavage, the same character of measures, and the same fitness for like economical purposes. Organic remains help us but little, but too little is yet known of their relative distribution. The plants are, as usual, the same; so also are shells of the genus *Anthracosia*, and a number of small *Entomostraca;* while there is a scarcity of many of the marine forms which are more common in some of our central and northern fields. That, therefore, which best indicates the relation between the coal-fields of the south-west of England and those of the north of France and Belgium, is the similarity of mass and structure, uniformity of subjection to like physical causes, and identity of relation to the underlying older and to the overlying newer formations.

It was in the north that the conditions fitted for the formation of coal first set in. The common *Stigmaria ficoides* and various Coal Measure plants appear at the base of the Carboniferous or in the Tuedian series of Northumberland, which there overlies conformably the Upper Old Red Sandstone; and productive beds of coal exist low down in the Mountain-Limestone series. These disappear in proceeding southward, and the great productive coal-series becomes confined to beds overlying the Millstone Grit. If the coal-growth set in earlier in the north, it seems to have been prolonged farther south, under more favourable conditions, to a later period. What those conditions were—whether the proximity of a greater land-surface, of a longer and greater subsidence, with more numerous rests—we cannot yet pretend to say.

Of the prolongation of the axis of the Ardennes under the south of England there can be little doubt; nor can there be much doubt that the same great contortions of the strata, which in Belgium placed the crown of the anticlinal arch at a height of four or five miles above the level of the base of the accompanying synclinal trough, to the bottom of which the Coal Measures descend, and was the cause of similar folds in the Coal Measures of Somerset and Wales, were continued along the whole line of disturbance, and that the preservation of detached portions of the same great supplementary trough is to be looked for underground in the immediate area, just as it exists above ground in the proved area; for the minor subordinate barriers dividing the coal-basins can, I conceive, in no way permanently affect the great master disturbance, by which the presence of the Coal Measures is ruled. Whether, however, admitting that the Coal Measures were originally present, they have been removed by subsequent denudation is another question.

(To be continued.)

SCIENTIFIC SERIALS

Annalen der Chemie und Pharmacie, December 1871. A considerable part of this number is occupied by a valuable paper "On valeric acids from different sources," by Erlenmeyer and Hell. They prepared isobutyl iodic acid, and from this the corresponding iodide, which they treated with alcoholic potash to convert it into potassic valerate; the valeric acid from these reactions had no action on polarised light. They prepared valeric acid from valerian root, and this also had no rotating action on a