and Kettle rivers, in Minnesota, where the Keweenawan beds are identical in all respects, even to the occurrence of interbedded porphyry-conglomerates and cupriferous amygdaloids, with those of Keweenaw Point.

As to the Animikie group, I have only to say, that I have not asserted its identity with the so-called Huronian rocks on the east shore of Lake Superior, spoken of by Mr. Selwyn, but merely its *probable* identity with the original Huronian of the north shore of Lake Huron, which neither I nor Mr. Selwyn have seen, and its certain identity with the iron-bearing schists of the south shore of Lake Superior. The term 'Huronian' has been so differently used by different members of the Canadian geological corps since the first establishment of the system, that much doubt must still remain as to whether there are two sets of schistose rocks north of Lake Superior, or not. This much, however, I regard as certain; viz., that the flat-lying Animikie rocks of Thunder Bay and northern Minnesota were once continuous with *some* of the folded schists lying north of them in northern Minnesota and Canada, — the Vermilion Lake iron-bearing schists, for instance, — although now separated from them by belts of gneiss and granite. The lithological differences between the Animikie rocks and the folded schists are often more apparent than real; while, in many respects, there is a very close lithological likeness. However, I do not expect, and indeed have no right to expect, acquiescence in my novel position as to the Animikie rocks until the evidence I have collected has been published. I am confident, that, with the evidence that I now have, in his hands, Mr. Selwyn would at least think the matter worth looking into.

With regard to the occurrence of volcanic ash in the Keweenaw series, I must acknowledge at once, that, so far as field-experience goes, Mr. Selwyn is far better equipped than I to judge of such materials, and that, not having seen Michipicoton Island, I am bound to accept his statement. I understood his first letter to indicate the occurrence of such ash in places which I had myself seen. Nevertheless, I bear in mind that a considerable school of English geologists has been long in the habit of calling almost any detrital rocks, not distinctly quartzose and associated with eruptive rocks, *volcanic ash*, when very often, at least, they might be simply derived by water-action from these rocks. Possibly there is some misunderstanding in our use of the term. Most of the detrital rocks of the Keweenaw series are volcanic detrital matter, in that they have been derived by water-action from the eruptive, massive rocks of the same series; but I used the term as applied to fragmental material produced by the volcanic action itself. I do not know of any *proof* of such an origin in stratified material, other than the vesicular character, and perhaps constant angularity, of the particles, which proof I have failed to find.

The discussion of such a question as the present one evidently cannot, however, be carried on satisfactorily in the pages of a journal; and I must ask my scientific *confrères* to defer their judgment until my publications on this subject, now in type, are issued. R. D. Irving.

University of Wisconsin,
April 12, 1883.

Pairing of the first-born.

As regards the pairing of the first-born, my calculation of which called forth Mr. Hendricks's criticism, permit me to call attention to the following letter from Mr. Edmands, which I hope will set the matter straight. I applied to Mr. Edmands, because mathematics is not my *fach;* and I now have the pleasure of thanking him for the very kind attention he has given this matter. Charles Sedgwick Minot.

Boston, April 24, 1883.

As J. E. Hendricks remarks in Science of April 13, p. 278, "the chance that the first-born male will pair with the first-born female is as one to ten;" but Dr. Minot's argument in Science of March 16, p. 165, depends upon "the probability of both parents" being first-born, as stated at the beginning of the last paragraph on p. 165. If we first restrict the case to the offspring of first-born males, the chance that both parents will be first-born is evidently one in ten. But in the remaining ninety per cent of the race there would be no case of both parents being first-born. Taking the race as a whole, out of one hundred pairs, one pair would be both first-born, nine would have the male only first-born, nine the female only, and eighty-one (9×9) neither male nor female first-born. This does not touch the question whether Dr. Minot is justified in giving no weight to the eighteen cases in a hundred, where only one individual of the pair is first-born. J. Rayner Edmands.

Cambridge, April 19, 1883.

Place the ten females in a row, and the ten males opposite them, with the 'first-born' opposite each other. The ten males are susceptible of $1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 \times 9 \times 10$ permutations, each of which furnishes a distinct system of pairing. Of these, $1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 \times 9$ are possible without disturbing the juxtaposition of the first-born. The chance of their pairing will therefore be,

$$\frac{1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 \times 9}{1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 \times 9 \times 10} = \tfrac{1}{10},$$

as stated by Dr. Hendricks in Science, April 13, p. 278. Mr. Minot's solution is correct only upon the supposition that *one pair, and no more,* will be formed. T. C. M.

JAMES CLERK MAXWELL.

The life of James Clerk Maxwell; with a selection from his correspondence and occasional writings, and a sketch of his contributions to science. By Lewis Campbell and William Garnett. London, *Macmillan & Co.*, 1882. 16+662 p., 3 portr., 4 pl., facsim., etc. 8°.

James Clerk Maxwell was born in Edinburgh on the 13th of June, 1831. He died Nov. 5, 1879.

The late Professor Benjamin Peirce once said in the hearing of the writer, that great geometricians did their best work before they had reached their fortieth year. This can hardly be said of the mathematical physicist; for the constant accumulation of new facts tends to make mature years the most fruitful in results to the student who still preserves his mental and physical activity. Commoner men doubtless, in time, make good the premature loss to the world of a genius. Those epochs, however, in a nation's history, in which men of scientific genius live to a mature old age, will always be considered important ones.

Maxwell was fortunate in possessing a father who early perceived the genius of his son, and directed his mind toward the study of mathematics and physics. He was also fortunate in springing from a race in which ability seemed to be hereditary. 'The Clerks' for two centuries had been associated with all that was most distinguished in the northern kingdom, from Drummond of Hawthornden to Sir Walter Scott. John Clerk, the father of James Clerk Maxwell, the subject of the present sketch, succeeded to the property of Middlebie, which descended to him from his grandmother, Dorothea, Lady Clerk Maxwell, and assumed the name of Maxwell. It is related of him, that he took the greatest interest in science, especially in practical science. In a letter to his son, then at Cambridge, who proposed to spend the Easter holidays at Birmingham, he wrote, "View, if you can, armorers, gun-making and gun-proving, sword-making and proving, *papier-maché* and japanning, silver plating by cementation and rolling, ditto electrotype, Elkington's works, braziers' works by founding and by striking out in dies, turning, spinning teapot bodies in white metal, making buttons of sorts, steel pens, needles, pins, and any sorts of small articles which are cunningly done by subdivision of labor and by ingenious tools. Glass of sorts is among the works of the place, and all kinds of foundry-works, engine-making, tools and instruments, optical and [philosophical], both coarse and fine."

His acme of festivity was to go with a boon friend to a meeting of the Edinburgh royal society. It is said by those who knew both parents, that the element of practicality entered very largely into their natures. The fine spirit of genius, the great imaginative powers, were not especially evident in them. Perhaps if the father had had the speculative mind of the son, he might have turned him toward philosophy and literature. The possession, in the father, of great interest in practical and useful processes, doubtless influenced the son's future.

At an early age Maxwell showed that he inherited the curiosity of his father in regard to machines and the phenomena of nature. It is related, that, when he was two years and ten months old, "he has great works with door-locks, keys, etc.; and 'Show me how it doos' is never out of his mouth." Throughout his childhood his constant question was, 'What's the go o' that?' He was especially interested in colors. 'That (sand) stone is red; this (whin) stone is blue.' — 'But how d'ye know it's blue?' His aunt, Miss Cay, was heard to remark "that it was humiliating to be asked so many questions one could not answer, by a child like that." The picture given of the boy's pursuits —his great activity of body and mind; his delight in nature's moods; his love for the deep brown of the brook, the shifting play of light on the foliage, the colors of the wandering clouds; his moods of lying on his back, watching the clouds, and 'wondering' — shows the boy as father of the man. On stormy days he read voraciously every book within his reach, or spent his time in drawing, or inventing curious combinations of colors. The specimens of his early drawings show that he had an accurate eye, which might have made him an artist of fair talent. At the age of ten his tutor pronounced him slow to learn, probably judging him by old scholastic methods, which were ill fitted to bring out the child's tastes; and his father accordingly placed him at the academy in Edinburgh. Here the boy, who had been brought up apart from other boys, and had been accustomed to '*gang his own gate*' with youthful fancies unridiculed by the average unpoetical schoolboy, was much persecuted at first by his school-fellows, who were amused by his singular clothes and broad accent. He gradually made a place for himself, however, and discovered that Latin was worth learning, and Greek very interesting. It is related that he took the foremost place in Scripture biography and in English. In arithmetic, as well as in Latin, his comparative want of readiness kept him down. At the age of thirteen he remarks in a letter, "I have made a tetrahedron and a dodecahedron, and two other hedrons whose names I don't know." At this time he had not begun geometry; yet he had discovered for himself the nature of the five regular solids, and had also constructed out of pasteboard other symmetrical polyhedra.

His sense of humor is early apparent. In one of his letters, written at the age of eleven, he writes concerning his place in the class, "Talking about places, I am fourteen to-day, but I hope to get up. Ovid prophesies very well when the thing is over, but lately he has prophesied a victory which never came to pass." He enjoyed writing letters with curious illustrations drawn with pen on the margins, and subscribed himself Jas. Alex. McMerkwell, an anagram of his name. In one of these letters there is the first inkling of his poetic taste: "I made four lines of Latin one week. . . . But I am not going to try for the prize, as, when I lithp in numberth, it ith but a lithp, for the numberth do not come. . . .

But I am making English ones on the apparition of Creusa to Aeneas.

"O father! can it be that souls sublime
Return to visit our terrestrial clime?"

The story of his school-years, told in his life, is of great interest to the American boy who has been fitted for college at the old Latin school in Boston, or at the ordinary American academy. Writing Latin verses was a marked feature of the academy at Edinburgh. This practice is comparatively unknown in our schools and academies. The present writer remembers that the subject of geometry was finished, so to speak, in the Boston Latin school in 1863, in about three months. In the Scottish academy the boy's mind was evidently allowed to rest upon the subject much longer, and he was stimulated to do problems of a more or less inventive kind. It was said of Maxwell at the age of fifteen, that, from "some mathematical principle, he would start off to a joke of Martinus Scriblerus, or to a quotation from Dryden, interspersing puns and other outrages on language of the wildest kind, humming and hawing in spite of P——; or, in a quieter mood, he would tell the story of Southey's Thalaba, or explain some new invention." This seems to show that the Scotch boy had a wider intellectual atmosphere around him than falls to the lot of the average American boy. But Maxwell, it may be remarked, was not an average Scottish boy. At the age of fourteen he gained the prize for English verse, for a poem on the death of the Douglas, and also the mathematical medal.

At the age of fourteen he was much attracted to the subject of decorative painting, especially to the attempts of those who sought to reduce beauty in form and color to mathematical principles, and often discoursed upon the Greek patterns and on the forms of Etruscan urns. The consideration of this subject led him to contrive methods of drawing a perfect oval, and ovals in general. His father, who had watched his son's intellectual development with sympathetic interest, took his son's ovals to Professor James O. Forbes, of the University of Edinburgh, who thought that the simplicity and elegance of the boy's method entitled it to be brought before the Royal society. In the diary of the father we read, "M. 6. — Royal society with James. Professor Forbes gave account of James's ovals. Met with very great attention and approbation generally." From this time the boy evidently studied geometry by the inventive method, to which the father of Mr. Herbert Spencer has deservedly called attention.

Maxwell entered the University of Edinburgh at the age of sixteen. It is said of him at that time, that the originality and simplicity of his ways occasioned some concern to his conventional friends. He had a rooted objection to the vanities of starch and gloves. While at table he had an abstracted manner, as if occupied in studying the effects of refracted light in the glasses, or in devising some curious way of viewing objects. His aunt used to recall his attention by crying, 'Jamsie, you're in a prop' (mathematical proposition). His teachers had formed the highest opinion of his intellectual powers; and his companions enjoyed his quaint humor, and began to appreciate his high moral qualities, which were exemplified by his deep reverence for higher things, and his devotion to friends and to those who were suffering.

Between the ages of sixteen and nineteen he studied at the University of Edinburgh. His studies were multifarious, but he was especially interested in polarized light, the stereoscope, galvanism, rolling curves, and the comparison of solids. His paper on rolling curves was presented to the Edinburgh Royal society, Feb. 19, 1849, by Professor Kelland; "for it was not thought proper for a boy in a round jacket to mount the rostrum there." A paper on the equilibrium of elastic solids was also presented in the spring of 1850. It is related of him at this time, that he was regarded as a discoverer in natural philosophy, and a very original worker in mathematics. He is said to have felt the importance of cultivating the senses, and to have regarded dulness in that respect as a bad sign in any man. It is curious to notice, that he took great interest in the lectures of Sir William Hamilton on metaphysics. The views of the latter on the inferiority of the study of mathematics as a means of discipline to the study of philosophy and the classics, apparently did not diminish Maxwell's interest in the lecturer. The editor of the life of Maxwell remarks, in regard to Maxwell's interest in the lectures of Hamilton, "This is perhaps the most striking example of the effect produced by Sir William Hamilton on powerful young minds, — an effect which, unless the best metaphysicians of the subsequent age are mistaken, must be out of all proportion to the independent value of his philosophy."

It is a noticeable peculiarity of great mathematicians, that their latter years are much given to metaphysics. With Maxwell, however, the reverse was true. While at the University of Edinburgh, he seemed to be as much attracted toward the study of metaphysics as toward mathematics, but hardly as much as to physics. As he grew older, the study of physics seemed to him more fruitful than that of mental philosophy.

His method of studying mathematics is often alluded to in his letters. Thus, in a letter to a friend, written at the age of sixteen, he says, "I read Newton's Fluxions in a sort of way, to know what I am about in doing a prop. There is no time of reading a book better than when you need it, and when you are on the point of finding it out for yourself, if you were able." Again, in another letter, in speaking of the division of his time: "Then I do props, chiefly on rolling curves, on which subject I have got a great problem divided into orders, genera, species, varieties, etc." He continually talks of doing 'props,' and apparently had a number upon which his mind was continually exercised. Nor was his method of studying physics less suggestive. In a letter dated Glenlair, July 5, 6, 1848, we read, "I have regularly set up shop now, above the wash-house at the gate, in a garret. I have an old door set on two barrels and two chairs, of which one is safe, and a skylight above, which will slide up and down. On the door (or table) there is a lot of bowls, jugs, plates, jam-pigs (jars), etc., containing water, salt, soda, sulphuric acid, blue vitriol, plumbago ore, also broken glass, iron and copper wire, copper and zinc plate, beeswax, sealing-wax, clay, rosin, charcoal, a lens, a Smee's galvanic apparatus, and a countless variety of little beetles, spiders, and wood-lice, which fall into the different liquids, and poison themselves. . . . I am making copper seals, with the device of a beetle. First I thought a beetle was a good conductor: so I embedded one in wax (not at all cruel, because I slew him in boiling water, in which he never kicked), leaving his back out; but he would not do. Then I took a cast of him in sealing-wax, and pressed wax into the hollow, and black-leaded it with a brush; but neither would that do. So at last I took my fingers and rubbed it, which I find the best way to use the black lead. Then it coppered famously. I melt out the wax with a lens, that being the cleanest way of getting a strong heat: so I do most things with it that need heat." He was busy at this age with experiments on polarized light and on colors. "I have got plenty of unannealed glass of different shapes; for I find window-glass will do very well, made up in bundles. I cut out triangles, squares, etc., with a diamond, about eight or nine of a kind, and take them to the kitchen, and put them on a piece of iron in the fire one by one. When the bit is red-hot, I drop it into a plate of iron sparks to cool; and so on till all are done."

The years he spent in the University of Edinburgh were full of what might be called original work. He studied under Professor Forbes and Professor Kelland, and worked, "without any assistance or supervision, with physical and chemical apparatus." In 1850 he left Edinburgh for Peterhouse college, Cambridge, and, after a short residence in this college, left it for Trinity, in the expectation that the larger college would afford him ampler opportunities for self-improvement. His tutor says of him in 1853, "It appears impossible for Maxwell to think incorrectly on physical subjects." He looked upon him as a great genius, with all its eccentricities, and prophesied that one day he would shine as a light in physical science. This impression was shared, apparently, by students who were the friends of Maxwell. He seemed at this period to be in great spirits, and to thoroughly enjoy his college-life. At no time a narrow specialist, he opened his mind, while at Cambridge, to all the intellectual influences of the place. He became one of the club known as the 'Apostles.' He sought the society of classical men as well as that of the mathematicians. His progress at the university was watched by his father with keen and sympathetic interest. In a letter he writes, "Explain the pendulum experiment to me. You used often to speak of the retardation of the rotation of the earth by the friction of the tides. What is the phosphate of lime theory of mental progress?" And again: "Do you like the trig. lectures A? Tacitus is not new to you. His style must be congenial to a deep, half-sentence lecturer. You seem to have great gayeties with college parties with scientific dons. Do you take note of Stokes's experiments on the bands of the spectrum? Will they be suitable for repetition in the garret of the old house?"

The intimacy of the father and son, touched upon here and there in the life of the son, was a beautiful one. Maxwell's nature was capable of great devotion, and his feelings were exquisitely sensitive to kindness. His love for animals was but one expression of this abundant humanity. The editor of his life says, "In the autumn of 1850 the neighboring estate of Upper Corsock had been let to a shooting-party, one of whom remarked to me, what a pity it was that young Mr. Clerk Maxwell was 'so little suited for a country life.' I clearly recollect his look of exulting mirth when this was repeated to him. . . . The moral of Wordsworth's Hart-leap well was not so much a principle as an instinct with him. I remember his once speaking to me of the subject of vivisection. He did not condemn its use, supposing the method could be shown to be fruitful, which at that time he doubted ; but 'couldn't do it, you know,' he added, with a sensitive, wistful look, not easy to forget."

In his twenty-first year his poetical side and religious side found greater expression than before, and his great strength in mathematics made itself felt. It is related that he often shortened the long train of analysis of the tutor by giving a short geometrical solution ; and, whenever the subject admitted, he had recourse to diagrams rather than to analysis. At the age of twenty-two, Maxwell was second wrangler, Routh being senior ; and Routh and Maxwell were declared equal as Smith's prizemen. At this age we find him speculating upon electricity and magnetism, and engaged in researches on color.

At the age of twenty-five Maxwell was appointed professor of natural philosophy at Marischal college, Aberdeen. At this period of his life he began his paper on the structure of Saturn's rings. His letters at this period are extremely suggestive. The death of his father, and his engagement to Miss Dewar, daughter of Principal Dewar, gave a characteristic coloring to them. These great events in his life had a powerful influence upon his speculations. His devotional side found full expression ; and the study of ethics and metaphysics seemed to be strongly controlled by that of science.

He writes after his engagement, —

"My lines are so pleasant to me that I think that everybody ought to come to me to catch the infection of happiness. This college-work is what I and my father looked forward to for long ; and I find we were both right, — that it was the thing for me to do."

In the same letter he remarks, —

"I have observed that the practical cultivators of science (e.g., Sir J. Herschel, Faraday, Ampère, Oersted, Newton, Young), although differing excessively in turn of mind, have all a distinctness and a freedom from the tyranny of words, in dealing with questions of order, law, etc., which pure speculators and literary men never attain."

The period of Maxwell's life extending from twenty-nine to forty was very rich in intellectual work. His calculations upon the character of Saturn's rings led him to speculate upon the molecular theory of gases. In 1860 he presented a paper on Bernoulli's theory of gases to the British association ; in 1862 we find him engaged with others in determining the electrical unit of resistance ; he was also occupied upon an investigation of the ratio between the electromagnetic and electrostatic units of electricity ; and his great work on electricity and magnetism was in progress. He speaks in his letters of wading through the works of German mathematical writers, and of the careful study of the results of Faraday. His intercourse with the latter was of the pleasantest character.

On one occasion he was wedged in a crowd attempting to escape from the lecture-theatre of the Royal institution, when he was perceived by Faraday, who, alluding to Maxwell's work among the molecules, accosted him in this wise : —

"Ho, Maxwell, cannot you get out? If any man can find his way through a crowd, it should be you."

The influence of Faraday's intellectual methods of thought can be plainly traced in Maxwell's later writings upon electricity. No one can understand Maxwell's intellectual growth at this time who has not read his great treatise on electricity and magnetism. In this book are embodied the results of long and continued study of the observed phenomena, and of the best methods of interpreting them by mathematics. In this treatise one can find his electromagnetic theory of light, upon which he spent much thought during this busy period of his life.

In 1870 he was appointed director of the Cavendish physical laboratory at Cambrige by the *consensus* of eminent men whose advice had been asked in regard to the best man for the position. Lord Rayleigh, who succeeded Maxwell as director, wrote to him at this time, —

Cambridge, Feb. 14, 1871.

"When I came here last Friday, I found every one talking about the new professorship, and hoping that you would come . . . What is wanted by most who know any thing about it, is not so much a lecturer as a mathematician who has actual experience in experimenting, and who might direct the energies of the younger fellows and bachelors into a proper channel . . . I hope you may be induced to come: if not, I don't know who it is to be."

Maxwell, in a letter to the vice-chancellor of Cambridge, expressed the opinion that the "special researches connected with heat, which I think most deserving of our efforts at the present time, are those relating to the elasticity of bodies, and, in general, those which throw light on their molecular constitution ; and the most important electrical research is the determination of the magnitude of certain electric quantities, and their relations to each other." The Cavendish physical laboratory was not opened until 1874. Maxwell died in 1879, five years later. In this short term of office he left the impress of his genius upon the scientific work of Cambridge. Sir William Thomson has said, "There is, indeed, nothing short of a revival of physical science at Cambridge within the last fifteen years, and this is largely due to Maxwell's influence." We have said that no one can thoroughly appreciate the genius of the man who has not read his treatises on electricity, on heat, and his various essays, which are soon to be collected and published.

His life, with its great expressions of reverence for higher things and its respect for true scientific work, is one to ponder over; and his correspondence is rich in literary suggestions, and enlivened by the play of humor. It will always be a source of gratification to Americans to know that the American academy of arts and sciences and the American philosophical society were the first of the foreign scientific societies to elect Maxwell a foreign honorary member.

WEEKLY SUMMARY OF THE PROGRESS OF SCIENCE.

MATHEMATICS.

The polar quadrilateral. — Given a conic and a polar quadrangle: the five quadrilaterals got by taking the poles of its vertices, or the pole of one vertex and the lines joining the other three, are polar quadrilaterals such that conics circumscribing their diagonal triangles osculate the given conic in the same six points. S. Kantor gives a geometrical proof of this theorem by showing that the six points in which a conic inscribed in a quadrilateral can be made to touch the given conic are the same for the five quadrilaterals, and that any one of the triply infinite number of conics with respect to which a fixed quadrilateral is polar osculates other conics of the system in the same six points in which it is touched by conics inscribed in the quadrilateral. He points out an application of the latter property to the determination of the points of inflection of the unicursal quartic obtained by a quadric transformation of the conic. — (*Math. ann.*, xxi. 299.) C. L. F. [754

Theory of functions. — The second part of a paper by Rausenberger treats of single valued functions with non-interchangeable periods. It is not convenient here to do more than refer to this paper, as a review of it can hardly be given without introducing a good deal of algebraical work. The paper, however, as introducing a certain number of new and interesting ideas, is decidedly worthy of consideration. — (*Math. annal.*, xxi.) T. C. [755

Impact of billiard-balls. — M. Resal has generalized some of the results obtained by Coriolis in his *Théorie analytique des effets du jeu de billard.* Coriolis has considered the two balls as being homogeneous, and possessing identical properties in every respect. M. Resal takes account of possible differences in the masses of the two balls, and in their moments of inertia with respect to a diameter, — two properties which might interfere very seriously with the play of even a skilful player. One of the principal results obtained by M. Resal is, that, during the instant of impact, the direction of the friction is not constant. The contrary was assumed by Coriolis. — (*Comptes rendus*, Oct. 16, 1882.) T. C. [756

PHYSICS.

Acoustics.

Vibrations of membranes. — A. Elsas has studied the vibrations of both square and circular membranes, exciting them by connecting the middle of the membrane with a tuning-fork by means of thread, attaching the thread to the membrane with sealing-wax. The nodes and loops were determined in the usual manner by the use of sand and lycopodium powder. Thirty different forks were used, and a great variety of membranes. The sound-figures showed a gradual change from one mode of vibration to another as the pitch of the fork was changed, thus verifying the results of Savart. — (*Beibl. ann. phys. chem.*, No. 2, 1883.) C. R. C. [757

Photography of sound-vibrations. — Boltzmann has studied the vibrations of a plate actuated by the voice, using a method similar in many respects to that employed several years ago by Prof. Blake of Providence. A thin platinum plate was attached perpendicularly to the iron plate; and, by an application of the principle of the photophone, it was shown to vibrate in the same manner as the iron plate. By means of a solar microscope, an image of the shadow of the platinum plate was thrown upon a screen, the straight bounding-line of the shadow being condensed by a cylindrical lens. The screen was then replaced by a sensitized plate, moved rapidly at right angles to the line of light produced by the cylindrical lens, while the iron plate was made to vibrate by the voice. The bounding-line between light and shadow on the plate formed a curve whose nature varied according to the sound uttered. The curves due to the vowels are simple; those due to consonants, much more complex. — (*Phil. mag.*, Feb.) C. R. C. [758

Optics.

Conditions of sight which affect accurate shooting. — Formerly the sight of a soldier as regards shooting was a matter of little consideration; but with the introduction of the Martini-Henry and other rifles, which are accurate at 1,500 yards, sound eyesight becomes an important element. Dr. Litton Forbes, surgeon-major in the Servian war, discusses the various changes taking place in the eye by which the sight is affected, and proposes to correct defective vision by means of a stenopaeic sight-adjuster. This consists of a disk of colored glass, perforated with a pin-hole aperture, having a correcting-lens of colorless glass cemented to its back. The whole is to be worn in a spectacle-frame. — (*Journ. roy. united service inst.*, no. 118, 1882.) C. E. M. [759

A new optical phenomenon. — Axenfeld describes the conditions of an experiment in which straight lines, a little on the near or far side of the