To remove this difficulty, Wheatstone invented a very ingenious apparatus, by which the vibratory motions of the luminiferous ether could be represented with considerable fidelity, and especially the phenomena of polarisation, whether rectilinear, circular, or elliptic.

Many were the achievements realised by Wheatstone in applying himself to optics: we owe to him the invention of a kaleidoscope, in which the persistence of impressions on the retina was utilised in demonstrating the transversal vibrations of an elastic rod fixed at one of its extremities; we owe to him one of the most sensitive photometers, as also the way of estimating the duration of lamps, the movements of the sea, and the ramifications of the retina; the difference between the solar and the electric light, and the lines of the light obtained from combustion of bodies brought to the poles of the voltaic battery. He was, further, the inventor of the polar clock, an instrument designed to indicate the hours through observation of the plane of polarisation of light of the blue sky in the region of the North Pole. That instrument, improved by Soleil, was marvellously adapted for finding the neutral points of Arago, Babinet, and Brewster.

The science of acoustics also profited by the valuable researches of our Lincean correspondent, for he experimented on sound and on hearing, devised his kaleidophone, occupied himself with resonance or reciprocal vibrations produced by a column of air; he also studied the transmission of musical sounds, and the figures obtained with sand on a vibrating surface, or acoustic figures.

Moreover, he cultivated, with great advantage to science, electro-dynamics; and devised two rheostats, one for great, the other for small resistances.

We are indebted to the illustrious deceased for many other scientific contributions, which have realised a notable progress in various branches of modern physics, and especially in telegraphy. Among these contributions, which time would fail fully to enumerate, we must not omit to speak of the method, so fruitful of valuable consequences, by which Wheatstone determined the velocity of the electric discharge in a metallic wire.

He was likewise skilled and practised in ballistics; and he employed the uniform rotation of two pasteboard discs, fixed on a common horizontal axis passing through their centres, to ascertain the initial velocity of a projectile fired from a gun. The projectile, traversing with uniform velocity these rotating discs, produced within two holes, the different situations of which afforded a means of determining the initial velocity of the ball.

Wheatstone was the first to employ the rapid rotation of a reflecting disc for measuring the velocity of propagation of an imponderable agent, without resorting to great distances, such as the planetary. After having in vain turned the spark-exciting organ round an axis, hoping to be able to increase the extent of sparks, and also to alter their direction, according to the direction of turning, he conceived the idea of communicating to a reflecting disc or plane mirror a very rapid rotatory action, by which the electric spark produced at a certain distance from the disc might be reflected.

The interesting consequences derived from these experiments are—(1) that electricity takes an appreciable time in traversing a distance, whence may be inferred approximately the velocity of the electric current; (2) that this velocity does not depend on the direction of the electric current; (3) that of three sparks, reflected by this means, in the same horizontal direction, the two lateral ones appear contemporaneously, but the middle appears retarded with respect to the first, which fact is not reconcilable with the hypothesis of Franklin on the nature of electricity; (4) that the same method was adopted by the celebrated Arago, whose experiments lead to a decisive judgment which of the two theories on the nature of light, that based on emanation, or that based on ethereal vibration, must prevail.

The fact that we now possess methods of determining the velocity of light so practical, elegant, and speedy as those of the distinguished physicists Fizeau and Foucault, is due to the method of rotating mirrors, which was introduced through this order of researches of the English physicist, of whom we deplore being for ever bereaved; the fame of whose discoveries is everywhere—

"And with the world itself shall still endure."

Dante, *Inf.*, ii. v. 60.

P. VOLPICELLI

THE PROGRESS OF THE LOAN COLLECTION

VARIOUS are the trains of thought suggested by a visit to those galleries in which the science of the past and the present is being represented by so goodly an array of its working implements. If one has been at all in sympathy with the movement which is now so near its goal (and who that has in the least appreciated the progress and benefits of science can be out of sympathy with it?), it will, first of all, be truly gratifying to him to observe on every hand such manifest tokens of hearty co-operation in the movement. Even those who are engaged in marshalling the various treasures of the departments which have been entrusted to their charge seem to be animated with an unusual zeal (a zeal promising the best results), and, at first sight even, it is evident that the various museums and private collections in this country and on the Continent have been ransacked for some of their choicest contents to be sent to these South Kensington galleries, aiding the completion of an ideal which is true in its comprehensiveness. The nations of the Continent who were appealed to for their support of the scheme, have shown, many of them, by an activity which is beyond all praise, how warmly the proposal has been entertained. This is especially true of Germany. The Berlin Committee appointed a short time ago, and including some of the foremost names in science, while it gained also the useful accession of Imperial influence, promptly made application (the time was short) to the various Universities and Polytechnic Schools throughout the country, and they were met as promptly; so that soon quite a network of subordinate committees came into being, all working harmoniously towards the common end. The German contributions form a very considerable proportion of the whole; and they, in common with contributions from the Continent generally, are indeed surprising in their extent, if we consider the shortness of time allowed and the unique character of the exhibition. Both Germans and French have been doing all that they

can up to the latest moment, and this has somewhat retarded the arrangements. The Russian contributions have not yet been received. The collection of instruments from Italy is, in many respects, of a peculiarly interesting character.

A catalogue and a series of handbooks are in course of preparation. Some idea of the extent of the collections may be obtained from the fact that in the former there will be somewhere about 6,000 entries. The nature and value of the handbooks for the various departments may be learned from the fact that they are prepared by such men as Huxley, Henry Smith, Clifford, Maskelyne, Carey Foster, Guthrie, Clements Markham, Lockyer, and others. The entire work, extending to some 300 pages, in which the history and functions of the several instruments are dealt with, will be expounded in a clear and succinct manner.

It would be impossible, we imagine, to walk through those corridors and inspect the various objects encased on either hand, without soon beginning to marvel at the multiplicity and complexity of the tools which science has come to construct for herself in the progress of her inquiries; and at the degree of precision and skill to which she has at length attained, after many a tentative and faltering step towards the end in view. Yet it may truly be said, that as the branches and divisions of science multiply in increasing ratio, and therewith also the apparatuses become more and more complicated, the investigator, acquiring a deeper insight and wider range, ere long perceives a unity where he had not previously imagined it, and finds that many things which had seemed to be so many *disjecta membra* are knit together in the closest interrelations. It is perhaps not among the least benefits accruing from an exhibition like the present, that scientific men are enabled to survey, in close juxtaposition with their own line of research, other lines which they may have given little heed to, or but imperfectly comprehended. To an outsider also, who appreciates the keen enjoyment of scientific tastes, and is not hopelessly devoted to a hobby, the comparison cannot fail to be pleasant and instructive.

Again, that progress of science just referred to, from the less perfect to the more perfect, from the rough and clumsy to the finished and refined, in the construction of her instruments, affords a retrospect that is fascinatingly instructive. In the inspection of the collection one comes ever and anon upon some antiquated-looking instrument of plain proportions and great simplicity, which almost seems as though it had stumbled by mistake into the company of its elegant and brightly furbished conquerors—had come among a generation that knew it not. Yet these ancient relics have a deeply interesting history, and they will doubtless attract to themselves no small share of attention from the visitors who will take advantage, we trust, in large numbers, of the unique opportunities this exhibition affords. Nor would any contempt which might momentarily arise for the unpretentious and uncouth figure of these instruments be long in giving place to a sort of veneration and awe, for the story they have to tell that they took shape under the hand or at least under the thoughtful direction of a Galileo or a Herschel.

The general arrangement of the exhibition, which, as already mentioned, is by no means complete yet, may here be briefly indicated. The space occupied is in the West and South Courts. After passing through the South Court, in which stand the South Kensington Museum instruments, the Educational apparatus, and those relating to Applied Mechanics, the visitor enters the West Court, the northern portion of which contains the greater bulk of the present collection. Here in succession are arranged the departments of Magnetism and Electricity, Mathematics, Meteorology, and Astronomy. On proceeding upstairs and returning, the rooms devoted to Geography and Geology, Biology, Chemistry, and Physics, are successively passed through. This will indicate the general arrangement of the whole; but the classification of the various instruments in the catalogue now being prepared is considerably more detailed.

It is not our intention here to attempt anything like an exhaustive account of the various objects of interest which line these courts. In the Astronomical department will be seen several of Galileo's instruments, including two telescopes made by himself, one of which served for his most important discoveries and experiments. The object-glass is shown by which he discovered Jupiter's satellites, and first saw spots on the sun. The Reale Institute of Florence, to which the Exhibition is indebted for these instruments, has sent sundry other relics of the great astronomer, including a natural magnet, which he armed, and an air thermometer and microscope, which were his. Nor should we fail to be interested in such instruments as a quadrant of Tycho Brahé, some object-glasses and eye-pieces, which were mostly polished by Christian and Constantine Huyghens, and a telescope of Huyghens. A venerable wooden object near the wall is Sir W. Herschel's 7-feet telescope, both mirrors of which were finished by Sir William's own hands, and there is also shown a 10-feet reflecting Newtonian telescope also made by him. Several of Gravesande's instruments are shown; also the apparatus used by Baily in repeating Cavendish's experiments, Foucault's pendulum apparatus, Gauss's pendulum for demonstrating the rotation of the earth, &c. The more modern aids of astronomical observation are largely represented, and, among others, there is a beautiful transit instrument, of novel construction, from Germany.

Among the instruments of a mathematical order are Babbage's celebrated calculating machine, also two calculating machines constructed in 1775 and 1777 by James Black for Viscount Mahon. We might also note the integrating machine of Sir W. Thomson. The laws of combination of harmonic motions have been illustrated by some ingenious apparatus of Messrs. Tisley and Spiller, and by a machine invented by Mr. Donkin; but the most important application of these laws is to be found in Sir W. Thomson's tidal clock, and in a more elaborate machine which draws curves predicting the height of the tide at a given part for all times of the day and night, with as much skill as can be obtained by direct observation. Then there are the "Napier bones" of the inventor of logarithms, used for performing multiplication and division. Among measur-

ing instruments the gauges lent by Sir Joseph Whitworth are remarkable for their delicacy. With one of these, for measuring the bore of guns, differences of one-ten-thousandth of an inch can be measured. There is another, moreover, by means of which a quantity so minute as one-millionth can be grasped. The apparatuses which Joule employed in ascertaining the mechanical equivalent of heat, are among the collection.

The field of magnetism and electricity is now a very vast one, and in the exhibition it is represented by a correspondingly large variety of apparatus. A peculiar halo of interest gathers round the instruments, many of them so simple and homely, with which Faraday worked out his fruitful ideas. Among old electric machines is one with two glass cylinders, one of which is covered with sealing-wax, so as to obtain both positive and negative electricity; there is also Nairne's early electric machine with glass globe, Armstrong's hydro-electric machine, &c. Volta's electric lamp is exhibited for lighting gas by means of the electric spark. There is an endless variety of batteries, and the numerous Holz and other electric machines exhibited will afford material for careful study, as also the novel forms of magneto-electric and other machines which have of late years multiplied so fast. Here may be found apparatus for regulating the time and place of an electric discharge; apparatus for accumulating electricity; apparatus for observing the effects of discharge of accumulated electricity; apparatus for producing, and apparatus for observing, effects of continuous electric currents; apparatus for measuring the strength of electric currents, and apparatus for measuring resistance, and so on. In the telegraphic department there is a complete historical collection which must be of great interest not only to electricians and telegraphists, but to the general public, illustrating the progress of the electric telegraph from the time when the first idea of it was crudely embodied, down to the present time. This collection includes, of course, all the classical apparatus which belonged to Wheatstone and Cooke, among which is the original Wheatstone Bridge. Many will be interested in seeing the instruments that were used on board the *Great Eastern* in laying the Atlantic Cable. There are copies of the first German telegraphic apparatus (Goemmering's), and the first needle telegraph (Schelling's); the electro-magnetic telegraph apparatus used by Gauss and Weber in Göttingen, from 1833 to 1838, &c., &c.

We must here desist for the present, though the majority of the sections are still unvisited. It may be understood, even from these hasty and imperfect notes—but in any case, the reader may soon convince himself by personal inspection—how rich and varied is the collection now in course of completion, and how ample is the feast therein provided for those who feel in any measure drawn to the "beautiful and true" in science.

The date of opening of the exhibition is still uncertain. It is hoped that her Majesty will grace the occasion with her presence, and conduct the opening ceremony. Some of the galleries of the exhibition will probably be lighted in the evenings with the electric light, and a considerable portion of the apparatus, it is intended, will be kept in motion.

GREEN'S GEOLOGY

Geology for Students and General Readers. Part I. Physical Geology. By A. H. Green, M.A., F.G.S., Professor of Geology in the Yorkshire College of Science, &c. (London: Daldy, Isbister, and Co., 1876.)

THE progress of geological research in every quarter of the globe is exceedingly rapid, and discoveries of new processes of investigation, leading to the opening up of fresh lines of thought in connection with the science, are constantly taking place. Hence, in spite of the acknowledged excellence of some of the existing manuals of geology, such as those of Lyell and Jukes, we cannot but hail with pleasure the appearance of a new text-book of the science—especially of one which, like the present work, is not a mere epitome of one or other of the standard treatises just referred to, but which aims at some originality in its arrangement and mode of treatment of the subject. Prof. Green may be congratulated on having written a work embodying a vast amount of valuable information, which is presented in a very clear and readable form.

Of the two classes for whom Prof. Green writes, we think the "general readers" are those for whom his work is best adapted. Some of the chapters, such as the ninth, which is entitled, "How the rocks came into the positions in which we now find them," and the tenth, of which the heading is, "How the present surface of the ground has been produced," are models of clear and accurate description, and of logical and forcible reasoning; they are evidently written by a man with a thorough acquaintance with his subject, and no little enthusiasm for it to boot. We may, perhaps, demur to the confident tone and the sometimes off-hand manner with which our author disposes of the objections of those who differ from himself on some of the questions discussed; yet we cannot but feel that the conclusions at which he has arrived and which he so clearly states, are the result of independent observation and personal conviction, and are not merely adopted at second-hand. While reading many parts of this work, it is impossible to avoid the consciousness that we are following the pleadings of an advocate, and not the expositions of a judge; yet the arguments are brought forward with such lucidity and earnestness, that we accept the work as embodying the ablest exposition yet offered to us, of the views of that school of geologists to which Prof. Green belongs. Occasionally, however, the author is so carried away by his enthusiasm in behalf of favourite doctrines, that his confidence becomes something very like arrogance, as in the following passage, with which he concludes his chapter on Denudation:—

"The reader will do well to compare with the theory of surface-sculpture upheld in the preceding memoirs, chapter xix. of the late Prof. Phillips' 'Geology of the Valley of the Thames.' Elegant and ingenious as is the explanation there put forward, there is about it an unsatisfactory vagueness and want of definition, which contrasts strongly with the sharp precision and logical coherence of the views on the subject of which a sketch has been attempted in the preceding pages, and which are steadily gaining ground among modern geologists."

In keeping apart from the other portion of his work purely speculative questions, and treating of them in two chapters *at the end* of the volume, we think the author