THURSDAY, APRIL 30, 1896.

THE INTELLECTUAL RISE IN ELECTRICITY.

The Intellectual Rise in Electricity: a History. By Park Benjamin, Ph.D., LL.B., Member of the American Institute of Electrical Engineers. Pp. (with index) 611. (London: Longmans, Green, and Co., 1895.)

SINCE the days of the distinguished Joseph Priestley, no physicist has ventured to give us series of lessons on the history of the origin and progress of electrical science. In a large and admirable volume entitled "Priestley on Electricity" the author of it tried to introduce everything that was known up to his own time, and he is a poor electrician who is not fully conversant with this gigantic labour. At last another author has risen who has undertaken to supplement preceding authors, and to put before the world in one volume the subject of "the evolution of electricity"; that is to say, to describe the history of electrical science from its origin up to the present day. The author who has undertaken this task is Dr. Park Benjamin, LL.B., a writer from the other side of the Atlantic, who, it must be said, has made himself fairly acquainted with the many electricians who have preceded him, and who makes an excellent effort to instruct the world at large by bringing into what may be called a nutshell the many pieces of information which he has been able to collect and put together in a readable form. The work is a large octavo, and consists of 611 pages, the whole being written in a style which is as commendable to the general scholar as to the particular electrician. The greatest care has been taken, step by step, to supply such illustrations as shall make the text comparatively easy. There are also portraits of men who have been engaged in the practical work of electricity; and although we would not compare the book with that written by Priestley, we must candidly say of it that all teachers, especially physical teachers, are certain to be benefited by its perusal and intimate study.

Like preceding writers, Dr. Park Benjamin, in tracing back the history of electricity, believes that in the dawn of civilisation the discovery of the force was connected with the substance commonly known as amber. The discovery of beads in the royal tombs of the Mycenæ, and at various places throughout Sardinia and the ancient territory of Etruria, proves, he says, that trade in amber existed in prehistoric times; while the identity in chemical constitution of the ornaments at Mycenæ and the Baltic amber from the tertiary formation of the Prussian Samland, the coasts of Southern Sweden, and the Northern Russian provinces, indicate the far distant source from which the resin was anciently derived. Who first brought the resin from the Baltic Sea to the Levant is an undetermined question, as it is known to have come across Europe by land as well as round the continent by water.

Giving full credit to the Phœnicians for their enterprise, and with speculations as to the mode in which amber may have travelled after its properties were first discovered, Dr. Benjamin proceeds to consider the magnet, or lodestone, and explains that the phenomena of the lodestone are two-fold: it not only attracts iron objects, but it has its polarity, or in other words exhibits its opposite effects at opposite ends, by reason of which, when in elongated form and supported so as easily to turn, it will place itself nearly in the line of a meridian of the earth, that is to say in a north and south direction. This is its attractive tendency, or as William Gilbert called it in 1600, its "verticity," and upon this duality, as is well known, depends the use of the magnetic needle in the mariners' compass. In the close of Chapter I., in which reference is specially made to the magnet and to iron as the substance upon which it acts, there is a short but sound notice of history collected from Jewish and Egyptian writers, which, though not strikingly convincing, is of unquestionable interest.

Getting lower down, Dr. Benjamin, as a matter of course, quotes Thales, who many suppose to have been the first man in the electrical field—though he lived before Christ—who understood the phenomena of magnetic attraction, on which point Dr. Benjamin remarks:

"It must be admitted that even if Thales had been cognisant of the amber phenomenon—that is to say, the effects of rubbing amber and presenting it, in the excited state, to the bits of straw which it attracts—it was not logically necessary, from his point of view, to include it specifically under his theory based upon the attraction of the lodestone, and hence lack of mention does, on his part, not imply lack of knowledge."

Wading through pages of matter touching largely on the Chinese origin of the compass and knowledge of the Chinese in regard to the lodestone, Benjamin asserts that no recorded evidence of the attraction of the magnet or amber appears in the Chinese books of earlier date than the fourth century of our era. He follows up scientific records from the decline of the divine school of Alexandria, which followed the period of the Ptolemies, and explains that through the earlier centuries of the Christian era we find the problem dealt with again and again, sometimes purely physically, more often metaphorically; sometimes by the poets, but with greater frequency by the fathers and historians of the Church. He quotes St. Augustine on the attraction of the magnet.

"I was thunderstruck ('vehementer inhorrui'). I saw an iron ring attracted and suspended by the stone (lodestone), and then, as if it had communicated its own property to the iron it had attracted and had made it a substance like itself, this ring was put near another and lifted it up; and as the first ring clung to the magnet so did the second ring cling to the first. A third and fourth were similarly added, so that there hung from the stone a kind of chain of rings with their hoops connected, not interlinking, but attached together by their outer surface."

Gliding along and touching on the voyages of the Northmen and the scientific writings of the Anglo-Saxons, the works of William Appulus, the Anglo-Norman magnetic knowledge, the labours of Alexander of St. Albans (Alexander Neckham), the contemporary of Richard of England, son of Henry II., Dr. Benjamin puts before us the first mariners' compass; touches on the penalty for falsifying the compass, and taking up numerous statements and stories in relation not only to magnetic phenomena, but to the men who studied them, including the discovery of variation by Columbus, the reasonings of Paracelsus as a speculator, and the work of physicians as discoverers, he brings us at last, as a necessity, to one of our first great Englishmen, William Gilbert of Colchester. He gives a little sketch of the life of William Gilbert, puts him down amongst the Fellows of the Royal College of Physicians, and states that he began to practise in London, establishing himself in a house on St. Peter's Hill, between Upper Thames Street and Little Knightrider Street. There Gilbert became a famous man, and, as we know, became physician to Queen Elizabeth, and was, it is said, the only man to whom she left a legacy. To Gilbert, Benjamin gives, naturally, a warm introduction and note of praise, and to Gilbert's original work, "De Magnete," he assigns as much credit as could be given by any one of the members of the new society founded in honour of his name, and which wishes to establish a monument to him in his native city. He also notes Gilbert's doctrine on the subject of the magnet, with his own criticism thereupon. Gilbert seems to urge, that the direction in space is such that the north pole of the earth constantly regards the pole star, so that if that pole were turned aside from this steadfast position it would go back thereto, from which it is apparent, says Benjamin, "that this doctrine rests upon the conclusion that the earth itself is a freely movable magnet, having poles, and amenable to the same laws as the compass needle."

Gilbert is capable of many errors which Dr. Benjamin is not slow to detect; while he makes, we must admit, a very fair and just statement or analysis of the work of Gilbert, supplying plates from his "De Magnete," and is very fair in reviewing the revelations of Bacon, who recognised Gilbert's eminence as a philosopher and discoverer.

All this is extremely interesting, and a grand introduction to the science of electricity as connected with the magnet, and when we get into the account of the way in which electric action and the discovery of electric propulsion, especially in reference to the discoveries of Cabæus on the magnetic spectrum, with Descartes' observations on the magnetic field, we arrive at the definite origin of electricity amongst English philosophers and their colleagues, of many of whom Dr. Benjamin has not the same knowledge, or, at all events, does not show the same sympathies as we ourselves do. We do not all consider, although his father was executed, that Sir Kenelm Digby, for instance, was an adventurer, conspirator, naval commander, and diplomatist, as well as man of science; neither do we take the same view of Sir Thomas Browne that our author seems to have taken, while, when we come to his description of Stephen Gray, we are forced to differ from him, in regard to his estimate of him, very sincerely. According to our own view, electricity was altogether chaotic as a science until this Charter House pensioner, Stephen Gray, appeared before the world, and revealed himself through the Royal Society. It was he who discovered conduction, induction, insulation, and minor thunder and lightning, and, indeed, almost all the basic facts, without which electricity could never have become a true science.

The story about Stephen Gray is fairly told, but it is far from complete, and should have tallied better with Emerson's sentence which the author has inserted on his title-page.

"Not the fact, but so much of man as is in the fact."

Gray, indeed, was himself an evolution, small though he may seem to have been to his contemporaries, and with them was, perhaps, petulant. He was just as great as Gilbert, and in any work on electricity deserves to be put on a level with him. It was he who first truly set up the electric telegraph, and, actually, between two and three hundred years ago, sent messages by it over ground which is still laid out in the front of an old mansion, Otterden Manor, near to Faversham. It was he who died relating to Mortimer, the Secretary of the Royal Society, his conviction that there was such a thing as an electric planetarium in the universe, and it is to him and his labours that we now owe the electric light which so brilliantly illuminates our darkness.

As we glance through the copious index with which this volume is concluded, and see name after name written down, for our edification, of men who have been engaged in electrical pursuits, the temptation is very great to follow Dr. Benjamin step by step, and to inquire on what ground some men are named at length, while others—Cavallo and Fowler, for example, are omitted altogether. We are not surprised that he dwells so long and favourably on one of his own countrymen, Franklin, whom we in England do not certainly ignore, and whose electrical knowledge is probably spoken of with an enthusiasm which few electricians have received. We do not object to the admirable picture of Franklin seated at his studies, which is given to us as a prelude to the sixteenth chapter, but we do regret that there should be any omissions of other men equally careful as Franklin, equally industrious, and quite as original; but we would not be severe with an author who has natural predilections, like all of us, and who is never wanting in industry. We would rather look over every omission and every possible error, and we commend our readers to place Dr. Benjamin's volume on their shelves as a book of electrical philosophy which cannot be too often read or too seriously studied.

It has for many long years past been felt by the teacher of electrical science, and we may add, by the learner also, that the course cannot be considered complete which does not include the beginnings as well as the endings of electrical advances. It is too often felt by those who teach, that it is necessary to deal solely with what is actually going on, and we must admit that when a professor stands at the lecture table with all the modern apparatus before him, and with the hosts of modern facts at his direct command, facts which he is anxious to illustrate and demonstrate, the temptation is great for him to confine himself to the subject immediately before him, and to show how, out of simple principles, he can explain some new and important truth or line of practice. At the same time he rarely ventures on this path without omitting, in the strangest way, a great deal of that wonderful past which Dr. Benjamin has made such fine attempts to describe. Of all words, again, we like the title he has chosen—evolution. "Evolution" is as applicable to electricity as it is to man himself, and, to be quite sincere, it must be admitted that every detail in respect to electrical developments is an evolution. It is in this way that electricity has progressed and will continue to progress, that is to say, on the bare data propounded by one man another will proceed. The one will modify experiment; will get an advanced result, and from his result the next man will take up the parable and will progress. Thus, though there may be a thousand discoveries in electricity, there will never be one prophecy; and if Dr. Benjamin's book exposes this startling truth, it has performed a duty which probably its author did not expect of it, and for which the world will be grateful.

ARTIFICIAL COLOURING MATTERS.

Traité des Matières Colorantes organiques artificielles, de leur préparation industrielle et de leurs applications. Par Léon Lefèvre. Two vols. Pp. xx + 1648. (Paris: G. Masson, 1896.)

IN the early days of the coal-tar colour industry the French chemists, Coupier, Lauth, Girard and De Laire, and others did good work in the way of investigation, and certain standard books of reference which were indispensable in their time bore the names of French authors. Then the centre of activity in this field seems to have been shifted to Germany, and for some years we have been accustomed to look to that country for new discoveries and authoritative treatises. The author of the work now under consideration, M. Léon Lefèvre, who is "Préparateur de Chimie" in the École Polytechnique, has once again set the current of coal-tar literature flowing in France, and he is to be congratulated on having produced a treatise which may, without exaggeration, be described as the most comprehensive that we have at present in any language. The two bulky volumes under notice cover the ground occupied by several distinct German works; for not only is the subject dealt with in its purely chemical aspect, but the methods of production on the large scale, and the modes of application of the various colouring matters are likewise given in detail. It is impossible in these columns to give a critical review of a technical work of this magnitude, but a general statement of the method of treatment will enable those who are interested in the subject to form an idea of the extent to which they are indebted to M. Lefèvre.

The colouring matters are classified into groups in accordance with the scheme originally adopted by Nietzki, and now familiar to all chemists who are acquainted with this branch of their science. Each group commences with a preliminary statement setting forth the history, general characters and constitutional formulæ of the compounds dealt with; then follows the description of the individual colouring matters, and afterwards a tabular summary of the whole group, from which can be seen at one glance the mode of preparation, the formula, the commercial name, the appearance and properties, and the references to the literature, patent or otherwise. Following these extremely valuable tables, there is a section on the technique, *i.e.* the method of manufacture, the processes being described in sufficient detail to be of value to technologists, and the plant being figured by well-executed cuts. The reader having thus been led up from the history of the discovery of the colouring matters to their production on the large scale by the latest and most approved methods, is then let into the mystery of the dyer's art, and is given explicit directions how each colouring matter should be applied as a tinctorial agent. With each group there is also associated a tabular scheme of the diagnostic reactions of the colouring matters on the fibre, a list of bibliographical references, and lists of patents.

It does not often fall to the lot of the reviewer of a technical work to be raised to an enthusiastic state of mind by the treatise which has been submitted to his judgment; but in the present case, it was certainly with something akin to enthusiasm that we turned over the pages of M. Lefêvre's luxurious volumes. The synopsis of the mode of treatment which we have attempted to give will show that in one work we now have the chemistry of the coal-tar colouring matters on the lines adopted by Schultz in his well-known treatise of 1887–90, the tabular synopses made familiar by the tables of Schultz and Julius, edited by Green in 1894, the technique of manufacture for which we have had to refer to such works as that by Mühlhäuser, the tinctorial characters and modes of application for which we have been in the habit of consulting special treatises on dyeing and printing, and lastly, the diagnostic reactions which are generally looked up in some work on proximate organic analysis. To say that the author has covered all this ground in a perfectly faultless manner would be to attribute to him superhuman faculties; but, with the exception of a few doubtful statements of history, we are bound to say that no serious flaw is to be found in the 1648 pages composing the work. The dyed and printed patterns on wool, silk, leather and paper, of which there are over 260 specimens, make the volumes somewhat ungainly, and would perhaps have been better collected together into a distinct supplementary volume. The thirty-one illustrations of plant are executed with that clearness for which our French colleagues are so justly celebrated, but, as is so generally the case, they suffer from the defect of having no scale of size attached. The structural formulæ occupy a very much larger amount of space than we are accustomed to here, owing to the free use of the benzene hexagon, but this is a matter of luxury and not a point for critical complaint; it must, however, have added considerably to the cost of printing.

The work is introduced to the public by a preface from the pen of M. Edouard Grimaux, Membre de l'Institut, who at the close of his remarks says:—

> "En raison de l'intérêt que je porte à l'auteur, mon fidèle compagnon de laboratoire depuis dix années, il me serait difficile de faire l'éloge de son livre et de dire tout le bien que j'en pense; mais j'ai vu naître et continuer cet ouvrage sous mes yeux, et je puis témoigner de la conscience avec laquelle il a été fait; j'ai tout lieu d'espérer qu'il recevra du public savant l'accueil qu'il mérite."

The commendation which M. Grimaux modestly withholds may be supplied by this notice; and in directing the attention of English chemists to M. Lefêvre's treatise, we have not the least hesitation in stating that the author has succeeded in producing a coal-tar classic which must take precedence over every other work on the subject.

R. Meldola.

OUR BOOK SHELF.

Grundriss der Psychologie. By Wilhelm Wundt. Pp. xvi + 392. (Leipzig: Wm. Engelmann, 1896.)

THIS is the third book on psychology which Prof. Wundt has written, and its special aim is to give an account of the general principles of the science apart from physiological considerations on the one hand, and philosophical on the other. Technical details are to a large extent omitted, the reader being referred for them to the "Grundzüge der physiologischen Psychologie." The book resembles in many respects Külpe's "Outlines," and it seems as if the author intended it to correct the departures from the Wundtian standpoint which are to be found in the latter. A novel feature of the book is the description of ideas, emotions and volitions as psychical structures ("Gebilde"), with the reservation, however, that both the structure and the elements of which they are composed are to be regarded as processes and not as objects. After considering psychical elements and "Gebilde," the subjects of consciousness and attention, association and apperception take up a third section; the fourth section treats of mental development in the animal and the child, and the book concludes with the formulation of certain laws of psychical causality.

Cours de Physique de l'École Polytechnique. By M. J. Jamin. *Premier Supplément.* By M. Bouty. Pp. 182. (Paris: Gauthier-Villars et Fils, 1896.)

THIS supplement to the latest edition of the "Cours de Physique" of Jamin and Bouty, deals with progress in heat, acoustics, and optics. It is not intended to be a complete account of work done in these three sections of physical science, but a description of investigations which have led to definite results likely to survive for some years. In the section on heat, the work described is concerned with the measurement of temperature, principles of thermodynamics, changes of state, dissociation, osmotic pressure, critical points, and capillary phenomena. In the section on acoustics and optics, the subjects of the chapters are: propagation of vibratory movements, propagation of sound, study of vibrations, propagation of light, and diffraction, interference phenomena and their applications. Students of physics will find the volume useful for consultation, especially as references are always given to the papers abstracted.

Les Rayons X, et la Photographie a travers les Corps Opaques. By Dr. C. E. Guillaume. Pp. viii + 127. (Paris: Gauthier-Villars et Fils, 1896.)

THIS is the fullest and most scientific account we have seen of work with X-rays, and the investigations which led up to Röntgen's discovery. The first part of the book contains a general account of the kinetic theory of gases and the nature of light, together with a few particulars with reference to electric discharges in gases. These facts, and the statement of the theories upon which they depend, prepare the way for a concise description of researches on the luminous phenomena exhibited by electric discharges in rarefied gases, from the times of Faraday and Hittorf until now, especial attention being given to the bearings of these investigations upon the nature of kathode rays. Röntgen's discovery, and many of the researches to which it has given rise, together with an account of its applications, make up the remainder of the volume. Most of the results described have appeared in the *Comptes rendus* of the Paris Academy of Science, or in NATURE, and Dr. Guillaume has now brought them together in a handy form. Having regard to the large amount of work still in progress, the volume can hardly be considered as permanent in its present shape; but when the proper time arrives, it may be expanded, and will then make a handbook well worth a place in scientific libraries.

LETTERS TO THE EDITOR.

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Blood-Brotherhood.

THIS very ancient custom, performed in so many ways, and still practised by all barbarous and semi-barbarous peoples, might, by the help of modern science, be turned to useful and beneficent ends. For some time I have thought, and the conviction grows on me, that residents and travellers in tropical parts of the world might the better withstand the climate, malaria and fevers to which they often succumb, by entering into blood-brotherhood with a healthy native.

The classical researches of Pasteur and his disciples have shown how various diseases may be controlled, and immunity secured to man and the lower animals, by the proper use of anti-toxins, and by diluted subcutaneous injections of virus in certain cases of blood-poisoning. Although not parallel in specific aim, blood-brotherhood may be found to possess similar prophylactic properties. Is it not probable that a European inoculated with the blood or serum of a native, would be better able to resist the climatic changes to which he is subjected in tropical countries? In other words, would blood-inoculation not set up in his system those changes necessary to adapt him to the climate, and render him immune to the diseases which are the result of climate? The suggestion is based on the assumption that the native is more healthy in his own climate than any foreigner can be, and that blood-inoculation would acclimatise the latter at once.

The advantages to be derived from such a system are obvious. Only strong, healthy persons can long withstand the climate of Central Africa. Many missionaries and pioneers are annually sacrificed to it. Men certified by medical practitioners as sound in lung and limb at home, are weakened and prostrated there. A recent example of great loss of life due to climate was that of the French expedition to Madagascar, where the army was decimated from this cause. And another noted example is that of the late lamented Prince Henry of Battenberg, who died on his way to Ashantee of a disease brought on by climatic change.

I have referred to the writings of African travellers for information on the effect on the system of blood-brotherhood, without positive result. No one seems to have suffered by it. Livingstone, Grant and Cameron mention the custom, and all of them entered into it in the person of one of their attendants. Perhaps they feared the consequences on themselves, but no explanation is given. Stanley is the only traveller whom I have been able to find entered into blood-brotherhood in person. At first he, too, seems to have done so by proxy, but afterwards he took part in it fearlessly, and underwent the operation fifty times! So that Trumbull ("The Blood Covenant," p. 38) is justified in saying that "the blood of a fair proportion of all the first families of Equatorial Africa now courses in Stanley's veins." We have not been told that Stanley suffered in any way from these inoculations. We may therefore conclude with a fair degree of reason that his healthiness (on the whole), endurance and success, was attributable in some measure to the exchange of blood with the natives he met.

Blood-brotherhood as practised in Central Africa varies in detail, and is accompanied by many formalities; but the essential part of the process, as described by Cameron ("Across Africa," p. 333) consists in "making an incision on each of the right wrists, just sufficient to draw blood, a little of which is scraped off and smeared on the others cut." In many cases the blood wasted is considerable, but the science of to-day does not demand this. It would only be necessary to use a small quantity, perhaps not more than the quantity of lymph required in small-pox inoculation. And it would be easy to get healthy natives at the port of debarkation, willing, for a small remuneration, to supply the necessary blood or serum. The operation might prove invaluable to persons joining the Civil or other Service in India or the colonies, to missionaries appointed to tropical countries—and, in fact, to all persons requiring to travel or reside in hot or unhealthy climates. It might also be found of value were the circumstances reversed—that is to say, with the natives of hot climates coming to reside in this country, or with persons electing to reside at home after long residence abroad.

Experiments conducted in the direction I have indicated, would, I believe, result in the acquisition of much useful and valuable information. And my object in addressing you now is to invite discussion on the suggestion, in the hope that it may be taken up by scientific men in a position to prosecute the inquiry. I hope too, some of the readers of NATURE, engaged in kindred studies, will give us the benefit of their experience and the results of any observations calculated to throw light upon it. T. L. PATTERSON.

Greenock, April 17.

Megalithic Folk-lore.

As I understand that many investigators have come to the conclusion that there are no traces of Dravido-Tibetan races to be found west of Persia, permit me to point out a fact which may not have been brought to their attention.

I have been in Asam now thirty-two years, and during that time the province, and part of Bengal, has been swept (suddenly) from end to end, by a severe scare, which folk at home would find it difficult to understand. It was similar in each case, and to the effect that the Queen wanted five children's heads from each village.

Our Bengali coolies nearly went frantic, in many factories demanding axes and daus (knives) to defend their families. In my own case they implored me to let them put their wives and children on the tea-leaf lofts, while they would guard them at night. In another factory all the doors in the lines were barricaded; or at still another, all were kept wide open so that at the first scream at night all could at once rush out and hide n the jungle.

The state of tension for a week was awful, and of course the ludicrous now and then came in. Two of my near neighbours, freshly out and bent on snipe, happened one morning to emerge from the jungle, muddy and with guns, among the women-folk at work, who all had their children with them for safety.

For the instant they were taken for the child-stealers, and the stampede and shrieks were something awful.

At one place I found an Asamese village deserted, not a soul left—all in hiding, no doubt.

It was quite useless to argue with the common folk, and my educated Babu even half believed it, for on my explaining the absurdity of it all, he simply answered, "Perhaps, sir, it is too foolish."

After a lot of trouble and correspondence, it turned out that the rumour (believed by all) was that the heads were wanted to put under the foundation of the piers for the Gorai bridge. There must be hundreds of Europeans now at home who can corroborate this.

And now to the point. It was a custom among the Kasias, I am told, to sacrifice a victim by putting him in the hole if great difficulty was experienced in raising any of the huge monoliths, and the same custom existed in Polynesia when raising the great posts of Maræ, or large communal houses.

But all over Chota Nagpur, Megalithic remains are common, and our coolies are mostly from thence.

Here then, I take it, we have fairly good evidence that one at least of the "Megalithic" races preserve vividly the folk-lore of past ages. Have we anything like this in European races *in re* these remains of prehistoric times?

That the building of houses on piles is essentially an Asiatic race custom, I need hardly point out, and that the villages in the Swiss lakes are on the same pattern anthropologists will allow.

It may not be so well known that the long communal houses still seen (as a survival) in Italy (Campagna) are on *precisely* the same pattern as those among most of our Naga, and among Dyaks.

Add to this, that the prehistoric remains of North Europe are like the present Lapps in character, and it seems not impossible or even unlikely that the races who erected the Megalithic remains in Europe and North Africa, may be allied to those among whom the traditions are yet so vividly remembered.

S. E. PEAL.

Sibsagar, Asam, March 27.

The Glacial Drift in Ireland.

SINCE the publication of Prof. G. A. J. Cole's letter in NATURE (vol. xlvii. p. 464), in which he records the discovery of pebbles of the Ailsa Craig Riebeckite-eurite from the drift gravels on Killiney strand, numerous observers have noted its occurrence in several places along the east coast of Ireland, but hitherto, I believe, not further south than Greystones, Co. Wicklow. Owing to the special interest of this rock, both to glacial observers and petrographers, it may be worth mentioning that two weeks ago I found one small pebble (about 3 c.m. square) of the rock on the shore of Tramore Bay, Co. Waterford, nearly 80 miles further south than the previously mentioned locality, and 230 miles from Ailsa Craig.

HENRY J. SEYMOUR.

Royal College of Science, Dublin, April 20.

The Bright Meteor of April 12.

THIS meteor was visible overhead at Dunstable, Beds., precisely at the time mentioned by A. G. Tansley (p. 581). I had just started one of my sons to London by the 8.5 p.m. train, and I saw the meteor sail slowly across the sky from north-west to south-east, directly the train had started. The nucleus as seen here was brilliant white and yellow-white with a bright yellow-white train. The train formed an equilateral triangle, the nucleus being in one angle in front. I did not see the train in the form of sparks, but as light. Before it died away, both nucleus and train became bright crimson and an equally brilliant blue. There was no explosion heard by me.

Dunstable. WORTHINGTON G. SMITH.

Remarkable Sounds.

THE following passage in a Chinese itinerary of Central Asia—Chun Yuen's "Si-yih-kien-wan-luh," 1777 (British Museum, No. 15271, b. 14), tom. vii. fol. 13, b.—appears to describe the icy sounds similar to what Major Head observed in North America (see p. 78, *ante*):—

"Muh-süh-urh-tah-fan (= Muzart), that is Ice Mountain[1], is situated between Ili and Ushi. . . . In case that one happens to be travelling there close to sunset, he should choose a rock of moderate thickness and lay down on it.[2] In solitary night then, he would hear the sounds, now like those of gongs and bells, and now like those of strings and pipes, which disturb ears through the night: these are produced by multifarious noises coming from the cracking ice." KUMAGUSU MINAKATA.

April 9.

THE ROYAL OBSERVATORY, EDINBURGH.

THE new Edinburgh Royal Observatory, which was formally opened by the Secretary for Scotland on the 7th inst., is situated on Blackford Hill, some two and a half miles due south of the centre of the city, in a public park, of which about three acres have been transferred to the Crown by the Edinburgh Town Council. The centre of the observatory is about 440 feet above the level of the sea. The name of Blackford Hill will suggest to many readers the lines from "Marmion":

Blackford! on whose uncultured breast
  Among the broom, and thorn, and whin,
A truant-boy, I sought the nest,
Or listed, as I lay at rest,
  While rose, on breezes thin,
The murmur of the city crowd,
And, from his steeple jangling loud,
  Saint Giles's mingling din.

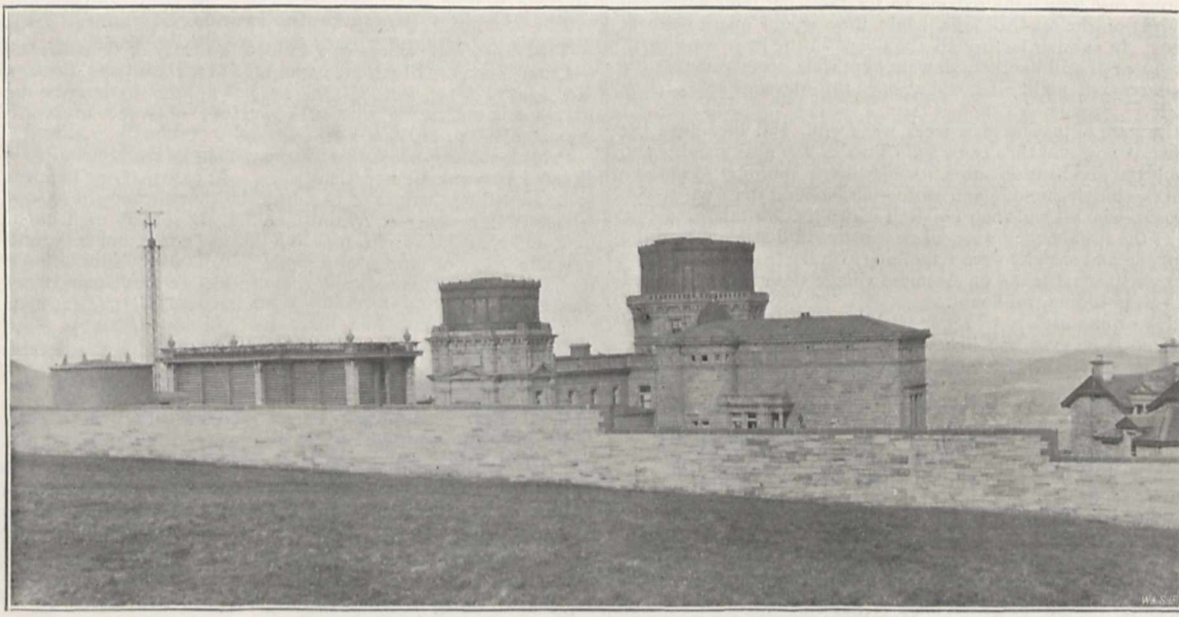
The main building is T-shaped, with a tower for the 24-inch reflector, removed from Calton Hill, at the west end, and a somewhat larger tower for the 15-inch Dunecht refractor at the east end. The clear length of the platform above the rooms connecting these towers is 110 feet. The stem of the T is built in three stories. In the basement are the gas engine and dynamo, storage cells and primary batteries, the heating apparatus and a bookstore; while above the library and adjoining rooms is a room 66 feet by 23 feet, with its floor on a level with the platform already mentioned.

This room, which ranges exactly north and south, is intended for optical experiments and spectroscopic

1 In Prejevalsky's "From Kulja, across the Tian-shan to Lob-nor," London, 1879, foot-note, p. 177, the word Muzart, or Mussart, is stated to mean "Snowy."

2 The old Chinese pilgrim, Hwen-tsang, who followed this same route, observed that the travellers passing thereby must sleep on the ice (Schuyler, "Turkestan," London, 1876, vol. i. p. 391).

research, for which purpose a siderostat by Foucault, with a silvered mirror 16·3 inches in diameter, is mounted at the northern edge of the platform under a movable cover. Arrangements have, of course, been provided for darkening this room at pleasure. In the north wall of the room, and facing the siderostat, is fixed a massive iron frame capable of carrying lenses ranging from the 15-inch object-glass down to that of an ordinary camera, the lenses most frequently used being provided with adjustable rings so arranged that they need only be centred once for all. For 39 feet of the length of the room three lines of rails are let into the floor, on which travel three iron carriages for the spectroscopes, gratings, or cameras in use, the side rails being intended for apparatus to receive deviated rays. In addition to these a narrow gauge line runs along the centre of the room from end to end, 66 feet. This is intended for long-focus photographs. All these rails are carried by steel beams distinct from those which support the floor. Any one who has been at Dunecht will recollect the comfort with which the most that of the 15-inch refractor. The viewing telescope is somewhat larger in aperture, to ensure catching the whole of the rays emerging from the prism. The tube of the collimator is made as rigid as possible, and is isolated from the large bronze tube which carries the whole spectroscope. The rays from the great object-glass may be intercepted, just in front of the slit, by a diagonal eye-piece, removable at pleasure, which allows the object to be viewed, and serves also as a finder. Attached to the same draw-tube is a second prism for throwing the light from any artificial source upon the slit. Only one prism can be used at a time, but it can be readily exchanged for another, without disturbing the adjustments. The prism is carried by a divided circle, so that its exact position is always known. The long rod shown in the figure rotates the prism; the shorter one moves the viewing telescope, the position of which may be read either by two opposite microscopes, or by a long reading microscope (not visible in the figure), carried close down to the observer's eye



6 in Refractor. Transit House. 24-inch Reflector. Siderostat. 12-inch Reflector. 15-inch Refractor. Optical Room. Library.

Fig. 1.—Royal Observatory, Edinburgh, from the South-west.

delicate solar work could be carried out in the optical room there, of which the room at Edinburgh is a copy.

In the east tower is mounted the 15-inch Dunecht refractor. Amongst the adjuncts to this instrument may be mentioned the large stellar spectroscope made by T. Cooke and Sons (Fig. 2). As this spectroscope has not yet been described, the following particulars may be of interest. It is provided with three prisms: (1) one of 60° by the makers, giving a dispersion of 5° 7′ from A to H, and capable of separating the lines 488·81 and 488·84 of Angström's map. It shows also 43 lines between B and C. It was with this prism that D_3 and another helium line, 487·6 mmm. ±, were detected in the Great Nebula of Orion at Dunecht in the winter of 1886–87 (see *Monthly Notices*, vol. xlviii. p. 360). (2) A large compound prism by Sir H. Grubb, with nearly twice the dispersion of the prism first mentioned. (3) A Merz prism with an angle of 20°, intended for use on the fainter stars. The collimator has a focal length of 24 inches, and an aperture of 2 inches, the ratio being 12 to 1, the same as The pointer in the field of view is illuminated by monochromatic light of any desired colour or intensity, produced by a small direct-vision spectroscope, on the plan devised by Prof. Smyth. No detail has been omitted that could contribute to the accuracy of the observations, such as focusing scales for collimator and viewing telescopes, eclipsing screens in the field of view as well as in front of the slit. A thermometer shows the temperature of the inside of the prism box. It will be seen from Fig. 2 that measures can be made on either side of the axial line by simply turning the viewing telescope and rotating the prism into the proper position.

It would be scarcely possible to enumerate the various minor instruments, but the following may be mentioned. Two heliostats by Duboscq and Browning; photo-measuring instrument by Grubb; dividing engine by Dumoulin Froment, of 64 cm. range, showing the thousandth part of a millimetre; delicate Oertling balance and weights; standard mètre à 0° by Dumoulin Froment; standard yard by Simms; two excellent spherometers by

Hilger; Foucault apparatus for measuring the velocity of light; Ladd polariscope with large collection of crystals; two extra large Nicols; anemograph, King's barograph, and standard barometer by Casella; resistance coils, large electro-magnet and a great variety of electric and physical apparatus, including one of Prof. Rowland's magnificent gratings. Among the smaller telescopes are:

12-inch reflector by Browning-With,
6-inch refractor by Dallmeyer,
6 " " " T. Cooke and Sons,
4 " " " " "
3 " " " " "

All the foregoing are equatorially mounted with clockwork, and there is an object-glass prism by Merz, which fits either of the 6-inch telescopes.

A 4-inch reversible transit by Cooke and Sons, with stand for both the meridian and prime vertical, is mounted in a detached hut.

A Zöllner's astrophotometer, a 12-inch altazimuth by Simms, a variety of theodolites, sextants, reflecting

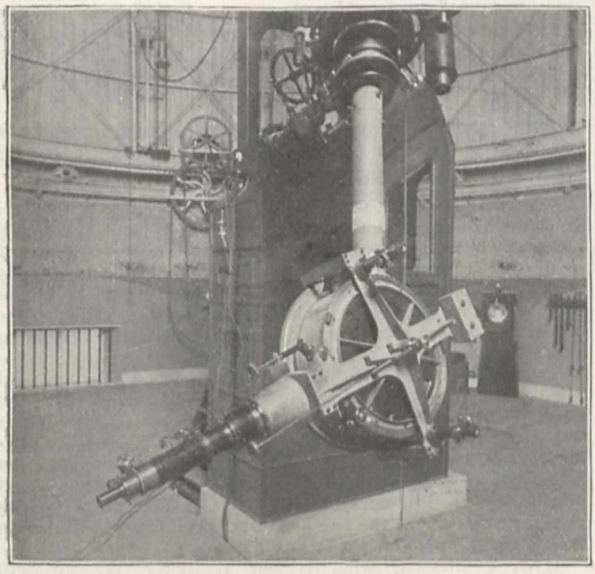


FIG. 2.—Stellar Spectroscope, by T. Cooke and Sons, attached to the 15-inch Dunecht Refractor. (The divided circle is 18 inches in diameter.)

circles, cameras, spectroscopes, and prisms from $4\frac{1}{2}$ inches downwards, complete the outfit for work at the observatory and on expeditions.

A word must be said about the clocks. Two of these, the Dunecht sidereal clock by Frodsham, and the excellent Makdougall-Brisbane clock by Dent, from Calton Hill, are mounted in the base of the pier of the larger tower, shut in by thick double doors stuffed with "slag-wool." This guarantees a nearly uniform temperature for both clocks, while the Brisbane timekeeper has the further advantage of being subjected to a uniform barometric pressure of 25 inches maintained inside a cast-iron case. This latter part of the arrangement has been most efficiently carried out by Messrs. Jas. Ritchie and Son, of Edinburgh. Automatic signals from this chamber serve to rate the mean time clock, which is kept to Greenwich time, and transmits currents to Edinburgh and Dundee for regulating the time signals.

The 8·6-inch transit circle by Troughton and Simms, formerly at Dunecht, is mounted in a detached double iron house 80 feet west of the observatory, with which it is connected by a covered way. It has two finely-divided circles—one of them movable. North and south of the instrument, but in the same room, are two 6-inch collimators, which can be pointed on each other through a hole in the $17\frac{1}{4}$-inch central cube of the telescope. The opening in the roof is 39 inches broad.

The great 4-barrelled chronograph by Cooke, from Dunecht, capable of recording six hours' continuous observations on each barrel, is mounted in the base of the west tower. It is supplemented by a small 3-pricker fillet chronograph by Fuess, of Berlin. Both instruments can be worked from six places in the observatory, and with either of the sidereal clocks. The clocks can also be compared automatically on the chronograph, or audibly by a sounder.

In the south wing the principal room is the library, 24 feet by 34 feet 6 inches, and 20 feet in height, which contains the astronomical library collected by Lord Crawford at Dunecht, comprising about 15,000 volumes. Divided amongst the computing rooms are the books removed from Calton Hill.

The observatory and instruments are lighted by electricity, generated by a 7-horse Crossley gas engine, charging 53 large storage cells.

Within the boundary wall of the observatory stand the house of the Astronomer Royal for Scotland, two semi-detached villas for assistants, and a gate-lodge for the care-taker and messenger.

The transit circle and reflector have only just been mounted, but the large refractor has been in use since last autumn, and in spite of the very unfavourable weather a considerable number of observations of comets have been secured with it. The provisionally-adopted coordinates of the transit house are: Latitude $+55° \; 55' \; 28''\cdot0$. Longitude 12m. 44·2s. west of Greenwich. It is not likely that these will have to be materially altered.

THE PLACE OF SCIENCE IN EDUCATION.

THE Bishop of London should know something about education. He has been the Principal of a Training College, an Inspector of Schools, and Head Master of Rugby School, and he has written in a broad spirit on educational matters. No wonder, then, he modestly confessed at the London Diocesan Conference last week, that "he happened to know a good deal about education." There is one branch of knowledge, however, which he thinks should be cut off from the educational tree nurtured in elementary schools, and that is the branch of science. "He had very often felt," he said, referring to the Education Bill, "that it had been a very great evil that we insisted upon instructing little children in elementary schools in a great many scientific subjects, and he should not have been at all sorry if all these scientific subjects were got rid of entirely, and it had been left to the managers, and to the teachers under the managers, to introduce other subjects which would be more suitable." And, later on, he remarked: "Teaching of an advanced character might very well be permitted in some schools, but in regard to all these scientific schools, and the apparatus connected with them, the sooner they were got rid of the better."

Evidently Dr. Temple is moved by the oppression which schools suffer from science, and he desires to emancipate them. But to any one familiar with the facts as to scientific instruction in this and other countries, and the beneficial results which proceed from it, Dr. Temple's strongly-expressed desire will appear astounding. The schools in which science is successfully taught (and we count success not so much by examinational results as by the training of the mind and eye and hand, and the development of the spirit of inquiry), invariably contain the most intelligent scholars; the towns or districts which possess properly organised and equipped science schools contain the largest proportion of skilled and inventive workmen. It is in the elementary schools that the foundations of natural knowledge should be laid, and there the faculty of observation should be trained to feed the mind; yet these are the schools which the Bishop of London would shut out from the light of science. For many years men interested in scientific education have been striving for a fuller recognition of science in our educational system, and not without a certain measure of success. But now comes Dr. Temple and says in spirit, if not in the exact words, "Away with all these abominations. Purge the elementary schools of everything scientific, and substitute dogmas and subjects more fitted to the stations of life in which it has pleased God to call the scholars." It is difficult to believe that sentiments so antagonistic to scientific study should have been uttered towards the end of the nineteenth century, and by one who is regarded as a friend of educational progress. But it is gratifying to know that Dr. Temple is only expressing the desire of a few ecclesiastics when he declares for the expulsion of science from elementary education. All who have the good of the country at heart, and who know the immense industrial harvest which Germany has reaped, and is reaping, as the result of generous provision for science in education, will regret that a man in the exalted position of the Bishop of London should have been the mouth-piece of words so narrow in their signification as those we have quoted—words which really lead one to think that he has not yet grasped the difference between "education" and "instruction." As it happens, we have received during the past week a copy of the address delivered by the Right Hon. A. J. Mundella to the members of the Association of Technical Institutions at their last annual general meeting, and we subjoin a few extracts from it, in the hope that they will lead Dr. Temple and his friends to a better appreciation of the value of scientific education.

Germany and Switzerland have, for more than half a century, been perfecting their educational system. They have trained up two generations in the most efficient and best manner that these two nations can afford, and they have profited very largely by it.

Now, to my mind, it is astonishing that this should be the case with such comparatively poor nations, because they have made their institutions accessible to every citizen, even to the poorest. There has been a lavishness amounting almost to extravagance in their expenditure. A few years ago I was in Berlin, and I was talking to my old friend Prof. Hofmann, who was then at the head of that great Charlottenburg Institution, the first technical institution in Europe. I remarked to him that I had been through various institutions in Germany and Switzerland the previous year, and it seemed to me that they were rather over-producing scientific men, the supply was in excess of the demand. "It is true," he said, "that we are producing more than we can absorb. We have a plethora of scientific men; only this year in my own department, two hundred Doctors of Science have taken degrees in the universities of Germany. But you must bear one thing in mind; *we have the export trade entirely to ourselves.*"

"Go where you will throughout the world, you will find the German chemist at the head of every industry into which chemical science enters. I was in America, making a journey through the States some two or three years ago, and wherever I went I was entertained by German chemists and German scientific men, many of whom were old students of mine. They were at the head of every industry to which scientific knowledge is applicable, chemical works, gas works, breweries, whatever it was a German was at the head of it." And he said, "You know that pays. When a German scientific man wants plant or machinery, and that plant is manufactured in Germany, he goes to Germany for it, he does not go to England." That is quite true. The position that the German chemist, the German scientist, the German technologist has taken throughout the world, has done much to assist German industry.

The extent to which Germany and Switzerland have profited by technical teaching, is hardly realised by the English people. We are beginning to learn it; Switzerland, we are told by Sir O. Adams, in his excellent book on the "Swiss Confederation," exports a greater amount of manufactures per head for her population, than any other country in the world. It seems almost incredible that it should be so, that a country without natural resources, without iron, without coal, without a port or a navigable river, should nevertheless have a greater export of manufactures than any other nation in the world, not excepting England. But it is *true*, gentlemen, and she owes it entirely to her *education*. . . .

Look at Germany. What has Germany gained by her sacrifices? I have been reading the most recent consular reports from that country: they furnish a mass of testimony in proof of the advantages she is reaping from her persistency in an enlightened educational policy. Hamburg trades very largely with English-speaking countries. Years ago she made English a compulsory subject in her common schools. She has been unsparing in expenditure for the equipment of her citizens, and she is reaping her reward. If, thirty years ago, any one had ventured to prophesy that in 1895 the tonnage of sea-going ships touching at Hamburg would exceed that of Liverpool, we should have laughed him to scorn; but this "striking fact" was announced to us a few days ago. Our Consul at Stettin reports that the educational authorities of that city propose to devote four hours a week to the study of English in the common schools. What would be said in England if a School Board on the north-east coast was to make German a compulsory subject?

After stating a number of remarkable instances of the effects that foreign competition is having upon British trade and employment, Mr. Mundella continued:—

Let us ask ourselves why it is that our rivals are so successful? In the first place their elementary schools are thoroughly efficient. The teaching staff consists of trained adults, 90 per cent. of them being men. The scholars attend with astonishing regularity, and the school-life is sufficiently long to permit of their mastering the full curriculum of the school. When at the age of fourteen (in Switzerland it is often fifteen) the continuation school perfects, and adds to, the knowledge acquired in the elementary school. Then follows the high school, the technical school, and the university. There is no waste of effort; no overlapping; everything is co-ordinated; and everything is accessible to "the youth of pregnant parts." Fees are sufficiently low, or scholarships are provided, to admit of the humblest scholar of promise securing a thoroughly sound education. In Switzerland the high schools are free as well as the elementary, and the fees at the Polytechnicum at Zürich do not exceed £4 per annum. . . .

Well, gentlemen, what is our position? We are still the first industrial nation in the world. What is our educational position? Are we first? Comparisons are odious. They are in this case; one hardly likes to make them.[1] Having regard to our wealth, the magnitude of our industries and of our commerce, the vast interests that we have in our keeping, we ought to be the first. Why are we behind, and what ought we to do to obtain supremacy in education as well as maintain it in industry? Well, you must begin at the bottom, you must improve the elementary education. We, to a great extent, owe the present condition of things to the early leaving of school, to the half-time system, to the low standards which prevail, especially in the country districts, where the fourth standard is the standard of total exemption. Think of the numbers that enter factories at eleven years of age. Think how few stay at school until they are thirteen or fourteen. It is true we have done excellent work under Forster's Act. We should take shame to ourselves that we have not done more. but we have done as much as the country would allow us; and we have been always, I think, in advance of the opinion of the country.

We trust that these extracts from Mr. Mundella's address will bring the Bishop of London to a better understanding of the place and value of science in education.

[1] Dr. Virchow visited England four or five years ago, and on his return to Berlin he reported, "England is a century before us in sanitation, and a century behind us in education."

NOTES.

A PHOTOGRAVURE of Sir Joseph Lister, President of the Royal Society, accompanied by a biographical sketch, will appear in next week's NATURE, as an addition to the series of "Scientific Worthies."

THE "James Forrest" lecture of the Institution of Civil Engineers will be delivered on Thursday, May 7, by Dr. A. B. W. Kennedy, F.R.S., the subject being "Physical Experiment in relation to Engineering."

PROF. EHRLICH has been appointed Director of the new State Institute in Berlin for the testing of therapeutic serum.

THE Trustees of the late Earl of Moray have granted a donation of £1875 to the Ben Nevis Observatory.

THE Bill before the House of Representatives adopting the metric system of weights and measures as legal standards in the United States, has (says *Science*) been referred back to the Committee. The Bill was ordered to a third reading by a vote of 119 to 116, but this vote was afterwards reconsidered.

DR. J. E. AITCHESON, C.I.E., the naturalist who was attached to the Afghan Delimitation Commission, has returned to London from North-West India and Kashmir, where for the past four years he has been continuing the further investigation of the fauna and flora of those regions.

WE regret to announce that Prof. Dr. Adalbert Krueger, Director of the Kiel Observatory, died on Tuesday, April 21. He was in his sixty-fourth year.

THE deaths are announced of M. Joaquim P. N. da Silva, distinguished for his archæological works, at Lisbon, in his ninetieth year; M. Jules Lefort, Member of the Paris Academy of Medicine, and the author of many treatises on pure and applied chemistry and pharmacy, his most important work being in connection with water analysis; Prof. Dr. Ofterdinger, at one time Professor of Mathematics and Astronomy in Tübingen University; and M. J. B. Dureau, the founder, in 1860, of the *Journal des fabricants de sucre*. M. Dureau was also the author of a "Rapport sur l'Industrie de sucre à l'Exposition universelle de 1867," and of a valuable work entitled "l'Industrie du sucre depuis 1860."

WE learn from *Terrestrial Magnetism* that M. Moureaux has been entrusted by the Minister of Public Instruction, at the request of the Imperial Russian Geographical Society, with the investigation of a pronounced anomaly in the distribution of terrestrial magnetism, which certain observations have revealed in Southern Russia.

ARRANGEMENTS are being made in Limoges to celebrate this year the centenary of the introduction of porcelain into France, by means of an Exposition, in which the history of porcelain manufacture will be traced by specimens of work and processes. The Exposition is being organised by the Société Gay-Lussac, working in conjunction with representatives of the town of Limoges.

ON Tuesday next, May 5, Mr. C. V. Boys, F.R.S., will begin a course of lectures at the Royal Institution, on "Ripples in Air and on Water"; and on Thursday, May 7, Mr. W. Gowland, late of the Imperial Japanese Mint, will begin a course of lectures on "The Art of Working Metals in Japan." The Friday evening discourse on May 8 will be delivered by Prof. Silvanus P. Thompson, F.R.S., his subject being "Electric Shadows and Luminescence." That on May 15 will be on "Cable Laying on the Amazon River," Mr. Alexander Siemens being the lecturer.

WE learn from *Science* that Mr. William I. Hornaday, formerly of the U.S. National Museum, has been appointed Director of the proposed Zoological Park in New York. He enters upon his duties immediately, and will first consider and report to the Executive Committee upon the difficult question of location of the Park. At the last meeting of the Society the three first honorary members were elected as follows: Sir William H. Flower, Prof. Alexander Agassiz, and Prof. J. A. Allen.

OUR American correspondent writes under date April 17:—"Prof. Frederick A. Starr, of the University of Chicago, has just returned from a three months' tour in Central America. He found many genuine dwarfs, but not constituting a tribe, as they spoke nineteen languages in Oaxaca, thirteen in Chiapas, and twenty-one in Guatemala, indicating a lack of unity among them.

"The new remedy for consumption, aseptolin, the formula for which has recently been given to the world by Dr. Cyrus Edson, is now used in the New York State's prisons at Sing Sing, Dannemora, and Auburn, with marked success. At the last-named prison there was not one death from consumption during the entire month of March, which is quite unprecedented. Twenty thousand cases are under treatment, the larger number being outside the prisons, with two hundred cures reported.

"It is remarkable that with the abundant sea-life teeming about it, and within short distances, New York City has never possessed an aquarium. Castle Garden has now been converted to that use, and will be opened to the public within a few weeks with admirable equipment. It is peculiarly fortunate that the underlying strata are such as to filter the water from the adjoining harbour, thus providing an inexhaustible supply of pure sea-water for the tanks from an artesian well.

"The extraordinary weather, perhaps, deserves another note. While snow-storms still prevail at the West, and three feet of snow, being the heaviest snow-fall in many years, was reported on Monday from New Mexico, unprecedented heat has prevailed along the North Atlantic seaboard for five days, the thermometer reaching 85° at New York City on the 16th, and again to-day, which exceeded by 14° all previous records of same date, and was hotter than any April weather previously recorded. From other points still higher temperatures were reported: 90° at Hartford, Conn., and Moonsocket, R.I.; 92° at Manchester, N.H., and 94° at Middletown, N.Y."

THE summer meetings of the Institution of Naval Architects will be held this year in Hamburg, on Monday, June 8, and the following day. On Wednesday, June 10, the meetings will be transferred to Berlin, on the invitation of the Imperial German Government, and they will be continued there during the remainder of the week. Full particulars of the papers to be read, of the works and places of interest to be visited, and of the excursions and entertainments which are being organised, will shortly be issued. The meetings are receiving the warmest support from the Imperial Government, under whose direction the arrangements in Berlin are being prepared.

ON July 2 the Second International Congress of Applied Chemistry will open in Paris. In addition to strictly technical questions, the congress will discuss the analytical processes needed for the guidance of manufacturers and the benefit of the consumer. The proceedings will be conducted in ten sections, and, judging from the number and interest of the questions which will be brought up in each, there will be no lack of work. The sections represent such diverse subjects as chemical products, electro-chemistry, colouring matters and dyeing, pharmaceutical products, metallurgy and mining, sugar-refining, vintnery, brewing, distilling, agricultural chemistry, photography, alimentation, and milk-supply. The Association des Chemistes de Sucerie et de Distillerie, which is organising the congress, has formed a omm comprising several members of the French Government, a large number of members of the Institute, and many of the foremost men in science and industry in France. Further information with reference to the congress can be obtained from M. Dupont, 156 boulevard Magenta, Paris.

The Marine Biological Laboratory at Plymouth has been the scene of more than usual activity during the past month. In addition to the permanent staff of the laboratory, five botanists and zoologists have been engaged in biological research, and the students' laboratory, recently equipped for the accommodation of vacation parties, has had its resources taxed to the uttermost. Fifteen students in all—six from Cambridge, five from Oxford, three from the Owens College, Manchester, and one from University College, London—have formed Mr. Garstang's vacation class, and have made full use of the liberal provision made for them by the Director of the laboratory and his staff. The arrangements for the class have consisted of daily expeditions for trawling, dredging, tow-netting, and shore-collecting purposes to various parts of the neighbourhood, and of daily lectures and demonstrations on the results of the expeditions, and on general topics connected with marine biology. Especial attention has been paid to the life-histories of animals—to their bionomical relations and to problems of use and function—so as to comprise a body of instruction supplementary to the morphological studies of university laboratories. The class has admittedly been a great success, and the students have returned to their various universities not only with a store of new facts, but with renewed interest in biological pursuits. A similar class will be formed for August next. The *Busy Bee*, the new steamboat of the Association, has satisfactorily fulfilled all the tests imposed upon her, and proves to be eminently suitable for the routine work of the laboratory. Among the more interesting of recent captures may be mentioned the discovery of several examples of a species of the Amphineuran *Proneomenia*.

The annual general meeting of the British Ornithologists' Union was held at 3 Hanover Square, on the 22nd inst. In the absence of Lord Lilford, the President, Mr. P. L. Sclater, F.R.S., took the chair. The report of the Committee stated that *The Ibis* (the journal of the Society) had been regularly published during the preceding year, and that the Union consisted of 269 ordinary members, besides honorary and foreign members. Twenty-nine new ordinary members and one new foreign member, were proposed and elected. Mr. Sclater brought forward a scheme for a new synopsis of the described species of birds, to be arranged in six volumes, corresponding with the six zoological regions of the earth's surface. This was referred to a Committee to report upon.

We have received a copy of the draft programme of questions proposed for discussion at the International Meteorological Conference to be held in Paris in September next. Numerous questions in general meteorology, terrestrial electricity and magnetism, and international meteorology are down for discussion. Among these questions and propositions we notice that Dr. P. Schreiber (Chemnitz) will propose that the meteorological day shall be reckoned from 9 p.m. to 9 p.m., and designated by the same number as the civil day, while meteorological extremes and sums, *e.g.* of rain fallen, shall be measured at 9 p.m. Prof. Willis L. Moore (Washington) will put forward the solar magnetic period 26·67928 days as the natural mode of classifying solar, physical, and terrestrial meteorological phenomena, and suggest the desirability of its introduction for general use in the year 1901. The Royal Meteorological Society suggests (1) the desirability of more extended observations on infiltration into the soil, and uniformity in the same; (2) the general adoption of a standard anemometer for the determination of the velocity of the wind; (3) the general adoption of a uniform system of exposure for anemometers; (4) uniformity of conditions under which earth temperatures should be taken. Prof. H. Mohn (Christiania) will introduce the question of determining the pressure of the air by means of the observation of the boiling point of water (the hypsometer) with the accuracy necessary for meteorological purposes; and also that of the determination of the gravity correction for mercurial barometers by simultaneous observations of the hypsometer and the mercurial barometer. Dr. Billwiller (Zürich) will urge the necessity for the introduction of a uniform method of reduction of barometer readings to the sea-level for the construction of synoptic weather charts. Rev. Father Faura, S.J. (Manilla), will suggest that the time has arrived to settle the question of air motion in cyclones, and to finally disprove the theory of descending currents in these phenomena. Prof. E. Mascart (Paris) will treat of atmospheric electricity and terrestrial magnetism. Prof. von Bezold (Berlin), and Prof. Eschenhagen (Potsdam) will propose that certain general principles should be introduced for the publication of magnetic observations, and should be laid down for magnetic surveys. They will also suggest that it is desirable that all institutes which publish magnetic charts should give additional tables containing the magnetic elements, and, if possible, also the components for convenient points of intersection of the geographical co-ordinates. Other questions which they suggest for discussion are the distribution of magnetic observatories, and simultaneous international observations.

The last published Report of the Central Physical Observatory of St. Petersburg gives particulars of the working of the vast and important meteorological service in Russia, and is the last summary which will be prepared under the efficient superintendence of Prof. H. Wild, who has now retired from the directorship. The number of stations returning regular observations amounted to 642, of which 438 were in Europe, and the remainder in extra-European localities. Before publishing these observations, they have been subjected to careful revision, *inter se*, and to comparison with synoptic weather charts. Storm-warning telegrams have been regularly issued to the Baltic and Black Seas, as well as to some inland seas, for which a success of 72 to 78 per cent. is claimed. Special attention is also paid to daily weather forecasts; the results are published for each separate element and for each month, the aggregate success being over 74 per cent. Special forecasts of wind and snow-storms are also issued to the railway companies. The report contains a long list of scientific investigations published under the auspices of the St. Petersburg Academy of Science.

Water-cress is eaten by Caddis-worms, Caddis-worms by trout, and trout by Herons. The result of disturbing this balance of nature in a particular case is described by Miss E. A. Ormerod in the Cirencester *Agricultural Students' Gazette*. Three-quarters of a large crop of water-cresses were found to have been injured by the attacks of the water-grubs which are so well known as Caddis-worms. Isaac Walton gives evidence of the love of trout for Caddis-flies as baits, and this points strongly to their knowledge of the goodness of the larvæ for food in more natural circumstances. But in the case which Miss Ormerod investigated, the trout had been eaten by Herons, and by their removal the water-cress grower appears to have lost very helpful friends. The sequence of events consequent on local encouragement (beyond what is known as a natura balance) of one large species of birds of special habits, downwar through destruction of insect-eating fishes, and overplus of vegetable-eating insects, to the great pecuniary loss of the grower of water-cress, deserves a place with Darwin's story of the relation between cats and clover.

DR. GREGG WILSON describes several peculiar cases of hereditary polydactylism, showing considerable variation in the position of the abnormality, in the *Journal of Anatomy and Physiology*. In one family, extra fingers or toes were so common that they were almost expected to appear upon some of the children. This abnormality persisted through six generations, and two interesting features connected with it are that it increased in the first four generations, and changed in position from the post-axial to the pre-axial side of the limb. In another case there was an increase of the abnormality, and also a change in the position from the post-axial to the pre-axial side of the limb. In a third case there was remarkable variability in the abnormality, a man with extra minimi on both feet having one son with extra great toes, and another son with extra minimi on the hands and a double middle toe on one foot. The instances studied by Dr. Wilson illustrate the variability of digital abnormalities, and in this regard they differ from the majority of cases of hereditary polydactylism, where the abnormality is very constant in position through several generations, though not in degree. In a few cases the abnormality has been found to pass in successive generations from the outer side of the hand to the outer side of the foot, and *vice versa*, but it is rare that i passes from one side of a limb to the other, as in the five cases sketched by Dr. Wilson.

ON April 13 a meteorite, weighing two kilogrammes, fell at Lesves, near Namur, Belgium. In its fall it very nearly killed a young man who was working in an orchard, and it embedded itself into the earth to a depth of 50 centimetres. The Abbé Renard, who examined the specimen, considers it to be a stony meteorite of chondritic structure. It consists of a whitish crystalline paste, from which are detached meteoric iron, troïlite, olivine, bronzite, and chondroi. An examination of the structure and the chemical composition of this aerolite is now being made in the laboratory of the University of Gand.

THE publication of Herr Gätke's theory of the moult in birds, in his work on Heligoland, seems to have induced other ornithologists, both in Europe and America, to turn their attention to this difficult subject. Mr. Witmer Stone has put forward his views "on the moulting of birds," in a communication made to the Academy of Natural Sciences of Philadelphia in January last. He has come to the conclusion that the annual moult at the close of the breeding season is a physiological necessity, and is common to all birds; whereas the spring moult and striking changes of plumage effected by abrasion are not physiological necessities, but depend in extent upon the height of development of colouration in the adult plumage, and do not necessarily bear any relation to the systematic position of the species. Mr. Stone scouts the idea of Gätke (adopted by Dr. Bowdler Sharpe) that feathers can actually change their colour without moult, unless it be by abrasion or bleaching. Mr. Stone gives us a large number of useful notes on the smaller land-birds of Eastern North America, based on his own observations.

A PAPER in the current number of the *Annales de Chimie et de Physique* gives the results of some recent determinations of the specific heat of boron, made by MM. Moissan and Gautier. Amorphous boron was used, and the specific heat measured by means of Bunsen's ice calorimeter. The boron was heated to three temperatures: 100°, 180°, and 230° C. The values for the atomic heat obtained at 50°, 146°, and 213° are 3·374, 4·153, and 4·766. By interpolation it is found that at a temperature of about 400° C. the atomic heat of boron would be 6·4, but the authors have made no attempts to make measurements at temperatures over 230°.

SINCE it has been shown that the velocity of propagation of an electro-magnetic disturbance in a dielectric is the same as that in a wire surrounded by the dielectric, the measurement of the velocity of such a disturbance in a wire is of great interest. M. Blondlot, who has already published the results of some experiments made on this subject, contributes an interesting paper to the current number of the *Annales de Chemie et de Physique*, giving the results of some recent experiments on the velocity of propagation of an electro-magnetic disturbance along a wire. The author employs the discharge between the outer coatings of two small Leyden jars (the "impulsive discharge" of Lodge), which occurs when a spark passes between the knobs connected to the inner coatings. Each of the jars has two outer coatings, one of which is connected to a small spark-gap by a short wire, while the other is connected to the same spark-gap by a wire about 1000 metres long. Hence on a spark passing between the knobs connected to the inside coatings, two sparks occur in the spark-gap, one produced by an electro-magnetic disturbance which has only traversed a few centimetres of wire, while the other, having started at the same time as the first, has passed along about 1000 metres of wire. An image of the sparks is thrown on to a photographic plate by a mirror rotating at a known speed. The speed of the mirror was determined by comparing, by means of a monochord, the pitch of the note produced by the vibrations of the axle in the bearings with the pitch of a tuning-fork. The "line" consisted of copper wires 3 millimetres in diameter, suspended on posts about 3 metres above the surface of the earth. The distance between each of the outgoing wires and the corresponding return, which was in the same vertical plane, was 80 cm., while the two circuits were at a distance of 40 cm. from each other. The mean of five sets of measurements gave 296,400 kilometres per second as the velocity of the disturbance, while three others in which the distance traversed was nearly twice as great, *i.e.* 1821 metres, gave 298,000 kilometres per second. The author considers that each individual measurement is probably correct to within 1 part in 100.

THE *Annals* of the Astronomical Observatory of Harvard College, vol. xl. part iv., contain an important appendix by Mr. S. P. Fergusson, upon anemometer comparisons made at Mr. Rotch's Observatory at Blue Hill, Massachusetts, in the years 1892–94. The object of the investigation was to determine the mean differences between anemometers used as standards in different countries, and to compare the results of recent whirling-machine experiments. The observatory in question is admirably adapted for the purpose, being situated upon an isolated hill, and is equipped with the best patterns of anemometers, in addition to which some instruments were supplied from other places for comparison. The anemometers, and method of comparison are fully described; very useful results were obtained, to which, however, we can only briefly allude here. The experiments show conclusively that the smaller anemometers are the most sensitive to sudden variations in velocity, the ratio of sensitiveness being nearly proportional to the size, in instruments of the same type. The fan anemometers are much more sensitive than the cup anemometers, and are therefore the most efficient for recording gusty winds; the Robinson pattern instruments, mostly used in this country, are least efficient in this sense, but they possess undoubted advantages for recording mean velocities. Dines' pressure tube anemometer was found to be an excellent instrument, especially for indicating maximum velocities. The comparisons clearly show the need of some standard form of anemometer, to which all observations heretofore made can be reduced.

THE results of much patient observation are recorded in *Bulletins* 129 and 130 of the Michigan Agricultural Experiment Station, which relate to fruit culture. Numerous varieties of fruits, embracing 156 of strawberries, 53 of raspberries, 30 of blackberries, 44 of currants and gooseberries, 63 of cherries, 191 of peaches, 72 of plums, 37 of pears, 101 of apples, besides quinces, apricots, nectarines, mulberries, and others, were separately grown. Cultural notes were periodically written, whilst quality, vigour, and productiveness were numerically estimated according to a fixed scale. In every case, the weight of an average specimen of the fruit is tabulated, the information thus conveyed being regarded as preferable to a record of the size, and at the same time more easily and accurately acquired. The difficulties of nomenclature and synonymy are somewhat lessened by a strict following of the rules of pomology, as formulated by the American Pomological Society and the National Division of Pomology, and every effort is made to avoid ambiguity. Notes on insects and other pests—such, for example, as the currant eelworm, *Nematus ventricosus*—are added wherever necessary, and the useful effects of sulphate of copper sprayed as an insectide are referred to. The *Bulletin* should be of great practical value to the cultivators of Michigan, a State the climate of which especially fits it for profitable fruit-growing.

Mr. David Flanery, of Memphis, Tenn., U.S.A., writes that on January 14 last, "while looking for certain stars in the east at 5·45 a.m., suddenly a great light shone behind and to the left of me, and after studying a moment to determine whether it was a flash from the trolley, or some other common occurrence, I turned around to the west, and looking up beheld a body of grey nebulous matter, such apparently as the Milky Way is made up of, slowly disappearing from view. It lasted a full minute, and without moving in any direction faded away. I heard no noise as of an explosion, but the light and the apparent smoke which had the form J plainly indicated that an immense meteor had fallen or had been consumed. The locality of the phenomenon was on the borders of the Great Bear, Ursa Major, and the Little Lion, Leo Minor, and around the two bright stars Lambda and Mu, which mark the hind feet of the Bear."

The phenomenal Eichener Lake in the Grand Duchy of Baden, which has the peculiarity of appearing and disappearing at uncertain periods, has recently again made its appearance after a lapse of time.

It will be fifty years next October since the first application of ether in surgical operations took place; and in honour of this scientific jubilee, Prof. C. Binz, of Bonn, has recently published in Richard Fleischer's *Deutsche Revue* a valuable historical sketch of the successive stages through which that beneficial discovery has gone in various countries.

Messrs. William Wesley and Son have just issued a valuable catalogue (No. 125) of works on zoology. Scientific men and institutions on the look-out for standard zoological books and papers will find the catalogue well worth consultation.

The Report of the Berlin branch of the German Meteorological Society for the current year contains, as usual, an interesting investigation into the climate of that city, by Prof. G. Hellmann, the Vice-President. The subject this year is the publication and discussion of the daily mean temperatures, and extreme values for the last forty-eight years.

The additions to the Zoological Society's Gardens during the past week include an Egyptian Jerboa (*Dipus ægyptius*) from Algeria, presented by Mr. F. J. Pringner; a Polecat (*Mustela putorius*) from Worcestershire, presented by Mr. F. D. Lea Smith; an Alexandra Parrakeet (*Polytelis alexandræ*) from Australia, presented by Mr. W. Pritchard Morgan, M.P.; a Natal Python (*Python sebæ*, var. *natalensis*), five Hoary Snakes (*Coronella cana*), a Rhomb-marked Snake (*Psammophylax rhombeatus*), a Cape Bucephalus (*Bucephalus capensis*), five Puff Adders (*Vipera arietans*) from South Africa, presented by Mr. J. E. Matcham; a Brown Mouse Lemur (*Chirogaleus milii*) from Madagascar, three Red Kangaroos (*Macropus rufus*, ♂ ♂ ♀), four Black Wallaroos (*Macropus robustus*, 4 ♂), an Alexandra Parrakeet (*Polytelis alexandræ*) from Australia, a Hamadryad (*Ophiophagus elaps*) from India, deposited; two Common Sheldrakes (*Tadorna vulpanser*), European, purchased.

Erratum.—In Prof. J. J. Thomson's article on Röntgen rays, p. 582, col. 2, line 5, for 4×10^{-8} centimetres, read 4×10^{-6} centimetres.

OUR ASTRONOMICAL COLUMN.

The Spectrum of Mira.—During the recent maximum of Mira Ceti, Prof. Wilsing was fortunate enough to obtain eleven photographs of the spectrum (*Sitz. Akad. Wiss.*, Berlin, March 26, 1896). The photographs are evidently very similar to those obtained by Prof. Pickering some years ago, hydrogen being represented by broad bright lines. The absence of the hydrogen line H_ϵ, which falls very near a broad line of calcium, is again very striking, and the simplest explanation of this fact is to suppose that the hydrogen light at that wave-length is absorbed by calcium vapour. This necessitates the supposition that there is a cooler layer of calcium outside the incandescent hydrogen, but the high atomic weight of calcium cautions us to regard this hypothesis as merely provisional. There is no certain evidence at present as to whether the hydrogen lines appear in the spectrum except about the time of maximum, and the Potsdam instruments are not of sufficient aperture to permit such an investigation to be made.

It is stated that there are no bright lines other than those of hydrogen, although there are parts of the spectrum (especially about wave-lengths 3894, 3906, and 4350) which give the impression of bright lines. The latter appearances are regarded simply as regions in which the continuous spectrum is thrown into relief by the absence of dark lines; similar effects, but not so marked, are said to be seen in the solar spectrum.

With the exception of the bright lines of hydrogen, the spectrum of Mira shows a nearly perfect agreement with that of the sun in the region more refrangible than $H\gamma$, while on the less refrangible side of this line the spectrum is characterised by dark flutings fading towards the red.

There is probably a slight displacement of the bright lines towards the less refrangible sides of their true positions, but the photographs are on too small a scale to permit any exact determination of the velocity in the line of sight. There is no suggestion of a doubling of the hydrogen lines such as is seen in the case of β Lyræ, but the occurrence of a strong dark line alongside $H\zeta$ reminds one of the appearance of this line in β Lyræ.

The paper concludes with a table of wave-lengths, extending from λ 3772 to λ 4755.

Comet Swift, 1896.—The comet observed by Swift on April 13 is a new one, and from its position on April 16, 19, and 20, Dr. R. Schorr has derived the following elements and ephemeris for Berlin midnight:—

$$T = 1896 \text{ April } 17.51 \text{ Berlin mean time.}$$

$$\left.\begin{array}{l}\omega = 1^\circ\ 12' \\ \Omega = 177^\circ\ 55' \\ i = 55^\circ\ 15'\end{array}\right\} 1896{\cdot}0$$

$$\log q = 9{\cdot}7515$$

	R.A. h. m.	Decl. ° ′	Brightness.
April 30 ...	3 1·8 ...	+51 55 ...	0·72
May 2 ...	2 51·3 ...	+55 22 ...	0·63

The unit of brightness is that on April 16. The comet will be very near to γ Persei on May 2.

This comet is now well placed for observation, and being circumpolar can be seen practically all night. Observations made at South Kensington by Mr. Shackleton, on the 28th inst., show that it is so bright that it can be seen with an opera-glass. The comet has a well-marked nucleus and a slight tail. Spectrum observations and measures made with a small 3-prism spectroscope, collimator 6-inch, showed three bright bands, but practically no continuous spectrum. Comparison was made with a spirit flame, and the carbon bands were seen to be identical with the bright bands of the comet, the one at λ 516 being especially bright.

RECENT WORK WITH RÖNTGEN RAYS.

IN our last week's number, Prof. J. J. Thomson brought together and discussed observations of prime importance selected from the mass of material recently published on Röntgen rays. As a supplement to this, and in continuation of the general summaries which have already appeared in NATURE, we present the following notes on papers and communications received during the past few days.

Prof. Oliver Lodge has sent us the following announcement, dated April 20.

"It has been asserted that the action of X-rays on a film is a photographic one, depending on the fluorescence of the glass backing. The truth is that a film on a ferrotype plate is just about as rapid as a similar film on glass. Thick films are much better than thin. It may be further interesting to state that if the platinum disk on which the kathode rays inside the bulb are converged is connected to the kathode, it fails to act as a source; if it be insulated, it acts fairly; while if it is connected to the anode, it constitutes a vigorous source."

It will be remembered that Prof. Röntgen found that "films can receive the impression as well as ordinary dry plates" (NATURE, January 23, p. 274), but he was doubtful whether the photographic effect was secondary or not.

From a number of papers dealing with various properties of Röntgen's rays, we learn that Herren V. Novák and O. Sulc (Prague) have observed the relative opacity for X-rays of different substances, both simple and compound (*Zeitschrift für Physikalische Chemie*, xix. 3). They conclude that the absorbing powers of the chemical element depend on their atomic weight alone, and that the absorbing power of a compound depends only on the atomic weights of the elements of which it consists, and not on the complexity of its molecules. It seems probable that the *average* atomic weight of a compound affords an index of its absorbing power. In the *Jenaische Zeitschrift für Naturwissenschaft*, Dr. A. Winkelmann and Dr. R. Straubel (Jena) have investigated the refraction of Röntgen rays, and by using prisms of various metals, obtain in each case a value of about 1 : 0·0038 referred to air. They also have measured the reflection produced by a sheet of tinfoil, and the relative transparency of different kinds of glass to Röntgen radiations. All glasses made with lead are found to be comparatively opaque. The same writers have experimented on the action of fluor-spar in intensifying the actinic effects of X-rays, and have found that the best results are obtainable with a coarse powder of the fluor-spar; finer powders producing a less marked effect. This effect is due to fluorescence, the spar emitting radiations whose index of refraction is about 1·48; indicating a wave-length of 219×10^{-6}. The March number of the *Atti della Reale Accademia dei Lincei* contains two papers, one by Signor Augusto Righi, and the other a joint paper by Drs. A. Fontana and A. Umani (Rome), both of which deal with the effect of Röntgen rays in stopping the action of Crookes' radiometer. The effect is found to be purely electrostatical, and to be due to the electrification of the glass bulb containing the radiometer; when the bulb is wetted, or electrification prevented by the interposition of a conducting screen, the radiation from a Crookes' tube does not affect the radiometer in any way whatever.

Mr. A. W. Isenthal has sent us the following letter, *à propos* of Winkelmann and Straubel's paper. He says:—"It may be of interest to your readers to learn that, within the last few weeks, Prof. Dr. Winkelmann and Dr. Straubel, of Jena University, have been successful in reducing the exposure required for the production of radiograms to a few seconds only. Acting on the few directions given, I have made a few preliminary trials, the result of which is very promising. By simply backing the sensitive plate with a most inexpensive material, I have obtained fair negatives of the finger-bones in about ten seconds, using only a 3-inch spark. As the rays in this method have first to pass through the glass of the sensitive plate, there is a probability of still further reducing the necessary exposure by substituting sensitive films (on celluloid) for the ordinary photographic plate."

With reference to the use of fluorescent screens in reducing the time of exposure, we have received the following letter from Dr. H. Van Heurck, of the Botanical Gardens, Antwerp, through Dr. Wynne E. Baxter:—

"I notice in your issue of April 16, that Messrs. L. Bleekrode and J. William Gifford announce that they have been able to reduce the time of exposure in radiography by the use of a fluorescent screen. Mr. Basilewski communicated the same fact to the Paris Académie des Sciences on March 23 last. Allow me, however, to lay claim to priority in this application of fluorescent screens, as the same was announced by me in various Antwerp journals on March 8, and again on the 12th of that month, in the *Annales* (*Belges*) *de Pharmacie*, an extract from which, in pamphlet form, I send herewith. You will also find described therein a chemical substance, viz. a newly-discovered double fluoride of uranyl and ammonium, with which screens can be made, at a nominal cost, of a luminosity and of a clearness superior to that of any screen now known to exist."

The combination of a fluorescent screen with a photographic plate was one to which every worker with Röntgen rays would naturally be led. Prof. M. L. Pupin gave a description of the combination before the New York Academy of Sciences on March 2. At a meeting of the Academy on April 6, reported in *Science* of April 10, he described an arrangement of apparatus by means of which it was found possible to produce very strong photographic effects, "but not sufficiently strong for penetration through the thigh and the trunk of the human body at reasonably short exposures and at long enough distances from the tube to obtain the desirable clearness in the pictures of these massive parts. A completely successful application of Röntgen's beautiful discovery to surgery depends for the present on a successful solution of the problem just mentioned. I have obtained one satisfactory solution with the method which I first described before the Academy on March 2. It consists in placing in contact with the photographic plate a fluorescent screen, and thus transforming most of the Röntgen radiance into visible light before it reaches the sensitive film. Photographs of the hand were thus obtained at a distance of twenty-five feet from the tube with an exposure of half an hour. At the distance of four inches the hand can be photographed by an exposure of a few seconds. It was in this manner only that I succeeded in photographing on a single plate the whole chest, shoulders, and neck of my assistant, with an exposure of seventy minutes and at a distance of three feet between the plate and the tube. The collar-button and the buttons and clasps of the trousers and the vest show very strongly through the ribs and the spinal column. This result seems to prove beyond all reasonable doubt the applicability of radiography to a much larger field in surgery than was expected a few weeks ago."

A communication on the same branch of the subject has been received from Mr. A. A. C. Swinton, under date April 22. We print his letter in full.

"The chemical action of the Röntgen rays upon a photographic film may be either a direct action or may be a secondary effect, due to the fluorescence produced in the support, or in the gelatine and silver bromide of the film itself. Be this as it may, the fact that an ordinary photographic film supported on celluloid is almost completely transparent to the rays, as may easily be proved with a cryptoscope, and also the fact that it is possible to simultaneously impress many super-imposed films, show that only a very small fraction of the energy in the rays is utilised under ordinary circumstances.

"As long ago as January 30, in some remarks that I made at the close of Mr. Porter's demonstration at University College, I suggested as a means of more completely utilising the energy in the rays, and thereby shortening the necessary exposure, the use of suitable fluorescent material applied either in the form of a screen behind the photographic film, or introduced into the substance of the film itself.

"Since I first made this suggestion, I have tried numerous experiments in the direction indicated. These were at first unsuccessful owing to the screens used not having been properly prepared. Some weeks ago, however, on renewing the experiments with a screen thickly coated with potassium platino-cyanide and gum, placed behind a celluloid photographic film, I obtained conclusive evidence that by this means the necessary exposure could be greatly shortened, and that in a less degree the same result could be accomplished by the employment of a screen thickly covered with powdered fluor-spar.

"The chief objection to this method lies in the fact that it is very difficult to avoid granular results. Unless the fluorescent material be in a very fairly divided condition, its grain shows distinctly and mars the detail of the finished picture. The platino-cyanide does not work so efficiently when finely powdered as when in moderately coarse crystals, but good results can be obtained by thickly coating a thin celluloid film with an emulsion of this salt ground to fine powder in collodion, and using the screen so prepared with its celluloid surface in contact with the sensitive surface of the photographic film. I have obtained considerably better results with a finely ground sample of tungstate of calcium, prepared for me by Messrs. Hopkin and Williams. This may be used either in loose powder or made up with gum into a paste and dried.

"With this substance it is easy to obtain sharp and fully-exposed negatives of the hand in from five to ten seconds with a moderately excited tube, with which, with ordinary arrangements, one to two minutes' exposure would be necessary.

"I have also tried some special plates prepared for me by Messrs. Marion, into the sensitive emulsion of which fluorescent substances such as powdered fluor-spar and calcium tungstate were introduced before application to the glass. Though the results so far obtained by this method are not very satisfactory owing to granularity, the presence of the fluorescent substance in the photographic film appears undoubtedly to increase its sensitiveness to the rays.

"There is a wide field for further research on the lines above indicated, both with regard to suitable fluorescent substances and the best method for their application."

A paper by Dr. Ferdinando Giazzi, of the Regio Istituto Tecnico, Perugia, is of importance in this connection, and the following translation of it, by Mr. G. H. Baillie, will be useful to chemists who are preparing fluorescent salts for use with Röntgen rays:

"Some days ago Prof. Ruata called my attention to the telegram sent by Edison to Lord Kelvin, and published in NATURE, according to which calcium tungstate, when suitably crystallised, showed fluorescent phenomena under the action of X-rays in a far more marked degree than barium platino-cyanide.

"I immediately consulted Prof. Bellucci, who informed me that calcium tungstate could be easily obtained from either sodium tungstate or tungstic acid, two commercial products selling at a low price. Having obtained these from the firm of Bonavia of Bologna, I set to work and produced some calcium tungstate, but in an amorphous form, which was, as far as I could test with the coil at my disposal, insensible to X-rays. I shall not describe all the attempts I made by wet and dry processes to obtain the salt in the desired form. I merely say that I never have dealt with a body so intractable. The following is the process I finally adopted in preparing it for surgical purposes. I treated a dilute aqueous solution of sodium tungstate with a solution of calcium chloride, given to me by my colleague Prof. Corneliani; I thoroughly washed the resulting pure white precipitate, and dried it at a gentle heat in a porcelain capsule. Next I made a small hole in a piece of fresh retort-carbon, and filled it with the precipitate, which I fused and boiled by means of a small flame from an oxyhydrogen blowpipe. After boiling for some seconds (at a bright white heat), I gradually removed the substance from the hottest parts of the flame, so that solidification took place only after a few minutes. In this way I obtained five globules of calcium tungstate of the required structure. I powdered them in an iron mortar and sifted the powder on to a gummed card, which I exposed in the camera to Röntgen rays. The result was most striking; I saw at once the shadow of the skeleton of my hand more clearly than I ever have with other preparations. A surgeon with this product, good Crookes' tubes. a large coil, and an apparatus such as I have arranged, could certainly dispense with the tedious process of photography.

"I publish this note for the assistance of those who perchance have not yet succeeded in preparing the invaluable tungstate in the desired form."

So far as the utility of the method of reducing exposure by means of fluorescent screens is concerned, the advantage gained must be understood only in a comparative sense. Some investigators obtain excellent results without the use of the screen in less time than others with a screen. Dr. John Macintyre, who has sent us several communications previously upon his work with Röntgen rays, has something to say about the reduction of exposure by screens, in a letter just received. He remarks:

"The object of this note is not to minimise the importance of any aid which the physicist may place in the hand of the surgeon. I have been aware of this new method, but my experience in practice has not encouraged me meantime to pursue it largely, because of want of time in developing what I consider of greater importance, viz. a better Crookes' tube. In surgery what we require may be divided into two parts: (1) rapid views of objects, and (2) permanent records. In practice we must have for the former not photographs but direct vision, and for the second, of course, rapid exposures. Now it may occasionally happen that a permanent record is desirable o. what must be done almost instantaneously. That point I think ought to be reached ere long.

"Some weeks ago I recorded a photo of the elbow-joint in $1\frac{3}{4}$ minutes, and that at a time when we did not understand the tubes as well as now. Since then I have obtained records of metallic objects in half a second, and the bones of the hand in six seconds, without the aid of fluorescent screens. What we desire most, however, in practice is a better Crookes' tube for fluorescent screens in direct vision. At present I go while the tube is being exhausted, and test the result before it is taken off the pump. When I am examining an object with the screen, or about to photograph, I heat the tube and keep the current passing through until the maximum effect is obtained. I have now seen by this means the different bones of the extremities and joints; moreover, I have no difficulty in seeing through the body itself. The spine ribs, sternum, clavicle and scapula can be seen; and I have shown to several medical men the shadow of a coin in the gullet (impacted for six months), opposite the fourth dorsal vertebra. Foreign bodies in the extremities are, as a rule, easily seen.

"For the examination of the cavities inside the head, *e.g.* the antrum, or mouth, or pharynx, also the teeth, I now place fluorescent screens in the mouth, and the Crookes' tube outside, either above or below the level of the buccal cavity as required, and sharp images are thus obtained on the screen of not only foreign bodies, but also of the bones of the face, and roots of the teeth as well.

"Other tissues than the bones are now yielding. I have photographed the side of the neck, and shown the tongue, hyoid bone, the pharygeal cavity, cartilages of larynx and trachea of the living adult subject.

"At present we cannot afford to ignore any aid, and hence we are glad to have such hints as the fluorescent screens in photography; but it is not unlikely that all such will be more or less dispensed with as a better source of the X-rays is obtained, viz. a still better Crookes' tube."

Since the above was written, and in consideration of the question at issue, Dr. Macintyre informs us that he has made a further series of experiments on the question of rapid exposures. The tube used was one of the now well-known ordinary focus tubes, made in Glasgow. He has obtained a well-defined image of metallic objects, and distinct, though faint, image of the bones of the fingers with one flash of the Crookes' tube, produced by a single vibration of the mercury interrupter, a large coil giving an eleven-inch spark, and, of course, without using any fluorescent screen. What the extent of the time of exposure was cannot be said, but he describes it as an unknown, unmeasured, small fraction of a second. In another experiment he was able to obtain a distinct image of the bones of the forearm with sixty similar flashes of the tube.

Prof. O. N. Rood found indications of reflection of Röntgen rays from a platinum surface on March 9, and on March 13, after an exposure of ten hours, he obtained a good negative, capable of furnishing prints, of a piece of iron wire netting reflected from a sheet of ordinary platinum foil and through a plate of aluminum (*Science*, March 27). The conclusion he arrived at from inspection of the image was that "in the act of reflection from a metallic surface the Röntgen rays behave like ordinary light." Experiments made to ascertain the percentage of the rays reflected, indicated that platinum foil reflected the 1/260th part of the X-rays incident on it at an angle of 45°.

Upon the question of reflection and refraction of Röntgen radiance, Prof. Pupin pointed out in his paper read before the New York Academy of Science, on April 6, that it was discussed by Prof. Röntgen in Sections 7 and 8 of his origina essay. Neither by photography nor by the fluorescent screen could Prof. Röntgen detect an appreciable refraction with certainty. A reflection from metallic surfaces in the immediate vicinity of a photographic film was detected, "but," translating Röntgen's own words, "if we connect these facts with the observation that powders are quite as transparent as solid bodies, and that, moreover, bodies with rough surfaces are, in regard to the transmission of X-rays, as well as in the experiment just described, the same as polished bodies, one comes to the conclusion that regular reflection, as already stated, does not exist, but that the bodies behave to the X-rays as muddy media do to light." "In face of these observations," continues Prof. Pupin, "Prof. Rood's and Mr. Tesla's experiments must be interpreted as a confirmation of Prof. Röntgen's results, and not as a demonstration of the existence of a regular reflection. Mr. Tesla infers regular reflection from his theory of bombardment. His experimental method is the same as that of Prof. Rood; that is, he places a reflecting plate at an angle of forty-five degrees to the direct ray, and then places the photographic plate at right angles to the direction in which the reflected ray should pass if regular reflection existed. On account of the greater power of his apparatus, his time of exposure was one hour, whereas that of Prof. Rood was ten hours. It is evident, however, that an effect upon the photographic plate does not prove the existence of regular reflection."

In his own experiments on reflection, Prof. Pupin aimed at getting rid of the photographic plate and substituting the fluorescent screen in its place.

He concludes as follows:—"These experiments prove beyond all reasonable doubt that the Röntgen radiance is diffiusely scattered through bodies, gases not excepted. We may call it diffuse reflection, if we choose, provided that we do not imply, thereby, that we must necessarily assume an internal inter-molecular regular reflection, in order to explain the phenomenon. For if a puff of smoke be forced through a pile of wood, some of it will come out pretty well scattered, although we cannot speak here of a reflection in the ordinary sense, but rather of deflection, reserving the term 'reflection' for those particular cases in which the angle of incidence is equal to the angle of deflection. It might turn out, for instance, that the X-rays are due to a circulating motion of ether, and that the stream lines are deflected and diffusely scattered within the molecular interstices of ponderable substances. Appearances seem to speak more in favour of this view than in favour of a wave motion of ether. The diffuse scattering of the Röntgen radiance by bodies placed in its path may be also described by saying that *every substance when subjected to the action of the X-rays becomes a radiator of these rays*. . . . The fact that opaque bodies, like metals, are less effective in producing this secondary radiation, leads to the conclusion that there is in these bodies an internal dissipation of the Röntgen radiance much greater than in the case of transparent dielectric substances. A properly constructed bolometer should give us much information on this point, and it is my intention to take up this subject as soon as time and facilities will permit. These diffusion effects, which are present even in air, bring the Röntgen radiance into still closer resemblance to the principal features of the kathode rays which were studied by Prof. Lenard. The difference in their behaviour towards magnetic force is still to be explained. Is it not possible that this magnetic effect in air is masked by the diffuse scattering of the X-rays?"

Our American correspondent says:—"Tesla has found that the X-rays are reflected from certain metals tested in the same order as in Volta's electric contact series in air. Zinc reflects 3 per cent. at an angle of 45°. Below it stand lead and tin, but his observations do not yet show which reflects more highly. Below these in order come copper and iron about the same, then silver. His first observations led him to infer that magnesium would reflect still more than zinc, and sodium most of all. Subsequent experiment has verified the conjecture as to magnesium; but sodium has not yet been tested. By availing himself of the reflection from a zinc cone, he has taken a picture of the ribs of an assistant at a distance of four feet from the vacuum tube, and with an exposure of forty minutes. His apparatus is so constructed that the bulb or bulbs are at the large end of the cone, and the subject at the small end, where the rays are concentrated. The cone or funnel is constructed at an angle less than 30°, so that the incident rays are reflected more than 3 per cent; and especially more the small end of the funnel the rays approach within a very few degrees of parallelism with the reflecting zinc. Prof. Tesla thinks the theory that the X-rays consist of streams of radiant matter, is confirmed by these results. He has not yet been able to detect any refraction of the X-rays."

In the summary of work done in connection with Röntgen rays (page 522), we give an account of experiments made by Prof. Joly, which demonstrate the existence of reflection.

"In confirmation of these experiments," writes Mr. Alfred W. Porter, "may I point out that a similar phenomenon to that described by Prof. Joly has been present on all my skeletal radiographs. Immediately surrounding the sharp geometric shadow of the flesh of the fingers a black line exists on the *negative*. This is especially noticeable where two fingers overlap one another; the partial shadow cast by one finger preventing the deposit on the plate from becoming so dense as to obscure th presence of the black line. I enclose a *positive* which shows th presence of the corresponding white line very clearly. M attention was first called to the presence of this line on my pictures on January 28, by Mr. John T. Morris, of this College. I believe that the prominence of the finger-nails is due to the same cause. I have also taken graphs of over-lapping wood, metal, and ivory objects which exhibit the same phenomena."

We have received the prints referred to by Mr. Porter, and they entirely bear out his description of the appearance presented.

For some time past Prof. FitzGerald and Mr. Fred. T. Trouton, at Trinity College, Dublin, have sought evidence of crystalline action, both on transmission and reflection at grazing incidence of Röntgen rays. Though so far this has been without success, we learn that they have noticed a marked scattering of the rays in transmission through some substances. The following arrangement is convenient for showing this. "On a plate of lead, which has a slit cut in it, is placed a sheet of, say, solid paraffin 2 or 3 m.m. thick, so as to cover one end of the slit; over this is laid a strip of lead—but slightly wider than the slit—so as to just entirely cover the slit. No direct radiation then can pass from a Crookes' tube, placed vertically over the slit, to a sensitive plate placed behind the lead; but with a lengthened exposure (20 to 30 minutes) with a focus tube, a darkening is found on developing at the end where the paraffin is placed. If the paraffin be then moved to the centre or other end, so as to eliminate accidental effects, on again exposing the darkening action is found to follow the paraffin. Some darkening always occurs even where there is no solid body. How much of this is due to successive reflections from the lead sheet and strip, or how much is due to scattering of the rays by air, is not easy to say."

Mr. Dayton C. Miller has obtained some good results at Case School of Applied Science in Cleveland, Ohio, U.S.A., but the exposures he finds necessary are longer than those given by the foremost workers in Great Britain. The tube used by him is spherical in shape, and about five inches in diameter. The coil gives a six-inch spark in air, and is excited by a current of about sixty watts, obtained from fifteen cells of storage battery. The voltage used varies from twelve to twenty. With this apparatus and power, Mr. Miller says:—

"The bones of the fingers are distinctly shown with exposures of ten seconds, while exposures varying from two to ten minutes are regularly used in locating bullets and shot in the hand, and in examining injured or deformed hands. An excellent picture of a hand and fore-arm, placed diagonally across an 11 × 14 plate, has been made with twenty minutes' exposure. The entire detail of the lettering and design of an aluminium medal has been taken in five minutes. Numerous interesting surgical cases of fractured and diseased arm-bones have been examined with satisfactory results. Photographs of the chest and head have been made with exposures of one hour in each case. A surprising amount of detail is visible. The chest picture shows the shoulder-joint, the collar-bone, the spinal column with its articulations, and a dark streak along its length corresponding to the spinal cord, and eight ribs on each side of the spine. In the region of the heart the detail is less conspicuous, indicating that the heart is more opaque than the lung tissue."

Mr. W. L. Goodwin, of the School of Mining, Kingston, Canada, has sent us the results of experiments made to determine the relative opacities of various substances to Röntgen rays. The only details as to the method employed is that the results were obtained "by photography with a small Crookes' tube similar in shape to a radiometer, but constructed to show the revolution of a platinum vane covered on one side with mica." The relative opacities thus determined are as follows:—

I. Solids:—

Transparent: Paraffin wax, wood charcoal, coke (in part), asphalte, albertite, starch, diamonds.

Fairly transparent: Citric acid, jet, anthracite, amber, natrolite, caustic potash, caustic soda, borax, soda crystals.

Somewhat transparent: Silicified wood, Epsom salts, serpentine, staurolite, stilbite, lazulite, $H_2(NH_4)PO_4$, cryolite, Mohr's salt, analcite, Na_2CO_3, borax glass, nitre, Rochelle salt.

Somewhat opaque: Mica, tourmaline, wulfenite, axinite, spinel, calcite, aragonite, kaolin, $NiSO_4(NH_4)_2SO_4.6H_2O$, $NiSO_4.K_2SO_4.6H_2O$, &c.

Opaque: Roll sulphur, crystal of rhombic sulphur, fluor-spar, topaz, beryl, ruby, quartz, NaCl, chalco-pyrite, $H_2(NH_4)AsO_4$, H_2KAsO_4, K_3FeCy_6, $K_2Cr_2O_7$, orpiment, anhydrite, celestine, barite.

Sulphuric acid is as opaque as the same thickness of sulphur. Water is more opaque than paraffin wax.

A number of crystals of about the same thickness were photographed on the same plate, and an attempt made to judge of their relative transparency with a scale from 1 to 10, with the following results:—

H_2KAsO_4	1
$H_2(NH_4)AsO_4$...	2
$NiSO_4.(NH_4)_2SO_4.6H_2O$	3
$MgSO_4.K_2SO_4.6H_2O$...	3
$NiSO_4.K_2SO_4.6H_2O$	3·5
$MgSO_4.(NH_4)_2SO_4.6H_2O$	4
$ZnSO_4.(NH_4)_2SO_4.6H_2O$	4
$CoSO_4.K_2SO_4.6H_2O$	4
$CoSO_4.(NH_4)_2SO_46H_2O$	4
$H_2(NH_4)PO_4$	5
Paraffin wax	10

The different values of arsenic and phosphorus in the isomorphous acid arseniates and phosphates are to be remarked.

Thin sections of a granite composed principally of quartz and feldspar and of a hornblende-gabbro were photographed. In both cases the feldspar was found to be distinctly more transparent than the other constituents.

Prof. E. Doelter, of Graz, has communicated to the *Naturwissenschaftliche Verein für Steiermark* some observations relating to the opacity of different rocks and minerals for the Röntgen rays, and their use as providing a test of the genuineness of precious stones. Dr. Doelter finds that (1) the opacity does not always increase with the density, although minerals having a specific gravity greater than 5 are relatively opaque; (2) the complexity of the chemical constitution of a mineral affects its opacity, but no general law of relationship can be enunciated; (3) dimorphous minerals exhibit but slight differences in their behaviour with regard to the rays in their different forms; (4) in most crystals, the amount of absorption does not depend sensibly on the direction of the incident rays; (5) all minerals naturally fall into about eight well-defined groups, according to their opacity, the order being as follows: diamond, corundum, talc, quartz, rock-salt, Iceland spar, &c. The diamond is ten times as transparent as corundum, and 200 times as transparent as tinfoil.

Mr. W. Ackroyd and Mr. H. B. Knowles have systematically examined the opacity of a number of substances for Röntgen rays, with a view to determining whether it bears any relation to molecular weight (*Journal* of the Society of Dyers and Cleaners, April).

With this view they have compared the isomorphous sulphates, RSO_4, $7H_2O$ of the eighth group of metals, iron, nickel, and cobalt; the oxides, RO, of some members of the second natural group, viz. magnesium, zinc, and mercury; the isomorphous oxides, R_2O_3, of the metals aluminium, chromium, and iron. In each of these series there are presumably similarly shaped molecules for comparison, and the disturbing factor is the difference of molecular weight. The result of an hour and a half's exposure showed that the alumina was practically transparent, the chromium sesquioxide semi-transparent, while the ferric oxide was opaque. In other words, the opacity of the substance was in some direct relation to the molecular weight. There are here marked differences with big jumps in molecular weights. The same observation applies to the oxides of magnesium, zinc, and mercury. The isomorphous sulphates of iron, nickel, and cobalt are extremely interesting, because of the nearness of the specific gravity numbers, and also of the molecular weights. The iron compound, with lower specific gravity and molecular weight, appears to be the least opaque of the three, while the nickel and cobalt compounds of nearly the same specific gravity and molecular weight have approximately the same degree of opacity. The following table correlates these facts with other properties:—

Compound.	Sp. gr.	Molecular weight.	Colour.	Behaviour to Röntgen rays.
$FeSO_4$, $7H_2O$	1·85	278	Light green	Slightly less opaque than others in this group.
$NiSO_4$, $7H_2O$	1·95	280	Deep green	About the same relative opacity.
$CoSO_4$, $7H_2O$	1·92	281	Pink	
Al_2O_3	4·00	103	White ...	Transparent.
Cr_2O_3	4·99	153	Green ...	Semi-opaque.
Fe_2O_3	5·13	160	Brown ...	Opaque.
MgO	3·42	40	White ...	Transparent.
ZnO	5·47	81	White ...	Semi-opaque.
HgO	11·13	216	Red	Opaque.

The foregoing figures, conclude the authors, demonstrate the weakness of an unqualified law of density, as the denser oxide of zinc is more transparent than the less dense ferric oxide. But they point out that, adopting the legitimate method, which they have initiated, of comparing only compounds with kinship, each of the above bodies conforms to the law of density as well as of molecular weight in relation to opacity.

Dr. A. Sella and Dr. Q. Majorana (*Rend. R. Accad. dei Lincei*) describe certain experiments on the influence of Röntgen rays on the sparks produced by the discharge of an induction coil in air. The sparking distance is found to be shortened by the Röntgen rays, this effect taking place whenever these rays fall on the positive pole. In this respect the phenomenon is the reverse of that obtained by Hertz with ultra-violet light, the effect of which is to lengthen the sparking distance whenever it falls on the negative pole. The authors found that the simultaneous actions of Röntgen rays and of ultra-violet light could be made to neutralise each other by arranging the coil to give a spark of suitable length (in their experiments about 30 mm.). When the sparking distance was less, the Hertz effect predominated; when the sparking distance exceeded 30 mm., the Röntgen rays had the greater influence.

Dr. Filippo Campanile and Dr. Emilio Stromei communicate to the *Rendiconto dell' Accademia delle Scienze fisiche e matematiche* (Naples) a note on the phosphorescence and the Röntgen rays in Crookes' and Geissler's tubes. The conclusions arrived at are as follows: (1) When in the circuit of an induction coil, containing a Crookes' tube, a spark is thrown off from the positive pole, the phosphorescence of the tube and the efficacy of the Röntgen radiations are augmented. (2) As the length of the spark increases the phosphorescence at first increases to a maximum, and then decreases. (3) If, on the other hand, the spark is thrown off from the negative pole, the phosphorescence and the Röntgen rays are thereby diminished. The same experimenters have also succeeded in obtaining Röntgen rays with an ordinary Geissler's tube. These radiations possessed all the characteristics of those which emanate from a Crookes' tube.

Signor E. Villari, writing in the same journal, considers that the phenomena of discharges in tubes seem to indicate the existence not only of kathodic but also of anodic rays. While the kathodic rays travel in straight lines and produce a negative charge wherever they strike the tube, the suggested anodic rays diffuse themselves all round the anode, and communicate a positive charge to the whole surface of the tube over which they are diffused.

The fundamental character of the new rays has led speculators to make various surmises as to a possible connection between these radiations and the phenomenon of gravitation, and two lengthy memoirs have been written on the subject by Rudolf Mewes.[1] In the second of these the author claims to have proved experimentally that gravitation is propagated through the ether with the velocity of light.

Finally, attention may profitably be called in this summary to the April number of the *Proceedings* of the Physical Society. In the admirable collection of abstracts of physical papers there published, will be found concise descriptions of the scope and results of no less than forty papers concerned with Röntgen rays.

1 "Licht- Electricitäts und X-Strahlen" (pp. 54); "Die Fortpflanzungs-Geschwindigkeit der Schwerkraftstrahlen" (pp. 93). (Berlin: M. Krayn, 1896.)

COLOUR PHOTOGRAPHY.

The scientific event of last week was the description and demonstration of colour photography given by Prof. Lippmann before the Royal Society. On the occasion of the centenary celebrations of the Institute of France last year, Lord Kelvin invited Prof. Lippmann to give the Royal Society an account of his researches on photography in colours, and last Thursday's meeting was the result. The methods employed by Prof. Lippmann are well known among men of science, but few of the Royal Society were prepared to see such remarkable results as those obtained and exhibited by the distinguished French physicist. The honour and fine feeling which such visits bring to the Society, and the extreme interest aroused, should help to make similar occasions of more frequent occurrence. We print Prof. Lippmann's lecture below, and our only regret is that it cannot give an at all adequate conception of the striking achievement with which it deals.

The problem of colour photography is as old as photography itself. The desire of fixing the colours as well as the design of the beautiful image thrown on the screen of the camera, very naturally occurred to the earliest observers. Since the beginning of this century three distinct solutions of the problem have been realised.

The first solution, not quite a complete one, is founded on the peculiar properties of a silver compound, the violet subchloride of silver. E. Becquerel (1860) converted the surface of a daguerreotype plate into this silver compound, and by projecting on it the image of the solar spectrum, and other objects, obtained good coloured impressions. Poitevin substituted paper for the silver plate as a substratum. No other substance has been discovered that can play the part of the subchloride of silver. Moreover the image is not fixed, in the photographic sense of the word; that is, the coloured impression is retained for any length of time in the dark, but it is blotted out by the action of daylight. The reason of it is this: the Becquerel images are formed by coloured silver-compounds, which remain sensible to light; so that they are destroyed by the continued action of light, in virtue of the same action which gave them birth. Despite the numerous experiments made by Becquerel, Poitevin, Zenther, and others, no substance has been found that is capable of destroying the sensibility of the subchloride for light without at the same time destroying its colour.

The second method for colour photography is an indirect one, and may be called the three-colour method. It was invented in France by Ch. Cros, and at the same time by M. Ducos du Hauron (1869). German authorities claim the priority of the idea for Baron Bonstetten. Three separate negatives (colourless) are taken of an object through three coloured screens. From these three positives (equally colourless) are made; and, lastly, the colour is supplied to these positives by means of aniline dyes or coloured inks. Thus three coloured monochromatic positives are obtained, which by superposition give a coloured image of the model. In the ingenious process lately invented by Prof. Joly, the three negatives, and apparently the corresponding three positives, are obtained interwoven on one and the same plate. The three-coloured method can give a very good approximation to the truth, and has probably a great future before it. We may call it, nevertheless, an indirect method, since the colours are not generated by the action of light, but are later supplied by the application of aniline dyes or other pigments. Moreover, the choice of these pigments, as well as of the coloured screens through which the negatives have been obtained, is in some degree an arbitrary choice.

The third and latest method by which colour photography has been realised is the interferential method, which I published in 1891, and the results of which I beg to lay before you this evening. It gives fixed images, the colours of which are due to the direct action of the luminous rays.

For obtaining coloured photographs by this method, only two conditions are to be fulfilled. We want (1) a transparent grainless photographic film of any kind, capable of giving a colourless fixed image by the usual means; and (2) we want a metallic mirror, placed in immediate contact with the film during the time of exposition.

A mirror is easily formed by means of mercury. The photographic plate being first enclosed in a camera-slide, a quantity of mercury is allowed to flow in behind the plate from this small reservoir, which is connected with the slide by a piece of india-rubber tubing.[1] The slide is then adapted to the camera, and the action of light allowed to take place. After exposure the slide is separated from the camera, the mercury reservoir lowered so as to allow the mercury to flow back into it; the photographic plate is then taken out, developed and fixed. When dry, and examined by reflected light, it appears brilliantly coloured.

The sensitive film may be made either of chloride, iodide, or bromide of silver, contained in a substratum either of albumen, collodion, or gelatine. The corresponding developers, either acid or alkaline, have to be applied; the fixation may be cyanide or bromide of potassium. All these processes I have tried with success. For instance, the photograph of the electric spectrum now projected before your eyes, has been made on a layer of gelatino-bromide of silver, developed with amidol, and fixed with cyanide of potassium.

As you see, bright colour photographs may be obtained without changing the technique of ordinary photography; the same films, developers and fixators have to be employed; even the secondary operations of intensification and of isochromatisation are made use of with full success. The presence of the mirror behind the film during exposure makes the whole difference. From a chemical point of view nothing is changed, the result being a deposit of reduced silver left in the film, a brownish, colourless deposit. And yet the presence of a mirror during exposure causes the colourless deposit to show bright colours. Of course we want to know how this is done; we require to understand the theory of those colours.

We all know that colourless soap-water gives brilliant soap-bubbles; the iridescence of mother-of-pearl takes birth in colourless carbonate of lime; the gorgeous hues of tropical birds are simply reflected from the brownish substance which forms the feathers. Newton discovered the theory of these phenomena, and subjected them to measurement; he invented for the purpose the experiment called by the name of Newton's rings. Newton showed, as you know, that when two parallel reflecting surfaces are separated by a very short interval, and illumined by white light, they reflect only one of the coloured rays which are the constituents of white light. If, for instance, the interval between the reflecting surface is only $\frac{2}{10000}$ of a millimetre, violet rays are alone reflected, the rest being destroyed by interference; that is, the two surfaces send back two reflected rays whose vibrations interfere with one another, so as to destroy every vibration except that which constitutes violet light. If the interval between the reflecting surfaces be augmented to $\frac{3}{10000}$ of a millimetre, the destruction of vibration takes place for every vibration except that of red light, which alone remains visible in this case.

If we consider now this photograph of the spectrum, and especially the violet end of the image, we find that this is formed by a deposit of brown reduced silver. In the case of an ordinary photograph, this deposit would simply be a formless cloud of metallic particles; here the cloud has a definite, stratified form; it is divided into a number of thin, equidistant strata, parallel to the surface of the plate, and $\frac{2}{10000}$ of a millimetre apart. These act as the reflecting surfaces considered by Newton, and as they are at the proper distances for reflecting violet rays, and these alone, they do reflect violet rays.

The red extremity of the photograph is equally built up of strata which act in a like manner; only their distance intervals here amount to $\frac{3}{10000}$ of a millimetre, and that in the proper interval for reflecting red light. The intermediate parts of the spectral image are built up with intermediate values of the interval, and reflect the intermediate parts of the spectrum.

The appearance of colour is therefore due to the regular structure above described, imprinted on the photographic deposit. The next question is—How has this very fine, peculiar, and adequate structure been produced?

It is well known that a ray of light may be considered as a regular train of waves propagated through the ether, in the same way as waves on the surface of water. The distance between two following waves is constant, and termed the wave-length; each sort of radiation, each colour of the spectrum, being characterised by a particular value of the wave-length. Now, when a ray of light falls on a sensitive film, this train of waves simply rushes through the film with a velocity of about 300,000 kilometres per second; it impresses the film more or less strongly, but leaves no record of its wave-length, of its particular

[1] The glass of the photographic plate has to be turned towards the objective, the film in contact with the metallic mirror.

nature or colour, every trace of its passage being swept out of form by reason of its swift displacement. The impression therefore remains both uniform and colourless. Things change, however, as soon as we pour in mercury behind the plates, or otherwise provide for a mirror being in contact with it. The presence of the *mirror* changes the propagated waves into *standing* waves. The reflected ray is, namely, thrown back on the incident ray, and interferes with its motion, both rays having equal and opposite velocities of propagation. The result is a set of standing waves—that is, of waves surging up and down each in a fixed plane. Each wave impresses the sensitive film where it stands, thus producing one of these photographic strata above alluded to. The impression is latent, but comes out by photographic development. Of course the distance between two successive strata is the distance between two neighbouring waves; this, theory shows, is exactly half the wave-length of the impressing light. In the case of violet, for instance, the wave-length being $\frac{4}{10000}$ millimetres, half the wave-length in the above quoted distance of $\frac{2}{10000}$ millimetres; this, therefore, is at the same time the interval between two standing waves, in the case of violet light, the interval between two successive photographic strata, and at last it is the interval required to exist, according to Newton's theory, for the said strata reflecting violet rays, and making these alone apparent, when illumined by white light.

The colours reflected by the film have the same nature and origin as those reflected by soap-bubbles or Newton's rings; they owe their intensity to the great number of reflecting strata. Suppose, for instance, the photographic film to have the thickness of a sheet of paper (one-tenth of a millimetre), the fabric built in it by and for a violet ray is five hundred stories high, the total height making up one-tenth of a millimetre. Lord Rayleigh, in 1887, has proved *à priori* that such a system is specially adapted to reflect the corresponding waves of light.

How are we now to prove that the above theory is really applicable to the colour photograph you have seen? How can we demonstrate that those bright colours are due not to pigments, but to the interference, as in the case of soap-bubbles? We have several ways of proving it.

First of all, we are not bound to the use of a peculiar chemical substance, such as Becquerel's subchloride of silver; we obtain colours with a variety of chemicals. We can, for instance, dispense entirely with the use of a silver salt; a film of gelatine or coagulated albumen impregnated with bichromate of potash, then washed with pure water after exposure, gives a very brilliant image of the spectrum.

Secondly, the colours on the plate are visible only in the direction of specular reflection. The position of the source by which we illumine the photograph being given, we have to put the eye in a corresponding position, so as to catch the regularly reflected rays. In every other position we see nothing but a colourless negative. Now, as you are aware, the colours of pigments are seen in any direction. By projecting again a photograph of the spectrum, and turning it to and fro, I can show you that the colours are visible only in one direction.

Thirdly, if we change the incidence of the illuminating rays, that is, if we look at the plate first in a normal direction, then more and more slantingly, we find that the colours change with the incidence exactly as they do in the case of soap-bubbles, or of Newton's rings; they change according to the same law, and for the same reasons. The red end of the spectrum turns successively to orange, yellow, green, blue, and violet. The whole system of colours, the image of the spectrum, is seen to move down into the part impressed by the infra-red. This is what we expect to happen with interference colours, and what again we cannot obtain with pigments.

Fourthly, if while looking at the film normally, we suffer it to absorb moisture—this can be done by breathing repeatedly on its surface—we see that the colours again change, but in an order opposite to that above described. Here the blue end of the spectrum is seen to turn gradually green, yellow, orange, red, and finally infra-red, that is, invisible. The spectrum this time seems to move up into the ultra-violet part of the improved film. By suffering the water to evaporate, the whole image moves back into its proper place; this experiment may be repeated any number of times.

The same phenomenon may be obtained with Newton's apparatus, by slowly lifting the lens out of contact with the plane surface. The explanation is the same in both cases. The gelatine swells up when imbibing moisture. If we consider, for instance, the v of the spectrum, the small intervals between the strata, corresponding to violet rays, gradually swell up to the values proper for green, and for red, and for infra-red; green, then red, then infra-red, are therefore successively reflected.

We will wet this photograph of the spectrum with water, project it on the screen, and watch the colours coming back in the order prescribed by theory.

It is necessary to use a transparent film, since an opaque one, such as is commonly in use, would hide the mirror from view; the sensitive substance must be grainless, or, at least, the grains must be much finer than the dimensions of the strata they are intended to form, and therefore wholly invisible. The preparation of transparent layers gave me at first much trouble; I despaired for years to find a proper method for making them. The method, however, is simply thus: if the sensitive substance (the silver bromide, for instance) be formed in presence of a sufficient quantity of organic matter, such as albumen, gelatine, or collodion, it does not appear as a precipitate; it remains invisible; it *is* formed, but seems to remain dissolved in the organic substratum. If, for instance, we prepare a film of albumeno-iodide in the usual way, only taking care to lessen the proportions of iodide to half per cent. of the albumen, we get a perfectly transparent plate, adapted to colour photography.

We want now to go a step further. It is very well for physicists to be contented with working on the spectrum, since that contains the elements of every compound colour; but we all desire to be able to photograph other objects than the spectrum—common objects with the most compound colours. We have again but to take theory as a guide, and that tells us that the same process is able to give us either simple or compound colours. We have then to take a transparent and correctly isochromatised film, expose it with its mercury backing, then develop and fix it in the usual way; the plate, after drying, gives a correct coloured image of the objects placed before the camera. Only one exposure, only one operation is necessary for getting an image with every colour complete.

A plausible objection was offered at first to the possibility of photographing a mixture of simple colours. The objection was this: a ray of violet gives rise to a set of strata separated by a given interval; red light produces another set of strata with another interval; if both co-exist, the strata formed by the red are sure to block out here and there the intervals left between the strata formed by the violet. Is it not to be feared that one fabric will be blurred out by the other, and the whole effect marred? The confusion would be still worse if we consider the action of white light, which contains an infinity of simple components; every interval here is sure to be blocked up.

Mathematical analysis, however, shows this objection to be unfounded; we have great complexity, but not confusion. Every compound ray, both coloured and white, is faithfully rendered. As an experimental proof of this, we will project on the screen photographs of very different objects, namely, stained-glass windows, landscapes from nature, a portrait made from life, and vases and flowers.

That the colours here observed are due to interference, and not to the presence of pigments, can be shown in the same way as with the spectrum. Here, again, we observe that the colours are visible only in the direction of specular reflection, that they change with the angle of incidence, that they change and disappear by wetting, and reappear by drying. Pigments remain equally visible and unaltered in colour under every incidence. If we attempted to touch up one of our photographs with oil or water-colours, the adulterated place would stand out on a colourless background by merely obscuring by diffused light. It is therefore impossible either to imitate or touch up a colour photograph made by the above described interferential method.

THE INFLUENCE OF ATMOSPHERIC AND OCEANIC CURRENTS UPON TERRESTRIAL LATITUDES.[1]

ALTHOUGH the following theorem should be implicitly contained in the formula for the rotation of a spheroid car ryng a fluid on its surface, I have nowhere seen it explicitly stated.

Theorem.—Let an unconstrained, rigid sphere, with equal moments of inertia, be in a state of free rotation:

Let this sphere bear on its surface a sheet or sheets of con tinuous movable mattei :

[1] Reprinted from the *Astronomical Journal*, No. 371, Apri 6.

Let this movable matter be kept in a state of steady motion relative to the sphere, by actions and reactions between it and the sphere, without the action of any external force :

Let P be the pole of the axis of rotation of the sphere, which will also be its momental axis :

Let Q be the momental axis of the total motions of the movable matter relative to the sphere :

Let I be the moment of inertia of the sphere, and M the total moment of momentum of all the movable matter around the axis Q :

Then shall the sphere take such a motion that the pole P, while remaining in a fixed direction in space from the centre of the sphere, shall move steadily relatively to the matter of the sphere around the pole Q, with an angular velocity M/I.

The application of this theorem to the case of the earth surrounded by its oceanic and atmospheric envelopes can now readily be seen. To obtain the value of M, we may roughly estimate the ratio of the moment of inertia of the earth to that of the ocean as 2600, and to that of the atmosphere as 1,000,000.

Observations, as discussed by Chandler, and interpreted by theory, indicate an annual change in the pole of the earth, which would be produced by a primary oscillation back and forth through a length of ten feet, or a revolution in a circle having a diameter of five feet. The former motion would, according to the theorem, be the necessary result of a general motion of the oceans on the two sides of the earth, which, at the point where the motion was a maximum, would be 2600 times as great. Approximately this motion would be represented by a continuous flow of the central parts of the Pacific ocean toward the pole of about 150 feet per day, with a correspondingly larger motion of the Atlantic in the opposite direction; followed by an opposite oscillation during the other six months. If, as may seem very likely, there cannot be so great a differential flow as this through Behring Strait, and between the American and Asiatic continents, it will be necessary to suppose a more rapid flow elsewhere, or a sufficient vortex in the currents of the Atlantic and Pacific oceans. Whether the currents in these oceans are deep enough to produce the observed effect must be left to hydrographers to decide.

Passing to the atmosphere, the excess of motion through one season over that of the other season, to and from the north direction, amounting to 4000 miles in six months, or say twenty miles per day, would also account for the observed change. In these statements respecting the required motions of the earth and atmosphere, I have presupposed a motion around an invariable momental axis. If the motions are such that their momental axis moves around the earth in the course of a year, the required differential motions between the opposite seasons would be only half as great.

In what precedes I have spoken of the earth as a sphere, and considered only differential motions. The actual earth being a spheroid, the motion of the pole already described would not be continuous. The actual effect of oceanic and atmospheric currents of a permanent character on the terrestrial spheroid would be to displace the mean pole of the earth from its pole of figure to such a point of equilibrium that the motion described in the theorem would be neutralised by an equal and opposite Eulerian motion, due to the ellipticity of the spheroid. The actual effect would be a revolution of the terrestrial pole, according to the known laws of rotation, around the central point of equilibrium thus fixed in 427 days. Just what the displacement is can be only a matter of guess-work ; from the known magnitude of the ocean currents they might produce a displacement ranging from ten to twenty feet.

A brief statement of the character of the theoretical variations of the latitude, due to these causes, may not be inappropriate. Since the directions of the currents of the air and ocean go through an annual period, we should expect a corresponding period in the latitude. Since, however, the amount of the annual change varies irregularly from year to year, though remaining constant in the general mean, the amplitude of the annual term should be subject to small variations from time to time, while preserving its mean value unchanged from age to age.

On the other hand, the amplitude of the Eulerian motion being permanently increased or diminished by every meteorological change, may be expected to vary its amplitude in a slow and irregular manner from decade to decade. The Eulerian motion, having a period of 427 days, ought to be nearly circular, unless the equatorial moments of inertia of the earth differ much more than we can suppose probable. The annual motion may differ somewhat from a circle, and be somewhat less regular. There can be no strictly periodic changes in the latitude but these two, but it is quite possible that, owing to secular changes, or changes continued through several years, in the currents of the ocean and atmosphere, corresponding changes of irregular long period may be found in the latitude.

It will be seen that these conclusions are accordant with Chandler's results as regards the double period, but do not fully agree with them in other details. SIMON NEWCOMB.

THE PAST, PRESENT, AND FUTURE WATER SUPPLY OF LONDON.[1]

IN a discourse to the members of the Royal Institution on the subject of the metropolitan water supply nearly thirty years ago, I stated that out of every thousand people existing upon this planet three lived in London ; and, as the population of London has, in the meantime, doubtless grown at a more rapid rate than that of the rest of the world, it will probably be no exaggeration to say that now, out of every thousand people alive on this earth, four live in London ; and therefore, any matter which immediately concerns the health and comfort of this vast mass of humanity may well merit our most earnest attention. Amongst such matters, that of the supply, in sufficient quantity, of palatable and wholesome water, is certainly not the least in importance.

It is not therefore surprising that this subject has received much attention from several Royal Commissions—notably from the Royal Commission on Water Supply of 1867, presided over by the Duke of Richmond ; the Royal Commission on River Pollution and Domestic Water Supply of Great Britain, presided over by the late Sir William Denison, of which I had the honour to be a member ; and, lastly, that of 1892, of which Lord Balfour of Burleigh was the chairman.

The Royal Institution has, for nearly three-quarters of a century, been prominently connected with the investigation and improvement of the metropolitan water supply ; no less than four of our Professors of Chemistry have been successively engaged in this work, namely Profs. Brand, Odling, Dewar, and myself, whilst three of them have been members of the Royal Commissions just mentioned. I may therefore perhaps be excused for bringing the subject under your notice again for the third time.

On the present occasion, I propose to consider the subject from three points of view, viz. the past, the present, and the future ; and, for reasons which will appear hereafter, I shall divide the past from the present at, or about, the year 1883, and will not go back farther than the year 1828, when Dr. Brand, Professor of Chemistry in the Royal Institution, Mr. Telford, the celebrated engineer, and Dr. Roget, Secretary of the Royal Society, were appointed a Royal Commission to inquire into the quality and salubrity of the water supplied to the metropolis.

The Commissioners made careful examinations and analyses, and reported as follows. "We are of opinion that the present state of the supply of water to the metropolis is susceptible of, and requires, improvement ; that many of the complaints respecting the quality of the water are well founded ; and that it ought to be derived from other sources than those now resorted to, and guarded by such restrictions as shall at all times ensure its cleanliness and purity. (At this time the water was pumped from the Thames between London Bridge and Battersea.) To obtain an effective supply of clear water free from insects and all suspended matter, we have taken into consideration various plans of filtering the river water through beds of sand and other materials, and considering this, on many accounts, as a very important object, we are glad to find that it is perfectly possible to filter the whole supply, and this within such limits in point of expense as that no serious objection can be urged against the plan on that score, and with such rapidity as not to interfere with the regularity of the service."

Before the year 1829, therefore, the river water supplied to London was not filtered at all ; but after the issue of this report the companies set themselves earnestly to work to improve the quality of the water by filtration.

[1] A discourse delivered by Dr. E. Frankland, D.C.L., LL.D., F.R.S., at the Royal Institution on February 21.

In the year 1832, and again in 1849, London was severely visited by epidemic cholera, and the agency of drinking-water in spreading the disease forced itself upon the attention of the observant portion of the medical profession. It was Dr. Snowe, however, who, in August 1849, first formally enunciated the doctrine that drinking-water polluted by choleraic matters is the chief mode by which cholera is propagated.

In every visitation of Asiatic cholera to London, the water supply was either altogether unfiltered or imperfectly filtered, besides being derived from highly polluted parts of the Thames and Lea; and the enormous loss of life, amounting in the aggregate to nearly thirty-six thousand people, can only be attributed to this cause; for it has now been satisfactorily proved that cholera is, practically, propagated by drinking-water alone; and that efficient filtration is a perfect safeguard against its propagation. Moreover, it is most satisfactory to know that, since the year 1854, no case of Asiatic cholera in London has been traced to the use of *filtered* river water. The first effect of Dr. Snowe's cardinal discovery was the removal of the intakes of the river water companies to positions beyond the reach of the tide and of the drainage of London. The second was the greater attention paid to the efficiency of filtration.

Such is the verdict in regard to cholera, and the same is true of that other water-borne disease typhoid fever. But unlike cholera, this disease is disseminated in several other ways, and its presence or absence in any locality may not, of necessity, have any connection with drinking-water; as is strikingly shown by the health statistics of Manchester, since the water supply of this city, derived as it is from mountain sources, is above all suspicion of this kind. These other causes have, during the last ten years, been much mitigated in London by various sanitary improvements; whilst, as shown in the diagram on the screen, there has been no corresponding mitigation in Manchester. There is no evidence whatever that, since the year 1869, when typhoid fever appeared for the first time as a separate disease in the Registrar General's report, it has been conveyed by the water supply of the metropolis.

Although very soon after the year 1856, all the water supplied to London was obtained from sources much less exposed to drainage pollution, it was still very carelessly filtered. Previous to the year 1868 there are no records of the efficiency, or otherwise, of the filtration of the metropolitan water supply derived from rivers; but at that time, I began to examine these waters for turbidity. In that year, out of 84 samples, 7 were very turbid, 8 turbid, and 10 slightly turbid; so that, altogether, no less than nearly 30 per cent. of the samples were those of inefficiently-filtered water. The metropolitan water supply then, up to the year 1868, may be shortly described as derived for many years from very impure sources with either no filtration at all, or with very imperfect filtration; and afterwards, when the impure sources were abandoned, the supply was still often delivered in a very inefficiently-filtered condition. But after the establishment of monthly reports, the quality of these waters gradually improved in this most important respect down to the year 1883, since which time the efficiency of filtration of all the river waters supplied to the metropolis has left little to be desired.

What is it, then, that separates the past from the present water supply of London? In the first place, there is the change of source—I mean the change of the position of the intakes of the several companies drawing from the Thames and Lea, and the total abandonment of the much-polluted Ravensbourne by the Kent Water Company. So long as the water was derived from the tidal reaches of the Thames and Lea, receiving the drainage of an immense population, the risk of infection from water-borne pathogenic organisms could scarcely be otherwise than imminent; for, although we now know efficient filtration to be a perfect safeguard, anything short of efficiency must be attended with risk in the presence of such extreme pollution.

Nevertheless, the line of demarcation between the past and the present water supply of the metropolis is, in my opinion, to be drawn, not when the intakes of the river companies were removed to positions beyond the possibility of pollution by the drainage of London; but, it must be drawn at the time when efficient filtration was finally secured and ever since maintained—that is to say, in the year 1884.

The removal of turbidity by sand filtration, however, refers only to suspended matter; but there are sometimes objectionable substances in solution, of which organic matter is the most important. River water and mountain water, even when efficiently filtered, contains more organic matter than spring or deep-well water; but this is reduced in quantity by storage and especially by filtration, although it can perhaps never be brought up to the standard of organic purity of spring and deep-well water.

THE PRESENT WATER SUPPLY.

At present London is supplied with water from four sources: the Thames, the Lea, the New River, and deep wells. Of these, the deep wells yield, as a rule, the purest water, requiring no filtration or treatment of any kind before delivery for domestic use. The river waters, on the other hand, require some kind of treatment before delivery—storage and subsidence in reservoirs, and filtration. The water from the Thames is abstracted at and beyond Hampton, that from the Lea is taken out at two points, viz. at Angel Road near Chingford, by the East London Water Company, and above Hertford by the New River Company, who convey it to Green Lanes by an open conduit twenty-five miles long, called the New River Cut, in which it is mixed with a considerable volume of spring and deep-well water.

Hitherto I have spoken of chemical purity, or comparative freedom from organic matter, only; but the spread of diseases, such as cholera and typhoid fever, through the agency of drinking-water, has no connection whatever with the chemical or organic purity of the water. These diseases are propagated by living organisms of extreme minuteness, to which the names bacilli, bacteria, microbes, and others have been given; and here comes the important question, how does filtration secure immunity from these water-borne diseases.

To Dr. Koch, of Berlin, we are indebted for the answer to this question. By his discovery of a means of isolating and counting the number of microbes and their spores in a given volume of water, we were, for the first time, put into possession of a method by which the condition of water as regards these living organisms, before and after filtration, could be determined with quantitative exactness. The enormous importance of this invention, which was first made known and practised in England in 1882 by the late Dr. Angus Smith, is evident when it is borne in mind that the living organisms, harmful or harmless, contained in water are of such extreme minuteness as, practically, to defy detection by ordinary microscopical examination. But, although the microscope cannot detect with certainty single bacteria or their spores, even the naked eye can easily discern towns or colonies consisting of thousands, or even millions, of such inhabitants.

Dr. Koch's method accomplishes at once two things: it isolates, in the first place, each individual microbe or germ; and, secondly, places it in conditions favourable for its multiplication, which takes place with such amazing rapidity that even in a few hours, or at most in two or three days, each organism will have created around itself a visible colony of innumerable members—a town, in fact, comparable to London itself for population. By operating upon a known volume of water, such as a cubic centimetre, for instance, the number of separate organisms or their spores in a given volume of the water under investigation can thus be determined.

In order to ascertain the effect of filtration upon the bacterial quality of the water, it is absolutely necessary that the sample should be taken immediately after it has passed through the sand filters; for, if it be obtained from the delivery mains in town—that is to say, after the water has passed through many miles of pipes—the rapid multiplication of these organisms, except in very cold weather, is such that a water which contains only a single living organism per c.c. as it issues from the filter, may contain 100 or 1000 in the same volume when, after several hours, it arrives at the consumer's premises.

Now, what is the effect of sand filtration, as carried out by the various water companies supplying London, upon the living matter contained in the raw river water? It is simply astounding—for water containing thousands of bacteria per c.c. (a single drop of Thames water sometimes contains three thousand separate living organisms) comes out from those filters with 50, 30, 10, or even less of these organisms per c.c., or the number of microbes in a single drop is reduced to 2, or even none.

Rather less than one-tenth of the total volume of water supplied to London is derived by the Kent Water Company from deep wells in the chalk. As it issues from the porous rock into the fissures and headings of these wells, this water is, in all probability, absolutely sterile; but by the time it has been pumped up to the surface, it usually contains a small number of microbes. Thus during the year 1892 it contained, on the average, 6 per c.c.; in 1893, 13; in 1894, 15; and in 1895, 8.

Thus, although the deep-well water has, from a bacterial point of view, a decided advantage, the filtered river waters are not very far behind; and there is every reason to believe that, with the improvements which are now being carried out by the various river water companies, the Kent Company's water will, before long, be run very hard by the other supplies.

By the examination of the water as it issues from the filters, the utmost freedom from microbes, or maximum degree of sterility of each sample, is determined. This utmost freedom from bacterial life, after all sources of contamination have been passed, is obviously the most important moment in the history of the water; for, the smaller the number of microbes found in a given volume at that moment, the less is the probability of pathogenic organisms being present; and, although the non-pathogenic may afterwards multiply indefinitely, this is of no consequence in the primary absence of the pathogenic; but, it is only fair in describing the character of the present water supply of London to say that not a single pathogenic organism has ever been discovered even in the unfiltered water as it enters the intakes of the various companies, although these organisms have been diligently sought for. It is sometimes said that the non-pathogenic organisms found in water may be beneficial to man; but this idea is not borne out by their entire absence from the food which nature provides for young animals. Milk, if healthy, is absolutely sterile.

As it is at present impracticable to obtain water, uniformly at least, free from microbes, it is desirable to adopt some standard of bacterial purity, and 100 microbes per c.c. has been fixed upon, by Dr. Koch and myself, as the maximum number allowable in potable water. This standard is very rarely infringed by the London water companies, whilst I have every reason to hope that, in the near future, now that special attention is directed to bacterial filtration, it will not be approached within 50 per cent. This hope is based not only upon my own observations, but also upon the exhaustive and important investigations carried out at the Lawrence Experiment Station by the State Board of Health of Massachusetts, under the direction of Mr. George W. Fuller, the official biologist to the Board. More than six years have already been spent in the prosecution of these American experiments, and many thousands of samples of water have been submitted to bacterial cultivation.

These important experiments, and my own observations on the London waters continued for four years, lead to the following conclusions:—

(1) The rate of filtration between half a million and three million gallons per acre per day exercises, practically, no effect on the bacterial purity of the filtered water. It is worthy of note that the rates of filtration practised by the several water companies drawing their supplies from the Thames and Lea are as follows:—Chelsea Company, 1,830,000; West Middlesex, 1,359,072; Southwark Company, 1,568,160; Grand Junction Company, 1,986,336; Lambeth Company, 1,477,688; New River, 1,881,792; and East London, 1,393,920. Hence, not one of the London companies filters at the rate of two million gallons per acre per day; at which rate in the Massachusetts filters 99·9 per cent. of the microbes present in the raw water were removed.

(2) The effect of the size of the sand-grains used in the filters is very considerable. Thus, by the use of a finer sand than that employed by the Chelsea Company, the West Middlesex Company is able, with much less storage, to attain an equal degree of bacterial efficiency.

(3) The depth of sand, between the limits of 1 and 5 feet, exercises no practical effect upon bacterial purity, when the rate of filtration is kept within the limits just specified. Thus the New River Company, with 1·8 feet of sand on their filters, compares favourably with the Chelsea Company, the sand on whose filters is more than twice that depth. Placed in the order of thickness of sand on their filters, the Metropolitan companies range as follows:—Chelsea, Lambeth, West Middlesex, Southwark, East London, Grand Junction, and the New River. Placed in the order of efficient bacterial filtration, they range as follows:—Chelsea and West Middlesex (equal), New River, Lambeth, East London, Southwark, and Grand Junction.

(4) When there is such an accumulation of deposit on the surface of a sand-filter that, for practical purposes, sufficient water cannot be made to pass through it, the surface of the filter has to be scraped; that is to say, mud and about half an inch of the sand are removed from the surface. After this operation, there is often an increase in the number of bacteria in the filtered water, and it has been noticed that the increase is greater in shallow than in deep filters, and with high than with low rates of filtration; and there is no doubt that the effect of scraping is considerably magnified when the coarser descriptions of sand are employed, as is the case in the filters of the London water companies. I should therefore like to impress upon the engineers of these companies the desirability of using finer sands than are at present employed.

The lecturer here described a long series of experiments proving that the temperature of the water and the presence or absence of sunshine has little or no effect upon the number of microbes in river water, whilst the presence of flood water is almost invariably accompanied by an enormous increase in the number of microbes, showing that the microbial population of a river is directly dependent upon the volume of water flowing in its bed.

THE WATER SUPPLY OF THE FUTURE.

In view of the rapid increase of the population of London, fears have from time to time been entertained that the water supply from the Thames basin—that is to say, from the rivers Thames and Lea, supplemented by water from springs and deep wells within the basin itself—would soon be insufficient in quantity, whilst the quality of the water taken from the river has, up to comparatively recent date, been considered unsatisfactory. On these grounds various schemes have from time to time been brought forward for the supply of the metropolis from other river basins—from the Wye, the Severn, the river basins of North Wales, and of the lake districts of Cumberland and Westmoreland. It is worthy of note, however, that all the Royal Commissions have arrived unanimously at the conclusion that the quantity of water obtainable from the Thames basin is so ample as to render the necessity of going elsewhere a very remote contingency.

I shall now endeavour to put, very shortly, before you the facts which, in my opinion, prove that both as regards quantity and quality the Thames basin will, for a very long time to come, afford an abundant supply for the metropolis. There is, indeed, no river basin in Great Britain which affords such an abundant supply of excellent water as that available in the Thames basin. Besides that which flows directly into the rivers, this water is contained in the Chalk, Oolite, and Lower Greensand, which are the best water-bearing strata in the kingdom. From these strata it issues in copious springs of unsurpassed organic purity. For dietetic purposes there is no better water in the kingdom than the underground water of the Thames basin. For sentimental reasons, I should like to see it conveyed to the works of the various companies in special conduits; but we have seen that, on hygienic grounds, it may safely be allowed to flow down the bed of the Thames, if it be afterwards efficiently filtered.

So much for quality, now as to quantity. The basins of the Thames and Lea include an area of upwards of five thousand square miles. Of this, more than one-half, including the Oolitic, Cretaceous, and portions of the Tertiary formations, is covered by a porous soil upon a permeable water-bearing stratum. The remainder is occupied by the Oxford, Kimmeridge, Gault, and London clay; being thus covered by a clay soil upon a stiff and impervious subsoil. The annual rainfall of the district averages twenty-eight inches. The rivulets and streams of the Thames basin are formed and pursue their course on the clay land. There are no streams on the chalk. That which falls upon the porous stratum and does not evaporate sinks, mostly where it alights, and heaps itself up in the water-bearing stratum below, until the latter can hold no more. The water then escapes as springs at the lowest available points. Innumerable examples of these springs occur all round the edge of the Thames basin, and at various points within it. Thus from the Chalk they are ejected at the lip of the Gault, and in the Oolitic area by the Fuller's earth below it, or by the Oxford clay, geologically, above it.

According to the gaugings of the engineer of the Thames Conservancy Board, there passed over Teddington Weir, in 1892, 387,000 millions of gallons, equal to an average flow of 1060 millions daily. In the following year, 1893, there passed over this weir an aggregate of 324,227 millions of gallons, or a daily average of 888 millions of gallons, the average for the two years being 974 millions of gallons; and this number does not include 120 millions of gallons daily abstracted by the five London water companies who draw their supplies from the Thames. Thus, in round numbers, we may say that, after the present wants of London have been supplied from this river, there is a daily average of nearly a thousand millions of gallons to spare. Surely it is not too violent an assumption to make that the enterprising engineers of this country can find the means of abstracting and storing, for the necessary time, one-fourth of this volume.

As regards the quality of this stored water, all my examinations of the effect of storage upon the chemical, and especially upon the bacterial quality, point to the conclusion that it would be excellent; indeed, the bacterial improvement of river water by storage, for even a few days, is beyond all expectation. Thus the storage of the Thames water by the Chelsea Company for only thirteen days reduces the number of microbes to one-fifth the original amount, and the storage of the river Lea water for fifteen days by the East London Company reduces the number, on the average, from 13,693 to 2752 per c.c., or to one-fifth. Indeed, quietness in a subsidence reservoir is, very curiously, far more fatal to bacterial life than the most violent agitation in contact with atmospheric air; for the microbes which are sent into the river above the Falls of Niagara by the city of Buffalo seem to take little or no harm from that tremendous leap and turmoil of waters; whilst they subsequently, very soon, almost entirely disappear in Lake Ontario. Thus it is not too much to expect that storage for, say, a couple of months, would reduce the number of microbes in Thames flood water down to nearly the minimum ever found in that river in dry weather; whilst, by avoiding the first rush of each flood, a good chemical quality would also be secured. There is therefore, I think, a fair prospect that the quantity of water derivable from the Thames at Hampton could be increased from its present amount (120 millions of gallons per diem) to 370 millions.

Again, in the river Lea, although here the necessary data for exact calculation are wanting, it may be assumed that the present supply of fifty-four millions of gallons could be increased by the storage of flood water to 100 millions of gallons per day. To these volumes must be added the amount of deep-well water which is obtainable from those parts of the Thames basin which lie below Teddington Lock; and in the Lea basin below Lea Bridge, and which was estimated by the last Royal Commission at rather more than 67½ millions of gallons. Thus we get the grand total of 537½ millions of gallons of excellent water obtainable within the Thames basin, the quality of which can be gradually improved, if it be considered necessary, by pumping from the water-bearing strata above Teddington and Lea Bridge respectively; instead of taking the total supply from the open rivers above these points. Such a volume of water would scarcely be required for the whole supply of the water area of London at the end of fifty years from the present time, even supposing the population to go on increasing at the same rate as it did in the decade 1881–91, which is an assumption scarcely likely to be verified.

In conclusion, I have shown that the Thames basin can furnish an ample supply for fifty or more years to come, whilst the quality of the spring and deep-well water and the efficiently-filtered river water would be unimpeachable. To secure these benefits for the future, storage must be gradually provided for 11,500 millions of gallons of flood water, judiciously selected, in the Thames Valley, and a proportionate volume in the basin of the Lea; whilst filtration must be carried to its utmost perfection by the use of finer sand than is at present employed, and by the maintenance of a uniform rate during the twenty-four hours.

The lecturer concluded as follows. There nothing heroic in laying pipes along the banks of the Thames, or even in making reservoirs in the Thames basin. They do not appeal to the imagination like that colossal work—the bringing of water to Birmingham from the mountains of Wales; and there is little in such a scheme to recommend it to the mind of the enterprising engineers of to-day. Nevertheless, by means of storage, by utilising springs, by sinking deep wells, and by such comparatively simple means, we have, in my opinion, every reason to congratulate ourselves that for half a century, at least, we have at our doors, so to speak, an ample supply of water which, for palatability, wholesomeness, and general excellence will not be surpassed by any supply in the world.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Conference on Secondary Education, held in the Senate House on April 21 and 22, was largely attended by representatives of all the various educational authorities. The discussions were in some cases animated, and turned largely on the provisions of the new Education Bill; but the resolutions prepared, in support of the Report of the Royal Commission on Secondary Education, were in every instance passed by large majorities.

Dr. A. A. Kanthack, of St. John's College, has been appointed Deputy-Professor of Pathology for the present Term, in place of Prof. Roy, who is unable to lecture.

DR. H. FRANK HEATH, Fellow of University College, London, has been elected Assistant Registrar in the University of London, in the place of Mr. Dickens, who has succeeded Mr. Milman as Registrar.

A SPECIAL meeting of the Board of Governors of the Yorkshire College was held on Wednesday, April 23, in the Philosophical Hall, Leeds. The business before the meeting was to obtain the assent of the Governors to the borrowing by the Council of the College of £30,000 at 3 per cent. per annum on a mortgage of the real estate of the college situate in College Road (except such portion as is held in trust for the Clothworkers' Company), and of the new Medical School in Leeds. The motion was ultimately agreed to.

THE annual report of the Whitworth Trustees has just been published, in which it is stated that a sum of £10,000, a portion of the surplus from the 1887 Exhibition, has been handed over to the Technical Instruction Committee of the Manchester Corporation for the purpose of erecting an additional wing to the School of Art in Cavendish Square of that city. We thought that satisfactory arrangements had been made for the accommodation of this art school in the new technical school which is being built at an estimated cost of £200,000.

THE following are among recent appointments:—Dr. A. Fleischmann to be extraordinary professor of anatomy and zoology in Erlangen University, and director of the Zoologischen Universitäts, Anstalt; Dr. Pockels, *privat docent* in physics at Dresden Technical High School, to be professor; Dr. Oertel to be observer at the Königlichen Sternwarte in Munich, and Dr. Julius Bauschinger, of the same observatory, to be full professor of astronomy in the University of Berlin; Dr. H. W. Bakhuis Rosebom to be professor of chemistry at the University of Amsterdam, and Dr. A. Bistrzycki to be professor of analytical and technical chemistry in the University of Freiburg.

THE Paris correspondent of the *Times* states that the General Council of the Paris Faculties has decided to send several delegates to the meeting of the Franco-Scottish Society to be held in Edinburgh in 1897. It has also decided to be represented at the jubilee of Lord Kelvin's connection with the University of Glasgow in June next. A similar decision was taken in reference to the Princeton College celebration *fêtes*. In this connection the Council passed a resolution in favour of closer relationship between French and foreign universities. It was declared that France held too much aloof from these international festivals, and did not sufficiently try to extend a knowledge of her scientific activity. But however this may be, it is certain that we have yet to cultivate the hospitality always freely and lavishly given when British men of science visit their French *confrères*.

THE Report of the Council of the City and Guilds of London Institute upon the work of the Institute for the year 1895 has come to hand. Reference is made in it to the assistance which Prof. Huxley gave to the Committee appointed in 1877 to prepare an educational scheme. It was fitting that some permanent record of his connection with the Institute should be established, and the Council have been gratified to receive from the Fishmongers' Company an intimation that, in consideration of the eminent and important services rendered by Prof. Huxley to the cause of technical education, the Court of that Company have determined to found a Scholarship of £60 a year to be called the "Fishmongers' Company's Huxley Scholarship," to be awarded to a scholar of the Technical College, Finsbury, to enable him to proceed to the Central Technical College. In recalling the work of their late Chairman and of Prof. Huxley in the early years of the Institute, the Council are reminded of the great extension which this movement has undergone during the past few years. In London alone the Technical Education Board of the London County Council, and the Central Governing Body of the City Parochial Charities are spending about £120,000 annually on technical education; and, probably, an equal amount is being spent in the same direction by the Livery Companies of London through the Institute or by individual action. Apart from the City and Guilds of London Institute, mention may be made of the Goldsmiths' Company's Institute, at New Cross; the support by the Drapers' Company of the People's Palace; and of the Skinners' and Saddlers' Companies of the Northampton Institute; the Carpenters' Company's Schools at Stratford and Great Titchfield Street; the Tanning School, recently established by the Leathersellers' Company in the Borough; and the technical schools and textile departments in Leeds, Bradford, Huddersfield, Halifax, and other towns in the north of England supported by the Clothworkers' Company, as a few of the institutions of a specially technical character to which individual Companies are devoting their funds. From a table given in the report to show the amount of the donations to the funds of the Institute since its foundation, we have extracted the following totals, running into four or more figures, which to some extent supplement the information given in a recent article on the grants of the City Companies to education and research. Goldsmiths' Company, £83,064; Clothworkers' Company, £71,500; Fishmongers' Company, £70,550; Drapers' Company, £50,500; Mercers' Company, £50,000; Skinners' Company, £25,835; Grocers' Company, £19,000; Corporation of London, £15,500; Salters' Company, £15,138; Merchant Taylors' Company, £14,657; Leathersellers' Company, £10,105; Carpenters' Company, £8155; Armourers' and Braziers' Company, £7700; Ironmongers' Company, £5973; Cordwainers' Company, £5878; Saddlers' Company, £5600; Dyers' Company, £4646; Coopers' Company, £2770; Vintners' Company, £2500; Pewterers' Company, £2019; Plaisterers' Company, £1537; Cutlers' Company, £1386. The present report furnishes the City Companies with food for congratulation upon the results of the generous provision they have made for technical education.

SOCIETIES AND ACADEMIES.

LONDON.

Physical Society, April 24.—Captain W. de W. Abney, President, in the chair.—A paper by Mr. R. A. Lehfeld, on symbolism in thermodynamics, was, in the absence of the author, read by the Secretary. The author proposes a system of about twenty-four separate symbols for the different quantities in thermodynamics. Prof. Silvanus Thompson said he was not at all favourably impressed by the symbols proposed. In particular, it was becoming usual to restrict the use of Greek letters to the representation of specific quantities or angles, and the author's proposal seemed in this way a retrograde step. Prof. Perry said he did not care for the suggested symbols. Mr. Elder thought the author's system would be a very severe tax on the memory, for he did not make use of suffixes, as was ordinarily done, which in a great measure define the symbol to which they are attached.—Mr. Appleyard read a paper on the adjustment of the Kelvin Bridge. In a recent paper read before the Society, Mr. Reeves had described a modified form of Kelvin Bridge, in which a double adjustment was necessary. The author proposes to employ two wires stretched side by side, with a sliding contact in connection with the galvanometer on each. These contacts are rigidly connected together, so that the segments into which one wire is divided necessarily bear to one another the same ratio as do the segments of the other wire. Hence a single adjustment is sufficient to give balance. Mr. Reeves said that apparently the author had completely missed the object of his (the speaker's) paper. For the object there aimed at was to make use of such sets of resistance coils as are always to be found in any laboratory. In the author's arrangement it would be necessary to carefully calibrate the two wires, and also, since the resistances used must neceesarily be small, to determine the resistance of the contacts. Prof. Ayrton (communicated) said the author's suggestion was ingenious, but did not obviate the necessity for much of Mr. Reeves' "addition." Further, Mr. Reeves' proposal to employ ordinary resistance boxes was not made because such resistances are absolutely necessary, but because, since they are to be found in any electrical laboratory, their use saves the expense of such a wire resistance accurately calibrated as Mr. Appleyard employs. Mr. Appleyard, in his reply, said that his instrument was designed for use in a factory where the time saved in making a series of tests was of more importance than the cost of the instrument.—Mr. J. Frith read a paper on the effect of wave-form on the alternate current arc. The author finds that an arc has the power of modifying the wave-form in a circuit in which it is included. Thus in the case of a dynamo for which, on open circuit, the curve of E.M.F. was decidedly peaked, it was found that when this dynamo was employed to feed an arc that the curve became changed to a flat-topped form. It is interesting to remember that the candle-power of the arc is greater when the wave-form is flat-topped than when it is peaked. By altering the resistance in series with the arc it is possible to alter the character of the curve, for as the resistance in series with the arc increases the arc affects the wave-form less and less. In some recent experiments described by Dr. Fleming, a resistance of about 7 ohms was used in series with the arc, so that the wave-form of the generator, which is not an efficient form, was forced on the arc. In practice, however, where a resistance is not used in series with the arc, this is not the case, and the differences between the efficiency obtained for alternate current arcs in the laboratory and that claimed in practice may thus be accounted for.—Mr. Blakesley said it seemed as if the more nearly the alternate current resembles a direct current, *i.e.* the longer in each period the current remains constant, the greater is the efficiency of the arc.—Mr. Price asked what was the cause of the reaction of the arc on the wave-form.—Mr. Tremlett Carter asked whether previous observers' results were vitiated by this action of the arc on the wave-form?—Prof. Ayrton (communicated) considered the author's suggestion of great importance as bearing on the question of the efficiency of the alternate current arc.—Prof. S. P. Thompson said that the dynamo employed by the author was one in which there was a large quantity of iron in the armature, so that the self-induction was large. Was it not on account of this large coefficient of self-induction, which would tend to keep the current constant, that the arc was able to alter the wave-curve? If an arc is connected to the mains of a supply station in which a number of machines in parallel are feeding a number of lamps, would the arc still be able to affect the wave-form of the current?—Mr. Tremlett Carter asked if the author had tried the effect of replacing the arc by a resistance such that it would absorb the same volts as did the arc, and comparing the curves for the current and impressed P.D. with those obtained with the arc.—The author, in his reply, said that the effect of the self-induction of the machine was shown in the curves. Current curves had not been taken with the arc straight on the machine. The current and self-induction were the same for all the curves, the voltage of the machine being increased by increasing the field when a resistance was placed in series with the arc. When, as is commonly the case, special machines are used to supply arcs, and the load consists solely of arcs, the arcs could alter the character of the wave-form. If the arc is replaced by a resistance, the wave-form is of the same type as is obtained for the E.M.F. of the machine on open circuit.

PHILADELPHIA.

Academy of Natural Sciences, April 7.—Mr. J. Willcox described the process of obtaining quartz from the Oriskany sandstone of Pennsylvania to be used in the manufacture of glass.—Mr. G. Vaux, jun., called attention to recent additions to the William S. Vaux collection, which included superb crystals of calcite from the Joplin region, Missouri. They occur in caves opened for the working of lead and zinc. The several mines are characterised by distinct forms of the mineral. The sphalerite, which is largely present, is being deposited at the present time, the handles of shovels and picks left in the mines being found covered with crystals.—Mr. Theodore D. Rand described a fine collection of polished serpentines presented by him to the Academy from numerous localities in South-eastern Pennsylvania. They belong to two groups: one bordering the ancient gneiss, the other and the more recent occurring in the mica schists and gneisses. The former are altered igneous rocks, either crysolitic or pyroxenic, the chief material being Enstatite.—Dr. Bascom reported the microscopic examination of thin sections of serpentine from the Black Rocks of Lower Merion.—It was announced that Mr. G. Frederic Russell, accompanied by Dr. Juelal and a taxidermist, had started from Georgetown, British Guiana, March 11, on a collecting tour in the interior for the benefit of the Academy.

PARIS.

Academy of Sciences, April 20.—M. A. Cornu in the chair.—On the subject of an unpublished letter of Gauss, by M. de Jonquières.—On a temporary case of parasitism of the *Glyciphagus domesticus* of Geer, by M. E. Perrier. An account of a case where this species of Acarus, usually free, became parasitic, with the result that two houses into which it was accidentally introduced became uninhabitable. Energetic measures of isolation and disinfection by sulphurous acid had to be adopted to stamp out the parasite.—The truffles (*Terfas*) of Mesrata, in Tripoli, by M. Ad. Chatin. — The extraction of the terpene alcohols contained in essential oils, by M. A. Haller. The essence is treated with a quantity of succinic or phthalic anhydride sufficient to convert the whole of the alcohol into the corresponding acid ether. Treatment of this with aqueous sodium carbonate gives the sodium salt of the acid ether, and this, digested with an excess of caustic soda, gives the alcohol free from hydrocarbons on appropriate purification. As an alternative method, the essence containing the alcohol is diluted with ether and treated with metallic sodium, then to the sodium derivative so formed the succinic or phthalic anhydride is added, and the salt worked up as before.—On the approximate value of the coefficients of terms of high order in the development of the principal part of the disturbance function, by M. A. Féraud. A study of the mutual influence of two planets upon each other, both of which are moving in elliptic orbits.—On the biuniform transformations of algebraic surfaces, by M. P. Painlevé.—On the diffraction of the Röntgen rays, by MM. L. Calmette and G. T. Lhuillier. By the use of two metallic screens pierced with narrow slits, photographs were obtained consistent with the assumption that the Röntgen rays exhibit the phenomenon of diffraction. The results obtained indicate that the wave-lengths are longer than those of light, but the photographs are hardly clear enough for exact measurement. The experiments are being continued.—Observations on a communication of MM. Benoist and Hurmuzescu, by M. A. Righi. A discussion of the conditions favourable to the discharge of an electrified body by the X-rays. The author maintains the accuracy of his earlier observations regarding the production of a positive charge upon isolated conductors by the Röntgen rays, and states that the potentials so produced are of the same order as contact electromotive forces. Hence a very delicate electrometer is required to exhibit these effects.—Photography in the interior of a Crookes' tube, by M. G. de Metz. The kathode rays in the interior of a Crookes' tube possess one of the properties of the Röntgen rays, inasmuch as they penetrate aluminium, cardboard and paper, but are stopped by platinum and copper.—Observations on the preceding, by M. Poincaré. The kathode rays, on striking the platinum or aluminium screen, may give rise to X-rays, which *then* go through the metallic plates. The kathode rays themselves may not necessarily possess this property.—On the compensation of the directing forces, and the sensibility of the galvanometer with moving coil, by M. H. Abraham. By attaching a small mass in front of the moving coil of a Deprez-d'Arsonval galvanometer so as to slightly displace its centre of gravity, and properly regulating the inclination of the instrument by means of its levelling screws, the effective sensibility is increased one hundred-fold, and is of the order of a Thomson galvanometer of equal resistance.—Rotatory dispersion of active non-polymerised liquid bodies, by MM. Ph. A. Guye and C. Jordan. An experimental study of normal and abnormal rotatory dispersion. The chief conclusions drawn are that active liquid bodies, not polymerised, present only normal rotatory dispersion, and that there is no simple relation between the refrangibility of the radiations and the rotatory dispersion.—On a new series of sulphophosphides, by M. Ferrand. These compounds, of which the copper, iron, silver, nickel, chromium, zinc, cadmium, mercury, lead, and aluminium salts are described, are thio-pyrophosphates, and possess the general formula $M'_4P_2S_7$.—The spontaneous adaptation of muscles to changes in their function, by M. Joachimsthal.—Influence of induced currents on the orientation of living bacteria, by M. L. Lortet. Living bacteria, in the form of mobile bacilli, are very sensible to the action of currents from a Ruhmkorff coil, and immediately set themselves in the direction of the current. This effect is only produced when the organisms are living, and is not observed after the introduction of an antiseptic, such as carbolic acid. Living organisms are unaffected by a constant current.—On the internal appendages of the male genital apparatus of the Orthoptera, by M. A. Fénard.—On the membrane of the *Ectocarpus fulvescens*, by M. C. Sauvageau.—On the abortion of the principal root in one species of the genus *Impatiens* (L.), by M. C. Brunotte.—The biochemical preparation of sorbose, by M. G. Bertrand. A specific organism, which can be obtained by exposing a mixture of wine and vinegar to the air for some time, is the cause of the conversion of sorbite into sorbose in the fermentation of the juice of various species of *Sorbus*. The direct production of sorbose in the fermentation of the latter is dependent upon the introduction of the organism by small reddish flies (the vinegar fly, *Drosophila funebris*).—On winter observations in the caves of the Causses (Padirac, &c.), by M. E. A. Martel.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—A Scientific Demonstration of the Future Life: T. J. Hudson (Putnam).—Studies in Ancient History: J. F. M'Lennan, 2nd series (Macmillan).—A Dictionary of Chemical Solubilities. Inorganic: Dr. A. M. Comey (Macmillan).—The Theory of Sound: Lord Rayleigh, Vol. 2, new edition (Macmillan).—Analytical Psychology: J. F. Stout, 2 Vols. (Sonnenschein).– Forschungsberichte aus der Biologischen Station zu Plön: Dr. O. Zacharias, Theil 4 (Berlin, Friedländer).—Know your own Ship: T. Walton (Griffin).—Annals of the Royal Botanic Garden, Calcutta, Vol. v. Part 1 (Calcutta).—The American Lobster: Dr. F. H. Herrick (Washington).—Artistic and Scientific Taxidermy and Modelling: M. Browne (Black.—Royal University of Ireland. Examination Papers, 1895; a Supplement to the University Calendar for the Year 1896 (Dublin).

PAMPHLETS.—The Physiology of the Carbohydrates: a Rejoinder to Dr. Paton's further Criticism: Dr. F. W. Pavy (Churchill).—City and Guilds of London Institute Report to the Governors, March 1896 (Gresham College).—Neber einige Eigenschaften der Röntgen, schen X-Strahlen: Drs. Winkelmann and Straubel (Jena, Fischer).

SERIALS.—English Illustrated Magazine, May (198 Strand).—Quarterly Review, April (Murray).—Good Words, May (Isbister).—Sunday Magazine, May (Isbister).—American Journal of Psychology, Vol. 7, No. 3 (Worcester, Mass.).—Encyklopædie der Naturwissenschaften, Dritte Abthg., 30 to 33 Liefg. (Breslau, Trewendt).—Journal of the Sanitary Institute, April (Stanford).—Longman's Magazine, May (Longmans).—Chambers's Journal, May (Chambers).—Terrestrial Magnetism, No. 2 (Chicago).—Journal of the Asiatic Society of Bengal, Vol. lxiv. Part 2, No. 3 (Calcutta).—Proceedings of the Academy of Natural Sciences of Philadelphia, 1895, Part 3 (Philadelphia).—Bulletin of the American Museum of Natural History, Vol vii. (New York).—Field Columbian Museum. Archæological Studies among the Ancient Cities of Mexico, Part 1: W. H. Holmes (Chicago).—Natural Science, May (Rait).—Schriften der Naturforschenden Gesellschaft in Danzig. Neue Folge, Neunten Bandes, Erstes Heft (Danzig).

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