THURSDAY, MARCH 1, 1900.

JAMES DWIGHT DANA.

The Life of James Dwight Dana, Scientific Explorer, Mineralogist, Geologist, Zoologist, Professor in Yale University. By Daniel C. Gilman, President of the John Hopkins University. With illustrations. Pp. 409. (New York and London: Harper and Brothers, 1899.)

SHORTLY after the death of Dana in 1895, a very admirable sketch of the scientific career of his father, from the pen of Prof. E. Salisbury Dana, appeared in the pages of the *American Journal of Science;* but the numerous friends and admirers of the distinguished man—who for many years was justly regarded as the foremost representative of science in the United States—will welcome the fuller memoir now given to the world by his old pupil and friend, President Gilman.

There appears to be some difference of opinion as to whether the members of the Dana family were descended from an Italian or a French stock, but there is little doubt that there were Danas settled in England early in the seventeenth century, and that the ancestor of the American branch was one Richard Dana, who about 1640 emigrated to Cambridge, Massachusetts. Many bearers of the name have attained distinction as divines, lawyers, or literary men; but the father of the great naturalist was engaged in business in the little town of Utica, New York, and it was only the strong bent towards the study of science, which young James Dwight Dana so early betrayed, that led to his abandonment of commercial pursuits, and his devotion to those studies in which he afterwards attained so much distinction.

In the education of Dana we have a striking illustration of the great results that may follow from the efforts of a teacher possessed of enthusiasm and originality—even when he himself may not be distinguished as a scientific discoverer. Dana's capacity for scientific work would seem to have been detected and encouraged by a Mr. Fay Egerton, a teacher in the Utica High School. We are told that

"Mr. Egerton gave lectures in a moderately-furnished laboratory" (this was in the year 1827, in a little backwoods settlement of only five or six thousand inhabitants!) "successively in chemistry, botany, mineralogy and geology, to classes of the older students, who in turn were required, after a study of the topic, to give back the lecture with its experiments to the teacher and their fellows of the class. He was an enthusiast in his own line of study and instruction. Besides his lectures in the lecture-room, he scoured the country round either with or without his pupils, showing them where to go in pursuit of whatever was instructive or curious, assisted them in the naming and care of their specimens, and inspired them with new zeal for natural science. During the long summer vacations he made long excursions with half-a-dozen or more of his class to different parts of the State or to neighbouring ones, visiting localities that abounded in particular rocks or minerals, and bringing home stores for their own or the school collection. These excursions were made almost wholly on foot, a single horse and waggon accompanying the party to carry their scanty wardrobe and relieve the oft-burdened mineral satchel worn by each of them, until such time as they reached a suitable place for shipment."

Every teacher of elementary science in this country may well find encouragement in reading this description of the labours of Fay Egerton. Who can say that among the bright-faced boys watching the experiments or eagerly scanning the specimens shown to them a future Dana may not be present?

It affords a curious comment on the methods of education in this country if we remember that at the very time when Fay Egerton was labouring in a little back settlement of New York to develop the scientific tastes of his pupils, Charles Darwin and his elder brother were being publicly reprimanded in the Shrewsbury Grammar School for wasting their time in setting up a laboratory in which to carry on their experiments!

In 1830, when only seventeen years of age, Dana left Utica and entered Yale College, New Haven, Connecticut, where he came under the influence of Prof. Benjamin Silliman, whose daughter he subsequently married. After taking his degree in 1833, he became an instructor of midshipmen in the U.S. Navy, and sailed in the warship *Delaware* to the Mediterranean, visiting the coasts of France, Italy, Greece and Asia Minor. It was during this voyage that he wrote his first paper, an account of a visit to Vesuvius, which was published in the *American Journal of Science.*

Returning to the United States, a period of suspense, but not of inaction, followed. While seeking for a scientific post, and acting as honorary assistant to Prof. Silliman, he prepared the first edition of his "Treatise on Mineralogy," a work which, being continually improved and enlarged in the five successive editions that have appeared in the last sixty years, will always remain a monument of Dana's great attainments and vast industry.

In 1838 Dana was appointed one of the naturalists to the celebrated exploring expedition under Commodore Wilkes. It is interesting to notice how curiously the careers of Dana and of Asa Gray, the botanist, were influenced by their mutual friendship. Asa Gray succeeded Fay Egerton as teacher of science in the Utica High School, though it does not appear that Dana was ever one of his pupils. When the United States Government determined to send out an exploring expedition, however, Gray accepted the post of naturalist, and it was by his persuasion that Dana was induced to do the same. But at the last moment Gray withdrew, while Dana, as is well known, accompanied the expedition throughout the whole cruise. Gray and Dana were lifelong friends, and among the most interesting letters in the volume before us is the correspondence that passed between them, especially that portion of it relating to the doctrine of evolution.

The United States exploring expedition consisted of five vessels, and between the years 1838 and 1842 it circumnavigated the globe, visiting the islands of the Atlantic and passing through the Straits of Magellan to the west coast of South America; thence through the Paumotu, Tahiti and Samoan groups to Australia, whence a portion of the expedition proceeded south, and discovered land in the Antarctic Ocean. While at Sydney, Dana first heard of the theory which Darwin had shortly before propounded to account for the origin of atolls and barrier-reefs, and during the remainder of the voyage, which led him by way of New Zealand to the Fiii Islands, the Sandwich Islands, the Kingsmill group, and the Carolines, Dana lost no opportunity of testing the theory by application of it to the various islands visited by the expedition. As is well known, Dana, while differing from Darwin on some minor questions, fully accepted the coral-reef theory of the latter author, and remained, to the end of his life, its most staunch and enthusiastic defender. While in Magellan's Straits, the ship to which Dana was attached only very narrowly escaped shipwreck, and, after leaving the Sandwich Islands, the *Peacock*, with Dana on board, was totally lost near the mouth of the Columbia River. After this unfortunate experience, in which Dana lost all his personal effects and many of his collections, he joined a party which crossed the mountains near Mount Shasta, and made their way down the Sacramento River to San Francisco. At San Francisco Dana joined the *Vincennes*, and returned to New York by way of the Sandwich Islands, Singapore, the Cape of Good Hope, and St. Helena.

The next twelve years of Dana's life were occupied in working out the results obtained during the expedition. In 1849 appeared a great quarto volume, with an atlas, on the geology of the expedition, this having been the part of the work which was especially under his charge. But in 1846 he had already issued a large volume, with folio atlas, a "Report on the Zoophytes," dealing with the corals collected by the expedition; and in 1853 two other large volumes, with another folio atlas, his "Report on the Crustacea," made their appearance. How unremitting were his labours in connection with these three reports will be manifest to all who have to consult these volumes, especially if it be remembered that a large part of the drawings in the plates are by Dana's own hands.

In this combination of geological and zoological work, by one who had so many opportunities for original observation during a long voyage of circumnavigation, we cannot fail to be struck by the parallelism between the careers of Darwin and Dana. Unfortunately, we have to add that, while both attained a great age, they were alike, during the later years of their lives, sufferers from ill-health—the result of the hardships they underwent in their long and arduous journeys in the cause of science. Dana and Darwin never met one another, but during many years they maintained a friendly correspondence, some of the letters that passed between them being printed in the volume before us.

In 1850 Dana was appointed Professor of Natural History in Yale College, but in 1864 his duties were restricted and he became Professor of Geology and Mineralogy. There are many interesting pieces of evidence in the work before us of the able and conscientious manner in which he discharged the duties connected with his chair, and of the esteem and love with which he was regarded by his students and colleagues. In addition to his "System of Mineralogy," he wrote a "Manual of Mineralogy and Lithology," and also a "Treatise on Geology," which is widely known and has passed through four editions, and a little work for beginners, entitled "The Geological Story briefly Told."

Another sphere of activity in which Dana was constantly employed was the editing of the *American Journal of Science*, which had been started by his father-in-law, the elder Silliman, in 1818, and has long occupied the foremost place among the scientific journals of the United States. Dana became joint editor of the journal with the elder and younger Silliman in 1846, and during the later years of his life was chief editor of the work—a task which has since devolved upon his son, Prof. Edward Salisbury Dana. *Silliman's Journal* has now existed for eighty-two years, and is widely known for its scientific articles, not only in the United States, but in every part of the British Islands and the Continent of Europe, where science is cultivated. Besides many of Dana's most important original contributions to science, the numbers of the *American Journal of Science* contain a long series of notes and reviews from the pen of its ever active editor.

In spite of ill-health, Dana maintained his scientific activity to the end. During his "Wanderjahr," his attention had been specially directed to the formation of coral-reefs, and in addition to his great monograph upon corals, he wrote a popular book, "Corals and Coral Islands," which passed through two editions. In the controversies on the rival theories of the formation of coral-reefs, Dana contributed a masterly summary and review of the whole question. Another subject which had interested him during his first voyage to the Mediterranean, and later in his visit to the Sandwich Islands, was that of Vulcanology. Since his visit to Hawaii, in 1842, so many changes had taken place in the volcanoes of the island, that in 1887, although he had reached the age of seventy-four, he determined to revisit them for the purpose of settling various doubts and difficulties which had arisen in his mind. His well-known work on "Volcanoes" was the outcome of this expedition.

We have spoken of the remarkable parallelism between the careers of Darwin and Dana. The reader of the interesting volume before us will not fail to notice another resemblance between the English and the American naturalists, namely, their singular simplicity and amiability of character. This is evidenced in the case of Dana by innumerable incidents and many expressions contained in letters in the work before us, which show that by all with whom Dana came in contact he was deeply loved. Dana's long and active life had a very quiet and peaceful ending early in 1895. The memoir is written by one who is evidently full of sympathy and admiration for the man, and he is to be congratulated upon having furnished a vivid portrayal of the characteristics of a naturalist whose memory men of science, all over the world, will not willingly let die. JOHN W. JUDD.

BILLIARDS MATHEMATICALLY TREATED.

Billiards Mathematically Treated. By G. W. Hemming, Q.C. Pp. 45. (London: Macmillan and Co., Ltd., 1899.)

THIS treatise will be useful to the amateur billiard player who has a competent knowledge of mathematics, though not, perhaps, to the very accomplished player who may have attained to excellence by natural gifts of eye and hand, and by long practice without theory. Mr. Hemming had better state in his own words his views upon this question.

"A rule of thumb," he says, "is as good as a scientific law to a man who has played often and well enough to regard the rule of thumb as a necessary law of nature. Amateurs of less experience than this may find it much easier to obey a law the reason for which they have grasped."

The possible motions of a billiard ball here discussed are five, viz.: (1) Perfect rolling; that is, rotation about a horizontal line through the point of the ball touching the table for the time being. This is the motion assumed by the ball when struck by a horizontal cue in a vertical plane through the centre at a height 7/10 of the diameter. (2) Sliding without rotation. (3) Pure side; that is, rotation about a vertical axis through the centre. (4) Curving motion; that is, rotation about a horizontal axis through the point touching the table, such axis coinciding with the direction of translation. (5) Imperfect rolling; that is, rolling as in (1) combined with any of the others.

These probably exhaust all forms of the motion for gentle strokes. A hard struck ball will probably jump many times before it finally subsides into rolling or sliding, just as a cricket ball neither rolls nor slides much till it is nearly spent.

The most interesting case occurring in practice is that in which the striking ball with perfect rolling impinges on the object ball at rest. The problem of the motion of the two balls after impact involves the determination of the important constants. The constants are:—(1) The coefficient of elasticity, $1-e$, between ivory balls, which, on authority accepted by the writer, is given as about 14/15. (2) The friction, f, between the balls, which is determined as follows:—The object ball, if struck obliquely, acquires from the friction with the striking ball a certain rotation about a vertical axis through the centre. This is proportional to f. With this is compounded a rotation about a horizontal axis due to direct impact, so that the resultant rotation is about an axis inclined to the horizon. And if we can guess the direction of that inclined axis, we can determine f. By using an old red ball, on which are irregular markings, as the object ball, Mr. Hemming says the inclination can be guessed with fair accuracy, and this method gives for f a value between 1/70 and 1/105.

A third possible constant is that of the impulsive friction between ball and cloth, denoted by μ. This Mr. Hemming retains provisionally in his formulæ, but ultimately rejects as inappreciable.

In the case of impact between ball and cushion, the action of the cushion varies so greatly with the speed, as well as with the direction, of the striking ball, that no constant can be determined.

Probably the most useful part of the book to the practical player is Appendix II., on the *margin of error* in billiard strokes, from which even the best player may learn something to his advantage. I select the following instances: in playing a winning hazard, the margin of error is least, and the stroke most difficult, when the object ball is half-way to the pocket. It is found also that the margin of error is smaller in a thin losing hazard than in the corresponding through stroke.—But is not the management of the cue more difficult in the latter case?

Appendix I. treats of the effect of nap on a ball played with side. It raises the question of the nature of rolling friction. According to Prof. O. Reynolds (*Phil. Trans.* 1876), rolling friction may be reduced to sliding friction. When a body rolls on a plane, expansion or contraction takes place in the substances immediately in contact, which, or the subsequent restitution, causes one to slide over the other. Sliding is thus always being created and destroyed by friction as fast as it is created. Mr. Hemming makes a different hypothesis—namely, that the cloth may be regarded as a series of stiff parallel ridges, facing the way of the nap. The rolling ball is instantaneously in contact with two of them, say, at the points P and P′, the line PP′ subtending at the centre a very small but finite angle, which depends on the nature of the cloth. Through P and P′ pass two reactions, which intersect (he says) in the vertical through the centre at the height 7/10 of diameter, and therefore cause the ball to continue perfect rolling. He is not writing a treatise on rolling friction, and does not therefore give any *a priori* reason why the two reactions should intersect at the point stated. *A posteriori* they must do so, for otherwise the ball could not continue perfect rolling as, in fact, it does. It would not be difficult to show, applying what is known as Thomson's theorem, that on Mr. Hemming's hypothesis, as to the nature of the cloth, the ball would pass from the state of rotation round P to a state of rotation round P′ with diminished energy, and so must continue perfect rolling.

S. H. BURBURY.

OUR BOOK SHELF.

A Rudimentary Treatise on Coal and Coal Mining. By the late Sir Warington W. Smyth, M.A., F.R.S. Eighth edition, revised and extended by T. Forster Brown. Pp. vi+346. (London: Crosby Lockwood and Son, 1900.)

NO man did more for the advancement of mining education in this country than the late Sir Warington Smyth. In 1851, when the Royal School of Mines was founded, he was appointed lecturer in mining, and he continued to give his annual course of mining lectures until June 20, 1891, when, sitting with his students' examination papers before him, he passed away—dying, as he had lived, in harness. In 1851 he found the art of mining in the trammels of empiricism; and, thanks to his wide practical experience and his familiarity with continental practice, he was able in his lectures to evolve order out of chaos, and to arrange heterogeneous facts in a comprehensive system. Moreover, his work underground as mineral inspector and adviser to the Crown enabled him constantly to keep his lectures abreast of the times. Unfortunately, he never prepared them for the press. But, while directing the higher education in mining, he was not forgetful of the needs of the elementary student, and was induced in 1866 to write for Weale's excellent series of rudimentary treatises a little book on coal and coal mining. This was eminently successful, and seven large editions were called for. No previous work gave so popular and yet so full and accurate a view of the subject. Written in a delightful literary style, it bore internal evidence of not being a mere extract of books, and afforded attractive reading not only for the unpractised, but also for the experienced mining engineer and geologist.

Since the publication of the seventh edition great progress in mining has been made, and the value of the book has necessarily greatly diminished. It is therefore most satisfactory to note that Mr. T. Forster Brown, an eminent mining engineer, and Sir Warington Smyth's successor as chief inspector of the mines of the Crown and of the Duchy of Cornwall, has edited a revised and extended edition, in which the principal changes and improvements in coal mining are treated. The chief additions made are two chapters dealing with blasting and explosives and with coal washing. In the latter, coke making (a subject usually included in metallurgical treatises) is also discussed. Mr. Forster Brown has very wisely been careful to retain the general character of the book. He has perhaps carried to too great an extent his unwillingness to alter the original text.. The prices mentioned throughout the book, for example, refer to the years 1864-6. The Saxon coal production is given in the long obsolete units of *Scheffel;* and references are made to New Granada, a country that changed its name in 1861, and to "the flourishing empire of Brazil," which ceased to exist in 1889. Again, with regard to the speculation that the Palæozoic rocks may be continuous from the Severn to the Rhine, which is described as of little practical importance, no allusion is made to the discovery of coal at Dover. Mr. Forster Brown, too, omits to point out that the statement that there are very erroneous ideas of the overwhelming importance of the American coalfields as compared with those of Europe is no longer accurate in view of the fact that last year the United States produced more coal than any other country in the world. BENNETT H. BROUGH.

Untersuchungen über die Chemischen Affinitaten. Von C. M. Guldberg und P. Waage. Herausgegeben von R. Abegg. Pp. 182 and 18 tables. (Leipzig: W. Engelmann, 1899.)

THIS latest addition to Prof. Ostwald's invaluable series of reprints will be welcomed by all chemists. The work of Guldberg and Waage is now well known, and is abstracted at some length in the larger books on theoretical chemistry; but we have here the complete series of papers with some recent annotations by Prof. Guldberg, and an interesting biographical and critical notice by Prof. Abegg.

The student of chemical history will do well to read this volume in conjunction with No. 74 of the series, which is a reprint of Berthollet's "Recherches sur la loi d'affinité." Berthollet's work was published in 1801; Guldberg and Waage's first paper is dated 1864. Between these years nothing advancing the mathematical theory of the subject had appeared except the unrecognised paper of Wilhelmy on the rate of inversion of cane-sugar, and the papers of Berthelot on estorification. When this is borne in mind it will be realised how great and how sudden was the advance made by the two Norwegians.

The three papers contained in the reprint, and dated respectively 1864, 1867 and 1879, show how, with the progress of time, the ideas of the authors grew in simplicity and generality, until in 1879 we have their theory in a form differing but little from that in which it is employed at the present day. The two earlier papers were very little known up to 1879, and several investigators worked unwittingly in the same field discovering facts a second time. This, however, can hardly be a matter for regret except in so far as it tends to bewilder the student. In other respects it has only served to strengthen the foundations of chemical dynamics.

A. S.

How to Know the Ferns. By Frances Theodora Parsons. Pp. xiv + 215; and plates. (New York: Charles Scribner's Sons, 1899.)

THIS book is intended to serve as a popular handbook to the ferns of the United States. It will probably fulfil its purpose, in enabling the reader to identify the majority of the ferns described by means of their general habit, aided by the form of the sorus. To this result the numerous original illustrations, which are clear and accurate, will largely contribute. An artificial key to the species is provided, in which the authoress depends to a considerable extent on the degree of difference between sterile and fertile fronds to characterise the main groups. It is to be regretted that attention is not directed to the artificial nature of these distinctions, and that the natural arrangement was not adopted in the part devoted to the description of the species. In this we find the species of *Osmunda* separated in two groups, while the *Ophioglossaceae* are placed in the midst of the true Ferns. The brief account of the reproduction of ferns on pp. 30-35 leaves much to be desired. The figures illustrating this are poor, notably the drawing of a sporangium on p. 31, while the description is bald and in places misleading. No mention is made of the peculiar subterranean prothalli of the *Ophioglossaceae.* Had space been found by the omission of irrelevant matter in the opening chapters for a clear, simply written, and well-illustrated account of the life-history of ferns, with special reference to the native species, the book would have been none the less popular, while its educational value would have been greatly increased. W. H. L.

Laboratory Note-Book for Chemical Students. By Prof. Vivian B. Lewes and J. S. S. Brame. Pp. viii + 170 (with alternate blank pages). (Westminster: A. Constable and Co., 1899.)

THE authors of this book, which is essentially one for the laboratory bench, are of opinion that there is room for a small volume containing all the necessary description for the laboratory preparation of gases, &c., together with the reactions of metallic and acid radicles, in a concise form, and some of the more simple quantitative experiments suitable for students. In the treatment of a few technical matters, such as the valuation of fuel, the simple examination of oils, the viscosity of oils, and the characteristics of explosives, the volume is in advance of most similar laboratory manuals, but the plan of interleaving the text with blank pages for the student's own notes cannot be unreservedly recommended. Many teachers find that such an arrangement is conducive neither to neatness nor originality in the pupil's expression of his own observations. The method has, however, its advantages; and the objection to it does not affect the text, which provides a good course of experimental work in chemistry suitable for technical students and others.

The Elements of Co-ordinate Geometry. "The University Tutorial Series." Part II. The Conic. By J. H. Grace and F. Rosenberg. Pp. viii + 315. (London: W. B. Clive, 1899.)

SO many text-books are available to day that the issue of a new one is generally accompanied by an explanation of its *raison d'être.* The one before us is that the present book seeks to develop the subject in a more gradual and more explanatory manner than its predecessors, and to pay more attention to curve tracing. That it succeeds in this endeavour will be gathered from a perusal of its pages, for no pains seemed to have been spared to lead the reader up small but ever rising steps. To gather a general notion of the scope of the book, we may say that, after briefly describing the three varieties of conics, the student is made acquainted with the general equation of the second degree, and the classification of curves which are represented by such an equation. This is followed by more detailed information relating to various properties of curves, taken at first generally and afterwards individually. The exercises are graduated as much as possible as regards difficulty of solution, and are very numerous.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Effects of Lightning upon Electric Lamps.

IN the last number of NATURE, Prof. Wood calls in question the reality of the remarkable phenomenon revealed by Mr. Webb's photographs, attributing the results obtained to a motion of the camera during exposure; laying special stress on the alleged fact that "a lamp close to the camera, and a distant lamp, show the trails *on the same scale*."

To this I reply that the fact is just the reverse, as is well shown in Fig. 4, which exhibits nine lamps which are situated in order of sequence along a strongly curved shore, the pictures of four lying to the left and of five to the right of that of the near lamp. It will be seen that there is a regular diminution of scale in these pictures as we pass from left to right, corresponding to the increase of length of the chords of the bay. I would remind the reader that at the conclusion of his letter (p. 343), Mr. Webb expressly states that on a subsequent occasion he actually *saw* a stream of electricity descending from an arc lamp towards the earth. This was a momentary appearance, obtained by so placing himself as to be protected in a measure from the glare of the lightning.

From my communications with Mr. Webb, and from the photographs themselves, I am satisfied that the camera was lying at rest, except *perhaps* as regards the fifth flash of the picture Fig. 6, which may possibly have struck while Mr. Webb was in the act of removing the camera; a point about which I have written to make inquiry. Should such prove to be the fact, I would withdraw my "digression" (p. 344) relative to the flash in the middle of Fig. 6.

G. G. STOKES.

Cambridge, February 24.

Stockholm International Conference on the Exploration of the Sea.

UNDER this title there appeared in NATURE, during November and December last year, several letters from some eminent British biologists containing criticisms of the resolutions of the Stockholm Conference. The principal objections to the conclusions at which the Conference arrived are:—

(1) *That the Conference has not elaborated any definite programme of biological work.*

I fully agree with Prof. Herdman that the biological part of the programme needs further development before it can be put into execution. The Conference has only drawn up the outlines of that part of the programme which regards fishery experiments, marking of fishes, &c., so far as they can be considered applicable to all parts of the area concerned. It is evident that, while the instruction for hydrographic work, deep-sounding, &c., will hold as well for the shallow depths of the southern parts of the North Sea as for the 2000-3000 metres depths of the Norwegian Sea, the character of the biological research and the fishery experiments will be somewhat different in the eastern and western parts of the North Sea, in the Barents Sea, and in the Baltic. It must be left to the specialists and the fishery authorities of each country to propose detailed rules for the experimental and statistical work as regards the most appropriate manner of investigation of the adjacent areas. It will be for the Governments to take care that the initiative thus taken is duly considered and made useful in the organisation of the co-operation, either by instituting the Central Bureau and Council at once, or—as an introductory step to this—by assembling the Commission mentioned under the head H of the Resolution. The most urgent thing at present is to ascertain if the different Governments agree *in principle* to the idea of co-operation or not. The Swedish Government some months ago communicated to the Governments of the North Sea powers and Russia, that it accepted the programme of the Stockholm Conference, and is resolved, in case of agreement on the part of the other Governments interested, to ask from the Riksdag the funds necessary to carry it out. On the same occasion, the Swedish Government requested the Hydrographic Commission to work out a detailed programme for the Swedish part of the investigation, and to calculate the costs. An abstract of this plan will shortly be published in the *Scottish Geographical Magazine.*

The meteorological work is not mentioned in this plan, otherwise than by reference to the detailed instruction contained in section A of the Resolution. The plan of the biological work and fishery experiments is illustrated by two maps. The annual costs are calculated at 3170*l.*, or with deduction for ships, coal, &c., 1000*l.* It must be well borne in mind that this plan is liable to alteration, and does not represent what we *are* to do, but what we *propose* to do, in case the co-operation is realised. To the note of the Swedish Government concerning the co-operation proposed by the Stockholm Conference, favourable replies have been received from the Norwegian and the German Governments.

(2) *That the Conference has not recommended to the Governments concerned the use of sea-going, well-equipped steamers for investigations of this kind.*

The necessity of having sea-going ships for such purposes will scarcely need recommendation. Several of the Governments in question, as Russia, Denmark, Norway, Sweden, have already procured, or made arrangements for procuring, steamers excellently fitted for the co-operative work. But the number and size of such ships must be left to the decision of each Government.

(3) *That the area to be investigated ought to have been extended to some part of the Atlantic proper.*

This seems to me to be the most serious objection hitherto raised. It seems, in fact, indispensable to keep some account of the state of the Atlantic W. of the Channel, and S. of the Wyville Thomson and Faroe Iceland ridge.[1] On the other hand, it must be agreed that, if a certain limit must be fixed, the Strait of Dover and the two ridges above-mentioned constitute the only natural boundary for a co-operation of the North Sea powers.

(4) *That the Central Bureau and laboratory proposed by the Conference is unnecessary, and might be substituted by some more elastic organisation.*

When listening to the proceedings of the Seventh International Geographic Congress at Berlin last year, I noticed that international co-operation was recommended almost in every case as the best method of attacking geographical problems. Resolutions were passed to such purpose regarding seismological, hydrographical, meteorological problems, antarctic explorations and others. It struck me that nobody seemed to take into account the difficulties combined with the starting and conducting of such co-operative work. I know that there *are* such difficulties, and I consider that in the present case the difficulties already existing are irrelevant if compared with those which will arise in future, when the organisation shall commence its work. If we only want as much as possible of scientific work of various kind to be done, the elastic (collegial) organisation which Mr. Allen recommends will do; but if we desire unity of work and practical results, we certainly must have a central institution at the head of the co-operation. It is a characteristic fact that this proposal emanated from delegates of most of the countries represented at the Conference. Without entering upon the state of things in other countries, of which I am no judge, I am sure that the prevailing circumstances with regard to fishery matters in my own country are such that we ought gratefully to accept the proposals of the Conference with regard to a central organisation.

(5) *That the Central Bureau, &c., will interfere with the freedom of the specialists and impede the originality of the scientific work at the biological stations.*

It seems not unlikely that the manifold labour of calculating and statistical work incumbent on the Central Bureau will occupy the time of the officials of that Bureau to such an extent that little time will be left for original scientific research on their part; but I cannot realise the possibility that such will be the case with the specialists belonging to the biological stations now existing. The co-ordination of the international research with their scientific work will, of course, be based upon free mutual agreement, wherein all advantages will be on the side of the biologists. Suppose that Mr. A., director of the marine station of X, studies the biology of the halibut, and that Mr. B., of the station Y, is specialist upon the cod or the plaice. Both communicate their wish to get scientific material from the North Sea and Norwegian Sea to the Central Bureau, which requests Messrs. A. and B. to elaborate each a detailed

[1] The position of the British and Danish lines (see the map of the Conference protocols, of which a reproduction has appeared in the *Geogr. Journal*, December 1899) is chosen so as to fulfil this purpose to a certain degree.

scheme with full instructions for the collection of the material desired, and for the counting, measuring, &c., of fishes, fry and eggs. If these schemes are approved by the General Council, the president or secretary of the Central Bureau is authorised to recommend the leaders of the fishery experiments in all parts of the seas concerned to select the material desired from every catch, and to measure, mark and register it in the manner prescribed. Messrs. A. and B. will thus receive preparations or specimens of cod, halibut, &c., of such size and stage of development as they wish to study from every corner of the area investigated. Likewise, they will get analytical data of the salinity, temperature of the water or samples of plankton, stomach contents, gases contained in the water or in the bladder, &c.

The field of research of each specialist will thus be immensely enlarged. Another advantage is that material of purely scientific value can be distributed to public and private institutions, museums, &c., in the different countries.

OTTO PETTERSSON.

Hydrografiska Kommissionen, Stockholm.

Gibbs's Thermodynamical Model.

IN Maxwell's "Theory of Heat" (p. 207) is a drawing showing some of the principal lines on a thermodynamical model suggested by Prof. J. Willard Gibbs, of Yale University. I have been told that Prof. Maxwell had two of these models constructed, one of which remained at Cambridge, England, the other being sent to Prof. Gibbs at Yale. There is also a copy of this model at Clark University, Worcester, the only one which I have seen. While there may be others in existence, these are the only ones which I have known of, and I suspect that very few have ever been constructed.

This year, in connection with a course in thermodynamics, two of my pupils are attempting to construct one of these models, but are met by various serious difficulties, which may interest others. In the diagram to which I refer, the directions chosen for the different co-ordinates are not immediately evident. Even by the aid of the description in the text, I have not been able to locate them satisfactorily. In the attempt so to do, I have been guided by the following general considerations. Using Maxwell's notation, in which v=volume, p=pressure, t=absolute temperature, e=energy, ϕ=entropy, the equation connecting these quantities is

$$t d\phi = de + p dv,$$

which, transposed, gives

$$de = t d\phi - p dv = \frac{\partial e}{\partial \phi} d\phi + \frac{\partial e}{\partial v} dv,$$

the differential equation of the thermodynamical surface of which the co-ordinates are the entropy, volume and energy, and the slope of which at each point in the principal directions gives the temperature and pressure, by the identities

$$t = \frac{\partial e}{\partial \phi}\ ;\quad p = -\frac{\partial e}{\partial v}.$$

These are subject to the conditions that t is always positive, and p is usually positive, always so for the gaseous state, usually for the liquid and solid states.

If, then, e is taken vertically downward, and v and ϕ horizontal, passing along a section of the surface by a plane of constant volume, in the direction of increasing entropy, the slope will always be downward, and generally convex, as the addition of heat, that is, energy to a substance at constant volume increases its entropy, and generally its temperature, never decreasing it. A section by a plane of constant entropy will have a slope in the direction of increasing volume, which is in general upward, corresponding to a positive pressure, and in all parts of the model referring to stable states of the substance this will be convex, since increase of volume is then accompanied by decrease of pressure.

I have attempted to determine the choice of co-ordinates by the properties of the critical state. In the two diagrams the broken line separates the parts representing stable or homogeneous states from parts representing unstable or non-homogeneous states. In the pressure-volume diagram, lines of constant pressure, volume, entropy and temperature are drawn. On the other are drawn lines of constant pressure and temperature, taken from Maxwell. In both diagrams these lines are tangent to the broken line. In Fig. 1 the line v=const. cuts sharply through the broken line.

I have attempted to find the behaviour of a line of constant entropy in the following way.

For a substance following van der Waals's equation

$$\left(p + \frac{a}{v^2}\right)(v - b) = Rt,$$

the equation of an isentropic can be shown to be

$$\left(p + \frac{a}{v^2}\right)(v - b)^k = \text{const.}$$

where k is the ratio of the specific heats at constant pressure and constant volume. The slope of this curve is then found to be

$$\frac{dp}{dv} = \frac{2a}{v^3} - \frac{k(p + a/v^2)}{v - b},$$

which becomes, substituting the values of the critical pressure and volume

$$\left(\frac{dp}{dv}\right)_{\text{crit.}} = \frac{2a(1 - k)}{27\,b^3},$$

which is negative for real positive values of a and b. Hence the isentropic appears also to cut through the broken line, but less sharply.

Still further, we believe that the line of constant volume does not again pass out of this non-homogeneous or unstable area, while the isentropic may. Hence it has seemed to me necessary

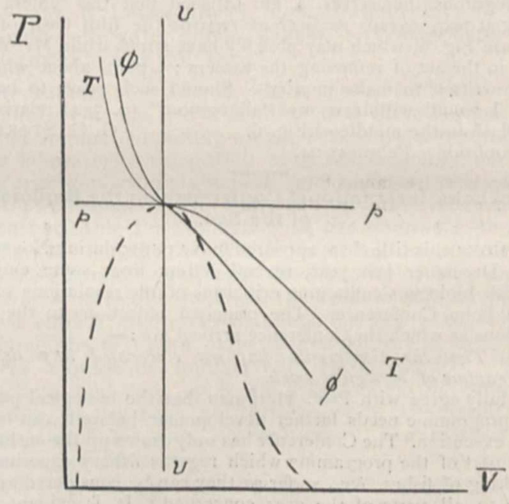


FIG. 1.

to consider the vertical line of Fig. 2 a line of constant volume, and the horizontal line an isentropic, while the critical point lies a little to the left of the vertex of the curve, so that the isentropic slightly cuts through the broken line.

The choice of co-ordinates will then be: energy, vertically downward, in the three-dimensional model, volume, measured to the right, in Maxwell's diagram, and entropy vertically downward in the same diagram. This choice is not inconsistent with the arrows in the upper left hand corner of the diagram. The model, which has been constructed in accordance with these considerations, is shown in the accompanying figure (Fig. 3). It satisfies the general requirements as to slope and convexity. It represents the gaseous or vapour state, as having in general the greatest volume and a great range of pressure, &c.

One property, however, does not seem to be indicated by this model, nor do I see how to satisfactorily change it so that this can be done. It has been deduced mathematically and shown experimentally that if a saturated vapour be expanded adiabatically, or isentropically, it may either become superheated, or partially condense to liquid, in fact both phenomena can be shown with one substance, for instance, chloroform above 127° C. becomes superheated, and below this temperature no visible effect is produced by either expansion or compression. That is, there is an isentropic which is at a particular point tangent to the "steam line," those on one side of it not touching it at all, while those on the other cut both in and out. This particular property is not shown by the model as constructed, with the present choice of co-ordinates. If, however, we had measured entropy horizontally in the diagram, then the isentropics, being vertical, might be tangent to cut through the steam-line. This choice of co-ordinates has, however, seemed impossible for the reasons previously given.

We may if we wish discuss the question by a different method. The lines drawn in Figs. 1 and 2 are all lines through the critical point. In Fig. 1 the lines of constant pressure and

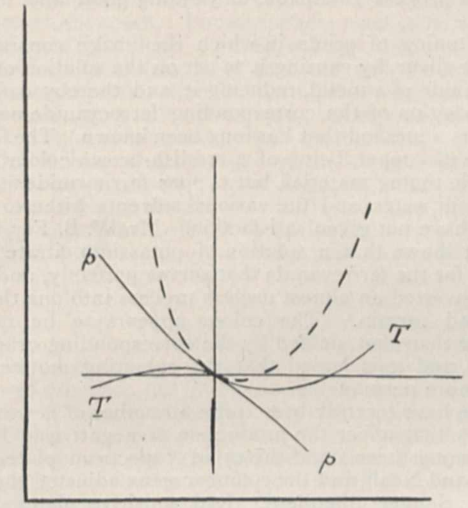


FIG. 2.

temperature are tangent to the broken line; Fig. 2 shows the same property. In Fig. 1 the line of constant entropy cuts the broken line twice, but no other pair of lines has more than one intersection. Fig. 2 does not, as drawn, show the same property. In Fig. 1, passing from the water-line around the critical point in the homogeneous region to the steam-line, one cuts the lines in the following order: water-line, pressure, temperature, entropy, volume, pressure, temperature, entropy, steam-line. Fig. 2 gives the same order, with the choice of co-ordinates, which we have adopted, if we let the temperature lines always

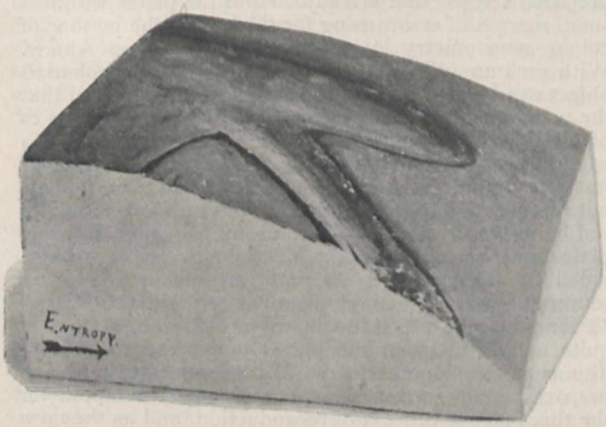


FIG. 3.

slope downward, as do the pressure lines. With this change the two diagrams seem to agree, but otherwise their disagreement seems hopeless.

I shall be very glad to receive from any one any suggestion which will help to remove the apparent disagreement between the two diagrams, or so modify the model that it may more completely represent the possible properties of actual bodies than it now seems to do. W. B. BOYNTON.

The University of California,
Berkeley, Cal., U.S.A., February 1.

To Calculate a Simple Table of Logarithms.

A YEAR ago Prof. Perry drew attention to a method by which a schoolboy knowing how to extract square roots could, with the help of squared paper, construct a table of logarithms (NATURE, February 23, 1899).

It does not appear to be known that it is possible for a boy to make a simple table of logarithms in a few minutes without even knowing square root in arithmetic.

Up to a few years ago the teaching of logarithms in schools was generally deferred until they were required in trigonometry for the solution of triangles, but the general introduction of practical physics into secondary schools has resulted in the teaching of logarithms to younger boys.

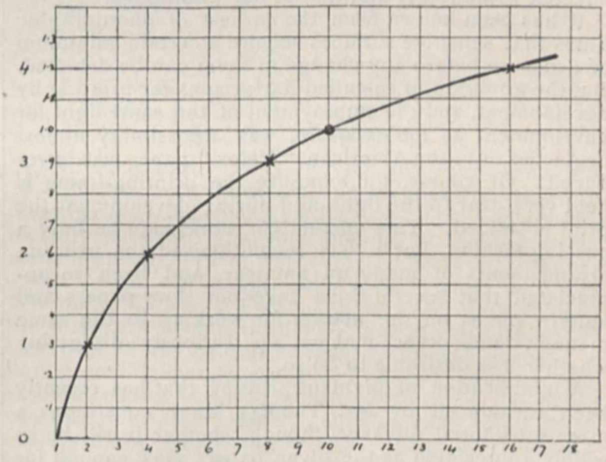
The following method which I have introduced into several Schools of Science in my district has been carefully tested in classes of boys of about thirteen years of age with excellent results.

On a sheet of squared paper ruled in inches and tenths, plot logarithms to base 2 : $\log 2 = 1 : \log 4 = 2 : \log 8 = 3 : \log 16 = 4$, and draw a curve.

It will be found convenient to arrange numbers from 1 to 16 on a horizontal axis, taking 1″ as unit, and the logarithms on the vertical axis, taking 3″ as unit.

From the curve read off the value of $\log_2 10$, which will be found to be approximately $3\frac{1}{3}$. Let us assume that $\log_2 10$ is exactly $3\frac{1}{3}$.

On any system of logarithms $\log 4 = 2 \log 2 : \log 8 = 3 \log 2$, &c. Hence the curve obtained may be used to represent



The left-hand vertical column of figures in the diagram represent scale logs. to base 2, and the right-hand column scale logs to base 10.

logarithms to any base if the ordinates are measured on a suitable scale.

The scale used for measuring logs. to base 2 is a plain scale. To construct a scale for measuring logs. to the base 10, write $\log 10 = 1$ instead of $3\frac{1}{3}$; and as this falls on the 10th line, the distance from 0 to 1 can be at once divided into 10 parts, and numbered 0·1 : 0·2, &c., the finer lines (not shown in the diagram) giving the second decimal place.

Having assumed that $\log_2 10 = 3\frac{1}{3}$, $\log_{10} 2$ becomes ·300 instead of ·301, so that the values from the curve are in error to the extent of 1/300; but this is not greater than small errors due to the freehand drawing of the curve and irregularities in the ruling of the squared paper. ARTHUR DUFTON.

Sheffield, February 13.

THE publication of Mr. Dufton's method will, I think, serve a useful purpose. It is a common exercise in schools to plot on squared paper, numbers and their logarithms to the base 2 (see Blaine's "Methods of Calculating," Spon), to give a general notion of how the logarithm varies as the number varies; but I have never known it to be made a method of calculation. Indeed, I do not think it right to give a boy the idea that he may find log. 10 by interpolation between log. 8 and log. 16. There is a specious appearance of accuracy due to the fact that $\log_2 10$ is so nearly $3\frac{1}{3}$; and Mr. Dufton heightens it by using squared paper on which the divisions are thirds of the unit, so that a boy will have it fixed in his mind that $3\frac{1}{3}$ is exactly $\log_2 10$.

My intention was to give a good exercise on the use of squared paper for interpolation; it happens to be a method of calculating logarithms correctly to as many places as we please. It keeps before a boy the simple notion that a common logarithm is the index of a power of 10. The idea before Mr. Dufton's pupil is much more complex, and he is not likely to find the logarithm of any number correct even to the second figure.

February 19. JOHN PERRY.

RECENT PROGRESS IN PHOTOGRAPHY.

THE progress of knowledge and of skill in its application is often so gradual that although there may be a vast difference between the condition of affairs a few years ago and at the present time, it may be impossible to discover definite steps in the general forward movement. And after a few specific cases of undoubted progress have been singled out, it may be that they, or some of them, will subsequently prove to be only side issues of comparatively trivial importance. On the other hand, a circumstance that is quite obvious to the scientific student may be worked upon by a commercial firm and so advertised that a method of work becomes largely modified, and a practical advance effected without any addition to our knowledge.

It has been known from the earliest of photographic times that sensitive surfaces require a certain minimum of exposure before any change in them can be detected. But the abolition of so-called dark rooms for printing by development, and the employment of the same light for development as for exposure, was a possibility almost neglected until the American "Velox" paper was introduced. Of course, for exposure the printing-frame is held very near to the light, and during development the print is shaded. This method of work may be only a passing fashion, but it has revolutionised the printing arrangements of many an amateur, and been so appreciated that several firms have put slow papers and lantern plates on the market for working in the same manner, and other makers are seriously discussing whether it is desirable to do so.

A modification of pigment printing that has recently been introduced by Mr. Thomas Manly constitutes a more substantial advance, though whether it will be so widely appreciated as the silver papers slow enough for development in gas-light remains to be seen. He calls his process "Ozotype." So far as concerns important and serious work, a small improvement in either carbon or platinum printing is likely to be of more real value than any possible change in silver printing. But Mr. Manly's is not a mere modification of detail. Putting it simply, he exposes the transfer paper instead of the pigmented tissue under the negative, and thus by one transfer he gets a print that is not laterally inverted, a result which requires a double transfer by the ordinary method, or else the making of a special inverted negative for single transfer. As the paper exposed is not pigmented, the progress of printing can be judged of by inspection, and there are other advantages of a less important character, such as the absence of any need for "safe edges" to the negatives. The paper that is exposed under the negative is made sensitive by means of a mixture of potassium dichromate and a manganous salt. On exposure, the chromate is reduced and the manganese is thereby oxidised, and both products of the change are insoluble in water. By washing, an image that has oxidising powers is obtained, and this may be utilised in many ways. It does not seem to deteriorate by keeping. To pigment the image, a piece of carbon tissue is soaked in a weak solution containing acetic acid, hydroquinone, and ferrous sulphate, squeegeed on to the print and allowed to dry. Development is effected as usual in carbon printing. Mr. Manly supposes that the acetic acid causes the manganic compound to reoxidise the chromic compound to a soluble salt (chromate?) which is absorbed by the gelatine of the tissue. In the gelatine the hydroquinone reduces the chromium compound to the chromic condition, which, as usual, renders the gelatine insoluble. This appears to be the inventor's working theory. Final practical details are not yet published, but it is certain that the process is capable of yielding good and useful results.

The toning of prints in which the image consists of metallic silver by causing it to act on the solution of the ferricyanide of a metal, reducing it, and thereby causing the deposition of the corresponding ferrocyanide on the image, is a method that has long been known. The ferrocyanide of copper, being of a reddish-brown colour, is a desirable toning material, but copper ferricyanide is not soluble in water, and the various solvents hitherto employed have not given satisfaction. Mr. W. B. Ferguson has just shown that a solution of potassium citrate is a solvent for the ferricyanide that serves perfectly, and has thus converted an almost useless process into one that is easy and certain. The colour appears to be rather browner than that yielded by the corresponding uranium process, and it is hoped that the colouring matter will prove more permanent.

There have recently been quite a number of new introductions that affect the production of negatives. Foremost among these stand the rapid "spectrum plates" of Cadett and Neall, and the colour screens adjusted thereto by Mr. Sanger Shepherd. Red sensitive plates have been made before, but the even sensitiveness throughout the spectrum that these plates show, has never, in our experience, been equalled. But no plate will of itself render the various colours according to their proportional visual brightness. The sensitiveness to blue and violet vastly preponderates in all cases, and in order to reduce this light and so compensate for the excessive sensitiveness thereto, various coloured screens have been in use. For general purposes, this screening has been done by the roughest of methods, whether yellow glass or dyed films have been used. But Mr. Sanger Shepherd has prepared screens that are adjusted to the plates within a small margin of error, using for the testing the method of colour sensitometry introduced by Sir William Abney. With such an adjusted colour screen and plate a coloured object can be photographed in almost any light so that the print will give the correct comparative luminosities of all the colours as they appear under the conditions when photographed. The chief exception is that light of less refrangibility than the solar line C, or about that, is not represented, this small portion of the less refrangible red being reserved as a light useful when making the plates and working with them. Colour screens are provided for dark-room lights, that transmit only the least refrangible red, far enough from where the practical sensitiveness of the plates begin to furnish a light that is quite unable to harm the plates under the usual conditions of development, &c. Mr. Sanger Shepherd also prepares colour screens for spectrum plates adapted for the three-colour process of reproduction, and as they are adjusted by measurement and to the same plate, this is a considerable step towards the simplification of work and the ensuring of correct results.

Some new intensifiers for negatives have recently been suggested, but as their effects have not been thoroughly investigated, they should not replace the use of mercuric chloride followed by ferrous oxalate, which is the only method that has yet been shown to give a definite result equally proportioned over the whole negative. Ammonium persulphate, as a reducer, has been shown to thin the image to a nearly equally proportioned degree all over, instead of removing a larger proportion of the thinner parts of the image, which, of course, lie near the surface of the film. This is an exceedingly useful effect; but here again the chemical changes have not been investigated, and the theories that have been suggested to account for the exceptional effect are far from satisfactory. It is not certain, indeed, that the remaining image is of pure silver.

The makers of apparatus are always seeking to improve their goods, and they are, as a rule, so successful that it is impossible to refer here to other than the most important advances. Photographers used to be satisfied with lenses that either covered a large field in proportion to their focal length, or that had a large aperture; but these properties that used to be considered incompatible now have to be combined; a large angle of view is maintained while the aperture is increased. Instead of *f*/8, which used to be regarded as the maximum aperture for outdoor work, we now have *f*/6, and even larger apertures, without the introduction of the peculiar faults usually associated with portrait lenses. The firm of Goerz, of Berlin, has quite lately put upon the market a doublet, each combination of which consists of five elements, the complete objective having an aperture of *f*/5·5. These—the stigmatics of Dallmeyer at *f*/4 and *f*/6, the planars of Zeiss with apertures of about *f*/4, and other lenses of similar properties—are instruments of precision for giving an image over an extended field, as telescope objectives are instruments of precision for giving definition over a very small field. In conjunction with the rapid gelatine plates of to-day, they place a power in the hands of scientific workers that was not conceived possible a few years ago.

The firm of Dallmeyer have recently improved their stigmatics, series *f*/6, by putting the combination of greater focal length in the front instead of behind. To use either combination alone, it is now only necessary to remove the other, and the extension of camera necessary is nearly the same for both the combinations, although their equivalent focal lengths are approximately as 1·5 to 2, taking the focal length of the whole combination as the unit. Dr. Rudolph, of Zeiss', has investigated the question of the use of cylindrical surfaces in objectives for the purpose of getting a different ratio of enlargement (or reduction) in two directions at right angles to each other. One result of this work is the "anamorphot" issued by Messrs. Zeiss, and its use is chiefly, if not exclusively, in the readjustment of the proportion of length to breadth of designs for their application in the decorative arts.

There does not appear to have been any radical improvement in cameras of late; but the system of cinematography, made possible by the perfection to which film-supported sensitive surfaces have been brought, continues to engage the attention of a large number of inventors. The most recent, and doubtless most interesting, application of this principle is in an apparatus that the Kodak Company are making for Sir Norman Lockyer, for use during eclipses of the sun. The apparatus will accommodate a film five inches wide and of length suitable for the required series of exposures. The opening behind which the film is exposed is twelve inches long and three inches wide. The apparatus is designed to photograph a series of spectra, as of the chromosphere, so that the exposures may follow each other with greater rapidity and certainty than is possible when plate-changing has to be done by hand. The operator has only to turn a handle continuously, and at each complete revolution an exposure is made, the exposed film is wound up, and a new portion brought into position. Three-quarters of the revolution effects the change of film; at the beginning of the remaining fourth the shutter is opened; it continues open until the revolution is completed, or nearly completed, when it is closed; then the film-changing takes place again, and so on. By stopping the crank during the last quarter of the revolution, a time-exposure of any duration may be given. It is expected that the apparatus will be used in conjunction with a twenty-foot objective of six inches aperture with a prism in front of the objective; and as this lens gives practically no curvature on a field twelve inches in length, the film will be used flat.

Scientific photographers on the Continent have lately been paying more attention to the measurement of the opacities of photographic plates. Dr. J. Hartmann, of Potsdam, has recently described an apparatus constructed for him for comparing opacities. It consists of a horizontal microscope with its ocular and objective, with a tube branching from it at right-angles, downwards, that carries a second objective. At the junction of the two tubes is the well-known arrangement of two right-angled prisms, with their hypothenuse surfaces cemented together except at a small disc in the centre of the adjacent sides; so that one sees a small portion of the plate being tested surrounded by the comparison tint. The apparatus appears to be unnecessarily costly and complicated when compared with apparatuses that have been used in this country for a similar purpose.

There are many other matters that would claim attention in a complete *résumé* of recent progress in photography, some of which have already been referred to in these columns.

C. J.

THE POSITION THAT UNIVERSITIES SHOULD TAKE IN REGARD TO INVESTIGATION.

THE American Society of Naturalists arranged for a discussion on the duties of universities with regard to investigation, and the American journal, *Science*, has recently published the contributions to the discussion made in the end of last year at the New Haven meeting. Profs. Dwight of Harvard, Chittenden of Yale, Jastrow of Wisconsin, Patten of Dartmouth, and Dr. Macdougal of the New York Botanic Gardens—five distinguished representatives of the natural sciences in America—made a formal and deliberate expression of their opinions, and an examination of these convictions cannot fail to be valuable to English readers. On all salient points these experts are in complete agreement. They have no doubt that the connection between universities and research is fundamental. Dr. Macdougal dismisses it as "axiomatic." Prof. Jastrow declares that a university should be the "natural habitat" of investigation. Prof. Dwight is "sure of a sympathetic hearing from public and universities for discussion of the modes and conditions of university research." The others differ only in the precise phraseology they employ. Nor is there any doubt but that university teachers should be investigators by temperament and habit. As Prof. Chittenden insists, the primary function of a university is a diffusion of the knowledge already gained, rather than the provision of new knowledge; but, although teachers who were not investigators have existed, the ideal teacher must be more than a diffuser. All universities of standing make success in investigation a necessary qualification for their teachers, and, in effect, our witnesses all agree that, having chosen rightly such men, it is the duty of the universities to see that time and opportunity for investigation should be found for them during their tenure of office.

There is a certain divergence of opinion as to the extent to which original investigation should be made an actual part of the training of students. Prof. Dwight and Prof. Patten are not inclined to encourage it, the former thinking chiefly of medical students and agreeing with Huxley, that whoever adds one tittle of what is unnecessary to medical education is guilty of a very grave offence, the latter disapproving of it entirely as a normal part of the curriculum. Others, again, incline to the view that actual new investigation, as opposed to ordinary laboratory work, is an extremely important and useful incident in training. On the other hand, there is no trace of difference of opinion as to whether or no it is not at once an imperative duty and an immense practical advantage for a university to provide every encouragement in the shape of equipment and scholarship or fellowship endowment for what may be called post-graduate research. In this respect the duties of a university are to be limited only by her resources.

The general result of this interesting discussion by experts is that an atmosphere of original investigation should pervade a university. Its professors must be investigators if only because otherwise they cannot be competent teachers. Its schools must be provided with the appliances and material facilities for research, and it must attach to itself by scholarships and fellowships numbers of young men devoting themselves, in the first place, to research; while the conduct of original investigation may be made an incident in the normal training of advanced students.

It is to be noticed that this emphatic pronouncement is based directly on experience, and on experience of a strictly pedagogic or university type. These experts in conference had no need to raise the underlying principles on which useful continuance of the existence of universities depends. Universities are organs of the community, and the pabulum that they absorb, whether it be derived from hoards of the past or from the circulating wealth of the present, obviously is diverted from other uses. Their utility depends upon the returns they make to the community. Such products consist of an output of trained men and of knowledge; these, to resume the metaphor, corresponding to the direct secretion of an organ, and the general diffusion of a subtle but pervading influence comparable with the internal secretions discovered by modern physiology. A university that starves and discourages research turns out into the world smooth and conventional graduates, blind to the surprising novelties of life, more ready to meet crises, small or great, with historical parallels than novel efforts; fitter to adorn success than to achieve it; it prefers criticism to knowledge, style to matter, glosses and reconciliations to the disconcerting energy of new ideas; it instils into the body politic a bland and slothful miasma of self-content. A university pervaded by the spirit of investigation sends out graduates ready to change with changing conditions, to whom difficulties are opportunities, and who, above all, are trained to watch for the inevitable changes in the most familiar ideas as new facts creep into light; it sends out the new knowledge, which becomes transmuted into new practical advantages for humanity, and it sends out the old knowledge not wrought into artificial harmonies, but with a bold presentation of the gaps and roughnesses which are the chief stimulus to new discovery; it radiates through the community the alert and adaptive spirit of progress.

It is needless to say that, like the American universities, the universities of the continent, and in especial those of Germany, are conspicuous for the extent to which they encourage research by their funds and by their arrangements. The historian of the future, who is to trace the vast progress made in recent years by Germany in power, wealth, commerce, the arts and industries, without doubt will notice the part played by her many universities in this momentous change. A single article in the pages of a scientific journal is not a suitable vehicle for any exact examination of the relative advances made by England and other countries in recent times. But, until matters have been put right, every opportunity is convenient to insist that the universities of Britain do not encourage research sufficiently, and that, in particular, her richest university habitually and systematically despises research in its general arrangements, in the allocation of its endowments, and in the distribution of its revenues. Moreover, it is especially unfortunate that not only is the amount of consideration given to research minute, but is diminishing.

A single example is more convincing than a multitude of general statements, and an appropriate instance lies unfortunately ready to hand in the preface to the last volume of "Linacre Reports," recently issued by Prof. Ray Lankester. The late Linacre Professor and present Keeper of the British Museum of Natural History, in a preface addressed to the Vice-Chancellor of the University of Oxford, deplores the attitude of the Oxford colleges to the natural sciences. "The College endowments," he states, and every one with knowledge of the matter is able to corroborate, "are now more largely than ever employed in maintaining a tutorial system, which is in itself of small value—if not positively injurious—and necessarily in complete antagonism to the development of the method of study, and to the wide range of subjects studied, which distinguish everywhere but in Oxford the University from the Preparatory School." Prof. Lankester believes that the natural sciences, the subjects particularly associated with research as a means of training and as a source of directive knowledge, should be supported by not less than two-thirds of the endowments at the disposal of these colleges. Oxford, no doubt, is an extreme example of the general failure of British universities to respond adequately to what everywhere but in England is regarded as the first duty of a university; but there is urgent need for inquiry into and redress of the conditions which have brought about the present state of affairs, and those institutions which have taken a larger view of their duties will be the first to approve a strong statement of the existing failure.

BRITISH DRAGONFLIES.[1]

MR. LUCAS is favourably known to entomologists by previous works on British Butterflies and British Hawk-moths; but in the present work he has broken new ground, and gives us a complete and trustworthy account of our British Dragonflies, the study of which has previously been much neglected in England.

Dragonflies resemble butterflies in being among the largest and most conspicuous of day-flying insects; but they are far less numerous in species, for while there are 300 butterflies in Europe in round numbers, out of which from 60 to 70 inhabit the British Islands, the Dragonflies of Europe barely exceed 100, of which, however, 40 are admitted by Mr. Lucas as British, a considerably larger proportion than in the Butterflies. It is curious, however, that among seven additional species, properly excluded by Mr. Lucas as not truly indigenous, is *Pantala flavescens*, Fabricius, said to have been taken years ago by Sparshall in the Fens. This is an abundant species in nearly all parts of the world (Asia, Africa, Oceania and America), but with the single exception above-mentioned, it has never been noticed as occurring in any part of Europe.

One advantage of dealing with a limited subject is that it permits of its being treated with sufficient fulness for most practical purposes, in a sufficiently portable form.

While not neglecting the literature of his subject, a large portion of the present volume is based on Mr. Lucas's own personal observations, which imparts much greater value to the whole of his work; for although every author must be more or less dependent on the observations of others as well as on his own, yet he is not

[1] "British Dragonflies" (Odonata). By W. J. Lucas, B.A., F.E.S. Illustrated with 27 Coloured Plates and 57 Black and White Engravings. Pp. xiv + 356. (London: L. Upcott Gill, 1900.)

competent to judge of them, or to estimate their relative value and importance, unless he himself has a practical as well as a theoretical acquaintance with the subject.

One disadvantage in collecting Dragonflies is the difficulty of preserving the colours of most of the species. Hence the importance of carefully coloured illustrations taken from fresh specimens; and although Mr. Lucas's illustrations, which appear to be colour-printed, are not equal to Charpentier's beautiful plates of the same insects, they represent the insects very well, and the neuration of the wings is also accurately reproduced. Photography would, however, be the only way in which the neuration of many of these insects could be produced with absolute accuracy, especially in the case of *Neurothemis* and one or two other East Indian genera, in which the network is excessively fine, and must include thousands of divisions in each wing.

Mr. Lucas has divided his work into nine chapters—introduction, life-history, classification, the nymph, the imago, genera and species, reputed species, breeding the nymph, and preparing for the cabinet. The book concludes with addenda and corrigenda, list of works referred to, and a good general index. There are also detailed tables of genera and species, and even of the nymphs. The plain figures represent oviposition, eggs, nymphs, parasites, and various details of the insects.

In order to show the full manner in which Mr. Lucas has dealt with his subject, we will take one of the best known, though not one of the very commonest species, *Libellula quadrimaculata*, Linn., to which nearly twelve pages are devoted. First we have synonymy, then the original description (which we would gladly see inserted, as a matter of course, in all descriptive works, whenever possible, as it would save much misunderstanding and inaccuracy), size, description of the male imago, the female, immature colouring, variation, oviposition, egg, nymph, emergence of imago, date, habits, migration and distribution within the British Isles. It might be suggested that notes on extra-British distribution, and when desirable, notes on allied non-British species, would have made the account of each species more complete.

L. quadrimaculata is the most remarkable of the European Dragonflies for its migratory habits, and if memory serves us, it has sometimes been observed migrating in company with butterflies, though whether pursuing them as prey, or whether both species were urged by some common impulse, may be a matter for investigation. Most Dragonflies, except the slender-bodied and delicately-formed Agrionidæ, are very strong on the wing, and many even of those which are not migratory in their habits are often met with a long way from water. But there is no doubt that many Dragonflies are habitually migratory, which may partly account for the wide distribution of other species besides *L. quadrimaculata*, which latter, it may be noted, is found throughout temperate Asia and North America, as well as in Europe. In Christmas Island, near Java, where three wide-ranging species of Dragonflies are found (one of them being the almost cosmopolitan *Pantala flavescens*, already referred to), they are never seen except when the wind is blowing from a certain direction, when they appear suddenly in swarms.

A century ago we had no systematic works on British insects at all, except Lewin's admirable book on British Butterflies, published in 1795; for even Marsham's pioneer book on Coleoptera, and Haworth's on Lepidoptera, did not begin to appear till the beginning of the present century. At present we have more or less complete works on several orders and families of insects; but there are still many large groups, including the great order Diptera, and a large portion of the orders Hymenoptera, Neuroptera, and some families of Homoptera, of which we have no adequate up-to-date monographs at all, at least in a separate form.

We congratulate Mr. Lucas on his having so successfully filled up one of these remaining gaps in our British entomological literature.

As a specimen of Mr. Lucas's style, we may quote his account of the habits of one of the commonest of the larger British Dragonflies, *Æschna cyanea*, Müller:

"Though sometimes seen flying over the water, where it is difficult to catch, this insect is oftener met with along hedgerows and lanes, where it sometimes for a long time flies backwards and forwards over a very restricted range. On such occasions, notwithstanding its rapid, powerful flight, it is usually possible, with careful watching, to make a capture. When once startled, however, it usually soars away out of sight, to return very possibly, however, to the same spot a little later. On one occasion, in Berkshire, I noticed an *Æ. cyanea* hawking along a hedge in this way, and presently saw it capture a butterfly (probably the Small Copper). After circling round it several times the Dragonfly secured its prey, and began wildly careering round as if rejoiced at its success. While thus engaged, a wing of the butterfly —or part of one—was let fall, and *cyanea* settled in the

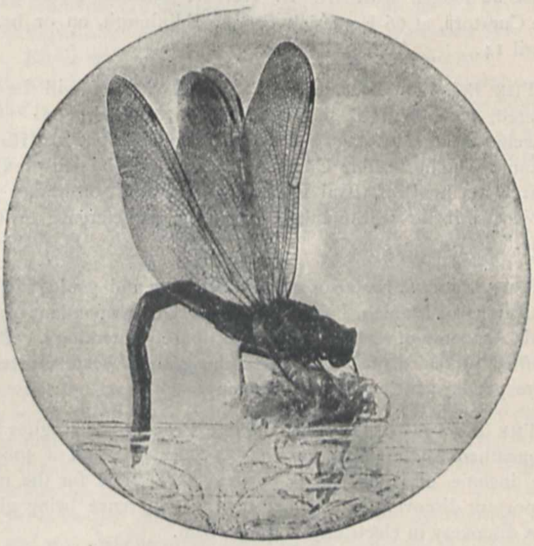


FIG. 1.—*Æschna grandis* ovipositing.

hedge, where it appeared to be further stripping its captive. Shortly after, the Dragonfly was captured in its turn, when the body of the butterfly was found still between its jaws. But it is, of course, not at all an uncommon thing for one of the larger Dragonflies to capture a butterfly, whose wings it removes in a very workmanlike manner."

Apropos of the above passage, we may remark that a large North American Dragonfly (*Anax longies*, Hagen), belonging to the same family as *Æschna cyanea*, is described as habitually *decapitating* its prey, which generally consists of some of the larger butterflies. W. F. K.

NOTES.

THE desire has been widely expressed in University circles in Edinburgh that the Curators of Patronage, with whom the appointment to the chair of medicine rests, should offer the post to Prof. Osler, of the Johns Hopkins University, who is well known as a teacher and clinicist of the highest scientific eminence, and whose acceptance of it would greatly strengthen both the systematic and clinical teaching in the University. It would appear, however, that the Curators have no choice in the matter, but are bound to advertise every vacancy, so that the far more satisfactory and dignified method of appointment by invitation is necessarily excluded. Nevertheless, it is confidently hoped that Prof. Osler may be induced to send in a formal application for the chair, since it is certain that his claims would receive every consideration from the present Board of Curators, who have more than once, on recent occasions, shown that they are superior to merely local considerations, and that they have regard in making these appointments solely to the best interests of the University. Prof. Osler is a Canadian by birth, and although he has for many years successively occupied the important chairs of medicine in Philadelphia and Baltimore, he has, we believe, never renounced his British nationality. His appointment to Edinburgh, although it would be felt as a serious loss by our kinsfolk on the other side of the Atlantic, would doubtless be considered by them, and especially by our Canadian fellow-subjects, as a graceful recognition that we are one people bound together in science, as in politics, by common interests, and that we are prepared to welcome the best man from whichever side of the water he may hail. Applications for the post, with testimonials, must be lodged with Mr. R. Herbert Johnston, Secretary to the Curators, at 66 Frederick Street, Edinburgh, on or before April 14.

The Bakerian Lecture of the Royal Society will be delivered, on March 8, by Prof. Tilden, F.R.S., on "The Specific Heat of Metals, and the Relation of Specific Heat to Atomic Weight." The Croonian Lecture will be delivered, on March 22, by Prof. Paul Ehrlich, of Frankfurt-on-Main; the subject will be "Immunity, with especial reference to Cell Life."

Prof. Zittel, professor of palæontology and geology in the University of Munich, has been elected a correspondant of the Paris Academy of Sciences in the section of mineralogy. Prof. Pfeffer, professor of botany at Leipzig, has been elected a correspondant in the section of botany.

The *Electrician* states that the late Prof. D. E. Hughes has bequeathed to the Paris Academy of Sciences a sum of 4000*l.*, the income of which is to be used as a prize for the most important discovery in physical science, preference being given to a discovery in electricity or magnetism.

Prof. C. Piazzi Smyth, for forty-two years Astronomer Royal for Scotland, and professor of practical astronomy in the University of Edinburgh, died on February 21, at the age of eighty-one.

The committee of the Liverpool School of Tropical Diseases has decided to send out almost immediately another expedition to West Africa. The expedition will make its headquarters in Old Calabar, and carry on researches in Southern Nigeria.

The *Times* states that Mr. Charles Whitehead, who has acted as technical adviser to the Agricultural Department of the Privy Council, and subsequently to the Board of Agriculture, during the past fifteen years, has been compelled to resign that appointment owing to ill health.

Dr. C. L. Griesbach, the Director of the Geological Survey in India, has gone for a tour in the famine districts of the Central Provinces, Bombay and Rajputana, with a view to examining into the practicability of sinking artesian wells.

A Bacteriological Institute for Ceylon, erected from funds provided by Mr. J. W. Charles de Soysa, after the best European models, was officially opened at the end of January. The Director of the Institute will be Dr. Marcus Fernando, who has personally superintended its construction.

The Government of India have added to Mr. John Eliot's designation of "Meteorological Reporter to the Government of India" the words "and Director-General of Indian Observatories." The meteorological office has been removed to a house specially built for it. The address of the office will henceforth be—Alipore (Calcutta), Bengal, India.

The Sugar Beet Committee of the Central Chamber of Agriculture have decided to make arrangements for a series of not less than twenty experiments in the growth of sugar beet in different parts of Great Britain and Ireland during the forthcoming season, each experimental plot to be at least one acre in extent. As, in certain cases, previous experiments have demonstrated the value of sugar beet for the feeding of stock, independently of the value of the root for the manufacture of sugar, this point will be specially kept in view in connection with the proposed experiments of the present year.

Mr. A. A. Campbell Swinton will give a lecture upon "Steam Turbines, Land and Marine," at the Camera Club, on Thursday, March 8.

As the Royal Meteorological Society will attain its jubilee on Tuesday, April 3, having been founded on April 3, 1850, it is proposed to observe this fiftieth anniversary in a special manner. The Council have arranged for a commemoration meeting on that day, at which the President will deliver an address, and delegates from other societies will be received. In the evening a conversazione will be held at the Royal Institute of Painters in Water-Colours. On the following day, April 4, the Fellows will visit the Royal Observatory, Greenwich, and in the evening will dine together at the Westminster Palace Hotel. In view of this Jubilee Celebration, Mr. G. J. Symons, F.R.S., was elected President at the annual meeting of the Society on January 17, but owing to illness he has since been obliged to resign this office. In these circumstances the Council at their last meeting appointed Dr. C. Theodore Williams as the President of the Society.

The awards of prizes by the Reale Istituto Lombardo for the past year seem to indicate rather a lack of essays of real merit. The "ordinary" prize offered by the Institution for the best catalogue of remarkable meteorological phenomena prior to 1800 was unawarded, but premiums of 400 lire have been awarded to three of the competitors, and the judges consider that the publication of the results arrived at conjointly by the three would be of great value. Under the Cagnola foundation five prizes were offered, and none awarded, the only award being a premium of 1000 lire to the sole competitor who sent in an essay on illustrations of Hertz's phenomena. On two of the other subjects no essays were sent in, and on the other two the essays were not of sufficient merit to justify an award. The Pizzamiglio prize and the Ciani prize, for essays in political science, and the Zanetti prize, for discoveries in pharmaceutical chemistry, are all unawarded. The Fossati prize, for an essay illustrative of the macro- and micro-scopic anatomy of the central nervous system, has been conferred on Dr. Emilio Veratti. In striking contrast to the paucity of competitors in subjects of a more or less academical character is the keen competition for the Brambilla prize, given "to one who has invented or introduced into Lombardy some machine or some industrial process from which the population may derive a real and proved benefit." Seventeen competitors entered for this prize, the awards including a gold medal and 500 lire each to Bianchi and Dubini, for desiccators of silk-cocoons; to Aurelio Masera, for new processes connected with the textile industry; and to M. Rusconi, for developing the "Mercer" process in the cotton industry. In addition, gold medals and 400 lire are awarded to Carlo Carloni, for his invention of a mastic called magnesite, as a substitute for red lead for junctions of pipes, also for a bicycle brake; to Demetrio Prada and Co., for extracts used in tanning and for the manufacture of oxygenated water; and to J. Löffler, for introducing into Milan the manufacture of artificial flowers in porcelain. A gold medal and 300 lire is awarded to the Italian Colour Manufactory under Max Meyer and Co., and a bonus of 300 lire to E. Tuffanelli, of Milan, for an invention connected with water and gas pipes.

THE present position of chemical industry in Japan is referred to in the *Board of Trade Journal*. Near Osaka, the Yuso Kwaisha alkali works and the Nippon Yuso Kwaisha sulphuric acid plant are both in steady operation. It is stated that the Yuso Kwaisha plant was started in 1893 by English engineers, who fitted it up on the most approved principles, but is now entirely under Japanese management. At the works of the Nippon Yuso Kwaisha sulphuric acid is concentrated in Kioto porcelain vessels in terraced succession. Wakayama and Okayama pyrites, containing from 47 to 50 per cent. of sulphur, are used. The sulphuric acid, packed in earthenware carboys, has been exported in small quantities as far as Bombay. Iodine is also manufactured from seaweed, but in a very small way.

AMONG the new instruments brought out by Messrs. Isenthal, Potzler and Co., for use in connection with radiography and wireless telegraphy, is a mercury jet interrupter, which is one of the most perfect forms of break yet designed, and is more serviceable than Wehnelt's electrolytic interrupter. It consists essentially of a fine jet of mercury forming one contact piece, and a series of teeth cut in a cylindrical surface forming the other contact piece. The cylindrical surface surrounds the jet. Its axis is vertical, and the teeth taper downwards. Hence, when the cylinder is made to revolve, by means of a small motor to which it is connected, contact is made when the jet impinges upon a tooth, and broken when it comes upon an interspace. By raising or lowering the jet the ratio of contact to interruption may be varied from zero to infinity, and thus the mean current strength may be adjusted to any required value without interposing resistances. The number of interruptions may be varied through a wide range, and with twenty-four contacts and the motor geared up to three thousand revolutions, it reaches 72,000 per second, which suffices for practically every purpose.

THE magnetic qualities of building brick, to which so much attention has been directed of late by the work of Folgheraiter and others, have been tested quantitatively by Messrs. G. A. Gage and H. E. Lawrence, who, writing in the *Physical Review*, describe experiments, the original object of which appears to have been connected with the choice of bricks used in building physical laboratories so as to cause the least possible magnetic disturbance to the instruments. From the diagrams and tables it appears that certain bricks, described as "brown" and "pressed red," exhibited the most marked magnetic properties, and some of those described as white were among the least magnetic; and the authors infer that the effects are due to the presence of magnetic iron oxide either a constituent of the clay or formed by heat.

REFERENCE was recently made in NATURE to Signor G. Guglielmo's observations on certain modifications of hydrometers. In a still more recent number of the *Atti dei Lincei* (ix. 2), the same writer describes certain still different forms of total immersion hydrometers, in which the inclination of the instrument to the horizon determines the density of the liquid. The principle is, to all intents and purposes, the same as that of the bent lever balance commonly used for weighing letters. The hydrometer is an unsymmetrical body capable of turning about a horizontal axis at one extremity, and having its centres of gravity and buoyancy *not* in a straight line through this axis. On pouring any fluid into the vessel containing the hydrometer, the latter will rotate into a position in which the moments about the axis of support of the weight of the hydrometer and the upward reaction of the liquid balance each other, and as the position of equilibrium depends on the density of the liquid, the latter is determined by reading off the inclination of the instrument to the horizon. The object of this device is to obviate the disturbances due to capillarity which are inseparable from all forms of total-immersion hydrometers. Finally, by the use of a mirror method for reading the inclination (the effects of refraction being practically avoided by attaching the scale to the face of the containing vessel), great sensitiveness is obtained. It is easy to obtain hydrometers in which two or three degrees variation in temperature changes the deflection by 40°, but these are necessarily available only for a very limited range of density.

THE quarterly formerly entitled *Terrestrial Magnetism*, but which has now adopted the more comprehensive title of *Terrestrial Magnetism and Atmospheric Electricity*, bids fair to become a cosmopolitan medium of publication for papers bearing on this department of geophysics. In the last number (iv. 4) Profs. Elster and Geitel discuss, in a paper in German, the question of the existence of free electrical ions in the atmosphere, and the possibility of explaining the phenomena of atmospheric electricity by the properties of ionised air (see p. 422). This theory, while still open to objection, would appear to overcome some of the difficulties attaching to Exner's and Arrhenius's theories. In the same language, Dr. Lüdeling describes certain researches on the diurnal variation and on magnetic disturbances in polar regions. Dr. Lüdeling investigates graphically the phenomenon of the diurnal variation of the earth's magnetism for eleven stations with the aid of Von Bezold's vector diagrams. It would appear that when the magnetic disturbances are excluded, the direction of the curve is clockwise, but that the direction of the disturbance vector diagram is anti-clockwise; and Schuster's assumption, that the part of the diurnal variation freed from disturbance can be referred to an invariable revolving system, is not far from the truth. An article by the late General de Tillo deals with the relation between the magnetic elements and the distribution of land and sea, and the mean temperature of the earth's surface. The other papers include notes on the magnetic anomaly near Kursk, Russia, by G. W. Littlehales; on new magnetic intensity variometers, by A. Heydweiller; and a biographical sketch of Prof. Wild, illustrated by a portrait and view of the Constantine Observatory at Paulowsk.

A REPORT on the commercial value of the metric system, with special reference to the classification of German iron manufactures, was recently forwarded to the Wolverhampton Chamber of Commerce by the British Consul at Amsterdam, and is referred to in the *Board of Trade Journal*. The Consul states that the iron and steel manufacturers' unions of Germany have adopted a uniform system of dimensions for articles of universal consumption at home and abroad. Angle iron of all descriptions, flanged boiler ends or fronts for Cornish or Lancashire boilers, the boilers themselves, and iron and steel tubes and all fittings connected with them, such as valves, cocks, T pieces, are made, so far as flange, diameter, and working lengths are concerned, in normal standard sizes, in order that every part of one work may be procured at once to fit every corresponding part of another construction. These normal standards are all fixed by the free co-operation of the combined German engineers' associations, and are unanimously adopted by the various manufacturers all over Germany. At present a committee of the engineers' associations is occupied in endeavouring to fix a metric thread for bolts and screws, nuts, bolt-heads, &c., as the present universal normal standard (the Whitworth) is so differently constructed by different works that the parts are not as interchangeable as should be the case. These classifications are naturally making more and more progress in Germany, not in the iron trade alone, but in other manufactures. In view of these facts, the Consul points out that Germany and the Continent generally will have a constantly increasing advantage over British manufactures in the future in foreign countries, unless the metric system be fully and entirely adopted by Great Britain.

THE Danish Meteorological Institute has for the last few years been carrying on the useful work of collecting from all available sources particulars of the state of the polar ice. In the first place, observations were collected around Greenland only, but more recently it has been able to extend its observations so as to comprise the seas from Novaya Zemlya and Spitsbergen to Davis Strait and Baffin Bay. The results for 1899, accompanied by charts, have been published in the "Nautical Meteorological Yearbook" of the Institute for that year, and exhibit the following peculiarities:—(1) In the Kara Sea, the western part of Barents Sea, the South-east and part of North Spitsbergen, and also in Smith Sound and the immediately adjacent waters, there appears to have been more ice present than is usually the case. (2) South of Franz Joseph Land and on the east coast of Greenland, there has been considerably less ice present than usual. This latter condition gives promise of a good spring season off the south-west coast of Greenland. The great scientific and practical value of knowing, as far as possible, the annual distribution, character and quantity of drift ice of polar origin was unanimously recognised by the International Geographical Congress in Berlin last year, and the Danish Institute will gladly receive any observations upon the subject, to assist in compiling similar information for future years.

IN advance of the complete report of the Indian Plague Commission, a chapter has just been published devoted to Mr. Haffkine's method of anti-plague inoculations. Among the results of the Commissioners' critical study of the nature and effect of the anti-plague vaccine are the following:—(1) Inoculation sensibly diminishes the incidence of plague attacks on the inoculated population, but the protection which is afforded against attacks is not absolute. (2) Inoculation diminishes the death-rate among the inoculated population. This is due, not to the fact that the rate of attack is diminished, but also to the fact that the fatality of attacks is diminished. (3) Inoculation does not appear to confer any degree of protection within the first few days after the inoculation has been performed. (4) Inoculation confers a protection which certainly lasts for some considerable number of weeks. It is possible that the protection lasts for a number of months. (5) The varying strength of the vaccine employed has apparently had a great effect upon the results which have been obtained from inoculation. There appears to be a definite quantum of vaccinating material which gives the maximum amount of protection; and provided that this quantum can be injected in one dose, and provided also that the protection turns out to be a lasting one, reinoculation might with advantage be dispensed with. The best results of inoculation will only be obtained after an accurate method of standardisation has been devised. (6) The Commissioners finally recommend that, under the safeguards and conditions of accurate standardisation and complete sterilisation of the vaccine and the thorough sterilisation of the syringe in every case, inoculations should be encouraged wherever possible, and in particular among disinfecting staffs and the attendants of plague hospitals.

WE have received from Mr. H. Geitel an interesting paper read before the Brunswick Society of Science, entitled "Contributions to the Knowledge of Atmospheric Electricity," by Mr. J. Elster and himself. The paper deals principally with a summary of the results of experiments on the ionic conduction of gases, first investigated by W. Giese, in 1882, and subsequently by Prof. A. Schuster, J. J. Thomson, and others, and explains the recent advances made in the problem of atmospheric electricity by treating it from a similar standpoint. The results attained agree well with those arrived at by Mr. C. T. R. Wilson, of the Cavendish Laboratory, at Cambridge, in recent experiments, made at the instance of the Meteorological Council, on the relation between rain and atmospheric electricity (*Phil. Trans.* Ser. A, 193, 1899). He found that positive and negative ions (at least those produced in air by Röntgen rays) differed in their efficiency as condensation nuclei, that the negative ions are more efficient as nuclei for the condensation of water vapour, and that a preponderance of negative electricity will consequently be carried down by precipitation to the earth's surface. Elster and Geitel found that normal atmospheric air contains positive and negative ions in nearly equal quantity, and that when the air is pure the ions meet with little obstruction to their movement, the negative (as shown by Zeleny) moving faster, but that if the air is misty their mass is greatly increased, and their mobility almost entirely prevented.

A MEMOIR on the geology of Newport, Monmouthshire, by Mr. Aubrey Strahan, has just been issued by the Geological Survey. It is notified as the first part of a general memoir on the geology of the South Wales coal-field. The original geological survey of that large area was commenced more than sixty years ago by De la Beche, and it is but natural that the old one-inch maps have long been out-of-date. The re-survey was commenced by Mr. Strahan in 1891, and now, with the aid of several colleagues, a large part of the coal-field has been mapped in detail on the six-inch scale. These larger maps are deposited for reference in the Geological Survey Office in Jermyn Street, while the one-inch maps, which are published, afford a good general idea of the structure of the country. Of these sheet No. 249 is now described. The main advances made are in the sub-division of the Old Red Sandstone and of the Coal-measures, and in the tracing out of the faults and disturbances which have affected the position of the productive coal-strata. The memoir contains the results of a systematic survey, whereby the variations in the character and thickness of the strata have been followed, and the numerous coal-seams have been tabulated and correlated. The practical importance of the work in the colliery districts will be appreciated by those interested in the further development of the great coal-field. On scientific grounds geologists will find matter of interest relating to the Silurian rocks and fossils of the Usk district, as well as in regard to the Old Red Sandstone, Carboniferous Rocks, Keuper Marls, Rhætic Beds and Lower Lias. It is noteworthy that there appears to be a sharp plane of demarcation between the Silurian and Old Red Sandstone; and that no break has locally been found in the series of strata which constitute the Old Red Sandstone. The mapping of the Drift deposits has thrown much new light on the extent of the glaciation of South Wales.

PROF. TACCHINI, in a recent contribution to the *R. Accademia dei Lincei*, describes the Roman earthquake of July 19, 1899. The earthquake belongs to the series which have their origins beneath the Alban Hills, the epicentre being situated near Frascati. At this place, and in some of the neighbouring villages, buildings were damaged. The shock was felt to a distance of 130 km. from the epicentre, and was recorded by the seismometrograph at Catania (520 km.), having travelled there with a velocity of about 4 km. per second. Diagrams of great interest were obtained by means of the seismographs erected in the cellar of the Collegio Romano at Rome.

MUCH interest attaches to a short note, accompanied by a plate, by Mr. D. le Souëf, in the February number of the *Zoologist*, on the mode in which the newly-born Kangaroo is transferred to the maternal pouch and affixed to the nipple. "When the young one is ready to be born," writes the author, "the mother sits down on the ground, resting on the upper portion of the base of her tail, and with that appendage resting level on the ground in front of her; she then holds her pouch open with her two fore-paws, and, as the helpless mite is born, it rests on the soft fur of the under side of the tail. The mother immediately transfers it to her pouch with her lips only, and evidently with great care attaches it to the nipple. The mouth of the young one is apparently only a round hole, and it as yet has no power of suction; but the nipple is of a peculiar shape, with the point hard, and the mother is thereby enabled to insert it into the mouth of the young one. She then holds it in position while she pours the milk into the nipple, which thereby swells out and holds the young one on; but if, after being once firmly attached, it is pulled off, it cannot be replaced, even by the mother, for the end of the nipple now being flaccid instead of hard cannot well be inserted into the mouth of the little one."

WE have received from Messrs. G. H. Carpenter and W. Evans a reprint of their memoir published in the *Proceedings* of the Royal Physical Society of Edinburgh, on the spring-tails (Collembola) and bristle-tails (Thysanura) of the Edinburgh district; a group of insects the study of which has hitherto received somewhat scant attention.

A PAPER by Prof. H. A. Kelly in the December number of the *Bulletin* of the Johns Hopkins Hospital, entitled "The Recognition of the Poisonous Serpents of North America," merits notice, if only for the sake of the beautiful photographs of snakes' heads with which it is illustrated. In addition to these life-like portraits, the author gives brief descriptions of some of the leading features of the various species.

To the January number of the *American Naturalist* Prof. H. F. Osborn contributes an instructive paper on the intercentra and hypapophyses in the cervical region of the backbone of various groups of reptiles. In the same issue Mr. Alës Hrdlicka publishes a plan for the best arrangement of large series of human bones intended for comparative study; this may be commended to the careful attention of museum curators.

LAST year, in an aviary in one of the wards at Caterham Asylum, a wild rabbit turned a dove off its nest and sat on two doves' eggs till they were hatched. A correspondent of *The Christian Globe* (March 1) states that this year the nurses are trying another hatching operation. They have placed two bantam's eggs in the same nest. The same rabbit has taken to these eggs, and only leaves the eggs to take its food, returning at once to the nest. The nest is six feet from the ground; the rabbit, in the presence of the correspondent, was taken out of the nest and placed on the floor by the nurse, but it very quickly climbed up again to the nest.

THE *Transactions* of the English Arboricultural Society, vol. iv. part 2, contains several valuable papers on the pruning and culture of trees, as also some interesting photographs.

WE have received a copy of the second edition of "Die Moor- und Alpenpflanzen (vorzugsweise Eiszeitflora) des Alpengartens Zöschen bei Merseburg, und ihre Cultur," compiled by Dr. G. Dieck. The list occupies over 70 pages, and gives a large amount of information respecting the habit and mode of culture of a very great number of Alpine plants. They are offered for sale either singly or in assortments.

MESSRS. JAMES BACKHOUSE AND SON, LTD., of York, have inaugurated a new department in their Nurseries, which may be of great service to botanical lecturers and demonstrators, in providing a supply of material especially for microscopic work. They have issued an extensive priced cata ogue, comprising objects in the Myxomycetes, Algæ (including diatoms), Characeæ, Fungi, Hepaticæ, Musci, Pteridophyta (prothallia and vegetative organs), Gymnosperms, and all the more important orders of Angiosperms. The department is under the management of an experienced practical botanist, Dr. Arthur H. Burtt, and seems likely to supply a long-felt want.

DR. PAUL TOPINARD'S volume on "Science and Faith" was recently noticed in these columns (p. 270). We have now received the French edition of the work, having for its title "L'Anthropologie et La Science Sociale," and published by MM. Masson and Co. Several sections are considerably larger in the French than in the English edition, and the section on social science is entirely different. The French title better expresses the scope of the work than the English one.

PROF. W. JOHANNSEN, of Copenhagen, has issued, in German, (Fischer, Jena) a pamphlet on the etherisation of plants, for the information of practical nurserymen. He has devised an apparatus for the exposure of growing plants to the action of the vapour of ether, and states that, while killing the leaves already on the plant, it promotes the rapid and luxuriant development of the buds after removal from the ether-box. The experiments were made chiefly on the lilac.

THE following lectures will be given at the Royal Victoria Hall, Waterloo Road, S.E., on Tuesday evenings during March:—March 6, Mr. A. Stanfield, "Money"; March 13, Mr. S. A. F. White, "The Polarisation of Light"; March 20, Prof. Frank Clowes, "Nature's Scavengers"; March 27, Mr. Bennett H. Brough, "The World's Copper Mines."

THE fourth part of the sixth edition of Sir Michael Foster's standard "Text-Book of Physiology" will be published immediately by Messrs. Macmillan and Co., Ltd. In previous editions this part has included Book III., on the senses and some special muscular mechanisms, and Book IV., on the tissues and mechanisms of reproduction. In the volume about to be issued, only the senses are dealt with; and in the revision of this part Sir Michael Foster has had the valuable assistance of Dr. W. H. R. Rivers, whose name appears upon the title-page. Part v. of this work will consist of the subjects of Book IV. formerly included in Part iv.

THE additions to the Zoological Society's Gardens during the past week include a Pinche Monkey (*Midas oedipus*) from Colombia, presented by Mrs. H. V. Holden; a Marica Gazelle (*Gazella marica*, ♀) from the Persian Gulf, presented by Mr. B. T. Ffinch; a Red-crested Cardinal (*Paroaria cucullata*) from South America, presented by Miss Power; a Jackal Buzzard (*Buteo jacal*) from Africa, presented by Mr. Douglas Mann; a Nilotic Crocodile (*Crocodilus niloticus*) from Africa, presented by Mr. Rupert D'Oyly Carte; an Indian Darter (*Plotus melanogaster*), an Indian Hornbill (*Anthracoceros malabaricus*) from India, two Common Wolves (*Canis lupus*, ♂ ♀, white var.), a Four-lined Snake (*Coluber quatuorlineatus*), European; a Serrated Terrapin (*Chrysemys scripta*), two Speckled Terrapins (*Clemmys guttata*), fifteen Mississippi Terrapins (*Malacoclemmys geographica*) from North America, four Black-headed Terrapins (*Damonia reevesi unicolor*) from China, deposited; an Undulated Grass Parrakeet (*Melopsittacus undulatus*) from Australia, received in exchange.

OUR ASTRONOMICAL COLUMN.

Astronomical Occurrences in March.

March 2. 6h. Mercury in conjunction with moon. Mercury 4° 37′ S.
7. 23h. Mercury at greatest elongation east (18° 16′).
8. 6h. 13m. to 7h. 3m. Neptune occulted by the moon.
8. 9h. 31m. Minimum of Algol (β Persei).
10. 13h. 43m. to 14h. 40m. Occultation of *f* Geminorum (mag. 5·2) by the moon.
10. 14h. 18m. to 15h. 57m. Transit of Jupiter's Sat. III.
11. 14h. 13m. to 15h. 6m. Occultation of 29 Cancri (mag. 5·9) by the moon.
15. Venus. Illuminated portion of disc, 0·708. Mars, 0·993.
15. 15h. 20m. to 16h. 25m. Occultation of ε Leonis (mag. 5·1) by the moon.
17. 18h. 7m. Transit (egress) of Jupiter's Sat. III.
21. 17h. 19m. to 17h. 33m. Occultation of ρ Ophiuchi (mag. 5·3) by the moon.
23. 20h. Saturn in conjunction with the moon.
23. 20h. 35m. to 21h. 46m. Occultation of Saturn by the moon.
28. 11h. 12m. Minimum of Algol (β Persei).
31. 8h. 1m. Minimum of Algol (β Persei).

Comet Giacobini (1900*a*).—The *Astronomische Nachrichten* (Bd. 151, No. 3624) contains an ephemeris and the elements of this comet computed from the observations made on January 31, February 3 and 6, at the Nice Observatory, by M. Giacobini.

Elements.

T = 1900 April 28·2085 Paris Mean Time.

$$\left.\begin{array}{l}\varpi = 23^\circ\ 8'\ 42''\\ \Omega = 40\ \ 7\ 29\\ i = 146\ 37\ 21\end{array}\right\}1900{\cdot}0$$

log q = 0·12902

Ephemeris for 12h. Paris Mean Time.

1900.	R.A. h. m. s.	Decl. ° ′	log Δ
Feb. 28	2 7 50	+2 19·1	0·304
Mar. 2	5 49	2 55·4	0·310
4	3 54	3 30·9	0·316
6	2 6	4 5·6	0·321
8	2 0 24	+4 39·8	0·327

Meteor Photography.—In the *Astronomische Nachrichten* (Bd. 151, No. 3623) Dr. Karl Kostersitz describes the photographic equipment which he employed at the Vienna Observatory for the detection of the Leonid and Bielid meteors in November 1899. A plate accompanies the article, showing the method of mounting the cameras, four of which were used without driving apparatus. The cameras were all fitted with rapid portrait lenses, and great care was taken to accurately orient the plates for subsequent reduction.

MOTIVE POWER. STEAM TURBINES. HIGH SPEED NAVIGATION.[1]

Twenty centuries ago the political power of Greece was broken, although Grecian civilisation had risen to its zenith. Rome was growing continually stronger, and was rapidly gaining territory by absorbing weaker States. Egypt, older in civilisation than either Greece or Rome, fell, but two centuries later, before the assault of the younger States, and became a Roman province. Her principal city at this time was Alexandria, a great and prosperous city, the centre of the commerce of the world, the home of students and of learned men, its population the wealthiest and most civilised of the then known world.

It is among the relics of that ancient Egyptian civilisation that we find the first records of the early history of the steam-engine. In Alexandria, the home of Euclid, and possibly contemporary with Archimedes, Hero wrote his "Spiritalia seu Pneumatica." It is doubtful if Hero was the inventor of the contrivances and apparatus described in his work; it is more probable that they were devices generally known at the time. Nothing in the text, however, indicates to whom the several machines are to be ascribed. Two of these machines are of special interest. The first utilised the expansive force of air in a closed vessel heated externally, the pneumatic force being applied to the surface of water in other vessels, and the hydraulic force utilised for opening the doors of a Grecian temple, and working other pseudo-magic contrivances.

Then after describing several forms of cylindrical boilers, and the use of the steam jet for accelerating combustion, he comes to the first of a type of steam engine, the steam turbine, which is the subject of our discourse this evening.

This is a veritable steam engine. The cauldron contains water, and is covered by a steam-tight cover, a globe is supported above the cauldron by a pair of tubes, one terminating in a pivot, and the other opening directly through the trunnion joint into the sphere; short bent pipes are attached to diametrically opposite points on the equator. The steam generated in the cauldron passes up into the sphere and issues tangentically from the bent pipes, and by the reaction causes the sphere to rotate.

It seems uncertain whether this machine was ever more than a toy, or whether it was used by the Greek priests for producing motion of apparatus in their temples; but from our experience within the last twenty years it appears that, with some improvements in design and construction, it could have been applied to perform useful work at the date of Hero, and further that, when so improved, it might have claimed a place among economical steam engines, even up to the middle of the present century.

A few years ago I had an engine constructed to test the capabilities of this class of reaction steam turbine, the only difference between this engine and Hero's being that the sphere was abolished, as a useless incumbrance, the arms were made of thin steel tube of oval form, so as to offer the least resistance to their motion, and the whole was enclosed in a cast iron case which was connected to a condenser. When supplied with steam at a pressure of 100 lbs. per square inch, and a vacuum in the case of 27″ of mercury, a speed of 5000 revolutions per minute was attained, and an effective power was realised of 20 horse, and the consumption of steam was only 40 lbs. per brake horse-power. By this very creditable performance, I was encouraged to further test the system, and constructed a compound reaction engine, in which the steam was caused to pass successfully through three pairs of arms on one hollow shaft, each pair being contained in a separate compartment through which the shaft passed, suitable metallic packing preventing the passage of steam from one compartment to the next. The performance of this engine was, however, not superior to that of the single two-arm Hero's engine, for the simple reason that the excessive resistance to motion of the arms in the denser steam of the compartments more than neutralised the gain from the compound form. The performance of this engine was, however, sufficiently good to have it placed on a par with many ordinary steam engines in the middle of the present century.

The great barrier to the introduction of Hero's engine was undoubtedly the excessive speed of revolution necessary to obtain economical results, and with the crude state of mechanical engineering at that time, it would have been a matter of some difficulty to construct the turbine engine with sufficient accuracy of workmanship for satisfactory results, to say nothing of the necessary gearing for applying the power to ordinary useful purposes.

The next steam engine mentioned in history, which is capable of practical and useful development, is Bianca's in 1629. It is of the simplest form, a jet of steam from a steam boiler impinges on a paddle-wheel and blows it round. This form of engine has since 1889 been developed by Dr. De Laval, of Stockholm, with great ingenuity, and is extensively used for moderate powers on the Continent. The speed is, however, necessarily very high in order to obtain economy in steam, and spiral reduction gearing is used in order that the speed of revolution may be reduced for the application of the power. The improvements that have been made in Bianca's steam turbine by De Laval are firstly, the ordinary steam jet is replaced by a diverging conical jet, which permits of the expansion of the steam before it emerges from the jet, and so transforming the

[1] A Discourse delivered at the Royal Institution on January 26, by the Hon. C. A. Parsons, F.R.S.

potential energy of the high pressure steam into kinetic energy of velocity in the direction of flow.

Secondly, the crude paddle-wheel of Bianca is replaced by a wheel of the strongest steel, fringed round the periphery with little cupped blades of steel, somewhat analogous to the buckets of a Pelton water-wheel.

Lastly, the steel wheel is mounted on a long and somewhat elastic shaft, to allow of its easy and free motion, and on one extremity of this shaft is mounted the pinion of the spiral reduction gear.

The speeds of revolution of the steam wheels of De Laval's turbine are from 10,000 to 30,000 revolutions per minute, according to the size, involving peripheral speeds up to 1200 feet per second, or about one-half the speed of the projectile from a modern cannon. Such speeds are necessary to obtain power economically from the high-pressure steam jet, issuing at from 3000 to 5000 feet per second, as calculated by Rankine.

It is somewhat remarkable that not till a century after Bianca, the piston or ordinary reciprocating engine made its first appearance, in about the year 1705, and has since become one of the chief factors in the great mechanical and engineering growths of the last century. During this period the steam turbine seems to have been, practically speaking, neglected, which is somewhat remarkable in view of the numerous attempts of inventors to construct a rotary engine, attempts which had no practical results.

In the year 1884, the advent of the dynamo-electric machine, and development of mechanical and electrical engineering, created an increased demand for a good high-speed engine. Engineers were becoming more accustomed to high speeds of revolution, for the speed of dynamos was at this time from 1000 to 2000 revolutions per minute, of centrifugal pumps from 300 to 1500, and wood-working machinery from 3000 to 5000; and Sir Charles Wheatstone had made a tiny mirror revolve at a speed of 50,000 revolutions per minute for apparatus for measuring the velocity of light. The problem then presented itself of constructing a steam turbine, or ideal rotary engine, capable of working with good economy of steam at a moderate speed of revolution, and suitable for driving dynamos without the intervention of reduction gearing. To facilitate the problem, the dynamo was also considered with the view of raising its speed of revolution to the level of the lowest permissible speed of the turbine engine. In other words, to secure a successful combination, the turbine had to be made to run as slowly as possible, and the dynamo speed had to be raised as much as possible, and up to the same speed as the turbine, to permit of direct coupling.

In 1884 preliminary experiments were commenced at Gateshead-on-Tyne, with the view of ascertaining by actual trial, the conditions of working equilibrium and steady motion of shafts and bearings at the very high speeds of rotation that appeared to be essential to the construction of an economical steam turbine of moderate size. Trial shafts were run in bearings of different descriptions up to speeds of 40,000 revolutions per minute; these shafts were about $1\frac{1}{2}$ inches in diameter and 2 feet long, the bearings being about $\frac{5}{8}$ inch in diameter. No difficulty was experienced in attaining this immense speed, provided that the bearings were designed to have a certain small amount of "give" or elasticity; and after the trial of many devices to secure these conditions, it was found that elasticity, combined with frictional resistance to transverse motion of the bearing bush, gave the best results, and tended to damp out vibrations in the revolving spindle. This result was achieved by a simple arrangement; the bearing in which the shaft revolved was a plain gun-metal bush with a collar at one end and a nut at the other; on this bush were threaded thin washers, each being alternately larger and smaller than its neighbour, the small series fitting the bush and the larger series fitting the hole in the bearing block, these washers occupying the greater part of the length of the bush. Lastly, a wide washer fitted both the bush and block, forming a fulcrum on which the bush rested; while a spiral spring between the washers and the nut on the bush pressed all the washers tightly against their neighbours. It will be seen now that, should the rotating shaft be slightly out of truth (which it is impossible to avoid in practice), the effect is to cause a slight lateral displacement of the bearing bush, which is resisted by the mutual sliding friction of each washer against its neighbour. The shaft itself being slightly elastic, tends to centre itself upon the fulcrum washer before mentioned, under the gyrostatic forces brought into play by the rapid revolutions of the shaft and influenced by the frictional resistance of the washers, and so the shaft tends to assume a steady state of revolution about its principal axis, or the axis of the mass, without wobbling or vibration. This form of bearing was exclusively used for some years in turbine engines aggregating some thousands of horse power, but it has since been replaced by a simpler form fulfilling the same functions. In this later form the gun-metal bush is surrounded by several concentric tubes fitting easily within each other with a very slight lateral play; in the interstices between the tubes the oil enters, and its great viscosity when spread into thin films has the result of producing great frictional resistance to a rapid lateral displacement of the bearing bush; the oil film has also a centring action, and tends under vibration to assume a uniformity of thickness around the axis, thus centring the shaft, and like a cushion damping out vibrations arising from errors of balance. This form of bearing has been found to be very durable and quite satisfactory under all conditions.

Having tested the bearings up to speeds above those contemplated in the steam turbine, the next problem was the turbine itself. The laws regulating the flow of steam being well known (which was not the case in Hero's time), various forms of steam turbine were considered, and it appeared desirable to adopt in principle some type that had been both successful in the water turbine, and also easily adapted to a multiple or compound formation, a construction in which the steam should pass successively through a series of turbines one after the other.

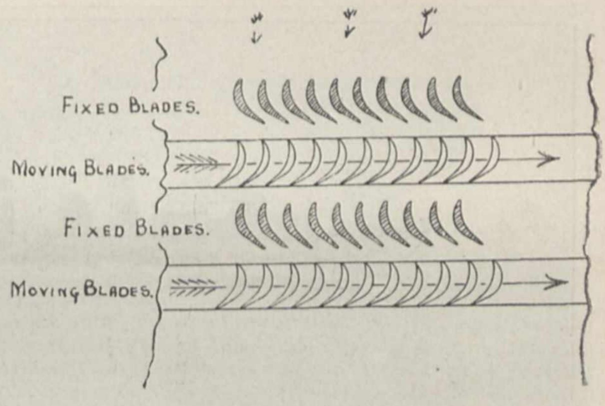


FIG. 1.—Fixed and moving blades of turbine.

The three best known of water turbines are the outward flow, the inward flow, and the parallel flow, and of these the latter appeared to be the best adapted for the multiple or compound steam turbine, for reasons which will afterwards appear.

The object in view being to obtain a good coefficient of efficiency from the steam with a moderate speed of revolution and diameter of turbine wheel, it becomes essential that the steam shall be caused to pass through a large number of successive turbines, with a small difference of pressure urging it through each individual turbine of the set, so that the velocity of flow of the steam may have the proper relation to the peripheral velocity of the turbine blades to secure the highest degree of efficiency from the steam, conditions analogous to those necessary for high efficiency in water turbines. A large diameter of turbine wheel, it is true, would secure a moderate speed of revolution, but this may be dismissed at once for the simple reason that the frictional resistance of such a disc revolving at the immense peripheral velocity, in the exhaust steam, would make it a most inefficient engine.

In the year 1884, a compound steam turbine engine of 10 horse-power and a modified high speed dynamo were designed and built for a working speed of 18,000 revolutions per minute. This machine proved to be practically successful, and subsequently ran for some years doing useful work, and is now in the South Kensington Museum.

This turbine engine consisted of two groups of fifteen successive turbine wheels, or rows of blades, on one drum or shaft within a concentric case on the right and left of the steam inlet, the moving blades or vanes being in circumferential rows projecting outwardly from the shaft, and nearly touching the case, and the fixed or guide blades being similarly formed and projecting inwardly from the case and nearly touching the shaft. A series of turbine wheels on one shaft were thus constituted, each one complete in itself, like a parallel flow water turbine, but unlike a water turbine, the steam after performing its work in each turbine passed on to the next, preserving its longitudinal velocity without shock, gradually falling in pressure on passing through each row of blades and gradually expanding. Each successive row of blades was slightly larger in passage-way than the preceding, to allow for the increasing bulk of the elastic steam, and thus its velocity of flow was regulated so as to operate with the greatest degree of efficiency on each turbine of the series (Fig. 1).

All end pressure from the steam was balanced by the two equal series on each side of the inlet, and the revolving shaft lay on its bearings revolving freely without any impressed force except a steady torque urging rotation, the aggregate of the multitude of minute forces of the steam on each blade. It constituted an ideal rotary engine; but it had faults. The comparatively high speed of rotation that was necessary for so small a size of engine as this first example, made it difficult to prevent, even with the special bearings described, a certain spring or whipping of the massive steel shaft, so that considerable clearances were found necessary, and leakage and loss of efficiency resulted. It was, however, perceived that all these defects would decrease as the size of the engine increased, with a corresponding reduction of rotational velocity, and consequently efforts were made towards the construction of engines of larger size, which resulted, in 1888, in several turbo-alternators of 120 horse-power being supplied for the generation of current in electric lighting stations, and at this period the total horse-power of turbines at work reached in the aggregate about 4000, all of which were of the parallel flow type and non-condensing.

In 1889, in consequence of partnership difficulties and the temporary loss of patents, the radial flow type of turbines was reluctantly adopted. This type of turbine consists of a series of fixed discs with interlocking flanges at the periphery, forming, when placed together, a cylindrical case with inwardly projecting annular discs. On the shaft are keyed a similar set of discs, the faces of the fixed and moving discs lie a short distance apart. From the faces of the fixed discs project the rows of guide-blades which nearly touch the moving disc, and from the moving disc project the rows of moving blades which nearly touch the fixed disc.

The steam is admitted into the case between the balance piston on the left and the first fixed disc, and passes outwards through the rows of fixed and moving blades between the first fixed and moving discs; then inwards towards the shaft at the back of the first moving disc, then again outwards between the second fixed and moving discs, and so on to the exhaust; the action being the same as in the parallel flow type.

In 1892, this type was the first to be adapted to work in conjunction with a condenser. The first condensing turbine of the radial flow type was of 200 horse-power, and at a speed of 4800 revolutions per minute, drove an alternator of 150 kilowatts output. It was tested by Prof. Ewing, and the general result of the trials was to demonstrate that the condensing steam turbine was an exceptionally economical heat engine. With a steam pressure of 100 lbs., the steam being moderately superheated, and a vacuum of 28 inches of mercury, the consumption was 27 lbs. per kilowatt hour, which is equivalent to about 16 lbs. of steam per indicated horse-power. This result marked an era in the development of the steam turbine, and opened for it a wide field, including some of the chief applications of motive power from steam. At this period turbine alternators of the condensing type were placed in the Newcastle, Cambridge and Scarborough Electric Supply Company's Stations, and soon afterwards several of 600 horse-power of the non-condensing parallel flow type were set to work in the Metropolitan Companies' Stations, where the comparative absence of vibration was an important factor. Turbine alternators and turbine dynamos of 2500 horse-power are now in course of construction in England and the United States, and larger sizes are in prospect.

A turbo-alternator manufactured at Heaton Works, Newcastle-on-Tyne, for the Corporation of Elberfeld in Germany, was tested a few days ago by a committee of experts from Germany, Prof. Ewing being also present, with the following remarkable results. At the full load of 1200 kilowatts, and with a steam pressure of 130 lbs. at the engine, and 10° C. of superheat, the engine driving its own air pumps, the consumption of steam was found to be at the rate of 18·8 lbs. per kilowatt hour. To compare this figure with those obtained with ordinary piston engines of the highest recorded efficiencies, and assuming the highest record with which I am acquainted of the ratio of electrical output to the power indicated in the steam engine, namely 85 per cent., the figure of 18·8 lbs. per kilowatt in the turbine plant is equivalent to a consumption of 11·9 lbs. per indicated horse-power, a result surpassing the records of the best steam engines in the production of electricity from steam.

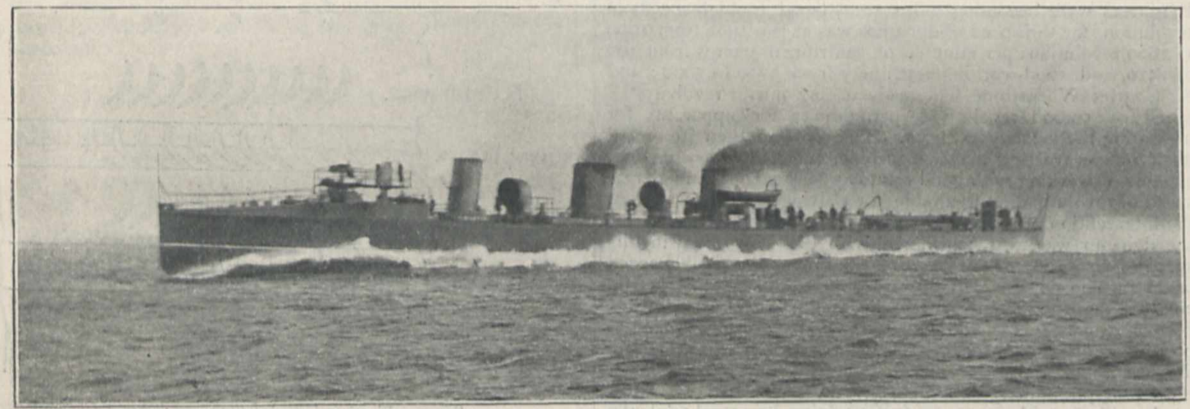


FIG. 2.—The *Viper*.

Turbine engines are also used for generating electrical current for the transmission of power, the working of electrical tramways, electrical pumping and coaling, and similar purposes. They are also used for coupling directly to and driving fans for producing forced and induced draught for general ventilating purposes, also for driving centrifugal pumps for lifts up to 200 feet, and screw pumps for low lifts.

The most important field, however, for the steam turbine is undoubtedly in the propulsion of ships. The large and increasing amount of horse-power and the greater size and speed of the modern engines tend towards some form which shall be light, capable of perfect balancing and economical in steam. The marine engine of the piston type does not entirely fulfil all these requirements, but the compound turbine engine, as made in 1892, appeared to be capable of doing so, and of becoming an ideal marine engine. On the other hand, an element of uncertainty lay in the high speed of the turbine engine, and to couple it directly to a propeller of ordinary proportions would have led to failure.

In January 1894, a pioneer syndicate was formed to explore the problem, those chiefly associated in the undertaking being the Earl of Rosse, Christopher Leyland, John Simpson, Campbell Swinton, Norman Cookson, the late George Clayton, H. C. Harvey, and Gerald Stoney. It was deemed expedient, for reasons of economy and also of time (as many alterations were anticipated), to build as small a vessel as possible, but not so small as to preclude the attainment of an unprecedented high speed in the event of success. The *Turbinia* was constructed, her dimensions being 100 feet in length, 9 feet beam, 3 feet draught of hull, and 44 tons displacement. She was fitted with a turbine engine of 2000 actual horse-power, with an expansive ratio of a hundred-and-fifty-fold, also with a water-tube boiler of great power, of the express type, with small tubes. The turbine engine was designed to drive one screw shaft at a speed of from 2000 to 3000 revolutions per minute.

Many trials were made with screw propellers of various sizes and proportions, but the best speeds were quite disappointing, and it was clear that some radical defect lay in the propellers. This was corroborated by dynamometric measurements. The excessive slip of the propellers beyond the calculated amount, and their inefficiency, indicated a want of sufficient blade area upon which the thrust necessary to drive the ship was distributed, in other words, the water was torn into cavities behind the blades. These cavities contained no air, but only vapour of water, and the greater portion of the power of the engine was consumed in the formation and maintenance of these cavities instead of the propulsion of the vessel. This phenomenon was first noticed in the trials of the torpedo boat *Daring*, by Messrs. Thornycroft and Mr. Barnaby, shortly before the commencement of the trials of the *Turbinia*, and was named "cavitation" by R. E. Froude.

To return to the *Turbinia*, a radical alteration was deemed necessary. A new turbine engine was made, consisting of three separate engines, high pressure, intermediate pressure, and low pressure, each of which drove one screw shaft, the power of the engine was distributed over three shafts instead of being concentrated on one, and three propellers were placed on each shaft. The result of these changes was marvellous. The vessel now nearly doubled her speed, 30 knots was soon reached, and finally 32¾ knots mean speed on the measured mile authenticated, or the fastest speed then attained by any vessel afloat. The economy of her engines was investigated by Prof. Ewing, assisted by Prof. Dunkerly, the consumption of steam per indicated horse-power for all purposes at 31 knots speed was found to be 14½ lbs., or in other words, with a good marine boiler the coal consumption would be considerably under 2 lbs. per indicated horse-power, a result better than is obtained in torpedo boats or torpedo-boat destroyers with ordinary triple expansion engines.

The vessel's reversing turbine gave her an astern speed of 6½ knots, and she could be brought to rest in 36 seconds when running at 30 knots speed, and from rest she could be brought up to 30 knots in 40 seconds.

The *Turbinia* cruised from the Tyne to the Naval Review at Spithead, where she steamed on the day of the Review at an estimated speed of 34½ knots. These results represent about 2300 indicated horse-power, and may be said to have been obtained without a very abnormal performance as regards the boiler; its total heating surface being 1100 square feet, and an evaporation of about 28 lbs. per square foot at the speed of 34½ knots.

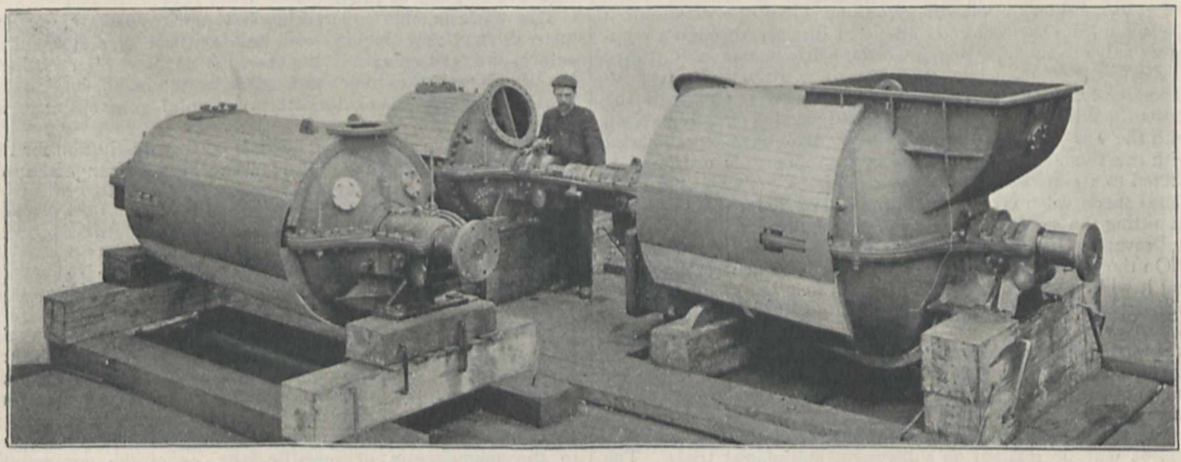


FIG. 3.—Turbine engines of the *Viper*.

This phenomenon has been investigated experimentally with propellers of small size working inside an oval tank, so as to represent approximately the conditions of slip ratio customary in fast ships. To enable the propeller to cause cavitation more easily the tank is closed, and the atmospheric pressure removed from the surface of the water above the propeller by an air-pump, glass windows are fitted for observation and illumination. Under these conditions the only forces tending to hold the water together and resist cavitation are the small head of water above the propeller, and capillarity. The propeller is 2 inches diameter and 3 inches pitch; cavitation commences at about 1200 revolutions and becomes very pronounced at 1500 revolutions. Had the atmospheric pressure not been removed, speeds of 12,000 and 15,000 revolutions per minute would have been necessary, rendering observations more difficult.

The arrangement we have now was kindly suggested by Mr. Heath, and is a decided improvement, the revolving disc with narrow slots synchronising approximately with the revolutions of the propeller. The propeller is now seen to rotate very slowly, it also permits of the projection of the phenomenon on the screen, which was not possible with my previous arrangement. The permanence of the vortices behind the blades is very striking. The inference to be drawn from these experiments seems to be that for fast speeds of vessels, wide thin blades, a coarse pitch ratio, and moderate slip, are desirable for the prevention of cavitation, and in order to obtain the best efficiency in propulsion of the vessel.

These speeds were not obtained by bottling up the steam and opening the regulating valve on coming to the measured mile, but were maintained for many miles together with constant steam pressure, and as long as the fires were clean. On the other hand, the endurance of the engines themselves seems to be unlimited, all heavy pressures, including the thrust of the propellers, that would in ordinary engines came on the bearings, being counterbalanced by the steam pressure acting on the turbines.

It seems clear that the results obtained in the case of the *Turbinia* were almost entirely due to the economy in steam of the turbine engines, and the unusually small weight of the engines, shafting and propellers, in proportion to the power developed.

It may also be said that generally speaking every part of the machinery was as substantial as in naval vessels of the torpedo-boat class, yet she developed 100 horse-power per ton of machinery, and 50 horse-power per ton of total weight of vessel in working order.

The results of the *Turbinia* having been found satisfactory, the original company which built her was merged into a large company under the same directorate for carrying on the work on a commercial scale. At Wallsend-on-Tyne, the Parsons Marine Steam Turbine Company erected works, and in 1898 contracted with the Admiralty for a 31-knot torpedo-boat destroyer, the *Viper* (Fig. 2), which is of the same dimensions as the usual 30-knot vessels of this class, viz. 210 feet length, 21 feet beam, and about 350 tons displacement, but with machinery of much greater power than usual in vessels of this size; they also contracted with Sir W. G. Armstrong, Whitworth and Co. for machinery for one of their torpedo-boat destroyers.

The turbine engines of these vessels are similar to those of the *Turbina*, but are in duplicate, and consist of two distinct sets of engines on each side of the vessel. There are four screw shafts in all, entirely independent of each other, the two on each side being driven by one high and one low-pressure turbine respectively of about equal power; the two low-pressure turbines drive the two inner shafts, and to each a small reversing turbine is also permanently coupled, and revolves idly with them when going ahead. The screw shafts are carried by brackets as usual, and two propellers are placed on each shaft, the foremost in each case having a slightly lesser pitch than the after one. The thrust from the screw shafts is entirely balanced by the steam acting on the turbines, so that there is extremely little friction.

The boilers, auxiliary machinery and condensers are of the usual type in such vessels, but their size is somewhat increased to meet the much larger horse-power to be developed, and to compensate for the lesser weight of the main engines, shafting, propellers, as well as the lighter structure of the engine beds. The boilers are of the Yarrow type, with a total heating surface of 15,000 square feet, and grate surface of 272 square feet, and the condensers have a cooling surface of 8000 square feet. The hull and all fittings are of the usual design.

Let us consider the machinery on one side of the vessel only: the steam from the boilers is admitted directly through a regulating valve to the high-pressure turbine driving one shaft, it then passes to the adjacent low-pressure turbine, driving its shaft independently, thence it flows to the condenser, and both the shafts then drive the vessel ahead; the reversing turbine revolves with the low-pressure shaft, and being permanently connected with the vacuum of the condenser no appreciable resistance is offered to its motion under these conditions. To go astern the ahead steam valve is closed and the astern steam valve opened, admitting the steam from the boilers to the reversing turbine, and reversing the direction of rotation of the inner screw shaft.

On the other side of the vessel the arrangement is the same, and it will be seen that she can be manœuvred as an ordinary twin-screw vessel, and with great facility and quickness.

On her second preliminary trial about three weeks ago, the mean speed of four consecutive runs on the measured mile reached 34·8 knots, and the fastest run was at the speed of 35·503 knots, which is believed to be considerably beyond the recorded speed of any vessel hitherto built. The vessel was scarcely completed at the time of this trial, and it is anticipated that still higher speeds will be realised on subsequent and official trials. The speed of 35·5 knots, or nearly 41 statute miles, represents about 11,000 indicated horse-power in a vessel of 350 tons displacement, as compared with 6000 to 6500 developed in the 30-knot destroyers of similar dimensions and 310 tons displacement.

At all speeds there was very little vibration. Her speed astern is guaranteed to be 15½ knots.

The *Viper* has surpassed the *Turbinia* in speed, and is at the present time the fastest vessel afloat.

In regard to the general application of turbine machinery to large ships, the conditions appear to be more favourable in the faster class of vessels, such as cross-Channel boats, fast passenger vessels, liners, cruisers and battleships; in all such vessels the reduction in weight of machinery, and economy in the consumption of coal per horse-power, are important factors; in some the absence of vibration is a question of first importance, as affecting the comfort of passengers, and, in the case of ships of war, permitting of greater accuracy in sighting of the guns.

The model exhibited represents a proposed cross-Channel boat for the Dover and Calais or Newhaven and Dieppe routes. She is 270 feet length, 33 feet beam, 1000 tons displacement, and 8 feet 6 inches draught of water. She has spacious accommodation for 600 passengers, and with machinery developing 18,000 horse-power would have a sea speed of about 30 knots as compared with the speed of 19 to 22 knots of the present vessels of similar size and accommodation.

It is perhaps interesting to examine the possibilities of speed that might be attained in a special unarmoured cruiser, a magnified torpedo-boat destroyer of light build, with scanty accommodation for her large crew, but equipped with an armament of light guns and torpedoes. Let us assume that her dimensions are about double those of the 30-knot destroyers, or of the *Viper*, with plates of double the thickness, and specially strengthened to correspond with the increased size and speed, length 420 feet, beam 42 feet, maximum draught 14 feet, displacement 2800 tons, indicated horse-power 80,000, there would be two tiers of water-tube express boilers, these, the engines and coal bunkers, would occupy the whole of the lower portion of the vessel, the crew's quarters and armaments would be on the upper decks. There would be eight propellers of 9 feet in diameter, revolving at about 400 revolutions per minute, and her speed would be 44 knots. She could carry coal at this speed for about eight hours, and she would be able to steam at from 10 to 14 knots, with a small section of the boilers and supplemental machinery, more economically than other vessels of similar size, and of ordinary type and power, and when required all the boilers could be used, and full power exerted in about half an hour.

In the case of an Atlantic liner or a cruiser of large size, turbine engines would effect a reduction in weight of machinery, and also increased economy in fuel, tending either to a saving in coal on the one hand, or, if preferred, to some increase in speed on the same coal consumption per voyage.

In conclusion, it may be remarked that in the history of engineering progress, the laws of natural selection generally operate in favour of those methods which are characterised by the greater simplicity and greater economy, whether these advantages be great or small.

The work in this undertaking has perhaps been slow, but many difficulties were met with besides those of a mechanical nature, and, as is generally the case, the success so far attained has been largely due to devoted colleagues and staff, and in the marine developments to the enterprising and generous financial assistance.

My thanks are due to the officials of this Institution for the kind assistance they have afforded me in the arrangement of the apparatus.

ADVANCEMENT OF ELECTRICAL CHEMISTRY.

ON reviewing the science of electro-chemistry and its application to modern manufacturing processes, one is struck with amazement at the enormous strides which have been made within the last ten or twenty years. On studying works on chemistry little more than ten years old, hardly a reference is found to the use of electricity in metallurgy, still less in regard to the manufacture of metallic salts, or of the non-metals, and absolutely none in reference to the preparation of organic chemical bodies, at any rate on a large scale.

We are told that in 1808 Sir Humphrey Davy discovered the metals—sodium and potassium—by the electrolysis of their moist hydroxides; we are then informed that they are now manufactured by the much cheaper method of heating the carbonates with charcoal and chalk, or the hydroxides with carbide of iron. To-day we find a retrograde step has been taken, and that they are manufactured by the vastly cheaper method of electrolysing their chlorides or hydroxides.

Notwithstanding that Faraday and others early in the nineteenth century had shown that metals could be deposited, from the solutions of their salts, upon other metals by means of an electric current, and Faraday had, in 1833, formulated his law that "The amount of any substance liberated is proportional to the total quantity of electricity passed through the solution," and that "the amount of different substances liberated by the same quantity of electricity are in the ratio of their chemical equivalents"; electricity until quite recently was not used as an adjunct to chemical analysis. Within the last few years electro-chemical analysis has been very much studied, and now most laboratories *abroad* are fitted with special apparatus for this class of analysis. It is to be feared that in this country we are hardly so advanced.

Within the last thirty years the process for depositing metals from their solutions, and so obtaining moulds for casting, &c., has not undergone any very radical changes, but the means at our disposal for carrying out the work have enormously improved.

Until the advent of the dynamo and the storage battery, methods of electrical analysis or of galvanic deposition could not profitably be employed, at any rate on a very large scale; now, however, with the cheapening of production, very much has been made possible, which but a few years ago would have been scouted as Utopian. Is it realised by those who admire the splendid photographic reproductions which are met with on every hand, even in penny illustrated journals, that the majority of these are reproduced by means of electrical processes? A scene, *e.g.* the leaving of volunteers for the seat of war, is photographed, and in a few hours by means of electrical stereotype is transferred to a metal plate and is ready for the printer.

Those interested in metallurgy knows how difficult it is to obtain absolutely pure copper by furnace methods, even after many processes of refining, the copper still contains small quantities of impurities from which it is only with great difficulty freed. When copper is required for electrical purposes, very small quantities of impurities considerably reduce its conducting power. For this reason then it is important to obtain perfectly pure copper; and as the impurities often consist of gold and silver, endeavours have been made to obtain a process which would produce absolutely pure copper, and at the same time leave the gold and silver in a workable condition. Thanks to electro-chemistry, such a process has been devised and is now very largely used. The copper which has either been cast into plates or bars, or granulated, is placed in a bath of copper sulphate and connected with an electrical machine as the anode, a plate of pure copper forming the kathode. On the current being passed, the copper at the anode dissolves and is deposited on the kathode in the pure condition; the impurities—gold, silver, antimony, arsenic, etc., dissolving in the bath or remaining on the anode as a sponge, finally falling to the bottom of the bath forming a muddy sediment ("anode sludge").

The electrolytic deposition of copper is also made use of in the manufacture of weldless copper tubing. In a bath of copper sulphate, granulated copper is made the anode, the kathode consisting of metallic spindles, the thickness of which is determined by the size of the tube it is desired to produce. The spindle is made to revolve at a very high rate of speed; by this means the copper, which ordinarily is deposited in a more or less crystalline condition, forms a dense and even deposit, which, when used for boiler tubes, &c., is capable of sustaining very high pressures without bursting.

Although it has not up to the present been found practicable to obtain zinc commercially from its ores by electrolytic methods, notwithstanding the many attempts which have been made, it is interesting to note that zinc galvanising by electrolysis is now being used to a very considerable extent, in place of the old method of hot dipping, the zinc, as in the case of the copper deposition just described, being made the anode in a weak acid bath, the material to be galvanised the kathode. The galvanising of the inner surfaces of tubes has always been very difficult; in the electrolytic method the difficulties are overcome. The bottoms of ships, torpedo-boats and other large surfaces are now frequently galvanised by means of the electrical galvanic process.

The advantages which this method has over the hot dipping process are obvious. In the latter, many tons of zinc have to be kept in a state of fusion over long periods, the expense of fuel being very great, and the loss of zinc through alloying and oxidation very considerable. In the old process the tensile strength of the iron and steel is said to be diminished. In the new process it is claimed that the quality is in no way depreciated.

Probably "the man in the street" would point to the manufacture of aluminium as being the triumph of electrical chemistry. Certainly, here is a triumph, and it will perhaps be interesting to briefly trace the development of the industry since the discovery of the metal by Wöhler in 1827. He obtained it as a grey powder by heating aluminium chloride with potassium. In 1856, Bunsen prepared it by electrolysis of the double chloride of sodium and aluminium. Deville, in 1854, obtained it by the action of sodium on this same double chloride, but owing to the high price of sodium, aluminium cost, in 1857, 5*l.* the pound; even in 1888 the price was over 2*l.* per pound. In this year the Netto-Castner process for the manufacture of sodium was perfected, and as a consequence the price of aluminium at once fell to 15*s.* the pound. Shortly after this the electrical methods were employed, and now aluminium may be obtained at less than 2*s.* the pound; the cost would probably be still further reduced if the metal itself were of more general use.

Calcium carbide, which is now being largely manufactured by heating a mixture of limestone and coke in an electrical furnace, has made it possible to obtain, at a small cost, acetylene gas, which, were it not for the restrictions that are placed upon the storage of the carbide, would probably be used to a very much greater extent. The extraordinary brilliancy of the light which this gas gives causes one to wonder that attempts have not been made to employ it for street lighting.

In gold, silver, and nickel-plating, electrolysis on a small scale has been employed for a number of years, and within the last few years it has been successfully used on a large scale for gold extraction. In the McArthur-Forrest cyanide process for obtaining gold from the "tailings," a double cyanide of gold and potassium is obtained; from this double cyanide the gold is precipitated by means of metallic zinc, the gold so obtained having to be refined and purified. By the Siemens-Halske process the cyanide solution is electrolysed by means of weak currents, the gold being deposited in a purer form than when precipitated by means of zinc. In this process the anodes are of iron, and the kathodes on which the gold is deposited of lead; an amalgam of lead and gold being obtained, from which the latter is recovered by cupellation. By this method the gold is obtained purer, and the quantity of cyanide employed is much less than is the case in the original cyanide process. There is little doubt that in a short time a very large percentage of the "tailings," both in Australia and Africa, will be worked by means of electrical processes, and it is not impossible that a process will be devised for the treatment of the auriferous quartz, though, up to date, attempts in this direction have not been commercially successful.

Either with the electric furnace or by electrolysis, it is now possible to obtain practically all the metals from their oxides or salts, *e.g.* chromium, by heating the sesquioxide with aluminium in an electric furnace; magnesium, by electrolysis of fused carnallite; the rare metals yttrium, lanthanum, and cerium have also been isolated by electrolysis of their fused chlorides. An interesting process for purifying tin might be mentioned here. The metal obtained from American sources often contains appreciable quantities of gold. A very neat method for separating the tin from the gold has lately been patented. The gold-containing tin forms the anode in a bath of sodium sulphide, the kathode being a strip of pure tin; on the current being passed, the tin at the anode dissolves, forming a thio salt, from which it is deposited, pure, on the kathode. The gold with other impurities hangs on the anode in a spongy form, or falls to the bottom of the bath, as "anode sludge," from which it is readily extracted.

As showing the many-sided character of electro-chemistry, an interesting process for obtaining accurately reflecting mirrors might be mentioned. Many attempts have been made to prepare perfect metallic mirrors, in which the use of glass could be done away with, and on a small scale for lamps the attempts have been fairly successful; but where a moderately large and true reflecting mirror is required, attempts to substitute cast, spun or stamped metal for glass have always been unsatisfactory. The difficulty seems to have been overcome in a process brought out by Mr. Cowper-Coles. A glass mould is obtained, the convex side of which is accurately shaped and polished to form a true parabolic or other reflecting surface. On the prepared surface a metallic coating of silver is deposited by chemical means; it is then polished, and a backing of copper is deposited to any desired thickness, by making the silver the kathode in a bath of copper sulphate, the mould being at the same time rotated in a horizontal position. The copper adheres firmly to the silver, and as soon as sufficient has been deposited the glass mould is placed in cold water, which is gradually warmed. The unequal expansion of the metal and the glass causes the two to separate, yielding a concave surface of silver on copper, exactly corresponding to the mould, which requires no further polishing. As, however, silver when exposed to atmospheric conditions rapidly tarnishes, metallic palladium is electrolytically deposited on its surface. Palladium is not affected by atmospheric changes, being practically unoxidised even at high temperatures. Its reflecting power, moreover, is but little inferior to that of silver.

A metallic reflector prepared after this method was recently tested at Portsmouth, a number of rifle bullets being fired through it; it was even then found that the beam was but slightly affected. Whereas one shot fired at a glass reflector smashed it to pieces. It is obvious then that such mirrors should be of great value in the Army and Navy, as reflectors for searchlights, where the breaking of the mirror in time of action might have very serious results.

In this article it has only been possible to touch the margin of the electro-chemical industry, and only, with the exception of calcium carbide, such processes as deal with electro-metallurgy and electrolytical deposition have been dwelt upon. It is hoped in another article to draw attention to the production of non-metallic elements, and to the manufacture of chemical products both inorganic and organic. F. MOLLWO PERKIN.

THE PROBLEM OF COALING AT SEA.

WAR, at the present time, brings home to us the necessity of considering "Energy," its different forms, and their practical application. In these days, when the machinery of a battleship not only propels the vessel, but lights, ventilates, and controls the working of the heavy guns, it may be said that the ship is primarily dependent on one source of energy—Coal. A vessel short of this requisite has hitherto been compelled to fall out of line and be thus useless until she has "coaled ship," which in many cases entails several miles steaming, delay, and perhaps lost opportunities.

On this account any efficient mechanical contrivance for overcoming the difficulty of obviating the ship putting into port and enabling a full recharge of energy while cruising to be possible must be looked upon by all with interest.

In the *Engineering Magazine* for February is an illustrated account of a series of trials made in the United States Navy with the "Miller Conveyor" for coaling at sea, and the method may be briefly described as follows:—

The battleship to be coaled tows the collier, from which it takes the coal in loads of 840 lbs. by means of an overhead cable and suspended carriage. During the experiments two points of interest presented themselves: (1) The proper distance between the ships; (2) The way of overcoming the variation required in the length of ropes caused by the rolling and pitching. With regard to the first point it was found that with 300 feet between the ships, the collier would not follow properly, but during the rough weather trial with about 400 feet between the ships, the collier followed perfectly.

The second point caused the chief difficulty, and in Mr. Miller's design we find the length of overhead cables made variable, as required partly by the movement of the ships themselves, and partly by the power engine on deck. In the following table will be found information and data of the five trials made:—

Trial Number	Speed	Number of loads (840 lbs.) or tons transshipped	Remarks
First	5 to 6 knots	9 loads only	Adjustments made
Second		14 tons 5 cwt. in 38m. 40s.	Work stopped through lack of skill on part of operator
Third		22 tons in one hour	Work could have continued but for lack of sufficient crew to fill the bags
		Between the third and	fourth slight alterations made
Fourth		75 tons in 3h. 43m.	Trial lasted four hours; water smooth, ground swell
Fifth		80 trips made in 80m., or 30 tons in 1h. 20m.	Could have continued indefinitely. Board of Judges satisfied. Water rough.

As we are informed that the battleship consumed about 3½ tons of coal per hour, the actual (or rather "paying") rate of coaling obtained was sixteen or seventeen tons.

The behaviour of the apparatus in rough weather was satisfactory, and the author writes, "The boats steered at first head on to the sea, the forecastle of the battleship *Massachusetts* was washed at every plunge, and no coal could have been delivered there, even if desired. The course was then changed quartering on the sea; the results were the same. Then the boats steered in the trough of the sea, and the rolling did not affect the working."

The article, which is illustrated with ten good photographs and a diagram, is certainly worthy of note, and deals with a subject which it is possible will revolutionise naval warfare in the near future.

MERCURY AS A NAKED EYE OBJECT.

RARELY visible, and always difficult to observe satisfactorily in a telescope, this planet is yet a most attractive object to the unaided eye. Not receding to a greater distance than 28° from the sun, he is, however, never above the horizon in England for a longer period than two and a quarter hours before sunrise, or for a similar interval after sunset. When an evening star in the spring months or a morning star in the autumn season, he may often be caught and watched for an hour or so, shining with a sparkling, rosy lustre, and presenting much the same aspect as a fixed star.

To secure a view of Mercury forms one of the earliest and greatest ambitions of the amateur astronomer. Among his first books there will sure to be a copy of Mitchell's "Orbs of Heaven," or Dicks's "Celestial Scenery," and on reading the statement that Copernicus never succeeded in seeing Mercury, he resolves that he will do his best to catch a glimpse of this elusive little "Messenger of the Gods." After some vain attempts he finally succeeds, and it is not too much to say that the spectacle sometimes excites and gratifies the observer more than any other subsequent event in his astronomical career. Who is there among us who does not remember the thrill of pleasure incited by the first detection of this fugitive orb, and the conscious pride with which we realised that we had commenced our celestial work by achieving a feat which had been denied to the greatest astronomer of the sixteenth century?

But, as a matter of fact, there seems to be considerable doubt whether Copernicus ever really complained of failure to see Mercury. There is evidence to show that he never expressed himself in the manner quoted in many of our popular text-books. There may, it is true, have been some ground for the statement, but it is well known that a biographer has only to introduce a special incident of the kind alluded to, or to unduly colour some expression, and whether on doubtful evidence or not, it is liable to be copied and recopied by subsequent writers without any investigation until it becomes generally accepted as a fact. But admitting for the moment that Copernicus really failed to discern Mercury, he seems to have had very good reason for it. His residence was at Thorn, in Prussia, and through the valley near ran the River Vistula, over which were frequent fogs which obliterated objects near the horizon.

This tradition about Copernicus and Mercury has certainly, however, enhanced the interest with which the planet is regarded as a naked eye object. The beautiful white lustre of Venus—incomparably brighter than the aspect of Mercury—the stronger and steadier, yellowish light of Jupiter, or the conspicuous ruddy hue of Mars may present a more striking appearance in the sky than the twilight-veiled splendour of Mercury, but there is something about the sparkling lustre of the latter orb, hovering fugitively on the brow of the horizon, which forms an attraction peculiarly its own.

The best time to observe the planet in 1900 will be during the first eleven days of March, when his times of setting will be as follows:—

		h. m.			h. m.
March	1*	... 7 10	March	7	... 7 36
	2	... 7 16		8	... 7 39
	3	... 7 21		9	... 7 41
	4	... 7 25		10	... 7 41
	5	... 7 29		11	... 7 41
	6	... 7 33			

During this period Venus will be a very brilliant object, situated about 21 degrees E.N.E. of Mercury. The greatest elongation of the latter (18° 16′ E.) will occur at 11 a.m. on March 8, on which day he sets about 1h. 50m. after the sun. If the western sky is clear on March 2 at about 6 p.m. an exceptionally good opportunity will occur for detecting the planet, for he will be in conjunction with the crescent of the new moon at that time, and about 4½ degrees south.

On reference to my note-book I find that I obtained naked eye views of Mercury on 102 occasions between February 1868 and December 1899. But the planet was very rarely looked for here at the morning apparitions, and not always at really favourable spring elongations. If an observer with good sight made it a point to secure as many unassisted eye observations of this object as possible, he might be successful on about twelve occasions in a year. In a finer climate than ours, the planet may, of course, be more frequently seen. I think that some disappointments in regard to finding Mercury are due to the fact that observers scan the heavens at or after the time of maximum eastern elongations, instead of during a week or more preceding them. The phase and apparent brilliancy decrease rapidly at these periods. I have occasionally noticed Mercury as a very brilliant object about ten or twelve evenings before his greatest elongation, while at the date of his elongation he has appeared quite faint, and a few evenings later, become practically invisible, though above the horizon for about two hours after sunset.

My observations in various years have led me to the following conclusions regarding the visibility of the planet at the evening apparitions :—

(1) The greatest brightness of the planet is attained ten or twelve days prior to his greatest elongation.

(2) In February and March the planet may sometimes be caught twenty minutes after sunset, in April thirty minutes after sunset, and in May forty minutes after sunset. The stronger twilight towards midsummer occasions the difference.

(3) The duration of his visibility to the naked eye is about 1h. 40m. in March, 1h. 30m. in April, and 1h. 20m. in May. On a very exceptional occasion it is possible these limits may be exceeded.

(4) The planet is a conspicuous object, and certainly much brighter than a 1st mag. star. In February 1868 I considered that his lustre vied with that of Jupiter, then only 2° or 3° distant. In November 1882 he appeared brighter than Sirius. In 1876 he looked more striking than Mars, then 13° distant, but the latter planet was faint and at a considerable distance from the earth.

The greatest number of naked eye observations of Mercury at the same elongation was obtained at Bristol in the spring of 1876, when the planet was seen on thirteen different evenings. When Venus is near Mercury at a favourable time, she affords an excellent guide to the identification of the latter. But errors have often been induced, and either Venus or Jupiter has been mistaken for Mercury on many occasions. In April 1898 Venus was near Mercury, and some people, including a few regular astronomical observers, readily saw Venus and believed (and still ardently believe) that they were looking at Mercury.

The albedo, or reflecting capacity of the planet, is rated exceedingly low, being only 0·11, whereas Mars is 0·27, Saturn 0·50, and Venus and Jupiter 0·62. This is remarkable when we consider the occasional striking brightness of the small planet in a region of the sky full of strong twilight. By telescopic comparisons of the disc of Mercury with other planets, it is, however, easily seen that the former is relatively feeble in brilliancy. On May 12, 1890, I viewed Mercury and Venus in the same field of view of a 10-inch reflector, and remarked that the brilliant silvery light of Venus contrasted strongly with the much duller hue of Mercury. The probability is that the latter object is provided with a much thinner atmosphere than that which envelops his sister planet. There are undoubted markings visible on Mercury, but they are nothing like the peculiar representations of them which have been published in the last few years. The extreme difficulty of obtaining satisfactory views of the planet furnishes the principal reason why his rotation period still awaits accurate determination.

W. F. DENNING.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—Junior Scientific Club, February 21.—Mr. H. B. Hartley (Balliol College) read a paper on liquid crystals, and showed, by microscopic demonstration upon the screen, experiments with para-azoxyanisol and para-azoxyphenetol which melt to doubly refracting liquids at 116° and 135° respectively. These remarkable bodies have not previously been shown in England; the curious transformations which they undergo were made clearly visible to a large audience.

CAMBRIDGE.—A very valuable and interesting collection of Irish antiquities, formed during the last seventy years by Mr. T. R. Murray, of Edenderry, has been acquired for the University by Prof. Ridgeway. It includes unique bronze weapons and ornaments, stone axes and arrowheads, medieval pottery, &c. The collection will be exhibited in the Fitzwilliam Museum on March 5.

A University Prize for the best M.D. Thesis has been founded in memory of Raymond Horton-Smith, M.A., M.B., late scholar of St. John's College, who, after a distinguished career in the University and at St. Thomas's Hospital, London, died last year at the untimely age of twenty-seven. Candidates must have taken honours in one of the Tripos examinations, and the Prize Thesis is to be printed and circulated.

The arrangement with Addenbrooke's Hospital, by which the Professors of Physic and Surgery are to have places on the staff, in consideration of an annual subsidy of 300*l*. from the University, is now submitted for adoption by the Senate. It has already been approved by the Hospital Court, and will probably come into effect forthwith. It puts an end to an old difficulty between the medical school and the hospital.

The thanks of the University are ordered for certain valuable gifts to the Engineering Laboratory. Lord Kelvin has presented a set of apparatus for electrical measurements, Messrs. Siemens Brothers a pair of coupled dynamos, and the Forward Engineering Company a gas engine.

The University Lecturer in Chemical Physiology, Mr. F. G. Hopkins, M.B., London, is to receive the honorary degree of Master of Arts.

THE Senators of Edinburgh University have decided to confer the degree of LL.D. upon Miss Eleanor A. Ormerod, in recognition of her services to entomology.

THE Senators of St. Andrews University have resolved to confer the honorary degree of Doctor of Laws upon Prof. McIntosh, Edinburgh, and Dr. Hugh Robert Mill.

THE Norwich Union Fire Insurance Company have just settled the claim of the West Ham County Borough Council, on account of the damage done in the disastrous fire at the Municipal Technical Institute last October, for the sum of 25,100*l*., the Council retaining the salvage. This sum is expected to cover completely the cost of the reinstatement. The opportunity will be taken to enlarge the Institute, accommodation having already proved too small for the classes. A new block is to be built to contain the whole of the chemical department. This block will contain two lecture rooms, an advanced and an elementary chemical laboratory, furnace room, combustion room, gas analysis room, balance room, and private laboratory, together with the usual private rooms and store rooms. A small forge and a foundry are to be added to the engineering department. The engine and dynamo laboratory, and the engineering laboratory are both to be enlarged, and extra accommodation will be provided for building-trade classes and for the Women's Department and Art Department, together with several extra class-rooms. The cost of these extensions is estimated at 8000*l*. The builders are busily engaged on the work of reinstatement, and it is fully expected that both new and old portions will be ready for use at the beginning of the new session in October next.

A COPY of an address recently delivered by Sir William White, K.C.B., F.R.S., at the Merchant Venturers' Technical College, Bristol, has been received. In the course of his remarks, Sir William White pointed out that what is wanted from the national point of view is increased individuality and intelligence among the workers engaged in manufactures and industries. A good technical institution provides the means for developing these qualities, and in such a college a student can find help and assistance in trying to obtain a fuller grasp of principles, and a better knowledge of fundamental principles upon which to base his own further efforts. An engineer, whatever his line may be, cannot be completely furnished with the means of carrying on his profession by studying it in the most completely equipped college that could be established; that is only one portion of his education. Until Technical Colleges came into existence, the system of training that was favoured, with those whose means and leisure permitted, was that of pupilage. Now it is quite recognised that an alternative method of commencing training is afforded by well-equipped Technical Colleges. In conclusion, Sir William White referred to the steps which have been taken in the organisation of educational work in Bristol, and to prevent over-lapping of the various institutions and authorities concerned with education. Prof. Wertheimer, the headmaster, reports that, acting on the suggestions of the Technical Instruction Committtee of the Bristol Town Council, the Governors of the Technical College have completed an agreement with the Bristol School Board, in virtue of which the evening class work of the Board and of this College, in science and technology, are so arranged as to avoid over-lapping. In virtue of an agreement with the Bristol School of Art, the Art School of the College will be closed at the end of this session, and art students will be advised to attend the other school; the School of Art on its side will close its science classes and advise its students of science to attend the College. The relation of the Technical College to the University College does not appear to be mentioned in the report.

SCIENTIFIC SERIALS.

American Journal of Science, February.—Sedimentary rocks of Southern Patagonia, by J. B. Hatcher. Two years of further study have greatly augmented the results obtained since the first report. Chief among the additional observations and resultant modifications of the author's former views are:—(1) The discovery near Sandy Point, in the Strait of Magellan, of an entirely new series of Tertiary deposits several hundred feet thick, and underlying the Patagonian Beds. These new Tertiary deposits have already been noticed by Dr. A. E. Ortmann, and have been named by him the Magellanian Beds. (2) The discovery near Lake Pueyrredon of several distinct fossil-bearing horizons in the Cretaceous.—Explorations of the *Albatross* in the Pacific (II.), by Alexander Agassiz. The choice of Dolphin Bank, Tahiti, as a standard to determine the growth of coral turns out to have been unfortunate, as it is in the midst of an area comparatively free from corals. Only a few growing corals were found by the author, the top of the bank being entirely covered by Nullipores. After coaling at Tahiti, the *Albatross* left for a cruise in the Paumotus. The western islands are probably all on a great plateau connected perhaps by the 800-fathom line. The soundings, like those off the Fijis, show that atolls do not necessarily rise from great depths, and that in this characteristic atoll district atolls are found, it is true, with steep slopes, but rising from moderate depths.—Action of ammonium chloride upon analcite and leucite, by F. W. Clarke and G. Steiger. When analcite is heated with four times its weight of ammonium chloride, about one-half of the soda in the analcite is converted into chloride, while variable ammonia is retained. Other zeolites, like leucite, natrolite, laumontite, stilbite, chabazite, apophyllite, show a similar reaction, varying, however, to an extent which probably depends upon their molecular structure. A new means of studying the latter is thus provided.—Devonian strata in Colorado, by A. C. Spencer. Devonian and associated strata were deposited originally over an extensive area in the southern Rocky Mountain region, the boundaries of which are as yet entirely unknown.—Estimation of thallium as the acid and neutral sulphate, by P. E. Browning. The salt obtained by heating thallous chloride with sulphuric acid until the excess of the latter is expelled, and then raising the heat to redness, has the constitution of a neutral sulphate. The author tested whether this neutral sulphate, or the acid sulphate described by thallium, can be used for the estimation of thallium, and finds that it can be done, provided the conditions of temperature are carefully attended to.—Motion of a submerged index-thread of mercury in the lapse of time, by C. Barus. The author endeavoured to frame a theory to account for the observed gradual sinking of an index-thread of mercury in a vertical tube containing water. He proceeded on the supposition that water penetrates past the index-thread in a very thin sheet, but found that the thickness of the sheet would have to be far below that of a molecule of water. He eventually found that the sinking was due to the volume viscosity of glass. A four years' experiment showed that the sinking proceeds at a regularly retarded rate through infinite time.

Annalen der Physik (formerly *Wiedemann's Annalen*), No. 1.—A study on soap-bubbles, by O. Dörge. The author performs on a soap-bubble a cyclical electric process analogous to a Carnot cycle, the expansion and contraction being either at constant charge or at constant potential. He arrives at a law which states that no process is possible in which electric energy is transferred without loss or gain from one potential to another. This law corresponds to the second law of thermodynamics.—Diffuse reflection of light, by H. Wright. If the angle of incidence is constant, the intensity of reflected light varies as the cosine of the angle of reflection in the case of perfectly dull surfaces. The converse does not hold good, so that Lambert's law is only partially correct.—Electric conductivity of dilute amalgams, by A. Larsen. Experiments upon amalgams of lead, zinc, cadmium, tin and bismuth show that the metal contained in dilute liquid amalgams is dissociated, and that the degree of dissociation increases with the dilution and the temperature.—Stationary temperature of an electrically heated conductor, by F. Kohlrausch. The author supposes a conductor whose surface is protected from loss of heat, except two terminals, each of which is kept at a constant temperature and a constant potential. When the stationary state has been attained, all points at the same potential will also have the same temperature. The greatest quantity of heat will be developed in those metals in which the ratio of the thermal to the electrical conductivity is smallest.—Spark potential in gases, by A. Orgler. The author proposes a new definition of the "specific electric strength" of a gas, which gives a real constant for any given gas. If δ is the width of the gap, and A and B the spark potentials in the gas and in air respectively, the specific electric strength is the ratio $\frac{dA}{d\delta} : \frac{dB}{d\delta}$. It is units for air, 0·888 for carbonic acid, and 0·563 for hydrogen, whatever the width of the gap.—Molecular susceptibility of paramagnetic salts of the iron group, by O. Liebknecht and A. P. Wills. Jäger and Meyer's series of atomic susceptibilities of Mn, Fe″, Co, and Ni, in the ratio of 6 : 5 : 4 : 2, is not confirmed, the numbers obtained being 6·98 : 5·86 : 4·70 : 2. Wiedemann's series a, $a+b$, $a+\frac{3}{2}b$, $a+2b$ agrees rather better with facts, but a still closer approximation is obtained by putting $b=1·25a$ instead of $1·15a$. There is a sudden rise from chromium to manganese and ferric iron, and a gradual fall from the latter to cobalt, nickel and copper.—Molecular susceptibilities of salts of the rare earths, by H. du Bois and O. Liebknecht. There is a gradual rise from cerium to praseodymium and neodymium; a decided rise in samarium, gadolinium and erbium, and a sudden fall to ytterbium.—Magnetic viscosity, by Lizzie R. Laird. To preserve the initial or instantaneous magnetisation of a disc for measurement, it is kept in rotation, and the rise of intensity of magnetisation on stoppage is recorded by a photographic device.

THE number of the *Journal of the Royal Microscopical Society* for February 1900 contains a further instalment of Mr. F. W. Millett's Report on the recent Foraminifera of the Malay Archipelago, collected by Mr A. Durrand; and a paper by Dr. H. C. Sorby, F.R.S., on the Preparation of Marine Worms as Microscopical Objects, the fluid used for removing the salt being a strong solution of glycerin. The character and arrangement of the blood-vessels are especially well brought out by this mode of treatment. Among the paragraphs relating to Microscopy may be especially mentioned an abstract of van Heurck's paper, from the *Annales de la Société Belge de Microscopie*, on Modern Apochromatic Objectives.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, January 18.—"An Experimental Investigation of the Thermodynamical Properties of Superheated Steam." By John H. Grindley, B.Sc., Wh.Sc. Communicated by Prof. Osborne Reynolds, F.R.S.

In Regnault's experiments on the relations between the pressure, temperature, and latent heats of saturated steam, the steam to be experimented upon was obtained by withdrawing it upwards from a boiler, allowing any entrained moisture to be separated by gravity. Saturated steam obtained in any other manner would not necessarily have the same total heat of evaporation as that obtained by Regnault.

Whether the steam could always be brought into the same condition, as regards its freedom from moisture, by such a process of drainage was open to question, and it remained to be determined by further researches whether this condition was unique at any particular pressure and temperature in the saturated steam.

When saturated steam is wiredrawn by free expansion through a small orifice, if the pressure in the wiredrawn steam be sufficiently reduced, the steam will become superheated, and, if the flow through the orifice is truly adiabatic, the total energy per lb. of steam is the same on both sides of the orifice. Now, if the energies of motion be made sufficiently small, this energy will exist as heat, and, assuming the steam before passing the orifice to be in the same condition as that experimented on by Regnault, its total heat energy above that of water at 32° F. is known, and hence the total heat of gasification of the superheated wiredrawn steam from water at 32° F. is known. If, therefore, we observe the pressures and temperatures in superheated steam wiredrawn from definite initial saturated conditions, simple calculations will suffice to give various values of the specific heat at constant pressure in superheated steam.

In the experiments, the author obtained adiabatic flow by using orifices drilled in pieces of plate glass. The temperature and pressure of saturated steam in a steam chest, in which a constant supply of steam is kept, are taken, the steam is then drawn upwards to the orifice, and, after wiredrawing, its pressure and temperature are again taken, using for the determination of the latter a thermoelectric junction immersed in the steam.

The results of the experiments show that saturated steam at any particular pressure, obtained by relieving it of suspended moisture by gravitation, has only one condition as to its dryness, and the total heat of evaporation of steam so obtained is that given by Regnault's experimental results.

It is further shown that steam obtained in this manner has not the maximum density at that particular pressure and temperature of saturation, there being still an effect as if a small quantity of moisture remained in the steam, which would require removal by further application of heat at the same temperature before the steam would become superheated, thus showing that the latent heat of such steam as given by Regnault's results, has not its maximum value.

It was also found that by an application of Prof. Reynold's method of determining the perfectly gaseous condition of steam, under ordinary pressures and temperatures, no indications of that condition of steam known as a perfect gas were even approximately obtained, and that Rankine's formula

$$H = H_0 + c(T - 32)$$

for the total heat of gasification H of superheated steam at a temperature T (H_0 being the latent heat of formation of steam at 32° F.), which was formed on the assumption that such a perfect gas condition did exist in steam, could not be applied to superheated steam.

The mean specific heat under constant pressure was obtained for various pressures and between various temperatures, showing a wide range of variation in its value with temperature. Thus, at atmospheric pressure the mean K_p between 230° F. and 246°·5 was 0·4317, and between temperatures of 295° and 311°·5, K_p was 0·6482.

The specific heat K_p was found to be independent of the pressure, but to vary very nearly as the fourth power of the absolute temperature.

If $c\left(=\frac{\partial\theta}{\partial p}\right)$ denote the cooling effect produced by free expansion, the following formula, which is thermodynamically correct, viz.:

$$\frac{\partial}{\partial p}\left(K_p\right) = -\frac{\partial}{\partial T}\left(cK_p\right) \quad \ldots\ldots (1)$$

enables a check to be made on the experimental results, for if K_p is independent of the pressure, the product cK_p must be independent of the temperature. In the experiments, the product cK_p was found to be independent of both pressure and temperature.

By integrating Thomson's formula

$$\frac{dT}{T} = \frac{dv}{v + cK_p} \quad \ldots\ldots\ldots (2)$$

for the cooling effect c, and using the experimental value of the product cK_p obtained, values of the specific volumes (v) of superheated steam at various pressures and temperatures were calculated, the lower limit of integration being taken from the known data in the saturated condition of steam.

It follows from equation (1) that, for any gas in which K_p is independent of the pressure, and this is so for many gases, formula (2) must be capable of direct integration in the form

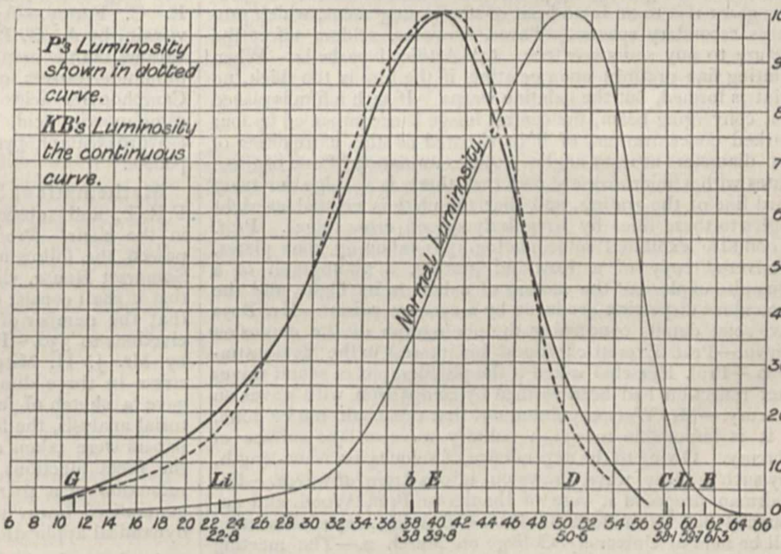
$$\frac{v + cK_p}{T} = f(p),$$

where $f(p)$ denotes any function of the pressure.

February 1.—"A Case of Monochromatic Vision." By Sir W. de W. Abney, K.C.B., F.R.S.

The patient, K. B., was aged twenty-five, and the notes of his case are as follows:—Vision always defective; has always been colour blind. Has quick horizontal nystagmus; probably an absolute central scotoma. He is always "day blind." His vision for right and left eyes is 6/60. He is not night blind. His fields are nearly, but not quite, full for white. He shows no definite changes in his eyes. As to his luminosity curve, he matched all colours with white, and with the same facility as if they were white.

In the accompanying diagram the curve shows the luminosity of the spectrum to the patient K. B. and also of a previous case, P., together with the curve of luminosity for the normal eye.



As regards the first two, it will be seen that the maximum of each curve is about scale number 40, or close to E. On the right-hand side of the maximum the curves do not absolutely agree. K. B.'s observations were first made in the red and green, and his readings at first were not very close, and a mean had to be taken. As the colours he had measured went towards the blue his measures were much more accordant, as he had become accustomed to the methods employed. The slight divergence on the left-hand side of the curve from that of P is probably due to his colouring matter in the yellow spot. Attention must be again called to the fact that these curves are practically identical with those obtained by the normal eye when it measures a spectrum of very feeble luminosity, and also agrees with the results obtained by measuring the diminution of each ray when it first becomes invisible, and making a curve of the reciprocals of the numbers, taking the highest point of it as 100.

Physical Society, February 23.—Prof. S. P. Thompson, F.R.S., Foreign Secretary, in the chair.—Prof. R. W. Wood, of the University of Wisconsin, U.S.A., exhibited and described: (1) Photographs of sound waves and the kinematographical demonstration of the evolutions of reflected wave-fronts. The sounds were produced by electric sparks, and photographed by means of the light emitted by carefully-timed subsequent sparks, according to the methods described in the *Phil. Mag.* for last year. The photographs included: (*a*) The reflection of a spherical wave, as a spherical wave from a plane surface; (*b*) the reflection, by an ellipse, of circular waves from one focus, and the concentration of the waves, as circular waves, at the other focus; (*c*) the plane wave-front formed by the reflection of a spherical wave at a parabolic surface; (*d*) the wave-front formed by a spherical wave incident on a spherical surface; (*e*) the wave-front formed by a plane wave incident on a spherical surface. In cases (*d*) and (*e*) the wave-fronts are complicated, and contain cusps. Prof. Wood pointed out that the paths of the cusps on the wave-fronts traced out the caustic curves. In the following cases the wave-fronts were drawn for one hundred successive positions, and the evolution of the reflected wave was made clear by means of a kinematograph: (*a*) Plane wave on a hemispherical mirror; (*b*) spherical wave on a hemispherical mirror; and (*c*) circular wave inside a complete circular mirror. (2) A new seudoscope. In this instrument the real and inverted images formed by two convex lenses are viewed stereoscopically. The inversion of the object viewed causes the relief to be reversed. (3) Diffraction colour-photographs. Prof. Wood showed some coloured photographs taken by his diffraction process. The principle of the method is based upon the tri-colour theory. Different colours are produced by gratings so ruled and arranged as to throw upon the eye the particular constituents of the required colours. The arrangement of gratings necessary to produce a coloured picture is obtained by photographing properly spaced gratings through red, green and blue chromograms of the object. The superposition of one grating upon another which occurs in this process gives rise to an in-and-out-of-step arrangement, which produces secondary spectra. These, however, seldom affect the picture to any serious extent. (4) Artificial parhelia. When printing fine gratings upon gelatine, if the film is too thick, no print is formed, but the gelatine warps. If such a film is placed in a converging beam, the central image is accompanied by four marked concentrations of light situated at the extremities of two diameters at right angles. An examination of one of these plates with a microscope shows that there is a ridge for every third line of the grating, and that the plate is crossed at right angles to these lines by irregularly spaced cross ridges. Prof. Wood also exhibited some photographs taken by zone plates, a silvered copy of a Rowland grating, a photograph of a dynamite explosion, the motion of a ball in its flight, and the anomalous dispersion produced by a cyanine prism.—Mr. Boys gave some details concerning the photograph of the explosion shown.—Prof. Everett expressed his interest in the demonstrations.—Prof. Herschel asked if the photographs of sound waves after reflection had been verified by comparison with waves on mercury.—Mr. Watson pointed out that this could not be done, as it is impossible to get a solitary wave on the surface of mercury. Owing to the dependence of velocity on wave-length, any such solitary wave draws out into a train of waves.—The chairman proposed a vote of thanks to Prof. Wood, and announced that, by invitation of Prof. Callendar, a special meeting will be held at University College on March 2.—The meeting then adjourned.

Chemical Society, February 8.—Sir Henry Roscoe, Vice-President, in the chair.—Prof. T. E. Thorpe, President, delivered the Victor Meyer Memorial Lecture.—February 15, Prof. Thorpe, President, in the chair.—The following papers were read.—Ammonium amidosulphite, by E. Divers and Masataka Ogawa. Dry ammonia and sulphur dioxide do not combine at a low temperature, but on passing sulphur dioxide into a dry ethereal ammonia solution, a colourless, deliquescent unstable salt, ammonium amidosulphite, $NH_4.SO_2.NH_2$, is deposited; it is decomposed by water and dissolves in alcohol with formation of ethyl ammonium sulphite.—On the products obtained by heating ammonium sulphites, thiosulphate and trithionate, by E. Divers and Masataka Ogawa. Anhydrous ammonium sulphite and pyrosulphite sublime unchanged on heating in dry nitrogen.—The colour of alkali nitrites, by E. Divers. The author confirms his previous statement that the alkali nitrites have a slight yellow colour which is specially marked in solution.—Solubility of mixed potassium nitrite and nitrate, by E. Divers.—The combination of sulphur dioxide with oxygen, by E. J. Russell and N. Smith. When a mixture of sulphur dioxide and oxygen acts on certain oxides, in addition to the absorption of sulphur dioxide, sulphur trioxide is formed, owing apparently to the "surface action" of the oxide; no sulphur trioxide is formed unless a simultaneous absorption of sulphur dioxide occurs.—Notes on the estimation of gaseous compounds of sulphur, by E. J. Russell. Volumetric methods of analysis are given which work satisfactorily in the estimation of sulphur dioxide, hydrogen sulphide, carbonyl sulphide and carbon disulphide in gaseous mixtures.—The influence of the "nascent state" on the combination of dry carbon monoxide and oxygen, by E. J. Russell. The nascent condition has no great effect in promoting combination between carbon monoxide and oxygen, the unburnt residue of carbon monoxide being similar in amount to that found in Dixon's experiments; the sources of nascent carbon monoxide used were carbonyl sulphide and nickel carbonyl, whilst nascent oxygen was supplied by the monoxide and peroxide of chlorine.—Asymmetric optically active tin compounds. Dextromethylethyl-n-propyl tin iodide. Preliminary note, by W. J. Pope and S. J. Peachey. The previously unknown mixed alkyl tin compounds of the type $SnX^{I}X^{II}X^{III}X^{IV}$ can be readily prepared from trimethyl tin iodide by the following series of reactions:

(1) $2SnMe_3I + ZnEt_2 = 2SnMe_3Et + ZnI_2$.
(2) $SnMe_3Et + I_2 = SnMe_2EtI + MeI$.
(3) $2SnMe_2EtI + ZnPr_2 = 2SnMe_2EtPr + ZnI_2$.
(4) $SnMe_2EtPr + I_2 = SnMeEtPrI + MeI$.

On treating methylethylpropyl tin iodide with silver dextrocamphorsulphonate, it yields dextromethylethylpropyl tin dextrocamphorsulphonate, $SnMeEtPr(C_{10}H_{15}OSO_3)$, from the aqueous solution of which dextromethylethyl-n-propyl tin iodide may be precipitated by potassium iodide.—Note on the refraction and magnetic rotation of hexamethylene, by S. Young and E. C. Fortey.—Apiin and apigenin. Part II. Note on vitexin, by A. G. Perkin.—The yellow colouring principles of various tannin matters, VII., by A. G. Perkin.—Note on the bromo-derivatives of camphopyric acid, by J. A. Gardner. Camphopyric acid yields two derivatives, α- and β-bromocamphopyric acid, with bromine; the former gives an α-hydroxycamphopyric acid, $C_9H_{13}(OH)O_4$, on hydrolysis with potash.

Mathematical Society, February 8.—Prof. Elliott, V.P., F.R.S., and subsequently Lieut.-Colonel Cunningham, V.P., in the chair.—Prof. Elliott announced that the Council had passed the following resolution, and registered the same at Somerset House, viz. that the objects of the Society requiring that it shall consist of more than 250 members, it is resolved that the number of its members may be increased by further elections to 350.—Prof. Love, F.R.S., communicated a paper, by Mr. J. H. Mitchell, on some elementary distributions of stress in three dimensions, and Major MacMahon, F.R.S., gave a sketch of further results arrived at by him in combinatorial analysis, the foundation of a new theory.—The following papers were taken as read, viz.: A formula in the theory of the theta functions, by Prof. A. C. Dixon; The canonical reduction of a pair of bilinear forms, and Reduction of a generalised linear substitution to a canonical form, with a dynamical application, by Mr. Bromwich.

Anthropological Institute, February 13.—Mr. C. H. Read, President, in the chair.—Mr. W. L. H. Duckworth presented a note on the Congress of German and Viennese anthropological societies held at Lindau in September 1899, and on the anthropological faculty lately established in the University of Munich.—Dr. R. Koettlity gave a detailed description of the ethnography and civilisation of the Somali, Galla, Abyssinian, and Shangalla tribes, which he had the opportunity of studyiug during a recent journey from the Gulf of Aden to Khartoum. The paper was illustrated by many lantern slides from sketches and photographs, and by a large number of specimens collected in the course of the expedition.—In the discussion which followed, Mr. E. G. Ravenstein laid great stress upon the importance of a careful and detailed study of the natives of the region in question, and especially of the southern Galla tribes, who remain practically uninfluenced either by the Mohammedanism of the coast or by the debased Christianity of the Abyssinians in the interior.

Royal Meteorological Society, February 21.—Mr. E. Mawley read his report on the phenological observations for last year, in which he showed that the weather for the year ending November 1899 was chiefly remarkable for its high temperatures, scanty rainfall, and splendid record of sunshine. The winter and summer were singularly warm seasons, while the autumn was also warm, but during the three spring months rather low temperatures prevailed. In the early part of the flowering season, wild plants came into blossom in advance of their mean dates, but after March they were mostly late in coming into bloom. Taking the country as a whole, the best farm crop of the year was wheat; the yield of barley proved also good, while oats were slightly under average. The crops mostly affected by the dry weather were those of hay and turnips, the latter being in most districts exceptionally poor. The only part of the British Isles where the summer drought was not severely felt was in Ireland, throughout a great part of which there was abundant keep in the pastures during the whole summer. This year was a very bad one for fruit. The yield of apples, pears, plums and strawberries varied greatly in different localities, but was in most of them much under average.—Dr. R. H. Scott, F.R.S., read a paper giving the results of the percolation experiments which have been carried on at Rothamsted by Sir J. B. Lawes and Sir J. H. Gilbert, from September 1870 to August 1899. Three gauges were used, with 20 inches, 40 inches and 60 inches depth of soil respectively; the area of each gauge being one thousandth of an acre. The amount of water collected at the depth of 40 inches is always in excess of that collected at 20 inches, and also of that collected at 60 inches. In the winter months more than half the amount of rain penetrates into the soil and is available for springs, while in summer this amount only reaches a quarter that of the rain.

MANCHESTER.

Literary and Philosophical Society, February 20.—Prof. Horace Lamb, F.R.S., President, in the chair.—Some criticisms on the modern theory of solutions, by Edgar F. Morris. By applying the ordinary assumptions of the kinetic theory of solutions to the case of a semipermeable cell depressed below the surface of the solvent, the result is deduced that the percentage composition of any solution is a linear function of its density. The form of the reaction equation for the catalysis of esters shows that the action cannot be attributed to independently moving ions. Other facts disproving this theory are the occurrence of electrolytic solutions with normal molecular weights, and of cases where the molecules would have to be regarded as split into most curious fragments to provide a sufficient number of ions—in the case of certain metals in mercury solution into more ions than atoms. Prof. Fitzgerald has previously shown the physical basis of this theory to be unsound, and, as the chemical applications give untrue results, it was held that the theory should be abandoned.

EDINBURGH.

Mathematical Society, February 9.—Mr. R. F. Muirhead, President, in the chair.—Remark on Dr. Peddie's proof of a theorem in potential, by Mr. R. F. Muirhead.—A general mechanical description of the conic sections, by Mr. Alex. Morrison.—On Bessel functions and spherical harmonics, by Mr. John Dougall.

DUBLIN.

Royal Dublin Society, January 17.—Sir Howard Grubb, F.R.S., in the chair.—Mr. W. E. Thrift read a paper on the possible rapidity of movements in cells produced by diffusion, the paper being communicated through Prof. G. F. FitzGerald, F.R.S.—Prof. J. Joly, F.R.S., read a paper on a fractionating rain-gauge. The apparatus was exhibited and described.

PARIS.

Academy of Sciences, February 19.—M. Maurice Lévy in the chair.—Researches on the isomerism of the sulphocyanide derivatives, by M. Berthelot. Determinations of the heats of combustion and formation of the sulphocyanides and isosulphocyanides of methyl, ethyl and phenyl.—On the determination of the integrals of certain partial differential equations by their values on a closed contour, by M. Émile Picard. —The tetrahedric deformation of the earth and the displacement of the pole, by M. Marcel Bertrand. A discussion of Lowthian Green's theory, in which it is shown that no results inconsistent with facts are obtained by the logical development of this view. Six diagrams are given showing the tetrahedron of volcanic fractures and various sections of the earth on the assumption of the existence of the tetrahedron.—On the culture of blue lupins (*Lupinus angustifolius*), by MM. P. P. Dehérain and E. Demoussy. The experiments described show that the blue lupin is incapable of utilising by itself atmospheric nitrogen, although it may attain full development in the absence of nodules upon the roots. In the latter case the plant appears to profit by work carried out by bacteria living upon certain algæ. It was found that the roots of the blue lupin may bear nodules containing bacteria that are of no use to the plant. —On the new Giacobini comet, by M. Perrotin.—M. Stokes was elected a Foreign Associate in the place of the late M. Weierstrass, M. Zittel a Correspondant for the Section of Mineralogy, and M. Pfeffer a Correspondant for the Section of Botany.—On calculating machines, by M. L. Torres.—Remarks on a meteor which fell at Bjurböle (Finland) on March 12, 1899, by the French Consul in Finland.—Determination of surfaces having a system of lines of equal curvature, by M. R. Bricard.—On a transformation of isothermal surfaces, by M. C. Guichard.—On the problems of Neumann and Gauss, by M. W. Stekloff. —On functions with four pairs of periods, by M. G. Humbert. —Theory of helices of propulsion, by M. Rateau.—On the determination of standard lines in the spectrum, by M. Maurice Hamy. Four rays from a cadmium tube are selected, having approximate wave-lengths 644, 515, 508 and 466, and the exact ratios of the first to each of the last three determined with a high degree of precision.—Determination of new points of reference in the spectrum, by MM. A. Perot and Ch. Fabry. An application of the interference method previously described by the authors to the measurements of eighteen wave-lengths between $\lambda = 435{\cdot}8\ \mu\mu$ and $\lambda = 670{\cdot}8\ \mu\mu$, the error of the determination being less than one-millionth. —On a method of focussing a photographic telescope, by M. Georges Meslin.—A new interpretation of the results of M. Michelson for the analysis of homogeneous light by Newton's rings, by M. E. Carvallo.—The instantaneous disappearance of magnetic rotatory polarisation, by MM. H. Abraham and J. Lemoine. The authors apply the method previously used by them in the measurement of the duration of the Kerr phenomenon to the study of the extinction of magnetic rotation, and find that the polarisation is less than a hundred-millionth of a second (·000,000,01 sec.) behind the current producing it. Hence the magnetic rotation follows without any lag the variations in the fields which produce it.—On a method of preparation of alkaline arsenides, antimonides, and some alloys of the alkali metals, by M. P. Lebeau. The ordinary method of preparing arsenides by heating together the elements composing it, never gives a pure product, but if the crude arsenide thus obtained is extracted with liquid ammonia at −80°, the excess of sodium is removed, and the Na_3As is left in a pure state. Na_3Sb, Na_3Bi, and Na_4Sn can be prepared in a similar manner.—On iodide of nitrogen, by M. C. Hugot. A study of the action of liquid ammonia upon iodine. The results obtained are expressed by the author in the equation

$$16NH_3 + 3I_2 = 3(NH_4I.3NH_3) + NI_3.3NH_3.$$

—Meconine, opianic acid, and hemipinic acid, by M. Émile Leroy. A thermochemical paper containing determinations of the heats of combustion and formation of meconine, opianic acid, its potassium salt, and methyl ether.—Resolution of racemic benzylidene-camphor. Isomorphism of the two active components, by M. J. Minguin. The splitting up was effected by adding a dextrorotatory crystal to the toluene solution of the racemic compound.—Rapid method for determining the carbonic acid in various gaseous mixtures, by MM. Léo Vignon and Louis Meunier. The method is only applicable to gases such as air or coal gas, which can be obtained in unlimited quantities, and consists of a titration with limewater tinted with phenolphthalein.—On the volumetric estimation of boric acid, by M. Alfred Stock. The solution containing the boric acid is treated with a mixture of potassium iodide and iodate to remove free mineral acids, and the boric acid, which is without action upon this mixture, then titrated with soda in presence of mannite. It is absolutely essential that all the solutions should be boiled till free from carbon dioxide, quite erroneous results being obtained in presence of dissolved carbonic acid.—Researches on the genesis of compounds of the menthol series in plants, by M. Eugène Charabot.—On a new Epicarid, *Crinoniscus equitans*, by M. Ch. Pérez.—Development of the azygospores in *Entomophthora*, by M. Paul Vuillemin.—Relation between the variation of excitement of nerves and the variation of the exciting currents of different potentials, by M. Stéphane Leduc.—The quotient of fatigue, $\frac{H}{N}$, by Mdlle. J. Joteyko.—New method for measuring the acuteness of hearing for the intensity of sound, by MM. Ed. Toulouse and N. Vaschide. The sounds are produced by drops of water falling upon a metallic plate, the variations in intensity being obtained by varying the height through which the drops fall.—On the normal asymmetry of the binary organs in man, by M. P. Godin.—On the composition and feeding value of the mammalia, birds and reptiles, by M. Balland.—The barometric oscillations of February 13-19, 1900, by M. Joseph Jaubert. The oscillations were remarkable on account of their amplitude and short period, four maxima and minima being noted in six days, with an average amplitude of over 10 mm.

CAPE TOWN.

South African Philosophical Society, January 31.—Mr. L. Péringuey, President, in the Chair.—Mr. Chas. F. Juritz read a paper, entitled "The Soils of the South-Western Districts of the Cape Colony." The low percentage of phosphates in some samples of oat-hay analysed by the author ten years ago, led him to urge the Government to allow investigations into the chemical nature of the colonial soils to be carried out. The work has progressed to a very considerable extent, but the area from St. Helena Bay to Mossel Bay having been also geologically surveyed, Mr. Juritz confined his present paper to it. Most of the soils analysed were from the Malmesbury and Bokkeveld Beds. In portions of the Malmesbury district the underlying limestone greatly aids the fertility of the soil and renders its wheat "rust-resistent." The lime dimishes in amount from D'Urbanville to Hopefield. The Caledon soils are poor, but those of Bredasdorp are much better. The soils on the Enon Beds of Swellendam and Mossel Bay are good all-round soils. Of the two hundred and twelve soils examined, only fifteen contain a satisfactory amount of phosphates, forty-five a normal amount of lime, and fifty-seven of potash.

DIARY OF SOCIETIES.

THURSDAY, MARCH 1.

OYAL SOCIETY, at 4.30.—An Experimental Inquiry into Scurvy: F. G. Jackson and Prof. Vaughan Harley.—The Velocity of the Ions produced in Gases by Röntgen Rays: Prof. J. Zeleny.—Mathematical Contributions to the Theory of Evolution. VIII. On the Correlation of Characters not Quantitatively Measurable: Prof. K. Pearson, F.R.S.

LINNEAN SOCIETY, at 8.—On Botanic Nomenclature: C. B. Clarke, F.R.S.—On some Foraminifera of Tithonian Age from the Limestone of Nesseldorf: F. Chapman.

CHEMICAL SOCIETY, at 8.—Pilocarpine and the Alkaloids of Jaborandi Leaves: Dr. H. A. D. Jowett.—Isomeric Partially Racemic Salts containing Pentavalent Nitrogen, Parts I.-VII.: Prof. F. S. Kipping, F.R.S.—New Synthesis of Indene: Prof. F. S. Kipping, F.R.S., and Harold Hall.—(1) Potassium Nitrito-hydroximidosulphates and the Non-existence of Dihydroxylamine Derivatives: (2) Identification and Constitution of Fremy's "Sulphazotised Salts of Potassium": Dr. E. Divers, F.R.S., and Dr. T. Haga.—Some Acids obtained from α-Dibromocamphor: A. Lapworth and E. M. Chapman.

RÖNTGEN SOCIETY, at 8.—Measurements of the Absorbability of Röntgen Rays: J. H. Gardiner.—Skiagrams of Two Cases of Renal Calculus before and after Removal: Dr. Hugh Walsham.

FRIDAY, MARCH 2.

ROYAL INSTITUTION, at 9.—Malaria and Mosquitoes: Major Ronald Ross.

PHYSICAL SOCIETY (University College), at 4.30.—The Relative Rates of Effusion of Argon, Helium, and some other Gases: Dr. F. G. Donnan.—On the Distillation of Liquid Air and the Composition of the Gaseous and Liquid Phases: E. C. C. Baly.—The Reversibility of Galvanic Cells: T. S. Moore.—On the Damping of Galvanometer Needles: M. Solomon.

GEOLOGISTS' ASSOCIATION, at 8.—Wind-worn Pebbles in the British Isles: F. A. Bather.

SATURDAY, MARCH 3.

ROYAL INSTITUTION, at 3.—Polarised Light: Lord Rayleigh.

MONDAY, MARCH 5.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—In the Heart of Borneo: Charles Hose.

SOCIETY OF ARTS, at 8.—The Photography of Colour: E. Sanger Shepherd.

SOCIETY OF CHEMICAL INDUSTRY, at 8.—The Presence of Naphthalene in Coal Gas: R. W. Allen.—Notes on the Determination of the Iodine Value of Oils: Arthur Marshall.

VICTORIA INSTITUTE, at 4.30.—Coins of the Ancients: Dr. Zimmerman.

TUESDAY, MARCH 6.

ROYAL INSTITUTION, at 3.—Structure and Classification of Fishes: Prof. E. Ray Lankester, F.R.S.

ZOOLOGICAL SOCIETY, at 8.30.—Descriptions of New Reptiles and Batrachians from Borneo: G. A. Boulenger, F.R.S.—On the Brain of the Siamang (*Hylobates syndactylus*): F. E. Beddard, F.R.S.—On a Collection of Mammals from Siam: J. Lewis Bonhote.

INSTITUTION OF CIVIL ENGINEERS, at 8.—*Paper to be further discussed*: Corrosion of Marine Boilers: John Dewrance.——*And, time permitting, Papers to be read with a view to discussion*: A Short History of the Engineering Works of the Suez Canal: Sir Charles Hartley, K.C.M.G.

ROYAL PHOTOGRAPHIC SOCIETY, at 8.—Some Beauty Spots of English Scenery: John A. Hodges.

WEDNESDAY, MARCH 7.

SOCIETY OF ARTS, at 8.—Macombe's Country (South of the Zambesi): its Ancient Gold Fields and Industrial Resources: Dr. Carl Peters.

GEOLOGICAL SOCIETY, at 8.—Notes on the Geology of Gilgit: Lieut.-Gen. C. A. McMahon, F.R.S.—(1) The Rocks of La Saline (Northern Jersey): (2) The Rocks of the South-eastern Coast of Jersey: John Parkinson.

ENTOMOLOGICAL SOCIETY, at 8.

SOCIETY OF PUBLIC ANALYSTS, at 8.—The Determination of Carbon and Sulphur in Steel: Bertram Blount.—Maize Oil: Rowland Williams.—Note on the Assay of Creosote: A. D. Hall.—Note on the Influence of Temperature and Concentration on the Saline Constituents of Boiler Waters: Cecil H. Cribb.

THURSDAY, MARCH 8.

ROYAL SOCIETY, at 4.30.—Bakerian Lecture: The Specific Heat of Metals and the Relation of Specific Heat to Atomic Weight: Prof. Tilden, F.R.S.

ROYAL INSTITUTION, at 3.

MATHEMATICAL SOCIETY, at 8.—On the Use of the Curve of Error as an Auxiliary Curve in Statistics with Tables: W. F. Sheppard.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—On the Applications of Electricity in Medical and Surgical Practice: Dr. H. Lewis Jones.

CAMERA CLUB, at 8.—Steam Turbines, Land and Marine: A. A. Campbell Swinton.

FRIDAY, MARCH 9.

ROYAL INSTITUTION, at 9.—Bacteria and Sewage: Prof. Frank Clowes.

ROYAL ASTRONOMICAL SOCIETY, at 8.

INSTITUTION OF CIVIL ENGINEERS, at 8.—The Distribution of Stress in the Walls of a Thick Cylinder: John Duncan, W. A. Wales, and G. J. Day.

SATURDAY, MARCH 10.

ROYAL INSTITUTION, at 3.—Polarised Light: Lord Rayleigh.

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