THURSDAY, SEPTEMBER 24, 1908.

RADIO-TELEGRAPHY.

Radio-Telegraphy. By C. C. F. Monckton. Pp. xvii+272. (London: A. Constable and Co., Ltd., 1908.) Price 6*s*. net.

ONE of the greatest triumphs of the school of philosophy founded by Bacon is, doubtless, the discovery and theoretical and experimental development of electromagnetic oscillations. In this, as in most other matters in the science of electricity, the foundation stone was laid by Faraday, in his conception that the medium between electrically charged bodies, and between bodies carrying electric currents, was the seat of the strains and stresses set up by the said electrical disturbances. The subsequent development is, nowadays, common knowledge. It will suffice to refer simply to Maxwell's mathematical formulation, in 1873, of Faraday's conceptions, and the hypothesis that the electromagnetic strains in the medium travelled at a definite speed, depending on the permeability and specific inductive capacity of the medium.

The next great step forward was the brilliant experimental demonstration of electromagnetic waves which Hertz made about the year 1890. There is no doubt that Hertz was the true discoverer of radio-telegraphy. True it is that the range of his transmission was only a few yards; nevertheless, he was the first man to transmit signals over a distance by means of electromagnetic waves. Hertz, however, worked for science and not for telegraphy, and it remained for a host of inventors to adapt the newly-discovered phenomena to practical use. Prominent among these latter is the name of Marconi. The great achievement made by him was in 1896, when, experimenting for the British Post Office, he constructed his oscillator, or transmitter, by carrying a conducting wire high into the air as one arm, whilst he connected the other arm to earth.

Since then a large number of improvements and developments have been made under Marconi's auspices, and this country certainly owes him its thanks for the energy and perseverance which he has put into pushing forward into practical use what is certainly one of the greatest applications of modern science. However, very many other eminent inventors and men of science have done a vast amount of work in bringing this new industry to its present state of relative perfection. Among these should be mentioned Lodge, Braun, de Forest, Muirhead, Fessenden, Fleming, Slaby, Arco, and others. One of the most recent, and what will probably be one of the most important, steps forward has been taken by Poulsen. In the musical arc Duddell had utilised the earlier discovery of Elihu Thomson, that electric oscillations could be produced by shunting an air gap in a continuous current circuit, with capacity and inductance, and he was thus able to produce frequencies of 50,000 per second, which were, however, too low to admit of radiation. Poulsen, by using an arc struck between carbon and copper electrodes, in an atmosphere of hydrogen, has obtained frequencies of 1,000,000 per second, and thus the possibility of radiating into space a continuous undamped train of waves has been attained.

As was, perhaps, not unexpected, the commercial exploitation of an industry developing at the rate this is doing has been attended with a certain amount of friction and recrimination. A short time ago it seemed possible that progress might be prevented by a radiotelegraphic war, due to the commercial rivalry between the Marconi and the combined German interests. Fortunately, however, the Governments of all the principal countries of the world have made a satisfactory agreement which came into operation on July 1 of this year. One of the things which the conference of 1906 did, and which will appeal perhaps to the man in the street, is that they standardised the name of the new method of communication, the official designation of the new system being that used as the title of this book.

Mr. Monckton is to be congratulated on having written a very interesting and valuable book, and the publishers likewise on the good style in which it is produced, and on the many excellent illustrations. The book contains a general exposition of the principles underlying the subject, together with a description of a large amount of the apparatus and methods used by the various companies. We would like specially to felicitate the author on chapters ii., iii., and iv., where, without the use of mathematics, he has given a really brilliant description of the properties of electric waves.

Authors of such books as this have a natural desire to start right at the beginning of their subject, and, as Mr. Monckton is not an exception to this rule, he has devoted chapter i. to an explanation of the elementary principles of electricity and magnetism. We are rather afraid that if an absolute layman were to take up the book his understanding of the same would not be greatly helped by this first chapter. Nevertheless, it serves as an appropriate introduction to the volume, and will perhaps be useful to those engineering readers whose elementary scientific ideas are apt to get a little rusty in the rush of modern business. In fact, we think this book will especially appeal to those engineers and scientific workers who are busily engaged upon some other branch of the profession, and yet laudably desire to know what progress this young and very lusty addition to the family of industrial applications of science is making.

To conclude this notice, reference must be made to chapter x., which deals with measurements in radiotelegraphy. It is a commonplace remark that electricity is a science of exact measurements. With the advent of radiotelegraphy it was found that hardly any of the instruments hitherto used were suitable for making measurements of the very high-frequency currents used. As a consequence, a considerable number of very ingenious instruments has been invented. The principles underlying many of the measurements, for example, of that all-important one—the measurement of wave-length—are identical. The measuring instrument consists of a circuit of variable self-induction and capacity. It is brought under the electric influence of the circuit to be tested, and by varying the self-induction and capacity the testing instrument is tuned to resonate with the vibration to be measured. The right point is shown, for instance, in the Fleming cymometer, by the point of maximum glow in a vacuum tube. From the known capacity and self-induction of the instrument, at this point, its oscillation constant can be calculated, and, therefrom, the wave-length obtained. For a description of these very interesting instruments and other valuable information we must, however, refer the reader to the book itself.

C. C. G.

THE SENSES OF INSECTS.

The Senses of Insects. By Auguste Forel. Translated by Macleod Yearsley. Pp. xvi+324; two plates. (London: Methuen and Co., n.d.) Price 10s. 6d. net.

COMPARATIVE psychology as a science is beset with more difficulties than most of its kindred natural sciences. One of the greatest of these difficulties is that man, a creature gifted with the most highly developed intelligence, endeavours to interpret and explain the actions of the lesser intellectually endowed members of the animal kingdom from their standpoint. However much he may endeavour to avoid assuming an anthropocentric attitude, he must invariably find himself seated again on his pedestal of intellectual preeminence. He cannot avoid it; it is the only criterion he possesses. This difficulty is never more apparent than when an effort is made to study the manifold activities of that most active of the animal groups, the insects, and especially those families in which social habits have attained such a high state of perfection. In the study of the senses of insects we are necessarily compelled to form inferences from our own sensory experiences, and the result is that we not only cannot obtain an adequate conception of their ordinary sensory powers, but are completely baffled by many organs of an undoubted sensory nature.

Dr. Forel's work on this subject is not so well known in this country as it deserves to be. This, no doubt, is due largely to the fact that most of it has been published in rather out-of-the-way journals. Those students whose interest in the subject has been stimulated by Lord Avebury's work will be grateful to Mr. Yearsley for having performed this "labour of love," as he describes his translation.

The direct translation and publication *in toto* of a series of writings of such a nature, however, has its disadvantages. The present volume contains writings which date from the year 1878 to 1906. We have, therefore, not only the author's natural changes of opinion, but also mistakes, in fact, which have been brought about by the gradual growth of entomological inquiry. For example, in the section on hearing, the author states that "only crickets and several other Orthoptera appear to perceive sounds," which, in the light of more recent work of Mayer, Child, and others on the acoustics of certain nematocerous Diptera, is not quite correct. Nor does the author devote sufficient attention to the thoracic and crural tympanal organs of the Orthoptera, so well described by Graber, and of insects of other orders. To a present-day student of entomology a book on the senses of insects is incomplete without fuller reference to the morphological aspect of the subject, notwithstanding the lack of experimental studies. The author truly says, "for the human and animal brain, as well as for its functions, it demands that we shall use anatomical, physiological, biological, and psychological methods." The presence in insects of many problematic organs, which from their histological structure and connections appear to be of a sensory nature, such as, for example, those associated with the halteres of Diptera and the various chordonotal organs which have been described, does not detract from the difficulties which confront the student of these problems. The author pays little attention to these problematic organs, and, in view of the absence of experimental work on them, he is no doubt wise in not discussing them in the absence of facts, as some writers on the subject are accustomed to do. Where he treats with the senses of sight and smell he is more at home; his experiments are very interesting and valuable, and some of his results conclusive; it is in the description of these experiments that the value of the book lies rather than in his, in places, extensive polemical references to some of the work of others.

The last chapter, on judgment, mind, and reflexes, is one of the most interesting. The author is of the opinion that plastic reaction is primary, and that instinctive or automatic activity which predominates in the insects is secondary. He does not think that instinct can proceed from inherited habits, but that the automatism of all nervous activity, whether by selective heredity or individual habit, is a secondary phenomenon derived from primitively plastic habits, and in support of this he refers to the plastic origin of the slave-making instinct of the species of Formica.

We venture to think that the book would have been improved had the translator dispensed with a detailed account of the author's earlier work, the essentials of which might have been incorporated in the account of his later work; or had the author brought these earlier writings up to date with regard to our present knowledge of the morphological aspect of the problem, its value to the general reader would have been considerably enhanced thereby. With the exception of sub-œsophageal ganglion (p. 5) where supra-œsophageal is surely intended, and Chalcidites (p. 140) for Chalcidides, there are few mistakes of nomenclature in the work.

C. GORDON HEWITT.

FORESHORE PROTECTION.

Coast Erosion and Foreshore Protection. By John S. Owens and Gerald O. Case. Pp. 148. (London: The St. Bride's Press, n.d.) Price 7s. 6d. net.

THIS book consists principally of a reprint of papers on foreshore protection read before various societies, and of articles contributed to magazines.

Although it does not deal in such a comprehensive way with the subject of coast destruction and protection as the book on "The Sea Coast" published by Messrs. Longmans about six years ago,[1] it contains a great deal of practical information that should be of great service to those interested in coast protection.

One of the authors is the son of the late Mr. Case, so well known for the very successful work he carried out in protecting and saving from destruction the coast land at Dymchurch, and afterwards for his advocacy of the system of low groynes.

The book is divided into fourteen chapters, dealing respectively with forces acting on coasts and the sea bed, transporting power of running water, movement of materials composing the foreshore and bed of the sea, causes of erosion, protection works, materials of construction, groynes, sea walls, sand dunes.

The authors very properly point out that there is no one method of protection that can be applied to all coasts, but that each shore must be considered on its merits, and that it is only after due consideration has been given to the special circumstances which may influence the effect of the sea upon any particular shore that the proper remedy can be designed.

By way of example, it has been frequently said that it is useless to erect groynes upon a foreshore where there is no material to collect. But there are other matters that require consideration besides the actual collection of material. On many sandy coasts low groynes may serve a useful purpose by preventing denudation and the formation of swills and lows.

With regard to the sometimes debated question of high and low groynes, the writers of this book are fully in accord with the author of "The Sea Coast" in advocating the use of low groynes both on account of efficiency, convenience, and economy. With regard to the direction to be given to groynes, the authors do not see any reason for departing from a direction at right angles to the shore, and the majority of the engineers who gave evidence before the Royal Commission on Coast Erosion were of the same opinion, although some stated that, as a matter of experience, they had found the best results were obtained where the groynes were directed away from the side from which the prevailing winds came.

As to the proper distance between groynes, this has been found by the experience of the authors to be the distance between high and low water mark, or practically the length of the groyne. Experience has fully shown that the carrying up of the groyne from low water to about half tide level, as practised in many instances by the late Mr. Case, is not sufficient, as the water is apt to work round the end and make gullies, but that in every instance the groynes should extend so far as the high spring tides reach.

The chapter on ferro-concrete groynes contains much useful information on the application of this material to sea defence work, and gives illustrations and cost of works carried out for the protection of the coast of Sussex. The cost of these groynes is given as twenty shillings a foot run, which compares favourably with timber.

[1] "The Sea Coast, Destruction, Littoral Drift, Protection." (London: Longmans and Co., 1902.)

OUR BOOK SHELF.

The Discovery and Settlement of Port Mackay, Queensland. By H. Ling Roth. Pp. viii+114; 82 figs., 4 maps and charts. (Halifax: F. King and Sons, Ltd., 1908.)

PORT MACKAY in Queensland was discovered by Captain Mackay in 1860. The town was founded in 1862, and declared a port of entry in 1863, and is now the chief seat of the sugar industry in Queensland. The early history of a colonial settlement is sometimes of great interest, but it is often impossible to recover it, excepting where, as fortunately is usually the case in Australia, the young town promptly establishes a local newspaper. Port Mackay had the advantage of including amongst its residents Mr. H. Ling Roth, the author of the standard work on the aborigines of Tasmania; he was at one time secretary of the Mackay Sugar Planters' Association, and in this volume gives a monograph of the history of the town up to 1867, whence the story is continued in the columns of the local Press. He describes the discoveries along the Queensland coast up to 1844, and the exploration of the coastal districts by land from 1813 to 1859; and he explains how it happened that so valuable a locality as Port Mackay was missed by all explorers until 1860.

The volume is most valuable as a contribution to the historical geography of Australia. It includes a collection of portraits and interesting sketches of the early settlers. It tells several good stories, as of the sarcastic Mackay magistrate, who, when joined on the bench by a distrusted local J.P., asked his colleague whether he appeared for the plaintiff or the defendant. In the appendices, Mr. Ling Roth gives a valuable account of the aborigines of the district and of its natural history. He objects to calling the blackfellows aborigines, as he holds that Australia was first occupied by a negroid people who have been supplanted by the present race. This view, well known from its adoption by Sir William Flower, appears to be now generally discredited, owing to the lack of evidence in its support. The author undertakes a forlorn hope in his objection to Australian lizards being called Iguanas—often abridged to "Goanas"—because they do not belong to the genus Iguana as now restricted. The name may conveniently be retained popularly for the lizards formerly included in the Iguanidæ, and it is not so incorrect zoologically as those of "native bear" or native "cat."

There are specially interesting notes on the habits of some of the snakes and of the crocodiles, and the author appears disposed to throw doubt on the established habits of crocodiles of other continents from the different behaviour of the sluggish Queensland *Crocodilus porosus*.

Stories are often told of the wanton extermination of the Australian aborigines by the colonists. It is interesting, therefore, to learn from Mr. Roth that a collector on the coast from 1863 to 1873 endeavoured in vain to get an aboriginal skeleton for a well-known European museum. His failure shows that at least in the Port Mackay district there is no truth in the legends about the wholesale shooting of the aborigines.

J. W. G.

Through the Depths of Space. A Primer of Astronomy. By Hector Macpherson, jun. Pp. viii+123; illustrated. (Edinburgh and London: William Blackwood and Sons, 1908.) Price 2s. net.

IN this small primer the author has attempted to give an outline of all the main features of the solar system, comets and meteors, and the stellar universe. As a journalistic collation the result is not without merit, but as a "primer," presumably for persons previously unacquainted with astronomy, we fail to recognise the need for, or the suitability of, it. Having attempted too much in too little space, the author is in places forced to be dogmatic, in others he is inexplicit, and the beginner will find tabular statements which, without external assistance, will puzzle him.

To a fair extent the book consists of quotations from well-known writers fitted together with such statistics as one usually finds in popular articles; where the writer's personality appears, we find either dogmatic statements or information which is too loosely or too briefly explained. For example, on p. 28 the reader is told that in 1882, 1893 and 1905, "the disc of the sun was covered with spots"; the subsequent explanation of spot zones will but tend to confuse the beginner. In the next paragraph we read that Sir Isaac Newton showed that if "light" be passed through a prism, a band of coloured light, "known as the solar spectrum," is produced, a statement which can only convey the truth when the beginner either assumes, or knows, that it was the light of the sun that Newton employed. These examples will suffice to show that, in attempting too much, the author has occasionally lost sight of the fact that he was intending to write a book for beginners. Seven reproductions of celestial photographs and drawings illustrate the volume, some of them being from Prof. Max Wolf's beautiful originals.

W. E. ROLSTON.

LETTERS TO THE EDITOR.

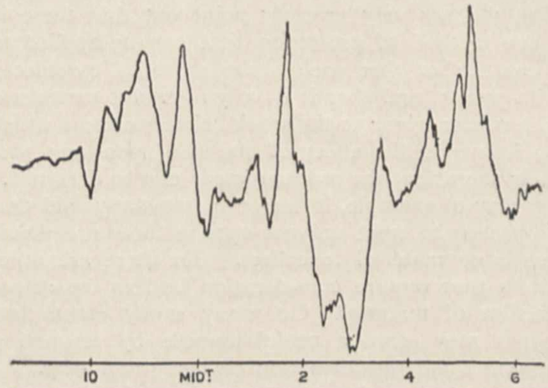
[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.]*

Large Magnetic Storm.

ON September 11–12 a large magnetic storm was experienced at Kew. There were minor disturbances earlier in the month, from September 4–6 and from September 8–10, and the magnetic traces were by no means absolutely quiet when the storm began. The commencement is, however, clearly indicated in the horizontal force curve (not reproduced). Starting at about 9h. 47m. p.m. on September 11, there was a very sudden change in the force. The movement of the horizontal-force magnet was of a type which not unusually ushers in large storms, but it was exceptionally large, representing an increase of about 112 γ in H (1 $\gamma \equiv$ 0·00001 C.G.S. unit) in less than two minutes of time. At the end of this movement H had reached its maximum during the storm. The first movement was followed by oscillations. A very rapid fall exceeding 300 γ took place between 11h. 35m. p.m. and midnight, followed by an equally rapid but smaller recovery. The other principal changes in H occurred between 1 a.m. and 2 a.m., and between 4.40 a.m. and 6 a.m. on September 12. Between 4.40 a.m. and 5.7 a.m. there was a fall of 300 γ. The extreme range was not shown on the curve, which went off the sheet, but it exceeded 500 γ. Later on September 12, between noon and 7 p.m., there was further disturbance of a much less striking character, but this was probably from a distinct origin, and the storm commencing on September 11 may be regarded as terminating about 9.30 a.m. on September 12. On this view, the immediate result was a diminution of about 100 γ in the value of H. Such temporary depressions in H are the usual legacy of magnetic storms, but the depression in the present instance seems above the average.

The declination curve, of which a tracing is reproduced on a reduced scale, shows the commencement about 9.47 p.m. on September 11 much less prominently. A small but sharp upward movement, representing an increase of about 1′ in westerly declination, is, however, visible, followed in the course of the next twelve minutes by an easterly movement of about 13′. The most salient features are the four peaks or turning points, where a prominent movement to the west terminated, and was followed by a similarly prominent movement to the east. The approximate times answering to these peaks are 11.4 p.m. and 11.44 p.m. on September 11, and 1.46 a.m. and 5.14 a.m. on September 12. The extreme easterly position was reached at about 2.53 a.m., and the extreme westerly position at about 5.14 a.m. on September 12, the total range of declination being about 1° 27′. The movements on September 12 were the most rapid. Between 1.24 a.m. and 1.46 a.m. there was a westerly movement of about 51′, followed in the course of the next eight minutes by an easterly movement of about 35′, while between 2.58 a.m. and 3.28 a.m. there was a westerly movement of about 53′. There were no large movements after 6 a.m.

The vertical force disturbance was of a somewhat unusual type. Whilst there was a certain amount of oscillation, the principal feature was that during the whole duration



September 11. Kew Declination. September 12.

of the storm—from 9.47 p.m. on September 11 to 9.30 a.m. on September 12—the vertical component, V, was depressed below its normal value. The extent of the depression may be judged from the fact that from 11.45 p.m. on September 11 to 6.10 a.m. on September 12—*i.e.* for more than six hours—V did not rise to within 150 γ of the value which it possessed when the storm commenced. By 9 a.m., however, on September 12, V had returned to its normal value. Owing to loss of trace, the extreme range of the vertical force disturbance was not recorded.

C. CHREE.

Observatory Department, National Physical Laboratory, September 14.

Bouvet Island and the Solar Eclipse of 1908 December 22–23.

A QUESTION having been raised as to whether the total phase of this eclipse will be visible at Bouvet Island, I have asked the Hydrographic Department for the most trustworthy coordinates of the island with the view of a settlement of the matter.

The position adopted for Bouvet Island on the Admiralty chart of the region is 54° 22′ S., 5° 21′ E.

Adopting the elements of the *Nautical Almanac*, the eclipse of next December for this position is a partial one, the magnitude (sun's diameter = 1) being 0·988. The island is about 10′ south of the southern limit of the zone of totality.

A. M. W. DOWNING.

H.M. Nautical Almanac Office, September 17.

Ruthless Extermination.

HAVING noticed in your issue of September 3 a most interesting article on the subject of the extermination of animals in Africa, I cannot say how indignant I feel that there should be persons who actually advocate the wholesale destruction—by international consent—of the many wonderful species which have been built up in their perfection during countless ages of evolution.

How happy should I be if the news were conveyed to me, that the man who is the ringleader of this diabolical scheme had himself fallen beneath the vengeance of a lion or a crocodile.

Even if there were sufficient proof that the sleeping sickness is propagated by the large mammals and reptiles, there are many other means of checking it besides the extermination of these animals. The increase of various birds should be encouraged which devour the flies which propagate the disease, and every other means should be taken of a reasonable character.

Although I recognise the undisputed fact that the wild species of Africa must be kept in due bounds in the more thickly populated districts, I am convinced that every State of that vast continent, should never cease to preserve a sufficient number of all the indigenous local species, and that in the near vicinity of all the principal towns national parks should be established for the preservation of these wonderful forms of life; so that future generations may not be deprived of the pleasure of beholding them.

RALPH DE TUNSTALL SNEYD.

Fairview, Leek, Staffs, September 8.

Instincts that are not Inherited Memories.

IF, as is not improbable, the presidential address to the British Association has the effect of reviving the dying embers of the use-inheritance discussion, it may not be out of place at this juncture to direct attention again to the fact that it is *impossible* to regard some of the instincts of insects as inherited memories.

Not only do the instincts of the neuters among the social Hymenoptera stand like a "lion in the path," but there are the less prominent but equally important section of instincts connected with oviposition, where, as in the case of some spiders, the female protects her eggs *after* deposition, with no possibility of the action being transmitted to the offspring so protected.

A bug, *Tectocoris lineola*, var. *banksi* (Don.), is recorded by Mr. Frederick F. Dodd (Transactions of the Entomological Society, 1904, pp. 483–5) as protecting its egg patch, laid on twigs of its food plant, by standing over them for a period of three weeks.

Females of some species of Psychid moths block the entrance of the larval case, which serves both as a puparium and place to deposit the eggs, with their bodies after depositing their ova.[1] Various species of Hymenoptera carefully block the entrance to the burrows where their eggs are laid, &c.

A. BACOT.

154 Lower Clapton Road, N.E., September 8.

Meteors and the Comet.

SEPTEMBER 13, 8h. 32m., mag. 1, rapid, streak, $343^\circ+26^\circ$ to $332\frac{1}{2}^\circ+12^\circ$. Radiant, $71^\circ+52^\circ$.

September 14, 9h. 19m., mag. 1, slowish, yellow, $336^\circ+38^\circ$ to $330\frac{1}{2}+48^\circ$. Radiant, $343^\circ+24^\circ$ or $347^\circ+15^\circ$.

On September 14, at 9 p.m., the comet was seen at Bristol in a 2-inch field-glass just north of 50 Cassiopeiæ as a misty patch, perhaps about equivalent to an eighth-magnitude star.

W. F. DENNING.

Bristol.

Meteors.

THE observation of meteors forms one of the most attractive branches of astronomy. No instruments are needed. The observer only requires patience, a pretty good eye, and experience, which, of course, must be learned.

Meteors fall on every night of the year. The sky may be lit with the moon, it may be murky, it may be cloudy, but still there are the meteors going on unceasingly. For every one seen by human eyes there are no doubt thousands, probably tens of thousands, unseen. Yet this branch, involving as it does star-gazing pure and simple, is a most attractive one, and in the bright years of the future it will no doubt occupy a very prominent place.

Bristol. W. F. DENNING.

[1] "Brit. Lepidoptera," Tutt, vol. ii., p. 367.

SURVEYING FOR ARCHÆOLOGISTS.[1]

III.

Instruments for the Measurement of Magnetic Azimuth alone.

THE most inefficient instrument to employ in measuring magnetic bearings is the ordinary mariner's compass, showing the compass points only.

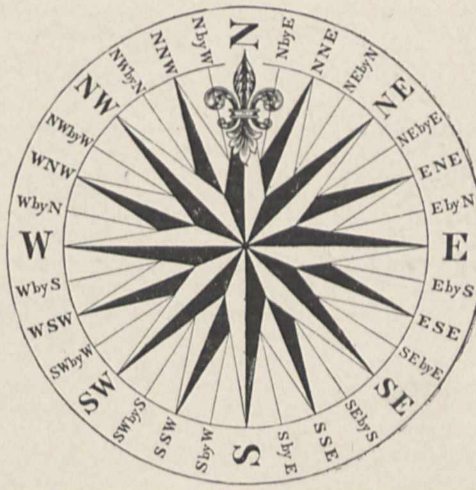


FIG. 7.—The "points" of the mariner's compass.

But there are now mariner's compasses available in which the bearings are stated in degrees, and in many ways, the degrees running from N. and S. to E. and W., and so on. The best form of card, however, is represented in Fig. 8, in which the degrees run from N. through E., S., W. to N. again.

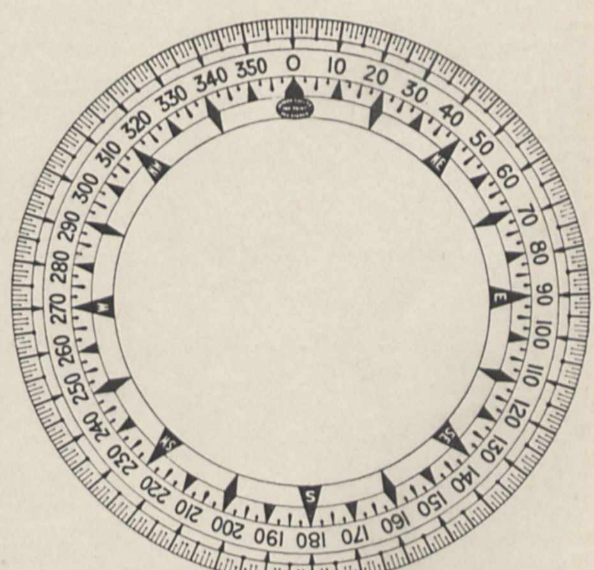


FIG. 8.—Compass with the circle of the horizon divided into 360 degrees, the N. point being 0°.

The magnetic bearings thus obtained should at once be changed into true bearings; this can be done approximately by reference to the appended maps, which bring together the recent results obtained by the Ad-

[1] Continued from p. 445.

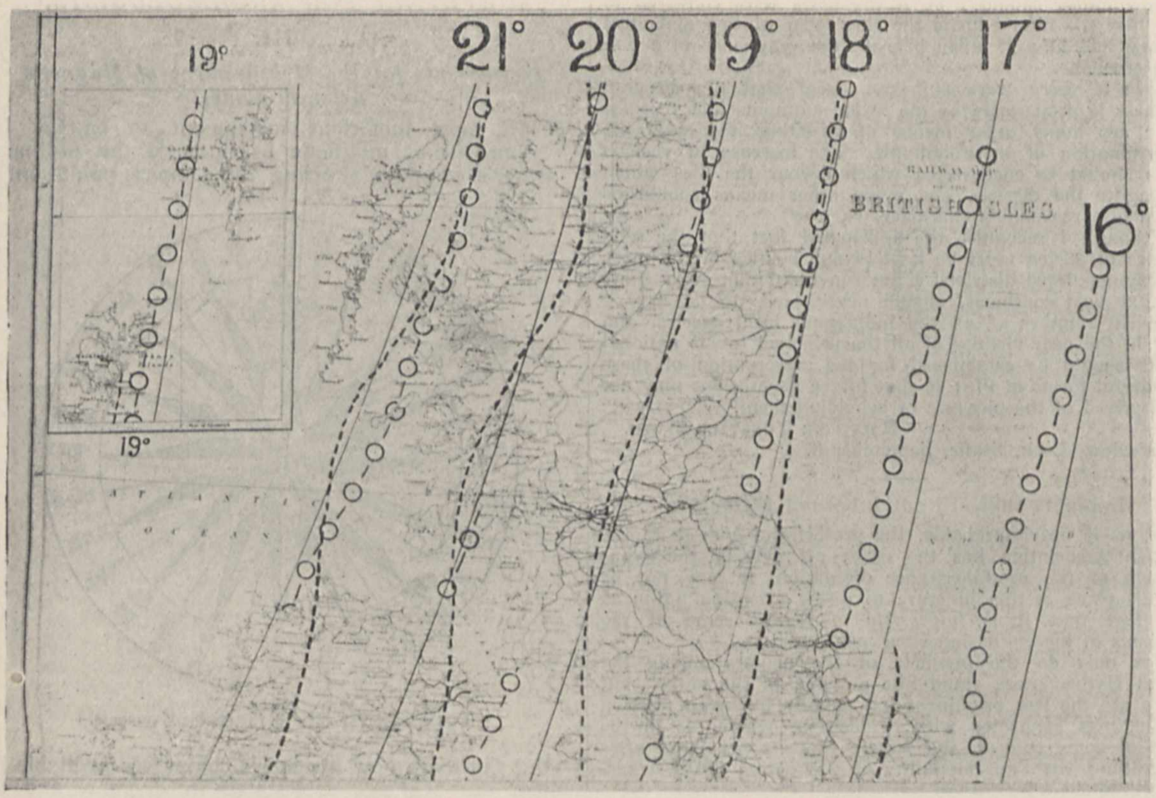


FIG. 9.—The western magnetic variation in N. Britain and N. Ireland in 1907.

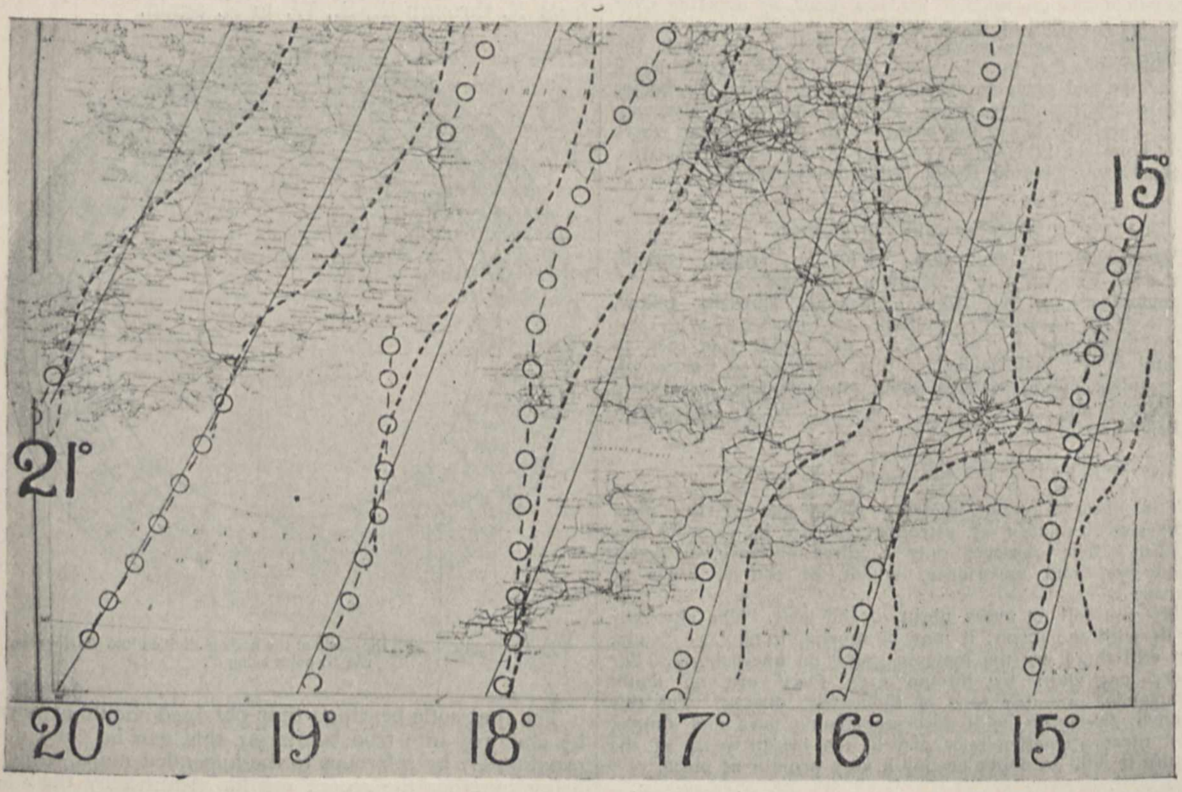


FIG. 10.—The western magnetic variation in S. Britain and in S. Ireland in 1907.

miralty. The full smoothed line shows the average position of the line of equal variation for 1907, the dotted line the variation obtained from land observa-

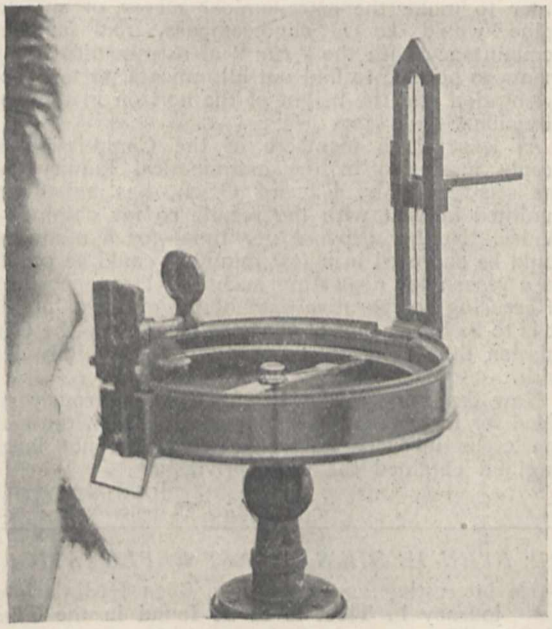


FIG. 11.—The prismatic compass, showing the sighting arrangement and manner of use.

tions alone, and the dot and circle line that got by observations at sea alone.

It will be seen that there is a strange divergence between the land and sea observations, but in spite of this the chart enables us to estimate the variation at any place on it within half a degree without astronomical observation.

I am glad to learn that the use of the mariner's compass pure and simple is now rapidly going out of use so far as archæologists are concerned, and for the rapid measurements of azimuths alone, using magnetic bearings, the azimuth, or prismatic, compass is the instrument generally employed.

It is cheap, light and handy. In the smaller instruments the needle is attached to the under surface of a compass card showing the thirty-two magnetic points. In the best forms a magnetised bar having an agate centre balanced on a steel pivot carries an aluminium or silver ring, which is graduated to half degrees, and with many monuments a greater accuracy than this is not possible. Its general arrangement will be gathered from Fig. 11. At one end of the box is a fine wire, at the other a right-angled prism; above the prism is a narrow slit, through which the wire is observed over the centre of the graduated ring. The prism reflects to the eye the graduation under the slit, so that this, the wire, and the object observed are seen together. The graduation runs from 0° to 360°, the zero lying in the N. point of the magnetic meridian, so that the graduation read is the magnetic azimuth of the object seen through the slit in line with the wire.

In order to get a zero reading under the prism when we are looking magnetic north, the zero of graduation is at the magnetic south end of the needle.

The support of the fine wire also carries a hinged mirror, by means of which the azimuths of objects considerably above the horizontal line can be measured. For measuring the azimuth of the sun on the horizon, dark glasses are attached to the slit plate, which can be thrown into use when required.

When at work, when the box is rotated to bring any object in the line of the slit and wire produced, the needle, and with it the graduated ring, remains steady.

An ordinary level, furnished with a needle and card, can also be used for taking magnetic azimuths alone.

The 25-inch maps of the Ordnance Survey have put into the hands of archæologists a tremendous engine of research, from which true azimuths can be at once found without the intervention of a magnetic instrument in the field. To do this a *circular protractor* is employed in the manner shown in the accompanying figure.

In the case of the Avenue represented, a line some 12 inches long is drawn parallel to its length. Another line is then drawn parallel to the side of the map, which is always a N. and S. line, or very nearly so. The zero of the protractor is brought on the N.

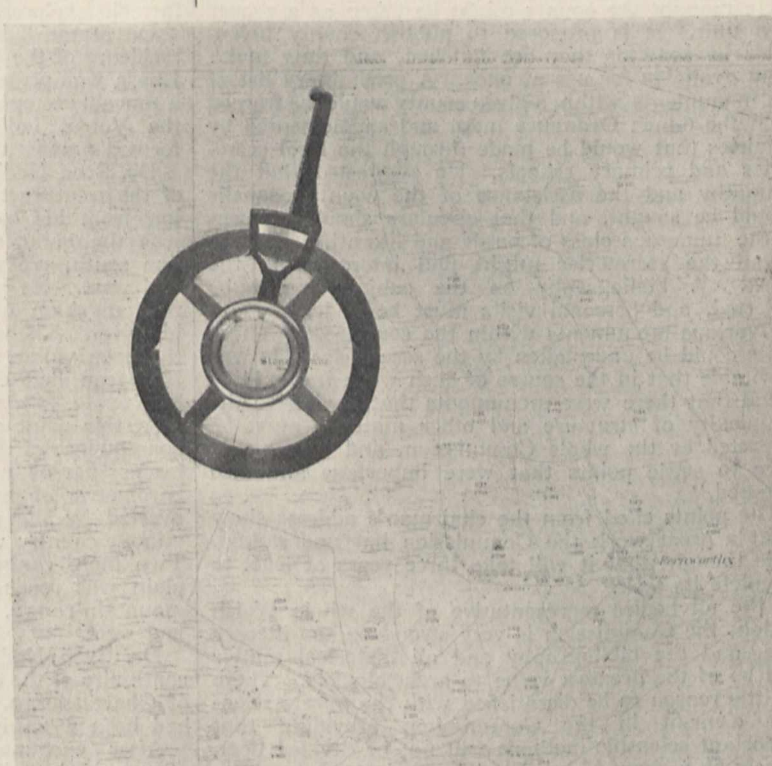


FIG. 12.—The circular protractor measuring the azimuths of an avenue on a 25-inch Ordnance Map of Dartmoor.

and S. line, and the centre on the point of intersection. The angle between the two lines is the azimuth.

NORMAN LOCKYER.

THE ROYAL COMMISSION ON WELSH MONUMENTS.

THE first meeting of the Royal Commission on Ancient Welsh Monuments in Wales and Monmouthshire, was held in London on Friday, September 11. Sir John Rhys, the Chairman of the Commission, after recounting the terms of reference, expressed his views as to the nature and scope of the Commission's work, and the lines upon which he proposed to direct its course.

"The work," he said, "would not be difficult if they proceeded from county to county and parish to parish, and simply drew up a bare list or inventory of the objects of antiquarian and historical interest therein; but it was clear that such an inventory would be of no scientific value unless those objects were classified according to their character, intention, and probable date. It was only by a comparative method that they could hope to answer many of the questions with which they would be confronted, and it was desirable, therefore, that the classificatory system adopted by the Commission should be uniform with that in use by other commissions of a similar character. With regard to ancient earthworks, he thought it would be better to adopt the divisions suggested by the Congress of Archæological Societies in 1901. No specific power was given to the Commission under which they could engage in exploratory work for the purpose of ascertaining the age or character of any particular object, though it was difficult to see how without such guidance the classification of some objects could be determined satisfactorily."

He thought the county might be taken as a proper area unit. It is proposed to publish county inventories as soon as they are finished, and thus make them available for use at once. A preliminary list of the monuments within a given county would be framed from the 6-inch Ordnance map, and supplemented by inquiries that would be made through the local secretaries and primary schools. He suggested that the sympathy and the assistance of the county councils should be sought, and that circulars should be sent to the numerous class of bards and literati, and those whom the secretaries might find interested in the work. A bibliography on the subject would be collected, and personal visits must be undertaken to the various monuments within the counties. "Those visits could be undertaken by the secretaries. It was inevitable that in the course of such work it would be found that there were monuments that, owing to the complexity of structure and other matters, must be inspected by the whole Commission, and they would have to settle points that were important and also disputed."

The points cited from the chairman's address show what a great work the Commission has undertaken. It is thought that it will take three years at least to complete its task.

Like all bodies representative of the whole Welsh nation, the Commission is very strong on the literary side, and the bibliography and all historical matter will be of the greatest value to archæologists. There is little reason to be dissatisfied with the purely scientific element in the Commission, providing that important scientific methods will not be decided upon merely by a show of hands. The chairman's remarks warrant our highest expectations as to the thoroughness with which the work will be done.

Though the Commission is not specifically empowered to engage in exploratory work, it is clear by the proposal to make personal visits to the monuments that a work more urgent and far easier than any explanatory work can and most likely will be done, namely, an astronomical survey of all monuments which lend themselves to such an inquiry. No body of experts would make such visits without an ordinary compass. All that would be required in order to make the astronomical survey of sufficient value would be a clino-compass, and sufficient acquaintance with the "run" of astronomical monuments to be able to find out alignments, to take their orientation and the height of the horizon in the same direction.

At least three members of the Commission are deeply interested in the astronomical inquiry, and the secretary, Mr. Edward Owen, has already acquainted himself with the results so far obtained in Wales. Neither expense nor time—for a monument could be surveyed in a few minutes—could be pleaded as a reason for neglecting such a golden opportunity of securing comparative data of the greatest interest. It is to be hoped that at the next meeting of the Commission this important matter will be definitely dealt with.

Now that little Wales has been so generously provided for in the matter of this Commission, the question crops up very naturally, Why has not larger England obtained the same privilege?

JOHN GRIFFITH.

DR. SVEN HEDIN'S LATEST EXPLORATIONS.

AN interesting account of Dr. Sven Hedin's latest journey in Tibet is to be found in the *Times* of September 17 and 18, from which we gather the following particulars of the discoveries made by this intrepid explorer.

On March 8 last he came across stone houses, the residence of the local chief, but only a high lama from Lhasa was present, living in a great tent, which was a movable temple, similar to that of the Kalmucks on the Volga, indicating that religious rites are performed among the nomads.

Dr. Sven Hedin then went along the northern edge of the great tract between latitudes 30° and 32°, stretching from his old route to the Brahmaputra, which was the great object of his journey. He marched due south, crossing several ranges all running east and west. He passed the enormous ice mountain of Shakangsham on the east, from which flowed the big river. Thence he went over the Ladang pass into the open valley, and the Bongba province, which no European had ever before entered, lay open before him.

At this point great precautions had to be taken in consequence of the suspicions of the Tibetans, and the leader narrowly escaped detection whilst making barometric observations. However, the danger was averted by the march being diverted to the mountainous country where Lake Chunitso was discovered. Two more ranges were crossed, and then the open plain was reached, bounded southwards by a great mountain range, 2000 miles long, which stretches east and west.

Dr. Sven Hedin was rewarded by discovering the continuity of the chain. He found also that the course of Chartatsango, a big effluent of the Brahmaputra, had been wrongly marked on the maps.

After encountering serious opposition, and his caravan being divided, Dr. Sven Hedin left Bis on May 5, and travelling due north crossed a pass of 1900 feet in the Great Range, and made for Lake Tederam, the existence of which Nain Singh reported in 1873, its real name being Terenam. He found the lake to be long, narrow, and salt, and entirely different from its representation on the map.

He then turned westward and visited the Mending temple, situated on the bank of the Somathangpo, the largest river in Tibet, without outlet to the ocean. Crossing a range 20,000 feet high, he reached Khala, shown on the maps as a great peak, but really a pass in a high range running from the main system. He then came to Ghalaringtso, which is described in the maps as containing a monastery on an island. Its real name is Ngnanglaringtso, and there are five islands. The shape given in the maps is reported to be wrong, as it runs east and west and is intersected by three rivers. The explorer again crossed the Great Range, and reached Mansorawar on July 26, and thence by known roads made his way to Simla.

Dr. Sven Hedin sums up the results of his explorations as follows:—

"First, the true sources of the Brahmaputra and Indus, and the genetic source of the Sutlej east of Mansorawar Lake.

"Secondly, the exploration of Bongba, whicn I traversed twice by different routes.

"But the greatest of all is the discovery of that continuous mountain chain which, taken as a whole, is the most massive range on the crust of the earth, its average height above sea level being greater than that of the Himalayas. Its peaks are 4000 feet to 5000 feet lower than Everest, but its passes average 3000 feet higher than the Himalayan passes. The eastern and western parts were known before, but the central and highest part is in Bongba, which was previously unexplored. Not a tree or a bush covers it; there are no deep-cut valleys, as in the Himalayas, for rain is scanty. The absolute heights remain to be calculated from observations made on the ten passes which I crossed."

It is stated that the new map of Tibet will be in 900 sheets, and that all the heights of the passes, the river crossings, and the encampments are recorded; a hundred astronomical points have been fixed, and several thousand panoramas have been taken, with compass bearings and names, while many photographs, pencil drawings and water colours have been brought back, together with meteorological observations and a collection of geological specimens, with the dip and fall of the rocks, from 1200 different points. The total length of Dr. Hedin's journeys is estimated at 4000 miles.

NOTES.

ACCORDING to Reuter's Agency, the negotiations which have been in progress for some time between Great Britain and Germany for the conclusion of the agreement to combat sleeping sickness in the African possessions of the two countries are now practically complete. It is thought that the new regulations will become operative on November 1. The convention, which is for a period of three years, provides that British and German doctors and the officials in charge of the concentration camps shall keep in touch with one another to compare the result of their various researches. Segregation camps will be established on either side of the international boundary, while infected natives will be prevented from passing into uninfected districts, such persons being detained and segregated. The convention also provides for the notification to the officials of both Governments of all infected areas, and for taking effective measures for dealing with crocodiles or other animals which may be found to be the food of the fly which carries the disease.

THE death is announced, at the age of eighty-nine years, of Prof. J. G. Hjalmar Kinberg, of Stockholm, well known as a medical practitioner and as a zoologist; also (at the age of sixty-two years) of Prince Ivan R. Tarkanoff, until 1895 professor of physiology in the Military Academy of St. Petersburg, and since that date *privat-docent* on biology and physiology.

THE death is announced, at the age of sixty-one years, of Mr. George Nicholson, formerly curator of the Royal Gardens, Kew.

A COMMITTEE has been formed, under the chairmanship of ex-President Loubet, for the purpose of erecting a monument to the memory of the late Prof. Cornil at his birthplace, Cusset, near Vichy, France, and a public subscription list for the object in view has been opened.

SOME time ago a subcommittee of the Royal Society of Victoria was appointed to consider the question of establishing a memorial of the late Dr. A. W. Howitt. We learn from the *Victorian Naturalist* that it has now been decided to raise a fund of at least 100*l*. to found a "Howitt" medal, to be awarded from time to time to the author of distinguished work dealing specially with the natural science of Australia.

WE have to record with regret that a serious accident, attended with a fatal result, happened to the aëroplane of Mr. Orville Wright on September 17. The machine, after successfully making several evolutions, suddenly fell to the ground, in consequence, it is stated, of the breaking off of a blade of one of the propellers, and thus disturbing the balance. Mr. Wright sustained a fractured leg, and Lieut. Selfridge, who accompanied him as a passenger, has died from the effects of his injuries.

MR. WILBUR WRIGHT made a successful flight in his aëroplane at Le Mans on Monday last. The flight lasted 1h. 31m. 25s., in which time he covered 66 kilometres 600 metres, thus surpassing all previous performances both as to distance and time.

DR. SVEN HEDIN has accepted the invitation to lecture before the German Geographical Society at Berlin on the results of his recent explorations.

ACCORDING to the Stockholm correspondent of the *Globe*, the expedition under Prof. Baron Gerard de Geer, of the Stockholm University, which has been exploring the Spitsbergen group of islands, has just returned. The results (in geography, geology, biology, and hydrography) are reported to be most interesting. They will be submitted to the International Congress of Geology which is to be held at Stockholm in 1910.

ACCORDING to the *Times* of Monday last, the Royal Geographical Society has received information (dated from Khotan, July 15) from Dr. M. A. Stein respecting that explorer's latest archæological and geographical investigations in Central Asia. March and the early part of April were spent in archæological labours along the desert belt adjoining the oasis from Domoko to Khotan. Amongst the ruins newly traced there are the remains of a large Buddhist temple, decorated with elaborate frescoes, now completely buried by high dunes in the desert strip between the Yurung-kash and the Kara-kash rivers. On the curious desert hill of Mazar-tagh, which flanks the Khotan river on the west, some six marches below the Khotan oasis, Dr. Stein discovered the ruins of a fortified watch station once guarding the river route, and from great masses of refuse recovered numerous documents on wood and paper, in a variety of scripts, mainly Indian, Chinese, and Tibetan, and none apparently later than the eighth and ninth centuries A.D., many of which are stated closely to correspond in appearance and character with the records brought to light by Dr. Stein last year from the ruined fort of Miran, south of Lop-nor. By the beginning of May the expedition reached Aksu, where Dr. Stein was able to arrange for the local help which Rai Lal Singh needed for the continuous survey he was to carry along the outer Tian-shan range westwards as far as the passes above Kashgar. Dr. Stein himself travelled up the Uch-Turfan valley, and thence marched by a route not shown by published maps across a barren but remarkably picturesque mountain range to the oasis of Kelpin. A rapid journey *viâ* Yarkand brought Dr. Stein by the middle of June back to Khotan, where he expected to remain until the end of July engaged in packing and arranging the archæological collections gathered in his two years' wanderings. After completing his task at Khotan, Dr. Stein hoped to carry out, with Rai Lal Singh, explorations in those parts of the high Kwenlun range about the Yurung-kash and Kara-kash sources which still remain to be surveyed, and late in September to be able to start on the return journey to India over the passes of the Kara-korum, and to arrive in England in December.

THE nomination for the directorship of the new Australian Institute of Tropical Medicine has been delegated to the Royal Society and the Schools of Tropical Medicine of Liverpool and London, which institutions, according to the *Times*, have formally accepted the delegation. After nomination, however, the actual appointment of the director will be made by Prof. Martin, F.R.S., of the Lister Institute of Preventive Medicine, acting in conjunction with the Bishop of North Queensland, on behalf of the Australian universities having medical schools and of the Governments concerned. The institute, assisted by a grant of 400*l*. from the Colonial Office, is being subsidised by annual grants from the Commonwealth and the Queensland Governments. It will be established at Townsville, North Queensland.

MR. ROBERT NELSON has been appointed by the Home Secretary to the newly created post of his Majesty's Electrical Inspector of Mines; he has also been directed to act as an inspector for the purposes of the Metalliferous Mines Regulation Acts, 1872 and 1875, and of the Quarries Act, 1894. Mr. Nelson has further been appointed an inspector of factories and workshops for the purposes of the Factory and Workshop Act, 1901.

DR. LEWIS GOUGH, of the Transvaal Museum, has been appointed zoologist to the Government veterinary bacteriologist, Pretoria.

THE first general meeting of the recently formed Institute of Metals is to take place at Birmingham on November 11. The gathering will probably occupy two days. Mr. G. Shaw Scott has just been appointed secretary of the institute.

AN all Russian Oto-Laryngological Congress (the first of its kind) is to be held at the Pirogoff Museum on January 8–11 next, and in connection with it there will be an exhibition of instruments, apparatus, &c.

THE trustees of the Samuel D. Gross prize of the Philadelphia Academy of Surgery give notice that they are prepared to receive essays in competition for the prize until January 1, 1910. The prize, value 1500 dollars, is awarded every five years to the writer (such being an American citizen) of the best original essay, not exceeding 150 printed octavo pages, illustrative of some subject in surgical pathology or surgical practice, founded upon original investigations.

MR. J. B. TYRRELL, of Toronto, offers a prize of 100 dollars for the best collection of minerals collected during the year 1908 in the province of Ontario by anyone not a professional collector. The collection must contain not less than thirty specimens, each bearing a label giving particulars as to the exact locality from which it was obtained and the date on which it was collected. Competing collections must be addressed "Tyrrell Prize, Government Assay Office, Belleville, Ont.," and reach the address in question by December 1 next.

AN appliance for working the keyboard of a typewriter on a type-setting machine from a distance by means of wireless telegraphy has been devised by Mr. Hans Knudsen, and a demonstration of the experimental apparatus was given at the Hotel Cecil on Thursday last.

THE skeleton of the mammoth which was found in January last in the sandy bed of the river Sangar-Yurach has now been conveyed under the auspices of the Imperial Academy of Science to St. Petersburg. The specimen is to be mounted in the zoological museum at St. Petersburg.

ALTHOUGH the capture of giant "devil-fish," or eagle-rays, in tropical waters is by no means an uncommon event, it is but seldom that accurate measurements and photographs of specimens of this nature are obtained. We have therefore reproduced the photograph of one of

Giant "Devil-fish" taken at High Island, Texas.

these fishes (for which we are indebted to the Rev. T. R. R. Stebbing) recently landed at High Island, off the coast of Texas, together with certain particulars regarding its size as recorded in the *Daily Picayune*, New Orleans, of August 2. The fish, as shown by the form of its "horns," is a species of Ceratoptera; it measured 12½ feet in transverse diameter, and 9 feet from the mouth to the root of the tail. The interval between the eyes was 44 inches, and the diameter of the mouth 36 inches. No means of ascertaining the weight of the monster were available, although, at a low estimate, this was surmised to be at least 1300 lb. When first seen, the fish was thought to be a couple of porpoises swimming side by side; it was killed by repeated rifle-shots, by the first of which it was struck in the head near one of the eyes. According to local observers, the pair of processes which project like horns from the sides of the head are used to make a disturbance in the water and drive small fishes into the creature's capacious mouth.

To the July number of the *Emu* Mr. H. C. Oberholser contributes a useful synopsis of the known species of swans, recent and fossil. Living swans the author divides into the genera Cygnus, Olor, and Chenopis, the South American Coscoroba being regarded (we think wrongly) as a duck. In our opinion such generic divisions seem superfluous, but if they are adopted surely the emendation Chenopsis for the absurd and meaningless Chenopis might be accepted. The large Pleistocene swan of Malta is referred to yet another genus, under the name of *Palaeocygnus falconeri*, on account of its relatively short thigh-bone, long metatarsus, and short, thick toe-bones. A fossil black swan (*Chenopsis sumnerensis*) has been named on the evidence of bones from a cave at Sumner, near Christchurch, New Zealand, and a second (*Ch. nanus*), of very small size, from Pleistocene or Pliocene deposits at Lake Eyre, South Australia. From the same locality have been obtained remains of a larger swan which Mr. de Vis has made the type of yet another genus, under the name of *Archaeocygnus lacustris*, despite the apparent slightness of the osteological differences by which it is distinguished from the existing black swan.

IN sending a copy of part iii. of the first volume of the Annals of the Natal Government Museum, Dr. Warren refers to the large number of plates necessary for the proper illustration of the specimens described, which comprise a large number of new species. As these plates, of which there are no less than fourteen (with five of double size) in the present issue, are executed, for the most part in London, in the best possible style, the expenses of publication are necessarily very great. An increase in the number of subscribers is therefore asked for, in order that this invaluable journal may be carried on in the same style as hitherto. The contents of the present part comprise an article by the editor on a collection of hydroid zoophytes, for the most part from the Natal coast, in which several new species are described, while others receive fuller illustration and description than have previously been accorded them. Mr. G. A. Boulenger describes several new fresh-water fishes and reptiles (including one of Zonurus and another of Gerrhosaurus), while in a third paper Mr. C. T. Regan contributes to our knowledge of the marine fish-fauna of this part of Africa.

THE greater portion of the third part of vol. xxxviii. of *Gegenbaurs Morphologisches Jahrbuch* is devoted to an article on the human sacrum, by Dr. C. Radlauer, of the Anthropological Institute of Zurich University. After the examination of a very large series of specimens, the author finds that, in addition to a remarkably large range of individual variation, this portion of the skeleton also shows modifications dependent upon sex and race, special attention being devoted to variations of the latter type. As regards individualism, it is pointed out that whereas five vertebræ normally unite to form the sacrum, the number may be occasionally reduced to four or augmented to six, the addition being less uncommon than the subtraction of an element. As regards sexual variation, the sacrum is relatively broader in the female than in the male. The breadth in both sexes (each for each) is, however, greater in European than in non-European races; there is also a distinction in the form of the under surface in European sacra compared with those of other races. Bushmen, Malays, and Chinese possess a sacrum of the "dolichohierische" type; in most negroes, Ainus, and Japanese the type is "subplatyhierische," while in some Japanese, Australians, and Europeans it becomes "platyhierische." In view of recent changes of view in regard to the relationship of the natives of Australia, their association from the present standpoint with Europeans is extremely significant.

GRAPHIC methods of recording and utilising bird-migration data form the subject of an article by Mr. W. Stone in the April issue of the Proceedings of the Philadelphia Academy of Sciences. The date of the first arrival of one particular species in a given locality is not a fact of much importance or value, and the author suggests, in lieu of the recording of such isolated cases, maps for certain districts embracing a ten-mile radius should be prepared on which all early arrivals can be plotted. Charts showing temperature-variation in connection with bird-migration are also suggested and exemplified by samples.

IN *Annotationes Zoologicae Japonenses*, vol. vi., part iv., Mr. I. Ikeda records the interesting fact that at certain seasons the relative of Balanoglossus known as *Glandiceps hacksii* consorts in swarms and assumes a pelagic habit. In the same issue Dr. A. Oka describes a new genus and species (*Stephanella hina*) of fresh-water bryozoans from Japan. In many respects the new genus differs from any hitherto known, this being specially noticeable as regards the peculiar conformation of the colony, which differs from that of all other phylactolæmatous fresh-water bryozoans in that it consists of a thick, creeping stolon and of a single upright polyp-stem, such as is found in certain marine members of the ctenostomatous group.

A SECOND botanical part of the *Philippine Journal of Science*, issued in June, contains a paper by Signor M. Ugolino on the native species of Pandanus, describing varieties of *Pandanus tectorius* and several new species. Among the determinations of Philippine fungi communicated by Dr. P. Hennings are new species of Uredo, Aecidium, Phyllachora, Rosellinia, and Diplodia. One species of Rosellinia and *Pestalozzia palmarum*, genera known as insidious pests in the tropics, were taken on cocoa-nut trees, and a Diplodia was obtained from the scales of a Pandanus fruit. Mr. E. D. Merrill contributes an article on the plants collected by the Wilkes United States Expedition in 1842, and a further instalment of botanical literature connected with the islands.

MR. A. M. F. CACCIA has compiled a glossary of technical terms for use in Indian forestry that has been published as Forest Pamphlet No. 3 by the Government of India. The forester's vocabulary consists of many technical expressions such as form factors, sylvicultural systems, classes of rotation, as well as terms that have a special application, to wit, fireline and forest devil. The Indian forester cannot be accused of coining terms, as "taungya" or "jhum" and "indaing" appear to be the only contributions, the former referring to sowing the seed of special trees with field crops, the latter to forests where "in" trees, species of Dipterocarpus, abound. A special list of American terms furnishes a tribute to the push of American foresters. Tree scribe, volunteer growth, and veteran require explanation, but to harden off and sapling sound distinctly British.

AN account of the plant formations in mid and southern Greece, contributed by Dr. E. Pritzel to Engler's *Botanische Jahrbücher* (vol. xli., part iii.), derives special interest from the classic associations connected with the regions described. Olive trees still clothe thickly the Attic plain, and the vine foliage colours the valley of the Cephissos that flows towards the Piræus. In other parts the evergreen formations termed "maquis" are found. The characteristic trees in the maquis are the Aleppo pine, species of Arbutus, and *Quercus coccifera*. A subformation, the "phrygana," consists of bushes and other xerophytes. Here grows the Greek thyme, *Thymus capitatus*, famous as the food of the bees of Hymettus; associated with it are *Poterium spinosum, Genista acanthoclada*, and *Phlomis fruticosa*.

IN the September issue of *Man* Prof. J. G. Frazer discusses three remarkable statues of kings of Dahome now deposited in the Trocadero Museum. The figures are symbolical, each king being represented in the guise of an animal. Thus, Guezo, who reigned from 1818–58, and was known as "the cock," is represented by a man covered with feathers; Guelele (1858–89), "the lion," as a lion rampant; Behanzin, his successor, who was finally deposed by the French, known as "the shark," appears as a dog-fish graced with the arms and supported by human legs. The "feathers" which once covered the statue of Guezo are nothing but metal plates, nails, gimlets, and scraps of old iron. Prof. Frazer observes that the existence of these statues seems to prove that certain kings of Dahome habitually posed as certain fierce animals or as birds. They possibly intended by this means to serve some magical purpose. At any rate, they cannot be totems hereditary in the male line, since they differed in three successive generations traced from father to son.

MR. A. L. KROEBER, in the second Bulletin of the eighth volume of the reports on American archæology and ethnology issued by the University of California, publishes an elaborate memoir on the Cahuilla Indian tribe which occupies the southern part of the province. The primitive culture of this people has in a great measure disappeared, but Mr. Kroeber has been able to collect a number of interesting exhibits which throw light upon their social and religious culture. This is not of a uniform type, being largely conditioned by the varied environment to which they are exposed. Basketry in the form of domestic appliances, mortars, caps, granaries, water jugs, and the like, is, as is usual among the neighbouring tribes, ingenious and artistic. The few examples of pottery discovered, though of an inferior class, are interesting as specimens of an art which has now practically disappeared; in fact, so little has been found that it was at one time supposed that the art of manufacture was unknown to these Indian tribes. Bows and arrows, flutes, and digging-sticks are some of their manufactures in wood. Most of the ceremonial objects connected with their pagan rites have disappeared since their adoption of Christianity, and the same is the case with their ceremonies, the most important of which were an annual tribal mourning for the dead, a puberty rite for girls, and an initiation ritual for youths, at which the jimson-weed was infused and drunk as a mode of producing religious ecstasy. The numerous illustrations appended to the report clearly illustrate the culture of this rapidly disappearing people.

THE Mitchelstown caves, described by Dr. C. A. Hill in a paper before the Geographical Section of the recent British Association meeting, have since been completely explored and surveyed. These caves are of great interest, not only from the fact that they are the largest in the British Isles, but also on account of their historical associations. The earliest plan is that of Dr. Apjohn, in 1833, and a later one was published by M. Martel in 1893. Many new passages have now been discovered, and it is hoped that the new plan, together with a description, will be published shortly. The work of survey and exploration was carried out by Mr. H. Brodrick, Drs. C. A. Hill and A. Rule, of Liverpool, and Mr. R. Lloyd Praeger, of Dublin.

THE current issue of the Transactions of the Geological Society of South Africa, covering the period from January to June, affords evidence of the admirable work that is being done in the scientific investigation of South African mineral deposits. Mr. H. Merensky describes the rocks belonging to the area of the Bushveld granite complex, in which tin may be expected. The descriptions of the deposits actually found show that the local conditions correspond in all essential points with those in other parts of the world. Mr. E. P. Mennell describes the occurrence of diamonds at Somabula and Bembezi, in Rhodesia. Mr. R. B. Young records the occurrence of yellow and red ochre in the Potchefstroom district, Transvaal. The occurrence is of interest commercially, and also on account of the clear indications that it is the result of the extreme decomposition of an igneous rock. Mr. A. L. Hall and Mr. W. A. Humphrey describe the occurrence of chromite deposits along the southern and eastern margins of the Bushveld plutonic complex. The ore occurs in veins in norites, hypersthenites, enstatite rocks, and olivine-bearing serpentines. The occurrence of platinum in some of the chromite deposits is of great interest in view of the close general resemblance to the conditions under which platinum is found *in situ* in the Ural, and suggests the possibility of finding alluvial platinum in South Africa. This number of the Transactions also contains important papers on contact metamorphism in the Pretoria series of the Lydenburg and Zoutpansberg district by Mr. A. L. Hall, on contemporaneous igneous rocks in the Pretoria series by Mr. A. L. Hall, and on the stratigraphy of Zwartkop by Mr. G. S. Corstorphine and Mr. E. Jorissen.

FROM the Department of the Interior, Manila, we have received an attractive pamphlet of thirty-nine quarto pages, with six plates and two maps, issued by Mr. Warren D. Smith, chief of the division of geology and mines. It deals with the mineral resources of the Philippine Islands, and contains the first annual statement of mineral production. The production in 1907 consisted of 4540 ounces of gold, 83 ounces of silver, 436 tons of iron, and 4545 tons of coal. Although the figures are insignificant, the record is a valuable one as indicating the progress that has been made in placing the mining industry on a satisfactory basis. Many difficulties are encountered. Natural features of the country are sometimes insurmountable, and the labour question is a serious one. The history of the district of Benguet shows, however, that a sure and profitable mining industry can be built up in the islands. Appended to the report are memoirs on the geology of north-western Mindanao, on mining prospects on the Zamboanga peninsula, on the characteristics of Philippine ores, and on the characteristics of Philippine coals. Most of the coals are useful for steaming purposes, and for the production of power the utilisation of the outcrop coal for producer-gas seems extremely promising.

IN view of the centenary of James Nasmyth's birth, the date of which was August 19, 1808, a review of his engineering work is published in the *Engineer* of September 18. Nasmyth invented the steam hammer in 1839, and applied the steam hammer to pile-driving in 1845. The details given of numerous other new ideas he presented to the world clearly show to what a large extent engineers are indebted to him.

THE new edition of the French pharmacopœia (the "Codex Medicamentarius"), which has been recently issued, differs materially from the edition immediately preceding it, which appeared in 1884. The alterations are chiefly concerned with the simplification of preparations, such as the tinctures of iron and opium, in the manner recommended by the recent International Convention which considered the maximum doses of potent drugs. Many preparations which have fallen into disuse, and which had become stereotyped in former editions, have been omitted from the one just published, while a certain number of new drugs are included, such as adrenalin, theobromine, tuberculin, and other agents employed in opsonic, vaccine, and serum therapy.

THE Journal of the Royal Sanitary Institute for September (xxix., No. 8) contains papers read at the congress at Bristol. Dr. Savage deals with the hygienic preparation of sausages, showing that, as ordinarily prepared, they always contain *Bacillus coli* in numbers varying from 10 to 120,000 per gram. The presence of this organism in such large numbers is evidence of an undesirable want of cleanliness in some part of the process of manufacture.

THE *Rendiconti* of the Reale Accademia dei Lincei, part ii., 1908, contain an account, by Dr. C. Alessandri, of observations of solar radiation at the Regina Margherita Observatory on Monte Rosa (lat. 45° 56′) in the months of August and September, 1905 and 1906. This study of solar radiation at an altitude of 4560 metres is an important contribution towards the solution of the intricate question of the possible influence of the sun's varying intensity on the weather at the earth's surface. The observations were made with Ångström's pyrheliometer, to which are added the readings of Arago's actinometer, air pressure, temperature, and other data. At the time of the solar eclipse of August 30, 1905, which occurred at Monte Rosa between 1h. 5m. and 2h. 55m. p.m., with a perfectly clear sky, the values obtained vary from 1·651 gram calories at 12h. 41m. to 0·298 at 2h. 20m. and 1·530 at 3h. 39m. p.m. The observations made in 1907 will be communicated to the academy in a subsequent note.

OUR ASTRONOMICAL COLUMN.

COMET MOREHOUSE, 1908*c*.—Although, according to its ephemeris, Morehouse's comet is increasing in brightness, it still remains a disappointing object except to those possessing large instruments; this is probably due partly to its diffuse nebulous nature and partly to the strong moonlight that has obtained during the time which has elapsed since its discovery on September 1.

Numerous observations of this object are recorded in No. 4273 of the *Astronomische Nachrichten* (p. 14, September 14), having been communicated, telegraphically, to the Kiel Centralstelle. The comet's magnitude was recorded as 9·0 at Copenhagen and at Uccle on September 4, as 10·0 by Prof. Palisa at Vienna on September 5, and as 9·3 and 9·0 at Strassburg on September 5 and 7 respectively. In the latter observation, Prof. Wirtz records the appearance of a small, fine tail in position-angle 230°. An indefinite condensation, 2′ in diameter and about as bright as a ninth-magnitude star, was observed by Prof. Abetti, at Arcetri, on September 4, the condensation appearing more especially in the north-east section of the nebulous patch. An observation by M. Sternberg at Moscow on September 6 revealed no nucleus.

A telegram from Paris, received at Kiel at midday on September 4, announced that the comet was discovered independently by M. Borrelly at 10h. 0m. (Marseilles M.T.) on September 3; its magnitude was given as 10·0, its movement as north-east, and it was said to possess a feeble condensation and a small tail. Prof. Morehouse described the tail as "long and conspicuous," and the apparent discrepancy is, possibly, due to the fact that he discovered the comet photographically. Observed visually, the tail is not conspicuous, but photographs taken with the 36-inch reflector of the Solar Physics Observatory show that there is a fairly prominent tail with at least two main streamers.

Owing to the diffuseness and faintness of the comet, no observations of its spectrum have, as yet, been possible.

According to the ephemeris given in these columns last week, the comet should be some $4\frac{1}{2}$m. W. and 2° 17′ N. of the 3·3 magnitude star β Cephei at 10 p.m. (G.M.T.) on September 30, and its brightness should then be about $3\frac{1}{2}$ times that at the time of discovery.

THE ORBITS OF SEVERAL SPECTROSCOPIC BINARIES.—Lick Observatory Bulletin No. 133 contains several notes referring to different stars which the observations have shown to be spectroscopic binaries.

First, Mr. Plummer discusses the orbit of o Leonis, the spectrum of which has been differently classified by different observers, and some difficulty found in bringing the velocity measures into accordance. It is now found that the spectra of both components appear when the latter are separated by the greatest distance.

The masses of the two components are almost equal, and the period is found to be 14·4980 days, the orbit being very nearly circular.

The period of β Herculis is found to be 410·575 days; the eccentricity of its orbit is 0·5498, and the length of the semi-major axis 60,280,000 km.

The perturbation discovered in the orbital motion of the visual binary ξ Ursæ Majoris by Mr. N. E. Nörlund is found by Mr. W. H. Wright to be due to the fact that the principal component itself is a spectroscopic binary, the measures already made indicating that Mr. Nörlund's period of 1·8 years is not far wrong.

In the last note Mr. A. B. Turner compares the elements of the orbit of ω Draconis as derived by the analytical method with those obtained by the method of Lehman-Filhés, and the final elements from a least-square solution. The period is found to be 5·2796 days, the eccentricity 0·016, and the semi-major axis 2,626,700 km.

THE DETERMINATION OF TIME IN SUBTROPICAL LATITUDES.—A paper by Messrs. Wade and Craig, appearing in No. 21, vol. ii., of the *Cairo Scientific Journal*, describes a method which was devised by the authors, and has been found very useful, for determining local time, with great precision, in subtropical latitudes. The method differs from those proposed by Chandler and Cooke, inasmuch as the observations are not restricted to a circle passing through the pole, and is therefore more suitable for equatorial latitudes. The method of observation consists in taking transits of a pair of stars, one east and one west, at the altitude of their maximum elongation when the star is rising vertically, stars being chosen so that the maximum elongation takes place as near as possible to the prime vertical. It is shown by the authors that the computation of results becomes a simpler matter, and that many corrections which have to be applied in other methods are either eliminated or negligible.

CAMBRIDGE UNIVERSITY OBSERVATORY.—From the annual report of the observatory syndicate we learn that the work of Cambridge University Observatory during the period 1907 May 19 to 1908 May 18 was directed along the usual lines. Stellar parallax work was continued with the Sheepshanks equatorial, and was somewhat retarded by poor weather at the beginning of this year. Valuable catalogues of star-places are evolving from the Eros solar-parallax reductions, and it is hoped that the first solution of the whole material will be made during the present year.

Stellar spectroscopy, solar observations, and the laboratory study of spectra formed the programme for the Newall telescope, and an attempt is being made to develop a method for utilising the sharply defined atmospheric lines of the α and B groups as standard lines in the determination of radial velocities of stars. At present the method is not successful with faint stars owing to the lack of sensitiveness of the photographic plates and to the want of brilliancy of the diffraction gratings available for use in the spectroscope employed.

THE ROYAL PHOTOGRAPHIC SOCIETY'S ANNUAL EXHIBITION.

THIS exhibition, which will remain open for a few weeks, is, as usual, at the New Gallery, Regent Street. It is divided into several sections, namely:—(1) pictorial; (2) scientific and technical; (3) lantern-slides; (4) autochromes; (5) portraits of eminent British subjects from the society's collection; (6) general professional work; (7) trade exhibits of apparatus and materials. We notice a welcome though slight tendency in the pictorial section to return to the old custom of stating by what process the print has been produced, information that is not only due to any prospective purchaser, but also gives the exhibit an interest for the technical student, while it in no sense detracts from its pictorial value.

There are no new methods of photography in colours. The coloured prints in the pictorial section are, so far as we notice, coloured by hand. The chief interest of the autochromes lies in the application of these plates to the photography of other subjects than portraits, views, and still-life groups. Dr. H. G. D. Brockman demonstrates, in a series of thirteen, their usefulness in recording the presence of blood-stains in a room, on various articles of clothing, and on a bottle, in connection with a trial for murder. In some cases the article was "subjected to a stream of oxygen in an atmosphere which was super-saturated with water vapour and at a temperature of 70° F. As a consequence, certain tarry-looking stains on the boots which were thought to be blood became ruddy." The effect of this treatment is shown by comparative photographs. The same exhibitor has eight autochromes of pathological subjects, which will convey a very good idea of what may be expected when these plates are used for such work. Mr. C. P. Butler shows a direct photograph of the solar spectrum taken on "Uto" paper, in which the colours of the spectrum are excellently rendered.

The natural history division includes a few autochromes which show the great advantage of colour photographs of such subjects, in spite of the fact that the tints depend to a certain extent upon the manipulation of the plates. In a very considerable collection of monochrome photographs, "The Stoat," by Mr. Douglas English, appears, we believe, for the first time. There are several series of pictures of great interest. Mr. William Farren, for example, gives fourteen photographs of the nest of a song thrush, which illustrate the rapid growth of the young birds and the feeding of them by the parents, and he appends a short history of the events, with dates and many details, from the hatching to the time the nestlings left the nest. Similar series are contributed by Mr. Alfred Taylor, which illustrate the "domestic habits of the song thrush" and "the life-history of the tawny owl." A series of eight radiographs, by Messrs. Wilson and Blackall, show the gradual development of the bones of the hand from three to eighteen years of age. Among the photomicrographs, some examples of low-power work, of five and ten diameters, by Mr. W. F. Cooper, are specially noteworthy.

The progress made in cutting the Panama Canal is clearly shown in ten photographs by Dr. Vaughan Cornish, with a map and vertical section. Mr. J. Howden Wilkie has succeeded in two cases in photographing the same flash of lightning with both a stationary and a moving camera. Captain Owen Wheeler, who has made a speciality of telephotography, demonstrates in a remarkable way that it is possible to produce telephotographs of seven and nine diameters' magnification of such good definition that they will well stand a further enlargement of four diameters. The detection of forgery by photographic means is well illustrated by Dr. R. A. Reiss.

Astronomical work is not largely represented, the only exhibits we noticed being the spectrum of "Mars" in the region of "a" compared with spectra of the moon, by Mr. V. M. Slipher, which shows the presence of water vapour in the atmosphere of the planet, and some lantern-slides of the sun and sun-spots made by Mr. C. W. Barlow using an old 4¼-inch refractor, with a deep yellow screen interposed.

C. J.

THE BRITISH ASSOCIATION.

SECTION G.

ENGINEERING.

OPENING ADDRESS BY DUGALD CLERK, F.R.S., M.INST.C.E., F.C.S., PRESIDENT OF THE SECTION.

AT the middle of the last century the steam engine had attained to a high degree of perfection. Its development was, it is true, incomplete, but it had been successfully applied to all the great duties of the mine, the waterworks, the factory, the railway, and the steamship. The engines were mechanically excellent; the fuel economy was good, and they were built in units of thousands of horse-power. Steam power, in fact, was revolutionising the whole of the social and industrial conditions of the globe. Notwithstanding this great material and engineering success, the world was in complete darkness as to the connection between steam motive-power and heat. It was seen that motive-power of almost any magnitude could be obtained by the agency of heat; but how it was obtained and how much power was connected with a given quantity of heat was quite unknown. The fuel consumptions of existing engines were known, and certain modes of improving economy were evident, and engineers were busily engaged in testing these modes by the slow but sure methods of invention, design, construction, and operation in practical work; but in this they had but little aid from pure science.

The science of thermodynamics did not yet exist.

New light was dawning, however, which gradually illumined the whole world of pure science and engineering practice.

Men of the first rank in intellect—Newton, Cavendish, Rumford, Young, and Davy—had long before expressed the opinion that heat was not material in its nature, but was a mode of motion; but their opinions, although to some extent supported by experiment, made little impression upon the scientific world, and in 1850 we still find the most distinguished physicists adhering to the "caloric" or material theory of heat.

The great change, from the errors of the old theories to the truth of the new, was due to the work of Joule, Thomson, and Rankine in Great Britain, and of Carnot, Meyer, Clausius, Helmholtz, and Hirn on the Continent. The story begins with the work of Carnot in 1824, who published in Paris in that year a pamphlet entitled "Reflections upon the Motive Power of Heat." He was attracted by the problem of the steam engine and the air engine. He saw that heat and motive power were connected in some manner, and he endeavoured to settle in a quantitative way the limits of that connection by the invention of an ideal series of operations by means of which the greatest conceivable amount of mechanical power may be obtained from a given quantity of heat in given circumstances. For the purpose of his demonstration he assumes only two things: (1) That if heat be added to any body under standard conditions of temperature, pressure, and volume, and the body be carried through any series of mechanical processes, returning ultimately to the standard condition of temperature, pressure, and volume, then the quantity of heat added to the body is the same as that which has been discharged from it; (2) no process can exist whereby a given mechanical energy can increase its own quantity. On these indisputable assumptions he bases his ideal cycle, which consists of four simple and easily imagined operations, occurring within a cylinder behind a piston, so arranged that during the cycle work can be done by the working fluid upon the piston or work done by the piston on the working fluid.

First Operation.—The given volume of the working fluid is to be imagined as confined at its highest temperature and pressure behind the piston, and heat is to be added to keep the temperature constant, while the fluid expands, moving the piston and doing work upon it.

Second Operation.—The supply of heat is cut off, and the working fluid expands also during work on the piston, while its temperature falls to the lowest point and its volume increases to its maximum.

Third Operation.—The piston returns, compressing the working fluid, but allowing the heat of compression to escape, so that the temperature remains during the operation at its lowest point.

Fourth Operation.—The piston compresses the working fluid, without allowing any loss of heat, to such an extent that the temperature rises again to its highest point, and the working fluid exists at the end of this operation at the same volume, pressure, and temperature as at the beginning.

This assumed series of operations would give a certain available work area, the indicated power of the engine, inasmuch as the work done by the working fluid would be greater than that done upon it. If, however, it be assumed that in all the operations the direction of motion of the piston be reversed, then compression without loss of heat would take place in the second operation; further compression, but with sufficient heat loss to keep temperature constant, would occur on the first operation; the fourth operation would follow with expansion, and the third operation would conclude also with expansion. The engine would be reversed by beginning with the second operation, moving the piston backwards in the order second, first, fourth, third. Carnot shows that this reverse operation would be performed by exactly the same amount of work as was given out by the direct operation, and that an amount of heat would be returned at the higher temperature equal to that which was added in the first case.

An engine which fulfils these conditions, Carnot states, will give the greatest amount of work which can be obtained from a given quantity of heat falling through a given temperature range. And it is evident that this must be so, because, if we assume the existence of any engine under the same conditions giving a greater amount of work from the same heat, then that engine could drive a Carnot engine in the reverse direction in such proportion as to return to the higher temperature a greater amount of heat than it abstracted, and so mechanical energy could be obtained without any heat fall whatever. This marvellous demonstration is obviously independent of the nature of the working fluid; it applies equally to all working substances, whether solid, liquid, or gaseous, whether physical state changes or not. It at once gives a standard of the limit of mechanical power which could possibly be obtained from a given amount of heat and a given temperature fall.

The Carnot cycle operations, as here given, are applicable either to the material or to the dynamical theory of heat; but Carnot originally stated that the whole of the heat added in the first operation was to be discharged in the third. Under the material or caloric theory, work was supposed to be done by the fact of fall in temperature. Naturally, as the heat was material it could not be destroyed or changed into mechanical energy. The production of mechanical energy was supposed to be incidental to the fall of temperature, much in the same way as mechanical energy was produced by the fall of water-level, and this analogy is used throughout Carnot's work of 1824.

Carnot thus succeeded in proposing a standard of efficiency which was applicable to any heat engine, whatever the working fluid and whatever the operative cycle. By his method a limit could be set, fixing the maximum of mechanical energy to be obtained from a given heat quantity and a given temperature range. To reduce this to numerical values it was necessary, however, to experiment on any one working fluid within the desired temperature range in order to determine the work area in its relation to heat quantity and temperature fall. Carnot's writings show that he intended to make such observations; and, had he succeeded, thermodynamics would have become a science at an early date. Carnot's death, however, in 1832, at the sadly early age of thirty-six years, prevented this development.

The name of Sadi Carnot will always be remembered by mankind as the founder of one branch of the thermodynamics of the heat engine.

His work remained practically without notice for thirteen years after his death, when, fortunately, it attracted the attention of William Thomson during his attendance at the Laboratory of Regnault in the year 1845. Thomson was then twenty-one years of age, and had already attained a considerable scientific reputation. He took up the study of Carnot's work with enthusiasm. He became Professor of Natural Philosophy in the University of Glasgow in 1846, and in 1848 he read a Paper before the Cambridge Philosophical Society "On an Absolute Thermometric Scale founded on Carnot's Theory of the Motive Power of Heat and calculated from Regnault's Observations." Like Carnot, Thomson accepted the "material" or "caloric" theory of the nature of heat, although, like Carnot also, he had doubts as to its truth. Assuming its truth, however, he carried Carnot's reasoning much further, and deduced from the Carnot cycle a thermometric scale which was absolute in the sense that it defined the idea of temperature independently of the properties of any particular body.

It is very difficult to carry one's mind back to the material theory of heat, but it is necessary to do so in order to appreciate the rigid accuracy of the reasoning of both Carnot and Thomson; and it is especially desirable to do so in order to understand the great step made in this Paper. According to the "caloric" theory, heat was supposed to be a subtle elastic fluid which permeated the pores of bodies and filled the interstices between the molecules of matter. The fundamental quality imagined of this caloric or heat fluid was that of indestructibility and uncreatability by any humanly controlled process. Bodies became warmer when caloric was added to them, and grew colder as it left them. Caloric, however, might be added to a body without heating it. In this case the heat was called "latent," and the state of the body changed from solid to liquid or from liquid to vapour or gas.

Caloric, too, was required in greater quantities for some substances than others in order to warm the body equally. The capacity for caloric was thus greater in some bodies than in others.

If any particular body were heated without change of state it was hotter; that is, its temperature rose when the quantity of caloric present was increased. It was not difficult to define equality of temperature. This was defined by a constant condition when brought into contact. But it was very difficult indeed to define temperature on any rational scale.

To the acute and brilliant intellect of William Thomson it became apparent that he had in the Carnot cycle a powerful instrument capable of widely general use, apart altogether from the theory of heat engines; and he here uses it in a most skilful way to give definiteness and universal application to the idea of temperature, as Prof. Larmor states, "elevating the idea of temperature from a mere featureless record or comparison of thermometers into a general principle of physical nature."

Thomson accordingly defines equal differences of temperature in terms of the reversible or Carnot engine.

Equal temperature differences are to be differences between the temperatures of the source of heat and the refrigerator, when the proportion of work produced from a given quantity of heat is the same. Thermometers graduated in degrees calculated in this way could naturally be treated as instruments based on definite principles, independently of any properties of any particular material. The idea of temperature here was in rigid logical consistency with the "caloric" theory of heat, and it carried out completely the analogy between power derived from the same quantity of heat falling from a higher to a lower level, and resembling a fall of water in producing its effects. For equal quantities of "caloric," as of "water," temperature fall was regarded as similar to fall in space, and so an accurate idea of the nature of temperature difference is attained.

This definition, however, gave a scale greatly differing from that of mercurial, air, and other thermometers, the degrees defined by it corresponding to larger and larger intervals on the air thermometer as temperature increases. Prof. Tait pointed out also that on such a scale the temperature of a body totally deprived of heat is negative-infinite.

All these difficulties do not detract from the fundamental importance of the idea here enunciated for the first time: the idea of an absolute thermometric scale theoretically applicable to all bodies—solid, liquid, and gaseous. On the "caloric" or "material" theory of heat, motive power is obtained during the letting down or fall from a higher to a lower level of a given quantity of heat. The quantity of heat does not alter in the process; it is only its relative level which alters. There is no reason, therefore, for mentally limiting the amount of mechanical energy obtainable from any given quantity of caloric, just as there is no reason for limiting the amount of mechanical energy to be mentally derived from a given weight. Any desired quantity of energy may be derived from a weight of, say, one pound, if it only be allowed to fall far enough, assuming gravity to be constant through the range.

The investigation of the work to be derived from a given quantity of heat at a given temperature is thus a matter of experiment, which can be settled by measurement of the properties of a few bodies.

Reasoning, it is conceived, in this way, Thomson follows up his absolute thermometric scale work with an investigation entitled "Carnot's Theory of the Motive Power of Heat," described in a Paper read in 1849 before the Royal Society of Edinburgh, in which he calculates from Regnault's experiments on steam the power developed by a Carnot reversible engine when using one centigrade heat unit; that is, the heat necessary to heat one pound of water through 1° C. for temperatures from 1° to 231° C., the temperature falling in the engine in each case to 0° C.

In this Paper he asks himself two questions: (1) What is the precise nature of the thermal agency by means of which mechanical effect is to be produced without effects of any other kind? and (2) How may the amount of the thermal agency necessary for performing a given quantity of work be estimated?

Using Regnault's values for the properties of steam, he calculates the lines of compression and expansion without heat loss, the lines of compression and expansion with heat flow at the lowest temperature, and heat addition at the highest temperature, and thus arrives at the work area per heat unit let down. He tabulates these results, and shows that what he calls Carnot's function diminishes as temperature rises, using the ordinary centigrade scale. On the caloric theory the methods are rigidly logical and correct, but some inaccuracy is introduced by the necessity of that theory for the discharge of the same amount of heat at the third operation as is taken in on the first. The Paper is of great interest, however, because it shows clearly how fully the distinguished author realises the necessity for re-examining the standard ideas of the nature of heat. Two paragraphs make this very clear:—

"7. Since the time when Carnot thus expressed himself the necessity of a most careful examination of the entire experimental basis of the theory of heat has become more and more urgent. Especially all those assumptions depending on the idea that heat is a substance, invariable in quantity, not convertible into any other element, and incapable of being generated by any physical agency; in fact, the acknowledged principles of latent heat would require to be tested by a most searching investigation before they ought to be admitted, as they usually have been, by almost everyone who has been engaged on the subject, whether in combining the results of experimental research or in general theoretical investigations.

"8. The extremely important discoveries recently made by Mr. Joule, of Manchester, that heat is evolved in every part of a closed electric conductor moving in the neighbourhood of a magnet, and that heat is generated by the friction of fluids in motion, seem to overturn the opinion commonly held that heat cannot be generated, but only produced from a source where it has previously existed either in a sensible or in a latent condition. In the present state of science, however, no operation is known by which heat can be absorbed into a body without either elevating its temperature or becoming latent, and producing some alteration in its physical condition; and the fundamental axiom adopted by Carnot may be considered as still the most probable basis for an investigation of the motive power of heat, although this, and with it every other branch of the theory of heat, may ultimately require to be reconstructed upon another foundation when our experimental data are more complete. On this understanding, and to avoid a repetition of doubts, I shall refer to Carnot's fundamental principle, in all that follows, as if its truth were thoroughly established."

In these two paragraphs Thomson sums up the whole situation in 1849, and promises further investigation and further attempts to deduce the nature of the connection between heat and work.

Assume, then, the truth of the caloric theory of heat, as Thomson does in the 1849 Paper: We have a complete theory of the heat engine, based on the Carnot cycle, accounting for efficiencies which vary with temperature differences, but requiring no definite mechanical equivalent of heat; nay, antagonistic to the existence of such an equivalent. The caloric theory, as has been pointed out, is quite consistent with the theoretical possibility of obtaining an indefinitely great amount of mechanical energy from any given quantity of heat, provided the *letting down* or fall of level be indefinitely great.

At the time we are discussing—1850—the bare conception of the idea of an absolute zero of temperature is one which is startling in its boldness; and it must have been difficult indeed then to imagine any definite line of proof which could be followed to establish the real existence of such a physical limit. We are so familiar with the existence of very high temperatures, vastly transcending the temperatures in which we personally exist, that we can hardly conceive a temperature limit on the ascending side; that is, we can hardly think of any given high temperature which could not in quite conceivable circumstances be exceeded. We know, for example, that any metal—say platinum—may be melted if its temperature be sufficiently increased; that a further sufficient increase will convert the liquid metal to the gaseous state, and that the gaseous metal may be heated indefinitely while in that state. We know the behaviour and properties of many substances at high temperatures, and are aware of the strong tendency of all chemical compounds, when highly heated, to split up into the elementary bodies composing them. All this we appreciate, but we find it difficult to see how a point of temperature could be reached when it could be said: This is a physical limiting point on the ascending scale; we may heat a substance up to this temperature, but it is impossible to conceive of any higher temperature. It is necessary here to distinguish between a conceivable limit to an ascending temperature and a practical limit under existing conditions. We may thus place limits, say, to the temperature of coal-gas and air explosions, or the temperatures possible from the electric arc; the limit with coal gas and air depending on one set of conditions, and the electric arc upon another set, such as the vapourising point of carbon, and so on. In the same way, at the middle of last century it would have been considered quite reasonable to suppose that human existence was carried on at an intermediate plane of temperature, and that temperatures might exist as low, relatively to our mean temperature, as our known furnace and combustion temperatures are high. At this time, no doubt, such an idea was quite a reasonable one.

No such limit could be proved, even by the aid of the Carnot cycle, reasoning on the material theory of heat. If we assume that heat is material, and that in some way temperature fall doing work resembles, as Carnot supposed, the fall of water doing work in passing from a higher to a lower level, then no absolute zero is possible, because the same quantity of heat is supposed to exist at the low as at the high temperature. On this theory nothing in the idea of temperature suggests a possible physical limit. On the material theory, the notion of temperature is one to which it is exceedingly difficult to attach a precise meaning.

Thomson's promises of further investigation were fulfilled in 1850, in which year he definitely accepted the dynamical theory of heat and finally abandoned the material. His conclusions are given in a Memoir of the first importance which was read before the Royal Society of Edinburgh in 1851. It was entitled "On the Dynamical Theory of Heat." Before dealing with it, however, it is desirable to consider the work of Joule and others on another side of thermodynamics.

Long before 1850 the equivalence of mechanical work and heat quantity had been accepted by many scientific men, and Rumford had, indeed, made measurements of a rough kind. It remained, however, for Joule experimentally to determine the mechanical equivalent in the most accurate manner and place what is now known as the first law of thermodynamics upon the sure basis of absolute experimental determination. His first Paper was read before the Cork Meeting of the British Association in 1843, and at the Oxford Meeting in 1847 he read another—"On the Mechanical Equivalent of Heat"—describing the results of experiments with paddles rotating in liquids driven by falling weights. By these years of work he had absolutely demonstrated the equivalence of heat quantity and mechanical work, so that no loophole of escape seemed possible; it appeared as if the material theory was rendered intellectually impossible to the trained intellect. This was not the fact, however, as is evident from both Joule's and Thomson's accounts of that British Association Meeting.

Joule's earlier Paper had been coolly received. Indeed, it is evident that the idea of a mechanical equivalent of heat was still distasteful to the physicists of the day, and its discussion was looked upon with dislike. Joule, at the 1847 Meeting, addressed a small audience, and the account of his experiments was received without enthusiasm. This adverse atmosphere, so discouraging to the investigator, was quickly removed, however, when a young man rose to make his remarks, and, by his enthusiastic comment and clear reasoning, at once succeeded in attracting the interest of those present. This young man was William Thomson, Professor of Natural Philosophy in the University of Glasgow. Speaking of this, his first meeting with Joule, at Manchester forty-six years later, Lord Kelvin said: "I can never forget the British Association at Oxford in the year 1847, when in one of the Sections I heard a Paper read by a very unassuming young man, who betrayed no consciousness in his manner that he had a great idea to unfold. I was tremendously struck with the Paper. I had first thought it could not be true because it was different from Carnot's theory, and immediately after the reading of the Paper I had a few words of conversation with the author, James Joule, which was the beginning of our forty years' acquaintance and friendship. . . . I gained ideas which had never entered my mind before, and I thought I, too, suggested something worthy of Joule's consideration when I told him of Carnot's theory." This Meeting was indeed fateful for the future of the science of thermodynamics, as it resulted in cooperation between two men of giant intellect, who between them performed most of the experimental work which was necessary to make thermodynamics an exact science. Their work alone sufficed to place the first and second laws of thermodynamics on the firm footing of accurate experiment and logical deduction.

Although Thomson was much struck by Joule's experiments, he did not accept the dynamical theory of heat at once. As he stated himself: "I had first thought that it could not be true because it was different from Carnot's theory."

Joule's discoveries at this date may be thus expressed:—

Heat and mechanical energy are mutually convertible, and heat requires for its production, and produces by its disappearance, mechanical energy in the proportion of 1390 foot-pounds for each centigrade heat unit, a heat unit being the amount of heat necessary to heat one pound of water through 1° C.

Knowing, as Thomson did, that mechanical energy could be produced by the agency of heat, but that its amount varied with the temperature and temperature fall, Joule's discoveries seemed antagonistic to Carnot's demonstration; and, convinced as he was that Carnot's law was true, he naturally felt at first that there must be some other way of looking at Joule's results than that adopted by Joule himself.

Joule naturally believed in his own manner of looking at his results, and he apparently agreed with Thomson as to the antagonism between what may be here called the Carnot and Joule laws.

The material theory of heat might have been true; in which case there was no more need for any direct quantitative connection between heat quantity and mechanical energy than between the mass of a body and its mechanical energy. Any unit of mass may acquire any conceivable amount of mechanical energy if its velocity be great enough, and so any unit of heat on the caloric theory may produce any conceivable amount of mechanical energy if the temperature fall be great enough. Joule considered the Carnot law to be so inconsistent with his law that in one of his Papers he proposes its abandonment as inconsistent with discovered facts. At this point the two ideas seem to be in opposition. The germ of reconciliation, however, is found in observations by Thomson in both the 1848 and 1849 Papers. In paragraph 8, quoted here from the latter Paper, it is stated:—

"In the present state of science, however, no operation is known by which heat can be absorbed into a body without either elevating its temperature or becoming latent and producing some alteration in its physical condition."

This is equivalent to saying that no case has been observed where heat disappears doing mechanical work. In a note occurring in the same Paper he alludes to the fact that engineers always assume that the amount of heat found in the condenser of the steam engine was the same as that taken into the engine by the steam, in the following terms:—

"So generally is Carnot's principle tacitly admitted as an axiom that its application in this case has never, so far as I am aware, been questioned by practical engineers."

This was quite accurate. Hirn's demonstration that heat disappears in a steam engine when work is done was not made until 1857, eight years later.

In the 1848 Paper he states:—

"The experiments of Mr. Joule of Manchester seem to indicate an actual conversion of mechanical effect into caloric. No experiment, however, is adduced in which the converse operation is exhibited; but it must be confessed that as yet much is involved in mystery with reference to these fundamental questions of natural philosophy."

Here we find Thomson's mind engaged—in 1848 and 1849—with the very matter requiring proof. Joule had proved the generation of heat by means of mechanical work; Thomson required the proof of the converse case—the disappearance of heat when mechanical work was done by the working fluid.

This proof was forthcoming in the results of experiments on the compression and expansion of air. Accordingly, we find the Carnot and Joule principles reconciled in Thomson's Paper of 1851, and the important deduction made of an absolute zero of temperature at $-273°$ on the centigrade scale. The introduction of the idea of the mechanical equivalent of heat leads at once to an absolute zero of temperature, and allows of the determination of this physical lower limit by the use of the Carnot cycle for investigating the efficiency of a perfect engine using any working fluid. Air was the working fluid actually investigated, and the determination of its properties at ordinary temperatures was a vitally important result of the cooperation of Thomson and Joule. Their experiments lasted for many years, and their rigorous investigation disclosed the fact that internal work was done in expanding a gas; in fact, that in a gas expanding isothermally doing work, part of the heat only disappeared in external work and part was absorbed in separating the molecules.

The Joule and Carnot laws are now known as the first and second laws of thermodynamics.

The second law, in modern form, may be thus stated:—

Although heat and work are mutually convertible and in definite and invariable proportions, yet no conceivable heat engine is able to convert all the heat given to it into work. Apart altogether from practical limitations, a certain portion of the heat must be passed from the hot body to the cold body in order that the remainder may assume the form of mechanical energy.

The proportion of the total heat convertible into mechanical energy depends on the absolute temperatures of the hot and cold bodies; it is unity *minus* the lower absolute temperature upon the upper absolute temperature.

It appears that during Thomson's struggle to reconcile the two apparently opposing laws, Clausius, who had seen the same difficulty, arrived independently at its solution and published a Paper, "On the Motive Power of Heat and the Laws of Heat which may be deduced therefrom," at the Berlin Academy in February, 1850. In this Paper, Clausius discusses Thomson's difficulties, and also arrives at the conclusion that the Carnot cycle may be reconciled to Joule's law by the omission of the supposition that during the third process the same amount of heat is discharged from the cool body as was taken in from the hot one. He states:—

"On a nearer view of the case we find that the new theories were opposed not to the real fundamental principle of Carnot, but to the addition that no heat is lost. For it is quite possible that in the production of work both may take place at the same time: a certain portion of heat may be consumed and a further portion transmitted from a warm body to a cold one; and both portions may stand in a certain definite relation to the quantity of work produced. This will be made plainer as we proceed; and it will be moreover shown that the inference to be drawn from both assumptions may not only exist together, but that they may mutually support each other."

In his 1851 Paper, Thomson gives Clausius full credit for solving the difficulty between the Carnot and the Joule principles. Thomson gives Clausius the full credit for priority, but states that he was working on the same problem and had arrived at the same solution in the year 1850, before he had seen Clausius' work. Clausius, however, assumed the theory of a permanent gas, which required the absence of internal work, but Thomson was not prepared to assume this without experiment. This determination rigidly to prove every necessary assumption, and his clear conception of the points necessary for proof, led to the extensive series of researches undertaken by Thomson and Joule with the object of determining how much gas thermometers differ from an absolute scale as determined by the combination of the Joule and Carnot laws.

Rankine, as early as 1849, arrived at the general equation of thermodynamics which expresses the relation between heat and mechanical energy, and indicated the result of his investigations to the Royal Society of Edinburgh in February, 1850. Rankine thus arrived independently at the same result as Clausius about the same time. Both Rankine and Clausius, however, adopted certain theories as to the molecular structures and motions of gases, and their demonstrations to some extent depended upon their theories. To Thomson and Joule we are deeply indebted for the rigid proof of the two laws and for the rigid deduction of the modern scale of temperature and the determination of absolute zero in its modern form. Thomson now thus defines temperature:—

"The temperatures of two bodies are proportional to the quantities of heat respectively taken in and given out in localities at one temperature and at the other respectively, by a material system subjected to a complete cycle of perfectly reversible thermodynamic operations, and not allowed to part with or take in heat at any other temperature; or, the absolute values of two temperatures are to one another in the proportion of the heat taken in to the heat rejected in a perfect thermodynamic engine, working with a source and refrigerator at the higher and lower of the temperatures respectively."

This definition leads to an absolute scale of temperature which is independent of the substance operated on, and Joule and Thomson's experiments have shown that this scale differs but slightly from that of the ordinary air thermometer. Joule had suggested to Thomson, in a letter to him in 1848, that the probable value of Carnot's function is the reciprocal of the absolute temperature as measured on a perfect gas thermometer.

Thus Clausius appears to have anticipated Thomson, not in the suggestion of an absolute scale of temperature, but in the idea of an absolute zero founded upon the combination of Carnot's law and Joule's law. Thomson, in his Papers, very modestly attributes the second law—the law of the transformation of heat—to Carnot and Clausius; but in this he undervalued his work, because Clausius appears to have assumed what Thomson and Joule proved; that is, the coincidence of the absolute scale with the air thermometer scale.

It will thus be seen that the position usually assumed by the engineer at 1850, of the equality between heat given to the engine and heat given to the condenser, was fundamentally untrue. Without this deduction, however, no determination of values of the Carnot function could have led to the determination of an absolute zero. According to the material theory, as seen in the light of Carnot's cycle, a heat unit could give an indefinitely increased amount of work with lowering of the temperature. Nothing in the theory sets a limit to this increase, and, accordingly, there is nothing to suggest an absolute zero. Immediately, however, we accept the dynamical theory of heat we find that a pound of water requires the exertion of 1390 foot-pounds of work to heat it through 1° C. We also know from the Carnot cycle that under ordinary conditions of human existence only a portion of this work can be returned; but as no conditions could conceivably exist in which a greater amount of work could be obtained from a pound of water than the 1390 foot-pounds put into it to heat it through 1° C., it follows that, inasmuch as the Carnot function increases with diminishing temperature, the limit of temperature is reached when, according to the Carnot cycle, the whole of that work, put into the pound of water, can be got out again as work. This limit is the absolute zero of temperature. No lower temperature is conceivable without introducing the idea of the creation of energy. So far as human beings are concerned, this idea is as inconceivable as the idea of the creation of matter. The determination of this limit with the close accuracy necessary for a well-founded constant is to be entirely attributed to Thomson and Joule. In his 1851 Paper Thomson thus succeeds in answering the questions which he put to himself in his 1849 Paper, and he supplies a quantitative method of connecting the amount of the thermal agency necessary with the amount of work which can be performed under varying conditions.

Engineers dealing with motive power are thus deeply in debt to Thomson and Joule for the secure position occupied by them to-day.

The brilliant work of Meyer, published so early as 1842, is held by some to have anticipated to a large extent both the work of Thomson and of Joule. Undoubtedly Meyer formulated true ideas and carried his generalisations through a wide range. Helmholtz also very early arrived at similar conclusions to those of Joule and Thomson; but it has been thought better to discuss the work of Thomson and Joule separately, in order to illustrate the transition period through which many distinguished minds were passing about the time. Undoubtedly great credit is due to Meyer, Helmholtz, Clausius, and Hirn, and Thomson himself recognised this in the most generous way.

The ideas of Thomson and Joule now form so much of the basis of all reasoning upon motive-power engines that there is some little danger to the present generation of forgetting what they owe to these two great men. To appreciate the step made by them it is necessary to consider the position of motive power produced by heat at about the middle of the last century. At that time many attempts had been made to displace the steam engine as a heat engine by air engines in various forms—both engines heated externally and those heated internally, now known as internal-combustion engines. Papers read at the Institution of Civil Engineers in 1845 and 1853, and the discussion of those Papers by eminent men of the day, supply an accurate measure of the knowledge possessed by the engineer of the principles of action of his heat engines. Many distinguished names occur in these Papers and Discussions, including James Stirling, Robert Stephenson, Sir George Cayley, Charles Manby, James Leslie, C. W. Siemens, Hawksley, Pole, W. G. Armstrong (afterwards Lord Armstrong), Edward Woods, E. A. Cowper, D. K. Clark, Benjamin Cheverton, Goldsworthy Gurney, George P. Bidder, Prof. Faraday, Isambard K. Brunel, Captain Fitzroy, and F. Braithwaite. At the date of the later of these discussions Brunel had already designed the *Great Eastern*, in 1852, with its engines of 11,000 horse-power. Armstrong was a Fellow of the Royal Society, and had started the Elswick Works and invented the Armstrong gun. Robert Stephenson was at the height of his fame. He was then a Member of Parliament, President of the Institution of Civil Engineers, and a Fellow of the Royal Society. Siemens was a young man, but was busy on the regenerative furnace; had considered regeneration as applied to steam engines, although his work on the air engine was still to come. All were distinguished men in their day, and their opinions may be taken as representing the very best scientific knowledge of the leading engineers of the day. The first of the Papers to which I refer is called "Description of Stirling's Improved Air Engine," by James Stirling, M.Inst.C.E. It was read on June 10, 1845, with Sir John Rennie, the President of the Institution, in the chair. The engine described was the later form of the well-known Stirling air engine, invented by the Rev. Dr. Stirling, a Scottish clergyman, in the year 1815. The development considered was the invention of the reader of the Paper, a brother of Dr. Stirling. The main improvement consisted in the use of air at a greater density than the atmosphere, and the engine at that date had so far succeeded that two had been used at the Dundee Foundry Company's works—one giving about 21 horse-power and the other about 45 horse-power. Practically, therefore, some success had been attained. Mr. Stirling claimed that the 21-horse engine consumed 50 lb. of coal per hour, which is about 2½ lb. per horse-power per hour. This was an extraordinarily good result for the time. At present, however, we are not interested in the practical result, but only in the opinions of the engineers of the day as to the fundamental principles of heat engines.

It is clear from the Paper that the theory of the regenerator was entirely misunderstood. It was imagined that with a perfect regenerator no heat would be required to perform work. This is evident from Mr. Stirling's answer to Sir George Cayley. Sir George Cayley described his engine, which was of the internal-combustion type, acting with solid fuel under constant pressure, and showed that, owing to dust and heat in the cylinder and valves, his experiments proved abortive. He stated, however, that his engine had consumed 6¼ lb. of coke—equal to 9 lb. of coal—per horse-power. To this Mr. Stirling answered: "It must be remarked that Sir George Cayley, in following an entirely different object, had overlooked the great leading principle of repeatedly using the same heat," and "he was of opinion that, except on that principle, the air could not be economically used as a moving power." Another speaker, Mr. Cottam, said: "It was evident that, if it was practicable to arrive at the theoretical condition of the absorption of all the caloric by the thin laminæ during the upward passage of the air and the giving it out again during the downward passage, there would not be any loss of heat." Mr. Robert Stephenson did not appear to understand Stirling's air engine at all, because he made the following remarks: "He understood the process to consist of heating the air in a vessel, whence it ascended to the cylinder between numerous thin laminæ, by which the caloric was absorbed, to be again given out to the descending air. Now it appeared to him that, though the ascending process was natural and easy, the reverse action would require a certain expenditure of power, in the depression of the plunger." This remark clearly showed that Stephenson, notwithstanding his eminence as an engineer, at that date had not appreciated the essential conditions of the hot-air engine.

In the year 1853 the subject of the air engine again came up before the Institution of Civil Engineers, interest being excited evidently by the building of the large engines of the hot-air ship *Ericsson* in America, the engines having air cylinders of no less than 14 feet diameter. Four Papers were read in this year: "On the Use of Heated Air as a Motive Power," by Benjamin Cheverton; "On the Caloric Engine," by Charles Manby; "On the Principle of the Caloric Air Heated Engine," by James Leslie, M.Inst.C.E.; and "On the Conversion of Heat into Mechanical Effect," by Charles William Siemens, A.M.I.C.E.

Cheverton evidently considers, from his Paper referring to Stirling and Ericsson, that "Both parties also rest the efficiency of their engines on the repeated use of caloric. They contend that in recovering from the ejected hot air the caloric which gave it superior tension, and employing it in heating the injected air, 'it is made to operate over and over again.' Mr. Ericsson aspires to embody a new principle in motive mechanics—no less, to use his own words, than 'that the production of mechanical force by heat is unaccompanied by the loss of heat,' except such as arises from radiation, or other practically unavoidable waste." Cheverton rejects this idea, but, strangely enough, does not appear aware of the work either of Carnot or of Joule. He comes to the conclusion, however, that "caloric, doubtless, is in all its aspects a manifestation of force, and unquestionably, as a mechanical agent, of a dynamic force, and therefore is directly amenable to the third law of motion." He appears to think that heat is accompanied with molecular activity, but is puzzled by what he accepts to be a fact, that in the steam engine the whole of the heat of the steam as it comes from the boiler is found in the condenser. With regard to the steam, he says: "Undoubtedly, in respect to the materiality of caloric, if it be material, it is transferred intact to the condenser, yet in its passage it may have parted with force, which it cannot communicate again." He comes to the conclusion that the change may take place, not in the quantity, but in the intensity of heat. Here he resembles Carnot; but it appears to him impossible to arrive at any useful theory of the heat engine, because he states: ". . . for every investigation leads to the conclusion that the effect of caloric is independent at least of the chemical, if not also of the physical, constitution of bodies. But economy of fuel is a different question from the economy of caloric; it is altogether a practical matter, and can only be determined by experiment; for this, and, indeed, most other points of practice, are too intractable to come within the grasp of the most powerful calculus." In the discussion a communication was read from Sir George Cayley, in the course of which he states, with regard to the regenerator: "There can exist no doubt of the effective re-application of heat to an almost unlimited extent by this beautiful invention, due originally to Mr. Stirling, and now carried out to a greater extent by Captain Ericsson." Sir George Cayley discussed the difficulties of Ericsson's engine, but he accepts the principle that heat may give work and yet be used over and over again practically undiminished. Armstrong did not express himself upon the theory at all, but he was doubtful as to the advantage of the air engine compared with the steam engine, although he believed that it was practicable to recover and use over again a large proportion of the heat applied, and he thought the balance of economy, so far as heat was concerned, would be found in favour of air. Siemens agreed to some extent in the advantages of a regenerator, but he showed clearly that expansion doing work was accompanied by a diminution of temperature, and stated that this heat had to be replaced by the fire. Bidder was of opinion "that no theoretical advantage was obtained in using heated air instead of vaporised water as a motive power, and it was incapable of being applied practically with as much convenience." It is most interesting to note that Dr. Faraday joined in this discussion. He said very little, and I will give his remarks complete. Dr. Faraday said: "Twenty years ago he had directed his attention to this question, and from theoretical views he had been induced to hope for the successful employment of heated air as a motive power; but even then he saw enough to discourage his sanguine expectation, and he had, with some diffidence, ventured to express his conviction of the almost unconquerable practical difficulties surrounding the case, and of the fallacy of the presumed advantages of the regenerator. He still retained his doubts as to the success of the innovation, and feared the eventual results, even of Captain Ericsson's spirited and ingenious efforts." Brunel considered the use of the regenerator to be an entire fallacy, and did not believe that the power derived from the expansion of air by heat could be used effectively, and then be recovered and used again. Mr. Hawksley considered that the machine involved a mechanical fallacy and that the regenerator produced no mechanical effect whatever. Mr. Rendel was the President at the Meeting which dealt with Mr. Cheverton's Paper, and, in view of the great differences of opinion on the subject, he stated that "he would not have the Meeting arrive at a hasty or erroneous conclusion on the question of this engine, and he therefore suggested that Mr. Siemens should draw up a Paper on the subject, and that the Members should collect, for a future Meeting, all the information within their reach, in order to the calm and deliberate discussion of the question." This resulted in the further Meeting of May 17, 1853, when Papers were read by Manby, Leslie, and Siemens. The Paper by Manby consists of the summary of a discussion by M. Galy-Cazalet, which took place in Paris in 1852. M. Galy-Cazalet comes to the conclusion that the regenerator involves a fallacy, and he concludes: "There appears to be at present so much doubt of the utility of the regenerator that it would be wise to abandon its use for a time, and by trials with a more simple form of caloric engine establish the fact either of the superiority or of the inferiority of heated air in comparison with steam as a motive power." Mr. Leslie, on the contrary, in his Paper upholds vigorously the accuracy of the principle of the regenerator or economiser. He comes to the conclusion that it is based on true principles and is attended in practice with real economy of heat, and consequently of fuel. In this conclusion he is doubtless correct; the regenerator is useful and does economise heat. But Leslie goes much further than this; he appears to support Stirling in the fallacy that the regenerator may be made indefinitely useful. Stirling states:—

"And thus it appears that by applying air successively to a series of bodies regularly increasing in temperature, and moving it alternately from one end of the series to the other, it may be heated and cooled ten times, with an expenditure of caloric which would barely have heated it once, if it had been applied at once, to the hottest body (*i.e.* beyond the series). It is evident also that if the series had been composed of twenty points, or bodies, having a difference of temperature of five degrees, the air might be heated and cooled twenty times at no greater expense of caloric. Nay, it is evident that by multiplying the members of the series indefinitely air could be heated and expanded and made to do work at no appreciable expense. But let no mathematician be alarmed with the idea of a perpetual motion, or the creation of power. There are many enemies to contend with in the air engine besides friction, which alone prevents perpetuity in some mechanical motions. We have no means, without consuming a part of our power, of applying the air so closely to the apparatus as to make it absolutely assume the temperature of the bodies to which it is applied. There is, therefore, a loss in the very act of heating and cooling."

Leslie comes to the conclusion that Stirling is right, but that an air engine without a regenerator would be a much less effective and economical application of heat than the steam engine. Leslie gives some interesting particulars of the later air engines of James Stirling. He states that an engine of 45 horse-power was started in March, 1843, at the Dundee Foundry; that in December, 1845—two years and nine months after starting—one air-vessel gave way, and in May, 1846, another failed, and in January, 1847, a third failed. This information was supplied to him by Mr. David Mudie, one of the lessees of the foundry.

We now come to Siemens' Paper "On the Conversion of Heat into Mechanical Effect," and for the first time we find the engineer guided by an intelligible principle. Siemens discussed the material theory of heat, and accepted unreservedly the dynamical theory, for which he gives a large measure of credit to Joule. This is the first of the Institution Papers in which I find the name of Joule. Siemens mentions Carnot, Clapeyron, Holtzman of Mannheim, Joule, Helmholtz, Meyer, Rankine, and Prof. Thomson. Curiously enough, although Siemens mentions Carnot and the other philosophers who dealt with the Carnot principle, including Thomson, he does not appear at this date—May 17, 1853—to have realised himself the effect of the law of Carnot upon the theory of the heat engine. He clearly appreciated the first law, and gives the mechanical equivalent of heat as determined by Joule at 770 foot-pounds, and by Thomson's formula as 772 foot-pounds, but in his discussion of the principles of the heat engine he is of opinion that a perfect engine is ideally possible giving 770 foot-pounds for each Fahrenheit heat-unit employed. This is clear from a Table found on p. 33 of the Paper, which I reproduce:—

SIEMENS' TABLE OF 1853.

Description of Engine	Theoretical Performance in foot-pounds	Actual Performance in foot-pounds	Actual Performance in pounds of Coal per H.P. per Hour.
A Boulton and Watt condensing engine, low pressure	51·8	29	8·00
The best Cornish engine ...	158·8	82	2·38
Combined steam and expansive ether engine ...	150·0	75	3·09
The expansive air engine...	91·0	35	6·63
Stirling's engine	130·0	65	3·57
Ericsson's engine	196·0	65	3·57
A Perfect engine	770·0	385	0·00

He apprehends the mechanical equivalent of heat, but he still appears under the impression that if heat be added to a certain upper temperature and expansion take place until the original temperature is reached, then he has a perfect engine indicating the full result of Joule's mechanical equivalent. He sees, however, that the old theory of the regenerator is quite wrong. He states:—

"The cause of the failure of Mr. Stirling's engine in practice may apparently be traced chiefly to insufficiency of heating surface, occasioned apparently from misapprehension of the principle involved, it having been thought that the same heat would serve over and over again to produce power, and that the necessary expenditure of heat consisted only in the mechanical loss by imperfect action of the respirative plates, which were approached to each other to the utmost limits, consistent with an unobstructed passage of the air. By the aid of the dynamical theory of heat it has been shown that there is another and far more important expenditure of heat, which should have been provided for."

Siemens, in the discussion, rightly upheld the regenerator as useful, and saw that there were limitations to its use. Mr. Hawksley contended that the regenerator was useless. Mr. Pole considered that the regenerator was useful, but he did not definitely adopt the mechanical theory of heat. He stated:—

"It must be allowed that the general action of caloric in producing power was still involved in much obscurity. The heat was often considered in reference to its quantity only, but it was certain also that its intensity performed a very important part; and it had even been surmised that power might be obtained by the reduction of intensity alone, without any change of quantity."

Armstrong concurred with Siemens and Pole. He believed in the utility of the regenerator, limited as described by both. Mr. Edward Woods certainly understood Siemens to have given 772 foot-pounds as the efficiency of an ideal heat engine, because he stated that this showed there was still great room for improvement in engines. Mr. E. A. Cowper had clear ideas; he said:—

"Steam, or gases, in expanding, and so giving out power, lost heat. Part of the sensible heat became latent in the production of power, and this heat could only be recovered by expending the power already produced in again condensing the steam back to its original bulk, when the latent heat again became sensible."

This discussion, then, puts us in the position of engineers at the date of the last Meeting referred to—May 17, 1853. Of all the distinguished engineers who spoke, Siemens alone had thoroughly apprehended the value of Joule's results and understood the full bearing of the mechanical equivalent of heat. He had not, however, understood Carnot's reasoning on the Carnot cycle, or Thomson's deductions from Carnot. He was under the impression that heat added in any way to a working fluid, raising the temperature, could be entirely converted into work by a sufficient expansion. He had not appreciated that, even if expansion be carried far enough to reduce the temperature to the original temperature before heat addition, yet complete conversion of the entire mechanical equivalent was impossible. When so able a man as Siemens had at this stage only reached partial enlightenment, it was evident that much hard work and clear thinking required to be done before a well-founded theory of heat motive-power could be obtained. The data for such a theory were accumulating; and one of the most interesting circumstances connected with these Institution of Civil Engineers Papers was a communication from M. Regnault to Colonel Sabine, Treasurer of the Royal Society, dated April, 1853, which was read at the Meeting, in which Regnault stated that

"He was about to publish immediately a series of elaborate experimental researches on various subjects connected with the effects of heat on elastic fluids, the results of which would solve many questions long in dispute, and by means of which engineers might accurately calculate the effect of a given amount of fuel, in whatever way it was applied. M. Regnault communicated in anticipation that he had arrived at the number 0·237 for the specific heat of air at constant pressure, and at 0·475 for that of steam under atmospheric elasticity, the specific heat of water being taken in each case as unity."

True to his word, Regnault produced his admirable investigations, and succeeded in solving many problems; but he did not settle the questions to the extent he had hoped. Even at the present time doubt arises as to the very values he gave for the specific heat of air and steam. The problem proved much more difficult than he had anticipated, and for modern engine purposes it cannot be considered as wholly solved now—fifty-five years later.

This description of the position of the hot-air engine, as shown by the opinions of eminent engineers, is most useful as proving how much practical men were in need of the work of Thomson and Joule. It is not surprising that, of all the engineers present, Siemens appeared to be alone in thoroughly grasping the new ideas. Thomson's own conversion from the material theory of heat to the dynamical theory was not complete until 1851, and although he had then succeeded in reconciling the ideas of Joule and Carnot, it is not to be wondered at that engineers two years later had not quite succeeded in grasping the combination of the two laws. This combination, however, supplied engineers with a new and accurate standard of measurement for studying and improving upon their heat engines, and they were by no means slow in grasping the help thus offered them by the abstract scientific man. The broad laws of thermodynamics have placed the theory of the heat engine in a position of certainty, which was much needed. It would be a mistake to assume, however, that even the determination of the mechanical equivalent of heat and the second law of thermodynamics expressed in terms of an absolute thermometric scale had solved all the difficulties of the engineer desiring to determine the efficiency of his heat engines. Thomson, Joule, Rankine, and their great Continental colleagues, it is true, settled once and for all the broad laws of thermodynamics, but the Carnot cycle is a cycle which is, as has been repeatedly shown, an impossible one in practice. Accordingly, actual engines have to operate upon imperfect cycles. The theory of these imperfect cycles has been worked out mostly during the last twenty-five years, although Rankine made a beginning in dealing with the theory of the Joule air engine. For the first time he showed the existence of what may be termed a cycle of constant efficiency in the case of the Joule air engine. Assuming constant specific heat for the working fluid, he calculates the efficiency of what we now call a constant-pressure air engine between certain limits of temperature, and he gives the efficiency of the fluid where U=energy exerted and H_1=heat received, and r=ratio of compression and expansion:—

$$\frac{U}{H_1} = 1 - \frac{1}{r^{0\cdot408}};$$

that is, he indicates in this formula that the thermal efficiency is independent of the maximum temperature so long as that maximum temperature exceeds the temperature of adiabatic compression. He makes no statement, however, that this engine is within a certain range independent of the maximum temperature; that is, that increasing maximum temperature does not increase efficiency. Subsequent work has shown that, on a simple assumption, such as constant specific heat, many engine cycles exist of a practicable nature having high theoretical efficiencies where the theoretical efficiency depends on one thing only—the ratio of compression. Some misunderstanding has arisen with regard to these imperfect cycles, and it has even been thought that such imperfect cycles would be contrary to the second law of thermodynamics. Lord Kelvin himself was of this opinion in 1881. I vividly remember a conversation I had with him at the Crown Iron Works, in Glasgow, over the results I had obtained from one of my early gas engines. I had then come to the conclusion that the "Otto" cycle as ordinarily operated was a cycle of constant efficiency, and I explained this to Lord Kelvin. He had not followed such cycles, and his view then was that no such cycle could exist, because he thought it was contrary to the second law of thermodynamics. Some idea of this kind has been held by many scientific men, and has prevented the minute investigation of imperfect cycles of different kinds, because of the feeling that the whole question of efficiency was entirely settled by the nature of the temperature limits; that is, by the maximum and minimum temperatures at the disposal of the engineer. It is true that these values, as has been shown, must always determine the extreme limit of possible efficiencies between certain temperatures, and in cycles of constant efficiency the particular efficiency of the cycle is always less than the efficiency of a Carnot cycle engine working between the same limits of superior and inferior temperature. The investigation, however, of these imperfect cycles is much more difficult than the broad investigation of the general thermodynamic laws, because it requires accurate knowledge of the properties of the working fluid dealt with under conditions rendering observation extremely difficult. The modern internal-combustion motor is the successor to the air engine so fully discussed by eminent engineers of fifty-five years ago; and the forebodings of even so eminent a man as Faraday as to its ultimate success have proved unfounded. Great difficulties have been encountered and many discrepancies have had to be explained, but a minute study of the nature of the working fluid has rendered it more and more possible to calculate the efficiencies to be expected under practical conditions. At the present time we can deal with almost any cycle or any working fluid with some fair approximation to an accurate result. Much work, however, is required before all problems of the working fluid can be said to be solved with regard to any heat engine. Indeed, it may be said that under modern conditions of the use of steam even the properties of the working fluid—steam—have not yet been satisfactorily determined. The mere question of specific heat, for example, of steam and its variations of temperature and pressure is now under review, and important experiments are in progress in Britain and on the Continent to determine those properties. The properties of the working fluid of the internal-combustion motor are also the subject of earnest study by many Continental and British investigators. Notwithstanding all the perplexities involved in the minute study of the imperfect heat-engine cycles, we are in a very different position to-day compared with the engineer of 1853. We know all the broad laws as to the conversion of heat into work or of work into heat; and, numerous as are the problems yet to be solved, we at least profit by the guiding light set out for us by Kelvin, Joule, and Rankine.

SECTION H.

ANTHROPOLOGY.

OPENING ADDRESS BY PROF. WILLIAM RIDGEWAY, M.A., F.B.A., LITT.D., LL.D., PRESIDENT OF THE SECTION.

The Application of Zoological Laws to Man.

THIRTY years ago in this very city I heard for the first time a Presidential Address at the British Association, and I was singularly fortunate in entering on my novitiate. I had the privilege of hearing Prof. Huxley deliver his Presidential Address to the embryo of that Section over which I, a very unworthy successor, have this day the honour to preside. On that occasion Huxley dealt almost exclusively with the physical evolution of man, and the Neanderthal skull played an important part in his discourse. The anthropologists of that day and since have severely criticised, and rightly so, the old teleological doctrine that everything except man himself had been created for man's use, and they emphatically enunciated the doctrine that man himself has been evolved under the same laws as every other animal. Yet the anthropologists themselves have not always carried out in practice their own principles to their logical conclusions. To-day I shall attempt to show that the chief errors which impede the scientific study of man, which lead to the maladministration of alien races, and which beget blunders of the gravest issue in our own social legislation, are due in the main to man's pride in shutting his eyes to the fact that he is controlled by the same laws as the rest of the animal kingdom.

I. Let us first consider some of the chief problems which at present are being debated by the physical anthropologists. Foremost in importance of these is the stratification of populations in Europe. It has generally been held as an article of faith that Europe was first peopled by a non-Aryan race. Of course it is impossible for us to say what were the physical characteristics of Palæolithic man, but when we come to Neolithic man the problem becomes less hopeless. It has been generally held that the first Neolithic men in Europe, whether they were descended or not from their Palæolithic predecessors, had long skulls, but were not Aryan; that later on a migration of short-skulled people from Asia passed along Central Europe and into France, becoming what is commonly termed the Alpine, by some the Ligurian, by others the Celtic race; that later these two primitive non-Aryan races were overrun by the Aryans, who, when these theories were first started, were universally considered to have come from the Hindu Kush, but are now generally believed, as held by Latham, to have originated in Upper Central Europe. Yet, although the view respecting the cradle of the Aryans has changed, anthropologists have not seen the important bearing that it has upon the problem of Neolithic man. The Aryans are generally held to have had a blonde complexion.

As our discussion must from its nature concern itself with questions of race, let us first examine the criteria by which anthropologists distinguish one race from another. If you ask an anthropologist how he distinguishes an Aryan from a non-Aryan race, he will tell you that he relies on three main tests: (*a*) the colour of the skin, hair, and eyes; (*b*) the shape of the skull and certain other osteological characteristics; and (*c*) the system of descent through males. Formerly language was included in the tests of race, but when it was pointed out that the Negroes of Jamaica speak English, those of Louisiana French, henceforward it was assumed that one race can embrace the language of another with the greatest ease. Yet it may turn out, after all, that language was too hastily expelled from the criteria of race. On the other hand, we may find that too implicit faith has been placed on the three criteria of cranial characteristics, pigmentation, and law of succession.

(*a*) As it is assumed that all Aryans were blonde and traced descent through males, so it is held that all Europeans, who are dark-complexioned, and whose forefathers traced descent through women, are non-Aryan in race, and that, although they now in almost every case speak an Aryan tongue, this is not their primitive speech, but simply that learned from their Aryan conquerors. According to this orthodox view, the dark-skinned inhabitants of Italy, Spain, and Greece are all non-Aryan, and all have borrowed the language of their masters, whilst of course the same is held respecting the melanochrous population of France and of the British Isles. Ever since Prof. Sergi comprehended under what he terms the "Eurafrican species" all the dark-complexioned peoples of Southern and Western Europe, as well as the Semitic and Hamitic peoples of Western Asia and Northern Africa, the doctrine that the dark-skinned peoples of Europe once spoke a non-Aryan tongue or tongues is supposed to have been finally established. But under his Eurafrican species Sergi includes the blonde race of Northern Europe who speak Aryan languages along with the dark races who speak non-Aryan tongues. It is argued that as all the dark-skinned peoples on the north side of the Mediterranean belong by their physical type to the same original stock as the Semites and Hamites, they must likewise have spoken non-Aryan languages. Yet it might as well be maintained that the Finns, who speak a non-Aryan tongue, and the Scandinavians, who speak an Aryan, were originally all of one stock, because both races are blonde.

This doctrine of a Mediterranean race depends upon the tacit assumption made by the physical anthropologists that identity or similarity of type means identity of race. Yet this assumption does not bear the test of scientific examination, for it assumes that only those who are sprung from a common stock can be similar in physical structure and coloration, and it leaves altogether out of sight the effects of environment in changing racial types, and that, too, in no long time. The change in the type of the American of New England from that of his English ancestor and his approximation to the hatchet face and thin, scraggy beard of the Red Indian have long been remarked, whilst the Boers of South Africa, in less than 150 years, have quite lost the old Dutch build, and become a tall, weedy race. The effects of climatic conditions are very patent amongst the native peoples of the New World. The Iroquois of the temperate parts (lat. 40°–45°) of North America were a tall, rather light-complexioned race, but as we keep moving south and approach the equator, their kindred tribes grow somewhat darker in complexion and more feeble in physique, except where they live at a considerable altitude, for of course altitude acts in the same way as latitude. When once we pass below the equator the physique keeps steadily improving until we come to the Pampas Indians, a vigorous race who defied all the efforts of the Spaniards to subdue them; and finally we meet the Patagonians (lat. 40°–53°), a fine, tall, light-complexioned race, who form in the south the counterpart of the Iroquois and their closely allied tribes in the north.

The same law, as is well known, can be seen at work in Europe. Starting from the Mediterranean, we meet in the lower parts a melanochrous race; but gradually, as we advance upwards, the population as a whole is growing less dark, until finally, along the shores of the Baltic, we meet the tallest and most light-complexioned race in the world. Of course it has been explained that the change in pigmentation, as we advance from south to north, is due to the varying proportions in the admixture of the blonde race of the north with the melanochrous of the south. But it is difficult to believe that the movements up or down of the people from the southern side of the Alps, or of those from the shores of the Baltic, have been so nicely proportioned as to give the general steady change from north to south in coloration without the aid of some other force. The case of America, which I have just cited, is in itself enough to raise a suspicion that climatic influences are at work all the time, and that environment is in reality the chief factor in the variation of both stature and pigmentation from the Mediterranean to the Baltic. The white race of the north is of the same proximate ancestry as the dark-complexioned peoples of the northern shores of the Mediterranean. I have already argued elsewhere that, as the ice-sheet receded, mankind kept pressing further north, and gradually under changed climatic conditions the type changed from area to area, and they all still continued to speak the same Indo-European tongue, but with dialectic variations, these also being no doubt due to the physical changes in the vocal organs produced by environment.

If we turn from man to the other animals we find a complete demonstration of this doctrine. For instance, the conditions which have produced a blonde race on the Baltic have probably produced the white hare, white bears, and the tendency in the stoat and the ptarmigan to turn white in winter, whilst in the same regions of Europe and Asia the indigenous horses were of a dun colour, who not only turned white in winter, but had a great tendency to turn white altogether. It may be objected that the Lapps and Eskimo are not tall and blonde, but on the contrary short and dark; but they live within the Arctic circle in regions where the sun does not shine at all for a great part of the year, and consequently they are quite outside the conditions of environment under which the tall, blonde race of North Germany has long dwelt. Of course, in dealing with man we are always confronted with the difficulties arising from his migrations; but if we can find a family of lower animals who cannot be said to have thus migrated, and who show the effects of environment, we shall be able to argue powerfully from analogy.

The horse family supplies the example required. If we follow it from Northern Asia to the Cape of Good Hope, we shall find that every belt has its own particular type, changes in osteology as well as in coloration taking place from region to region. First we meet the old dun horse, with its tendency to become white, the best European examples of which were probably the now extinct ponies of the Lofoden Isles. In Asia, Prejvalsky's horse is the best living instance—a dun-coloured animal with little trace of stripes. Bordering on the Prejvalsky horse or true tarpan come the Asiatic asses: first the dzeggetai of Mongolia, a fawn-coloured animal, the under-parts being Isabella-coloured; then comes the kiang of the Upper Indus valley, seldom found at a lower altitude than 10,000 feet, rufous-brown with white under-parts, whilst, as might be expected from its mountain habitat, its hind-quarters are much more developed in length and strength than in the asses of the plains. The *Onager indicus, onager* and *hemippus* are found in all the great plains of the Punjab, Afghanistan, Western India, Baluchistan, Persia, and Syria, whilst a few are said to survive in South Arabia. All these are lighter in colour than the kiang, the typical onager being a white animal with yellow blotches on the side, neck, and head. All the Asiatic asses are distinguished by the absence of any shoulder stripe, though they occasionally show traces of stripes on the lower parts of the legs. The southern Asiatic asses just described, in their greyer colour and smaller hoofs approximate to the wild asses of Africa, especially to those of Somaliland, whilst it is maintained that in their cry, as well as in their colour, the kiang and dzeggetai come closer to the horse, the next neighbours of which they are.

Passing to Africa, we find the ass of Nubia and Abyssinia showing a shoulder stripe, and frequently with very strongly defined narrow stripes on the legs, the ears being longer than those of the onager. But in closer proximity to South-Western Asia comes the Somali ass, which differs from those of Nubia and Abyssinia by being greyer in colour, by the entire absence of shoulder stripes, and by smaller ears, in all which characteristics it comes closer to its neighbours on the Asiatic side than it does to its relations in Abyssinia and Nubia.

Next we meet the zebras. First comes the magnificent Grévy zebra of Somaliland, Shoa, and British East Africa. It is completely striped down to its hoofs, but the coloration of the specimens from Shoa differs from that of those from Somaliland and from those of British East Africa. The Grévy zebra has its hoofs rounded in front like those of a horse, but its ears are more like its neighbours the asses than those of any other zebra.

In the region north of the river Tana the Burchelline group of zebras overlaps the Grévy, and though it differs essentially in form, habits, and shape of its hoofs from the Grévy, some of those in the neighbourhood of Lake Barringo show grid-iron markings on the croup like those on the Grévy zebra, whilst, like the latter, they also possess functional premolars.

All the zebras of the equatorial regions are striped to the hoofs, but when we reach the Transvaal, the Burchelline zebra, known as Chapman's, is divesting itself of stripes on its legs, whilst the ground colour is getting less white and the stripes less black. Further south the true Burchell zebra of the Orange River has completely lost the stripes on its legs and under-surface, its general colouring being a pale yellowish-brown, the stripes being dark brown or nearly black. South of the Orange River the now extinct quagga of Cape Colony had not only begun to lose the stripes of its under-part and on the hind-quarters, but in Daniell's specimen they only survived on the neck as far as the withers, the animal having its upper surface bay and a tail like that of a horse, whilst all specimens of quagga show a rounded hoof like that of a horse.

In the quagga of 30° to 32° S. we have practically a bay horse corresponding to the bay Libyan horse of lat. 30°–32° N.

But the production of such variations in colour does not require great differences in latitude. On the contrary, from a study of a series of skins of zebras shot for me in British East Africa, each of which is from a known locality and from a known altitude, there can be no doubt that such variations in colour are found from district to district within a comparatively small area.

In addition to the two species of zebra already mentioned, there is the mountain zebra, formerly extremely common in the mountainous parts of Cape Colony and Natal, though now nearly extinct in that area. Its hind legs, as might naturally have been expected from its habitat, are more developed than those of the other zebras, just as these same limbs are also more developed in the kiang of the Himalayas than in any other ass.

With these facts before us, there can be no doubt that environment is a most potent factor, not only in coloration, but also in osteology. No less certain is it that environment is capable of producing changes in animal types with great rapidity. Thus, although it is an historical fact that there were no horses in Java in 1346, and it is known that the ponies now there are descended from those brought in by the Arabs, yet within five centuries there has arisen a race of ponies (often striped) some of which are not more than two feet high. Darwin himself has given other examples of the rapid change in structure of horses when transferred from one environment to another, as, for instance, when Pampas horses are brought up into the Andes.

Another good example is that of the now familiar Basuto ponies. Up to 1846 the Basutos did not possess a single horse, those of them who went down and worked for the Boers of the Orange River usually taking their pay in cattle. At the date mentioned some of them began to take horses instead. These horses were of the ordinary mixed colonial kinds, and we may be sure that the Boers did not let the Basutos have picked specimens. The Basutos turned these horses out on their mountains, where, living under perfectly natural conditions, their posterity within less than forty years had settled down into a well-defined type of mountain pony.

Nor is it only in the horse family that we meet with examples of the force of environment. The tiger extends from the Indian Ocean, through China up to Corea, but the tiger of Corea is a very different animal from that of Bengal. Instead of the short hair of the Indian tiger, the Corean has clothed himself with a robe of dense long fur to withstand the rigours of the north. It is not unlikely that if we had a sufficient number of skins from known localities we could trace the change in the tiger from latitude to latitude, just as I have shown in the case of the Equidæ.

Now whilst there is certainly a general physical type common to all the peoples round the Mediterranean, it by no means follows that all those peoples are from the same original stock. On the contrary, the analogy from man in other parts of the world, as well as that of the Equidæ, suggest that the resemblance between the Berbers, who speak Hamitic, the Greeks who speak Aryan, and the Jews and Arabs who spoke Semitic, is simply due to the fact that those peoples, from having long dwelt under practically similar conditions in the Mediterranean basin, have gradually acquired that physical similarity which has led Sergi to the assumption that they have a proximate common ancestry, and that they accordingly form but a single race.

Nor is there any lack of instances of convergence of type under similar conditions in the case of the lower animals. We saw that the asses of South-Western Asia approximate in colour to the asses of North-East Africa, and in respect of the size of the ears and absence of shoulder-stripe, more especially to the nearest of these, the ass of Somaliland. Yet it does not follow that they are more closely related to the Somali ass than they are to their own next neighbours, the kiang. On the contrary, it is much more likely that the Somali ass is closely related to those of Abyssinia, and that the South-Western Asiatic asses are closely related to the kiang. The approximation in colour, absence of shoulder-stripe, and size of the ears between the asses of Somaliland and those of South-Western Asia must rather be explained by a convergence of types under the somewhat similar climatic conditions of Somaliland and the nearest parts of South-Western Asia. Again, though there are very strong specific differences between the Grévy and Burchelline zebras met in the neighbourhood of Lake Barringo, there is a curious approximation not only in marking but also in the teeth between these two species, which is best accounted for by supposing that it is the outcome of similar environment. It may be said that this approximation may be due to the interbreeding of the two species of zebras in the region where they overlap. This, in itself a most unlikely contingency from all that is known of the habits of wild species, certainly cannot be alleged in the case of the convergence in type between the asses of South-Western Asia and the Somali ass, since they are separated by the Red Sea and the Persian Gulf.

Again, the representative of the crocodile family in the Ganges is distinguished by the extreme elongation of the head and jaws, whilst the same elongation of the head is equally characteristic of the representative of the dolphin family found in the same waters. Again, all through the Indian Ocean wherever any family of crabs have become inhabitants of coralline sands its members have long legs. Again, it has long been noticed that in Cutch all the larger animals have a tendency to become a sandy colour, whilst in certain areas of South America insects, no matter to what family they belong, have a tendency to one common aspect.

It may of course be said that the changes in colour of the horse family, tigers, and insects are for "protective" reasons. But the case of the horse family alone is sufficient to dispose of this objection. The kiang of the Himalaya had no dangerous enemy until man was armed with a rifle. In Africa the zebras have had only two formidable foes—man and the lion. It is asserted by the most experienced hunters that the gaudy livery of the zebra makes him conspicuous from afar, whether he is on the mountain, on the plain, or in the shade of a tree. His brilliant colour therefore really exposes him to man. But it will be said that it is well adapted to conceal him at night, at which time the lion seeks his prey. Yet as the best authorities hold that the lion hunts entirely by scent, the coloration of the zebra affords him no protection against his inveterate foe.

I have shown that in horses the colours—such as bay, black, grey, and white—accompany certain well-defined inward qualities. But as black is most certainly not a primitive horse colour, it follows that coat colours may be intimately connected with certain other characteristics quite irrespective of protective colouring. Again, as the variation in the size and shape of the ears and hoofs of the asses and zebras cannot be set down to protective colouring, but must be due to other causes, there is no reason why variations in colour should not be ascribed to similar causes.

The argument based on the analogy of the horse family and the tigers, and on that of the natives of the New World, may be applied to the races of Africa. Next to the Mediterranean lie the Berbers and their Hamitic congeners, who are regarded as part of the Eurafrican species by Sergi and his school. But the Berbers are not all of the typical Mediterranean physique. The blonde Berbers of the highlands of Rif in North-West Morocco and of the Atlas have long been well known. In the region lower down and in Western Tunis the occurrence of the xanthochrous type seems much less frequent, whilst further east it practically disappears.

It is certain that there was a fair-haired element in Libya long before Rome conquered Carthage or the Vandals had passed into the ken of history. Callimachus testifies to the existence of blonde Berbers in the third century B.C. We may hold, then, with Sergi and others that the blonde element in the Berbers is not a survival from invasions of Vandals or Goths, or from Roman colonists, but that they rather owe their fair complexions and light-coloured eyes to the circumstance that they were cradled in a cool, mountainous region, and not along the low-lying border of the Mediterranean like their dark-coloured relations whose language and customs they share.

If, then, some of those who speak Hamitic are fair, and have been fair for centuries before Christ, as Sergi himself admits, whilst others are dark, there is no reason why some of the peoples who speak Aryan might not be dark whilst others are blonde.

The Berbers and their Hamitic congeners shade off on the south into other peoples, but this is not altogether due to intermarriage, as is commonly held, for it is more probably to be explained as due in a large part to climatic conditions. The Bantus, who are said to have originated in the Galla country and to have spread thence, are now regarded by the chief authorities as the result of an inter mixture of Hamites and Negroes. But, on the grounds I have already stated, it is more rational to regard them as having been evolved in the area lying between the Hamitic peoples on the north and the Negroes on the south, just as we have corresponding types of the horse family in Nubia and Abyssinia and in the equatorial regions. The same hypothesis also explains the existence of those cattle-keeping tribes which lie west of the Nile stretching across Northern Nigeria, who border on the Berbers, but yet differ from them, and border also on the Negroes, but differ from them likewise. South of these tribes come the Negroes, the true children of the equator. The Bantu is able to live in elevated equatorial areas, and he has burst his way down to the subtropical and temperate parts of South Africa, where he especially flourishes in the highlands, thus showing that his race was originally evolved under similar conditions. The Bantu found in the South the Hottentots, who are especially distinguished by steatopygy, a feature which has led some to identify them with the primitive steatopygous race supposed to have once lived in Southern Europe, Malta, and North Africa, and to have left evidence of their characteristic in their representations of themselves. But, granting that such a race once lived in North Africa and Southern Europe, there is really no more reason for supposing that they and the Hottentots formed one and the same race than there is for assuming that Daniell's quagga, which was practically a bay horse, was proximately akin to the bay horse of North Africa. The occurrence of steatopygy in two areas so wide apart is not due to an ethnical migration, but rather to similar climatic conditions producing similar characteristics.

As some anthropologists so commonly explain the origin of races such as the Bantus by intermarriage, it may be well to see whether intermarriage between two races, one of which is an invader, is likely to produce a permanent effect upon the general physique of a whole community. I have shown elsewhere that the many invasions of fair-haired races into the three southern peninsulas of Europe and into the Ægean islands have left no permanent trace on the population. It is a matter of common knowledge that the offspring of British and native parents in India have a constant tendency to die out. The same undoubtedly holds true for the offspring of British soldiers serving in Egypt, the Soudan, and West Africa. The native race always reasserts itself. In America the Spanish blood has died out, or is dying out, everywhere except in the temperate regions of Chile, Quito, and Argentina, where the descendants of the Spanish settlers thrive in a climate very analogous to that of Spain. In the Southern States of North America the whites cannot flourish, and only just manage to survive. On the other hand, the descendants of the Negro slaves imported into Brazil, the West Indies, and the Southern States of North America thrive and multiply with extraordinary vigour, a fact doubtless due to their race having been evolved under similar conditions in equatorial Africa.

Even from the evidence already to hand there is high probability that intermarriage can do little to form a new race unless the parents on both sides are of races evolved in similar environments.

I have already pointed out that although the fair-haired race of Upper Europe has age after age kept pouring over the Alps into Italy and the other southern peninsulas, and have constantly intermixed with the indigenous populations, it is only in the upper part of Italy that the blonde race is able to hold its own. In Italy the xanthochrous race in ancient times, as to-day, had its maximum along the Alps, and gradually dwindled towards the south until the melanochrous race stood practically alone in the lower part of the peninsula. So too in the Balkan, whilst the fair-haired element was at its maximum along the Alps and the Danube, southwards the melanochrous becomes more and more completely dominant, as it practically is to-day in the lower part of the peninsula.

(*b*) In the Alpine regions there has been from Neolithic times a brachycephalic race, also found in Central France and in the British Isles, whither it is supposed to have come in the Bronze age. It has been a fundamental article of faith with Sergi and others that this round-headed race came from Asia, the home of brachycephalism. It is Mongolian according to most, and spoke a non-Aryan language; but Sergi regards it as Aryan, thus reverting to the old doctrine, which made the Aryans come from Central Asia, and he assumes that these invaders imposed their language both on the aborigines of Italy, such as the Ligurians, and on the blonde race of Northern Europe; but we shall soon see that this assumption has no base. Now, as these folk dwelt in the region where we find the Ligurians of historical times, others have argued that the Ligurians were a non-Aryan people from Asia. But it is impossible to find any hard-and-fast lines between the Alpine race and the peoples north and south of it in culture and sociology. For that reason when treating of the people of the Alps in my "Early Age of Greece" I did not take any account of the difference in cranial measurements. In 1906, at the British Association, I maintained that this difference of skull type did not mean any racial difference, and on the analogy of the changes in the osteology of the Equidæ I urged that the roundness of the skulls was simply due to environment, as the horses of the Pampas when brought up into the mountainous regions of Chile and Peru rapidly change their physical type. Physical anthropologists have already maintained that the round head of the Mongolian has been developed in the high altitude of the Altai. If that be so, there is no reason why a similar phenomenon should not have taken place in the Alpine region, in Albania, Anatolia, and wherever else in mountain areas brachycephaly has been found in more than sporadic examples, which of course may well be due to migrations or importation of slaves. But I am far from suggesting that altitude is the only cause of brachycephaly.

The evidence then, so far as it goes, points to the same conclusion as that to which we came as regards pigmentation, and it may eventually be proved that just as each area has its own type of coloration, so also has it its own osteological character. In support of this I may point out that recently Dr. William Wright, Hunterian lecturer, has come to the conclusion from his craniological investigations that the brachycephalic Alpine race was evolved on European soil, whilst Dr. C. S. Myers has been led by his researches on Egyptian skulls to conclude that, "in spite of the various infiltrations of foreign blood in the past, modern Egypt contains a homogeneous population which gradually shifts its average character as we proceed southwards from the shores of the Mediterranean to Nubia beyond the First Cataract."

It is not impossible that Alpine environment may have acted upon the shape of the skull of the ox as well as that of man. We know from the examination of the fauna of the Lake dwellings of Switzerland that the Celtic ox (*Bos longifrons*) was there the common type, and its descendants still continue to be the typical breed along the Alpine chain. This ox is characterised by its strongly developed occipital region and its small horns curved forward and inward. As it differs so essentially from the urus (*Bos primigenius*) and from the long-horned cattle of the Mediterranean lands, it seems not unlikely that the peculiar cranial formation may have been evolved under mountainous environment.

It is now clear that differences in the shape of the skull and in the colour of the skin, hair, and eyes cannot be at all implicitly relied on as criteria of race. The defenders of the non-Aryan character of the dark races of Greece, Italy, Spain, France, and the British Isles have now to depend on two arguments only, one of which is linguistic, the other sociological. It is admitted that it is very difficult to point to any non-Aryan survivals in the vocabularies of the languages of these countries, and it is also admitted that in them all the tense system of the Aryans has been taken over in its entirety. Neither Kretschmer nor anyone else has ventured to affirm that there is any survival of non-Aryan syntactical forms in Greek, the language of all others in which the Aryan tense system is found in its greatest delicacy and perfection. But we know that in all cases where an Aryan language has without doubt been adopted by a non-Aryan folk the tense system is invariably broken up. No better example than this is needed than ordinary "pigeon" English. So difficult is it for the defenders of the non-Aryan theory of the origin of the aborigines of Greece to maintain their position that one of the latest, Prof. Burrows, has to rely on certain supposed syntactical survivals of a non-Aryan language which Sir John Rhys believes that he has found in Welsh and Irish and in the remarkable resemblance which Prof. Morris Jones thinks that he has traced between the syntax of those languages and that of Berber and ancient Egyptian.

Yet when we examine the evidence on which Sir John Rhys relies, it turns out to be only three Welsh and Cornish oghams, written not in pure Celtic, but in dog Latin, and also two Irish oghams, which show a looseness in the use of the genitive suffix at a time when final syllables were dropping out of use in Irish. Sir John Rhys supposes that the non-Aryan inhabitants of these islands derived their Gaelic speech from a people whom he terms Celticans, who spoke Goidelic, and who were followed by the Brythons, who found the aborigines already Celticised. Prof. Morris Jones freely admits that the aborigines must have borrowed the full Aryan tense system, a fact in itself sufficient, from what I have already said, to arouse grave suspicions as to the validity of any arguments based on supposed fundamental grammatical differences. But this supposed taking over of the full Aryan tense system by the non-Aryan aborigines of these islands is rendered all the more miraculous from the circumstance that Sir John Rhys holds that his Celticans who spoke Goidelic "came over not later than the great movements which took place in the Celtic world of the Continent in the sixth and fifth centuries before our era," that the Brythons came over to Britain between the time of Pytheas and that of Julius Cæsar," and that the Brythons were not likely to come into contact on any large scale with the aborigines "before they had been to a considerable extent Celticised." It is thus assumed that it was possible for the aborigines to have been so completely Celticised as to have adopted the Aryan tense system, as well as the Aryan vocabulary, in its fulness in the interval between the sixth or fifth century and the second century B.C. Yet English has been the master speech in Britain for many centuries, and that, too, when reading and writing have been commonly practised; yet Gaelic still survives, whilst Welsh not only survives, but flourishes. It is therefore simply incredible that such a complete transformation as that postulated could have taken place in three or four centuries in an age when writing and literature can be hardly said to have existed in these islands.

Let us now see under what conditions does one race or people borrow the language of another. Slaves of course take over the language of their masters, but we have to consider (1) the adoption by a conquering people of the language of the conquered; (2) the adoption by a conquered people of that of their conquerors; and (3) the adoption by a people, themselves unconquered, of the language of their neighbours. Under what conditions do the conquerors adopt the language of the conquered? Ireland affords us at least two certain examples. Cromwell planted large bodies of his English soldiers in Tipperary, but they had no English women, and therefore took as wives the daughters of the land, who spoke the Irish language. From this union resulted a splendid offspring, who spoke chiefly the language of their Irish mothers, and not their fathers' English. So it came to pass that in a single generation the progeny of Cromwell's Puritans were in language as Irish as the purest-blooded aboriginal of Munster. Yet this adoption of the Irish language by the great majority of the children of these settlers took place in spite of the effect which the reading of books in English must have exerted to counteract the tendency to adopt the Irish language. Let us go back five hundred years in Irish history, and we find exactly the same process going on. The Normans who followed Strongbow into Ireland, like their captain, frequently married native women. It is a matter of common knowledge that the Anglo-Norman settlers in a short time became *Hiberniores ipsis Hibernis.*

These and other examples too numerous to cite here prove that the children of bodies of conquerors who marry the women of the land will have an inevitable tendency to follow their mothers' speech. We may also lay down as a solid factor in the tendency of the conqueror to merge into the conquered the isolation of the conquerors from their original homes and from the great mass of those who speak the same language.

Next we come to the case where the conquerors bring with them some women of their own race. This of course helps to keep their own language alive, as a certain number of the children speak it as their mothers' tongue. But even in these circumstances the invaders are liable to drop their own language and practically adopt that of the natives. Thus the Northmen who settled on the coast of France gradually abandoned their national tongue for French, though modifying dialectically their adopted language. When under the name of Normans they conquered and settled in England, they again adopted the language of the conquered, though modifying the English tongue by many words and phrases brought with them from Normandy, and we have just seen how some of their descendants who settled in Ireland for the third time changed their speech for that of the conquered.

Hitherto all our examples show the adoption by the conquerors of the language of the conquered, even when they bring a certain number of their women with them.

We now come to undoubted cases where the language of the conqueror has been able to get a firm foothold. From the time of the plantation of Ulster, the advance of the English tongue, and consequent decadence of the Irish, has steadily proceeded, for the settlers, unlike Cromwell's Ironsides, brought with them women of their own race and speech. Consequently their children grew up speaking English as their mothers' tongue. Yet even with such a basis the advance of English amongst the Irish has been exceedingly slow. In the glens of Antrim the Irish language still lingers on, whilst in Donegal, Connaught, Kerry, Cork, and Waterford, English has not succeeded in ousting completely the native language, though the former is the language of the national schools, of the newspapers, and of trade.

The story of the establishment of English itself in Britain is just the same as in Ulster. We know from Bede that the Angles who settled in Britain left Holstein in large bodies, bringing with them their wives and families, and leaving their old homes without inhabitant. Having thus settled in solid masses in the east of Britain, they retained fully their own tongue, impressed it upon their menials, and gradually, as they extended their conquests westward over the island, English became the language of the land. Yet in Wales the ancient speech still flourishes.

We may therefore conclude that the adoption by the conquered of the language of the conqueror, even when it does take place, which is but rarely, is a very slow and tedious process, although every advantage is on the side of the invading tongue, and that when the native speech gets a fair field, as in Wales, the language of the conqueror can make little or no advance.

Only the third possibility now is left—that one people can adopt without conquest the language of another. But no example of such can anywhere be found, although Europe presents numerous instances to the contrary. There can be no stronger case than that of the Swiss Republic, in which peoples with more than four kinds of language combine for national defence and other advantages. Here, if anywhere, we ought to find a gradual adoption by certain cantons of the language of their neighbours. But, far from this being so, the German, French, Roumansch, and Italian cantons rigidly preserve their respective mother-speeches. In the Austro-Hungarian Empire there is no tendency observable on the part of either Magyars or Slavs to adopt German; nay, the very opposite is the case. Again, the Finns have not adopted either Swedish or Russian, though partitioned between their more powerful neighbours.

To sum up, it seems that no nation readily adopts the language of another, even though it be in close ties of friendship; whilst there is still less tendency when national hostility intervenes. Secondly, the adoption of the language of the conqueror by the conquered, except in the most favourable circumstances, is not common, and only takes place by a very gradual process, as is seen in the case of Ireland. Thirdly, there is a strong tendency for the conqueror to adopt the language of the conquered, as was done by the Normans in England, in Ireland, in Sicily, and in Italy; by the Cromwellian settlers in Tipperary, by the Bulgari in Bulgaria, by the Franks in Gaul, by the Lombards in Italy, and by the Visigoths in Spain. There is thus an inevitable tendency for the children to speak their mothers' tongue, and indeed the phrase "mother-tongue" is based on the fact, observed through long ages, that the child learns its first words from its mother, and thus takes after her in speech. This law, which still holds good in modern days and in civilised communities, must have been far stronger in earlier times in countries where the tie of marriage hardly existed and the child belonged to its mother's and not to its father's tribe, as is still the case in many parts of the world.

In view of these facts we cannot accept Sir John Rhys's hypothesis that when a few bodies of invaders, whom he terms Celticans, passed into Ireland the indigenous supposed non-Aryan race within two centuries completely abandoned its own language, taking over in its entirety the Aryan tense system as well as the Aryan vocabulary of its conquerors.

Now let us turn to Greece, Italy, and Spain. It is admitted that neither Arcadia nor Attica was ever conquered by Acheans or Dorians, yet in both these areas the Greek language existed through all historical time, and in Attica especially the Aryan tense system is found in its highest perfection. The dialect of Arcadia cannot have been taken over from Acheans or Dorians, because it is the same as that of the Cypriotes from Arcadia who settled in Cyprus at least 1100 B.C. It is also very close to the dialect of Pelasgiotis in Thessaly, the home of the aboriginal Pelasgian population, whilst it comes closest of all Greek dialects to that of the ancient Epic. There can therefore be no doubt that Arcadian is no mere bastard lingo, half non-Aryan, half Aryan, but is the genuine speech of the oldest and most unmixed population of Greece, who were undoubtedly a melanochrous race, and who also most certainly had occupied Greece from the Stone age.

The Ligurians, who formed from the Stone age the bottom stratum in all Upper and Central Italy, are now admitted to have spoken an Aryan language, and I have recently given some reasons for believing that the Latin language is simply the native tongue of the aboriginal Ligurian population of Latium with some admixtures derived from the Italic tribes of Siculi and Sabines. I have also shown that the ancient Iberians, the next neighbours of the Ligurians, used the same forms of place-names as the latter, and that some of the words plainly exhibit Aryan terminations. Thus we may conclude that with the exception of the Basques, who are probably a non-Aryan spurt from North Africa, the melanochrous populations of Spain, Italy, the Balkan Peninsula, France, Britain, Ireland, and Holland have from the first spoken none but an Aryan language.

(*c*) Only one argument is now left to the defenders of the non-Aryan theory. When the study of sociology first sprang up in the last century, it at once became a fundamental doctrine that the Aryans had always been strictly patriarchal, and that polyandry and descent through women was unknown amongst them. Though this view has received many rude shocks in later days, Prof. Zimmer argues from it that the indigenous people of Britain and Ireland were non-Aryan.

It is well known from the ancient writers that the Picts were polyandrous, and that succession was consequently through females. Again, it is certain, both from the ancient Irish literature and also from statements of external writers, that the Irish were polyandrous, and that they also almost certainly traced descent through women. Accordingly Prof. Zimmer infers that the indigenous race was non-Aryan. But McLennan has long since pointed out that descent through women was the ancient law at Athens, and I have just shown that the Athenians and Arcadians, the autochthonous, dark-complexioned people of Greece, never spoke any save an Aryan tongue. Moreover, I have shown elsewhere that the Ligurians, who are now generally admitted to have spoken always an Aryan language, had descent through women, whilst I have also pointed out that there is good evidence that the ancient Latins, who have generally been taken as typical Aryans, had the same system. Again, it is admitted that the ancient Illyrians and dark-complexioned Thracians spoke an Aryan language, which, inasmuch as it differed materially in certain ways from that spoken by their Celtic overlords, must have been aboriginal, whilst I have further given grounds for believing that the ancient Iberians (though not the Basques) were also an Aryan-speaking folk. But there is good evidence that the Illyrians, melanochrous Thracians and Iberians all traced descent through women. In view of these facts it is useless to urge that because the Picts of Scotland and the ancient Irish had that system of succession through females these peoples must have been non-Aryan.

We have now reviewed the three main criteria of race at present used by anthropologists: (*a*) pigmentation of the skin, hair, and eyes; (*b*) the shape of the skull and other osteological characteristics; and finally (*c*) their system of tracing descent. We have seen that osteological differences may be but foundations of sand, because it is certain that such variations take place within very short periods, not only in the case of the lower animals, as in the horse family, but in man himself. Pigmentation is no true criterion, for we have found a steady tendency to change in colour in the case of the lower animals from latitude to latitude, whilst in the case of man the steady shading off in colour from dark to blonde may be traced from the equator to the Baltic. Unless then we postulate that man is entirely free from the natural laws which condition the osteology and pigmentation of other animals, we must admit that neither bone nor colour differences can be regarded as crucial criteria. Further, we saw that the test of descent through males or females broke down absolutely in the case of peoples who can be proved historically never to have spoken any but a non-Aryan language. Finally, we are forced to the conclusion that language, now that we realise what are the laws which govern its borrowing by one race from another, is really the surest of all the known tests of race when dealt with broadly and over wide areas, and not merely in the way of guesswork etymologies.

II. Hitherto I have dealt only with the need of a rigid application of zoological laws in studying the evolution of the various races of man. In the time that is still left I propose to touch briefly on the vast importance of such natural laws when dealing with the native races of our great dependencies and colonies, and in our own social legislation. I venture to think that the gravest mistakes which at present are being made in our administration and legislation are due to the total disregard of the natural laws, which not only modify and differentiate one race from another, but also are constantly producing variations within our own community. As physical characteristics are in the main the result of environment, social institutions and religious ideas are no less the product of that environment. Several of our most distinguished Indian and Colonial administrators have pointed out that most of the mistakes made by British officials are due to their ignorance of the habits and customs of the natives. It has been in the past an axiom of British politicians that in the English Constitution and in English law there is a panacea for every political and social difficulty in any race under the sun. Only let us give, it is urged, this or that State a representative parliamentary system and trial by jury and all will go well. The fundamental error in this doctrine is the assumption that a political and legal system evolved during many centuries amongst a people of North-Western Europe, largely Teutonic, and that too living not on the mainland but on an island, can be applied cut and dried to a people evolved during countless generations in tropical or subtropical regions, with social institutions and religious ideas widely different from those of even South Europeans, and still more so from those of Northern Europe. We might just as well ask the Ethiopian to change his skin as to change radically his social and religious ideas. It has been shown by experience that Christianity can make but little headway amongst many peoples in Africa or Asia, where, on the other hand, Mohammedanism has made and is steadily making progress, acting distinctly for good, as in Africa, by putting down human sacrifice and replacing fetish worship by a lofty monotheism. This is probably due to the fact that Mohammedanism is a religion evolved amongst a Semitic people who live in latitudes bordering on the aboriginal races of Africa and Asia, and that it is far more akin in its social ideas to those of the Negro or Malay than are those of Christianity, more especially of that form of Christianity evolved during the last twelve centuries by the Teutonic peoples of Upper Europe, who are of all races furthest in physical characteristics, in religious ideals and social institutions, from the dark races of Africa and Asia. This great gulf is due not merely to shallow prejudice against other people's notions, it is as deep-seated as is the physical antipathy felt by the Teuton for the Negro, which is itself due to the very different climatic conditions under which both races have been evolved. The Teuton does not freely blend with the black, and even when he does intermarry he treats his own half-bred progeny with contempt, or at most with toleration. On the other hand, some South Europeans, for example the Portuguese, are said to have little objection to intermarrying with dark races and allowing the mixed progeny an equal social status, whilst the Arab through the ages has freely taken to wife the African, and has never hesitated to treat the hybrid offspring as equals. There is thus a wide breach between the physique and the social and religious ideas of the African and our own; but, as political and legal institutions are indissolubly bound up with social and religious, it follows inevitably that the political and legal institutions of a race cradled in Northern Europe are exceedingly ill adapted for the children of the equator. Accordingly in any wise administration of these regions it must be a primary object to study the native institutions, to modify and elevate them whenever it may be possible, but never to seek to eradicate and supplant them. Any attempt to do so will be but vain, for these institutions are as much part of the land as are its climate, its soil, its fauna, and its flora. "Naturam expellas furca, tamen usque recurret." Let us hope for a successful issue for the effort now being made by the Royal Anthropological Institute to establish an Imperial Bureau of Anthropology the function of which will be, not only to carry out systematically the scientific study of man, but also to aid the administrator and the legislator, the merchant and the missionary.

III. I now pass to my last and most important topic—natural laws in relation to our own social legislation. We have seen that environment is a powerful factor in the differentiation of the various races of man, alike in physique, institutions, and religion. It is probable that the food-supply at hand in each region may be an important element in these variations, whilst the nature of the food and drink preferred there may itself be due in no small degree to climatic conditions. Each zone has its own peculiar products, and beyond doubt the natives of each region differ in their tastes for food and drink. The aboriginal of the tropics is distinctly a vegetarian, whilst the Eskimo within the Arctic circle is practically wholly carnivorous. In each case the taste is almost certainly due to the necessities of their environment, for the man in the Arctic regions could not survive without an abundance of animal fat. It is probable that the more northward man advanced the more carnivorous he became in order to support the rigours of the northern climate. The same holds equally true in the case of drink. Temperance reformers would enforce by legislation complete abstinence from all alcoholic liquors, and they point to the sobriety of the Spaniards, Italians, and other South Europeans, and urge, if these nations are so temperate, why should Britons and Irish continue to drink beer and spirits in such large quantities? This appeal depends unfortunately on the false assumption that the natives of these islands enjoy the same climate as the people of the sunny south. All across Northern Europe and Asia there is a universal love of strong drink, which is not the mere outcome of vicious desires, but of climatic law. In Shakespeare's time "your Englishman was most potent in potting," and this was no new outbreak of depravity, for the earliest reference in history to the natives of these islands tells us the same tale. When Pytheas of Marseilles travelled in these regions, about 350 B.C., he found the people making "wine from barley," and, though he does not explicitly say so, we need not doubt that it was meant for home consumption. In view of these facts we must regard this tendency as essentially climatic. This view derives additional support from the well-authenticated fact that one of the chief characteristics of the descendants of British settlers in Australia is their strong teetotalism. This cannot be set down to their having a higher moral standard than their ancestors, but rather, as in the case of Spaniards and Italians, to the circumstance that they live in a country much warmer and drier than the British Isles. We must therefore, no matter how reluctantly, come to the conclusion that no attempt to eradicate this tendency to alcohol in these latitudes can be successful, for the most that can be done by the philanthropist and the legislator is to modify and control it, but especially by moral means.

I have spoken of the principles at work in the differentiation of one race from another. It may be that the same principles or others closely allied may be at work within each community, for each community is but the whole world writ small. Within the United Kingdom itself there are not only different physical types, but very different ideas respecting marriage and divorce embodied in the laws regulating those fundamental institutions in England, Scotland, and Ireland. If such fundamental differences exist in that most important of social institutions, we may well expect that the natural laws which differentiate one race from another may be at work within every community in the United Kingdom.

Yet though the world has been ringing with the doctrine of natural selection and the survival of the fittest for nearly half a century, no statesman ever dreams of taking these great principles into consideration when devising any scheme of education or social reform. On the contrary, it is a fundamental assumption in all our educational and social reforms that all men are born with equal capacities; that there is no difference in this respect between the average child of the labourer, sprung from many generations of labourers, and one born of many generations of middle or upper-class progenitors; and it is held that all that is necessary to make the children of the working classes equal, if not superior, to the children of the bourgeois is the same food, the same clothing, and the same educational advantages. On that account we have devised the so-called educational ladder. Yet if we ask any social reformer why are there middle classes, the answer will probably be that they are better off. But why are they better off? We are told that their fathers and mothers were better off, and that they thus got a better chance than the poor labourer. But why were the parents of these middle-class folks better off? Oh! they came of families that had been long well-to-do. But why were these families long well-to-do? At last we are brought to the conclusion of the northern farmer, that "Work mun 'a gone to the gittin' whiniver munny was got," and to his brutal correlative respecting the labourers that "Them or thir feythers, tha sees, mun 'a beän a laäzy lot."

Work no doubt has been a main factor in the evolution of the middle and upper classes, especially in later times, though undoubtedly other qualities, such as superior physique and superior courage, have been very important elements in the earlier stages. But at all times it is not improbable that the special quality which led to their rise was a superior self-restraint, that enabled them to resist the vices which are too often attendant on prosperity. This superior morale acts in turn upon the offspring by setting up a better standard of life in the home, which of itself gives children brought up in such an environment an advantage at the outset of life denied to the children of inferior parents. It needs no elaborate induction to prove that the middle classes are not the outcome of chance, but of a long process of natural selection and the survival of the fittest in the struggle for life, the two main factors in this evolution being, in the language of Aristotle, heredity and training. Each community is but a microcosm of the whole human race, which, as I have endeavoured to show, is bound by the same laws as the rest of the animal kingdom. One race becomes a master because of its superior physique, courage, brain power, and morale; another sinks in the struggle or lags behind owing to its inferiority in the very qualities which have given the mastery to its rival. What is true of master races in relation to inferior races is equally true of the individuals in each community. The middle and upper classes are in the main sprung from ancestors with better physique, courage, and morale, and who have generation after generation been brought up in a better moral atmosphere than the children of the masses. Their ranks are also continually being reinforced by the best of the working classes. But this is not due to any educational ladder provided in modern times, for the process has always been at work, though of course its action has been distinctly aided by modern legislation. Mediæval history supplies many examples of those who, though sprung from the humblest parents, rose to high place in Church and State. This was not due to any legislative enactments, but rather to a principle well known in the whole field of Nature. Everyone knows that the superior varieties of flowers and vegetables are commonly the "sports," as they are termed, from inferior species. The skilful gardener watches carefully for good "sports," for they may become very valuable additions to his *répertoire* of useful plants. So, too, the legislator must watch carefully for good human "sports," not for those with criminal propensities. In the mediæval world the Church provided a ladder by which the son of the peasant could rise to be the counsellor of kings and princes. In modern times the State provides an educational ladder by which the child of the humblest parents may rise, if it has the capacity, to the highest positions in the community. It is right—nay, essential—that such a ladder should be provided, but this ladder is not for the mass of children. The vast majority can never climb beyond its lowest rung owing to their heredity, and in a less degree to their home environment. The ladder is for the good "sports," who by its aid are thus continually reinforcing with fresh blood the ranks of the middle and upper classes.

It may be said that I underrate the number of the good "sports." Of course it is very difficult to get any exact statistics on so complex a subject; but according to information which I have obtained from one of our great industrial centres, where the educational ladder enables any child who passes the fourth standard in the primary schools before it is eleven to rise into the secondary schools, it is probable that no more than 5 or 6 per cent. of the children of the working classes have at the age of sixteen the same amount of brain power as the average children of the middle classes at the same age. But even all this 5 or 6 per cent. of "sports" cannot be credited to parents of the working class alone, for it may be that a certain proportion of them must be ascribed to middle- or upper-class parents. Of course these rude statistics must be corrected by others collected on a large scale all over the country before we can form a final judgment; but I believe that the evidence already to hand makes it improbable that more than a very limited percentage of the children of the working classes have the same ability as the average child of the middle classes.

In ancient days the chief end of the legislator was to produce a stalwart brood of citizens capable of bearing arms in defence of their country and advancing her material prosperity. Still more ought this to be the aim of our legislators to-day, for under modern conditions great masses of population are huddled together in a manner hardly known to ancient cities. To accomplish this great end, the legislator must not merely look to improved housing of the poor and the development of the physique of city populations. He must, so far as possible, conform to the principles of the stockbreeder, whose object is to rear the finest horses, cattle, or sheep. Amongst wild animals Nature selects the fittest for continuing the race, and the wise breeder simply aids Nature by selecting still more carefully the best animals. The legislator, on his part, ought similarly to foster the increase of the best element in the State, and on the other hand discourage the multiplication of the worst. Yet in our community statesmen of both parties have adopted the very opposite policy. The children of the working classes are educated at the cost of the State, the offspring of the wastrels are given free meals, and already there are demands that they shall be clothed at the expense of the ratepayers, and that the parents shall even be paid for providing them with lodging. It is not impossible that before long these demands will be conceded by either party in the State. The heavy additional expense incurred in this policy falls upon the middle-class ratepayers and taxpayers, who have to feed, educate, and clothe their own children at their own expense. It may be said that they can get free education for their children by sending them to the State schools; but this is to level down instead of to level up; for if they do so, they will be lowering the general morale of their own class, the most priceless asset of the nation. The heavy burden of taxation entailed by this policy, falling as it does with special weight on the middle classes, renders it more difficult each year for the young men and the young women in that class to marry before thirty, for they naturally shrink from the expense of bringing up large or even moderate-sized families. We need not then wonder at the falling-off in the rate of increase of the middle classes. Our legislators are bad stockmasters, for they are selecting to continue the race the most unfit physically and morally, whilst they discourage more and more the increase of what we have proved to be the outcome of a long process of natural selection. The present policy therefore tends to reduce that which in all ages has been the mainstay of every State, the middle class. The yeomen of England, the free burghers of Germany and of Italy, formed the best element in the Middle Ages. So was it also with the great republics of the ancient world. Aristotle, in more than one passage, has pointed out that the middle class, that which stands between the "excessively wealthy" and the "very poor," between the "millionaire" and the "wastrel," are the mainstay of every State, and he shows that, where the middle class has been crushed out by the millionaire or the mob, ruin has inevitably overtaken the State. Indeed, it is clear that the chief defect in the Greek democracies was the smallness and weakness of the middle class, whilst it is notorious that Rome prospered only so long as the middle-class citizens flourished. Her downfall came when they were extinguished by the great capitalists, who made common cause with the masses against them. The latter had no patriotism, were incapable of bearing arms, and had no aspirations beyond free meals and popular entertainments at the expense of the State.

It is of great scientific interest to discover how the short-skulled peoples of Asia and Europe became differentiated from their long-skulled congeners; it is of great practical importance to apply to the administration of our great dependencies and colonies the lessons taught by anthropology; but it is infinitely more important to maintain a vigorous stock of citizens for the kingdom and the empire. Questions of the origin of races are, after all, only academic; but the other two, more especially the last, are intimately bound up with the life of the nation. If the present policy of our legislators is adhered to, the moral and the physical standard of the British citizen will steadily deteriorate, for the population will gradually come to consist of the posterity of those who are themselves sprung from many generations of the most unfit. Should this unfortunately come to pass, it will be the result of human pride refusing to apply to the human race the laws which inexorably regulate all Nature.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

St. Andrews.—Dr. Hugh Marshall has been appointed successor to Prof. James Walker, F.R.S., in the chair of chemistry in University College, Dundee, and Dr. Percy J. Herring has been appointed to the Chandos chair of physiology in the United College, St. Andrews, in the room of the late Prof. Pettigrew, F.R.S.

Mr. T. J. Rees has been appointed superintendent of education for the borough of Swansea.

The directorship of the research hospital of the Rockefeller Institute of New York City has been accepted by Prof. Rufus I. Cole, of the Johns Hopkins University.

Mr. J. A. Gilruth, chief veterinarian and Government bacteriologist of New Zealand, has been appointed director of the National Veterinary College and Research Institute now being established by the Government of Victoria, Australia.

A course of public lectures on hygiene and public health has been arranged (in cooperation with the State Department of Health) for delivery at Cornell University. The introductory lecture will be given on October 8 by President Schurman.

The *Times* reports that Prof. Borgman has resigned the rectorship of St. Petersburg University as a protest against the policy of the Minister of Education; it also says that the Council of Ministers has empowered the Minister of Public Instruction to forbid women to attend university lectures in future, but to permit those to complete their studies at universities who have already received permission, and whose transfer to higher educational institutions for women is impossible.

The Royal Agricultural College, Cirencester, after an existence of sixty-three years, has been re-organised, that its sphere of activity and usefulness may be greatly widened, and that it may no longer be handicapped by non-eligibility to receive grants from public monies. Taking advantage of the enlarged powers now conferred upon it, the college proposes to advance the cause of agriculture in general, and the agricultural interests of the west of England in particular, by actively engaging in the following kinds of work:—(1) scientific research in agricultural subjects; (2) cooperation with the University of Bristol (by which it will, no doubt, be fully recognised) in the establishment of degree courses and degrees in agriculture and forestry; (3) continuance of the important work of training landowners, estate agents, and colonists; (4) training county scholars in agriculture; (5) continuing and extending the system of short courses for sons of tenant farmers; (6) establishing classes in subjects of rural education for the benefit of teachers; (7) cooperation with county councils in their instructional and experimental work; (8) acting as a bureau of information for the benefit of west of England agriculturists.

The new session of the Birkbeck College, London, will be opened on September 28 with an address by Dr. Albert Griffiths. The new calendar, which is now available, shows that the college provides courses of day and evening instruction for degrees in arts, science, laws, and economics in the University of London, in addition to other important educational work. Twenty-eight members of the large staff are recognised teachers of the University of London. The work of the college has developed so greatly in recent years that there is pressing need for increased space. In some departments the stage has been reached where students have to be refused, and the usefulness of the college is curtailed by its limited accommodation. There is, in fact, urgent need for more spacious college buildings. We commend this calendar to intending students who live within access of the college as being likely to provide information of the kind they seek. The calendar of the Bradford Technical College for 1908–9, issued by the education committee of the city, has also been received. It not only provides full information of the comprehensive day and evening courses in technology provided at the Technical College, but also of an efficient department for external examination work, such as that in connection with the Board of Education and the Pharmaceutical Society. The volume concludes with particulars of the evening continuation schools and the branch technical and commercial schools provided throughout the city.

From time to time during the past six months handsome bequests to assist the development of higher education in the United States have been announced in *Science*. In addition to many gifts of 10,000*l*. or less, the following benefactions have been made. By the will of the late Mrs. Frederick Sheldon, 60,000*l*. has come to Harvard

University, and the amount will be increased eventually to something like 160,000*l.*; and the same university has also received from its class of '83 the sum of 20,000*l.* Princeton University has announced a gift of 50,000*l.* from Mrs. Russell Sage, and the University of Virginia received the same amount by the will of the late Mr. E. W. James. Mr. Andrew Carnegie has given 40,000*l.* to the Mechanics Institute of New York City and 20,000*l.* to Rochester University. The Hampden Agricultural School obtained 32,000*l.* by the will of the late Miss Alice Byington, and from that of the late Mr. Warren D. Potter the Massachusetts College of Pharmacy has benefited to the extent of 30,000*l.* The children of the late Rev. Orlando Harriman have presented 20,000*l.* to Columbia University, and Yale University has received 15,000*l.* by the will of the late Mr. G. B. Griggs. There would not appear to be any falling off in the enthusiasm shown for higher education by wealthy Americans, who continue to be fully alive to the need for well-endowed colleges throughout the States in order to fit American citizens to hold their own in the ever-increasing industrial competition.

LORD ROSEBERY opened the new engineering laboratories of the Heriot-Watt College, Edinburgh, on September 16, and delivered an inspiring address, in which he reviewed the history of the college and emphasised the value of technical training. After reminding the audience that Sir Walter Scott once said it was, in his opinion, as great a crime to hide knowledge from the people as it would be to hide the sun from them if we had the power, Lord Rosebery pointed out that the Heriot-Watt College was one of the first institutions founded in Great Britain for the express purpose of giving evening instruction to artisans, and it was the parent of all the mechanics' institutes and polytechnics that now are so rife and so much used throughout the country. It began by teaching only the principles of mechanics and chemistry and other branches of science of practical application to the several trades in Edinburgh. Now it works with the University, and gives what is practically extra-mural teaching, and while training in the evening classes corresponds to that given in the trade and commercial schools in Germany, the day college is doing the work which is done in the technical universities of Germany. Referring to the work of the day students, Lord Rosebery had something to say to employers of labour. If the number of day students could be multiplied, and if it were found possible for employers to give their apprentices days for study, besides the evenings that apprentices furnish for themselves, both the students and the employer would find their reward. If the college is ever to receive its full development, that fact will have to be recognised, and the number of day students will have to be greatly enlarged. Dealing with the training of specialists, the suggestion was made that the technical institutes in our great university towns should each specialise one side of their teaching to the extent that it would not be necessary to repeat it in other university towns, but that it could be carried to the highest pitch in each institute, and that each institute, being recognised by other local universities as regards the acceptance and reception of their students in these special branches, there would be an enormous advantage for the universities, and a vast economy of teaching power. "What a magnificent and inspiring sight is the contemplation of these thousands of students who utilise this college," said Lord Rosebery towards the end of his address. "They come, not forced, to education, as is the case in so many of our class of gentle birth, but after a day's hard work, determined, whatever their stress or fatigue may be, to utilise their evenings for the raising of their minds and the perfecting of their methods. There is no more encouraging symptom in any community than this, and if we can even contemplate the possibility of a nation in the main composed of such youths, the nation will have nothing to fear in the long run. It is on its honest and strenuous youth that every nation depends, and youth such as that, determined and resolute on its own perfection and its own efficiency, is the surest sign of the health and strength of a country."

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 4.—"The Electrical Qualities of Porcelain, with Special Reference to Dielectric Losses." By Dr. H. F. **Haworth**. Communicated by Prof. W. E. Ayrton, F.R.S.

This research was undertaken to determine some of the electrical qualities of porcelain, and their variations with respect to potential, temperature, and time. The electrical properties investigated, and the results briefly stated, are as follows:—

A. Capacity Measurements.

(1) The rate of charge of a porcelain condenser.

The rate of charge is comparatively slow; practically the porcelain is fully charged in one minute, if we take the first galvanometer swing as a measure of the capacity.

(2) The charge of a porcelain condenser as a function of the potential.

For potentials up to 1200 volts the charge was directly proportional to the potential, if the potential changes were made slow enough.

(3) The influence of sudden cyclical changes of potential on the charge of a porcelain condenser.

If the potential changes were made rapidly the charge was not quite proportional to the potential. A lagging effect was shown, indicating a loss in the dielectric.

(4) The dielectric constant, measured after one minute's electrification, varied with the temperature according to the following laws:—

Between 0° and 30° C., $C_t = C_0 (1 + 0{\cdot}00223t + 0{\cdot}0005t^2)$.
Between 30° and 100° C., $C_{t_1} = C_{t_2} . e^{0{\cdot}0264(t_1 - t_2)}$.

The dielectric constant at 20° C. was 8·95.

B. Conductivity Measurements.

(5) The apparent conductivity of porcelain, as measured by the ratio of current to potential, varies with the applied potential and the duration of the application. The dielectric polarises, or generates a back E.M.F., when a potential difference is applied to it. The conducting mechanism shows viscosity.

(6) The apparent conductivity of porcelain, measured after one minute's electrification, increases with the temperature according to the following law:—

$$\gamma_{t_1} = \gamma_{t_2} . e^{0{\cdot}090337(t_1 - t_2)}.$$

The specific conductivity at 20° C. is $0{\cdot}2624 \times 10^{-13}$ mhos per centimetre cube.

C. Dielectric Loss Measurements.

(7) The dielectric loss varies as the 1·74th power of the applied voltage, and is independent of the time of the cycle.

The dielectric losses at high potentials, and reasonable frequencies, may be termed hysteretic (*i.e.* independent of the time of the cycle of electrification). At very slow frequencies the loss is mainly C^2R loss, and this shows viscosity effects; but these losses are swamped at working frequencies by the dielectric hysteresis.

The dielectric loss was measured by the difference of temperature which could be maintained by the central surface of the porcelain plate above atmospheric temperature. This temperature difference being only a few degrees, it follows from Newton's laws of cooling that the heat lost is proportional to this difference, and as the heat lost is equal to the heat gained, if the temperature is constant, a thermopile placed with one end in contact with the porcelain will generate an E.M.F. which is directly proportional to the dielectric loss. This E.M.F. was measured by connecting the thermopile to a low-resistance galvanometer, and noting the direct and reversed deflections to eliminate the effect of local E.M.F.'s, &c. The losses were first measured at constant frequency of fifty per second, with pressures up to 38,000 volts (R.M.S.), and were then determined at constant pressure, 30,000 volts R.M.S., and for frequencies between 15·8 and 200.

The results are summarised in the following formula:—

$$\left.\begin{array}{l}\text{Dielectric loss per}\\ \text{cubic centimetre}\\ \text{in time } t \ldots\ldots\end{array}\right\} = 1{\cdot}83\times10^{-12}\ V^{1{\cdot}74}_{\text{R.M.S.}}(f+14{\cdot}4)t \text{ Joules},$$

where V is the R.M.S. potential gradient per centimetre and f is the number of cycles per second.

The results are illustrated with curves and tables, &c. A historical *résumé* is also given.

June 25.—"On the Atomic Weight of Chlorine." By Dr. Edward C. **Edgar.**

Three years ago Prof. Dixon and I published the results of nine direct determinations of the equivalent of chlorine. Our method was to burn a jet of hydrogen in an atmosphere of chlorine; and the number we obtained was appreciably higher than that approved by the International Committee on Atomic Weights. We found, however, when water was used to condense the hydrogen chloride formed in the flame, that some of the water vapour was decomposed by the free chlorine; so, in continuing the investigation, I avoided this by burning a jet of chlorine in *dry* hydrogen, condensing the hydrogen chloride as it was formed in a tube dipped into liquid air. In some of the experiments the hydrogen chloride formed has been weighed. My experiments (concluded in 1907) agree closely with the results previously obtained in 1905. The method employed was briefly as follows:—

A vacuous quartz combustion vessel was filled with hydrogen from a weighed palladium bulb. Chlorine was ignited by a spark at the tip of a quartz jet, and continued to burn in the atmosphere of hydrogen until nearly all the chlorine weighed had been burnt. The hydrogen chloride as it was formed in the flame condensed in a limb of the combustion vessel dipped into liquid air, and a little chlorine which had escaped burning also solidified. At the end of the combustion the residual gas was extracted by the pump and analysed; it proved to be practically pure hydrogen.

Then the hydrogen chloride was allowed to pass through a quartz tube filled with mercury vapour, where the chlorine it contained was completely removed, and the purified gas passed on to a steel bomb immersed in liquid air, where it was condensed in six experiments and successfully weighed in three. In two other experiments the hydrogen chloride was absorbed by water and weighed as aqueous acid.

In eight complete combustions about 15·5 grams of hydrogen were burnt. Taking the atomic weight of hydrogen as 1·00762, the direct ratio

$$\frac{\text{weight of chlorine burnt}}{\text{weight of hydrogen burnt}}$$

yielded the mean value 35·462 + 0·0008 for the atomic weight of chlorine, while the ratio

$$\frac{\text{weight of hydrogen chloride caught} - \text{weight of hydrogen burnt}}{\text{weight of hydrogen burnt}}$$

gave 35·461 ± 0·0009 (mean value of five experiments).

The accepted value for chlorine, 35·45, is in process of revision by the International Committee this year.

"Further Note on a Luminous Glow generated by Electrostatic Induction in an Exhausted Vessel made of Silica." By F. J. **Jervis-Smith,** F.R.S.

A glow-bulb rotating within a cylindrical inductor, end dome-shaped, placed symmetrically, with respect to the axis of rotation of glow-bulb, exhibited glow and magnetic phenomena described already (Proc. Roy. Soc., January 30; NATURE, May 21, p. 71). Sir Oliver Lodge repeated some of the author's experiments with glass bulbs, and obtained the same effects. Bulbs similar in shape and size to those described, but of pure silica, were employed. The residual gas in silica glow-bulbs was air. The glow-bulb was supported 0·5 cm. from a disc-shaped terminal of an induction coil. Opposite the bulb a pointed terminal (negative) was placed, a brush discharge played over the bulb. Coil in action, bulb illuminated with brilliant emerald-green glow. Discharge stopped, glow continued, dying out in about fifteen minutes. This remarkable after-glow could be easily seen at a distance of 4 metres from the bulb. *Glass* bulbs do not exhibit this phenomenon.

A silica glow-bulb was mounted in the rotating apparatus already described. The inductor charged from about 1800 volts to 2000 volts. The silica glow-bulb gave out a glow unlike that of the glass bulbs. In experiments with glass bulbs the glow was not strong when the inductor was charged to about 1800 volts; also, magnetic phenomena could only be seen at a distance of 0·25 metre to 0·5 metre from the apparatus; but when a silica bulb, similar in size and exhaustion to the glass bulbs, was rotated, it could be seen without difficulty in the dark at a distance of 5 metres, and when the inductor was charged up to 3000 volts to 4000 volts it was clearly visible at 15 metres from the glow-bulb.

The magnetic phenomena are the same as those which exist when a glass glow-bulb is used.

A silica glow-bulb rotated in contact with dry mercury was negatively electrified, and exhibited a greenish glow. The potential on surface reached 1500 volts, and through an applied collector charged a Leyden jar. A mercury jet playing on a silica glow-bulb caused it to glow, and negative electricity was generated.

PARIS.

Academy of Sciences, September 14.—M. Bouchard in the chair.—Determination of the triple orthogonal systems comprising a family of Dupin cyclids, and, more generally, a family of surfaces with lines of curvature plane in the two systems: Gaston **Darboux.**—Some mixed forms of nuclear alterations: Joannes **Chatin.**—Observations of the comet 1908*c* made at the Observatory of Marseilles with the Eichens equatorial of 26 cm. aperture: M. **Borrelly.** Observations were made on September 3, 4, 6, 7, and 11, the positions of the comparison stars and apparent positions of the comet being determined. The comet is of the tenth magnitude.—Observations of the new comet 1908*c* made at the Observatory of Besançon with the bent equatorial: P. **Chofardet.** Similar observations for September 5.—The quadric of Lie: A. **Demoulin.**—Plane flight without motive power: Ernest **Esclangon.** Remarks on the recent notes by M. Marcel Deprez on the hovering flight of birds.—The liquid crystals of the ether salts of ergosterol: Paul **Gaubert.** The ethers of ergosterol present a liquid anisotropic phase, but with the propionate and acetate this phase is rather difficult to show, thus differing from the corresponding ethers of cholesterol.—The virulence of bacilli in relation to the course of pulmonary tuberculosis: A. **Rodet** and P. **Delanoë.** The virulence of the bacilli from a large number of tuberculous patients was tested by inoculation into rabbits and guinea-pigs. The experiments on the two animals do not lead to exactly parallel results; the two scales of virulence agree nearly absolutely at the extremes, but in the intermediate stages the concordance is not so good. There is a distinct relation between the virulence as shown by these experiments on animals and the course of the disease in the patients from whom the bacilli were derived. Predisposition of the tuberculous patient is not the only factor in determining the course of the disease; the virulence of the bacillus is also a determining factor. —The intra-dermo-reaction with tuberculin in animals: G. **Moussu** and Ch. **Mantoux.** The intra-dermo-reaction, if practised in the manner described, is absolutely without any effects on healthy animals; in the case of tuberculous animals there is no general thermal reaction and no interference with the general health, and the method appears to be very certain in its indications.—Some physiological properties of the muscles of invertebrates: Jan **Sosnowski.**

CALCUTTA.

Asiatic Society of Bengal, September 2.—A polyglot list of birds in Manchu, Chinese, and Turki, part ii.: Dr. E. D. **Ross.** In 1877–8 Robert Shaw published in the journal of this society a grammar and vocabulary of the Turki language. At the end of the vocabulary was printed a list containing upwards of 150 Turki names of birds with their identifications, prepared by Dr. Scully, who accompanied the second mission to Yarkand. The present paper forms the introduction to a memoir on the birds of Central Asia which is, in a manner, a supplement to Dr. Scully's list. The British Museum possesses a very valuable MS. in many volumes containing an exhaustive vocabulary in five languages, viz. Manchu, Mongolian, Tibetan, Turki, and Chinese, on every conceivable topic. The memoir, to which the present paper is an introduction, contains a transcript of the section on birds, omitting the Mongolian and Tibetan versions. Three hundred and fifty birds are enumerated. With the object of adding to the knowledge of the Turki language, and with the view of collecting and identifying as many Turki birds as possible, the writer has prepared an index containing not only all the bird names mentioned in the polyglot list and by Scully, but which further comprises all the bird names he has been able to find in Turki dictionaries and other works. The index contains 650 bird names, of which more than half have been more or less identified.—The retardation and acceleration in the dissolution of mercury in nitric acid, in the presence of minute traces of ferric nitrate and manganous nitrate: Prof. P. C. **Rây**.

CAPE TOWN.

Royal Society of South Africa, August 19.—Mr. S. Hough, F.R.S., president, in the chair.—The application of Doppler's principle to astrophysical problems: Dr. J. K. **Halm**. The importance of this principle in determining the motions of the celestial bodies in the line of sight by means of the displacements of the lines of their spectra from their normal positions was dealt with, and its application was illustrated by such examples as binary stars, Saturn's rings, the rotation of the sun, and the motion of the earth in its orbit round the sun.

NEW SOUTH WALES.

Royal Society, July 1.—Mr. W. M. Hamlet, president, in the chair.—Records of Australian botanists: (*a*) general, (*b*) New South Wales: J. H. **Maiden**. The author is endeavouring to do for Australian botanists what Britten and Boulger have done for British ones, and publishes many details concerning them for the first time. He omits references to living men, and also to the French botanists who did so much for Australia in the early years of settlement; he proposes to deal separately with these on some future occasion. The term "general" has been taken to include those botanists who have dealt with the plants of all the States or in more than one of them; the present paper gives a separate account of New South Wales botanists, and the author is making arrangements for the publication of the records of the botanists of the other States in those States.—The elastic substance occurring on the shoots and young leaves of *Eucalyptus corymbosa* and some species of Angophora: Henry G. **Smith**. The author records the results of a chemical investigation of this elastic substance, which is formed at the time the shoots are developed. As the buds expand, and the individual leaves are formed, the elastic coating stretches and expands with them. Changes then rapidly take place as the need of the protective coating is removed, and by light and oxidation a white powdery substance is formed, which remains on the surface of the leaves, and although no white coating can be detected upon the mature dull green leaves of this group of Eucalypts, yet it can readily be removed by ether with only five minutes' contact. A small quantity of a vegetable wax is formed at the same time, and this can be removed from the powdery substance by solution in boiling petroleum ether, and purified from boiling alcohol. As the genus Eucalyptus descends, and that group having white pulverulent young growth is reached, including such species as *E. cinerea*, *E. pulverulenta*, *E. globulus*, &c., then it is found that the wax has increased considerably in amount, and that the white appearance of these young leaves is due to the presence of a comparatively large amount of this wax, together with the white substance found on the leaves of the earlier members of the genus. The reason why the leaves of the "bloodwoods" (to which group *E. corymbosa* belongs) are not pulverulent is that there is a deficiency of the wax. In those species where the wax predominates, the elastic substance does not occur, the corresponding protective medium being supplied by the wax. The amount of material removed from the fresh young leaves of *E. corymbosa* by ether was equal to 0·84 per cent., of which 0·0224 per cent. was wax. From the fresh young leaves of *E. cinerea* the total removed was 1 per cent., of which 0·355 per cent. was wax. The elastic substance was found to be a very good form of caoutchouc, thus bringing the Myrtaceæ into those families of plants yielding this substance, and showing that both Eucalyptus and Angophora are "india-rubber" bearing plants. The best solvent was found to be chloroform, as the other usual solvents acted but little upon it. The sheet rubber obtained by the evaporation of the chloroform had great elasticity, did not melt below 250° C., and quickly regained its elasticity on cooling. In every other respect it acted as did crude commercial "rubbers." The rubber was also obtained from the plant by destroying the leaf substance by allowing the material to remain for five days in a 5 per cent. solution of potash, and removing the "rubber" by mechanical means. When heated in melted sulphur it vulcanised very well. If Eucalyptus "rubber" was obtained in quantity it would have considerable commercial value. This, however, from the natural plant is not possible, as the collection would be too costly, without considering the rapid alteration it undergoes on the leaf.

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