empire is still expanding, and we and our competitors in that field are still absorbing new districts—a practice which will probably continue as long as any spot of ground remains on the face of the globe occupied by an uncivilised race.

Would it not be worth while at this juncture to extend to the peoples of Africa, for instance, the principles and methods of the Ethnographic Survey—to study thoroughly all their physical characters, and at the same time to get an insight into the working of their minds, the sentiments and ideas that affect them most closely, their convictions of right and wrong, their systems of law, the traditions of the past that they cherish, and the rude accomplishments they possess? If for such a service investigators like Dr. Roth, who began his researches in Queensland by so close a study of the languages and dialects of the people that he thoroughly won their confidence, could be found, the public would soon learn the practical value of anthropological research. If the considerations which I have endeavoured to urge upon you should lead not only the scientific student but the community at large to look upon that which is strange in the habits and ways of thinking of uncivilised peoples as representing with more or less accuracy a stage in that long continuity of mental progress without which civilised peoples would not be what and where they are, it could not but favourably affect the principles and practice of colonisation. *Tout comprendre c'est tout pardonner.* The more intimate our acquaintance with the races we have to deal with and to subjugate, the more we shall find what it means to stand with them on the same platform of common humanity. If the object of government be, as it ought to be, the good of the governed, it is for the governing race to fit itself for the task by laying to heart the lessons and adopting the processes of practical Anthropology.

PHYSICS AT THE BRITISH ASSOCIATION.

THE reputation for industry which Section A has acquired in past years will not suffer in any way by the proceedings of the recent meeting in Bristol. In addition to the ordinary meetings of the Section, the International Magnetic Conference met on four days; and as all communications to the Section relating to terrestrial magnetism and atmospheric electricity were referred to the Conference, it may be said that the Section sat in duplicate on five out of its six days of meeting. On Saturday, when the Magnetic Conference did not meet, the two departments were devoted to mathematics and meteorology respectively, and on Wednesday the Section was not divided. On two occasions the Section was associated with others in joint discussions, namely with Section B, on the results of the recent solar eclipse expeditions, and with Section G, on the magnetic and electrolytic effects of electric railways. The members of the International Magnetic Conference also took part in the latter discussion. The papers read before the Section were representative of almost every branch of physics. In the following account they are grouped according to subject, and are not arranged in the order in which they were read.

Before the commencement of his address the President, Prof. Ayrton, referred to the loss to science occasioned by the death of Dr. John Hopkinson. The address, which was published in NATURE of September 8, suggests a new field for physical and chemical research, namely the investigation of the phenomena of smell. For the physicist the most striking experiments described are those which show the slowness of diffusion of odorous particles in still air, and the absorption of scents by glass, while the physiologist cannot fail to be interested in the superior sense of smell possessed by the female sex. In moving a vote of thanks to the President, Lord Kelvin referred to the identity of the senses of taste and smell, including both as the chemical sense, and hoped Prof. Ayrton's address would lead to another bond of union between the chemist and the physicist. Prof. Mascart seconded the vote, specially thanking the President for his welcome to the members of the International Magnetic Conference.

In the subject of heat Prof. Rosa described the continuation of important work by himself and Prof. Atwater, the object being to determine whether the law of conservation of energy holds good for the vital processes going on in the human body. For this purpose a space large enough for a man to live in was enclosed as a calorimeter, and surrounded by alternate jackets of flowing water and air, in such a manner that the heat evolved from the "calorimeter" could be accurately measured. The details of construction of the apparatus were described at the Toronto meeting last year. During the past twelve months the authors have made experiments on men living in the calorimeter for periods varying from four to eight days, and doing different kinds of work. The heat-value of the food supplied and of the excreta were obtained by combustion, and the amount and composition of the gases entering and leaving the calorimeter were also determined. A full description of the work is to be published by the United States Government, under whose auspices the experiments have been carried out; it may, however, be stated that the law of conservation of energy is found to be true within the limits of experimental error. The ratio of the mechanical work done by a man to the total energy supplied to him, that is to say his efficiency as an engine, is usually about 7 per cent., and may be as high as 10 per cent. These figures are higher than the efficiency of a perfect heat-engine working between the same limits of temperature, and lead us to the conclusion that the energy transformation in the human body is not effected solely by heat, but is most probably analogous to that in a circuit containing a battery and electromotor.

Another series of experiments to decide a question of theoretical interest was described in a paper by Dr. A. Galt, on the heat of combination of metals in the formation of alloys. Lord Kelvin has shown how a lower limit to the size of atoms may be found by comparing the work done by the approach of the electrical charges on a thin film of zinc and a thin film of copper, their difference of potential being that due to contact, with the heat of combination of the films to form brass. On the other hand Prof. Oliver Lodge has pointed out[1] that on the chemical theory of electromotive force of contact the heat of formation of an alloy should be much smaller than Lord Kelvin assumes it to be, and an exact determination of its value would form a crucial test between the rival contact and chemical theories. In Dr. Galt's experiments a thin glass bulb with holes in its sides contains the alloy or the mixed metals, and is lowered into a calorimeter of glass containing nitric acid; as the acid passes through the holes the metal is dissolved, and the evolved gases do not escape. The rise of temperature of the acid is noted, and the heat of combination calculated. The results are so far preliminary, and the Association has made a grant for their continuation. Mr. W. N. Shaw read a paper on Dalton's law, in which he called attention to Regnault's experiments on the pressure of mixtures of air and saturated ether vapour; these experiments show a discrepancy between the saturation pressure of ether in air and in a vacuum. The explanation afforded by Regnault is that errors are introduced owing to the condensation of vapour on the vertical walls of the barometer tube; but from experiments on mixtures of air and water-vapour, Mr. Shaw considers that a real departure from the law of Dalton is indicated. The subject is to be investigated in the Cavendish Laboratory. Dr. C. H. Lees described experiments on the thermal conductivity of rocks at different pressures, according to which the conductivities of slate, granite and marble are very slightly increased by increased pressure, while in the case of a rather soft sandstone the increase amounted to 3 per cent. under a pressure of about sixty atmospheres. Mr. S. R. Milner and Prof. Chattock read a paper on the thermal conductivity of water, which they find to be 0·00143 C.G.S. units at 20° C.

Among papers relating to light Mr. J. W. Gifford read a communication on lenses, not of glass, in which he compared the transparency of calcite, quartz and fluor-spar for extreme ultra-violet rays, the last-named being the most transparent. Lord Kelvin discussed the various theories of refraction and anomalous dispersion, and stated that none of the dynamical theories hitherto proposed is satisfactory or free from difficulties. Prof. T. Preston described his experiments on radiation in a magnetic field. Zeeman found that when the spectrum of the sodium light emitted from a source in a magnetic field is viewed at right angles to the lines of force, the bright lines are tripled and the polarisation of the side lines is in a plane perpendicular to that of the central line. By using a very large grating and photographing the lines, Prof. Preston finds that all bright lines in a spectrum are not treated alike; some are unchanged, some become doublets, triplets, quartets, or even sextets. He explained how absorption of the original radiation by vapour surrounding the source might account for the multiplication of lines, but he considers from the sharpness of definition of the lines that the effect is not due to absorption. Prof. S. P.

[1] *Philosophical Magazine*, vol. xix., 1885.

Thompson described and exhibited an experiment by Righi on the production of the Zeeman phenomenon by absorption. A beam of plane polarised white light is passed along the lines of force of a magnetic field, and received in an analyser adjusted to extinction with zero field; in the magnetic field is a sodium flame or a tube filled with nitric oxide. On setting up the field a brilliant yellow light is seen, which cannot be extinguished by rotating the analyser; spectroscopic examination shows it to consist of doubled sodium lines, the constituents of each doublet being slightly more and slightly less refrangible respectively than the original lines. In the case of nitric oxide the light seen is bluish-green, being complementary to the colour of nitric oxide by transmission, and the spectrum consists of doublets. Profs. Lodge and Glazebrook thought that the phenomenon might be fully explained by supposing the magnetic field to alter the period of vibration of the ions so that they respond to waves of slightly higher or lower frequency than their natural one. Dr. C. E. Curry read a paper on the electromagnetic theory of reflexion on the surface of crystals.

A communication from Mr. J. Burke referred to the luminosity produced by striking sugar. The rim of a rapidly revolving disc of sugar is struck automatically by a hammer at the rate of about two blows per second; this causes an almost continuous luminosity extending from the hammer inwards and downwards. The spectrum of the light is confined to the more refrangible side of the F line, and the nature and appearance of the luminosity are unchanged by altering the medium surrounding the sugar. No satisfactory explanation of the phenomenon has yet been found.

The report of the Electrical Standards Committee is a record of progress made in the determination of the standard ampere. Profs. Ayrton and J. V. Jones have designed an ampere balance, for the construction of which a grant has been made by the Association. The details of the instrument were described to the Section. An appendix to the report contains an account of the determination of the temperature-coefficients of two coils used in the determination of the ohm by Profs. Ayrton and Jones, the measurements having been made by Mr. M. Solomon. The coils do not appear to have changed since 1896, but their resistances as measured in 1894 were slightly lower (0·006 to 0·007 per cent.) than the present values. The Electrolysis Committee has investigated the electrical conductivity and the freezing point of several dilute solutions of salts, which furnish some unexpected and, therefore, interesting results. The data are, however, not yet complete. The report was accompanied by a paper from Mr. Whetham on the measurement of the electric conductivity, and one from Mr. E. H. Griffiths on the freezing point determinations. Mr. S. Skinner has investigated the carbon-consuming cell of Jacques, consisting of an iron crucible into which is put fused caustic soda with a carbon rod as electrode, the crucible forming the other electrode. In order to maintain the electromotive force of the cell, air is blown into the caustic soda. Mr. Skinner found that the air acts by cleaning the surface of the iron crucible, and can be usefully replaced by adding sodium peroxide to the caustic soda. By measuring the current furnished by the cell, and the loss of weight of the carbon electrode per second, the author hopes to determine the electro-chemical equivalent of carbon. Messrs. Cahen and Donaldson communicated the results of some comparisons of the output and efficiency of a secondary cell (Tudor type) when charged at constant current and constant electromotive force respectively. By charging at constant potential the time of charging is reduced to less than half that required at constant current, the capacity is thirty per cent. greater, but the energy efficiency is ten per cent. less. Neither method of charging appears to damage the cell. Mrs. Ayrton read a paper on the drop of potential at the terminals of the electric arc, in which she described the exploration of potential distribution in the arc by means of a third electrode of carbon inserted laterally. If the arc be maintained at constant length the power expended at each carbon is a linear function of the current, and if the current be maintained constant the power expended at each carbon is a linear function of the arc-length. The experiments are subject to errors pointed out by Mrs. Ayrton in her paper: (1) the third carbon may not take up the potential of the point of the arc in which it is placed; (2) it alters the potential-distribution and the length of the arc. The author proposes to repeat her experiments, using an insulating third carbon. Prof. Chattock described experiments to determine the velocity of electricity in the electric wind. He finds that the electricity in the electric wind travels much more rapidly than the gaseous particles themselves, reaching in hydrogen a velocity of 900 cm. per second. Profs. Rosa and A. W. Smith have investigated the heating effect of alternating currents upon the dielectric of a condenser, measuring the net watts supplied to the condenser and the heat developed per second in the dielectric. Their results were communicated to the Section by Prof. Rosa. Mr. F. B. Fawcett described standard high resistances constructed by depositing kathode films on glass and heating them for a long time in a partial vacuum; this process renders them constant. Prof. Callendar exhibited a platinum voltmeter, in which the change of temperature of a platinum wire on passing a current through it is utilised to measure the current, and hence electromotive force; the instrument is made self-recording. Mr. E. H. Griffiths exhibited an apparatus for the measurement of resistance, by which the resistance of a coil can be measured to within one part in three millions. Prof. Lodge described a new magnifying telephone, for calling up the operator at the receiving end in systems of wireless telegraphy. The minute current set up in the receiving circuit passes through a small, light coil suspended in a strong magnetic field and rigidly attached to the disc of a microphone transmitter; the coil moves, and so sets the microphone disc in motion. A relay current in the microphone circuit is thus interrupted, and can be sent through the coil of a second similar apparatus. By using three or four magnifications a slight sound can be made to approximate in intensity to the human voice. Prof. Barrett, Messrs. W. Brown and R. A. Hadfield communicated the results of some determinations of the electrical conductivity and magnetic permeability of various nickel-steels. Prof. S. Lemström and Dr. E. H. Cook read papers on the action of electricity on plants. Both agree that the growth of plants is accelerated by electrical discharges or currents; Dr. Cook, however, considers that the increased growth takes place only during germination of the seed and its growth underground, the mature plant being unaffected by electrical actions. In another paper Dr. Cook described experiments on the reflexion of the brush discharge.

The discussion on the magnetic and electrolytic actions of electric railways was opened by Dr. Schott, who described the total destruction of two American magnetic observatories by the approach of electric street-railways. Prof. Rücker indicated disturbances of a magnetometer needle due to the South London Electric Railway felt as far away as 3½ miles, and referred to the complete destruction of the Greenwich vertical force and earth-current records. He pointed out that the trouble could be remedied if electrical engineers would meet physicists in a friendly way, as they had done hitherto in this country. The principal disturbances arise from want of insulation of the return circuits of railway systems and the excessive distance between the outward and return circuits; the former gives rise to earth currents, and the latter to magnetic induction. Dr. Eschenhagen stated that in conjunction with Prof. von Bezold he had found a disturbance of magnetic instruments at a distance of 15 kilometres from electrical railways near Potsdam. Mr. W. H. Preece claimed protection for telegraphs and telephones as well as for magnetic observatories; the telephone, however, when provided with a complete twisted metallic circuit, is not capable of being disturbed, but earth-currents due to leakage seriously interfere with telegraphic work. Signor Palazzo described a method of damping the swings of a magnetometer needle so as to make it unsensitive to small-period oscillations. Prof. Fleming gave many instances of corrosion of gas and water pipes by electrolytic action, the pipes forming part of the earth-return of a leaky circuit. Prof. S. P. Thompson suggested the use of alternating currents and no earth-return, or of continuous currents with well-insulated circuits and the return wire very close to the outward circuit. Prof. Ayrton pointed out that it was to the advantage of the electrical engineer himself to use a well-insulated return-circuit.

In the discussion on the results of the recent solar eclipse expeditions, Prof. Turner classified the work of solar eclipses as referring chiefly to the shape, movements, nature and brightness of the sun's surroundings. The success of Mrs. Maunder in photographing a long coronal streamer has led to a discussion on the efficacy of triple-coated plates and a small camera, such as she used. Again, evidence is very conflicting concerning the relations of coronal extensions and solar prominences; from their positions they appear to be connected, but spectroscopically there is no evidence of any such connection. Another

unsettled point is the question whether the corona takes part in the sun's rotation. Sir Norman Lockyer explained the connection between the spectra of stars and their temperature, and referred to the discovery that the spectrum of the sun's chromosphere is similar to that of the principal absorbing layer in γ Cygni, which he characterised as a Rosetta stone of solar and stellar spectroscopy. He showed how the spectra of the various layers of the chromosphere indicate a gradual increase of temperature from without inwards, and announced with reserve, that the Indian photographs suggested that the wave-length of the chief coronal line required revision. Sir William Crookes suggested the appointment of a joint committee of chemists and physicists to examine quietly the question of solar spectra. Captain E. H. Hills exhibited his photographs of the spectrum of the inner corona. Captain Abney and Prof. Thorpe, who intended to take part in the discussion, were unable to be present at the meeting.

In meteorology, the Ben Nevis Committee sent a report of extended work, a station having been established at a point halfway up the mountain, and observations taken hourly during a portion of the year. The Committee on Meteorological Photography reported through Mr. Clayden that the work of simultaneously photographing clouds near the sun from two stations in an east and west line had been continued, the results showing that in hot, thundery weather the alto-cumulus and cirro-cumulus clouds attain great heights, sometimes reaching 90,000 feet. In order to make observations in the early morning and late afternoon a change of base line to a north and south direction is contemplated. The report of the Seismological Observations Committee deals with many phases of earthquake work, and in introducing it Prof. Milne emphasised the importance of securing better accommodation for seismological apparatus. He compared the seismological laboratories of Italy and Japan with the only one of this country, namely his own house at Shide, Isle of Wight. The Sectional Committee has taken steps towards securing the aid of the Government in providing suitable housing for seismological apparatus. The Montreal Meteorological Observatory reports having obtained successfully in McGill University Physical Laboratory records of the temperature on the top of Mount Royal; the installation of other apparatus recording at a distance is being proceeded with. Prof. Callendar described an application of his platinum thermometer as a sunshine recorder, by registering the temperature-difference between a bright and a blackened thermometer. Mr. A. L. Rotch recorded an ascent of the Hargrave kite to a height of 11,440 feet at Blue Hill, Mass., U.S.A. Dr. van Rijckevorsel drew attention to a similarity, even in details, between the annual curves of temperature, air-pressure, rainfall, magnetic declination, vertical and horizontal magnetic force. He considered this to be a proof of similarity of origin of magnetic and meteorological phenomena. Mr. Douglas Archibald indicated a classification of weather types in western Europe, lasting for several days, and thus permitting the possibility of extending the present daily forecast. Simultaneous telegraphic reports from a greater number of stations would be necessary. Mr. Hopkinson read a paper on the climate of south-western England.

Among papers on general physics, Mr. W. N. Shaw exhibited a pneumatic analogue of the potentiometer, in which air-currents set up by gas jets at the lower ends of two tubes take the place of electric currents. The author pointed out its application to some problems of ventilation. Mr. A. W. Warrington described hydrometers of total immersion, which are hydrometers loaded with platinum weights until they are on the point of sinking; a slight rise of temperature of the liquid then causes them to do so. For liquids, the method is accurate to one part in a million. For solids, a kind of Nicholson hydrometer without tray is used, and the temperature is determined at which the instrument has no weight in water (1) loaded with mercury alone, (2) loaded with the solid and mercury. The results are accurate to one part in 100,000. Mr. W. R. Barker described and exhibited some interesting old weights and measures of Bristol. In sound, if we except Lord Kelvin's communication on the continuity of undulatory theory for sound, elastic-solid and electric waves, the only paper presented was that of Dr. R. J. Lloyd on the articulation and acoustics of the spirate fricative consonants. In this paper the differences between the articulation and resonance of the consonants *f*, *th*, *h*, *s*, *sh* and *ch* are discussed, and the author points out that the first three differ in the length and width of the frictional passage of the throat producing them, whereas the last three require some kind of fore-cavity which modifies and subdues the frictional noises. In the case of *s* and *sh* there is strong resonance from both the fore-cavity and the hinder cavity, the two sounds being differentiated by the second friction against the tips of the lower teeth in producing *s*.

We shall take another occasion to refer to the proceedings of the Magetic Conference.

During the meeting a collection of physical apparatus was exhibited in the physical laboratory of University College by Messrs. J. J. Griffin and Sons. It included an assay balance entirely free from steel, carrying 5 grammes and weighing to 0·00002 gramme, and a chemical balance weighing to 0·0001 gramme, both of which were provided with arrangements for weighing fractions of a gramme without opening the case. Holloway's crucible furnace, Davis' induction coil and X-ray bulbs, were also exhibited, as well as a simple form of apparatus for the measurement of expansion of solids, in which a rod fixed in a water bath between two glass rods is heated and displaces the glass rods; these pass through the sides of the water bath, and their displacement is measured directly by micrometer screws. The absence of optical devices for measurement increases greatly the simplicity of the instrument, which is said to yield fairly good results for lecture purposes.

MATHEMATICS AT THE BRITISH ASSOCIATION.

SATURDAY in the British Association week is a holiday for most of the Sections; the mathematicians and physicists, thus freed from competition, bid for two audiences instead of one, and take papers on mathematics and meteorology in separate rooms. This year the mathematical session, over which Lord Kelvin presided, was very well attended.

The first paper, read by Colonel Allan Cunningham, was a report on the work of the Committee appointed some years ago, with Lord Kelvin as chairman, for calculating tables of certain mathematical functions. It was explained that a set of tables has been prepared, giving the residues of powers of 2 for all prime moduli less than 1000. The plan is much the same as that of Jacobi's Canon Arithmeticus; but Jacobi uses as base a primitive root of the prime number concerned, which is inconvenient in practical calculations. The tables are now complete in MS., and nothing remains but to print them. It is to be hoped that the Association will see its way to printing them separately in quarto, as their usefulness will be much diminished if they are printed on the smaller page of the Annual Report; but it seems likely that, partly for financial reasons, they will not be published at all for another year.

The next paper, "The mathematical representation of statistics," by Prof. Edgeworth, was read in abstract by one of the Secretaries, in the absence of the author; and the following one, "On the use of logarithmic co-ordinates," by Mr. J. H. Vincent, was taken as read, but is to be published in full in the Annual Report.

One seldom sees lantern illustrations to a paper read at the mathematical session. But the next two subjects on the list can be treated experimentally as well as mathematically. In the first, "A new method of describing cycloidal and other curves," Prof. Hele-Shaw, of Liverpool, showed a new instrument for drawing the curves which can be got by rolling one circle on another. Perhaps its most striking feature is that the radii of the fixed and rolling circles may be as great as we please, their centres not being restricted, as in the ordinary instruments, to the limited range of a drawing board. Thus the radius of the fixed circle may be made infinite, when its circumference becomes a straight line, and the common cycloid is traced on the paper.

Another considerable advantage is, that the complete curve required can be drawn in many cases where the ordinary methods would only give a portion of it, or would only give the whole curve after several operations.

Since an ellipse of any eccentricity may be described by means of a point attached to a circle rolling within another of twice its diameter, it is clear that this instrument can be used for drawing ellipses. It differs from the elliptograph of Messrs. Alexander and Thomson, which depends on the same property, in having two pairs of toothed wheels instead of one; this improvement gets rid of some of the defects of the older arrangement, with which ellipses can only be got under limited conditions.

The inventor expressed his opinion that mathematicians would