pressure to the velocity of the wind. He points out that the formula generally used by English and American engineers and meteorologists, and which seems to have come down from a preceding century, is undoubtedly very erroneous. The formula, viz. $p = 0{\cdot}005\ v^2$, is used at all altitudes and for all temperatures, without regard to the varying densities of the air. The true theoretical formula—that is, one that would hold good in case of no viscosity of the air—is given at p. 302 of his "Recent Advances in Meteorology" (NATURE, July 14, p. 255). For an average temperature of, say, 15° C., and air of the standard pressure of 760 millimetres, this formula becomes $p = 0{\cdot}00255\ v^2$, which gives the ratio 1 : 1·96 between the two constants, from which it follows that the velocities usually deduced from pressures should be very considerably increased. The author also objects to the use of the constant 3 which is employed in the reductions of wind velocities obtained from a Robinson's anemometer of the Kew pattern, and which is about one-fourth too large, except for low velocities, as is shown by recent experiments by Stokes and Whipple in this country, and by others abroad. The same journal also contains interesting articles on the comparison of rain-gauges, by F. Pike, and on tornadoes, by H. Allen. The latter recommends the adoption of the term "low area," or "helicone," instead of cyclone, which he thinks should be applied to West Indian storms only.

THE results of rain and river observations made in New South Wales and part of Queensland during 1886, published by the Government Astronomer for New South Wales, contain a large quantity of valuable statistics on the distribution of rain, the heights of rivers, and evaporation. The number of stations in New South Wales has increased from 641 in 1885 to 772 in 1886, yet there are many parts of the colony still unrepresented. The Report is accompanied by a map, showing very plainly by means of black spots of various sizes the increase in the amount of rainfall as we go northwards into tropical regions, until Innishowen, in Queensland, caps the list with 176 inches. The greatest average rainfall in New South Wales is only 64 inches, at Antony, just under a very high mountain range, and next to this Port Macquarie, 60 inches. The mean rainfall for the whole colony amounted to 26·04 inches in 1886, being 11 per cent. more than the average for the past twelve years.

THE Meteorological Council have issued a new edition of their "Fishery Barometer Manual." The first edition of this work was published by Admiral FitzRoy about thirty years ago, and was freely distributed by the Board of Trade to small ports and fishing-stations supplied with public barometers. This useful practice of supplying barometers to fishing-stations has been continued to the present time, nearly 170 barometers having been erected, in addition to those issued by the Royal National Lifeboat Institution. The present Manual contains much additional elementary information likely to be of use to the fishermen, and refers briefly to the recent advances in the development of weather prediction, especially by means of daily charts. Reference is also made to the telegrams now received daily from America, and to the warnings issued by the *New York Herald* Service. The Manual also contains a table showing the distribution of gales on our coasts during fifteen years, from which it appears that November is generally more stormy than December, and that the maximum storminess in March, which is especially marked in North-East England, entirely disappears in South-West Ireland and South-West England.

WE had occasion recently (NATURE, June 23, p. 184) to refer to the active steps taken by Mr. Clement L. Wragge in promoting the meteorological service in Queensland, and we have now to record a further development by the publication of daily weather charts for Australasia. The charts are drawn for 8 a.m. daily, giving isobars, wind direction and force, and the temperature and humidity of the air. Rainfall is represented by dots of various sizes, while other phenomena, such as dust-storms, fog, hail, &c., are shown by appropriate symbols, and there is also a synopsis of the existing weather. The charts will be of great utility in the study of the weather of the Australian colonies.

WE are pleased to notify the publication of a Monthly Weather Record for the Mauritius, the first issue of which, for January last, has been received. The Record, which is after the style of the United States Weather Review, but without plates, contains the results of observations taken at the Royal Alfred Observatory, together with the means and extremes of temperature at four other stations, rainfall observations taken at fifty-five stations, observations taken at Rodrigues and the Seychelles, and observations taken on board ships in the Indian Ocean. The Observatory of Mauritius stands on a plain near Port Louis, three miles from the west coast, 179 feet above the sea-level. From west-south-west through west to north there is an uninterrupted view of the sea, and from north through east to south-east the ground generally slopes to the summit of the Piton, four miles distant, and 917 feet above the sea. Between south-east and south-west there is a chain of mountains, the highest peak of which bears nearly six miles due south, and has an altitude of 2874 feet above the sea. Among the miscellaneous observations it is noted that the tail of a comet (supposed at first to be Barnard's comet) was seen on January 20, and three subsequent evenings from various parts of the island.

THE BRITISH ASSOCIATION.

SECTION A—MATHEMATICAL AND PHYSICAL SCIENCE.

On the Magnetization of Iron in Strong Fields, by Prof. Ewing, F.R.S., and Mr. W. Low. Read by Prof. Ewing.—In the experiments described iron was subjected to very intense magnetization by placing a narrow neck between two massive pole-pieces. In this way values of magnetic induction higher than those previously reached had been attained. Through the kindness of Prof. Tait the large electro-magnet of the Edinburgh University had been transferred to University College, Dundee, and by its means the induction was pushed up to the value of 38,000 C.G.S. units. There seemed, indeed, to be no limit to the value attainable, and so the neck was then turned down to about one-sixth of its previous diameter, and the induction was forced up to 45,000. By turning the neck still further and annealing it, the highest value of 45,350 was reached. An attempt was made to determine the strength of the magnetic field in the immediate neighbourhood of the neck. The quantity $\frac{B - \text{field}}{4\pi}$, where B was the magnetic induction, was found to change from 1680 in an experiment where B was 24,700, to 1420 in the case of the highest value of B attained. This would favour the idea that the intensity of magnetization has a limit. But it is difficult to be quite sure that the field in the immediate neighbourhood of the neck is the same as in the neck itself.

In order to overcome this difficulty the field in the air round the neck was explored by means of three or four coils wound one on top of the other. This will show if the field is varying fast near the iron. If not, it would be natural to assume that the field is much the same as in the iron, because in the median plane there is no surface magnetism.

On Some Points in Electrolysis and Electric Conduction, by Prof. G. Wiedemann.—Before proceeding to the discussion of electrolysis the author wished to congratulate the Association on the appointment of a Committee to investigate this important subject, and further to congratulate the Committee on having Prof. Lodge to direct their labours. He had read with great interest the able report on electrolysis which had been some time ago presented to them by Prof. Armstrong. His own communication would contain much that was old, and something that was new. There was a difficulty in the definition of an electrolyte. Some people say an electrolyte is a salt. Some say it is a binary compound. But what is a binary compound? It is something which can be decomposed into two parts. But water-free hydrochloric acid does not conduct. Nevertheless it can be decomposed into two parts. Whether the water plays a part in decomposition is still an open question, although Kohlrausch thinks he has shown that in very dilute solutions the water does take part. The resistance of an electrolyte is measured by the work done in the wandering of the ions. It had been said that his view was that the viscosity is proportional to the resistance. This is not quite correctly stated. There are to be considered (1) friction of the ions in the liquid, (2) friction of the salt in the liquid, (3) friction of the whole liquid on the walls of the vessel. (3) may be avoided, and therefore we can omit it. The main thing considered has been the friction of the ions in the liquid. Kohlrausch has lately taken very dilute solutions, and can only find the friction of the salts and not that of the ions present here, which agrees with his theory. A difficulty in this connexion is, that in very dilute solutions the impurities of the

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water conduct better than the salt. There may be double decompositions between those impurities and the salt. Further we know that many salts decompose in water, *e.g.* magnesium salts. Again HCl separates from a solution of ammonium chloride, and here we have acid and base separate in the solution. He did not know how to avoid this difficulty, and must content himself with pointing out the existence of it. Then another question is, What is it that is decomposed in the decomposition of salts? Is the process a simple molecular decomposition? We may ask further how hydrides are decomposed. But it is generally assumed that in the liquid it is only the salt which is decomposed. His son had sent a paper on solutions of chloride of copper. He observed that there is a change of colour in very dilute solutions; and we may be sure that in those solutions the salt has combined with the water. We cannot say whether a salt in solution is alone electrolyzed, or the salt in combination with the water. A relation between conductivity and chemical constitution had recently been obtained by Mr. Hartwig in his laboratory. He found that with rising concentration the conductivity of solutions of acids attains a maximum earlier the more carbon they contain. In regard to the friction of the salt in the liquid there is no doubt that the undecomposed salt in the liquid has a certain influence, and work must be done to produce motion of the salt in the liquid.

Prof. Quincke said that he agreed with the views of Prof. Wiedemann as to the influence of secondary decompositions in the liquid. It was difficult to distinguish between secondary and primary decompositions.

Prof. Fitzgerald, F.R.S., read a paper by Mr. F. Trouton and himself *On the Accuracy of Ohm's Law in Electrolysis.*—To avoid the difficulties due to heating of the liquid by the current the method which Chrystal and Maxwell used for solid conductors was employed, but the alternation had to be more rapid. The amount of accuracy obtained was approximately 1/2000 per cent.; and up to this Ohm's law was verified.

On the general question of electrolysis Prof. Fitzgerald said that the usual reasoning was that if the *atoms* are to be dragged asunder this requires finite E.M.F. On the whole, however, no work is done; and therefore, he contended, whatever theory may be adopted, it cannot require a finite E.M.F. to detach atoms. He believed that by this the whole Williamson-Clausius hypothesis was swept away. There were no separate atoms in the liquid. If in the case of HCl there were separate atoms of hydrogen in the liquid, surely some of them would escape from the surface of the liquid.

Prof. S. P. Thompson read a communication from Prof. von Helmholtz on *Further Researches concerning the Electrolysis of Water.*—Prof. Helmholtz has been working at the question, whether, when you electrolyze water at different pressures, it needs different electromotive forces. He found that in water which was originally free from gases the smallest E.M.F. will send a current through. He likens the difficulty which there is in getting gas to develop in an electrolytic cell originally quite free from gas to the difficulty which is experienced in getting a perfectly clean liquid to boil.

His apparatus consists of a U-tube, bent over at one end, and there blown into two bulbs, which contain the electrolyte. The electrodes are fused into the glass. One limb of the U-tube is open. From the other, which is in connexion with the bulbs containing the electrolyte, there comes off a side tube through which mercury poured into the open limb can escape, and so exhaust the space over the electrolyte to any required extent. An air-bubble is left in the large bulb above the electrolyte.

In another apparatus there was no air, and the mixed gases collected. With 1·79 volts at atmospheric pressure a balance was obtained, and the mixed gases did not increase. He finally fixes upon the superior limit of the E.M.F. with atmospheric pressure at 1·775 volt.

Experiments on the possible Electrolytic Decomposition of Alloys, by Prof. Roberts-Austen, F.R.S.—Experiments were made on gold-lead and silver-lead alloys. The results are absolutely negative. No electrolytic action whatever could be found, although cupellation would certainly have detected a variation of 1/100 per cent. in the composition.

Dr. Gladstone and Prof. Wiedemann were able to confirm the result from experiments performed by other methods in their own laboratories.

Sir W. Thomson said it was a most important discovery.

Experiments on the Speeds of Ions, by Prof. Lodge, F.R.S.—These experiments are still going on. The object is to determine directly the speeds of the ions in a liquid. The current is sent through a tube of liquid which contains some detecting substance.

At first something to give a precipitate was used, the advance of which could be timed. But this has the disadvantage of removing the substance from the tube, because the current does not affect it when it becomes solid. Now he uses fluid detectors—such as some of the aniline bodies—to detect the advance of acidity or alkalinity. Thus, for example, he may have the tube filled with solution of sodium chloride, with a trace of caustic soda, and a body which is coloured in alkaline solution, but which loses its colour when the alkalinity disappears. If now, in the course of the electrolysis, ions from the substance being electrolyzed which will unite with the Na of the caustic soda travel along the tube, they will cause the alkalinity to disappear, and the rate at which this change travels can be measured.

The composition of the liquid, however, does not remain constant, and therefore we get a broken slope of potential in the tube, because the bad-conducting alkali is turned into the good-conducting acid. This difficulty is got over by making the principal ingredient in the measuring tube the same as the product of the action for any given case. A small addition to its amount is therefore of no consequence.

The theory of Kohlrausch with regard to the speed of ions was shown to be in accordance with the results.

On Chemical Action in a Magnetic Field, by Prof. H. A. Rowland.—It had been observed by his colleague, Prof. Remsen, that if a thin plate of iron be placed between the poles of an electro-magnet and then acted on by $CuSO_4$, the copper was deposited in lines very similar to the equipotential lines. Around each pole was a clear space where the iron was not acted on at all. This part of the field is of course the part where the rate of variation of the square of the magnetic field is greatest; and it occurred to Prof. Rowland that the want of action of the sulphate of copper in this position was due to the attraction of the magnet on the iron. With the help of Mr. L. Bell he had carried out experiments on the point.

Between the poles of a powerful electro-magnet was placed a glass beaker containing the liquid whose action upon iron it was desired to test. Nitric acid generally acted very well; so did sulphate of copper, and almost any salt which would deposit metal on iron. In the liquid were immersed two pieces of iron, one of which was pointed. The greater part of each piece was covered with wax, and what was exposed to the liquid was a point in the one case and a plane surface in the other. They were connected through a galvanometer, and a current was obtained which was not reversed on reversing the direction of the current of the electro-magnet. This indicated that the point was protected from the action of the liquid.

On the Electro-deposition of Alloys, by Prof. S. P. Thompson.—In a mixture of metals which is electrolyzed, the most negative metal comes down first. Prof. Thompson made a series of experiments on solutions of zinc and copper in cyanide of potash solution of different strengths. The electromotive force was measured for each strength of the cyanide of potash solution. The curves representing the E.M.F. for copper and zinc were found to cut at a certain strength of the KCN solution. Beyond this strength copper became positive to zinc. In the ordinary brassing solution he found that it depended on the temperature whether zinc was positive to copper or copper to zinc.

On the Action of the Solvent in Electrolytic Conduction, by T. C. Fitzpatrick. This paper was communicated by Mr. W. N. Shaw.—Mr. Fitzpatrick found that although methyl alcohol has greater conductivity than water, yet a solution of calcium chloride in the former liquid is a worse conductor than an aqueous solution. He found similar results for calcium nitrate, lithium chloride, and lithium nitrate solutions. Solutions in ethylic alcohol were also used. He was much impressed with the idea that electrolysis is the electrolysis of molecular aggregates.

The next paper was by Prof. S. P. Thompson, on the *Industrial Electro-deposition of Platinum.* He exhibited specimens illustrating a new process.

The Princeton Eclipse Expedition, by Prof. C. A. Young.—The expedition had its origin in his desire to repeat observations

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made by him seventeen years ago, as objection had been taken, not to the accuracy of the observations themselves, but to the conclusions he had drawn from them. Prof. Libby was to do the photography. Photographs of the corona were to be taken; and they were anxious to determine whether there are true dark lines in the corona or not. The place selected for the observations lay 150 or 160 miles to the north-west of Moscow. It is needless to say that on the morning of the eclipse it rained, and hardly anything could be done. They made an attempt to determine the end of totality by the amount of light. The diminution of the light was gradual, but after totality there was a sudden burst.

Prof. L. Weber, of Breslau, described photo-metric measurements made during the eclipse at Breslau; and then read a paper on *Observations of Atmospheric Electricity*. Prof. Weber said that the increase of potential seemed to be a linear function of the height; but the presence of dust in the air disturbed this relation. The earth represents a surface of equipotential, and the other surfaces of equipotential are parallel, but come closer together above the mountain-tops.

Prof. Schuster said that, granting that the earth has a given potential at any moment, the convection-currents in the air would tend to reduce this, or to equalize the potential within the earth itself.

Prof. Everett remarked that wherever electricity is carried down by raindrops, an inequality of potential will be caused; and evaporation would also cause inequalities.

Prof. Rowland said that observations had been made during the last four years at his laboratory by the U.S. Signal Service. He did not see how the raindrops could disturb the distribution of potential much. If the earth is electrified most of the electricity would be on the outside of the atmosphere. He therefore looks for some other theory, and has given one in the *Phil. Mag.*, viz. that the earth would naturally be uniformly electrified if it were not for currents of air in the upper atmosphere, which will carry the electricity of the atmosphere towards the poles, making auroras there. At the equator, therefore, a space must be left which has to be filled up with electricity, and this takes place by thunderstorms. Accordingly there is a circulation of electricity. In this connexion it is to be remembered that thunderstorms are most common about the equator.

The Hygrometry of Ben Nevis, by Mr. H. N. Dickson.—This paper gives an account of observations which were undertaken for the purpose of testing the applicability at high-level stations of existing tables and formulæ for calculating the dew-point and humidity from the readings of wet- and dry-bulb thermometers. The construction of the direct hygrometer used, that of Prof. Chrystal, is described, and the action of the wet and dry bulbs under different meteorological conditions is examined in considerable detail; the results showing that for investigations of this kind a great range of humidity is necessary, the indications of the wet and dry bulbs being very uncertain when the difference between them is small.

The reduction of the observations is performed, in the first place, by a graphic method, from which the following expression is reduced: $f' - f'' = (t - t')k$, f' being the vapour-pressure at the temperature t' of the wet bulb, f'' that at the temperature of the dew-point, and t the air temperature. The truth of the above equation being assumed, the values of the quantity k are next found by direct calculation from the observations. A sudden large change takes place in its value at the freezing-point, and a similar, though much smaller, discontinuity is shown to occur when the wet bulb stands between 39° and 40°.

The Different Varieties of Thunderstorms, and a Scheme for their Systematic Observation in Great Britain, by the Hon. R. Abercromby.—The writer said that there were three well-defined types of thunderstorms in this country: (1) squall thunderstorms, *i.e.* simply a squall associated with thunder and lightning; (2) a very common form which occurs in secondary cyclones: the nature of this class needed investigation; (3) far the most curious class was that which might be called line-thunderstorms, because their shape was a long narrow belt sometimes 200 or 300 miles long and only 4 or 5 broad. They move broadside on, and are usually preceded by a squall of extreme violence. He explained a scheme for the future systematic study of thunderstorms, and invited the co-operation of volunteer observers.

Sir W. Thomson said that the natural history of thunderstorms was less known than any other part of meteorology, and that Mr. Abercromby's scheme would be likely to give much information on the subject.

On the Magnetization of Hadfield's Manganese Steel in Strong Fields, by Prof. J. A. Ewing, F.R.S., and William Low.—Messrs. Hadfield, of Sheffield, manufacture a steel containing about 12 per cent. of manganese and 0·8 per cent. of carbon, which possesses many remarkable qualities. Prominent amongst these, as the experiments of Hopkinson, Bottomley, and Barrett have shown, is a singular absence of magnetic susceptibility. Hopkinson, by applying a magnetic force, $\mathfrak{H}$, of 244 C.G.S. units to a specimen of this metal produced a magnetic induction, $\mathfrak{B}$, of only 310 C.G.S. units; in other words, the permeability μ was 1·27, and the intensity of magnetization $\mathfrak{J}$ was a little over 5 units.

The experiments made it clear that even under magnetic forces extending to 10,000 C.G.S. units the resistance which this manganese steel offers to being magnetized suffers no break-down in any way comparable to that which occurs in wrought iron, cast iron, or ordinary steel at a very early stage in the magnetizing process. On the contrary, the permeability is approximately constant under large and small forces.

The conclusion has some practical interest. It has been suggested that this steel should be used for the bed-plates of dynamos and in other situations where a metal is wanted that will not divert the lines of induction from neighbouring spaces. In such cases the magnetic forces to which manganese steel would be subjected would certainly lie below the limit to which the force has been raised in these experiments. We may therefore conclude that in these uses of the material it may be counted upon to exhibit a magnetic permeability only fractionally greater than that of copper, or brass, or air.

On the Influence of a Plane of Transverse Section on the Magnetic Permeability of an Iron Bar, by Prof. J. A. Ewing, F.R.S., and William Low.—It has been remarked by Prof. J. J. Thomson and Mr. H. F. Newall that when an iron bar is cut across and the cut ends are brought into contact, the magnetic permeability is notably reduced (Cambridge Phil. Soc. Proc., February 1887). The attention of the authors was directed to the matter by finding the same phenomenon present itself in experiments on the magnetization by the "isthmus" method; and they proceeded to examine the effect by an application of the method Hopkinson has used to measure magnetic permeability ("Magnetization of Iron," Phil. Trans., Part 2, 1885). A round bar, nearly half a square centimetre in section, and 13 centimetres long, had its ends united by a massive wrought-iron yoke to reduce it to a condition approximating to endlessness, and its magnetization by various magnetic forces was examined, both when free from stress and when compressed by a load of 226 kilos. per square centimetre. It was then cut in the lathe and the halves placed in contact, and the magnetization again examined with and without load. It was next cut into four parts, and finally into eight parts, and magnetized in each case. Every new plane of section caused a notable loss of permeability. The following are the maximum values of the permeability in each case:—

Solid bar	...	1220
Bar cut in two	...	980
Bar cut in four	...	640
Bar cut in eight	...	400

Next another bar was tested, first when solid, next with one cut finished in the lathe, and finally with the cut surfaces faced true by scraping and comparing them with a Whitworth plane. So long as the bar was not compressed its magnetic permeability was nearly the same, whether the ends were left roughly finished or were faced true. But when load was applied the effect of facing the ends was remarkable: the faced bar then behaved as a solid bar would, while the bar with rough cut ends still showed a decided defect of permeability as compared with a solid bar.

This made it seem highly probable that the whole effect was due to a film of air between the cut faces. Applying Hopkinson's method to calculate the thickness this film would need to have in order to account for the observed increase of magnetic resistance, the authors find its thickness is only about 1/35 of a millimetre when the magnetic force is 10 C.G.S. units, and diminishes to about 1/70 of a millimetre when the force is 50 C.G.S. In the case of the bar cut into four or eight parts, each cut has an effect equivalent to the introduction of a film of

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this thickness. The authors conclude that in all probability the whole phenomenon is due to the surfaces being separated by these short distances.

On the Magnetic Properties of Gases, by Prof. Quincke, Ph.D. —A few years ago he invented what he called a magnetic manometer. It consists of a bent tube, of which one limb is much wider than the other. In the wide limb is the gas to be experimented on. The narrow limb and the connecting horizontal piece contain liquid, and the difference of level of the liquid in the narrow limb produced by the magnetic field is what is measured.

The magnetic pressure per unit of area is given by the formula—

$$p = \frac{R}{8\pi} H_1^2.$$

If h be the difference of level of the liquid in the two limbs, *i.e.* the hydrostatic pressure, we have—

$$h\sigma = \frac{R - R_1}{8\pi} H_1^2.$$

The smallest diamagnetic constant for the gases experimented on was found to be that of hydrogen. Oxygen had the highest. He compares his results with Faraday's, and finds that they agree substantially, the differences being probably due to impurities.

Final Value of the B.A. Unit of Electrical Resistance as determined by the American Committee, by Prof. H. A. Rowland.—His determination in 1876 gave 1 B.A. unit = ·9878 ohm. For his present determination the apparatus was on a very large scale. He employed both the Kirchoff and the Lorenz method. By the former method he got a final value of ·98646 ± 40, by the latter a value of ·9864 ± 18; so that the latter method has a probable error of less than a half that of the former. His value for the resistance of 100 cubic centimetres of mercury came out ·95349 B.A. units.

Lord Rayleigh said that the results showed that the absolute determination of the B.A. unit by various experiments agreed much better than the comparison with the mercury standard. This was exactly the opposite of what he would have expected. Prof. Rowland had suggested that one cause of the difference between their determinations of the mercury standard might be that in the American experiments the tubes had been mechanically wiped, so that there was no chance of dust remaining in them. He hardly thought however, that this was likely. The want of uniformity in the diameter of the tube might possibly have an effect.

On Induction between Wires and Wires, by W. H. Preece, F.R.S.—A continuation of a subject brought before the Association last year, when it was shown that electro-magnetic disturbances extended to distances much greater than was imagined, and that effects were observed across many miles of country. Experiments were made on the banks of the Severn and Mersey, on the Portcawl Sands of South Wales, in the fields in the neighbourhood of Cardiff, on the roads and railways of Oxfordshire, Worcestershire, and Shropshire, in the air and under water, in the corridor of the General Post Office in London; and the law was formulated that the distance depended directly on the strength of the currents inducing the disturbance and on the length of the wires opposed to each other, and inversely on the square of the distance separating them, and on the electrical resistance of the disturbed wire.

The influence of 1 mile of wire carrying 1 ampere of current can apparently extend to a distance of 1·9 mile. The law is given by the following formula:—

$$C_2 = M\frac{C_1 l}{d^2 r_2},$$

where C_1 is the primary current, C_2 the secondary, l the length of the wires opposed to each other, d the distance separating them, r_2 the resistance of the secondary circuit. When these quantities are represented in C.G.S. units, M equals ·005. The current induced by 1 mile, of 1 ampere at 1 mile distant is $1·3 \times 10^{-13}$ ampere. A current is still perceptible at 1·9 mile distant; hence we can calculate that a Bell telephone requires six ten-thousand-millionths of a milliampere, or, in figures, ·0000000006 milliampere, to be audible.

One curious result of these inquiries is that the disturbances are transmitted equally well through water and the earth as through air, and hence our cables are disturbed as well as our land wires. Communication with coal-pits is possible, though nothing but the earth intervenes.

On the Effect of Continental Lands in altering the Level of the adjoining Oceans, by Prof. Edward Hull, F.R.S., Director of the Geological Survey of Ireland.—The effect of the attraction of continental lands upon the oceanic waters adjoining seems to have been very much overlooked by British physical geographers. That some slight effect arises in the direction of elevating the surface of the ocean in proximity to the coast is generally admitted, but the amount of rise is considered to be small, perhaps insignificant. The prevalence of these views was attributed by the author to the widespread influence of Lyell's hypothesis of the uniformity of the ocean-surface all over the globe.

The author proceeded to discuss the effect of continental lands, showing that this was in the first instance divisible under two principal heads: The effect (1) of the unsubmerged, and (2) of the submerged masses. In the former case, where the mass rose above the surface, one component of the attraction acted in a more or less vertical direction; in the second case, all in a lateral direction; but both had the effect of elevating the surface of the ocean. The horizontal distance to which the vertical effect extended owing to the curvature of the earth's surface was then considered: and it was shown that, where continental lands rise from a deep ocean, the effect of the lateral attraction far exceeds that of the vertical attraction of the unsubmerged mass. Prof. Stokes has furnished the author with a hypothetical case, in which the elevation of the ocean was estimated to reach 400 feet above the mean geodetic surface of the earth.

For the purposes of illustration three cases were selected, viz.:—

(1) The table-land of Mexico, between lats. 18° and 26° N.
(2) The table-land of Bolivia, ,, 19° and 26° S.
(3) The Andes of Chili, ,, 26° and 35° S.

The mean elevations, distances from the ocean, and extent having been determined, and the mean density of the crust being taken at 2·6 for emergent, and 1·6 for unsubmerged land, the results of the attraction of the mountain masses in each case were as follows:—

(1) Mexico, 780 feet; (2) Bolivia, 2160 feet; (3) Chili, 1580 feet.

The total calculated rise of the ocean-waters at a distance of 900 miles from the coast in lat. 10° S. would amount to 2568 feet.

The above results, which are probably rather under than over estimates, fall considerably short of those to be drawn from Suess and Fischer's formula, but are probably much in excess of the views held by British physical geographers generally; and the conclusion was drawn that if the same processes of reasoning and calculation were applied to all parts of the world, it would be found that the ocean waters were piled up to a greater or less extent all along our continental coasts, producing very important alterations in the terrestrial configuration as compared with an imaginary ellipsoidal, or geodetic, surface, to which all these changes of level must necessarily be referred.

On a Standard Lamp, by Prof. A. A. Vernon Harcourt, F.R.S.—At one of the meetings of this Section last year a lamp devised by the author for producing a constant amount of light was shown and described by Mr. W. S. Rawson. The lamp now exhibited serves the same purpose, but is simpler in principle, more easily adjusted, and less affected by draughts. It consists of a glass reservoir with tubulure and stopper of the form and size of a large spirit-lamp, mounted on a metal stand provided with levelling screws. The wick can be turned up and down in the normal manner within a long tube attached to the body of the lamp. Round this tube is a wider tube 100 × 25 mm., and the two being joined together above and below by flat plates constitute the burner of the lamp. When the burner becomes warm by conduction of heat from the flame of the lamp, the pentane in the wick volatilizes and burns at a considerable distance above the point to which the wick is turned down. Thus the size, or texture, or quality of the wick does not affect the flame. Around the burner and the lower part of the flame is another cylinder open at both ends and contracted above the burner to a tube 21 mm. in diameter. A similar tube forms the lower part of an upper chimney, which is enlarged above to a diameter of 25 mm. The upper part of the

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flame is concealed by this chimney, excepting where a narrow slit, 10 × 3 mm., on each side shows the tip of the flame and enables its height to be regulated. Through the interval between the two chimneys the flame shines, and the light which it gives is the same whenever the tip of the flame is visible through the slit, whether towards the lower or the upper end. The two chimneys are attached together by two curved metal bands sufficiently removed from the flame on either side not to affect it. The attachment of the bands to the lower chimney are adjustable, so that the opening through which the central parts of the flame are seen may be made larger or smaller. By means of small cylindrical blocks, whose thickness is accurately gauged, the width of the opening may be set either to that at which the light emitted is one candle, or, if a greater or smaller light is desired, a candle and a half or half a candle. The liquid with which the lamp is fed is pentane, obtained in a manner already described from American petroleum.

Mr. W. N. Shaw read a paper by Mr. J. T. Bottomley on *Expansion by Heat of Wires under Pulling Stress*. The wires were two fine copper wires. One of them carried about half its breaking weight and the other about a tenth of its breaking weight. The wires were suspended in a tube, a scale being attached to one, and a pointer moving over the scale to the other. Thermometers were inserted into the tube at various points, and the wires were heated by passing steam into the tube. It was found that the more heavily weighted wire extended much more than the lightly-weighted one. An amount of permanent elongation remained, but more in the heavily-strained wire. Each time the heating was done there was more and more permanent elongation, and ultimately one of the wires was broken under less than its breaking load in the normal state. Further experiments were made with wires which had been hardened, and the final result is that the coefficient of expansibility for heat of copper wire strained by a certain weight is greater than that of similar wire less heavily weighted.

Experiments on Electrolysis and Electrolytic Polarization, by W. W. Haldane Gee, Henry Holden, and Charles H. Lees.—This is a preliminary notice of experiments that are in progress in the Owens College Physical Laboratory. The experiments fall under four heads: (*A*) electrolysis under pressure; (*B*) time-rate of fall of polarization in closed circuit; (*C*) irreciprocal conduction; (*D*) the production of an oily fluid in electrolysis with palladium electrodes.

A. Numerous experiments have been made in order to determine the variation of the resistance of polarization of a sealed voltameter in which dilute sulphuric acid was electrolyzed between platinum wire electrodes, it being thus subjected to the pressure (up to 200 atmospheres) of the evolved gases. It was found that the resistance markedly decreased, and the polarization decreased slightly. These changes may, however, it is thought, be due to change of temperature, the influence of which would appear from later experiments not to have been fully eliminated. In two cases no change whatever was perceived: (1) when two platinum *plates* were used as electrodes, and (2) when two voltameters were connected together forming a sealed vessel, one voltameter being used to increase the pressure, while observations were made on the other. As it has not been possible to obtain glass tubes sufficiently strong for the high pressures desired, an apparatus of gun-metal has been constructed. This apparatus, which is fitted with a Bourdon's gauge recording to six tons on the square inch, may also be arranged for pressure experiments in general by attaching to it, by means of a strong metal tube, a suitable receiver. In two of the experiments, when the pressure had reached between 200 and 300 atmospheres, the evolved oxygen and hydrogen gases combined with explosion, although precautions had been used to prevent the gases from coming into contact with the platinum, except in the liquid.

B. The object of this research was to try to learn the parts played by the various portions of the evolved gases: (1) that occluded by the electrodes; (2) that deposited on them; and (3) that contained in the liquid in influencing polarization. The method employed was to vary the conditions under control, *e.g.* time of changing, density of current, &c., and to observe the time-rate of the fall of the polarization thus produced in closed circuit. It was found to be very difficult to apply this method, because though the conditions under control were kept as constant as possible, yet the time-rates of fall in two successive observations were often different. This was thought to be due to the insufficient cleaning of the electrodes between each experiment, and various methods were tried to remedy it, with the general result that the more perfect the cleaning became the more regular did the curves giving the time-rate of fall of the polarization become, but still the inconsistencies were not wholly removed. Heating the electrodes by the electrical current seemed preferable to the other methods of heating.

C. Whilst electrolyzing strong sulphuric acid between platinum electrodes, it was noticed that when the current density at the anode had exceeded a certain value decomposition apparently ceased. The value of the anode current-density necessary to produce this phenomenon is increased by diminishing the concentration or increasing the temperature of the acid (thus diminishing the viscosity), and is diminished by cleaning the electrodes. It was found that this great diminution of the current was not caused by the formation of an opposing E.M.F., but by a sudden increase of from 500 to 50,000 ohms in the resistance of the circuit. That the insulating condition occurs at the anode is shown by successively replacing the kathode and the anode by clean plates; in the first case the stoppage of the current persists, in the second case the current is readily conducted. The cause seems to be a sheath of oxygen bubbles which firmly adhere to the anode when the insulating condition is formed. The film is removed by momentarily breaking the circuit, or short-circuiting the voltameter, or reversing the current, or by replacing the anode by a clean plate.

D. During the electrolysis of various liquids between palladium electrodes it has been observed that a dense-looking liquid streams from *one* of the electrodes (the anode in dilute sulphuric acid, the kathode in caustic soda) *after a reversal of the current*. The liquid seems to be a compound of oxygen and hydrogen, presumably hydroxyl.

On the Vortex-Theory of the Luminiferous Ether, by Prof. Sir W. Thomson, F.R.S.—"In endeavouring to investigate turbulent motion of water for my communication on that subject to this Section, I have found a solution (many times tried for within the last twenty years) of the problem—to construct, by giving vortex-motion to an incompressible viscid fluid, a medium which shall transmit waves of laminar motion as the luminiferous ether transmits waves of light. Let *xav*, *xzav*, *xyzav* denote space-averages, linear, surface, and solid, through infinitely great spaces." After defining and illustrating this method of averages by examples, and remarking in passing that a general property of it is that

$$xav\,\frac{dQ}{dx} = 0,$$

where Q is any quantity which is finite for infinitely great values of x, he proceeded thus:—

Suppose now the motion to be homogeneously distributed through all space. This implies that the centres of inertia of all great volumes of the fluid have equal parallel motions, if any motions at all. Conveniently, therefore, we take our reference-lines, OX, OY, OZ, as fixed relatively to the centres of inertia of three (and therefore of all) centres of inertia of large volumes; in other words, we assume no translatory motion of the fluid as a whole. This makes zero of every large average of u, and of v, and of w; u, v, and w being the velocity-components; and we may write as the general expression for nullity of translational movements in large volumes—

$$0 = \text{ave. } u = \text{ave. } v = \text{ave. } w,$$

where ave. denotes the average through any great length of straight or curved line, or area of plane or curved surface, or through any great volume of space. In terms of this generalized notation of averages, homogeneousness implies—

$$\text{ave. } u^2 = U^2,\ \text{ave. } v^2 = V^2,\ \text{ave. } w^2 = W^2,$$
$$\text{ave. } vw = A^2,\ \text{ave. } wu = B^2,\ \text{ave. } uv = C^2,$$

where U, V, W, A, B, C are six velocities independent of the positions of the spaces in which the averages are taken. These equations are, however, infinitely short of implying, though implied by, homogeneousness.

Suppose now the distribution of motion to be isotropic. This implies, but is infinitely more than is implied by, the following equations in terms of the above notation, with further notation, R, to denote what we shall call *the average velocity* of the turbulent motion—

$$U^2 = V^2 = W^2 \tfrac{1}{3}R^2,$$
$$0 = A = B = C.$$

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Large questions now present themselves as to transformations which a distribution of turbulent motion would experience in an infinite liquid left to itself with any distribution given to it initially. If the initial distribution be homogeneous through all large volumes of space, except a certain large finite space, S, through which there is initially either no motion or turbulent motion, homogeneous or not, but not homogeneous with the motion through the surrounding space, will the fluid which at any time is within S acquire more and more nearly as time advances the same homogeneous distribution of motion as that of the surrounding space, till ultimately the motion is homogeneous throughout? Probably, I think I may say certainly, yes—at all events for a large class of cases.

But can it be that this equalization comes to pass through smaller and smaller spaces as time advances? In other words, will any given distribution, homogeneous on a large enough scale, become more and more *fine-grained* as time advances? Probably *yes* for some initial distributions; probably *no* for others. Probably *yes*, for vortex-motion given continuously through all of one large portion of the fluid while all the rest is irrotational. Probably *no* for the initial motion given in the shape of equal and similar Helmholtz rings, of proportions suitable for stability, and each of overall diameter considerably smaller than the average distance from nearest neighbour. Probably also *no*, though the rings be of very different volumes and vorticities. But probably *yes* if the diameters of the rings or of many of them, be not small in comparison with distances from neighbours, or if the individual rings, each an endless slender filament, be entangled or nearly entangled among one another.

Again a question: If the initial distribution be *homogeneous and æolotropic*, will it become more and more isotropic as time advances, and *ultimately quite isotropic?* Probably *yes* for any random initial distribution, whether of continuous rotationally-moving fluid or of separate finite vortex-rings. Possibly *no* for some symmetrical initial distribution of vortex-rings, conceivably stable; though it does not seem probable that there is any such stability.

If the initial distribution be homogeneous and isotropic (and therefore utterly *random* in respect to direction) will it remain so? Certainly *yes*.

We shall now suppose the initial motion to consist of a laminar motion $[f(y), 0, 0]$ superimposed on a homogeneous and isotropic distribution $(\mathfrak{u}_0, v_0, w_0)$; so that we have—

$$\text{when } t = 0,\ u = f(y) + \mathfrak{u}_0,\ v = v_0,\ w = w_0;$$

and we shall endeavour to find such a function, $f(y, t)$, that at any time, t, the velocity-components shall be—

$$f(y, t) + \mathfrak{u},\ v,\ w,$$

where $\mathfrak{u}$, v, w are quantities of each of which every large enough average is zero.

With this assumption the equations of motion yield the following—

$$\frac{df(y, t)}{dt} = -\ xzav\ \frac{d(\mathfrak{u}v)}{dy}.$$

It is to be remarked that this result involves no isotropy, no homogeneousness in respect to y; and only homogeneousness of *régime* with respect to y and z, with no translational motion.

The translational component of the motion is wholly represented by $f(y, t)$, and, so far as our establishment of the above equation is concerned, may be of any magnitude, great or small relatively to velocity-components of the turbulent motion. It is a fundamental formula in the theory of the turbulent motion of water between two planes; and I had found it in endeavouring to treat mathematically my brother Prof. James Thomson's theory of the "Flow of Water in Uniform *Régime* in Rivers and other Open Channels" (Proceedings of the Royal Society, August 15, 1878). In endeavouring to advance a step towards the law of distribution of the laminar motion at different depths, I was surprised to discover the law of propagation as of distortional waves in an elastic solid, which constitutes the conclusion of my present communication—

$$\frac{d}{dt}\ xzav\ (\mathfrak{u}v = -\ \tfrac{2}{9}R^2\frac{df(y, t)}{dy}.$$

Eliminating the first member from this equation, by the former, we find—

$$\frac{d^2f}{dt^2} = \tfrac{2}{9}R^2\frac{d^2f}{dt^2}.$$

Thus we have the very remarkable result that laminar disturbance is propagated according to the well-known mode of waves of distortion in a homogeneous elastic solid; and that the velocity of propagation is $\frac{\sqrt{2}}{3}$ R, or about 47 of the average velocity of the turbulent motion of the fluid. This might seem to go far towards giving probability to the vortex-theory of the luminiferous ether.

But a difficulty remains unsolved: a possible rearrangement of vortices within each wave, giving rise to dissipation of the wave-energy.

The mathematical investigation appears in full in the October number of the *Philosophical Magazine*, with some slight farther considerations regarding this virtual viscosity, and the question of what, if any, distribution of vortices can either have no tendency to the vitiating rearrangement, or can, with the requisite fine-grainedness, be slow enough in the vitiating rearrangement to allow the propagation of waves of light to go on through a hundred million million miles of space, or a million times the earth's distance from the sun.

The Committee of the Section reported that at a meeting of the Committee it had been resolved, on the motion of Prof. Gustav Wiedemann, of Leipzig, seconded by Sir William Thomson:—"That this Committee of the Mathematical and Physical Science Section of the British Association hereby convey to Dr. Joule their sense of the great loss sustained by the Section in consequence of his inability to take part in this meeting of the British Association in his native city, and express their sincere regret at the cause of this loss, and their hearty sympathy with him in his illness. The Committee take this opportunity of recording their appreciation of the splendid work of this most painstaking and conscientious seeker after truth, who, with his discoveries, has led the way in the greatest advance in knowledge made in this age, and, by his life, has conferred on mankind a precious example for their admiration and imitation."

SCIENTIFIC SERIALS.

American Journal of Science, August.—History of the changes in the Mount Loa craters (continued), by James D. Dana. In this paper the history of Kilauea is continued from January 1840 to the end of 1886, during which period sufficient facts were accumulated for a widened and apparently final explanation of the method of filling the pit. The eruptions of 1849, 1855, 1868, and 1886 are fully described, and the whole subject is illustrated with maps of the burning mountain at various dates during the period under consideration.—On some phenomena of binocular vision (continued), by Joseph Le Conte. In this paper, the twelfth of the series, the author deals with certain peculiarities of the phantom images formed by binocular combination of regular figures. The phenomena here described, none of which have hitherto been satisfactorily accounted for, are all explained by the law of corresponding points, justly regarded as the most fundamental law of binocular vision.—Chemical integration, by T. Sterry Hunt. In this paper the author deals more fully with several points connected with chemical metamorphosis, which were more briefly noticed in his recently published work, entitled "A New Basis for Chemistry."—Studies in the mica group, by F. W. Clarke. In this paper the author deals with specimens of muscovite from Alexander County, North Carolina; of lepidomelane from Baltimore and Litchfield, Maine; of iron biotite from Auburn, Maine; and of iron mica from near Pike's Peak.

SOCIETIES AND ACADEMIES.

LONDON.

Institution of Mechanical Engineers, September 30.—Mr. E. H. Carbutt, President, in the chair.—A supplementary paper by Major Thomas English, R.E., on the initial condensation in a steam cylinder, was read and discussed in connexion with the paper by the same author on the distribution of heat in a stationary steam-engine, read at the spring meeting on May 17, an abstract of which has already appeared in NATURE (vol. xxxvi. p. 115). The supplementary experiments were carried out in a portable engine of ordinary type, the cylinder of which was jacketed on the cylindrical portion but not at the ends. The steam was admitted directly from the boiler into the steam chest, and the quantity required for each experiment being small compared with the capacity of the boiler, no question of priming or condensation before admission can arise. The con-

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