is invariable in tint and disappears by inclination of the body. Such instances are no real exceptions, but are due to the reflecting plates being curved, or having pigmentary matter beneath them, or an opalescent medium above them. In this way some of the most extraordinary and beautiful colour effects it seems possible to conceive are produced.

In examining objects with the perforated mirror a single light is necessary. The sun is of course the best, and the electric light probably almost as good. I frequently employ the lime-light, but a good paraffin lamp may be used as a substitute. Ordinary gas is unsuitable. The light should be placed in front of the observer, its direct rays being prevented from falling on the objects by means of a book or partition of some kind resting on the table, and of such a height that the light can be seen above it. On placing the mirror to the eye the light may be reflected from the mirror on to the object, and the latter manipulated so as to reflect the ray back through the perforation in the mirror to the eye. The incidence is thus known to be normal, and the colour observed is the one to be recorded.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The following letter has been addressed by the University of Cambridge to that of Padua, which is about to celebrate the tercentenary of Galileo's professorship :—

Universitas Cantabrigiensis Universitati Patavinae S.P.D.

Litteras vestras, viri doctissimi, GALILAEI GALILAEI Professoris vestri celeberrimi in laudem conscriptas vixdum nuper perlegeramus, cum statim in mentes nostras rediit non una Italiae regio viri tanti cum memoria in perpetuum consociata. Etenim nostro quoque e numero nonnulli urbem eius natalem plus quam semel invisimus, ubi Pisano in templo lucernam pensilem temporis intervallis aequis ultro citroque moveri adhuc iuvenis animadvertit ; etiam Vallombrosae nemora pererravimus, ubi antea scholarum in umbra litteris antiquis animum puerilem imbuerat ; ipsa in Roma ecclesiam illam Florentinam intravimus, ubi doctrinae suae de telluris motu veritatem fato iniquo abiurare est coactus ; Florentiae denique clivos suburbanos praeterivimus, ubi provecta aetate caeli nocturni sidera solus contemplabatur, ubi extrema in senectute diei lumine orbatus cum MILTONO nostro collocutus est, ubi eodem demum in anno mortalitatem explevit, quo NEWTONUS noster lucem diei primum suspexit.

Hodie vero ante omnia non sine singulari voluptate sedem quandam doctrinae insignem, intra colles Euganeos urbemque olim maris dominam positam recordamur, ubi trecentos abhinc annos saeculi sui ARCHIMEDES discipulorum ex omni Europae parte confluentium numero ingenti erudiendo vitam suam maturam maxima cum laude dedicavit ; ubi, ut LIVII vestri verbis paulum mutatis utamur, ultra colles camposque et flumen et assuetam oculis vestris regionem late prospiciens, caelo in eodem, sub quo vosmet ipsi nati estis et educati, instrumento novo adhibito inter rerum naturae miracula primus omnium Lunae faciem accuratius exploravit, Iovis satellites quattuor primus detexit, Saturni speciem tergeminam primus observavit, ultraque mundi orbem ingentem a Saturno lustratum fore suspicatus est ut etiam alii planetae aliquando invenirentur.

Ergo vatis tam veracis, auguris tam providi in honorem, nos certe, qui Professorum nostrorum in ordine planetae etiam Saturno magis remoti ex inventoribus alterum non sine superbia nuper numerabamus, hodie alterum ex Astronomiae Professoribus nostris, Georgium DARWIN, nominis magni heredem, nostrum omnium legatum, quasi Nuntium nostrum Sidereum, ad vosmet ipsos libenter mittimus. Vobis autem omnibus idcirco gratulamur quod tum Italiae totius, tum vestrae praesertim tutelae tradita est viri tanti gloria, qui divino quodam ingenio praeditus rerum naturae in provincia non una ultra terminos prius notos scientiae humanae imperium propagavit quique caeli altitudines immensas perscrutatus mundi spatia ampliora gentibus patefecit. Valete.

Datum Cantabrigiae
a. d. viii *Kal. Decembres*
A. S. MDCCCXCII.

Mr. F. Darwin has been appointed Deputy Professor of Botany for the current academical year, Prof. Babington being unable to lecture on account of the state of his health.

SCIENTIFIC SERIALS.

American Journal of Science, November.—Unity of the glacial epoch, by G. Frederick Wright. An examination of the evidence in favour of two successive glacial epochs separated by an inter-glacial epoch, during which the glaciated area was as free from ice as it is at the present time. This evidence is shown to be inconclusive, at least as far as American observations go.—A photographic method of mapping the magnetic field, by Charles B. Thwing. Iron filings are strewn upon the film side of a dry plate laid horizontally in a magnetic field, and the plate is exposed to light from above. The filings are then brushed off, and the plate developed. From the negatives excellent lantern slides may be obtained.—Contributions to mineralogy, No. 54, by F. A. Genth, with crystallographic notes by S. L. Penfield. Description and analysis of aguilarite, metacinnabarrite, döllingite, rutile, danalite, yttrium-calcium fluoride, cyrtolite, lepidolite, and fuchsite.—The effects of self-induction and distributed static capacity in a conductor, by Frederick Bedell, Ph.D., and Albert C. Crehore, Ph.D.—The quantitative determination of rubidium by the spectroscope, by F. A. Gooch and J. I. Phinney. The method is that of comparing photometrically the intensity of a certain line in the spectrum of the metal under investigation with the intensity of that given by a standard solution containing a known amount of the metal. A definite amount of the salt solution—usually the chloride—is taken up by a hollow coil of platinum wire, which may be made to take up constant quantities of liquid by taking care to plunge the coil while hot into the liquid, and removing it with its axis inclined obliquely to the surface. The coils were made of platinum wire 0·32 mm. in diameter, wound in about thirty turns to a spiral 1 cm. long by 2 mm. across, and twisted together at the ends to form a long handle. Each coil held 0·02 gr. of water. With such a coil, the blue rubidium lines were produced in a Muencke burner from 0·0002 mgr. of the chloride. Some test experiments showed that in the case of pure solutions of rubidium chloride the percentage could be found spectroscopically up to 1 part in 30,000 with an error as low as 1·25 per cent. In presence of potassium or sodium, however, the error may be as great as 20 per cent.—Notes on the meteorite of Farmington, Washington County, Kansas, by H. L. Preston.—A note on the cretaceous of North-western Montana, by H. Wood.—A deep artesian boring at Galveston, Texas, by R. T. Hill.—Notice of a new Oriskany fauna in Columbia County, New York, by C. E. Beecher, with an annotated list of fossils, by J. M Clarke.—Description of the Mount Joy meteorite, by E. E. Howell.—Influence of the concentration of the ions on the intensity of colour of solutions of salts in water, by C. E. Linebarger.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, November 17.—"Stability and Instability of Viscous Liquids," by A. B. Basset, F.R.S. (Abstract.)—The principal object of this paper is to endeavour to obtain a theoretical explanation of the instability of viscous liquids, which was experimentally studied by Professor Osborne Reynolds.[1]

The experiment, which perhaps most strikingly illustrates this branch of hydrodynamics, consisted in causing water to flow from a cistern through a long circular tube, and by means of suitable appliances a fine stream of coloured liquid was made to flow down the centre of the tube along with the water. When the velocity was sufficiently small, the coloured stream showed no tendency to mix with the water; but when the velocity was increased, it was found that as soon as it had attained a certain critical value, the coloured stream broke off at a certain point of the tube and began to mix with the water, thus showing that the motion was unstable. It was also found that as the velocity was still further increased the point at which instability commenced gradually moved up the tube towards the end at which the water was flowing in.

Professor Reynolds concluded that the critical velocity W was determined by the equation

$$W a \rho / \mu < n,$$

where a is the radius of the tube, ρ the density, and μ the viscosity of the liquid, and n a number; but the results of this

[1] *Phil. Trans.* 1883, p. 935.

paper show that this formula is incomplete, inasmuch as it does not take any account of the friction of the liquid against the sides of the tube.

In the first place, if the surface friction is supposed to be zero, so that perfect slipping takes place, the motion is stable for all velocities. If ϵ^{kt} be the time factor of a disturbance of wave-length λ, the value of k is

$$k = -\frac{2\iota\pi W}{\lambda} - \frac{\mu}{\rho a^2}\left(\frac{4\pi^2 a^2}{\lambda^2} + n^2\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad (1),$$

where n is a root of the equation $J_1(n) = 0$.

Experiment shows that when the velocity is greater than about six inches per second, the frictional tangential stress of water in contact with a fixed or moving solid is approximately proportional to the square of the relative velocity. This introduces a constant β, which may be called the coefficient of sliding friction, whose dimensions are [ML^{-3}], and are therefore the same as those of a density. This constant may have any positive real value; $\beta = 0$ corresponding to perfect slipping or zero tangential stress, whilst $\beta = \infty$ corresponds to no slipping, which requires that the velocity of the liquid should be the same as that of the surface with which it is in contact. Owing to the intractable nature of the general equations of motion of a viscous liquid, I have been unable to obtain a complete solution, except on the hypothesis that β is an exceedingly small quantity. This supposition, I fear, does not represent very accurately the actual state of fluids in contact with solid bodies; but at the same time the solution clearly shows that the instability observed by Prof. Reynolds does not depend upon viscosity alone, but is due to the action of the boundary upon a *viscous* liquid.

To a first approximation, the real part of k is proportional to

$$\frac{W a \beta}{\mu} - \frac{(n^2 + m^2 a^2)^2}{4n^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2),$$

where $2\pi/m$ is the wave-length of the disturbance, and n is a root of the equation $(J_1 n) = 0$. Since the second term is a number, this shows that the motion will be stable, provided

$$W a \beta/\mu < \text{a number.}$$

The experiments of Prof. Reynolds conclusively show that the critical velocity at which instability commences is proportional to μ/a; and the fact that the theoretical condition of stability turns out to be that Wa/μ, multiplied by a quantity of the same dimensions as a density, should be less than a certain number, appears to be in substantial agreement with his experimental results.

The results of the investigation may be summed up as follows:—

(i.) *The tendency to instability increases as the velocity of the liquid, the radius of the tube, and the coefficient of sliding friction increase; but diminishes as the viscosity increases.*

(ii.) *The tendency to instability increases as the wave-length* ($2\pi/m$) *of the disturbance increases.*

The remainder of the paper is occupied with the discussion of a variety of problems relating to jets and wave-motion.

I find that when a cylindrical jet is moving through the atmosphere, the tendency of the viscosity of the jet is always in the direction of stability. The velocity of the jet does not affect the stability unless the influence of the surrounding air is taken into account; if, however, this is done, it will be found that it gives rise to a term proportional to the product of the density of the air and the square of the velocity of the jet, whose tendency is to render the motion unstable. The tendency of surface-tension (as has been previously shown by Lord Rayleigh) is in the direction of stability or instability according as the wave-length of the disturbance is less or greater than the circumference of the jet.

If in addition, the jet is supposed to be electrified, the condition of stability contains a term proportional to the square of the charge multiplied by a certain number, n. When the ratio of the circumference of the jet to the wave-length is less than 0·6, n is positive, and the electrical term tends to produce stability; but when this ratio is greater than 0·6, n is negative, and the electrical term tends to produce instability. It must, however, be recollected that when the above ratio is greater than unity the tendency of surface tension is to produce stability; but if the influencing body is capable of inducing a sufficiently large charge, the electrical term (when $2\pi a > \lambda$) will neutralize the effect of surface tension and viscosity, and the motion will be unstable.

The well-known calming effect of "pouring oil on troubled waters" has passed into a proverb. The mathematical investigation of this phenomenon is as follows:—The oil spreads over the water so as to form a very thin film; we may therefore suppose that the thickness l of the oil is so small compared with the wave-length hat powers of l higher than the first may be neglected. Also, since the viscosity of olive oil in C.G.S. units is about[1] 3·25, whilst that of water is about 0·014, the former may be treated as a highly viscous liquid, and the latter as a frictionless one.

The result is as follows:—

Let ρ_1, ρ be the densities of the water and oil, T_1 the surface tension between oil and water, T the surface tension between oil and air, μ the viscosity of the oil, and ϵ^{kt} the time factor, then, to a first approximation,

$$k = -\frac{\{g(\rho_1 - \rho) + T_1 m^2\}(g\rho - Tm^2)l}{4\mu\{g\rho_1 - (T - T_1)m^2\}}$$

For olive oil, $T_1 = 20·56$, $T = 36·9$, so that $T > T_1$; and I find that the motion will be stable unless the wave-length of the disturbance lies between about 9/11 and 6/5 of a centimetre. This result satisfactorily explains the effect of oil in calming stormy water.

OXFORD.

University Junior Scientific Club, October 26.—Mr. E. L. Collis, in the absence of Mr. Bourne, gave an exhibit of *Codium tomentosum*.—Mr. F. C. Britten gave an exhibit of the nest of a trapdoor spider.—Mr. Hill read an interesting paper on the determination of sex, which was followed by a long discussion.—Mr. Fisher exhibited some specimens of crystallized anhydrous oxalic acid, and described their methods of preparation.

CAMBRIDGE.

Philosophical Society, October 31.—Prof. G. H. Darwin, President, in the chair.—The following officers were elected for the ensuing session:—President: Prof. Hughes. Vice-Presidents: Dr. Cayley, Prof. G. H. Darwin, Dr. Hill. Treasurer: Mr. R. T. Glazebrook. Secretaries: Dr. Hobson, Mr. J. Larmor, Mr. Bateson. New Members of Council: Prof. Thomson, Mr. F. Darwin, Dr. Shore, Mr. Ruhemann.—The retiring President addressed the Society.—The following communications were made:—Note on the determination of low temperatures by platinum-thermometers, by Mr. E. H. Griffiths and Mr. G. M. Clark. The authors, following up the suggestion of Profs. Dewar and Fleming, that the resistance of certain pure metals vanishes at absolute zero, have assumed the possibility of extrapolating the platinum thermometer formulæ, and have thus found the temperature at which $R = 0$. From the previously-published constants of seven different thermometers—including Callendar's original wire—the mean value deduced by them is $-273°·86$, which is in remarkable agreement with Joule and Thomson's thermodynamical value $-273°·7$. They further suggest that the simple method of determining the resistance in ice and steam and assuming $R = 0$ when $t = -273°·7$ is sufficient to graduate a thermometer constructed of fairly pure wire, as they show that the errors so introduced will only amount to a fraction of a degree over the range $-273°$ to $+150°$.—Carnot's principle applied to animal and vegetable life, by Mr. J. Parker. The author discusses the question whether the conditions of the growth of plants are limited by the law of entropy. The assumption is made that Carnot's principle takes account only of the exchange of heat, and the temperature of the material system at which the exchange takes places; that the differential effect of solar radiation of different kinds consists in variation of the activity but not of the mechanical type of the growth. The increase of available energy due to the building up of inorganic materials into a plant can then only be explained, in conformity with the second law of thermodynamics, by the aid of differences of temperature during growth: the author gives calculations to prove that the difference between day and night is amply sufficient for this purpose.—Note on the geometrical interpretation of the quaternion analysis, by Mr. J. Brill.

[1] Osborne Reynolds, *Phil. Trans.* 1886, p. 17.

PARIS.

Academy of Sciences, November 14.—M. d'Abbadie in the chair.—Heat of combustion of camphor, by M. Berthelot.—Remarks on a note by M. A. Colson on the rotating power of the diamine salts, by M. C. Friedel.—Researches on the chemical constitution of the peptones, by M. P. Schützenberger.—Influence of the distribution of manures in the soil upon their utilization, by M. H. Schlœsing.—On the laws of dilatation of gases under constant pressure, by M. E. H. Amagat. Tables are given of coefficients of expansion of carbon dioxide under pressures ranging from 50 to 1000 atm., and temperatures up to 258°; and for oxygen, hydrogen, nitrogen and air, under pressures up to 3000 atm. For CO_2 the coefficient has a maximum at a certain pressure for each range of temperature. This maximum corresponds to a higher pressure as the temperature rises. For the other gases the coefficient decreases regularly as the pressure increases. As regards temperature, the coefficient of expansion of CO_2 for each pressure reaches a maximum at a certain temperature and then decreases. This temperature is the higher, the greater the pressure. The more permanent gases behave as if they had already passed their maximum.—Study of the pathogenic power of fermented beet-root pulp, by M. Arloing.—Observations of the new comet Holmes (*f* 1892), made at the Paris Observatory (west equatorial), by M. G. Bigourdan (see Astronomical Column).—Transformation of the great telescope of the Paris Observatory for the study of radial velocities of the stars, by M. H. Deslandres (see Astronomical Column).—Summary of solar observations made at the Royal Observatory of the Roman College during the third quarter of 1892, by M. P. Tacchini.—On the inversion of Abelian integrals, by M. E. Goursat.—On the summation of a certain class of series, by M. d'Ocagne.—On the equations of dynamics, by M. R. Liouville.—Experimental researches on the deformations of metallic bridges, by M. Rabut.—Conditions of equilibrium and of formation of liquid microglobules, by M. C. Maltézos. The following experimental results were arrived at: When a liquid spreads over the free surface of a denser liquid, microglobules are produced on inverting the position of the two liquids. If a liquid rests in drops on the surface of a denser liquid, then in the inverse position the denser will spread over the less dense liquid.—Demonstration of the existence of interference of electric waves in a closed circuit, by means of the telephone, by M. R. Colson. A Rhumkorff coil was kept vibrating at 130 per second by a thermopile. To one of its terminals was attached a copper wire ending in a hook, to which a linen thread soaked in calcium chloride was attached by one end, the other hanging free. One of the terminals of a telephone was placed in contact with the thread, the other terminal being isolated. Under these conditions, the sound in the telephone was completely extinguished at a certain distance from the copper. When both the ends of the thread (which was 3 m. long) were connected up by fine copper wires, two points of extinction were reached, one from each end. On shortening the thread these points approached each other and formed a zone of extinction between them. This zone of extinction spread over the entire copper wires as the thread was shortened to zero. The neutral zone is due to interference of two waves of the same period and of equal potential meeting in opposite directions.—On the co-existence of dielectric power and electrolytic conductivity, by M. E. Cohn.—Observations on the preceding communication, by M. Bouty.—Magnetic properties of bodies at different temperatures, by M. P. Curie. These were measured by bringing samples of the bodies between the ends of two electromagnets inclined to one another, and measuring the forces experienced by means of a torsion balance. The bodies were heated in a porcelain crucible, the heat being supplied by platinum wires carrying a current, and measured by a Chatelier thermocouple.—On the propagation of vibrations through absorptive isotropic media, by M. Marcel Brillouin.—On a new relation between variations of luminous intensity and the numerical order of the sensations, determined by means of a luminous paint, by M. Charles Henry.—Essay of a general method of chemical synthesis: experiments, by M. Raoul Pictet.—On the fusion of carbonate of lime, by M. H. Le Chatelier.—On the molecular weights of sodammonium and potassammonium, by M. A. Joannis.—On some crystallized sodium titanates, by M. H. Cormimbœuf.—On a propylamidophenol derived from camphor, by M. P. Cazeneuve.—On the colouring matter of the pollen, by MM. G. Bertrand and G. Poirault.—On the manufacture of melanite garnet and sphene, by M. L. Michel.—On the rotating power of solutions, by M. Wyrouboff.—Researches on the mode of elimination of carbonic oxide, by M. L. de Saint-Martin.—Vital fermentations and chemical fermentations, MM. Maurice Arthus and Adolphe Huber.—Remarks on the preceding communication, by M. A. Gautier.—Influence of the transfusion of blood from dogs vaccinated against tuberculosis upon tuberculous infection, by MM. J. Héricourt and Ch. Richet.—On a new species of chromogenic bacteria, the *Spirillum luteum*, by M. Henri Jumelle.—On two parasitic myzostomes of the *Antedon phalangium* (Müller), by M. Henri Prouho.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Manners and Monuments of Prehistoric Peoples: Marquis de Nardaillac, translated by N. Bell (Putnam).—An Elementary Text-book of Hygiene: H. R. Wakefield (Blackie).—More about Wild Nature: Mrs. Brightwen (Unwin).—The Pharmacy and Poison Laws of the United Kingdom (office of the *Chemist and Druggist*).—Lessons in Elementary Algebra, 1st series: L. J. Pope (Bell).—The Visible Universe: J. E. Gore (Lockwood).—Man and the Glacial Period: Dr. G. F. Wright (K. Paul).—Sinai from the Fourth Egyptian Dynasty to the Present Day: late H. S. Palmer, new edition, revised by Prof. Sayce (S.P.C.K.).—Time and Tide, 2nd edition: Sir R. S. Ball (S.P.C.K.).—Les Races et les Langues: Prof. A. Lefèvre (Paris, Alcan).—A Contribution to our Knowledge of Seedlings, 2 vols.: Sir John Lubbock (K. Paul).—Australasian Newspaper Directory, 3rd edition, 1892 (Gordon and Gotch).—Sultan to Sultan: M. French-Sheldon (Saxon).

PAMPHLETS.—Recherches d'Optique Physiologique et Physique, Part 2: C. Royer (Bruxelles, Monnom).—Fauna Americana: D. T. de Aranzadi (Madrid).

SERIAL.—L'Anthropologie, tome iii. No. 4 (Paris, Masson).

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