majority of these organisms appear to be beneficial rather than inimical to man. There is not time to attempt even a brief description of all the "useful fermentations" due to bacteria, but the following cases will point the conviction that a school of bacteriology, which has nothing to do with medical questions, but investigates problems raised by the forester, agriculturist, and gardener, the dairyman, brewer, dyer, and tanner, &c., will yet be established in England in connection with one or other of our great botanical centres.

(*To be continued.*)

PHYSICS AT THE BRITISH ASSOCIATION.

THE meeting of the American Association at Detroit and the central position of Toronto have contributed greatly in bringing together a large number of Canadian and American mathematicians and physicists to meet their co-workers on this side of the Atlantic The opportunity thus afforded of conference and exchange of ideas has been one of the chief pleasures of the meeting.

It was universally felt that the presidential address of Prof. Forsyth (pp. 374–378) formed a clear and eloquent exposition of the claims of pure mathematics, and at its close Lord Kelvin, in moving a vote of thanks, declared that any one in science who could possibly choose would elect to belong to the mathematical rather than the non-mathematical class. President London, of the Toronto University, in seconding the vote, said that the address was specially needed in Toronto, because the public there had accused the university of attaching too much importance to mathematics.

Mr. J. A. Paterson, in a paper on the unification of time, described the efforts made by several scientific societies in Canada to secure uniformity in the specification of time by astronomers, navigators and the public; the suggestion being that the day should commence and end at midnight, and the hours be counted from 0 to 24. The proposal gave rise to some discussion. Prof. Newcomb pointed out that navigators, making observations usually at noon, found that time most convenient as the commencement of the day, while astronomers for similar reasons would choose midnight. Prof. Rücker gave an account of the inquiries made by the British Royal Society, Foreign Office and Admiralty, from which it appears that any international agreement is at present hopeless; so that the Nautical Almanac for 1901 will be compiled in the same manner as its predecessors.

Prof. Rücker exhibited photographic records of objective combination tones, both summational and difference tones having been obtained. In this research he was assisted by Messrs. Forsyth and Sowter. The method and apparatus used were the same as in the investigation of Prof. Rücker and Mr. Edser—namely, the observation of interference bands produced by the light reflected from a mirror carried by a resonant tuning-fork; the shift of the bands by the motion of the fork was, however, photographed on a moving sensitive surface, instead of being observed by eye.

An account of the work of the Committee on Seismological Observations was given by its indefatigable secretary, Prof. Milne. An examination of earthquake records seems to show that sub-oceanic earthquakes and landslips are more frequent than those on land, and that the Tuscarora deep is the origin of many of them. The most important portion of the report is, however, that relating to the rate of propagation of seismic waves from their origin to various points on the earth's surface. The records show that the velocity of propagation increases with the distance travelled, so that most probably the wave goes through the earth and not round its superficial crust, the speed of transmission being greater in the interior than in the crust. This, as Lord Kelvin pointed out, indicates that the moduli of elasticity of the material of the earth's interior are greater than those of the crust, possibly because of the higher pressure at great depths.

At the meeting of the section on Friday, Dr. N. E. Dorsey described some careful experiments to determine the surface tension of water by the method of ripples, the results of which agree with those of M. Sentis, obtained by an entirely different method. In the case of dilute aqueous solutions, the surface tension obtained by this method is a linear function of the concentration.

Prof. Callendar and Mr. Barnes gave an account of their new method of measuring the specific heat of liquid, by passing an electric current through a fine tube through which a current of the liquid flows. The experiment is continued until the temperature-difference between the ends of the tube becomes steady; this temperature-difference and the rate of flow of the liquid are then measured. Loss of heat by radiation is almost eliminated by surrounding the tube with a vacuous chamber, and small losses are allowed for. Another important communication on calorimetry was that of Profs. Ewing and Dunkerley on the specific heat of superheated steam. Their method consists in passing saturated steam through a porous plug, thus superheating it; the results show that for 10° superheating at atmospheric pressure the specific heat is about 0·44, while the ordinarily accepted value, 0·48, is only correct if the superheating exceeds 25°, as in Regnault's experiments.

A crowded audience assembled to hear Lord Kelvin's paper on the fuel-supply and air-supply of the world. He argued that, as the earth was in all probability originally hot and liquid, no primeval vegetable fuel existed; further, no free oxygen existed at that period, since it is not found in gases evolved from minerals or in the spectra of stars. Probably, therefore, the oxygen of the air has resulted from the action of sunlight on plants, and as this oxygen would be furnished by 340 million million tons of fuel, we have an upper limit to the amount of fuel in the world. On the other hand, the British Coal Supply Commission of 1831 estimated the amount of available fuel in England and Scotland to be 146,000 million tons, which is greater than the average for the whole earth. It follows, then, that the oxygen of the atmosphere resting over Britain is insufficient to burn up the fuel of the country, and the cessation of life may possibly occur by asphyxiation rather than want of fuel. In the discussion on this paper Prof. Fitzgerald stated that, according to his calculations, the sun's energy will support five persons to every square metre, so that there is no fear of life becoming extinct by failure of the sun's energy, as some people have supposed.

In spectroscopy, Prof. Runge stated that Prof. F. Paschen and himself had succeeded in separating the spectrum of oxygen into six series, two principals each having two subordinates, the lines of one principal series and its subordinates being triple. The importance of this paper lies in the fact that the oxygen spectrum is shown to be analogous to that of helium; and as oxygen does not, so far as we know, contain a mixture of elements, the idea that helium is a mixture has now been abandoned. Profs. Runge and Paschen find also that the spectra of sulphur and selenium each give a principal series of lines and two subordinate series, but in each case one line occurs which does not fit into any of the series, and which may be the fundamental line of another series. Using the large grating of the Johns Hopkins University, Mr. W. J. Humphreys has succeeded in causing the lines in the arc spectra of metals to shift appreciably by increasing the pressure of the atmosphere surrounding the arc; in all cases increased pressure causes the wave-length of the lines to increase, the lines move towards the red end of the spectrum. The shift is of the same order of magnitude as the Doppler effect, but could be distinguished from the Doppler effect in a celestial spectrum by the fact that lines belonging to principal and subordinate series are differently shifted by pressure, whereas they are all displaced equally in the spectrum of a receding body. Dr. J. Larmor has discussed the subject mathematically, and finds that the displacement is of the same order as would be produced by change of specific inductive capacity of the air by pressure. Prof. Schuster has photographed a metallic spark-spectrum on a film moving rapidly at right angles to the slit of the spectroscope; the result shows that the air-lines flash out for an exceedingly short time: the metallic particles, however, remain luminescent for a much longer period with gradually diminishing intensity. He was able to trace the motion of the metallic particles from the electrodes to the middle of the spark, and to measure their velocity, which ranged from 400 to 2000 metres per second.

Prof. S. P. Thompson distinguished four varieties of kathode rays, differing in their power of exciting fluorescence, exciting X-rays, and deflexion by a magnet. The first kind is the ordinary kathode ray; the second kind is produced when kathode rays have fallen on a surface and produced X-rays (they have then lost their power of exciting more X-rays). The third variety arises when kathode rays are passed through a negatively charged metallic spiral or gauze-sieve; they cannot be deflected

by a magnet. The fourth kind appears at the openings in a Holtz's funnel-tube; it produces no fluorescence, but can be deflected by a magnet.

A serious state of things was revealed by Prof. A. Johnson in his paper on a Canadian and Imperial Hydrographic Survey. He said that in some parts of the St. Lawrence basin places had been found where the depth of water, charted at five fathoms, was not more than three fathoms, and navigation was thereby rendered dangerous. A committee has been appointed to consider the question of approaching the Canadian Government with reference to a new hydrographic survey.

On Monday the section met in two departments, devoted to mathematics and meteorology respectively. In the mathematical department Dr. Harris Hancock gave a short account of the historical development of Abelian Functions, and the complete paper will be published as one of the reports of the Association. Prof. Henrici proposed a new notation to denote the different products of vectors, which consists in using square brackets for vector products and round brackets for scalar products. He likewise advocated the adoption of Heaviside's term "ort" for a vector, the tensor of which is the number 1. Prof. A. Macfarlane read a communication on the solution of the cubic equation, in which he explained how the two binomials in Cardan's formula may be treated as complex quantities, either circular or hyperbolic; all the roots of the cubic can then be deduced by a general method. Prof. Michelson described some new Harmonic Analyses made by himself and Mr. S. W. Stratton with an instrument which is capable of rendering 80 terms of a Fourier series and of checking the accuracy of its own work. The only limit to the number of terms obtainable is the expense of making the instrument.

In the department of meteorology, Dr. van Rijckevorsel pointed out that the curves of daily temperature for the different meteorological stations in Europe indicate a possible division of the continent into two regions with marked differences of climate. The eastern region includes Russia and adjacent countries, the rest of the continent being in the western region. Small irregularities, such as secondary maxima and minima, are reproduced in all the curves for places in the same region, and serve to show that the temperatures are determined by external causes operating over the whole area. Mr. F. N. Denison described observations on "seiche" movements on Lakes Ontario and Huron, obtained by means of a tidal gauge. Mr. A. L. Rotch reported progress made during the year in the exploration of the air by means of kites. Meteorographs have been raised to a height of 8740 feet above the Blue Hill Observatory, and important information has been obtained concerning humidity, changes of temperature and wind in free air. The value of these results in aiding the forecasting of the weather is so great that the United States Weather Bureau has taken up the subject. Prof. Marvin described his experiments with tailless kites, and afterwards exhibited one in flight in the University grounds.

In electricity, several forms of apparatus for mapping out the form of an alternate current wave were described and exhibited. In the instrument of Prof. Rosa a contact revolving on the dynamo shaft puts a point in the circuit into contact with a potentiometer at any phase of the revolution. By means of an electro-magnetic ratchet arrangement the contact can be advanced in phase by small equal amounts, and the same current similarly rotates a revolving cylinder on which the length of wire necessary for a balance on the potentiometer is automatically recorded. Mr. Duddell makes use of the force urging a straight conductor carrying a current and stretched in a magnetic field; two parallel phosphor-bronze strips are placed in a strong magnetic field and attached to a mirror, so that when the alternating current goes up one of these strips and down the other one, the mirror is deflected. Prof. Braun uses a kathode ray instead of a strip, and puts it in a magnetic field set up by the alternating current; the ray is thus deflected and follows every pulsation of the current. The source of luminosity in the electric arc has been investigated by Prof. Henry Crew and Mr. O. H. Basquin. They maintain an arc between an iron rod and a rotating iron disc by a rapidly intermittent electric current, and observe the arc in the intervals when no current is passing. It is found that the luminosity is of two kinds, a bright cloud yellow persisting some time and a much fainter and rapidly evanescent blue flame; the spectra of these two portions differ in the distribution of intensity of their lines.

The Electrical Standards Committee report that they have decided to undertake the experiments necessary for the specification of the standard of electric current, which will be conducted by Profs. Ayrton and J. V. Jones.

At Wednesday's sitting, Prof. Ramsay described experiments on the refractivity of mixtures of gases, from which it appears that an expansion takes place on mixing hydrogen and helium, and a contraction on mixing nitrogen and oxygen. Prof. Fitzgerald suggested that the viscosity of mixtures of gases should be more fully examined. Prof. Lodge described Zeeman's discovery of the effects of magnetism on spectral lines, and discussed the nature of the dark space between the two lines into which the originally single band is split. Profs. Lodge, Michelson and Runge were agreed that this space is a part of the Zeeman phenomenon, and is not produced merely by the absorption of light in the region round the flame. Several papers on galvanometry were communicated by Prof. Ayrton and Mr. Mather. In the discussion on papers by Prof. Callendar and Mr. Barnes, and Messrs. Spiers, Twyman and Waters, on Clark cells, it was stated by Prof. Webster, that Clark cells with cadmium electrodes in place of zinc are as trustworthy and easily set up as the older form. Such cells have a much smaller temperature coefficient than zinc-cells.

The meeting concluded with a paper by Mr. J. W. Edmondson, read by Prof. Webster, on spark-length and potential relations in air and dielectric liquids. For air a hyperbolic formula apparently fits the results in the case of spheres of 3 cm. diameter.

A vote of thanks to the President, moved by Prof. Ayrton and seconded by Prof. Lodge, brought the proceedings of the section to a close.

CHEMISTRY AT THE BRITISH ASSOCIATION.

THE meetings of the Chemistry Section were usually well attended throughout the whole of the somewhat protracted sittings at Toronto. A large number of the chemists of Canada and of the United States were present, and added much to the interest of the meeting, both within and without the section room. The section only participated, and that in an informal way, in one united discussion, which took place between Sections I and K on the chemistry and structure of the cell. This was opened by Prof. Meldola in a very striking and suggestive paper on the rationale of chemical synthesis.

In connection with the section an important new committee has been appointed, under the chairmanship of Sir John Evans, for the promotion of agriculture, its object being to report on the methods and results of the Government Agricultural Stations in Canada and other countries, with a view to the establishment of similar institutions in Great Britain. As an unusually large number of papers were read, only those of the most general interest can be here mentioned.

Prof. Ramsay followed up his address, which was none the less interesting because of its speculative character, by an account of the methods employed in the work on helium and in the determination of the remarkable properties by which that gas is characterised. He expressed the opinion that helium is occluded, and not definitely combined in the various minerals in which it occurs. A short communication was also read, in which it was pointed out by Mr. M. Travers that the hydrogen obtained by heating many igneous rocks *in vacuo* is in reality derived from water which is present, and is reduced by various substances, such as ferrous oxide, contained in the material of the rock.

The section devoted a considerable portion of one of its sittings to the consideration of atomic weights, and was fortunate in the attendance of Profs. B. Brauner, F. W. Clarke, E. W. Morley and T. W. Richards, in addition to the home contingent of chemists distinguished in this particular field. Prof. Brauner, resting from his labours on tellurium, has turned his attention to thorium, and has succeded in making a satisfactory determination of its atomic weight by the oxidation of the double ammonium oxalate. The number which he has obtained is 232·5 (O = 16), and is considerably lower than Cleve's number. Prof. Richards has attacked the problem of the atomic weights of nickel and cobalt, about which great uncertainty has hitherto prevailed, and has analysed the very carefully dried and purified bromides of these metals. The separate determinations agree admirably among themselves, and it seems probable that the