This he gives as the complete expression; wherein, therefore, $J\theta\epsilon$ is the chemical portion of the total E.M.F., and $J\theta\epsilon \frac{T}{T_0}$ the thermal portion of the whole E.M.F., equal to $J\Sigma\Pi$.

If this were a correct mode of regarding the matter, it would be of the highest interest to be able to calculate dissociation temperatures in this way. Unfortunately, several of the best judges in this country have expressed to the Committee their serious doubts as to the validity of thus stepping, unguided, outside the region of safe knowledge, across the great gap separating ordinary from dissociation temperatures. We wish Prof. Willard Gibbs were here to support and strengthen his position.

These are the main problems at present under discussion among the members of the Committee, and with this summary of them and reference to such of to-day's papers as seem likely to contribute towards their solution the report proper may be understood to close.

I think, however, I am only expressing the feeling of the Committee if I say that they view this joint sitting of Sections A and B with great interest, and with the anticipation and hope that it may be the precursor of many other such gatherings during the era of development in the borderland of chemistry and physics which in many directions they feel to be now imminent.

Section A—Mathematical and Physical Science.

New Electric Balances, by Sir William Thomson, F.R.S.—These balances are founded on the mutual forces, discovered by Ampère, between the fixed and movable portions of an electric circuit. The mutually-influencing portions are usually circular rings. Circular coils or rings are fixed, with their planes horizontal, to the ends of the beam of a balance, and are each acted on by two horizontal fixed rings placed one above and the other below the movable ring. Six grades of instrument are made, named centi-ampere, deci-ampere, ampere, deca-ampere, hecto-ampere, and kilo-ampere balance. The range of each balance is about 25. Thus, the centi-ampere balance will measure currents of from 2 to 50 centi-amperes, while the kilo-ampere balance will measure currents of from 100 to 2500 amperes. Since the indications of the instrument depend on the mutual forces between two parts of an electric circuit of permanent form and relative position, they are not subject to the changes with time which are so troublesome in instruments the constants of which depend on the strength of permanent magnets.

The most important novelty in these balances is the connexion between the movable and the fixed parts of the circuit. The beam of the balance is suspended by two flat ligaments made up of fine copper wires placed side by side. These ligaments serve instead of knife-edges for the balance, and at the same time allow the current to pass into and out from the movable coils. The number of wires in each ligament varies from 20 in the centi-ampere to 900 in the kilo-ampere balance. The diameter of the wire is about $\frac{1}{10}$ of a millimetre, and each centimetre breadth of the ligament contains about 100 wires.

The electric forces produced by the current are balanced by means of weights which can be moved along a graduated scale by means of a self-relieving pendant. Two scales are provided—one a scale of equal divisions, the other a scale the numbers on which are double the square roots of the numbers on the scale of equal divisions. The square-root scale allows the current to be read off directly to a sufficient degree of accuracy for most purposes. When high accuracy is required, the fine scale of equal divisions may be used, and the exact value of the current obtained from a table of doubled square roots supplied with the instrument.

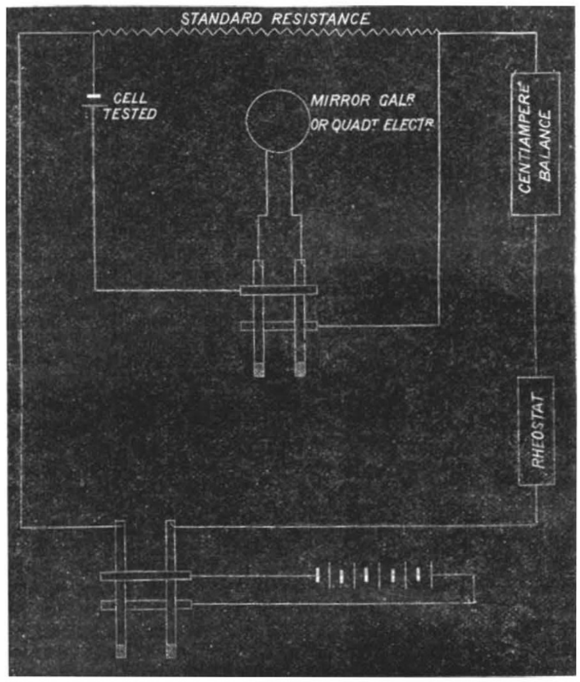
An engine-room voltmeter on a similar plan was described. It consists of a coil fixed to the end of a balance arm (suspended as above described) and acted on by one fixed coil placed below it. The distance apart of the two coils is indicated by means of a magnifying lever, and serves to indicate the difference of potential between the leads to which the instrument is connected. The coils of the instrument are of copper wire, and an external platinoid resistance of considerably greater amount is joined in circuit with it. The electrical forces are balanced by means of a weight placed in a trough fixed to the front of the movable coil and weights suited to the temperatures 15°, 20°, 25°, 30° C., as indicated by a thermometer with its bulb in the centre of the coil, are provided.

Two other instruments were described—namely, a marine voltmeter suitable for measuring the potential of an electric circuit on board ship at sea, and a magneto-static current-meter suitable for a lamp-counter.

In the marine voltmeter an oblate spheroid of soft iron is suspended in the centre of, and with its equatorial plane inclined at about 40° to, the axis of a small coil of fine wire, by means of a stretched platinoid wire. When a current is passed through the coil, the oblate of soft iron tends to set its equatorial plane parallel to the axis of the coil, and this tendency is resisted by the rigidity of the suspension wire.

The lamp-counter is a tangent galvanometer with special provision for preventing damage to its silk fibre suspension, and for allowing the constant to be readily varied by the user to suit the lamps on his circuit.

On the Application of the Centi-ampere or the Deci-ampere Balance for the Measurement of the E.M.F. of a Single Cell, by Sir William Thomson, F.R.S.—For the purpose of measuring the E.M.F. of a single cell, the centi-ampere or the deci-ampere balance is put in circuit with a battery of a sufficient number of cells, a rheostat, and a standard resistance in the manner shown in the diagram. The current measured by the balance is then



varied by means of the rheostat until the difference of potential between the ends of the standard resistance is exactly equal to the potential of the cell. The equality is tested by placing the cell in series with a mirror galvanometer or a quadrant electrometer in a derived circuit, the ends of which are connected with the ends of the standard resistance, and observing whether any deflection is obtained by closing this circuit. Suppose, for example, the standard resistance to be 10 ohms, and the current, as indicated by the balance, 0·108 amperes, when no deflection is obtained on the mirror galvanometer by closing its circuit, the potential of the cell is 10 × 0·108, or 1·08 volts. Proper precautions must, of course, be taken to eliminate thermo-electric or other disturbances in the circuit. The quadrant electrometer may be used with advantage in the derived circuit when it is important that no current should flow through the cell, but the mirror galvanometer has the advantage of much greater sensibility.

Conduction of Electricity through Gases, by Prof. A. Schuster, F.R.S.—A short time ago he communicated to the Royal Society the results of certain experiments which showed that, although a current can usually be sent through a gas only by employing a high electromotive force, yet a steady current can be obtained in air from electrodes which are at a difference of potential of only a fraction of a volt, provided that an independent current is maintained in the same closed vessel. He was now prepared to show the experiments in his laboratory.

On the Nature of the Photographic Star-Disks and the Removal of a Difficulty in Measurements for Parallax, by Prof. Pritchard, F.R.S.—If the telescope could be made to follow the star with perfect accuracy during the whole time of exposure of the photographic plate, the photographic image should be circular.

It is necessary, in order that photography may be of use, say in measuring parallax, that this condition should be approximately fulfilled. For it is from the centre of the star-image that the measurement must be made.

Now the image of a star exposed to a photographic plate driven by a clock having a small rate, and subject to small periodic oscillations, as is generally the case with the majority of driving-clocks, is not a simple linear trace, but a series of black dots joined together by intervals less dense. By hand-driving, those black dots, &c., coalesce or are superimposed. If for the purpose of measurement for parallax or otherwise a bright star be covered over by a stop during the greater part of the duration of the exposure of the plate, and the stop be then removed for a brief interval, it is shown by experimental measurement that the bright star is accurately represented on the plate.

Instruments for Stellar Photography, by Sir Howard Grubb, F.R.S.—He said that in considering the best form of object-glass for photographic purposes, one important point was to have as large a field as possible. An arrangement suggested by Prof. Stokes by which the first and second surfaces of refraction could be readily interchanged afforded the means of providing amateurs with an instrument which could be used at will either for ordinary or for photographic work. But by far the most important point in stellar photography was the clockwork. It was true that, no matter how perfect our clockwork might be, we could never dispense with the guidance of the hand. But if the clockwork be as good as it can be made, one is not tied down to the telescope as one is with bad clock-work. He thought it Utopian to expect that it might be possible to construct a clock accurate to 1/75 of a second, which some supposed to be necessary. He was at present able to correct any error greater than $\frac{1}{10}$ or at any rate than $\frac{1}{8}$ of a second, and he expected to be able to reduce the error to 1/20 of a second, but not farther. He did not believe that greater accuracy than this would be of any use.

In the course of a discussion which followed, Dr. Pritchard said he had actually traced the origin of the dots in the trail of his star-photographs to the periodicity of the screw.

On the Turbulent Motion of Water between Two Planes, by Prof. Sir W. Thomson, F.R.S.—He said that one of the most important questions in practical hydraulics was the flow or slipping of a liquid on a solid. He supposed for simplicity that there was nothing of finite slip of the fluid on the solid; but this was not essential to the reasoning. He considered the case of water flowing between two parallel planes; as an example of which a river with a plane bottom and covered with a sheet of ice might be taken. If the motion be laminar, *i.e.* free from turbulence, then the line of flow is represented by a parabola, supposing that there is no finite slip. The fluid moving in this way under the influence of gravity and possessing viscosity is in a state of stable equilibrium. If we suppose gravity and viscosity both suddenly reduced to zero, the motion becomes one of unstable equilibrium. The smallest amount of viscosity gives stability to the laminar motion, but the limits of stability are narrowed by either diminishing the viscosity, or increasing the effective component of gravity Osborne Reynolds made experiments some years ago on the flow of water through tubes. With great pressure there is always eddying, because the limits between which stable equilibrium is possible are narrow, and narrower the greater the pressure. He found that the laminar flow continued in a central film of the water for a certain distance, and then broke up suddenly into turbulence. Froude had made experiments on the resistance which a very smooth thin board met with in being moved at a uniform rate through water. His results show that, if one of two infinite planes (both at rest to begin with, and bounding a piece of water) be suddenly set in uniform motion, the water will at first move turbulently, and the turbulence will gradually pass into shearing motion. In conclusion Sir W. Thomson expressed the hope that candidates for the Adams prize would take up this subject.

Lord Rayleigh mentioned experiments which he had made on jets of coloured liquids and of smoky air. In the case of a jet projected into air the motion is unstable from the first, but the instability only shows itself at a certain distance. This distance diminishes with the velocity. He thought it possible that in Reynolds's experiments the instability was in like manner present from the first in the central film, and that the film remained distinct for a certain distance only in virtue of the purchase it had obtained.

On the Theory of Electrical Endosmose and Allied Phenomena, and on the Existence of a Sliding Coefficient for a Fluid in Contact with a Solid, by Prof. Lamb, F.R.S.—This paper deals with the laws governing the electric transport of conducting liquids through the walls of porous vessels or along capillary tubes, and other related phenomena, which have been investigated experimentally by Wiedemann and Quincke, and explained by the latter writer on the assumption of a contact difference of potential between the fluid and its solid boundaries. This explanation has been developed mathematically by Von Helmholtz. Applying the known laws of viscous fluids, he finds that the calculated results, so far as they depend on quantities which admit of measurement, are in satisfactory agreement with the experiments, and that the values which it is necessary to assign to the contact difference above spoken of are in all cases comparable with the E.M.F. of a Daniell's cell. Incidentally he arrives at the conclusion that in the cases considered there is no slipping of the fluid over the surface of the solid with which it is in contact. In the present paper a slightly different view is taken, and it is assumed that a certain finite (though possibly very minute) amount of slipping takes place, and that it forms an essential feature in the phenomena. The various cases considered by Von Helmholtz are treated on this assumption, and in some respects extended. In all cases the results differ from those obtained by Von Helmholtz by a factor $\frac{l}{d}$, where l is a linear magnitude measuring the "slip," viz. $\beta = \mu/l$, and d denotes the distance between the plates of an air-condenser whose capacity per unit area is the same as that of the apposed surfaces of solid and fluid. For example, by comparison with Wiedemann's experiments, Von Helmholtz infers that, for a certain solution of $CuSO_4$ in the pores of a clay vessel, E/D = 1·77, where D is the E.M.F. of a Daniell's cell. On the modified hypothesis adopted in the present paper, the inference would be that $\frac{E}{D} \cdot \frac{l}{d} = 1{\cdot}77$.

As this involves two unknown ratios, no such definite conclusion can be drawn, but it is evident that the phenomena are consistent even with very small values of E/D, provided l be a sufficient multiple of d. Since d is a quantity of molecular order of magnitude (comparable probably with 10^{-8} centimetres) the value of l may still be so minute as to render the effects of slipping quite insensible in such experiments as those of Poiseille. They come to be of importance in the cases at present under consideration only in consequence of the relatively great forces, due to the fall of potential along the course of the current, which act on the outer electrified layer of fluid and drag it over the surface of the solid.

On the Ratio of the Two Elasticities of Air, by Prof. S. P. Thompson, D.Sc.—Prof. Thompson said his paper would be chiefly interesting to those who had to teach thermo-dynamics to beginners. It was important to have some simple form of experiment for determining the ratio of the two elasticities of air, such as might readily be shown to a student. He described a simple form of apparatus which he considered more suitable than the usual one.

A Null Method in Electro-Calorimetry, by Prof. Stroud, D.Sc., and Mr. W. W. Haldane Gee, B.Sc.—The method is a modification of Joule's method for determining the specific heats of liquids and solids, possessing, however, the unique advantages of eliminating the correction for radiation as well as that for the thermal capacity of calorimeter and stirrer. The liquids for comparison in the two calorimeters are heated by wires carrying electric currents in such a way that the rises in temperature are the same in each case as tested thermo-electrically. The adjustment is effected by shunting the current through one of the calorimeters.

Prof. H. A. Rowland gave a description of a map of the solar spectrum. He said that for several years he has worked with concave gratings. He first tried a grating of 12 feet focal length, and the results were not as good as he thought they should be, so he then constructed a grating of 21 feet focal length, and the results he would be able to submit to the Section in his photographs. Having made the negatives, the next thing was to place the scale upon them. He first tried Ångström's numbers, but they would not match. He had therefore to determine the relative wave-lengths, and this he did by using overlapping spectra and micrometer measurements. As the spectrum was normal, all that was necessary was to get the scale to agree at two points of the photograph, and then it would agree at all. He had found it necessary to adopt a new scale. He was now engaged in making measurements in the red end of the spectrum in order to complete his work. This he is doing by the eye, and not by photography, as in this part of the spectrum photographs do not show so much as the eye. In laying the maps before the Section Prof. Rowland said that it would be seen how crowded the lines were in the ultra-violet region. He believed that on this account it would be almost impossible to determine the metals to which they belonged.

Capt. Abney thought it a serious thing to change the standard of wave-length, and suggested that a Committee of the Association should be appointed to confer with an American Committee on the subject.

Prof. Rowland said that Ångström's numbers do not agree among themselves, and therefore he could not fit a scale to his map in any way until he had made a new determination.

Prof. Young, of America, agreed with Prof. Rowland in thinking that Ångström's numbers were not consistent.

Mr. R. T. Glazebrook, F.R.S., exhibited negatives of photographs of the solar spectroscope taken by Mr. G. Higgs. The spectroscope was one constructed by Mr. Higgs himself. Twenty-one lines can be counted on the negatives between H_1 and H_2. There is a length of about 4 inches between G and H, and from 900 to 1000 lines can be counted between them.

Recent Determinations of Absolute Wave-length, by Mr. L. Bell, of Baltimore.—Some two or three years before Ångström's death he became aware that there was an error in the standard metre used in his researches. Nothing in the way of correction was done, however, until some three years ago, when Thalèn obtained a more accurate value for the metre and applied the appropriate correction to Ångström's wave-lengths. This amounted to 1 part in 8500.

Some few years ago a very careful determination was made by Mr. C. S. Pierce, and it was with the view of confirming or correcting his result that the writer began work. Pierce had found an absolute value corresponding to the wave-length 5896·26 for the less refrangible of the D lines, as the mean result from four gratings. The writer using two of Prof. Rowland's glass gratings, obtained for the same quantity respectively 5893·95 and 5896·11. The outstanding error must be ascribed to faults in the gratings. Nearly all gratings are afflicted with variations in the distance between the lines in various portions of the ruling. If the irregularity is extensive, the grating is likely to show false lines and give bad definition.

If, however, the abnormal spacing—however great—is confined to a few hundred lines, this portion, having little defining power, takes no part in the formation of the spectra actually seen, but simply scatters light, and of course introduces an error in the average of grating-space obtained by measuring the whole ruled surface.

The gratings used by the writer were therefore calibrated, and corrections calculated and applied to the above wave-lengths, reducing them to 5896·04 and 5896·09. The mean value taken was 5896·08.

On subjecting Pierce's gratings to a like examination, values nearly coincident with the above were obtained. During the present summer an admirable thesis by Dr. Kurlbaum has appeared giving results quite close to the writer's—about 5895·93 for the mean of two gratings, uncorrected, however, for errors of ruling.

We can, from the close agreement of the results obtained by Kurlbaum, Pierce (corrected), and the writer, feel sure that the wave-length of D is very near to 5896·00, and consequently all wave-lengths based on Angstrom's value are incorrect by at least one part in 8000. But this would not be a very serious matter if Ångström's relative wave-lengths were exact, which they are not.

On the Existence of Reflection when the Relative Refractive Index is Unity, by Lord Rayleigh, Sec. R.S.—He wished to find whether there was any reflection from a plate of glass immersed in a liquid of the same refractive index as the glass. The liquid used was a mixture of carbon bisulphide and benzole, and it was contained in a hollow prism. The glass plate was roughened behind to get rid of the second surface of reflection, and was mounted in the prism.

It was found that when the index was the same there was nothing like abolition of the reflection. The flame of a candle could be seen distinctly reflected in the glass. The phenomenon may be better followed by mounting the glass in such a way that it is possible to pass from a grazing to a perpendicular incidence. The ray for which the refractive index is made the same being chosen about the middle of the spectrum, as you alter the obliquity of the light, total reflection occurs for either end of the spectrum, and a dark band occupies the middle region. No doubt this band appears dark by contrast. In this way one could be certain that the index had really been equalized.

He next tried freshly-polished glass, and the reflection from it was not more than one-fourth of that from old glass, although the latter had been carefully cleaned. Still even from the polished glass the reflection was very copious. It did not need any care of adjustment in order to get the reflection of the candle-flame. The light so reflected was not coloured. There was a moderate reflection of all kinds. He confirmed this by using sunlight.

Where dispersion exists there is no reason to suppose that reflection should cease merely because the refractive index is equalized. If recently-fractured glass should give the same result, one might safely conclude that there was no residual film in play, and there would then be no doubt of the inaccuracy of Fresnel's law.

On the Action of an Electric Current in hastening the Formation of Lagging Compounds, by Dr. Gladstone, F.R.S.—The influence of the current was tried on various solutions from which, under normal conditions, precipitation takes place only slowly. A mixture of tartaric acid and potassium nitrate, a mixture of potassium oxalate and magnesium sulphate, a mixture of calcium sulphate and strontium nitrate, and some other mixtures were used. It was demonstrated that the current does hasten the action.

NOTES.

THE International Hygienic Congress at Vienna (attended by no fewer than 2250 members) was opened on Monday by the Austrian Crown Prince, who in a brief address referred to the vast importance of hygiene. After the Crown Prince's speech, which was much applauded, Prof. Grüber, the Hon. Secretary, read a report on the organization of the Congress. Two addresses were delivered by M. Brouardel and Herr Pettenkofer, the former of whom spoke on *typhus abdominalis*, the latter on hygienic instruction in Universities and technical schools. M. Brouardel said that the disease of which he spoke is far more dangerous to man than cholera, and that it is still an open question whether it owes its origin to the decomposition of organic matter or whether there is a specific virus. He maintained that in 80 cases out of 100 typhoid fever is caused by polluted water, and that the question of water supply must always take a foremost rank in hygienic administration. Herr Pettenkofer lectured on hygienic instruction in Universities and technical schools, and dwelt on the necessity of spreading hygienic principles among all classes of society. He largely quoted English authorities, and, in alluding to the English proverb "Cleanliness is next to godliness," remarked that the statistics of the mortality of London show how hygienic piety has been rewarded by the heavens. In the course of his address he dealt with the question of quarantine arrangements. He denied that the English are responsible for cholera coming to Europe through the Suez Canal. "This opinion," he said, "is clearly refuted by the fact that we were frequently visited by the disease before the Suez Canal was opened, and that since that time the epidemic has appeared in many European countries, while Great Britain, which now stands accused, and has suffered much through cholera in former times,