always subsists in such numerous meetings of lively and eager youths, of submitting to certain restrictions calculated to preserve the tranquillity of their comrades and that of the citizens. It is to this necessity that, in cases of conflict, the disciplinary jurisdiction of the University authorities responds. However, this end is still more surely attained by the sentiment of the honour of the body, and it is gratifying to have to acknowledge that this consciousness of their moral solidarity, and of the obligations of honour in the case of every one resulting therefrom, remains alive among German students. I do not mean by this to approve of all the special prescriptions of the code of honour of students. There are among the number certain remains of the middle ages of which it would be good to get rid, but this is a thing which can only be done by the students themselves.

(*To be continued.*)

STRIDULATING CRUSTACEANS

AT the November meeting of the Entomological Society of London, the president, Prof. Westwood, directed the attention of the Society to a letter in NATURE (vol. xvii. p. 11) from Mr. Saville Kent, on the above subject, *à propos* of Mr. Wood-Mason's recent discovery of the existence of stridulating apparatus in scorpions.

Mr. Wood-Mason remarked that structures in Crustacea, some of which certainly, and all of which probably, are for the production of sounds, were first brought to notice by Hilgendorf—in V. der Decken's "Reisen in Ost-Africa (Crustacea)"—but had been independently observed by himself in a number of species during his dredging excursion to the Andaman Islands in 1872. They were paired organs, as in scorpions, the *Mygale*, and the *Phasma* to be brought to notice that night—that is to say, organs working perfectly independently of each other were on each side of the body. In some forms (I.) they were seated partly on the body (carapace) and partly on a pair of appendages; of these some (*a*) had the *scraper* on the body and the *rasp* on the appendages—*e.g. Matuta*, in which the organs are developed in both sexes; and others (*b*) had the *rasp* on the body and the *scraper* on the appendages—*e.g. Macrophthalmus et affinia*, in which the scraper was formed by a sharp-edged lamellar projection on the meropodite of each of the chelipeds, and the rasp was the crenulated infraorbital margin; in these the apparatus could only be developed in the males, the females having short and small and quite inconspicuous chelipeds, which hardly reached so far as to the margins of the orbits. In others (II.) they were seated wholly on the appendages; in the males of the species of *Ocypode* the *rasp* was on one and the *scraper* on another part of the same appendage; in those of *Platyonychus bipustulosus* the *rasps* were on one and the *scrapers* on another pair of appendages; the walking-legs of the second pair were here very long and robust, and their third joint (meropodite) had its upper margin produced upwards at apex into a sharp crest (the *scraper*); both Dana and Milne-Edwards had noticed the remarkable length and structure of this pair of legs, but the former alone had mentioned, in his description of the species, the regular transverse plication of the under surface of the propodite of the chelipeds, which constituted without doubt the *rasp*. The above did not pretend to be a complete account of stridulating apparatus in Crustacea; but separated as he at present was from notes, drawings, and specimens, he could not go into greater detail. The cases of *Macrophthalmus* and of *Platyonychus* had not, he believed, been previously recorded. In the forms alluded to by Mr. Kent, no special sound-producing apparatus seemed to be developed. Everybody who had searched for animals on coral-reefs or had dredged in tropical seas was familiar with the "clicking" sounds emitted by the *Alphei* and their allies. The sounds which here always accompanied so sudden an opening of their claws to their fullest extent that dislocation seemed imminent each time, might be caused either by the impact of the dactylopodite upon the joint to which it is articulated, or by the forcible withdrawal of the huge stopper-like tooth of the dactylopodite from its pit in the immovable arm of the claw; in which latter case the noises might be susceptible, *mutatis mutandis*, of the same physical explanation as that produced by the withdrawal of a tightly-packed piston from a cylinder closed at one end. These were the explanations that occurred to him while watching a small species that lived in force amidst the branches of the zoophytes called *Spongodes*, the masses of which crackled all over when brought to the surface. The sounds in this case resembled very closely those made when sparks were taken by the knuckles from the prime-conductor of a small electrical machine. The sounds emitted by the Sphæromid might possibly be produced by the impact of the terga of the posterior somites upon one another at the end of each movement of extension.

Mr. Wood-Mason then announced the discovery of stridulating organs in *Phasmidæ*, in a species of *Pterinoxylus*, and in illustration of his remarks exhibited an impression of Westwood's plate of Serville's species, *P. difformipes*. Here, as in Crustacea and some other Arthropods, an apparatus working perfectly independently of its fellow was developed on each side of the body. The rough prominent basal portion of the costal nervure of the wings formed the rasp, in connection with which was developed a large oval "speculum," "talc-like spot," or "mirror." The rasps were scraped by the sharp and hard front edges of the tegmina, the dome-like form of which seemed admirably adapted, and probably did, to some extent, serve to increase the sound by resonance. In Serville's species, according to Westwood's figure, the stridulating apparatus appeared to be more highly developed, the "mirror" being more distinct, and the tegminal cavities more spacious. The males of the *Pterinoxyli* were unknown. We had here another case in which functional stridulating organs are present in females. The only other insects known to him in which stridulating organs were seated partly on the wings and partly on the tegmina were the orthopterous *Œdipoda*, which, according to Scudder (*Amer. Nat.* ii. 113), stridulate during flight, in connection with which fact it was interesting to observe that the female *Pterinoxyli*, though incapable of flight, needed to expand their organs of flight in order to bring their similarly situated apparatus into play.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

OXFORD.—At Queen's College, James Henry Hickens, Epsom College, has been elected to a Natural Science Scholarship.

CAMBRIDGE.—The Rede Lecture will be delivered by Prof. Clerk-Maxwell, in the Senate House, on Friday, May 24, at half-past 2 o'clock, on the Telephone.

OWENS COLLEGE.—Should this institution ever be transformed into the University of Manchester, it will only be after overcoming a good deal of strong opposition. The Liverpool Town Council are to petition in favour of a new corporation with power to incorporate Owens College and other institutions, and that the new University do not bear any merely local or personal appellation. Naturally, also, the Yorkshire College does not look kindly on the proposal, although until Owens College resolved to take this step the two institutions were on very friendly terms. We trust some arrangement will be come to ultimately that will satisfy all concerned.

WORKING MEN'S COLLEGE.—The Science Classes at the Working Men's College, which, during the last three years have, under Mr. Dunman's teaching, have become so popular and useful a feature of that institution, assembled on Saturday last at the Broad Street Restaurant to celebrate the termination of a very successful course by a dinner. Mr. Thomas Hughes had promised to be present, but in his compulsory absence Mr. Dunman himself occupied the chair. A pleasing feature of the evening was the presentation to Mr. Dunman, by the students in these classes, of a handsome despatch box as a token of their appreciation of the thoroughly efficient manner in which he has discharged the duties of science teacher.

STRASSBURG.—The Extraordinary Professorship of Petrography, lately occupied by Prof. Rosenbusch, is to be filled by Dr. Cohen, of Heidelberg.

SCIENTIFIC SERIALS

THE *Journal of the Russian Chemical and Physical Societies* of St. Petersburg (vol. x. No. 3) contains the following papers:—On the mono- and dioxymalonic acids (Part 2), by R. Petrieff.—Researches on the transformation of diethylcarbinol into methylpropylcarbinol, and on the synthesis and the properties of diethylacetic and methylpropylacetic acids, by A. Saytzeff.—On the synthesis of diphenylenephenylmethane and of diphenylenetolylmethane, by V. Hemilian.—On the falsification of butter, by P. Koulechoff.—On the elementary law governing the reciprocal actions between currents and magnets, by A. Socoloff.

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Verhandlungen der k.k. Zoologische botanischen Gesellschaft in Wien. (1867, vol. ii.) This volume, like its predecessors, contains valuable additions to zoological and botanical literature. By far the most important papers contained in it are Dr. L. Koch's notes on Japanese *Arachnida* and *Myriapoda*, and Herr H. B. Möschler's remarks on the *Lepidoptera* fauna of Surinam, continued from a former volume. Of other interesting papers we note:—Lichenological excursions in the Tyrol, by F. Arnold.—On the spiders of Uruguay and other parts of America, by E. Keyserling.—Introduction to the monography of *Phanero-pterida*, by Brunner von Wattenwyl.—Hymenopterological notes, by F. F. Kohl.—On the flora of the Ionian Islands of Corfu, Cephalonia and Ithaca, by G. C. Spreitzenhofer.—On a species of *Aphis, Pemphigus Zeae Maïdis*, L. Duf, which attacks Indian corn, by Dr. Franz Löw.—Notes on the *Aeolidiadae*, by Dr. Rudolph Bergh.—On the Brazilian ants collected by Prof. Trail, by Dr. Gustav Mayr.—There are also in this volume some smaller communications from the botanical laboratory of Dr. H. W. Reichardt.

SOCIETIES AND ACADEMIES

London

Royal Society, April 11.—"On Stresses in Rarefied Gases arising from Inequalities of Temperature," by J. Clerk-Maxwell, F.R.S., Professor of Experimental Physics in the University of Cambridge.

1. In this paper I have followed the method given in my paper "On the Dynamical Theory of Gases" (*Phil. Trans.* 1867, p. 49). I have shown that when inequalities of temperature exist in a gas, the pressure at a given point is not the same in all directions, and that the difference between the maximum and the minimum pressure at a point may be of considerable magnitude when the density of the gas is small enough, and when the inequalities of temperature are produced by small solid bodies at a higher or lower temperature than the vessel containing the gas.

2. The nature of this stress may be thus defined; let the distance from the given point, measured in a given direction, be denoted by h, and the absolute temperature by θ; then the space-variation of the temperature for a point moving along this line will be denoted by $\frac{d\theta}{dh}$, and the space-variation of this quantity along the same line by $\frac{d^2\theta}{dh^2}$. There is in general a particular direction of the line h, for which $\frac{d^2\theta}{dh^2}$ is a maximum, another for which it is a minimum, and a third for which it is a maximum-minimum. These three directions are at right angles to each other, and are the axes of principal stress at the given point; and the part of the stress arising from inequalities of temperature is in each of these principal axes a pressure equal to—

$$3\frac{\mu^2}{\rho\theta}\;\frac{d^2\theta}{dh^2},$$

where μ is the coefficient of viscosity, ρ the density, and θ the absolute temperature.

3. Now, for dry air at 15° C., $\mu = 1{\cdot}9 \times 10^{-4}$ in centimetre-gramme-second measure, and $\frac{3\mu^2}{\rho\theta} = \frac{1}{p}\,0{\cdot}315$, where p is the pressure, the unit of pressure being one dyne per square centimetre, or nearly one-millionth part of an atmosphere.

If a sphere of one centimetre in diameter is T degrees centigrade hotter than the air at a distance from it, then, when the flow of heat has become steady, the temperature at a distance of r centimetres will be

$$\theta = T_0 + \frac{T}{2r}, \text{ and } \frac{d^2\theta}{dr^2} = \frac{T}{r^3}.$$

Hence, at a distance of one centimetre from the centre of the sphere, the pressure in the direction of the radius arising from inequality of temperature will be—

$$\frac{T}{p}\,0{\cdot}315 \text{ dynes per square centimetre.}$$

4. In Mr. Crookes's experiments the pressure, p, was often so small that this stress would be capable, if it existed alone, of producing rapid motion in small masses.

Indeed, if we were to consider only the normal part of the stress exerted on solid bodies immersed in the gas, most of the phenomena observed by Mr. Crookes could be readily explained.

5. Let us take the case of two small bodies symmetrical with respect to the axis joining their centres of figure. If both bodies are warmer than the air at a distance from them, then in any section perpendicular to the axis joining their centres, the point where it cuts this line will have the highest temperature, and there will be a flow of heat outwards from this axis in all directions.

Hence $\frac{d^2\theta}{dh^2}$ will be positive for the axis, and it will be a line of maximum pressure, so that the bodies will repel each other.

If both bodies are colder than the air at a distance, everything will be reversed; the axis will be a line of minimum pressure, and the bodies will attract each other.

If one body is hotter, and the other colder, than the air at a distance, the effect will be smaller; and it will depend on the relative sizes of the bodies, and on their exact temperatures, whether the action is attractive or repulsive.

6. If the bodies are two parallel discs, very near to each other, the central parts will produce very little effect, because between the discs the temperature varies uniformly and $\frac{d^2\theta}{dh^2} = 0$. Only near the edges will there be any stress arising from inequality of temperature in the gas.

7. If the bodies are encircled by a ring having its axis in the line joining the bodies, then the repulsion between the two bodies, when they are warmer than the air in general, may be converted into attraction by heating the ring, so as to produce a flow of heat inwards towards the axis.

8. If a body in the form of a cup or bowl is warmer than the air, the distribution of temperature in the surrounding gas is similar to the distribution of electric potential near a body of the same form, which has been investigated by Sir W. Thomson.[1] Near the convex surface the value of $\frac{d^2\theta}{dh^2}$ is nearly the same as if the body had been a complete sphere, namely, $2T\frac{1}{a^2}$, where T is the excess of temperature, and a is the radius of the sphere. Near the concave surface the variation of temperature is exceedingly small. Hence the normal pressure on the convex surface will be greater than on the concave surface, as Mr. Crookes has shown by the motion of his radiometers.

Since the expressions for the stress are linear as regards the temperature, everything will be reversed when the cup is colder than the surrounding air.

9. In a spherical vessel, if the two polar regions are made hotter than the equatorial zone, the pressure in the direction of the axis will be greater than that parallel to the equatorial plane, and the reverse will be the case if the polar regions are made colder than the equatorial zone.

10. All such explanations of the observed phenomena must be subjected to careful criticism. They have been obtained by considering the normal stresses alone, to the exclusion of the tangential stresses; and it is much easier to give an elementary exposition of the former than of the latter.

If, however, we go on to calculate the forces acting on any portion of the gas in virtue of the stresses on its surface, we find that when the flow of heat is steady, these forces are in equilibrium. Mr. Crookes tells us that there is no molar current, or wind, in his radiometer vessels. It may not be easy to prove this by experiment, but it is satisfactory to find that the system of stresses here described as arising from inequalities of temperature will not, when the flow of heat is steady, generate currents.

11. Consider, then, the case in which there are no currents of gas, but a steady flow of heat, the condition of which is

$$\frac{d^2\theta}{dx^2} + \frac{d^2\theta}{dy^2} + \frac{d^2\theta}{dz^2}\;(= -\Delta^2\theta) = 0.$$

(In the absence of external forces, such as gravity, and if the gas in contact with solid bodies does not slide over them, this is always a solution of the equations, and it is the only permanent solution.) In this case the equations of motion show that every particle of the gas is in equilibrium under the stresses acting on it.

Hence any finite portion of the gas is also in equilibrium; also, since the stresses are linear functions of the temperature, if we superpose one system of temperatures on another, we also superpose the corresponding systems of forces. Now the sys-

[1] Reprint of Papers on Electrostatics, p. 178.

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