It will be found that the determinant is equal to

$$-(2 + c^2(k + K))^8.$$

Also

$$U - u + c\omega = -(U' - u' + c\omega'),$$

whence the condition of permanence becomes

$$\phi(u \dots \omega_3)\phi(U \dots \Omega_3) = \phi(u' \dots \omega'_3) - \phi(U' \dots \Omega'_3);$$

a condition which is satisfied when

$$\phi = m(u^2 + v^2 + w^2) + A\omega_1^2 + B\omega_2^2 + C\omega_3^2.$$

A simpler case of verification, involving exactly the same principles, is obtained by replacing the spheres by circular disks confined to one plane. Here there will be only 6 co-ordinate velocities, $u, v, \omega, U, V, \Omega$, and the notation may be preserved as before, only

$$\omega = P\Omega + \rho\omega, \quad K = \frac{P^2}{A}, \quad k = \frac{\rho^2}{A};$$

and neglecting v and V , the velocities resolved in the tangent, as before, we have, now, the factor multiplying the determinant reduced to $\frac{1}{(2 + c^2(K + k))^4}$, and the determinant to 4 rows and columns instead of 8, which will readily reduce to

$$-(2 + c^2(K + k))^4.$$

There is, therefore, really nothing *vague* in Boltzmann's treatment: all that it does is to show on general dynamical principles that the functional determinant must be unity in all cases, and therefore avoid the labour of evaluation.

What has been thus done for the collisions of heterogeneous spheres and circles may be equally well done by the application of the Boltzmann method to colliding systems of any number of degrees of freedom; it will be found that there is no vagueness in the process, although, of course, the analytical difficulty may be greatly increased with the circumstances of different cases. And what I understand to be the meaning of the Boltzmann-Maxwell law of partition of energy will, I believe, be found to be true in each case. I understand that law to assert that when the kinetic energy of each system has been expressed, as it always can be, as the sum of n squares, as $P_1^2, P_2^2, \dots, P_n^2$, each of the P 's being a linear function of the n generalized velocity components, the average value of each of these squares is the same in the special or equilibrium state. For example, where the system is a single rigid body with 6 degrees of freedom and twice the kinetic energy is

$$M(u^2 + v^2 + w^2) + A\omega_1^2 + B\omega_2^2 + C\omega_3^2,$$

the average kinetic energy in the special or equilibrium state contributed by each translation is $\frac{1}{2}$ of the whole, and the average kinetic energy contributed by each rotation component is the same. It does not appear to me that the law asserts more than this, or that any application that has been sought to be made of it requires anything more than this.

These conclusions are confirmed by Mr. Burbury in the paper to the Royal Society already mentioned, and by an entirely independent treatment.

I have purposely limited myself to the consideration of colliding elastic systems treated by the conventional laws of impact, because one such case had been specially singled out in the British Association Report, and I believe that in all such cases the Boltzmann-Maxwell law of partition will be found to hold good. The most general cases contemplated by Boltzmann and Maxwell, involving the considerations of forces between parts of the molecules themselves, with continued interchange of Kinetic and Potential Energies, as well as intermolecular and external forces, demand further space than could reasonably be asked of you.

H. W. WATSON.

Berkeswell Rectory, Coventry, March 21.

The Functions of Universities.

As it is most desirable that students of all classes should, as far as possible, be in contact with one another during the impressionable years of training, it is eminently desirable that schools of engineering should be connected with Universities. It is distinctly contrary to public policy that the present denominational education of students of different professions in special seminaries, whether they are ecclesiastical, or medical, or engineering, should be encouraged. The existing separation of professional and commercial education is most mischievous, and

is very largely due to compulsory Greek. Anent this, all that I said was that the danger of a Pagan revival was the *best* argument for compulsory Greek; I did not say it was a *good* argument. About going to Colleges and Universities, I did *not* say that the student should go to a College and *not* to a University, if he ever had time and ability to benefit by University training. Very few can do this, hardly any undergraduates ever do; and what I deprecate is that University Professors should be expected to waste their time in making cripples run—that is what College teachers and private coaches are paid for doing. Some Universities, as, for example, that of Dublin, are too poor to pay double sets of teachers, but that is their misfortune, and should not be a precedent for a rich country like England, nor for the wealthiest city in the world, like London.

As to Prof. Ayrton's forgetting the debt due to those who studied useless subjects, I chide him for it because he sneered at useless subjects. If he still sneered at useless subjects, I would chide him still, even though he whited his prophets' sepulchres by using the whole scientific hierarchy to name his units after. As to my forgetting the debt due to the practical applications, my letter was too short to include everything in it.

Anyway, I entirely agree with Prof. Ayrton that the business of technical schools is to teach *useful* knowledge, and further, that the enormous majority of mankind are most fortunately employed in doing useful things, and should not be asked to waste their time on trying to do useless ones.

GEO. FRAS. FITZGERALD.

A New Comet.

IN last week's NATURE (p. 484) I announced the discovery of a new comet on March 18, and an editorial note was appended to my letter as follows: "This is stated to be Winnecke's comet." Will you kindly allow me to point out that this statement is based on a misconception, for the two comets alluded to are situated in widely different regions of the sky, and cannot possibly be identical, as a comparison of the following positions will show:—

March 18, 1892.

	R. A.	Decl.
Winnecke's Comet	191°	+ 31°
Denning's Comet	341	+ 59

Bristol, March 26.

W. F. DENNING.

P.S.—The following is an ephemeris of the latter comet computed by Dr. Birdschof for Berlin midnight:—

	R. A.	Decl.	Light.
	h. m. s.		
March 29	23 49 2	+ 60 32	1'01
April 2	0 13 50	+ 60 39	1'00
6	0 38 8	+ 60 34	1'00
10	1 1 37	+ 60 18	1'00
14	1 24 4	+ 59 52	1'00

The comet reaches its perihelion on May 12.

W. F. D.

ON INSECT COLOURS.

I.

THE Editor of NATURE has been so kind as to invite me to give in these columns a short summary of certain investigations that I have been for some time past engaged in, upon the behaviour of various insect colours when tested by chemical reagents. A full account of these experiments, of the methods of working, and of the reagents used, has been published in the *Entomologist*,¹ to which journal I must refer my readers for any details that they may desire. Here, space will allow me only to give in a condensed form the broad results. It is necessary to say, however, that the remarks in this article have reference only to the colours of the Lepidoptera; and, further, of the *imagines* only. The experiments have been made by immersing the wings for *one hour* in the following reagents: strong hydrochloric acid; 50 p.c. nitric acid; 45 p.c. sulphuric; strong acetic; strong ammonia; 25 p.c. potassic hydrate; and 10 p.c. sodic hydrate.

¹ April 1890 to September 1891.