former by bringing scientific workers together and giving them due opportunity for the interchange of knowledge and opinions. To secure this end, it is important that *sectional* and *intersectional discussions* should, in future, become *the feature* of the meetings, but to be successful these must be conducted with far greater forethought than heretofore—they must be true discussions and must not consist of a number of short papers written without reference to each other or to any central idea, and there must be no limitation of discussion so long as it is to the point. Probably the best plan will be that sectional committees, specially appointed for the purpose, select subjects, and that on each of these some one open a discussion by means of a carefully-prepared paper, printed and circulated at least a month beforehand, among those likely to take part in the debate. Such discussions should be carefully reported, and the edited report should be subsequently published, those who had taken part in the discussion having full liberty allowed them to give expression to their carefully-considered opinions instead of being required merely to punctuate their sentences in proof. The resolution not to report discussions arrived at last year by the Council is most unfortunate. If it were understood that discussions would be reported, speakers would be far more interested, and would take far more pains in preparing to take part in them than has hitherto been the case. It is, I think, unnecessary to dwell on the value of true discussion among workers in different, but cognate, branches of science.

As regards the public functions of the Association, it is unquestionable that much more might—and should—be done on behalf of those who are interested spectators rather than active workers in science. The evening lectures now delivered are often very brilliant expositions, but, as a rule, they have been "above the heads" of a very large proportion even of the members of the Association who have listened to them. I know many who think with me that a more direct effort should now be made to advance the knowledge of science among the general public at these meetings.

One great reform which *must* be carried out is the general curtailment of the expenses of the meetings, which make it impossible for any but the largest and richest towns to receive the Association. The lavish expenditure on the Reception Room which has been so frequently witnessed of late years should be unnecessary. So long as we can come together and can accomplish our object—the *advancement of science*—we should be satisfied with the most modest accommodation and should even be prepared to submit to some privation. At the German Naturforscher Versammlungen the vast majority cater for themselves, and private hospitality is almost unknown, the social demon, which is so ruthless a destroyer of much of the effectiveness of the B.A. meetings, being kept entirely in the background; and yet, in my opinion, these meetings are at least as enjoyable and fruitful of result as our own B.A. meetings.

Then we want younger presidents, on the average—men who are in their prime as scientific workers.

Of late years our Council has been far too cautious and conservative a body, and a large infusion of a liberal and progressive element is necessary if we are to set our house in order, so that it may suit the times. Many of us think that the Council is not in touch with us as a body—somehow we know of its existence, but its functions are mystic and akin rather to those of the Archives of the Royal Society than to those of an energizing and propulsive organ. In these democratic days, it would be well if each section were to return a member to Council.

HENRY E. ARMSTRONG.

## The Position of $4\pi$ in Electromagnetic Units.

THERE is, I believe, a growing body of opinion that the present system of electric and magnetic units is inconvenient in practice, by reason of the occurrence of $4\pi$ as a factor in the specification of quantities which have no obvious relation with circles or spheres.

It is felt that the number of lines from a pole should be $m$ rather than the present $4\pi m$, that "ampere turns" is better than $4\pi n$C, that the electromotive intensity outside a charged body might be $\sigma$ instead of $4\pi\sigma$, and similar changes of that sort; see, for instance, Mr. Williams's recent paper to the Physical Society.

Mr. Heaviside, in his articles in the *Electrician* and elsewhere, has strongly emphasized the importance of the change and the simplification that can thereby be made.

In theoretical investigations there seems some probability that the simplified formulæ may come to be adopted—

$$\mu \text{ being written instead of } 4\pi\mu, \text{ and } k \text{ instead of } \frac{4\pi}{K};$$

but the question is whether it is or is not too late to incorporate the practical outcome of such a change into the units employed by electrical engineers.

For myself I am impressed with the extreme difficulty of now making any change in the ohm, the volt, &c., even though it be only a numerical change; but in order to find out what practical proposal the supporters of the redistribution of $4\pi$ had in their mind, I wrote to Mr. Heaviside to inquire. His reply I enclose; and would merely say further that in all probability the general question of units will come up at Edinburgh for discussion.

OLIVER J. LODGE.

*Paignton, Devon, July* 18, 1892.

MY DEAR LODGE,—I am glad to hear that the question of rational electrical units will be noticed at Edinburgh—if not thoroughly discussed. It is, in my opinion, a very important question, which must, sooner or later, come to a head and lead to a thoroughgoing reform. Electricity is becoming not only a master science, but also a very practical science. Its units should therefore be settled upon a sound and philosophical basis. I do not refer to practical details, which may be varied from time to time (Acts of Parliament notwithstanding), but to the fundamental principles concerned.

If we were to define the unit area to be the area of a circle of unit diameter, or the unit volume to be the volume of a sphere of unit diameter, we could, on such a basis, construct a consistent system of units. But the area of a rectangle or the volume of a parallelepiped would involve the quantity $\pi$, and various derived formulæ would possess the same peculiarity. No one would deny that such a system was an absurdly irrational one.

I maintain that the system of electrical units in present use is founded upon a similar irrationality, which pervades it from top to bottom. How this has happened, and how to cure the evil, I have considered in my papers—first in 1882–83, when, however, I thought it was hopeless to expect a thorough reform; and again in 1891, when I have, in my "Electromagnetic Theory," adopted rational units from the beginning, pointing out their connection with the common irrational units separately, after giving a general outline of electrical theory in terms of the rational.

Now, presuming provisionally that the first and second stages to Salvation (the Awakening and Repentance) have been safely passed through, which is, however, not at all certain at the present time, the question arises, How proceed to the third stage, Reformation? Theoretically this is quite easy, as it merely means working with rational formulæ instead of irrational; and theoretical papers and treatises may, with great advantage, be done in rational formulæ at once, and irrespective of the reform of the practical units. But taking a far-sighted view of the matter, it is, I think, very desirable that the practical units themselves should be rationalized as speedily as may be. This must involve some temporary inconvenience, the prospect of which, unfortunately, is an encouragement to shirk a duty; as is, likewise, the common feeling of respect for the labours of our predecessors. But the duty we owe to our followers, to lighten their labours permanently, should be paramount. This is the main reason why I attach so much importance to the matter; it is not merely one of abstract scientific interest, but of practical and enduring significance; for the evils of the present system will, if it continue, go on multiplying with every advance in the science and its applications.

Apart from the size of the units of length, mass, and time, and of the dimensions of the electrical quantities, we have the following relations between the rational and irrational units of voltage V, electric current C, resistance R, inductance L, permittance S, electric charge Q, electric force E, magnetic force H, induction B. Let $x^2$ stand for $4\pi$, and let the suffixes $_r$ and $_i$ mean rational and irrational (or ordinary). Also let the presence of square brackets signify that the "absolute" unit is referred to. Then we have—

$$x = \frac{[E_r]}{[E_i]} = \frac{[V_r]}{[V_i]} = \frac{[H_r]}{[H_i]} = \frac{[B_r]}{[B_i]} = \frac{[C_i]}{[C_r]} = \frac{[Q_i]}{[Q_r]};$$

$$x^2 = \frac{[R_r]}{[R_i]} = \frac{[L_r]}{[L_i]} = \frac{[S_i]}{[S_r]}.$$

The next question is, what multiples of these units we should take to make the practical units. In accordance with your request I give my ideas on the subject, premising, however, that I think there is no finality in things of this sort.

First, if we let the rational practical units be the same multiples of the "absolute" rational units as the present practical units are of *their* absolute progenitors, then we would have (if we adopt the centimetre, gramme, and second, and the convention that $\mu = 1$ in ether)

$$
\begin{aligned}
[R_r] \times 10^9 &= \text{new ohm} = x^2 \text{ times old.} \\
[L_r] \times 10^9 &= \text{new mac} = x^2 \text{ ,, ,,} \\
[S_r] \times 10^{-9} &= \text{new farad} = x^{-2} \text{ ,, ,,} \\
[C_r] \times 10^{-1} &= \text{new amp} = x^{-1} \text{ ,, ,,} \\
[V_r] \times 10^8 &= \text{new volt} = x \text{ ,, ,,} \\
10^7 \text{ ergs} &= \text{new joule} = \text{old joule.} \\
10^7 \text{ ergs per sec} &= \text{new watt} = \text{old watt.}
\end{aligned}
$$

I do not, however, think it at all desirable that the new units should follow on the same rules as the old, and consider that the following system is preferable :—

$$
\begin{aligned}
[R_r] \times 10^8 &= \text{new ohm} = \frac{x^2}{10} \times \text{old ohm.} \\
[L_r] \times 10^8 &= \text{new mac} = \frac{x^2}{10} \times \text{old mac.} \\
[S_r] \times 10^{-8} &= \text{new farad} = \frac{10}{x^2} \times \text{old farad.} \\
[C_r] \times 1 &= \text{new amp} = \frac{10}{x} \times \text{old amp.} \\
[V_r] \times 10^8 &= \text{new volt} = x \times \text{old volt.} \\
10^8 \text{ ergs} &= \text{new joule} = 10 \times \text{old joule.} \\
10^8 \text{ ergs per sec.} &= \text{new watt} = 10 \times \text{old watt.}
\end{aligned}
$$

It will be observed that this set of practical units makes the ohm, mac, amp, volt, and the unit of elastance, or reciprocal of permittance, all larger than the old ones, but not greatly larger, the multiplier varying roughly from $1\frac{1}{4}$ to $3\frac{1}{2}$.

What, however, I attach particular importance to is the use of one power of 10 only, viz. $10^8$, in passing from the absolute to the practical units; instead of, as in the common system, no less than four powers, $10^1$, $10^7$, $10^8$, and $10^9$. I regard this peculiarity of the common system as a needless and (in my experience) very vexatious complication. In the $10^8$ system I have described, this is done away with, and still the practical electrical units keep pace fairly with the old ones. The multiplication of the old joule and watt by 10 is, of course, a necessary accompaniment. I do not see any objection to the change. Though not important, it seems rather an improvement. (But transformations of units are so treacherous, that I should wish the whole of the above to be narrowly scrutinized.)

It is suggested to make $10^9$ the multiplier throughout, and the results are :—

$$
\begin{aligned}
[R_r] \times 10^9 &= \text{new ohm} = x^2 \times \text{old ohm.} \\
[L_r] \times 10^9 &= \text{new mac} = x^2 \times \text{old mac.} \\
[S_r] \times 10^{-9} &= \text{new farad} = x^{-2} \times \text{old farad.} \\
[C_r] \times 1 &= \text{new amp} = \frac{10}{x} \times \text{old amp.} \\
[V^r] \times 10^9 &= \text{new volt} = 10x \times \text{old volt.} \\
10^9 \text{ ergs} &= \text{new joule} = 10^2 \times \text{old joule.} \\
10^9 \text{ ergs p. sec.} &= \text{new watt} = 10^2 \times \text{old watt.}
\end{aligned}
$$

But I think this system makes the ohm inconveniently big, and has some other objections. But I do not want to dogmatize in these matters of detail. Two things I would emphasize :— First, rationalize the units. Next, employ a single multiplier, as, for example, $10^8$.

OLIVER HEAVISIDE.

P.S.—Heaven preserve us from dynamics based on the Act of Parliament !

## Neutral Point in the Pendulum.

IN the theory of the pendulum the position of the neutral point of support is a matter of practical importance, which is, nevertheless, quite disregarded.

Taking a rigid uniform bar as the simplest case, there are four points of support from which its vibrations are equal, the two ends and the two respective centres of oscillation. But there are two symmetric points, situated between either end and the centre of oscillation nearest to that end, from which points of suspension the rate of vibration is most rapid. Hence, when suspended from these points, a change in the position of the point of support produces a minimum difference in the rate of vibration. Or, in practical terms, there is a great advantage in having a small amount of overhead weight above the support, as then, if the support approach the bob (owing to changes in elasticity of the spring, or of the knife edges), and so increase the number of vibrations, it recedes from the top weight, and so diminishes the vibrations to a corresponding amount, and *vice versa*.

This neutral point of support seems to have been overlooked in the main pendulum researches, as it was what had to be avoided rather than sought in the determination of the length, which was then the main interest. Probably some one has already noticed such an elementary property; but it is of so much value in minimizing sources of error that it is worth some attention.

Bromley, Kent. W. M. FLINDERS PETRIE.

## Induction and Deduction.

CAN we determine the precise relation between Induction and Deduction? Both are said to be a species of Inference. *Deduction* is, no doubt, Mediate Inference. Is *Induction* Mediate or Immediate Inference? If Immediate it must be of the form :

This X is Y (or these X's are Y's) . . . . . (1)
∴ All X's are Y's . . . . . . . . . . . . . (2)

But such "inference" as this is not illative; (1) can furnish only a suggestion, not by any means a justification, of (2).

Still it is true that if, *e.g.* I have proved that the angles at the base of an isosceles triangle are equal to each other, I henceforth believe and assert unhesitatingly, that *all* isosceles triangles have the angles at the base equal. *How* do I justify such a conclusion of an universal from a particular? In this way, I think :—Every nameable or cogitable object is an identity in diversity—that is, it is itself, it is *something*, and it has a plurality of characteristics. This principle is involved in the assertion of any statement of the form *A is* B, and it seems moreover to be, in itself, evident on reflection. Further (as Bacon surmised), every property (or group of properties) has a "form," some invariable and inevitable coexistent. In other words, there is uniformity of coexistence as well as of causation in nature. In the case of any one isosceles triangle, I have *seen* the connection of interdependence that there is between the characteristics of "having equal sides," and "having the angles at the base equal;" I have perceived it to be self-evident that the one property involves the other. Hence, my whole argument might run thus :—

Every characteristic is invariably accompanied by some other characteristic ;
Equality of sides in a triangle is a characteristic ;
∴ Equality of sides in a triangle is invariably accompanied by some other characteristic.

Again :—

Equality of angles at the base is a characteristic which is (self-evidently) inseparable from equality of sides in one [this particular] case ;
What is inseparable from equality of sides in one case is inseparable in all cases ;
∴ Equality of angles at the base is inseparable from equality of sides in all cases—
That is, *all* isosceles triangles have the angles at the base equal.

What we rely on here is Interdependence of characteristics and Uniformity of that interdependence; *i.e.* we rely on a principle of coexistence or coinherence, parallel to Mill's "Law of Causation"; and this is a principle which we find to be a necessary condition of what we accept as strictly self-evident propositions. The assertion with which we conclude in the above generalization, is an assertion of uniformity of interdependence between certain specified characteristics.

Again, if I administer a certain amount of arsenic to a healthy animal, and it dies, and I hence conclude that arsenic is a cause