

quarters, an impression not fair to him, and as the same accounts may produce the same impression abroad, it seems proper to make the following statement:—

When on the morning of August 17 Prof. Hall showed me his observations, the communication was purely confidential and friendly, and was not made either in the line of duty or because he failed to recognise the significance of his observations, or because any special skill he did not possess would aid in interpreting them. I suggested that, from the few measures he had made, it was possible to estimate the time of revolution of the satellite, if the object really were one; and thus ventured the prediction that it would be hidden during most of the following night, but would reappear toward morning near the position in which it was seen the night before. The fulfilment of this prediction facilitated the establishment of the true character of the object, but, without it, an equally certain hold on the satellite would very soon have been obtained by Prof. Hall alone. The credit of sole discoverer is therefore due to him.

SIMON NEWCOMB

### The Satellites of Mars

It may interest some of the readers of NATURE to know that one of the recently-discovered satellites of Mars appears to have been certainly seen with the six-foot reflector at Parsonstown. My assistant writes me on the 17th instant:—

“On the 8th instant (before receiving the Washington circular) I suspected very strongly at 11:45 P.M., while using the six-foot, that a satellite was visible, following the disc, about 14 diameters. It appears now from the elements that it must have been the outer one. On the 15th instant, at 11:30 P.M., I saw it quite distinctly preceding the planet, however not well enough to measure it, as I lost it again after a couple of minutes, owing to the strong glare of Mars. Last night I saw it again, but only by glimpses, twice or three times.”

The unfavourable weather prevented the satellites from being looked for between the 8th and 15th instant.

I may add that it seems probable that the satellites might have been measurable on the 15th instant with the bright line micrometer had it not been in the maker's hands. The low meridian altitude of the planet ( $25^{\circ}$  at Parsonstown as compared with  $40^{\circ}$  at Washington) is of course a serious drawback to observations at the former place.

ROSSE

Yorkshire, September 20

THE weather in this neighbourhood has been very unfavourable for observation ever since the announcement of the discovery of two satellites of Mars. Last night, however (about 9.30), during little more than half-an-hour's interval of clear sky, the air being extremely steady, and the planet beautifully defined, I succeeded in seeing the outer satellite of the two. With the full aperture of my 18-inch silvered-glass equatorial reflector, and an ordinary achromatic eye-piece with a bar across the field hiding the planet, the satellite was but glimpsed occasionally; with a single double-concave lens (power about 180) it was visible, in spite of the brilliant light of the planet. Had I not known its exact position, however, I question whether I should have seen it at all. It is a most difficult object.

HENRY COOPER KEY

Stretton Rectory, Hereford, September 19

### A Good Suggestion

THE approaching meeting in London of librarians representing the most important English, and, I believe, foreign, collections of books, makes the present a suitable time to offer suggestions as to the management of such collections.

It has long seemed to me that an improvement might be made of a very simple nature, but capable of greatly increasing the working value of reference libraries, especially those of the first rank; namely, to provide, somewhat as follows, for their being consulted by those who cannot personally visit them.

Suppose that the authorities of such an institution as the British Museum or the Bodleian designate certain persons, not paid officers of the library, but known to its directors as well-educated, trustworthy, and acquainted with the resources of the particular library; publishing the names and addresses of these gentlemen as willing, and believed to be competent, to undertake researches amongst the books for those who may write to them from a distance; the official authorities assuming no actual

responsibility for the work so done, but merely recommending the persons to do it; publishing at the same time a definite statement of the payment expected per day or hour by these persons.

Often when one would desire to consult a great public library in a foreign land, or in a distant part of one's own country, nothing short of a personal visit would be of use, but in very many cases it would be quite possible to obtain all that one desired by a simple business-like correspondence with a proper agent. Sometimes the question is merely whether such or such a book exists in the library, with perhaps an accurate copy of its title; sometimes a special reference to a single page in an old and scarce scientific journal or set of transactions is to be verified; sometimes a few paragraphs are to be copied in the exact words of the author; sometimes a name, date, or number is to be sought out; sometimes a larger amount of work would be needed, but so definitely shaped out that instructions in writing could easily be given for it to an intelligent person on the spot. As it is, the consulting of such a distant library in person is often simply impossible, and even when possible, often involves such expense and delay as to make themselves seriously felt; whereas by the plan proposed, the object in view might often be attained at a cost of time and money altogether trifling. In my own very small experience I once found it necessary to travel some 700 miles, losing three days, and spending about 7*l.*, in order to refer to a book for about ten minutes, while directions for making the same search could have easily been put upon half a sheet of note-paper, and carrying them out would have occupied a person living in the city in which the library was situated altogether not more than an hour or an hour and-a-half.

In the neighbourhood of almost every large library competent men might readily be found to undertake such work as is suggested, and to whom the opportunity of increasing their income, or probably in time earning from this source alone a satisfactory income, would be welcome. The plan would admit of being carried out upon a small or an extended scale; a library of the third or fourth class might afford a field for a single man only, while one of the first class would be likely gradually to enlist the services of a number; if this were so sub-division of labour would be desirable, one person undertaking researches in natural history, another in mathematics, physics, or chemistry, another in classical learning, &c.

While such work could not properly be done by the regular officers of a public library, it would be important that the private individuals who were to enter upon it should have the approval of, and should be recommended by, the library authorities, who might also very properly fix the rate of payment, recommending only those who were willing to accept the rules laid down.

This plan has at least the merit that it might be tested with very little trouble, risk, or disturbance of existing arrangements. I believe that even in England with great libraries situated at comparatively moderate distances from almost every one in the kingdom, it would prove a great convenience; to persons placed as are those who live here in America, with no library of the first rank on this side of the ocean, and with hundreds of miles often separating one from the larger of even those libraries which do here exist, the boon of access by letter to the greatest collections of the world would be inestimable. It would be in a new direction, and a noble one, carrying out the tendency of the most modern civilisation which looks to placing, as far as possible, the resources of the whole earth within the reach of him who lives at any one spot upon its surface.

J. W. MALLETT

University of Virginia, September 5

### Some of the Troubles of John O'Toole respecting Potential Energy<sup>1</sup>

#### II.

#### B.—Potential *E.*, as meaning “energy related to Potential Functions.”

WE now pass to the second meaning of “potential *E.*” It happens, by a most singular and unfortunate coincidence, that this class of *E.* can very well be called by that title for a reason quite distinct from that which we have been deprecating. The idea of the potential function, or briefly, potential, was first formed and thus named by Green. It has no reference whatever to existing in possibility; it is concerned with present potency or power; and it happens that potential *E.* of unit of mass may

<sup>1</sup> Continued from p. 447.

be very appropriately so termed by some physicists as being *E.* of potential, or rather *E.* of difference of potential, or *E.* which is the complement of potential. This is evidently sometimes in the minds of our teachers: indeed, Clerk Maxwell directly tells us<sup>1</sup> that this is one sense in which the title is suitable; he calls it a "very felicitous expression," because it has the two differently applicable meanings we have mentioned.

7. Here, then, is our next gravamen. These two characters of this type of *E.* are quite heterogeneous and unconnected. Now a *simple name* can only refer to one character of a person or thing; and if it happens, by accident, that the *word* that constitutes the name has two quite different meanings or references, and that both are applicable to the person or thing, if we mentally apply them both to that individual, we are guilty of a sort of punning or verbal skylarking; as if for instance we should call Mr. Smith an upright man on account both of his erect carriage and of his moral probity. This is bad enough; but further, the two characters which might be implied in the name "potential *E.*" are not merely heterogeneous; they are mutually incompatible; they cannot be put together into the same complex idea, at least by ordinary mortals. Surely there is no occasion to stop to prove this.

It is evident that the majority of our teachers feel this and the preceding inconveniences themselves. And I confess that I am now going to bring against them a more serious accusation than that of merely using unsuitable language. There is a most singular and apparently significant omission to be noticed in nearly all the manuals, referring to this subject, into which I have looked; we have already alluded to this.

8. But we must take this opportunity of numbering it as the eighth of our gravamina. It is this, while teaching us about the different classes of *E.* and telling us that one is called "potential," they abstain from telling us why it is so called! This omission is so remarkable, in itself, as occurring in books intended to impart instruction, and so unlike the ordinary behaviour of our doctors, that there must be some very particular reason for it. A single person might make this omission by pure accidental inadvertence; but when a number of persons do so it cannot be thus accounted for. There is no explanation but this—that they perceive the botherations connected with this confounded, I mean confounding, name, "potential *E.*," and rather than acknowledge how matters stand, and own themselves to blame, they try to slur the thing over by giving no meaning of the name at all. Rankine, indeed,<sup>2</sup> just alludes to the last meaning of "potential *E.*," which refers to its connection with potential (function); but that is all; not a word about the incongruity between it and his own original meaning, just as if none existed. Clerk Maxwell, however, as we have just seen, boldly takes the bull by the horns, and tries to make both himself and us believe that he is delighted with this Janus-like name and with the compounding of its two incompatible meanings. It so happens that the writings of that distinguished physicist contain as striking an illustration as could be conceived of the inconvenience of the ambiguity of this "very felicitous expression." We have already mentioned it, but with a different object in view. Having told us in one place that "potential *E.*" is "the *E.* which the system has not in actual possession," he also tells us elsewhere<sup>3</sup> that "the leaden weight of a clock when it is wound up has potential *E.*, which it loses as it descends." The weight sets to and works with *E.*, which it has not in possession, but only has the power to acquire, and which it loses the power of acquiring!<sup>4</sup> In the first statement he was thinking of the first meaning of potential *E.* and in the second statement of the other meaning.

It might be said that if we discard the first meaning of "potential *E.*" on account of its intrinsic wrongness, we shall, at the same time, abolish this last difficulty, which arises from its relation with the second meaning, and that this second meaning, which is admittedly good *in itself*, will then have nothing against it. But in the first place the associations of the name "potential *E.*" with the first meaning are too strong to be easily got rid of. It would be all but impossible to retain the word and confine it strictly to the second meaning.

9. But besides, "potential *E.*" in this second meaning, though

<sup>1</sup> "Heat," p. 91; "Matter and Motion," p. 81:—"Potential *E.*—A very felicitous expression, since it not only signifies the *E.* which the system has not in actual possession, but only has the power to acquire, but it also indicates its connection with what has been called (on other grounds) the Potential Function."

<sup>2</sup> *Phil. Mag.*, February, 1867.

<sup>3</sup> "Theory of Heat," p. 281.

<sup>4</sup> We have already seen above, that the weight never acquires more than a quite insensible amount of "actual *E.*," so called.

good in itself, has inconveniences independent of this when applied as I believe it universally is, to *E.* conceived of as existing in the *body* moved; for potential (function) does not appertain to the *body* moved, but entirely to the *force* concerned.

### C.—Potential *E.*, as meaning "Energy of Potency."

As to the third meaning of "potential *E.*," it has been said (and indeed Rankine may have had this in view in one place<sup>1</sup>) that it need not be taken to imply anything more than *E.* of potency or power without reference to Potential (function).

10. But according to this, "potential *E.*" would mean the power of doing work which consists in power; and it would be as great a tautology as "umbrageous shades."

11. And again, if it be the special distinction of one class of *E.* that it is *E.* of potency it necessarily follows that the other class, observe the so-called actual *E.*, is *E.* of *impotency*!

12. And besides, there is the same incompatibility between this meaning, C, and meaning A, as there is between B and A.<sup>2</sup>

### As to the whereabouts of Potential Energy.

We shall now pass from the perplexities connected with this unlucky name, "potential *E.*," to consider the behaviour of our teachers towards the thing itself. It will conduce to clearness to drop this name now, since our objections are no longer directed against *it*, and adopt another very common one for the same thing, viz., "*E.* of position."

13. The *E.* of position is usually regarded and spoken of as belonging to, or being *in the body* in question which may be about to move and acquire *E.* of motion. This puzzles poor P. terribly; not only on account of the difficulty of grasping the thing mentally and of putting any clear meaning into it, but also because the doctors, both individually and collectively, often display such curious inconsistency respecting it.

But before proceeding to consider directly the undesirableness of this way of viewing *E.* of position, let us observe that it is the cause of all the above perplexities, which, indeed, seems to be sufficient objection to it; and let us endeavour to find out why the doctors should have had recourse thereto.

The physicists having determined, for the reasons below, to talk of this *E.* of position as being in the *body*, and that *body* being just the same (and, when regarded as attracted or repelled, as is usually done, equally inert) in whatever position it stands, it becomes necessary to provide for this by a little ingenious dodge; for such the phrase "potential *E.*," as now generally used, really is. "Potential *E.*," plays the same part as a conjurer's empty case or shape, which is made to represent some solid object which is really lying elsewhere, or is perhaps actually doing duty there. Our physical prestidigitators tell poor P. that this *E.* is "in the *body*," that the *body* "*has it*," that the *body* "*possesses it*," with other similar expressions. But what is it that they are presenting to him all the time? "Potential *E.*," which sounds to him very fine, and which he thinks must be something very serviceable, but which is in reality only an empty shape, for it is "*E.* which the *body has not in actual possession*!"! They have adopted the precise inverse of the famous device employed by Ulysses when he told Polyphemus that his name was *Obrius*. We have mentioned and reckoned this grievance already, on its own account; we have returned to it now only to show how the present one necessitates the use of this delusive name "potential *E.*"

Why then is it that our teachers (save the mark!) wish thus to make-believe that they have got their *E.* of position in the *body*? The principal reason is this—They have to keep straight with the metaphysicians. In these days it is generally perceived that we should, as much as possible, avoid treating force as an objective *something*. When energy does not come prominently forward into discussion they can use the same forms of expression about force as their grandfathers did, though intending them only as such. The term "force" is "very useful," in that "it enables us to abbreviate statements which would otherwise be long and tedious;" and no harm is done by using it when the necessary reservation as to its being only a convenient mode of speech is known to underlie all the statements and discussion. But when Energy, which must be taken as real and objective in some sense, is the subject of their talk, they become extra cautious, and, fearing to put this objective affair into non-objective

<sup>1</sup> "Encyclon. Brit." (1857), vol. xiv., article "Mechanics."

<sup>2</sup> In Nicholl's "Cyclop. of Phys. Sciences" potential *E.* is said to mean *E.* of a power or force, but it is easy to see that this does not mend the matter at all. As a *distinguishing* title it implies that a moving *body* has no force nor power. No "power of performing work," that is to say no *E.*



live force, or tension, or stress, they are driven to thrust it into the body, notwithstanding the perplexities and contradictions caused by so doing, and notwithstanding the painful necessity incurred thereby of hoodwinking poor P. in the above manner, and endeavouring to hoodwink the metaphysicians. But there is really no reason why force with the saving reservation should not be introduced as freely into the discussion of E. as into other questions of dynamics; and the physicists often do introduce it thereinto; but then, when frightened at what they have done, they will silently withdraw it again. All the inconsistencies of the doctors, and their capriciously varying moods of freedom and shyness respecting "force," and their stepping up and down from one platform of thought to another, perplex poor P. beyond measure. He knows nothing but what they tell him; and he dares not attribute his difficulties to anything but either the abstruseness of the subject or his own stupidity.

But probably there was another motive, also, for this melancholy idea of putting the E. of position into the body, viz., the desire for simplicity of arrangement. Since E. is E., and the kinetic E. is undeniably in the body, it would seem to be an orderly proceeding to put the other there too. But this would be as if a methodical housekeeper should keep her coals and her blankets in the same "hole" because they are both warming apparatus, though in very different ways. And besides, we shall find that whatever may be the gain in this respect in putting both the types of E. into the body, it is outweighed by a certain loss of true correspondence and clear analogy, which will be mentioned farther on.

We now come to the more direct consideration of the merits of this procedure of putting the E. of position into the body. Let us begin with an interesting little illustration of its character. It is the ordinary and legitimate mode of expression to say that when a stone is projected vertically upwards, the gravitational attraction between the earth and stone draws the stone down again and gives it the kinetic E. with which it strikes the earth. And the gravitation attraction is usually and conveniently conceived and spoken of as being all the earth's; and the stone is usually regarded as being simply attracted. Every doctor will frequently speak thus; and nevertheless he will also, and sometimes in the same breath,<sup>1</sup> tell us that it is the *stone*, say at the highest point of its ascent, that has E. of position due to its height from the ground. So then the connecting attractive force, which is to do the work of drawing the stone down again, and which is therefore one factor of the E. present, is regarded as being in the earth, but the E. as being in the stone! This is *one* way no doubt of teaching poor P. the difference between force and E.! Take another illustration. Some of our foremost doctors<sup>2</sup> tell us that when a bow is drawn and about to discharge the arrow or the bolt it is the arrow or the bolt that has E. of position; in this they have at least the merit of consistency. Poor P. generally feels that this conveys no distinct idea at all to his mind; of course he dares not think it wrong. Then he finds other doctors<sup>3</sup> who tell him (though in so doing they are inconsistent<sup>4</sup> with themselves) that in this case the E. is in the bow. What is to be done now? Is this distracting E. of position "like a bird so that it can be both here and there at the same time"? Or are the doctors on one side—how shall we write it—wrong? At any rate, since the doctors differ, poor P. must needs choose for himself, and in order to escape the above perplexities and also for the following reasons, he elects to conceive of the E. of position as not in the body but in the force or forces concerned which are at least virtually there; it being an ulterior and quite another question, what is force?

The discussion is of course now, as it has been all along, only as to modes of conception or of expression, and not as to the science of our doctors. All agree that if you *spend* E. against the resistance of the inertia of a mass in giving it velocity or acceleration, you have bestowed your E. on the inertia of that body, you have transferred your E. to that inertia. So, in exact correspondence and analogy, if you *spend* E. against the resistance of the gravitation attraction, for instance, in raising a stone to a certain height you have bestowed your E. on that

attraction, you have transferred your E. to gravity. That attraction was beforehand pulling at the stone as hard as it could; but it had no power of doing work, according to the definition of work, *i.e.*, it had no energy according to the definition of E. You have given it E., or the power of performing work by affording it the condition necessary for its doing work, viz., space to work through. Why will not the doctors say this in so many words, when they do say it virtually in various forms? From Newton down they tell us this, that the work done by a force is  $fs$  ( $s$  being the space through which the force  $f$  acts); but the work done is the measure of the preceding E. or power which of course the force had of doing that work; why then will they scarcely ever say that the E. of a force is  $fs$  ( $s$  being now the space through which the force will have opportunity of acting)? When they do say in substance what we want them to say, they avoid most carefully the direct clear statement of it in so many words.<sup>1</sup> "This kind of E. [potential] depends upon the work which the forces of the system would do if the parts of the system were to yield to the action of those forces." That, of course, means *precisely the same* as the following, which, however, expresses the thing more directly. This kind of E. (potential) is the E. which the forces of the system possess in consequence of the possible displacements of the parts of the system under the action of those forces. Tait himself, both in his Glasgow lecture and in his "Recent Advances," tells us that a wound up spring or bent bow has potential E. Clerk Maxwell tells us the same. If so we have a right to speak of the energy of the gravitation attraction. In a certain respect the cases are different, but not so as to affect the present point.

This, our putting of the E. of position into the forces, instead of into the body or bodies, does not, of course, *explain* the action any more than the other does, but it gives a conception (provisional, if you like) which is much clearer and *in better analogy*, and, as we have said, free from all the above-recounted confusions. Moreover, the expression "E. of a force" has the great advantage of keeping before the mind of poor P. the fact that force and energy are not the same, a distinction which he is slow to apprehend, and which it is of the utmost importance to him that he should get proper hold of.

And now that we have got our E. of position into its most convenient seat, what shall we call it, and how shall we speak of its action? We cannot be dreadfully wrong if we call it by a name suggested by an expression of Helmholtz; let it be "*Energy of Tension*." Does it not seem more logical to designate it by its essential characteristic than by what is only a condition though an indispensable one; for this latter we do when we call it E. of position or configuration. And as to its action let us say that when E. is being, as it is usually expressed, transformed from potential to actual E., or *vice versa*, it is *transferred* from the forces to the bodies of the system, or *vice versa*. If these expressions are unsuitable and erroneous, then let every one abstain from language which is precisely tantamount to them. But our doctors do not do this; and it fortifies us greatly in the belief that we are right to know that our doctors, when they are quite themselves, say the very same in substance, though not in so many words. On the other hand, if these expressions recommend themselves to us, let us use them boldly and consistently without mincing matters. Deschanel seems to have been on the point of using them in one place.<sup>2</sup> However, the fear of his *confrères* suddenly rose before his eyes, and having written (or his translator for him) the word "transferred," he stops short without telling us from what and to what the transference is made; he leaves us to complete for ourselves the sense of the passage, which clearly is that the transference is from the forces to the bodies, and *vice versa*.

Poor Publius and myself have several other complaints to make; but probably we have said enough to excite the sympathy of all considerate persons.

Dublin

X.

### New Electric Lights

UNDER the above title Mr. Munro describes, in NATURE, vol. xvi. p. 422, M. Lodighin's device for an electric light. This is no novelty but a simple repetition of an invention made

<sup>1</sup> Clerk Maxwell's "Heat," p. 281 bottom; see Willson's "Dynamics,"

p. 247.  
<sup>2</sup> E.g. Balfour Stewart, "Cons. of E.," p. 25 (but see his "Elem. Phys.," p. 106).

<sup>3</sup> Tait, "Recent Advances," p. 18; Willson, "Dynamics," p. 278.

<sup>4</sup> The inconsistency is startlingly exhibited in a single sentence for which two doctors are responsible, "Uns. Univ.," p. 111, "the potential E. of a raised weight or bent spring." If the potential E. is in either one of these it cannot be in the other. We have the same in a single sentence in Thomson and Tait, p. 178 (two doctors, again, responsible); also in Tait's Glasgow lecture.

<sup>1</sup> The only exception that I remember to have seen is afforded, curiously enough, by Rankine himself, the inventor of E. *in posse*. In *Phil. Mag.*, February, 1853, he says, "E. of gravitation;" and in "Encycl. Brit.," vol. xiv., "Mechanics," he speaks of the E. of an effort.

<sup>2</sup> "Nat. Phil.," p. 79