hints are given for the management of the battery. In an appendix is a description of the arrangement of his accumulator house, a photograph of the interior of which forms the frontispiece to his book. He also gives a brief account of the history of the installation, from which we learn that the total cost of buildings and installation has been about 6000*l.*, that the number of lamps is about 500 of 20-candle power, but that the greatest number used at any one time has rarely exceeded 200, and that an arc lamp taking 40 or 50 amperes and one or two motors have been used together with them. The expenses—including wages, coal, oil, waste, washers, repairs, lamp renewals, &c.—were, in 1886, 210*l.*, or at the rate of $\frac{1}{4}$ *d.* per 20-candle lamp per hour. He does not, however, say anything as to the cost of the accumulators; and as to the length of time which they may be expected to last he only says vaguely that “the cells may last for years in perfect order if all the instructions here given are properly attended to.” His present accumulators were only put up in August 1885, those previously erected having proved to be unsatisfactory.

It is a pity that the useful information in this work is not conveyed in better language. In what is intended as a workshop hand-book we do not look for the elegance of an Addison; but we do want plain English. As an example of the language we may quote the following sentence from the preface: “Only cells of the Electrical Power Storage Company, of Messrs. Elwell-Parker, and their type, are dealt with, because at this moment there is probably no other better kind, or largely in use.” The meaning of this is clear, though even that is more than may be said of other sentences in the book.

Among minor faults we protest against the coinage of such a hideous word as “acidometer,” by which, apparently, is meant the instrument commonly known as a hydrometer; we do not think “s.g.” is an improvement on the ordinarily accepted abbreviation for specific gravity; and we object to the plural “dynamos” as against the ordinary rule of our language which gives us “potatoes” and “echoes.”

A more serious error is found in the “Index of Terms” on the back of the title-page—

“Watt = volt $\times$ ampere = measure of force or energy.”

We should recommend the author to get the work revised by some onewho understands the rudiments of science as well as those of the English language.

School Hygiene: The Laws of Health in Relation to School Life. By Arthur Newsholme, M.D. (London: Swan Sonnenschein, Lowrey, & Co., 1887.)

ABOUT the importance of the matters dealt with in this little book there can, of course, be no dispute; and, as Dr. Newsholme points out in his preface, they have engaged the serious attention of many School Boards and Committees, and been made the subject of a good deal of useful legislation. Most school-managers still have something to learn about the principles of school hygiene, and many of them will, no doubt, find in Dr. Newsholme's volume exactly the kind of information they want. He discusses the subject under two heads, “Schools” and “Scholars.” Under the first head he presents his ideas on questions connected with the choice of sites for schools, the construction of school buildings, school furniture, lighting of school-rooms, general principles of ventilation, natural ventilation, ventilation and warming, and draining arrangements. In the part relating to “Scholars” he has chapters on mental exercise, excessive mental exercise, age and sex in relation to school work, muscular exercise and recreation, rest and sleep, children's diet, children's dress, baths and bathing, eyesight in relation to school life, communicable diseases in schools, and school accidents. Dr. Newsholme has studied his

subject thoroughly, and his conclusions are all the more valuable because they have been to a large extent suggested by his experience as a medical officer of health, and as a medical referee for various schools and training colleges.

LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.]

[The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.]

Mass, Weight, and Dynamical Units

IF the laws of dynamics were made solely for the use of engineers, as a celebrated engineer declared of rivers that they were intended to feed canals, it might be conceded to Prof. Greenhill that it would not be necessary that the more abstract notion of mass should be distinguished from that of weight, and that the fundamental equation of dynamics might conveniently be

taken as $P = W \frac{f}{g}$, where W is the weight (or mass) of the body moved expressed in pounds or tons &c., and P the force producing in it the acceleration f , and reckoned in the same units. But a pound weight as a force is a variable unit, unless it is taken at some particular place (as Greenwich), and then the corresponding value of g must be employed (though the variation of g on the surface of the earth is not so great as often to need to be taken account of by the engineer); and so the astronomer and physicist, as well as the student of abstract dynamics, are right in demanding a less arbitrary measure of force than one founded on the force acting vertically downwards on a body at the earth's surface, as well as an absolute constant belonging to each body (its mass) independent of time and place. I conceive, therefore, in spite of Prof. Greenhill's arguments, that, in the interest of clearness of thought, as well as to avoid the practical inconvenience of a variable unit of force, the notions of mass and weight must be kept distinct, and the equation $W = Mg$, as a special case of the general equation $P = Mf$, still insisted on by all teachers of dynamics, at any rate to non-engineering students; while it would be well for engineers also (*me judice*) to have their dynamics cast in the same mould as the rest of the scientific world.

I should not have troubled you with the above very obvious remarks had I not wished to observe, *à propos* of Mr. Geoghegan's suggestion of names for units of velocity and acceleration in NATURE of April 7 (p. 534), that it is highly desirable that a convenient and consistent notation, as well as nomenclature, should be adopted for the several dynamical units.

With respect to the particular suggestion that *vel* and *cel* (or *velo* and *celo*, as used by Mr. Lock in his forthcoming book, “Dynamics for Beginners”) should be employed for the units of speed and acceleration in the foot-second system, I regard it as an almost fatal objection that the accepted C.G.S. system having appropriated the words *dyne* and *erg* for its units of force and work has a prior right to *vel* and *cel* for its units of speed and acceleration; namely, the centimetre per second, and the centimetre per second per second. If so, the units of the foot-second system might be called the *footvel* and the *footcel*.

Names for the dynamical units are, however, I think, of less importance than a convenient and suggestive notation for them. I have endeavoured to devise such a notation (or, rather, to fill up and complete notations which have more or less come into use) in a table, which is now under the consideration of a Committee of the Association for the Improvement of Geometrical Teaching, and which is substantially as follows.

In a perfectly general system, let **L**, **M**, **T** stand respectively for the fundamental units of length, mass, and time, and let **V**, **A**, **U**, **Δ**, **E** stand for the units thence derived of speed, quickening (acceleration), momentum or impulse, force, and energy or work respectively: then the statement that the unit of speed is the speed of the unit of length *per* unit of time is

naturally expressed thus, $V = L/T$. On the same principle we should have—

$$A = V/T = L/TT, U = MV = ML/T, \Delta = MA = ML/TT, \\ E = LA = LML/TT.$$

This may be simplified, using the analogy of the fluxional notation, by writing $\dot{L}$ for L/T and $\ddot{L}$ for L/TT . Then $\dot{L}$, $\ddot{L}$ may take the place of V and A , and we have—

$$U = M\dot{L}, \Delta = M\ddot{L}, E = L\Delta = LML.$$

Names for the several units are hardly needed in the general system.

In the C.G.S. system the units of length, mass, and time are respectively the centimetre, gramme, and second, denoted by **C, G, S**. Then if U_G , Δ_G , E_G denote the units of momentum or impulse, force, and energy or work, we have, on the same principle as before, $\dot{C}$, $\ddot{C}$ to denote the speed of a centimetre per second and the acceleration of a centimetre per second per second respectively, and the equations—

$$U_G = G\dot{C}, \Delta_G = G\ddot{C}, E_G = C\Delta_G = CG\ddot{C}.$$

If names for all these units are required, we may use these: *vel*, *cel*, *mom*, *dyne*, *erg*; and we may say, a *mom* is a *gramme-vel*, a *dyne* is a *gramme-cel*, and an *erg* a *centimetre-dyne*.

In the F.P.S., or British system, the units of length, mass, and time are respectively the foot, pound, and second, denoted by **F, P, S**. Then, if U_P , Δ_P , E_P denote the units of momentum or impulse, force, and energy respectively, we have, on the same principles, $\dot{F}$, $\ddot{F}$ to denote the speed of a foot per second and the acceleration of a foot per second per second respectively, and the equations—

$$U_P = P\dot{F}, \Delta_P = P\ddot{F}, E_P = F\Delta_P = FP\ddot{F}.$$

I propose as names for these units: *footvel*, *footcel*, *poundem*, *poundal*, *pounderg*. I should have called the unit of force a *pound-dyne* or *poundyn*, but that *poundal* has already obtained general acceptance.

The foregoing are all absolute units. The corresponding (Greenwich) gravitation-units are the *pound-weight* = 32.19 *poundals*, the *foot-pound* = 32.19 *poundergs*, and the *second-pound* (as it has been proposed by Prof. Unwin to name the gravitation-unit of momentum, or time-integral of a pound-weight through one second) = 32.19 *poundems*; so that to convert absolute F.P.S. units into gravitation-units, or *vice versa*, it is only necessary to divide or multiply by 32.19 , since the acceleration due to gravity at Greenwich = 32.19 $\ddot{F}$.

It is, I think, comparatively unimportant whether the *names* above suggested are, all of them, accepted or not; but the *notation* will, I believe, be found a great aid to the beginner in fixing in his mind the dimensions of the different magnitudes, and an effective safeguard against the too common confusion of units of force, impulse, and work. I doubt whether in speaking much would be gained by saying "*footvel*" instead of "*foot per second*," or "*footcel*" instead of "*foot per second per second*," while in *writing*, the symbols $\dot{F}$ and $\ddot{F}$ might be always used and read either way.

Harro, April 12

ROBT. B. HAYWARD

Units of Weight, Mass, and Force

FAR be it from me to interfere between Mr. Alfred Lodge and Prof. Greenhill; but, whilst leaving Mr. Lodge to his fate and Prof. Greenhill, perhaps, as an engineer, I may be permitted to offer a few remarks on the general question. First, then, it appears to me that Prof. Tait's thoroughgoing condemnation of certain phrases of the engineering vernacular, and of the grave errors of certain writers, has been strained in some quarters to mean a general charge against engineers of inability to think or write clearly on the physical laws which lie at the root of their every-day practice. Such an unqualified charge is on the face of it absurd; for otherwise we must confess that the lives' work of Thomson and Tait has been a total failure as regards its influence on the truly practical men of their generation. Can this be so?

Prof. Greenhill's remarks on the abominable semi-numerical equation $W = Mg$, or $\frac{W}{g} = M$, I most heartily welcome [where

W is a mass and g a numeric; the moment writers on dynamics, who use the gravitation system, pass from merely proportional equations to their physical interpretation, then must we face with them this most wretched equation]. But perhaps it will be at once a surprise and a gratification to Prof. Greenhill to know that a whole (academic) generation of Scottish University engineering students has been taught to eschew this same equation as an unclean thing, and to adopt the mode of thought clearly set forth in the last two paragraphs of his letter of February 28. Some five or six years ago I was myself so taught by one who is now, alas! no more. The possibility of thus clearing of cant not only the engineering but the purely mathematical mind seems to me, as indeed Prof. Greenhill indicates, to be a direct consequence of the acceptance by Thomson and Tait of the British Imperial pound as the unit of mass or quantity of matter.

Having fixed, then, for good and all, the unit of mass, and taking the British foot and the second as the units of time and length respectively, the unit of force defines itself in virtue of Newton's Second Law. To this unit—the British unit of force—Prof. James Thomson has given, as nearly everyone knows, the name "*poundal*." Now the most convenient practical unit of force, for physicists as well as engineers, is not the poundal, but the gravitation at the earth's surface of the unit of mass, a quantity which is not absolutely constant, the inconvenience so arising being, however, practically unimportant, or at most involving a reduction to an arbitrary standard. To pass, then, from a force expressed in poundals to a force expressed in units of gravitation of the Imperial pound at the standard place, one simply wants to know how many poundals go to the gravitation of the Imperial pound at that place—in other words, the change ratio. The answer is simple: the numeric g for the standard place; for a force equal to the gravitation of the Imperial pound at the standard place acting upon a mass of one Imperial pound would generate a momentum per second of g (numeric) pounds mass $\times$ feet per sec. per sec.; and the poundal a momentum per second of one pound mass $\times$ feet per sec. per sec.; and by Newton's Second Law the ratio of the forces is, therefore, the numeric g . What more does the physicist or engineer want to know? How many poundals go to the gravitation of a ton mass at the standard place? Answer, the numeric $2240g$. Could anything be simpler? The difficulty is to find the difficulty, or to assign the *raison d'être* of the so-called gravitation unit of mass.

When the old unnatural gravitation unit of mass is abandoned, and the transition from the natural unit to the gravitation unit of force made by means of the change ratio, the vicious use of the word mass to denote the result of dividing by the numeric g the mass of a body in standard pounds (viciously on the same system called the weight and denoted by W) ceases; and the dire confusion between weight and mass becomes a thing of the past. The emancipation of the term weight from its bondage to mass would appear to have afforded opportunity for its use wherever it might be of service in suggesting or denoting gravitation. For example, there are three units, each called a pound, viz. the Imperial British unit of mass, the gravitation of the same mass at any the same place on the earth's surface, and the pound sterling. Physicists, like Sir Wm. Thomson and Prof. Tait, use terms such as "*pound weight*," "*gramme weight*"; similarly we have "*pound mass*" coming into use; and probably we shall soon hear of "*pound money*." Prof. Greenhill, with his strong engineering sympathies, objects to the time-honoured "*pounds per square inch*" being rendered "*pounds weight per square inch*"; and if I may presume to offer an opinion, the old phrase is already cumbersome enough. Still, if Prof. Tait and Prof. Greenhill ultimately agree that there is anything to be gained in perspicuity, for the sake of the weaker members perhaps it might be well for us to put in practice, on some occasions, the injunction to sacrifice all rather than cause our brother to offend.

Some one might possibly step in to draw attention to the fact that the pages of even our own great high priest of exact applied science are disfigured by $\frac{W}{g}$; but sure I am that were Rankine now with us he would lead the way with Prof. Greenhill in a crusade against the apologists for the obscurity of which W/g is the symbol. Take, for example, Rankine's bold introduction of the dynamical unit of quantity of heat. Take the opinion of