SAMPLES OF CURRENT ELECTRICAL LITERATURE.[1]

THESE four books are samples of the different classes of text-books of the present day. The first, as its title implies, is intended for workmen actually engaged in the electrical industries, and is therefore of the non-mathematical technical order. The second, on the other hand, is intended for the practical man who is not afraid of a differential equation, and is a very suitable book for a student of one of the higher technical colleges. The third is a mathematical treatise of the University type; while the fourth is intended for the general public unacquainted with mathematical or scientific principles, but anxious to learn something about this electricity and its distribution, which are now constantly being referred to even in the daily newspapers.

Of the four books, the second, on "Absolute Measurements in Electricity and Magnetism," is the most valuable, because the information it contains is correct, and much of it is not to be found in other books. On opening the first book, "Short Lectures to Electrical Artisans," we anticipated seeing how Dr. Fleming had struck out an entirely new line; but we must confess our disappointment at finding that the author has such a veneration for the authority of antiquity that he felt compelled to commence this book with a description of the loadstone. These lectures, we are told in the preface to the first edition, are on "subjects connected with the principles underlying modern electrical engineering," and were delivered "to the pupils and workmen associated with" Mr. Crompton's firm at Chelmsford. We presume, then, that the lectures were intended to enable workmen to make better dynamo machines, electromotors, &c., but as we never yet met with a piece of loadstone in any electrical factory in England or the Continent, we fail to see how the purpose of the lectures was served by their starting with an account of the "native oxide of iron" called the loadstone. Neither the loadstone nor the classical lump of amber, so dear to the hearts of the writers of electrical text-books, are workshop tools. The latter a workman may perhaps come into contact with as a mouthpiece to his pipe, but a piece of loadstone he will probably never even see out of the lecturer's hand. Apart from this academic start, Lecture I. is decidedly good; the author, for example, not merely mentions that an alloy of steel with 12 per cent. of manganese is nearly non-magnetic, but he gives the name and address of the firm from whom manganese steel can be obtained, and he follows the same wise course when explaining how ferro-prussiate photographic paper may be used for obtaining permanent records of magnetic lines of force.

But why give Rowland's curve connecting permeability and magnetic induction, since later experiments have shown that this curve is quite wrong for large magnetic inductions? The same mistake is made in Lecture III., where it is assumed that for a certain magnetizing force iron becomes saturated, so that no greater induction can be produced, no matter how much the magnetic force is increased.

Lectures II. and III. have many blemishes. The expression 50 ampères of current, on p. 24, is misleading; you cannot have 50 amperes of anything else but current. An ampere is the English name for a unit of current; why, then, put a grave accent over the name? One might as well in speaking of so many metres give this last word its French pronunciation? In justice, however, to Dr. Fleming, we should mention that the use of the grave accent over the word *ampere*, when used in English, is not peculiar to him. We wish, however, that he had been bold enough to Anglicize this word. In describing the construction of a simple mirror galvanometer, the *technical* reader ought to have been warned that, unless, in sticking the three magnets on the back of the mirror with shellac varnish, the shellac be put just at the middle only of each magnet, the mirror will be distorted and rendered useless. To say, when speaking of the induction of a current in a secondary coil by the starting or stopping of a current in the primary, that the interposition of "a plate of iron prevents it altogether," shows that the author has never tried the experiment.

On p. 30 is given a picture of the apparatus the author employs for ascertaining the laws of the production of a current in a coil by the insertion or withdrawal of a magnet. The magnet that is being moved has, judging from the figure, at least 1000 times the mass of the needle of the galvanometer, which is attached by two *very short* wires to the coil in which the current is induced. If an electrical artisan were to perform this experiment with the apparatus placed as in Fig. 17 of Dr. Fleming's book, he would probably ascertain the laws of magneto-electric induction with the same amount of accuracy as we once saw obtained at a lecture where the decisive, and applause-producing, swings of the galvanometer needle, on suddenly bringing up the magnet to the coil and removing it again, were certainly produced by the *direct* action of the magnet on the galvanometer needle, since it was observed at the close of the lecture that one of the wires going from the coil to the galvanometer had never been connected with the galvanometer terminal. And the same sort of criticism applies to Fig. 28, p. 57, representing the arrangement of apparatus for measuring the magnetization of the iron core of an electro-magnet by a current passing round its coil. The reader is told that the magnetometer, which is, of course, to be directly affected by the magnetism of the iron bar, is, for some reason unexplained in the book, to be put at a considerable distance from the bar, but he is not warned that the meter used for measuring the current passing round the electro-magnet (and which, of course, ought not to be directly affected by the magnetism of the bar) must on no account be placed, as in this figure, close to the powerful magnet.

On p. 32 the author says that a core of soft iron "acts like a lens, and concentrates or focusses more lines of force from the magnet on the primary coil through the aperture of the secondary." But this simile with a lens is but a repetition of an old error; a lens simply bends rays of light, and, so far from adding to the total amount of light, actually slightly diminishes this amount by absorption. A lens for light is like a funnel for a fluid, it directs the stream along a narrow channel, so that while the flow is on the whole diminished by friction the flow along a certain cross-section is much increased. But the insertion of an iron core into a coil traversed by a current vastly increases the *total* number of lines of force. The solenoid without the iron core is like a cistern with water in it which is being emptied with a pipe full of dirt, through which the water can only trickle; and the insertion of the iron core into the solenoid is like the cleaning out of the pipe, so that the stream of water now becomes vigorous and rapid. Even Dr. Fleming knocks his own simile on the head, for he states 27 pages further on, "The joint effect of the" (iron) "bar and coils is the sum of the effects of each separately." Fancy any-one saying that the joint effect of a lens and a candle was the sum of the effects of each separately.

We consider it archaic for Dr. Fleming to define the volt for practical men as the E.M.F. generated in one centimetre of wire moving with a velocity of one centimetre per second in a magnetic field of unit force. As well

[1] "Short Lectures to Electrical Artisans." 2nd Edition. By J. A. Fleming. (London: E. and F. N. Spon, 1888.)
"Absolute Measurements in Electricity and Magnetism." 2nd Edition. Revised and greatly Enlarged. By Andrew Gray. (London: Macmillan and Co., 1889.)
"The Theory and Practice of Absolute Measurements in Electricity and Magnetism." By Andrew Gray. (London: Macmillan and Co., 1888.)
"Electricity in Modern Life." By G. W. de Tunzelmann. (London: Walter Scott, 1889.)

might a kilogramme be defined for a French butcher as the weight of a cubic decimetre of distilled water at 4° C., and the butcher's business be absolutely stopped because he did not possess any distilled water and because the temperature of his shop was 20° and not 4° C. In fact, Lectures II. and III., although containing a large amount of valuable information, are professorial rather than practical.

On p. 74 a Ruhmkorff induction coil is correctly described, but in Fig. 36 on the same page the primary coil, with the vibrating interrupter and four cells in its circuit, is shown as consisting of many convolutions of fine wire, and the secondary of a few turns of thick wire. On p. 83 one centimetre is given as equal to 0·0328087 of a foot—that is, correct to *six significant figures*—while even in the second edition, "the call" for which "has afforded the opportunity to erase several typographical errors and to remove some other blemishes which had escaped notice and correction in the first edition," the previous statement is *immediately* followed by the announcement that one inch equals 2·500 centimetres, an equation which is only correct to *two significant figures*, the number expressed correctly to six significant figures being 2·53995. But why not use 2·5400, the value commonly adopted, and which is correct to four places of decimals? As a further example of the want of precision which runs through this book, it may be mentioned that on p. 9 a falling body acquires per second a velocity of 981 centimetres per second. Throughout the whole of p. 85, where the number is frequently mentioned, the body, as if a little tired, cannot get up a velocity of more than 980 centimetres a second. Proceeding, however, to the next page, the body, like the reader, turns over a new leaf, and hurries up its speed, for it acquires per second a velocity of 981 centimetres per second all through this page. Further on, however, in the book, the poor falling body gets tired again, for on p. 97 it cannot do more than the 980. On p. 87 we find the statement, "Hence one foot-pound = 1·356 *joules*, or one joule = ·7373 foot-pound," whereas a simple division shows that if the first part of the statement be correct, the second is not.

To say that "the work is numerically measured by the product of the displacement and the mean stress estimated in the direction of the displacement" is learned and academical, but might not the poor electrical artisan mix this up with the displacement of the factory hands that usually occurs when there is no stress of work?

On p. 99 it is stated that the "E.M.F. of Clark's cell = 1·435 true volt," but, as no indication has been given in this book that there is more than one volt, we are left in ignorance of the reason why the volts used to measure the E.M.F. of a Clark's cell have to be *so especially true*, and why 10^9 C.G.S. units, which is the volt that has been previously used, is not good enough for this sort of measurement. On looking in the index for the definition of the "Ohm British Association," we find ourselves referred to p. 136, and the reader is left to wonder what is a "B.A.U." of resistance used some forty pages previous to this. Similarly the "Legal Ohm" is spoken of and its value given in terms of a "B.A.U." thirty-seven pages before the reader is told what a "Legal Ohm" is. For this the arrangement of the book and not the index is, of course, to blame. And while on this subject we should like to point out that the indexes of scientific books appear to furnish a conclusive proof of the inherent modesty of scientific writers. Take up some large and important treatise, and turn to the index. There you are told that the book contains almost nothing. On the title-page the publisher may have indiscreetly added after the author's name line after line of small print enumerating the various scientific and unscientific societies to which the author belongs, but in the index all pretension to such a wide acquaintance with science is disclaimed. You may have a distinct recollection of reading in this very book many pages on some special subject, but rack your brains as you will to discover under what heading in the index this subject may have been entered, not a reference to it can you find. Accumulators, storage cells, transformers, the volt, voltmeters, &c., seemed likely subjects to be treated on in "Short Lectures to Electrical Artisans," but the index says no; and it is only by carefully reading through the book that you discover that it contains much valuable information on these very points. We would suggest to the writers of scientific treatises, and also to those who communicate scientific papers to learned societies, that the practical man of to-day cannot possibly afford the time to read through ninety-nine things that he does not want to know about, before he can light on the one thing regarding which he is searching for information.

In speaking of Messrs. Crompton and Kapp's meter, on p. 115, Dr. Fleming says:—

"The only difficulty which arises in connection with such an instrument as this, is the tendency of a long thin iron wire of this kind to retain strongly residual magnetism and fail to de-magnetize itself, but this effect would only prevent the return of the indicating needle to zero when the current was stopped, but would not prevent the instrument from giving a definite and fixed deflection corresponding to a definite and fixed current passing through the coils." It was no doubt a somewhat delicate task for Dr. Fleming when lecturing to Mr. Crompton's staff to fully criticize Mr. Crompton's meters, but since actual published experiments on some of these meters show that, for the low readings, the apparent value of a given current differs by as much as 10 per cent., depending on whether the current is ascending or descending, we fail to see how the scientific knowledge of any artisans can be improved by their being told that no such error exists.

Fig. 50, p. 122, showing the level of the columns of water in stand-pipes attached to a horizontal tube through which water is flowing, was never drawn from an actual apparatus. The author has forgotten that the water has not merely to flow through the horizontal tube A*a*, but through the much longer vertical tube CA, and therefore, there is a much greater difference of level between the height of the water in the cistern and in the first stand-pipe, *aa'*, than there is between the level in this stand-pipe and in the next, *bb'*. If Fig. 50 were correct, it would follow that when a battery of even *large internal resistance* was sending a considerable current the difference of potentials at its terminals was equal to the E.M.F. of the battery. Not merely, then, is this opportunity lost of explaining to the readers that the difference of potentials at the terminals of a battery may be very much less than the E.M.F., but the information conveyed by the diagram is actually contrary to fact.

The statement that "Storage cells for lighting purposes cease to give a useful discharge when the electromotive force falls below two volts" is hardly consistent with the fact that, when storage cells are discharged at the current that is considered quite safe by the Electrical Storage Power Company, the E.M.F. for nine-tenths of the period of the discharge is slightly below two volts.

We have said enough to show that, although the book called "Short Lectures to Electrical Artisans" is written by one who, from his University and factory experience, has a large amount of valuable information at his command, the second edition reads far too much like an uncorrected proof of the first edition; and instead of the statements it contains possessing weight because they are made in the book, there is an uneasy feeling when reading its pages that any statement may be wrong, and requires to be checked. We trust, however, that the sale of this, the second edition, may be large and rapid, so that the author may have an opportunity of shortly bringing out as a third edition a book more worthy of his acknowledged power.

"Absolute Measurements in Electricity and Magnetism," by Prof. A. Gray, is a most interesting book to read. It opens with a detailed description of Gauss's methods for determining the horizontal intensity of the earth's magnetism, and with an account of the results of the measurement of the variation, produced by a unit field, on the magnetic moments of steel magnets of different sizes tempered to different degrees of hardness. If it be desired to determine the magnetic moment of a bar-magnet as well as the horizontal intensity of the earth's magnetism, which is of course necessary when variations of the magnetic moment of a bar are in question, Gauss's methods are admirable. But if the value of H is all that is needed, then the simpler method of employing an earth inductor with a ballistic galvanometer, which is described on pp. 317-21, might well be employed. It would, therefore, have been well to give a reference to this method in the first two chapters, which are mainly devoted to the determination of H.

Next follows a concise statement of the various ways of defining the absolute current, and a fairly complete chapter on standard galvanometers. In Chapters IV. and V., and in Chapter XI., to which reference is made, there is given the ablest description of the dimensions of the electric and magnetic units that we have ever read. It is both correct and comprehensible, which is saying a very great deal for an exposition of a subject which, as usually explained, generally leaves even a thoughtful student semi-dazed as to whether the dimensions are the dimensions of the unit, or the dimensions of a quantity measured in the unit. Indeed, the early reports of the Electrical Standards Committee of the British Association were actually wrong on the very subject of dimensions, so that "v" was regularly defined as the ratio of the electrostatic to the electromagnetic unit of quantity instead of as the reciprocal of that expression.

The volt, ohm, ampere, coulomb, watt, and joule are also explained and defined in Chapter V., and Prof. Gray gives Sir W. Thomson's expression "activity" for the rate of doing work. He does not mention, however, that the equally short word "power" is regularly employed with this signification.

Chapter VI. is devoted to the laws of the currents sent by galvanic cells through single and parallel circuits, and through any branch of a network like that of the Wheatstone's bridge. A neat proof is given of the arrangement of a given number of cells that sends the greatest current through a fixed resistance, and the reader is very properly warned against confusing the arrangement which develops maximum power with the most economical arrangement.

In Chapter VII. we have a complete description of Sir William Thomson's meters, but, as the book is a scientific treatise (in fact, a very good scientific treatise) and not an instrument-maker's catalogue, we think that the author would have done himself more justice had he described, in addition, some of the other many forms of electric meters in common use at the present day for carrying out the same measurements. Further, in view of the large experience that the author of this book has probably had with Sir W. Thomson's meters, it would have been well had there been a description not merely of the advantages of these instruments, but also of their disadvantages, a subject no one would be more willing to discuss than the inventor himself. On pp. 133-35 is given a very simple proof of the ordinary formula for the quadrant electrometer, but the reader is not here warned that the formula may give an answer many per cent. wrong in practice. On p. 302 it is stated that this formula may be slightly wrong if the aluminium needle of the electrometer be not accurately adjusted relatively to the quadrants, but this, we fear, is rather misleading, since it is further stated that "if the needle hangs at its proper level, and is otherwise properly adjusted, and the quadrants are close, the equation may be taken as accurate enough for practical purposes," a conclusion regarding which we understand there is grave doubt. In this chapter the very important subject of calibrating instruments by the use of the silver or the copper voltameters is fully entered into. The large amount of valuable work done on this subject by the author's brother, Prof. T. Gray, of which a description is given, endows this chapter with an authoritative character.

Chapter VIII. commences with the construction and use of the various forms of Wheatstone's bridges, the description of the modes of using them, and hints as to the care of a resistance box. The methods for calibrating relatively and absolutely the wire of a bridge devised by Matthiessen and Hockin, Foster, T. Gray, and D. M. Lewis are discussed at length, and specimens given of the actual results obtained at University College, North Wales, by the use of these methods. The ingenious bridges, which have been arranged by Sir W. Thomson, Matthiessen and Hockin, Tait and T. Gray, for measuring very low resistances, are fully entered into, and the construction of standard coils, the measurement of high resistances, and of the resistance of a battery finish a chapter of especial interest. The method of measuring the resistance of a battery, proposed several years ago by Sir Henry Mance, is condemned by Prof. Gray as being "so troublesome as to be practically useless," on account of "the variation of the effective electromotive force of the cell produced by alteration of the current through the cell which takes place when the key is depressed." We think that it should have been stated that this is not a defect especially of Mance's method, but of *all* methods for measuring the resistance of a battery based on the alteration of a steady current by the alteration of the resistance in the battery circuit. Would it not also here have been well to describe and discuss the condenser method of measuring a battery resistance, as it is the one to which the fewest objections can be raised?

Good as are all the chapters in this book, the next one, Chapter IX., on "The Measurement of Energy in Electric Circuits," is so good that it takes the palm. It commences with the practical methods of measuring the power and efficiency of motors and secondary batteries; the construction and employment of activity meters (watt-meters); and then discusses very fully the laws of alternate currents, the mathematical theory of alternate current generators singly, or coupled in parallel or in series; the theory of the action of an alternate current generator supplying current to an alternate current motor; the true method of measuring the power given to any circuit by an alternate current; and the error produced when an ordinary watt-meter is employed. The work of Joubert, Hopkinson, Potier, Ayrton and Perry, and Mordey on this subject is summed up in a masterly fashion. Chapter IX. is, in fact, the most complete exposition of many problems connected with the all-important subject—the electrical transmission of energy by *alternate* currents—that is to be found in any existing text-book, and especially in a small octavo text-book, that can be easily carried in one's coat pocket.

In Chapter X. the measurement of intense magnetic fields is dealt with, and a description is given of ingenious methods proposed by Sir W. Thomson for measuring the force on a conductor conveying a known current placed in the magnetic field, and so determining the strength of the field. The ordinary method of ascertaining the strength of a magnetic field by suddenly withdrawing a coil, of known area and number of convolutions, attached to a ballistic galvanometer, is described. But in order to ascertain the constant of the ballistic galvanometer, the author only gives the old method of observing the swing of the needle when a large coil is turned in the earth's field, a method which necessarily requires for its employment a previous knowledge of the strength of the earth's field at the place. A far simpler method of ascertaining the constant of a ballistic galvanometer is to charge a condenser of known capacity with one or more Clark's cells, of which the E.M.F. at any ordinary temperature is now well known, and discharge the condenser through the ballistic galvanometer; or, if a sufficiently delicate ampere-meter be available, the ballistic galvanometer may be very accurately calibrated for steady currents, and then its constant for a sudden discharge is at once known by simply measuring, in addition, the periodic time of vibration of the needle and its logarithmic decrement.

The book concludes with an appendix giving the decisions arrived at in 1886 by the Electrical Standards Committee of the British Association, and the further resolutions which were passed at the meeting of the Electrical Congress in Paris last year, and subsequently agreed to by the British Association Committee. Then follow twelve sets of useful tables.

Although we have made a few suggestions that the author may perhaps like to adopt in publishing the third edition of his "Absolute Measurements in Electricity and Magnetism," we desire to emphasize our warm appreciation of this the second edition. On every page may be seen evidences of the firm grip of the subject so characteristic of the author's teacher—the teacher, in fact, of us all—Sir William Thomson; and did we know of higher praise than this we would give it.

"The Theory and Practice of Absolute Measurements in Electricity and Magnetism, Vol. I.," also by Prof. A. Gray, is a mathematical expansion of the *electrical* portion of his book on "Absolute Measurements, &c.," the mathematical treatment of the *magnetic* portion being reserved for Vol. II. of the larger work. As many of the remarks that we have already made regarding the smaller work apply equally well to the larger, it is unnecessary to criticize the larger book at any considerable length. The two books may be read quite independently of one another, since much of the descriptive matter is the same in both. If there be a fault in the larger work, we think that it arises from the author forgetting that a book intended initially for the University student can also be made of great value to the more practical electrician if first the subject-matter be arranged in propositions, or with distinct headings to the paragraphs, so that it is easy to find the proof of any particular fact; and, secondly, if complete proofs be given of important practical problems, instead of simply deducing them as special cases of more general problems. For example, a practical electrician may desire to see how the logarithmic formula for the capacity of a cable is arrived at. Now, there is no difficulty in giving a fairly short complete proof of this; but, on turning to Prof. Gray's "Theory and Practice, &c.," the electrician finds that he must first master the theory of charged ellipsoids; he sees several double integrals and several lines of long mathematical formula in small print, and he probably decides that he had better pass by that subject for the present. We hold that, since the pure science of electricity owes so much to its practical development, it is but fair that the pure mathematician should endeavour to repay this debt by stating his results and methods of proof in such a form that they can be most easily grasped by anyone who desires to use them, and not merely to get up the subject for examination purposes. The general mathematical investigations are also, of course, of great value, and we are therefore glad to see in this book a fairly complete mathematical treatment of Green's theorem, inverse problems, electric images, problems of steady flow in non-linear conductor, and variable linear flow, with its application to the speed of signalling in submarine conductors.

Very interesting information is given regarding the strength and torsional rigidity of the fine silk fibres used in suspending galvanometer needles, followed by the mathematical theory of oscillations, the description of the practical methods of measuring periodic times of oscillation and moments of inertia, and concluding with a comparison of unifilar and bifilar suspensions. The succeeding chapters on electrometers, the general measurement of resistance, the calibration of the wire of a metre bridge, the measurement of very low resistances, the measurement of very high resistances, the determination of specific resistance, contain what is given on these subjects in the smaller book amplified.

The last chapter, No. VIII., in this larger treatise, on capacity, is very complete. It gives a description of the most important investigations that have been made on the specific inductive capacity of solids, liquids, and gases, together with the mathematical theory of each experiment.

Although we cannot but feel that the smaller of the two books published by Prof. A. Gray is the more unique, the larger is a very creditable production, and will be valuable as a book of reference for those who desire to consult a shorter book on mathematical electricity than that of Messrs. Mascart and Joubert.

We now come now to the fourth book, "Electricity in Modern Life," by Mr. de Tunzelmann, which is written on an excellent basis, and contains a great deal of useful popular information, but it unfortunately also contains many unnecessary errors. For example, the statement on p. 11, that "a single cell of this kind," potash bichromate, "holding about a quart of solution, is capable of maintaining the light of a small incandescent lamp for some three or four hours," would rather disappoint a purchaser of a quart, or any size, bichromate cell, as he would find it most difficult to purchase an incandescent lamp that would glow with so small a difference of potential as *one* cell could produce. Again, to say in Chapter II., on "What we Know about Magnetism," "Weber's theory of magnetism may now be considered as raised from the rank of an hypothesis to that of an established fact," gives a totally wrong idea as regards our knowledge, or, rather, as regards our ignorance, of the mechanism of magnetism. "The face of the magnet that before pointed to the north," &c., is not exactly wrong; but can a face point towards anything? "If a current goes round the solenoid in the direction of the hands of a watch with its face directed towards the end from which the current flows, the end of the steel bar within the end of the solenoid at which the current leaves will be found to be a north pole and the other end a south pole," would lead the reader to imagine that the polarity of the core of an electromagnet depended partly on the direction in which the current flows *parallel* to the core, instead of depending, as is the fact, wholly on the way it flows *round* the core.

Chapter IV., on "Force, Work, and Power," is good, and the careful distinction drawn between work and power is forcible and apt. But why does the author limit the definition of a horse-power, 33,000 pounds raised 1 foot per minute, to the "indicated horse-power" of a steam-engine.

Chapter V. deals with the "Sources of Electricity." In describing the chemical action of a galvanic cell formed "of a plate of zinc and a plate of copper partly immersed in sulphuric acid," it is an obvious mistake to speak of the action as a simple liberation of hydrogen at the copper plate, and oxygen at the zinc, and to omit all reference to the formation of zinc sulphate. The first part of the following statement has been experimentally disproved some fifteen years ago:—"If either the copper or zinc is immersed alone in dilute sulphuric acid, a difference of potential will be produced between the metal and the liquid; but if the two metals are immersed side by side into the liquid, then no electrification can be detected." A galvanic battery is defined by the author as "a series of galvanic cells so arranged that the zinc of each cell is connected with the copper of the next cell." What, then, is a collection of galvanic cells arranged in parallel, in which the zinc of every cell is connected with the zinc and not with the copper of the next? Excluding these mistakes, this chapter is fairly good; the matter, however, is rather too condensed to be intelligible to a reader not previously acquainted with the subject.

Chapter VI. deals with "Magnetic Fields," and in order to lead up to the mapping out of a magnetic field, the mapping out of the gravitation field of force in which a comet moves is first explained. But it appears to us that, since the magnetic field can be easily mapped out with iron filings in the well-known way, while the conception of a gravitation field of force is a less simple matter to grasp, Mr. de Tunzelmann has in this case explained the easy by means of the difficult.

The next chapter, on "Electrical Measurement," is quite correct, but, in view of the great difficulty that is always experienced by a beginner in grasping the idea of measuring so intangible a thing as electricity, would not this subject have been made clearer if not merely the scientific definitions of the electrical units had been given, but in addition an illustrated description of the meters used to measure amperes, volts, &c.?

Chapter VII., on "Magneto and Dynamo Electric Machines," gives a short comprehensive description of the principles of these machines, but, in order that the reader might understand what a real dynamo was like, we think it would have been better if the author had given in this chapter at least some one of the illustrations representing real dynamos which appear in other parts of this book. The symbolical figures that are given are, as the author mentions, taken from Dr. Thompson's book on dynamo machinery, and are very clear, with one exception, that while in each case the direction of the current in the wires attached to the brushes is indicated by arrows, the direction in which the wire is coiled on the armature is omitted, hence such statements as "the arrows show the current in the circuit when the armature revolves as indicated by the position of the brushes," are just as likely to be wrong as right, and tell the reader nothing. When comparing the series dynamo with the shunt dynamo, the author says that the former "will not begin to excite itself until a certain speed has been obtained depending on the resistance of the circuit." From this the reader might easily be misled into thinking that the shunt machine did not possess a similar defect. Further, he states, as "the principal objection to shunt-wound machines," that the self-induction of the field-magnet coils leads to the result that "any variation in the speed produces its effect upon the lamps before the current in the existing circuit has had time to undergo a sensible change." But, as a matter of fact, the self-induction of the field-magnet coils of a shunt machine is an *advantage*, not a *disadvantage*; for suppose that the speed increases, then the E.M.F. increases, this causes the difference of potentials between the lamp-mains to increase, which not only sends a larger current through the lamps, but also through the shunt coils. This strengthening of the field causes an additional rise in the E.M.F. of the machine, and therefore in the terminal difference of potentials. Consequently the second objectionable rise is hindered, and not accelerated, by the self-induction of the shunt coils; hence self-induction of the field-magnet coils of a shunt machine makes the difference of potentials between the lamp-mains less quickly, and not more quickly, affected by a change in the speed of driving. In speaking of alternate-current dynamos, it is stated that "in some machines the armature remains at rest, and the field-magnets are made to rotate; and in this case no sliding contact is required, the terminals of the main circuit being attached permanently to the armature." But the statement is misleading, since at least one sliding contact must *always* be used; only when the armature is fixed it is to lead the exciting current into and out of the rotating field-magnets that one, and in some cases two sliding contacts are employed.

Chapters IX., X., and XI., on "The Story of the Telegraph," "Overland Telegraphs," and on "Submarine Telegraphs," are excellent, we may almost say exciting, and they lead the reader on like the pages of a well-written novel. It is not right, however, on p. 112 to say, when speaking of telegraphing with sounders, "The dots are formed by giving a sharp stroke to the key; the dashes by depressing it more slowly," since a dash is formed not by depressing the key slowly, but by holding it down for a time when depressed. Whether a key be depressed slowly or quickly makes no difference in the signal received; what the receiver listens for is the interval between the commencement of the current produced when the key is fully depressed and its termination when the key is caused to begin to rise again. We presume that when the author says, on p. 129, "The cups" of insulators "are made of such a form as to expose the upper portions freely to the cleansing action of the rain while the lower portions are shielded from the rain so as to keep them fairly dry," he means by "upper portions" the *outside* of the cup of the insulator, and by the "lower portions" the *inside*; but if so, he has a curious way of expressing himself. The "speaking galvanometer" used in receiving the message sent through a submarine cable is not, as the author describes it on p. 150, an astatic galvanometer; and even if two magnets were employed so as to form an astatic combination, it would be quite wrong to say "each of them is attached to the back of a small mirror," since, unnecessary as it would be to use two suspended magnets in a speaking galvanometer, it would be still more useless to employ two suspended mirrors. But these are not very serious errors in chapters that are so good.

Chapters XII. and XIII., on "The Telephone" and "The Telephone Exchange System," appear to us to be too much of the newspaper special correspondent order, the descriptions in several cases being very meagre, suggestive rather than descriptive, in consequence of the author having attempted to touch on too many different things. For instance, if the photophone had to be described at all, it required more than one page and a quarter, inclusive of the illustration, to make it intelligible; in fact, unless the framework of the telephones and the gentleman's head which is between them in Fig. 53 are all composed of electrically conducting material, we fail to see how the instrument, as there depicted, works at all. Some very interesting information is given on the subject of telephone exchanges, and we should have liked to have had much more information on this electrical subject; for example, greater details regarding the switches, the reasons of the babble of many conversations that everyone hears who tries to use the telephone in London, &c.; space, if necessary, being economized by the omission of the description of the non-electrical instruments, the graphophone and phonograph.

Chapter XIV., on the "Distribution and Storage of Electrical Energy," is very good and forcible. We fail, however, to see how the use of the three-wire system leads to the result stated on p. 199, that "a variation of 5 per cent. in the E.M.F. in the mains would produce a variation of only $2\frac{1}{2}$ per cent. at the lamp terminals."

The next chapter, XV., on "Electric Lighting," is also very good; "flashing" the filament of an incandescent lamp, however, does not mean sending a current through the filament while the lamp is attached to the Sprengel pump, but sending a current through the filament and making the filament incandescent when in a hydrocarbon atmosphere before it is placed inside the glass bulb of the lamp. Is it a fact that "the Shaftesbury theatre" is "now lighted by incandescent electric lamps?"

The chapter on "Electro-Motors and their Uses" is good considering how much may be said on this subject and how short a space is 14 pages to say it in. By what means, however, Messrs. Immisch have succeeded in making the dogcart for the Sultan of Turkey go "ten miles an hour for about five hours" by means of "twenty-four small accumulators which weigh about seven hundredweight" we are at a loss to conceive, since the weight of accumulators, according to our calculation, must be much greater than this in order that they may have anything like a reasonably long life.

Chapter XVII., on "Electro-Metallurgy," is interesting although very brief, but the descriptions of the electrical circuit-closers for torpedoes in the next chapter, on "Electricity in Warfare," we find too short to be intelligible. A chapter of 5 pages then follows on "Medical Electricity," and another chapter of the same length on "Miscellaneous Applications of Electricity," in which a very interesting account is given of the electrical method employed in America for protecting furnished dwelling-houses that have been left locked up during the absence of the tenants.

On closing this book one certainly cannot deny that one has had one's money's worth, even if the entertainment has been of the "variety order" so characteristic of the amusements of the present day. If a member of the general public will read the book right through, as we have done, he may perhaps feel with exultation that he has mastered the whole subject of electrical engineering; indeed, even a well-trained electrician can learn from it many things that he did not know before, concerning those branches of the subject to which he has not given special attention. But we fear that, if even a general reader were to turn up any particular subject to study in detail, he would probably wish he had been told a good deal more about what was most important, and not so much about everything electrical whether important or not. The best features of "Electricity in Modern Life" are the many interesting scientific narratives, in the writing of which Mr. de Tunzelmann appears to excel; the worst are the mistakes in the science, which more knowledge, or more care, ought to have eliminated.

ON THE TENSION OF RECENTLY FORMED LIQUID SURFACES.[1]

IT has long been a mystery why a few liquids, such as solutions of soap and saponine, should stand so far in advance of others in regard to their capability of extension into large and tolerably durable laminæ. The subject was specially considered by Plateau in his valuable researches, but with results which cannot be regarded as wholly satisfactory. In his view the question is one of the ratio between capillary tension and superficial viscosity. Some of the facts adduced certainly favour a connection between the phenomena attributed to the latter property and capability of extension; but the "superficial viscosity" is not clearly defined, and itself stands in need of explanation.

It appears to me that there is much to be said in favour of the suggestion of Marangoni ("Nuovo Cimento," vols. v.–vi., 1871, p. 239), to the effect that both capability of extension and so-called superficial viscosity are due to the presence upon the body of the liquid of a coating or pellicle composed of matter whose inherent capillary force is less than that of the mass. By means of variations in this coating, Marangoni explains the indisputable fact that in vertical soap films the effective tension is different at various levels. Were the tension rigorously constant, as it is sometimes inadvertently stated to be, gravity would inevitably assert itself, and the central parts would fall 16 feet in the first second of time. By a self-acting adjustment the coating will everywhere assume such thickness as to afford the necessary tension, and thus any part of the film, considered without distinction of its various layers, is in equilibrium. There is nothing, however, to prevent the interior layers of a moderately thick film from draining down. But this motion, taking place as it were between two fixed walls, is comparatively slow, being much impeded by ordinary fluid viscosity.

In the case of soap, the formation of the pellicle is attributed by Marangoni to the action of atmospheric carbonic acid, liberating the fatty acid from its combination with alkali. On the other hand, Sondhauss (*Poggendorff's Annalen*, Ergänzungsband viii., 1878, p. 266) found that the properties of the liquid, and the films themselves, are better conserved when the atmosphere is excluded by hydrogen; and I have myself observed a rapid deterioration of very dilute solutions of oleate of soda when exposed to the air. In this case a remedy may be found in the addition of caustic potash. It is to be observed, moreover, that, as has long been known, the capillary forces are themselves quite capable of overcoming weak chemical affinities, and will operate in the direction required.

A strong argument in favour of Marangoni's theory is afforded by his observation,[1] that within very wide limits the superficial tension of soap solutions, as determined by capillary tubes, is almost independent of the strength. My purpose in this note is to put forward some new facts tending strongly to the same conclusion.

It occurred to me that, if the low tension of soap solutions as compared with pure water was due to a coating, the formation of this coating would be a matter of time, and that a test might be found in the examination of the properties of the liquid surface immediately after its formation. The experimental problem here suggested may seem difficult or impossible; but it was, in fact, solved some years ago in the course of researches upon the capillary phenomena of jets (Roy. Soc. Proc., May 15, 1879). A jet of liquid issuing under moderate pressure from an elongated, *e.g.* elliptical, aperture perforated in a thin plate, assumes a chain-like appearance, the complete period, λ, corresponding to two links of the chain, being the distance travelled over by a given part of the liquid in the time occupied by a complete transverse vibration of the column about its cylindrical configuration of equilibrium. Since the phase of vibration depends upon the time elapsed, it is always the same at the same point in space, and thus the motion is *steady* in the hydrodynamical sense, and the boundary of the jet is a fixed surface. Measurements of λ under a given head, or velocity, determine the time of vibration, and from this, when the density of the liquid and the diameter of the column are known, follows in its turn the value of the capillary tension (T) to which the vibrations are due. *Cæteris paribus*, $T \propto \lambda^{-2}$; and this relation, which is very easily proved, is all that is needed for our purpose. If we wish to see whether a moderate addition of soap alters the capillary tension of water, we have only to compare the wave-lengths λ in the two cases, using the same aperture and head. By this method the liquid surface may be tested before it is $\frac{1}{100}$ second old.

Since it was necessary to be able to work with moderate quantities of liquid, the elliptical aperture had to be rather fine, about 2 mm. by 1 mm. The reservoir was an ordinary flask, 8 cm. in diameter, to which was sealed below as a prolongation a (1 cm.) tube bent at right angles (Figs. 1, 2). The aperture was perforated in thin sheet brass, attached to the tube by cement. It was about 15 cm. below the mark, near the middle of the flask, which defined the position of the free surface at the time of observation.

[1] A Paper read by Lord Rayleigh, Sec.R.S., before the Royal Society, on March 6.

[1] *Poggendorff's Annalen*, vol. cxliii., 1871, p. 342. The original pamphlet dates from 1865.