Review VIII.

1. *Traité des Applications de l'Electricité à la Thérapeutique Médicale et Chirurgicale.* Par A. Becquerel, Médecin de l'Hôpital de la Pitié, &c.—*Paris,* 1857.

Treatise on the Application of Electricity to Medical and Surgical Therapeutics. By A. Becquerel.—*Paris,* 1857.

2. *Die Electricität in der Medicin.* Studien von D. Hugo Ziemssen. Privat-Docent und Assistenz-arzt an der Medicinischen Klinik zu Greifswald. *Berlin,* 1857.

Electricity in Medicine. Studies by Dr. Hugo Ziemssen.—*Berlin,* 1857.

3. *Ueber das Hemmungs-Nerven-System für die peristaltischen Bewegungen der Gedärme.* Von Dr. Edward Pflüger.—*Berlin,* 1857.

Upon the Inhibitory Nervous-System for the Peristaltic Movements of the Intestines. By Dr. Edward Pflüger.—*Berlin,* 1857.

4. *Preliminary Account of an Inquiry into the Functions of the Visceral Nerves, with special reference to the so-called "Inhibitory System."* By Joseph Lister, F.R.C.S., Eng. and Edin. ('Proceedings of the Royal Society of London; vol. ix. No. 32.')

5. *Epilepsy and other Convulsive Affections, their Pathology and Treatment.* By Charles Bland Radcliffe, M.D. F.R.C.P. *Preliminary Considerations respecting the Physiology of Muscular Motion.—London,* 1858.

6. *Ueber Methodische Electrisirung gelähmter Muskeln.* Von Dr. R. Remak.—*Berlin,* 1845.

Upon methodical Electrification of Paralysed Muscles. By Dr. Remak. Revised by Duchenne, in Schmidt's 'Jahrbücher, 1856. Bd. 89. p. 250.')*

7. *On the Therapeutical Action of the Constant Galvanic Current.* By Dr. Robert Remak. ('Medical Times and Gazette, May 8, 1848.')

8. *Bericht über medicinische Electricität.* Von Dr. H. E. Richter, und Dr. B. A. Godmann. ('Schmidt's Jahrbücher, Bd. 94, Heft i. p. 97.')

Review of Medicinal Electricity. By Drs. Richter and Godmann.

9. *Recherches Expérimentales sur la Possibilité du Passage à travers le Centre Nerveux, de Courants Electro-Magnetiques appliqués à la Peau, chez l'Homme.* Par M. F. Bonnefin. ('Journal de la Physiologie, tom. i. No. 3.')

* We much regret that an important work by Dr. Remak, entitled, 'Galvano Therapie der Nerven und Muskel-krankheiten' (Berlin, 1858), has reached us too late to be noticed in the present article. Ed.

Experimental Researches upon the possibility of Passing Electro-Magnetic Currents through the Nervous Centres of Man, by means of their application to the Skin. By M. F. BONNEFIN. ('Journal of Physiology, edited by Dr. BROWN SÉQUARD. No. 3.')

10. *On Local Anæsthesia and Electricity.* By BENJAMIN W. RICHARDSON, M.D., &c. ('Medical Times and Gazette, September 11, 1858.')
11. *On the Treatment of Paralysis by Electricity.* By J. ALTHAUS, M.D. ('Medical Times and Gazette, December 26, 1857.')
12. *On Localized Galvanism, applied to the Treatment of Paralysis and Muscular Extractions.* By RICHARD MOORE LAWRANCE, M.D. —*London*, 1858.

IF, jealous for its reputation as a therapeutic agent, electricity could just now become articulate, its earnest cry would be, "Save me from my friends!" Rescued, but a few years ago, from comparative poverty, obscurity, and disgrace, by the praiseworthy exertions of Golding Bird, Duchenne, and Richter, it advanced under the guardianship of these and like-minded men until it found itself not only in good society, but enjoying a somewhat proud position in the apparatus medicus of England, Germany, and France. But, so soon as it had attained this eminence, and attracted the regard of the general community, numbers of men, who, judging from their own works, were unable to observe correctly or think wisely, gathered round the popular novelty; with a grand flourish of brazen trumpets announced themselves its protectors, and issued proclamations, in the form of worthless books, that this mighty agent, under the guidance of their mightier selves, not only would, but had healed all and every one of the "thousand natural shocks that flesh is heir to." From such vain pretension nothing but disappointment and disgust could follow, and already the tide of popularity is turning. Electricity cannot do what these, its so-called "friends," have asserted that it can; and, despite its manifold powers for good, it is in danger of being again regarded as a quackery, and condemned to another period of obscurity and neglect.

In France there are treatises on Electricity "appliquée au traitement curatif des nevralgies, des rhumatismes, des paralysies, des tumeurs, &c., et en général des affections morbides, souvent reputées incurables;"* and in Germany there are similar productions, written, as Richter says, in "halb-populärer echt-französisch floskel-reicher Weise," while in our own country there are individuals who write works for the purpose of instructing the profession and the public in the theory and practice of electric therapeutics, but manifest a lamentable want of acquaintance with some of the first principles of physical and physiological science. The unqualified laudation which this valuable agent receives at the hands of such writers is not likely to secure to it a permanent place in our *materia medica.*

Convinced of the great utility of a well-applied electricity in properly selected cases, it is with earnestness that we protest against its

* By M. Briand.

ruthless and quack-like advertisement as a panacea, and shall endeavour, in the following article, to point out its real physiological effects, its true therapeutic position, and the best modes for its application.

Within the last ten years two articles on the employment of electricity in medicine have made their appearance in this journal. In the first of them* the researches of Dr. Golding Bird, Mr. Donovan, and others, were brought under review; and in the second† an account was given of the then recent labours of Duchenne, Meyer, Guitard, and Richter; we shall not, therefore, in the present article, revert further to those positions which we considered established in the year 1855, but shall confine our remarks to the history of electricity, and especially as a therapeutic agent, since that period.

Those effects of electricity which may be termed "physiologic," differ widely in their character; their variety being dependent upon two classes of conditions, one appertaining to the electricity, the other to the organism.

As to the conditions inherent in the electricity, we must notice the quantity, intensity, and mode of transmission of the currents, each of which influences the physiologic effect.

The quantity of electricity is dependent, theoretically, upon the number of polar chains that can be established at the same time in a particular voltaic arrangement; and is determined, practically, by the size of the positive plate, and the relatively larger size of the negative. Other conditions affect the quantity of electricity, but do so only to a trifling degree. Now, although variations in the quantity of electricity occasion corresponding variations in its physiologic effects, the latter are, for the most part, brought about indirectly; *i.e.*, through the intervention of some other changes, either thermal or chemical, which come between the electric force and the vital or physiologic result. Thus, the amount of heat generated in a wire connecting the two poles of a battery is in direct proportion to the size of the positive plate, or to the quantity of electricity evolved; and therefore, when an apparatus of such kind as to yield a large quantity is employed, a very painful amount of caloric is produced, which not only modifies the physiologic effects, but complicates and renders difficult the therapeutical application. Again, the amount of chemical decomposition which is produced by a voltaic apparatus, is determined by the quantity of electricity, or the number of polar chains which can be established; and this amount is sometimes so great that tissues are acted upon chemically, and their proper vital functions held in abeyance. A very strong current, as Bernard has shown, may destroy the property of a nerve, by acting chemically upon its tissue, thus producing a condition which differs entirely from that of exhaustion by a direct continuous current; for under the latter circumstances the inverse current restores the property, whereas in the former it is impossible to restore it.

Thus, the employment of electricity in too large quantity determines two classes of result which modify the physiologic effects—on the one

* Med. Chir. Rev. vol. iii. p. 373, 1849. † Med. Chir. Rev., No. xxix. p. 138, 1855.

hand the phenomena of sensation are deranged by the caloric produced; and on the other, nervous properties, of any kind, may be destroyed by chemical decomposition of the tissue. There are circumstances, however, in which both the thermal and chemical effects of galvanism are needed, such as the employment of the cautery, the coagulation of blood in an aneurysmal sac, the attempted solution of calculi, or the extraction of metallic poisons from the body; and as under all these circumstances a large quantity of electricity is required, the choice of instruments for such operations will be determined by their fulfilling that condition of supply.

The degree of tension, or intensity of the electric current, is, however, more influential than its quantity in determining physiological results; and it is to variations in this quality that we ordinarily apply the terms "strong" and "weak." There are several currents in common use for physiological experiment and therapeutical exhibition; and as this quality of tension or intensity is predicated of all of them, it is necessary that we should describe separately the conditions upon which its variations depend. But before doing so, inasmuch as some confusion has crept into the language of modern electricians, we will state as concisely as possible what these several currents are, what are their proper names, and in what way they have been erroneously designated.

In the wire which unites the two poles of a voltaic arrangement,—whether this consists of one pair of plates, or of one hundred pairs,—there is, when the wire is unbroken, a current of electricity, termed the "*initial current.*" This passes in the direction from the copper or negative metal, through the wire, to the zinc or positive plate. If this wire is broken, and the two ends of it are grasped by the hands, the individual so doing, becomes in that part of his body which intervenes between those two ends, a part of the voltaic apparatus; and the initial current passes through him in the direction described. If this wire, in any part of its course, be broken, there is at the moment of division, and existing at that moment only, another current setting in the opposite direction to that taken by the initial current. This has received various names: Duchenne has termed it an "induced current of the first order," but its proper designation is the "*extra-current.*"

Another wire placed near and parallel to the conducting wire,—viz., that through which the initial current passes,—has its polar condition so affected that an "*induced current*" is propagated through it in an opposite direction to the initial current. Several of such wires may be employed, at different degrees of proximity to the conducting wire, and in all of them there is an induced current, that which is nearest to the conducting wire being called the "*induced current of the first order,*" the next of "*the second order,*" and so on.

The currents employed by M. Duchenne, and about the different properties of which so much has been said and written, are the "extra-current" in the conducting wire, and an "induced current of the first order," in a parallel wire; and M. Becquerel states, that for

Duchenne to designate them induced currents of the first and second order respectively :—" c'est créer . . . un langage tout à fait different de celui qui est employé par tous les physiciens" (p. 89).

The most striking differences between these various currents are to be referred to their degree of intensity, and this is determined by different conditions, of which the following are the most important. The "initial current" is intense in proportion to the number of the active cells in the battery, the nature of the electrolytes employed, and the integrity of conducting material throughout the whole circuit. The force of the "extra-current" is determined by the same circumstances; but that of the "induced currents" depends partly upon these, and also upon other conditions—viz., the size of the wire, the length of it which is brought into proximity with the conducting wire, and the presence and degree of additional magneto-electric induction. *Cœteris paribus*, the finer the wire and the greater its length the more intense is the induction.

In order to obtain great, and at the same time convenient, length of the wires, they are twisted into the form of a hollow spiral, or helix, the latter becoming, in itself, endowed with magnetic properties, one end of the helix being a north and the other a south pole. If into the hollow of this spiral or helix there are introduced bars of soft iron or steel, these bars become magnetic by induction; and thus the electrical force, developed in the battery cells by chemical action, becomes resolved into the correlated force of magnetism. But precisely the reverse order of induction may take place in another apparatus, and the "lifter" of a permanent magnet, around which a copper wire is twisted spirally, at the instant that it becomes a magnet by induction, from contact with the poles of the permanent magnet, developes chemico-polarity, or electricity in the copper wire. The former arrangement is termed "electro-magnetic," the latter "magneto-electric;" in the one, electricity is developed from chemical decomposition, in the other, from magnetism; but in the former—inasmuch as magnetism is induced by the initial current—there is in addition to the "primary induced current," that order of induction which exists alone in the latter, and the addition of this is one mode of augmenting the intensity of the current.

Thus, then, the initial current developes magnetism in the bars of soft iron which are inserted into the hollow of its helix, and the presence of magnetism in these bars, at the moment of its induction, developes an electrical current in the copper wires; the intensity of the latter induced current, being, *cœteris paribus*, in proportion to the size of the temporary magnet, and determined or regulated by the length to which these soft bars are inserted in the helix. The tension, therefore, of the induced current depends upon that of the initial current, upon the size of the wire, upon its length—i.e., upon the number of turns in the spiral—and upon the force of magnetism temporarily developed in the bars of soft iron.

Whatever form of current is employed, the nature and degree of its physiologic effects—i.e. of its power to occasion vital phenomena, as

distinct from chemical and thermal—are determined mainly by differences in this quality of tension. Generally speaking, a weak current produces feeble contractions of the muscles, and slight effects upon the organs of sensation; whereas a powerful current produces strong contractions and violent sensations. Both sensory and motor phenomena may be occasioned by the application of any one of these currents, but their variations in intensity render some more useful for one class of effects, and others for a second class. Thus, Duchenne has drawn considerable attention to the fact that the "extra-current" acts very readily on the muscles, and that the "induced current" affects more powerfully than the extra-current, the skin, nerves and retina. This difference of action he refers to a special elective power on the part of the two currents respectively; but Becquerel has proved that, in reality, it is merely dependent upon the difference of their intensity, the induced current having much greater tension than the extra-current. M. Becquerel has shown, by a simple experiment, in which he modifies the arrangement of the wires, that the effects which Duchenne attributes to the one current may be obtained from the other, and *vice versâ*, p. 90.

In proportion to the intensity of the current employed, electricity has the power of evoking the ordinary physiologic action of a nerve or muscle; of occasioning excessive and perverted action; of exhausting the functional activity for a time; or of destroying it altogether. In the first degree there is sensation or motion, each of these being within the limits of physiologic function; thus, luminous appearances, gentle sounds, gustatory effects, &c., on the one hand, and slight muscular contraction on the other,—contraction so slight as merely to exhibit the persistence of muscular contractility, and not to test its power,—are the results of applying an electric current of low intensity. If a stronger current is employed, the impressions upon the sensory organs become excessive in degree and painful in character; while, in the place of gentle muscular contraction, there is distressing cramp, or arrested (inhibited) action in certain organs. A still more violent current exhausts both nerve and muscle; and here sensation and contraction, though for a time withdrawn, are capable of being restored by repose, or by the inverted current; whereas the electricity may be so powerful as at once to put an end to the vitality of the tissues—i.e. to kill the nerve, limb, or individual through which it passes.

It is owing to these different effects of variations in intensity that electricity may be employed both physiologically and therapeutically for so many different purposes. As a test of irritability, or a gentle stimulus of weakened sensibility and contractility, the current of low intensity may be employed. For the sake of displaying the inhibiting influence of the vagi and the splanchnic nerves, or for awakening the torpid nervous centres of an individual poisoned by opium or alcohol, a more powerful current is required. Whereas for the relief of excessive muscular contraction, or of neuralgia, a still more intense current, one that shall temporarily exhaust the nervous function, may be employed.

Besides the quantity and tension of a current, the mode of its transmission exerts a notable influence upon its physiologic effects. Under this head we place the different actions of the continuous and interrupted currents; and with regard to the former, the changes produced by altering their direction; and with regard to the latter, their convection by means of moist or dry conductors, the rapidity or slowness of their interruption, and the degree of pressure with which the conductors are applied.

The most general differences between the effects of the continuous and interrupted current, are displayed very simply by an arrangement of M. Claude Bernard's, in which there are introduced into the same current from a small Cruickshank's battery; 1st, the nerve of a frog's leg, and 2nd, a delicate voltameter; the apparatus being so constructed that the current may be either continuous or intermittent. By this arrangement, says M. Bernard, it is shown that—

"so long as the current is continuous, chemical effects are produced, and the physiological effects are 'nuls,' or at all events inappreciable. The facts are, that the water in the voltameter is decomposed by the current, whilst the limb of the frog remains perfectly motionless. But immediately that, by means of the interrupter, the current is rendered intermittent, everything is changed; the decomposition of water ceases in the voltameter, and the frog's limb becomes violently convulsed."*

But this experiment, although it illustrates very aptly the broadly marked difference between the effects of the continuous and intermittent current, by no means exhausts the subject of that difference, nor does it accurately represent all the facts. For the continuous current is not devoid of physiologic action, nor is the interrupted, under all circumstances, incapable of acting chemically. True, there is no visible contraction of the frog's leg, but under certain conditions the irritability of the nerve is exhausted, and under others it becomes increased. True, there is no sign of sensation in an amputated frog's leg, but the continuous current can produce sensory effects; for the proof of which let any one pass a continuous current through his tongue, or eyeballs; or, as Purkinje did, through the ears.† And, further, it is quite easy to produce permanent, *i.e.* tonic contraction of a muscle or group of muscles, as we have often done, by a current of this kind; and there is evidence to show that not only persistent contraction of muscles may be relaxed by such influence,‡ but that hyperæsthesia may be reduced.§

Here then we have evidence of four kinds of physiologic action due to the continuous current, viz., the production of sensory effects, and also of motor, as well as the relaxation of spasm, and the reduction of hyperæsthesia, the different manner in which the current acts being mainly due to its intensity.

Other circumstances, however, influence the quality and degree of action exerted, viz., the direction of the current. Generally speaking, the transmission of a continuous current through a nerve, in the

* Leçons sur la Physiologie et la Pathologie du Système Nerveux, 1858, tome i. p. 151.

† Rust's Magazin, bd. xxiii. p. 297.

‡ Remak, Medical Times and Gazette, May 8, 1858.

§ Becquerel, p. 97.

direction from the centre to the periphery, exhausts the vital property of the nerve; whereas, a current passed in the opposite direction, *i.e.* from the periphery towards the centre, increases the vital property. The former is termed "direct," the latter "inverse." Again, the direct current acts more energetically than the inverse in producing muscular contractions. This we have often witnessed, when employing, for the purpose of experiment or therapeutic application, an ordinary Cruickshank's battery, and so making use of the initial current that its intensity could be regulated and measured by varying the number of plates employed. Not only is the muscular contraction produced by transmitting a current from twenty plates, much stronger when this current is direct than when it is inverse, but a current of such low intensity as to cause no appreciable contraction when transmitted in the latter direction (inverse), will occasion very evident action when passed in the former (direct). Thus the difference between these currents must be remembered in testing irritability, as well as in testing power. It is sometimes a source of fallacy in physiologic experiments; as, for example, in examining the irritability of muscles in a paralysed limb, by passing the current from one arm to the other. In this case, it is, of course, direct in one arm, and inverse in the other; and we have frequently seen the difference between the irritability of the muscles on the paralysed and non-paralysed sides so slight as merely to equal, or even fall below that which exists between the action of the inverse and direct current respectively. When such is the case, the irritability appears greater in that limb through which the direct current passes, whereas it may be really less.

Two conditions affect the result of applying the interrupted current; one of these being the rapidity of intermittence, and the other the degree of contact which is ensured. Dr. Lawrance states that—

"if we cause a paralysed muscle (whose irritability is normal), for instance, the flexor communis digitorum, to contract alternately with quick and slow intermissions, hanging weights at the same time to the fingers acted on by this muscle, we shall find that a rapidly intermittent current does not enable the muscle to raise a heavy weight so readily as one which intermits slowly."*

When the intermittence is extremely rapid, the effects resemble, *pro tanto*, those of the continuous current,† viz., exhaustion of motor and sensory functions; whereas in proportion to the integrity of contact, there is, *cæteris paribus*, a relative depth of effect. Thus, if dry conductors are placed upon the dry skin, the skin alone is irritated, whereas when moist conductors are applied with pressure the underlying muscles are affected. To these differences attention has already been directed in an earlier number of this journal.

The physiologic effects of galvanism are in part determined by the organism, and this in two ways, 1st, by the special property or function of the organ (nerve or muscle), and 2nd, by its condition at the time of application. With regard to the first of these, let it be observed, that there are different kinds of action, and degrees of action, in the same organs, and that the effect of galvanism is, in relation to its

* On Localized Galvanism, p. 44. † Becquerel, p. 97.

intensity, to elicit these different degrees of action. Thus, a nerve may have the power of either causing, increasing, diminishing, or arresting activity in certain muscles; and any one of these effects may be produced by galvanism, the particular effect which follows its application being determined by its intensity. The experiment of Eduard Weber* upon the cardiac branches of the vagus is familiar to every one; the subsequent researches of Pflüger† have shown that an influence upon the intestinal movements is exerted by the splanchnic nerve, similar to that which the pneumogastric exhibits upon the action of the heart; irritation of the splanchnic nerves producing almost immediate arrest (*erzeugt fast augenblicklichen Stillstand*) of the peristaltic movements of the small intestines. (p. 66.) But the conclusion at which Pflüger arrived, viz., that there is a certain set of nerve fibres, the "inhibitory system," whose peculiar function it is to arrest or diminish action, is, we think, ably refuted by Mr. Lister,‡ who has shown that the same nerves may either increase or diminish muscular contraction, according to the degree to which they are stimulated by galvanism. Mr. Lister thus "sums up" that portion of his paper which refers to the intestines:—

"It appears that the intestines possess an intrinsic ganglionic apparatus, which is in all cases essential to the peristaltic movements, and which, capable of independent action, is liable to be stimulated or checked by other parts of the nervous system; the inhibiting influence being apparently due to the energetic operation of the same nerve fibres which, when working more mildly, produce increase of function." (p. 372.)

A similar difference of effect, in dependence upon the degree of stimulation, has been demonstrated by Mr. Lister to exist in regard of the influence not only of the vagi, but also of "the sympathetic branches connecting the cord with the cardiac ganglia" (p. 378); and he has, as we think, very ably shown the error of the conclusion to which Professor Schiff arrived—viz., that the "inhibiting influence depends upon nervous exhaustion." (p. 379.)

As the result of all these researches we may conclude that the different powers are inherent in the nerves, and that galvanic stimulation does but call one or the other of them into exercise, in the same manner that other "stimuli," or "occasions of action," are known to operate; for example, emotion, which may either accelerate, retard, or even arrest the action of the heart.

Whatever, then, may be the properties of a nerve; whether they are sensory or motor; in relation to the particular properties of matter (light, taste, sound), or to peculiar conditions of the organism (fatigue, exhaustion, excitement); whether their function is to increase or to repress muscular activity; to occasion slight contraction, or persistent spasm; whatever these nervous properties may be, they can be called

* Wagner's Handwörterbuch. Art. Muskelbewegung.

† Ueber das Hemmungs-Nervensystem für die peristaltischen Bewegungen der Gedärme.

‡ Preliminary Account of an Inquiry into the Functions of the Visceral Nerves, with special reference to the so-called "Inhibitory System." Proceedings of the Royal Society of London. vol. ix. No. 32.

into operation by means of galvanism. But the special property which is elicited stands in definite relation to a certain amount of galvanic stimulus; and just as electric irritation of the retina produces the sensation of light, while a similar irritation of the crural nerve occasions muscular contraction, so a definitely proportioned galvanic stimulus of the splanchnic or pneumo-gastric nerves will elicit their property of increasing muscular movement in the intestines or the heart; and the same stimulus, differently proportioned, will call forth their inhibiting influence, and arrest the rhythmic or peristaltic action which they are destined to control.

But further, the condition of the organism at the time of its exhibition very materially influences the effect of electricity. To this we have already partially referred in detailing the different results of the continuous current. A nerve in a state of hyperæsthesia may be reduced in sensibility; an enfeebled nerve may have its dormant faculties aroused; a motor nerve, half paralysed from inaction, may be stirred up to healthy exercise; while a similar nerve, so irritated as to induce tonic spasm, may have its augmented irritability brought down to the average standard. But besides these results, there are some due to the action of electricity which should be borne in mind. The nerve may be so affected by a galvanic current that it becomes partially or completely "exhausted;" and at the different stages of its exhaustion there are different phenomena. Thus Bernard has shown, that when first operating upon a motor nerve, there is a simple contraction in the muscles it supplies at the entrance of the current, whether the latter be direct or inverse. That after a time there is contraction at both the exit and the entrance of either current. That subsequently there is contraction only at the entrance of the direct current, and at the exit of the inverse; and that, finally, there is contraction only at the entrance of the former. These four phases he terms respectively—1, unique; 2, double; 3, alterne; and 4, ultime;* and they represent different conditions of the nerve-function. In the first, there is the physiological result; in the second, there is, as we take it, somewhat augmented irritability; in the third, diminished irritability, or commencing exhaustion; and in the fourth, exhaustion carried to a further degree.

It appears, however, probable that many of the positions hitherto considered to be established with regard to the irritability of nerves will be found to require considerable modification. Eckhard has recently shown that if a constant current is transmitted upwards through a motor nerve (i.e., inversely), that the irritability of the whole nerve is diminished; but that if it is directed downwards (i.e., directly) through a portion of the nerve-trunk, diminution of irritability is found only in those parts through which, and above which, the current passes, while below the negative electrode the irritability is augmented.†

Another difference of effect, in reality dependent upon the part of the organism to which electricity is applied, but practically deter-

* Leçons cit. p. 185.

† Schmidt's Jahrbücher, 1857. ii. p. 266.

mined by the mode or locality of administration, is that which Duchenne pointed out between what he termed "direct and indirect faradisation." This Remak and Ziemssen agree in referring to the excitation of the muscular nerves, without or within the muscles themselves, and which Remak terms "extra and intra-muscular galvanisation." Ziemssen further shows that the value of extra-muscular irritation is this, that a feeble current will cause a whole muscle to contract, whereas with intra-muscular excitation a much more powerful current is required. (p. 6.)

Much that has been said and written upon the subject of modern or "localised galvanism," as compared with the older method of applying that agent, rests simply upon the fact that whereas, years ago, the different tissues (skin, muscles, and nerves) were indiscriminately affected, now the action of electricity can be limited with considerable precision to either one of them. This we owe in great measure to Duchenne,* who discovered, clinically, that there were certain points of the surface, applied to which the electric currents acted more vigorously than when directed upon other points. Further experience has shown that, in the main, Duchenne was right; but a somewhat curious and unworthy controversy has arisen as to whom the credit belongs for having systematised and explained these facts.

Dr. Robert Remak† claims for himself the discovery that these "boasted points of election" (*diese berühmten Wahlpunkte*) are simply those at which the muscular nerves make their entrance. But Duchenne replies,‡ that he had already, in 1852, exhibited his *modus operandi*, and the effects thereof, to Dr. Remak, and that he had deemed it quite unnecessary to give an anatomical dissertation to those distinguished men who attended his demonstrations, and among whom was Dr. Remak himself; and that now, instead of a great discovery having been made by his former visitor, and present critic, all that he can suppose is that in 1852 Dr. Remak was wanting in that anatomical knowledge which in 1855 he appears to have acquired.

Notwithstanding this reply by Duchenne, so lately as May, 1858,§ Remak thus describes his share in the investigation:—

> "I was not a little curious to know the nature of these mystical points, and on directing my attention to this subject I soon found that they corresponded with the points of entrance of the muscular nerves, and that the degree of contraction of a muscle was proportioned exactly to the number of motory nerve-fibres embraced by the current at its point of application."

The truth of the matter appears to be that the practical discovery was Duchenne's; and that, whether or not he understood his own discovery, he did not distinctly explain it. Remak accomplished this part of the process, and gave a theory to account for the result; and this theory has, we think, been most ably proved to be correct by the laborious investigation of Ziemssen, who conducted two series of inquiries, in one of which he determined clinically the precise localities

* Brit. and For. Med.-Chir. Rev., No. xxix. p. 138.
Ueber methodische Electrisirung gelähmter Muskeln. Berlin, 1855.
‡ Schmidt's Jahrb. 1846. Bd. 89, p. 250.
§ Medical Times and Gazette, No. 410, p. 479.

of these "points of election," and marked them upon the skin; in the other he examined post-mortem the course of the nerves, especially their motor branches, and noted accurately their points of entrance into the muscles; and, upon subsequent comparison of the two series, he found that they agreed perfectly with each other. (p. 3.)

In Dr. Lawrance's book some useful practical directions are given with regard to the points through which certain nerves and muscles may be reached most readily. (pp. 62 et seq.)

Ziemssen has also added to our definite knowledge of the influence exerted by the organism upon electric application two further facts, one that the conductibility of the tissues is in direct proportion to the quantity of water they contain (p. 39), and the other that the central organs of the nervous system, as well as nerve-branches in the large natural cavities of the body, escape the electric current on account of their envelopment in good conductors. He asserts, however, that with an extremely powerful current these organs may be reached. (p. 12.)

The latter point has been confirmed by M. F. Bonnefin,* who concludes from carefully conducted experiments, that it is possible to pass an electric current through the nervous centres, but that this current is always very feeble, even when a very powerful electro-magnetic apparatus is employed. He infers, further, that the influence exercised by those electro-magnetic currents which produce movements due to excitation of the spinal cord, only take place through the intervention of sensitive or excito-motor nerves. And hence, that in order to act upon the nervous centres, it is necessary to employ metallic conductors (and not moist sponges), so as to affect powerfully the cutaneous nerves. (p. 548.)

In regard of the theory or explanation of these diverse physiological effects of galvanism, but little that is satisfactory has been proposed. Du Bois Reymond, Matteucci, Dr. Radcliffe and others, starting from another ground, viz., the galvanic properties of the living tissues, have endeavoured to supply a rationale for many of the phenomena. Dr. Radcliffe says truly, concerning "the action of the ordinary galvanic current upon muscle, it is to be expected that the existence of the muscular current is not to be ignored," and he arrives at the conclusion that "it is difficult, if not impossible, to find any reason for supposing that the contractions (of a muscle) are due to any direct action of the current, natural or artificial" . . . . but that on the contrary "there appears to be only one course open, and that is, to connect the contraction with the *absence* of the current." (p. 36.)

The main facts upon which this opinion is based are these, 1, that during rest there is a galvanic current in the muscle; and 2, that during muscular contraction this current is weakened, or reduced to zero. This reduction takes place when the muscle is tetanised by an artificial current, and Dr. Radcliffe says, "there is no difficulty in con-

* Recherches Exp. sur la possibilité du passage à travers le Centre Nerveux de Courants El-Magn. appliqués à la peau, chez l'Homme. Journal de la Physiologie. Par E. Brown-Séquard. tom. i. No. III.

necting the contractions with that clashing and mutual neutralization of the muscular and artificial current" which takes place when the former is supplanted by the latter.

There is, according to Dr. Radcliffe, a "*moment of inaction*" between the disappearance of the one (muscular current) and the establishment of the other (artificial); and the whole tenor of his argument is to this effect, that the muscle contracts by virtue of its own inherent property; but that its contraction, instead of being stimulated or occasioned by galvanism, is prevented from occurring by the presence of that agent. The "moment of inaction," galvanically, is the moment of action for the muscle.

The argument so far amounts to this,—because A disappears when B is produced, the disappearance of A is a condition for the production of B. Or, because the several prismatic colours not only disappear from the surface of a card when it is rotated rapidly, but reappear when the card is brought to rest, therefore the disappearance of the colours is a condition which allows the rotation to take place. Ingeniously as Dr. Radcliffe has developed his theory, and partially met numerous objections, we regard the balance of the whole evidence as opposed to the view he entertains. There is the radical error of mistaking for a causative condition of a certain phenomenon that which may be more justly regarded as its effect; and there are many circumstances attending muscular action which are not fully met by the hypothesis. Thus, the force of muscular contraction is in proportion to the strength of the stimulus which is brought to bear upon it; whether this is galvanic, chemic, mechanical, or vital; and if contraction is to be referred to the absence of the muscular current, there are causes of contraction—such as pinching, percussion, and irritation with a non-conducting body—which cannot be shown to operate by producing this removal. Again, when we have on the one side a current so feeble that it requires an apparatus as delicate as that of Du Bois Reymond to demonstrate its existence; on the other, a current so powerful as to produce violent contraction of the muscles; and we advance to the idea of their bellicose "clashing" on the blood-stained field of a few muscular fibres, we cannot but think that the chances are very much against the result being a "drawn-battle;" a mere "neutralisation," and "moment of inaction," during which, and as the result of which, this most remarkable phenomenon of contraction occurs. The experiments of Weber, Pflüger, and Lister, show that entirely different effects are produced by currents differing only in intensity, and we must confess that in the present state of physiological science there is yet wanting a satisfactory rationale of the phenomena.

For a perfectly successful therapeutic exhibition of electricity, such a comprehensive knowledge of the *modus operandi* of the agent, physiologically, is required; but while this is still a desideratum, much may be and has been done towards solving the problem of its practical utility. Attempts have been made to relieve many morbid conditions, and these, though sometimes directed by a true deduction, sometimes by *à priori* considerations, and at other times by simple em-

piricism, have met with varied, but in the main increasing success; and it is to these attempts and their results that we would now direct attention.

There are four principal results which electricity may be called upon to effect: 1, restoration of contractility in the muscles; 2, re-establishment of sensibility; 3, reduction of augmented contractility; and 4, diminution of hyperæsthesia.

1. *Treatment of Paralysis.* Becquerel states that when this is dependent upon a persistent lesion of the brain, spinal cord, or nerves, electricity is "tout-à-fait contre-indiquée, elle ne pourrait qu' être nuisible." (p. 125.) This is substantially the same as Duchenne's statement made many years ago; but M. Becquerel goes on to affirm that when the central lesion is cured, "et que le diagnostic permet d'établir que cette cicatrisation s'est operée (a nice point for diagnosis!), then electricity may be employed with advantage. When cerebral hæmorrhage has been the cause of paralysis, the experience of M. Becquerel is, that in the "immense majority of cases" electricity exerts no favourable influence. (p. 138.)

It appears, as the result of experience in the treatment of paralysis from cerebral hæmorrhage, (*a*) that nothing electric ought to be attempted for many months after the attack; (*b*) that a certain proportion of cases get quite well at the end of that time without any treatment of this kind; (*c*) that others at that period present paralysis to the will, but the irritability of muscles to electricity persists; and in such cases the application of electricity is not wanted, does no good, and sometimes is mischievous in its results; and (*d*) that in other cases the electric irritability is diminished, and here electric treatment is of use.

M. Becquerel agrees with Drs. Marshall Hall and Duchenne, that in the great majority of cases the contractility of the muscles persists; but he states that, in old paralysis, the "prolonged inaction of the muscles almost always diminishes" that property. According to our own experience the electric contractility of the muscles is more frequently diminished than either increased or unaffected; and further, this diminution has not appeared related to the length of time during which the paralysis has lasted.

With regard to paralysis dependent upon cerebral softening, M. Becquerel states that the contractility is preserved in recent cases, but lost in those of longer standing. He gives no results of practical experience on the matter, but asserts that the utility or uselessness of galvanism depends upon a recognition of the persistence or "cicatrisation" of the softening! When paralysis depends upon the existence of an intra-cranial tumour, M. Becquerel says that galvanism should be rejected altogether. (p. 146.)

When paralysis is caused by an injury or disease of the spinal cord, there may or may not be loss of muscular contractility. The original statement of Dr. Marshall Hall upon this question has been, in reality, confirmed by every subsequent observer. It is, that when the muscle is functionally separated from the cord,

there is diminution and loss of irritability; and this is Dr. Hall's "spinal paralysis." But a disease in the spinal cord, although it may cause paralysis,—i.e., separation of the muscles from the will ("cerebral paralysis")—need not, and often does not, sever the functional relationship of those muscles and the cord itself. Such cases Dr. Hall did not term "spinal paralysis," but "cerebral."* If a disease destroys a portion of the medulla, the muscles supplied by nerves coming from that disintegrated portion present "spinal paralysis" and loss of irritability; but those muscles which are supplied by nerves arising from that portion of the cord which remains uninjured below the lesion, present only "cerebral paralysis," and retain their irritability. Nothing appears more distinct than Dr. Hall's statements upon this question; and it is not less distinct that their truthfulness has been abundantly confirmed even by those modern electricians who, while recognising the facts, seem, curiously enough, but almost universally, to mistake the meaning of Dr. Hall.

In a former article in this journal a true statement of the case was made, and we should not again have referred to the matter, had not the misstatement been recently reiterated both in England and France. M. Becquerel does not escape the error, but he gives some further information on the subject, in affirming that the degree of electric irritability which persists is in direct proportion to that of the capacity for volitional exercise. (p. 152.) Further, that the treatment of paraplegia by electricity is positively injurious when the paralysis is progressing, and is of service only when this symptom is either stationary or diminishing. In complete paraplegia with irritability diminished, electricity does no good, and it is useful only in those cases of incomplete paralysis in which there is no diminution of the irritability. (p. 155.)

In "traumatic paralysis," or true "spinal paralysis," electricity is sometimes of service. Professor Oré relates a case of cure of facial paralysis of eight and a half years' duration, in which all muscular irritability was lost.† In our own practice we have seen notable improvement of a case of facial paralysis after fourteen years' duration; but in this case, although the distortion of features and lagophthalmia were extreme, some slight electric contractility remained.

Duchenne states that, in cases of traumatic paralysis it is sometimes observed that volitional power remains partially while electric contractility is destroyed. But this M. Becquerel appears to doubt (p. 159), stating that, in a great number of cases, he has observed that the two properties "marchent ensemble." When there is not a complete loss of both, there may be one of the two following conditions:—1, voluntary power lost completely; sensibility diminished or not; electric contractility intact or diminished; 2, voluntary power incompletely lost; sensibility diminished or not; electric contractility intact or diminished. The first class of cases is curable, but the second curable much more readily. With regard to hysteric paralysis

* Medico-Chir. Transactions, vol. xxx. p. 207.

† Quoted from Journal de Bord. Avril, 1856, in Schmidt's Jahrb., 1856. vol. iv. p. 55.

there is nothing new; they are well known to be amenable to this kind of treatment, and M. Becquerel says truly, "le traitement de ces affections a fait la fortune de plus d'un electriseur!" (p. 175.)

The paralysis which is symptomatic of such genito-urinary lesions as nephritis, calculus, stricture of the urethra; and which persists after the removal of its remote cause, may be rapidly cured by electricity. The paralysis remaining after the inaction of a limb from rheumatism, may likewise be treated successfully in the same manner; and M. Becquerel describes an essential or idiopathic paralysis, which is amenable to this agent. The characters of this form of paralysis are, A, positive;—paraplegia, complete or not; anæsthesia, or not; digestive and urinary functions natural; other "nervous" phenomena present; embonpoint normal; contractility completely preserved. B, negative;—no spinal pain; no feeling of cord round the trunk; no tonic contraction; no paralytic affection of bladder or rectum.* A case somewhat resembling this kind of paralysis was successfully treated by Dr. Althaus.†

In lead palsy, M. Becquerel states, in opposition to Duchenne, that the contractility is not lost unless the palsy has come on slowly, and there is atrophy of the muscles; and further, the contractility which remains is in direct proportion to the voluntary power remaining. (p. 190.)

Writer's cramp may be completely cured.‡

Intestinal atony has appeared in some instances to be overcome by galvanism; and notwithstanding the peculiar inhibiting influence of the splanchnic nerves it seems probable, from Ziemssen's observations, that this agent may be hereafter usefully employed upon the intestines. The latter observer states that powerful contractions of the intestinal walls may be produced, and that these persist after removal of the electrodes, and the only pain so caused is in the skin at the point of contact—"*diese äusserst stürmischen Actionen*"—continued for one quarter of an hour—"*aber ganz schmerzlos.*" (p. 13.) But as for the action of the galvanic current upon the bowels, Becquerel gives his experience thus: after placing one pole in the mouth, and another in the rectum, and trying all sorts and directions of currents, "je n'ai jamais obtenu aucun résultat." (p. 202.)

Duchenne has cured three cases of prolapsus ani; and M. Stacquez§ relates cases of impotence cured by powerful shocks from a Leyden phial, passed from the lower part of the vertebral column to the tip of the penis—"de manière à produire l'explosion à ce dernier point.‖ The individual who would submit to this operation could not be impotent, we should think, through "want of nerve."

In "wasting palsy," or progressive muscular atrophy,

"The most effective remedy," says Mr. Roberts,¶ "is galvanism applied locally to the wasting muscles . . . . It has generally, indeed nearly always, been found to yield encouraging results: too often the amendment has been

* Becquerel, p. 181.
‡ Becquerel and Remak.
‖ Becquerel, p. 31.
† Med. Times and Gazette, December 26, 1857, p. 656.
§ Archives Belges de Méd. Militaire, 1849.
¶ Essay on Wasting Palsy, 1858, p. 204.

but temporary, but in several instances it has brought about arrest, and, in a few, re-establishment of the bulk and power of the wasted muscles, either wholly or in part."

In a case of this kind, however, under the care of Dr. Hare, galvanism was applied twice daily, from the 20th July to the 24th August, the result being that the patient is described as "not deriving much benefit from this treatment."* And in a case under our own care, four years ago, localised galvanism was negative in its effects.

2. *Treatment of Anæsthesia.* Not much that is of value has been added to our information on this subject. When an anæsthesia depends upon some general morbid condition, such as, for example, amaurosis in Bright's disease, electricity can accomplish nothing. When it is but the symptom of a distinct organic lesion, intra-cranial tumour, hæmorrhage, &c., there is the same negative result. But when the anæsthesia is idiopathic or essential, then, say the electricians, much may be accomplished. In such cases, however, the phenomenon frequently disappears with some general alterative treatment, or without any treatment at all.

With regard to analgesia, which may be regarded rather as a boon than a misfortune, M. Becquerel makes the very sensible remark that, "s'il y a analgésie seule on la laissera parfaitement tranquille." (p. 220.)

3. *Treatment of Spasm, or augmented muscular contractility generally.* With regard to convulsions and contractions, M. Becquerel states that, notwithstanding the physiological and pathological basis for the employment of electricity, he has failed to obtain a cure. Others have been more successful. Dr. Remak states as follows :—

"I was induced in July, 1856, to apply the constant current as a means of treatment of contractions of muscles, in cases of hemiplegia from cerebral apoplexy. The most important result of this application was the fact, that the continued current, applied for a few minutes to a contracted muscle, had the effect of immediately relaxing it to a certain extent, and rendering it amenable to the influence of volition."†

Another mode of reducing permanent contraction of the muscles is that commonly employed by Duchenne, viz., the excitation of those muscles which are their natural antagonists. By this method Duchenne treated three cases of torticollis, but although there was improvement there was no cure.

The curability of cases of tonic contraction, when this has been of long duration, appears to us at best to be extremely doubtful; for in such cases there is reason to suspect the existence of a central lesion, which electricity has not yet been shown to be capable of affecting, even though it may temporarily suspend or counteract the symptom. And further, these tonic contractions, when produced artificially, are among the most persistent results of central injury, even when the latter has been of very trifling extent.

* Med. Times and Gazette, April 24, 1858, p. 426.

† Ueber die Lösung paralytischer Contracturen. Deutsche Klinik, 1856. No. 28. Med. Times and Gazette, May 8, 1858, p. 479.

4. *Treatment of Hyperæsthesia.* Of late the activity of the professional mind has been especially directed towards the cure of neuralgia, or the artificial production of anæsthesia by means of electricity. In regard of the former there has been considerable success. Dr. Hiffelsheim presented to the Academy of Sciences of Paris a paper detailing the results of his experience in thirty-six cases in the wards of M. Rayer, and these are highly satisfactory.*

Dr. Althaus has published some of the results of his own experience, which are also satisfactory.† And M. Becquerel speaks with confidence of the good effects of galvanism in cases of this kind. But the utility of galvanism as an anæsthetic agent has yet to be shown. Dr. B. W. Richardson performed careful and painful experiments upon himself, but the result at which he arrived was "that the electric current cannot, according to our present knowledge of its application, be made practicable for the production of local anæsthesia."‡

To him replied Dr. Althaus, that when the current is applied in a different manner, "the sensibility is notably diminished."§ But Dr. Althaus further states, that "the result is much more striking if there is a morbid increase of sensibility in a nerve, as in neuralgia, than if a nerve in its normal state is acted upon." And in the same number of the journal is a letter from Mr. Harry W. Lobb, which reminds us somewhat of the character of proceeding adopted by those individuals who present themselves "where angels fear to tread;" for Mr. Lobb, after stating with regard to electricity "I have never used it to prevent pain during the extraction of teeth," displays his qualifications for being a scientific observer by going on to say, "but from what I know of its success in toothache, the following plan will, I have no doubt, be found perfectly successful. Procure a 60-link . . . . &c. &c."‖

Mr. Eden, of Brighton, did "procure a 60-link &c. &c.," and "follow minutely the directions in Mr. Lobb's letter," but was "sorry to say" that he "did not obtain any diminution of sensibility."¶

Thus, then, stands the question of "Electrical Anæsthesia." It appears that hyperæsthesia may be reduced; and even that the normal sensibility may be diminished; but there is no evidence that the reduction can be carried so far as to render electricity a useful anæsthetic agent.

There are two modes in which electricity operates in obtaining this therapeutic effect, first, by direct reduction of the nervous sensibility, and secondly, by counter-irritation of the skin. M. Brown-Séquard refers the beneficial results of electrical or other irritation of the skin, in the treatment of neuralgia, to a reflex action upon the vessels of the irritated nerve, producing temporary anæmia therein.

The other uses to which electricity has been applied, such as the treatment of amenorrhœa, of atrophy, and of aneurism, and its employment as a cautery for the removal of tumours, or for other purposes in

* Extract from the Minutes of the Meetings of the Academy, vol. xlvi.
† Med. Times and Gazette, Aug. 14, 1858.
‡ Ibid., Sept 11, 1858. § Ibid., Sept. 18, 1858. ‖ Ibid., Sept. 18, 1858.
¶ Ibid., Oct. 9, 1858.

which the actual cautery is required, need no comment now, as nothing of much value has been added to our knowledge upon the question.

But the mode in which electricity is applied has probably much, if not everything, to do with the beneficial or other results which follow. In regard of paralysis, it appears quite clear that the continuous current is of great practical utility, and the interrupted current of induction is also serviceable. Hiffelsheim is, we think, correct in saying that the physiological and therapeutical effects of the permanent continuous current are "not obtained by the contractions;" and in his further observation we entirely agree, viz., that "this might perhaps lead to the supposition that the interrupted current does not, any more than the continuous, act *immediately* by contraction; and that in both cases dynamic electricity acts directly on the different elementary acts of the complicated function called nutrition."*

Practically, the application of either current should, in cerebral paralysis, be limited to the muscles; the electrodes being placed at short distances, and the intermissions (when an intermittent current is employed) should be rapid. But when the attempt is made to affect the muscles through the agency of their nerves, those special points must be selected which Duchenne was the first to point out. A most minute description, and careful delineation, by well-executed drawings of these points, will be found in the work of Ziemssen; and for practical information on the electric anatomy of man, it will prove more useful than any other treatise on the subject.

Where the object of electrical application is to awaken sensibility or induce certain movements in an individual intoxicated with alcohol, or poisoned by opium, the interrupted current of high intensity is required; but for the treatment of hyperæsthesia, either the interrupted or the continuous may be employed, and with an equal measure of success.

Thus, except in the particular instance referred to, the therapeutic effects of galvanism may be obtained from the one form of application as well as from the other; but inasmuch as the continuous current is free from pain, and can be so applied as to avoid all undue calorification, thus rendering it free from the injurious effects sometimes following an application of the interrupted, it possesses the decided advantage, and will, we believe, eventually be employed almost exclusively.

As to the apparatus to be used, but few words are necessary. The intermittent induced current may be obtained from the electro-magnetic, or the magneto-electric arrangement. In the one there is the trouble and frequent inconvenience of employing "exciting" fluids; in the other there is the necessity for rotation of the temporary magnet; but the latter will be found to be the lesser evil. When a continuous current is required, there is nothing which can equal the elegant chain-battery of M. Pulvermacher.

As a thoroughly successful application of electricity can be hoped for only by a comprehensive and profound knowledge of its physiological effects; the great desideratum of the present time is the acqui-

* Extract from the Min. of the Meetings of the Acad. of Sciences, Paris. vol. xlvi.

sition of this knowledge. An agent which appears capable of inducing, increasing, reducing, or destroying the functions of both muscles and nerves, ought not to be employed without extensive information and careful adaptation to the exigencies of the several cases to which it is applied; and until it can be so exhibited its success will be partial and accidental only. What is required, then, is the most cautious experiment and logical induction; for by this both the science of physiology and the art of therapeutics will advance; while they can but retrograde and become the object of contempt, if a few accidental successes are made the basis of an advertised panacea.

While, in the present day, there are a few who are thus intent upon the progress of that which may prove a great boon to suffering humanity, and whose recommendation of electricity is always guided by a definite knowledge of the effects which it is already known to produce; there are the many whose careless employment of the agent in all kinds of maladies resembles rather the prescriptions of the middle ages, embracing every kind of material—from man's skull to sparrows' dung, and from diamond dust to copper filings—in the hope that some one of them might be of use to the sufferer, and that the others might mutually counteract their several injurious effects.

Review IX.

1. *The British Army in India: its Preservation by an appropriate Clothing, Housing, Locating, Recreative Employment, and Hopeful Encouragement of the Troops; with an Appendix on India.* By Julius Jeffreys, F.R.S., formerly Staff-Surgeon at Cawnpore, and Civil Surgeon of Futtegurh.—*London*, 1858. pp. 393.
2. *A Brief Review of the Means of Preserving the Health of European Soldiers in India.* Part I.. By Norman Chevers, M.D., Bengal Medical Service.—*Calcutta*, 1858. 8vo, pp. 131. Reprint from "Indian Annals of Medical Science," July, 1858, p. 632 to 762.

The author of the former of these works, during a lengthened period of service in India, was distinguished for the great attention which he bestowed upon every question which related to the health of the British soldier, for his proficiency in physical science, and for a vast amount of innate mechanical ingenuity. In this country he is better known as the inventor of the "Respirator," which bears his name, and which is in universal use. The volume before us, though written in a style somewhat quaint, is full of most original views and suggestions, and well deserves the serious attention of all who are interested in the preservation in health and strength of our armies in India. We proceed to give a brief epitome of its contents in the order followed by the author:—

I. *On the Specific Properties of Matter through which heat operates and is to be resisted.*—It is argued that the example of the natives of India is an uncertain guide in dress. *Slow Conduction* is the prin-