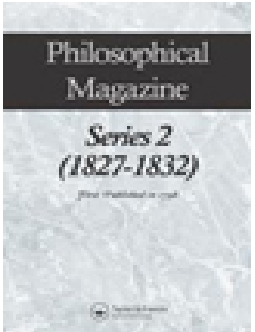


Philosophical Magazine Series 2

ISSN: 1941-5850 (Print) 1941-5869 (Online) Journal homepage: http://www.tandfonline.com/loi/tphm13

XXII. Exposition of a new dynamico-chemical principle

Mr. John James Waterstone

XXII. *Exposition of a New Dynamico-Chemical Principle. By Mr.* JOHN JAMES WATERSTONE*.

"The new discoveries, in short, reveal to us the world of secret motions, whose laws are probably analogous to those of the universe, and which deserve to be the subject of our most earnest meditations."

Œrsted on Thermo-Electricity, Edin. Encyc.

WHEN we reflect on the progress which has been made, and is still making, in the physical sciences, and more especially in those which investigate the active properties of matter; when we behold that insatiable thirst after discovery, that enlightened spirit of inquiry, which so universally pervades the philosophic world, it becomes a source of exalted gratification to trace the steps which have led to so many brilliant results, and in contemplation of the future to look forward to that period when all that is now concealed under the veil of mystery shall finally be exposed in the sublime grandeur and simplicity which so eminently characterizes the works of nature. The illustrious example which Newton held forth to posterity, of a philosopher who applied mathematical reasoning with so much success in explaining the grander phænomena of the universe, introduced the same system amongst those who succeeded him; which, joined to experimental analysis, have unfolded a series of the most splendid discoveries in every department of natural philosophy. Heat, electricity, magnetism, and light, are the principal fields in which the powers of induction have been most conspicuously displayed. The late discoveries and researches of Young, Œrsted, Seebeck, &c. have shown that those sciences are intimately connected, and that the actual principles of nature, if we except perhaps gravitation, interfere with each other in such a manner as to lead us to conjecture they may all be particular modifications of one agent. If we, however, consider the numerous insulated facts which experimental investigation is so fertile in producing, that cannot even be generalized under any special laws, or included under any common analogy, we must be sensible that a vast distance yet separates us from the primary causes of all those phænomena.

Experiment, however ably conducted, has as yet shown nothing in heat, electricity and magnetism, but simply and exclusively the existence of force, and it seems doubtful if it will ever lead us directly to the knowledge of the essential nature of those powers. Heat is an example of a repulsive energy existing between the constituent atoms of bodies, and all the

* Communicated by the Author.

the different situations in which it and various substances are placed in relation to each other, serve only to exhibit instances in which the quantity and intensity of the repulsive power varies, thereby enabling experimentalists to deduce general laws which govern a diversified series of phænomena.—Electricity and magnetism, on the other hand, present still more curious instances of invisible forces exercising functions which rival gravitation in the important parts they sustain in the œconomy of nature. Modern discoveries have developed the intimate nature of their connections; and the display of polar forces being their most remarkable feature, is so peculiar to them alone, that we are induced to look upon them as modifications of the same elementary principle. These powers are likewise connected with heat and light, which latter are in most cases coexistent.—Electricity is the basis of chemical affinity, and heat is either absorbed or evolved in chemical action; the former is in most cases accompanied with a simultaneous change in the latter, whilst the latter in peculiar circumstances induces electrical phænomena.—Magnetism is weakened or destroyed by an excess of heat; whilst the more refrangible rays of light possess evident magnetic properties.

Thus are all those subtle agents connected together in the different effects which they communicate to matter, and in the variety of forces which harmonize the routine of natural phænomena. Gravitation alone appears to be excluded from this system of interference; no difference in its intensity, as far as experiment has yet shown, being consequent upon any change which may take place either in temperature or in electric state. Are we then to conclude that heat and electricity are removed from the sphere of its action? that they act independently of its general influence? If such is their relation to each other, our conceptions of relation and quantity are violated, and the nature of their existence must not only be different but contradictory to every thing of which we can form the remotest conception. Experiment, however, warrants no such conclusion; the process appears too delicate, and the magnitude of the results may, like the parallax of the fixed stars, be placed far beyond the range of our means of observation, without at the same time justifying doubts which may be entertained either of the intimate connection of gravitation and caloric, or of the real magnitude of these heavenly bodies.—Is it not more consonant to reason to consider them as inseparably combined in their operations? We know that both powers surround every particle of matter, exist in the same space, and generate motion, at the same time and in the same place: may we not therefore with justice conclude, that so far from acting independently, gravitation may communicate to heat all the pro-

 perties

perties by which it is distinguished, and that they may both be examples of the same elementary force exhibited through different media?

Such conjectures, although derived from an extensive and minute survey of the facts elicited by experiment, are yet prevented from ever becoming of practical utility, by our ignorance of motion. How does it originate? In what manner are its effects so complex, and its development so varied? These are questions which first naturally arise, and indeed comprehend all that can form the object of philosophic inquiry. The first, relating to its origin, has often been investigated both by physical and metaphysical authors: many abstract speculations have engaged the attention of the latter, but they universally partake of the usual defects of that science, referring every effect to a primary cause, which in whatever way it may be defined in words, fails to convey any definite conception or satisfactory meaning to the mind. Disgusted with such idle and inconclusive reasoning, and despairing of being practically useful to science by prosecuting such inquiries, it is not surprising that philosophers have never devoted themselves to investigate this subject on simple physical principles, by the application of which alone we may expect to further the progress of natural philosophy.

Two opinions are entertained by philosophers relating to this subject: the first, that the absolute quantity of motion in the universe is always the same, suffering neither the smallest increase or diminution; the second, that "motion is much more apt to be lost than got*," and that therefore "some other principle is necessary for conserving it," to supply the continued loss incurred "by reason of the tenacity of fluids and attrition of their parts, and the weakness of elasticity in solids." The former doctrine was maintained by the Cartesians, who defended their opinions by the aid of such extravagant hypotheses, that Newton and his followers, by showing the obvious absurdity of their demonstration, adopted the contrary belief, not so much from the satisfactory proofs brought forward in support of it, as because it was contradictory to the great principle of Des Cartes, which was naturally supposed to have partaken of the general fallacy of his vortical system. Later philosophers, although ardent admirers of Newton and his philosophy, have yet rejected his doctrine, and in refutation of it have brought forward mathematical proofs of its fallacy, which if not conclusive, are at least plausible and ingenious. To prove either hypothesis however, involves reasoning distinct from the abstract comparison of quantities. An intimate ac-

* 30th Query, Newton's Optics.

quaintance

quaintance with nature is requisite. The constituent principle of the attractive and repulsive powers, and their mode of operation, may differ from all we can deduce in comparison. When we therefore perceive matter, once in a state of motion, gradually arrive at a state of rest, without any visible transference of its power, having no direct proof to the contrary, we are induced to consider it absolutely lost. Still the following simple analogy appears to afford evidence of the contrary, and authorizes the conclusion, that momentum like matter cannot by natural means be annihilated, the existence of both being of equal importance in the œconomy of nature. A body when falling towards the earth, gradually accumulates a quantity of momentum, which is visibly lost when it arrives at the ground. In this instance the momentum, before it is transferred to the falling body, is invisible; why may not, therefore, the same momentum after collision, be again reduced to the same invisible state without being actually destroyed? The manner in which it appears and disappears is certainly different, but the latter may be governed by laws as unalterably fixed as those of the former, although from the complexity of the attending circumstances their influence cannot so readily be appreciated. Thus after collision, in the above example, undulations or vibratory motions are always observed to take place. These changes are influenced by the nature of the composing substance, which again is an immediate consequence of the peculiar molecular forces of the ultimate constituent particles. Since we have this reason to suppose that their molecular forces are, like gravitation, subject to fixed laws, and are every way of like importance and universality, it becomes highly probable that they are alone the invisible agents which abstract this momentum of collision, without any evidence of its existence being afterwards perceived.

These views of the transference of motion are further deserving of attention by their accordance with the simplicity of nature, and by tending to clear science of all those auxiliary causes, the introduction of which, though necessary to explain the contrary hypothesis, has yet proved a serious obstacle to the progress of true philosophy. If founded on truth, they induce a lively hope that matter and motion alone will be found sufficient to explain all the phænomena attending the grand cycle of nature's operations, and that that system of unity and simplicity which the advancement of discovery is always bringing further into view, will at length be completely unfolded, and all the physical sciences eventually traced to the varied development of these two principles.

Two

Two opinions are at present entertained of the origin and nature of gravitation. In the first, no intermedia are deemed necessary to convey its influence; whilst in the second, direct impulsion is considered essential, and a subtle fluid or æther is supposed to transmit the power from one region of space to another. This last doctrine has been reckoned by some unphilosophical, by introducing a clumsy mode of explaining that, which certain refined metaphysical speculations on causality do not require to be explained. But although the cause which is sought may not on these metaphysical principles be necessary, yet it will always remain inconceivable how two bodies in an absolute vacuum will move towards each other in accordance with the laws of gravitation; and it is certainly preferable to adopt the contrary opinion, more especially if we discover a certain arrangement of the fluid which will explain the development of an attractive and repulsive energy on the most simple and evident mechanical principles.

In the following three articles it has been attempted to show, how an attractive force may exist between two particles proportional to the quantity of matter in each, and which is in every other respect subject to laws similar to those of gravitation. As it is intended at present to introduce and explain the general principle alone, without entering into mathematical details, the systematic arrangement which would otherwise become necessary, will not be so particularly attended to as briefness in demonstrating what will be sufficient to convey a distinct notion of the system; reserving for a future opportunity its mathematical elucidation and further extension in explaining a diversified series of chemical and electrical phænomena. The following particulars define what is intended to be understood as properties of matter coexistent with perfect solidity, and are the foundation of all the reasoning afterwards made use of.

Postulates.—Let it be granted that,

1st, Perfect solidity is accompanied with an inseparable union of parts.

Many may deny this as an unwarrantable assumption; but although hypothetical, it is but a corollary to the doctrine which is at present supported by the most enlightened and distinguished philosophers, who have inferred from the combining ratios of the simple chemical elements, that matter is divisible to a certain extent only, after which no force is capable of effecting any change in the relative situation of its parts; and that when a plenum exists within the surface of the ultimate particle, no disunion of parts can be effected*.

* See Phil. Mag. vol. lxii. p. 360; lxiii. p. 372.—Edit.

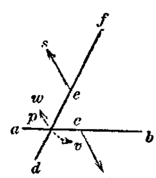
2nd, Per-

2nd, Perfect solidity is accompanied with perfect elasticity. This proposition, although inserted in the form of a postulate from being dependent on the foregoing, is yet capable of being demonstrated. If after collision two elastic bodies recover their shape with a force equal to that by which they have been compressed, they will recoil from each other without any alteration being effected in the sum of their motions. This will likewise happen, however much we consider the extent of compression to be enlarged or diminished; perfect elasticity being always consequent to an equality existing betwixt the force of the contracting and that of the dilating vibration. This vibration may be therefore conceived to be infinitely reduced; the body will then be *perfectly* solid, and this finally becomes the limit of perfect resiliency.

Exposition of a principle by which it is proposed to explain the manner in which a mutual attraction may exist between two particles of matter by the direct impulse of an intermedium.

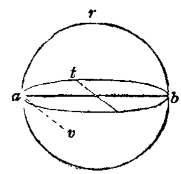
I. Let there be an infinite number of particles of *cylindric form*, the length of each being indefinitely greater than its breadth; and let them be extended through space at finite equal distances from each other; and let an indefinite velocity be then communicated to each, which may cause them to assume a rectilineal motion in different directions. What will be the after state of the medium so constituted?

Each rigid line will pursue an undeviating course, until it meets with another moving in a contrary direction, when a collision will take place, and by 2nd postulate a perfect reflexion, without the sum of their motions being diminished, although the whole momentum will then be stored up in the particles in a different manner, *a considerable portion being gradually abstracted to effect a rotatory movement*, whilst the rectilineal velocity becomes greatly diminished. Thus let the line $a\,b$, having at first a motion in the direction $c\,r$, impinge against another $d\,f$, having likewise a rectilineal motion in a contrary direction $e\,s$. Let p be the point of concourse: then by dynamical formula $\frac{f\,d^2\;6{\cdot}2832}{12\;e\,p}$ and $\frac{a\,b^2 \times 6{\cdot}2832}{12\;c\,p}$ are the spaces which would be afterwards described by e and c respectively during one revolution of the line $f\,d$, $a\,b$; and the ratio of the rotatory to the rectilineal momentum, will therefore be $\frac{1{\cdot}5708\;e\,p}{{\cdot}5236\;d\,f}$ and $\frac{1{\cdot}5708\;c\,p}{{\cdot}5236\;d\,f}$ if no elastic force is supposed



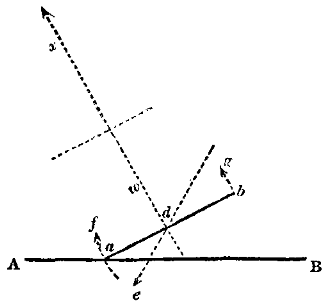
to

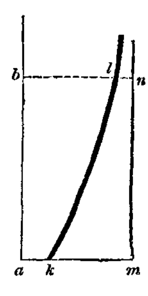
to be exerted. Since perfect resiliency however occurs, the force of impact will be reflected in contrary directions, and the supplementary momentum will be exerted at *p* on *f d* in the direction *p v*, and on *f d* in the direction *p w* in both lines; it will therefore tend to augment the rotatory, and simultaneously lessen the rectilineal motion. The actual ratio which these quantities will have to each other, after the condition of the medium is established, will be influenced by the following circumstances; 1st, It is equally probable that the point of concourse *p* may be anywhere situated in the lines *a b*, *d f*; the extreme cases are, when it coincides with their extremities or centres of gravity: in the former by the above formula the rotatory motion is $\frac{3}{5}$ths of the whole; in the latter it is 0; the mean quantity or $\frac{3}{10}$ths will, therefore, show the ratio of the whole quantity of rotatory momentum generated in the medium by this cause singly, and $\frac{7}{10}$ths that of the remainder, by which the lines continue their rectilineal motions. 2ndly, The rotatory motion by the diversified concourse of the particles will be performed simultaneously in planes perpendicular to each other. For while *a b* revolves in the plane *a r b*; another particle may communicate a rotatory impulse in any other direction *v a*, which by a well-known principle in dynamics will cause the line *a b* to revolve at the same time in the planes *a t b*, *a r b*, perpendicular to each other. In this manner the whole quantity of rotatory momentum effected by the first cause will be nearly doubled, whilst the elastic recoil will tend further to diminish the rectilineal motion of the particles. Before ascertaining exactly this ratio, the principles of chance require to be employed in estimating the frequency of peculiar modes of concurrence, and thus discovering the mean results of the combined action of the whole medium. It is not intended, however, to enter upon this investigation at present, as it is unnecessary to prove the truth of what has been advanced, that the *primitive momentum is separated into two parts, one of which is employed in sustaining a rectilineal and the other a rotatory motion.*



II. Let a rigid plane be introduced into this medium: What will be the corresponding change in its relative density? Let the line *a b*, having a rectilineal motion in the direction *d e*, and a rotatory motion *h g*, impinge against the plane of which AB is a section; the whole momentum in the line will immediately after the first collision be separated into 1st, a reflecting impulse in the direction *a f*; and 2ndly, the influence of the

the remaining force in continuing the motion towards A B, and bringing the other extremity *b* likewise in contact with it, thus inducing a contrary rotatory motion, which by encountering and balancing the former will concentrate the whole force in the centre of gravity, and thus cause the line to shoot forwards from AB in radiating lines *w x*; nearly the whole momentum being now exerted in a rectilineal direction. Thus the lines after collision with the plane A B will convey a newly acquired impulse radiating from every point of its surface, and the rectilineal force thus generated will be communicated from one part of the medium to another. For we may suppose the fluid surrounding the plane to be divided into concentric films, and the primary rectilineal impulse occasioned by the introduction of the plane to be communicated from the first to the second, from the second to the third, and outwards successively. After the mutual reflection which takes place between the first and second, the former will have given away a portion of its rectilineal force, whilst the supplementary portion is converted into a rotatory motion. The same interchange will take place between the second and third films, whilst at every collision an absolute loss of rectilineal momentum will be incurred, which will continually replace the vibratory reflections of the first film on the rigid plane. The radiating influence will be thus conveyed through boundless space, its intensity diminishing in a ratio of the distance. The balance of forces which before the introduction of the plane A B had preserved the homogeneity of the medium will be now destroyed, and the density of its relative parts will be proportional to the intensity of the rectilineal velocity of the component particles. Thus the difference between the density of the fluid at any point surrounding the plane, and of the same before the introduction of the plane, will decrease in a ratio expressed by some function of the distance of that point from the centre of impulsion. This ratio if *linearly* developed will be represented by a curve *k l* originating at a finite distance *a k* from the axis *a b* expressing the density of the medium at the surface of the plane at *a*, and gradually

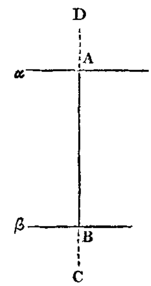




approaching the asymptote *m n*, which is parallel to *a b*; their mutual distance *a m* being proportional to the density of the fluid at an infinite distance from *a*, or to every part of it before the introduction of the rigid plane.

III. Let a second rigid plane be introduced and placed at a distance from the first, indefinitely greater than the extent of its longitudinal dimensions. What are the effects consequent on this arrangement?

Let A B be the relative position of the two planes, which let first be considered parallel, and intersected by a common perpendicular A B. Let α A, β B, represent their indefinite extension. The rareness of the medium occasioned by the impulsive force radiating from the plane being proportional to the quantity of rectilineal force exerted amongst the particles in the same space, and the sums of the intensities of the rectilineal motion proceeding from both planes being greater in the interior space A B than in B C A D, on the exterior sides, it follows that the medium will be denser in the latter than in the former, *and more particles will thus impinge in the same time on the exterior than on the interior face of each.* The equilibrium which kept the first plane at rest before the introduction of the second will be therefore destroyed, and a motion communicated to each, which will cause them mutually to approach with an accelerating velocity; and this by the decomposition of forces will likewise take place at whatever angle the particles are inclined to each other. *Thus the effect consequent on this new arrangement will be the development of a mutual attractive force.*



Observations.—The foregoing principle is founded on a simple mechanical effect, which may be made the subject of experiment. Take a small glass cylinder, suspend it by a fine thread, and communicate to it a spinning motion round that centre. Bring it now gently in contact with a glass plate; the instant that collision takes place the cylinder will be thrown from the plate with considerable violence, whilst its revolving motion will have almost totally disappeared. This experiment, which is easily performed, corroborates what is mentioned in the first part of Article II. and affords a satisfactory proof of the efficacy of the general principle. As a corollary to Articles II. and III. we have to observe, that if the finite particles were rigid planes of uniform thickness, the attractive power at the same distance would be proportional to the extent of surface; in other words, to the quantity of matter contained in the

the particle. Again, since the intensity of all radiating influences are inversely as the squares of the distance, it is extremely probable, although not yet demonstrated, that the attractive power generated by the above principle will likewise follow the same law. When the distance, however, is so small that the peculiar shape of the particles will modify the effect, polar forces will be developed, and the planes will gradually arrange themselves in a parallel direction, while other peculiar changes relating to chemical phænomena will simultaneously take place. These modifications of the influence of the medium when the mutual distance of the rigid planes is small, will be more complex and interesting according to their number and mode of clustering together. Thus if we were to suppose every particle to be composed of an indefinite number of rigid planes arranged in a fixed order, and kept in their relative places by the balancing influence of an attractive and repulsive force, an accordance may be discovered with the theory now generally adopted, that the atomic weights of all the chemical elements are simple multiples of that of hydrogen; and that the particular properties of the particles of every different substance result from their individual organization.

The introduction of another medium, the particles of which may be considered as indefinitely larger than those of the first, and yet indefinitely smaller than the elementary plane, opens a new and wide field for the display of an unlimited number of curious phænomena. These, as far as the subject has as yet been explored, appear to coincide remarkably with the known properties of heat, whilst other simple combinations are likewise successful in explaining many other interesting facts in chemistry. Before entering, however, into this boundless region of inquiry, the circumstances which influence the variable ratio of the attractive force, and other preliminary theories, must be subjected to a course of mathematical examinations;—this will perhaps form the subject of a future communication.

In conclusion it may be observed, that were the size of the particles indefinitely reduced, whilst their velocity was indefinitely augmented, the density of the medium would be simultaneously diminished, whilst the quantity of force existing in a finite portion by remaining constant may be conceived sufficient to impel bodies with powers of equal intensity to those which are exhibited in nature; and this more especially since we may likewise suppose the rigid planes which constitute these bodies to be indefinitely reduced in thickness, whilst they still present the same superficies: thus by lessening the quantity of matter acted upon, the intensity of the action will be proportionably more vivid and efficacious. Thus were

 the

the velocity of the particles such as would carry them in void space from one extremity of the planetary regions to another in a second of time, the ratio of their magnitude and mean distance will approach that of the stars which form a nebula; whilst the mean space described in the medium by a particle before the direction of its motion is altered by impingeing against others, may be indefinitely smaller than any conceivable magnitude. However extreme the rapidity of this action may be considered, it is yet finite, and cannot therefore be reckoned irrational or contrary to the institutions of nature. It is the true primitive standard to which all velocities [upon the hypothesis] may be compared, as from it every other motion in the universe is derived.

Professor Œrsted, as far back as 1813, in his work on the Identity of Electricity and Chemical Affinity, deduced, from an extended series of experiments and general view of science, "that all effects are produced by a fundamental power operating in different forms of action." It is remarkable that the principle we have been explaining is in perfect unison with the sentiments of this eminent philosopher. A medium is supposed to envelope the universe, every particle of which is a minute reservoir of power, which is conserved in the rectilineal and rotatory motion with which it is endowed. These motions, by the introduction of the gross particles of different substances, are alternately transformed into each other; and thus the primordial power of Œersted's doctrine by the varied structure of the particles of matter "operates in different forms of action," and is everywhere developed in the diversified series of natural changes.

St. John's Hill, Edinburgh, April 14, 1831.

XXIII. *An Examination of* M. Virey's *Observations on Aëronautic Spiders, published in the* Bulletin des Sciences Naturelles. *By* JOHN BLACKWALL, *Esq. F.L.S.**

THE *Bulletin des Sciences Naturelles* for July 1829, p. 131—134, contains a notice, from the pen of M. Virey, of my memoir on Aëronautic Spiders, printed in the Transactions of the Linnæan Society, vol. xv. part ii.; and it is particularly deserving of attention, that the author, by an extraordinary misapprehension, originating apparently in an imperfect acquaintance with the English language, not only distorts the facts I have promulgated and perverts the arguments founded upon them, but even attributes to me opinions the

* Read before the Linnæan Society, May 4, 1830; and communicated by the Author.

very